2008
2011

NEWSLETTERS

MEGACITIES • AIR QUALITY • CLIMATE • FEEDBACKS • ECOSYSTEMS • HEALTH • WEATHER • MITIGATION

EDITED BY A. MAHURA, A. BAKLANOV
FOREWORD

This is the Volume of the MEGAPOLI Project NewsLetters (collection of 12 issues in total; starting from the 1st issue in December 2008 and ending with the last one in September 2011) for the European Collaborative Project "Megacities: Emissions, urban, regional and Global Atmospheric POLLution and climate effects, and Integrated tools for assessment and mitigation" for the Seventh Framework Programme of the European Union, Theme 6: Environment (Including Climate Change), Sub-Area: ENV-2007.1.1.2.1: Megacities and regional hot-spots air quality and climate.

The purpose of the Newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the researchers and end-users communities, to monitor the project activities and to exchange input and experiences. Each Newsletter includes short contributions from the MEGAPOLI Partners / Collaborators / End-Users, as well as Research Teams introductions.

Details on the project achievements can be also found in the Project Final Report, about 50 research reports / deliverables, 2 books, 3 special issues and corresponding journal papers (see MEGAPOLI project public website at http://megapoli.info).

Copenhagen Denmark
September 2011

On behalf of the MEGAPOLI Project Office
Alexander Mahura
Alexander Baklanov
MEGAPOLI PROJECT OFFICE

OFFICIAL WEB-SITE: http://www.megapoli.info

COORDINATOR
Alexander Baklanov
E-mail: alb@dmi.dk
Phone: +45-3915-7441
Fax: +45-3915-7400

VICE-COORDINATORS
Mark Lawrence
E-mail: lawrence@mpch-mainz.mpg.de
Phone: +49-6131-305331
Fax: +49-6131-305511

Spyros Pandis
E-mail: spyros@chemeng.upatras.gr
Phone: +30-2610-969510
Fax: +30-2610-990987

MANAGER
Alexander Mahura
E-mail: ama@dmi.dk
Phone: +45-3915-7423
Fax: +45-3915-7400

SECRETARY
Britta Christiansen
E-mail: brc@dmi.dk
Phone: +45-3915-7405
Fax: +45-3915-7400

EC SCIENTIFIC OFFICER
Jose M. Jimenez Mingo (since 9 Mar 2009)
Phone: +32-2-2976721
Fax: +32-2-????????
E-mail: jose.jimenez-mingo@ec.europa.eu

Wolfram Schrimpf (until 9 Mar 2009)
E-mail: Wolfram.Schrimpf@ec.europa.eu
Phone: +32-2-2971504
Fax: +32-2-2995755

POSTAL ADDRESS
MEGAPOLI Project Office
Danish Meteorological Institute (DMI)
Research Department
Lyngbyvej 100
DK-2100, Copenhagen
DENMARK

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MEGAPOLI Kick-Off-Meeting
October 2008, Mainz, Germany
Welcome to the first issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 1st issue of the MEGAPOLI Newsletter. A short presentation of the project is given here. Details can be found in public documents available at the project website (megapoli.dmi.dk), description of work (DoW), scientific presentations at international conferences and the project's brochure.

The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

MEGAPOLI Project Office

Latest News

- 10 Sep 2008 - Nature news (Nature, 455, pp. 142-143) on the FP7 EC MEGAPOLI Project – "Megacity project seeks to gauge urban pollution" (by Declan Butler)
- 1 Oct 2008 – Official Starting Date of the MEGAPOLI Project
- 26-28 Oct 2008 – Kick-Off-Meeting (Mainz, Germany) – 1st official meeting of the MEGAPOLI Project participants/representatives of the Partners/Teams
- 30 Nov 2008 – Official Web-Site (megapoli.dmi.dk) of the MEGAPOLI Project is launched for an open public and partners/teams restricted access
- coming soon - Consortium Agreement signing
- coming soon - Official Leaflet of the MEGAPOLI Project
- 7 Jan 2009 – Telephone Conference with sister CityZen Project - with coordinator Dr. Michael Gauss (Met.no) and two other key project partners

Kick-Off-Meeting

- Attended by more than 40 participants representing all MEGAPOLI Project partners/teams and workpackages;
- Officially opened by the Welcome speech by host Dr. Mark Lawrence (MPIC) and by the Introduction from the Commission by the EC Sci. Officer Dr. Wolfram Shrimpf;
- Introduction into the MEGAPOLI project goals and plans by Prof. Alexander Baklanov
- Short presentations by WP Leaders and discussions of working plans;
- Discussion of the working program and project coordination (plans for achieving first milestones, need for smaller group meetings; etc.);
- Parallel sub-groups meetings:
  - Field campaign planning (for Paris megacity, main focus – primary and secondary organic carbon sources; summer campaign - Jul 2009, winter campaign – 1 Jan – 15 Feb 2010), and
  - Modelling coordination (selecting base year, details on models used, formats for data exchange, European megacities in focus: Paris – Mathias Beekmann (CNRS-LISA), London – Sue Grimmond (KCL) and Ranjeet Sokhi (UH-CAIR), Rhein-Ruhr – Rainer Friedrich (USTUTT), Po Valley – Sandro Finardi (ARIANET));
- Reports from sub-groups meetings and cross-group (modelling/ experiment) coordination;
- Closed meeting of the Coordination Board and WP Leaders.
Project Summary
The MEGAPOLI project brings together leading European research groups, state-of-the-art scientific tools and key players from third countries to investigate the interactions among megacities, air quality and climate. MEGAPOLI will bridge the spatial and temporal scales that connect local emissions, air quality and weather with global atmospheric chemistry and climate.

Objectives
- to assess impacts of megacities and large air-pollution hot-spots on local, regional and global air quality,
- to quantify feedbacks among megacity air quality, local and regional climate, and global climate change,
- to develop improved integrated tools for prediction of air pollution in megacities.

Scientific Questions
In order to fulfil the objectives the following scientific questions will be addressed:
- What is the change of exposure of the overall population to the major air pollutants as people move into megacities? What are the health impacts of this exposure?
- How do megacities affect air quality on regional and global scales? What is the range of influence for major air pollutants (ozone, particulate matter, etc.)?
- What are the major physical and chemical transformations of air pollutants as they are moving away from megacities? What happens to the organic particulate matter, volatile organic compounds, etc?
- How accurate are the current emission inventories for megacities in Europe and around the world? What are the major gaps?
- How large is the current impact of megacities on regional and global climate?
- How will the growth of megacities affect future climate at global and regional scales?
- What is the impact of large-scale dynamic processes on air pollution from megacities?
- What are the key feedbacks between air quality, local climate and global climate change relevant to megacities? For example, how will climate change affect air quality in megacities?
- How should megacities (emissions, processing inside megacities, meteorology) be parameterised in regional and global models?
- What type of modelling tools should be used for the simulation of multi-scale megacity air quality - climate interactions?
- Which policy options are available to influence the emissions of air pollutants and greenhouse gases in megacities and how can these options be assessed?

Introduction Background
For the past few hundred years, human populations have been clustering in increasingly large settlements. In 2007, for the first time in history, the world’s urban population will exceed the rural population. At present, there are about 20 cities worldwide with a population of 10 mln or greater, and 30 with a population of exceeding 7 mln. These numbers are expected to grow considerably in the near future. Such coherent urban areas with more than about 5 mln people are usually called megacities (although there is no formal definition of a megacity at present). In Europe there are 6 major population centres that clearly qualify as megacities: London, Paris, the Rhine-Ruhr region, the Po Valley, Moscow, and Istanbul (Fig. 1).

Megacities and heavily urbanized regions produce a large fraction of the national gross domestic product. Human activities in megacities lead to serious challenges in municipal management, such as housing, employment, provision of social and health services, the coordination of public and private transport, fluid and solid waste disposal, and local and regional air pollution.

This project focuses on the latter, spanning the range from emissions to air quality, effects on regional and global climate, and feedbacks and mitigation potentials. The project will take into account the different features and growing trends that characterize cities located in developed and developing countries to highlight their present and future effects on local to global air quality and climate.

Our hypothesis is that megacities around the world have an impact on air quality not only locally, but also regionally and globally and therefore can also influence the climate of our planet. In Fig. 2 a schematic description of how megacities, air quality and climate interact is presented. Some of the links shown have already been considered by previous studies and are reasonably well-understood. However, a complete quantitative picture of these interactions is clearly missing. Understanding and quantifying these missing links will be the focus of MEGAPOLI.
Field measurements will be conducted to examine the evolution of aerosols and gas-aerosol interactions in the urban outflow of the Paris megacity. The WP4 objective is to improve our understanding and modelling of local and urban-scale impacts of megacity emissions, on the urban and the surrounding area air quality. Continental and global scale impacts of megacities on atmospheric composition and climate will be considered in WPs 5-6. These WPs will also consider effects of future climate and emission scenarios. Each WP activity will comprise basic research concerning individual processes critical for understanding the impacts analysed. Additionally, applied research will be devoted to building bridges between the scales and aspects previously introduced, and towards developing integrated assessment tools to define impacts and mitigation strategies.

In WP7 the information and model developments from WPs 1-6 are used to develop integrated tools for prediction of megacity impacts on air quality. Here, the integrated methodology is implemented to assess air quality and climate impacts of selected world megacities employing improved models from WPs 4-5, 6. In addition, results of the atmospheric and climate modelling will be used to estimate and assess (in monetary terms) impacts on human health and ecosystems and climate change impacts of megacities. Finally, information from integrated assessments will be input into WP8, focusing on mitigation options, which will be assessed by creating scenarios of possible future developments of megacities, where these options are implemented. The emissions for these scenarios (from WP1) will be used as input for the integrated modelling. By comparing results, the different scenarios and policy options are assessed. The project results will be disseminated to the Commission, policy makers and public by WP9, which will oversee coordination of individual WPs. Results and instruments made available by WP deliverables will support the definition of areas and scales of effective measures to improve present and future air quality in large conurbations.

Overall Strategy and General Description

The 1st critical step in improving our understanding of how megacities impact air quality, atmospheric composition and climate on different scales is the development of high-quality inventories of the emissions of relevant gases and aerosols and their precursors, and determining how these are anticipated to change in the mid-term future, as well as how these change under various scenarios. This will form key input to remaining components of the study, and through an understanding of the sensitivity of emissions of different compounds and from different sectors, will form basis for sensible approaches to mitigation strategies. This task will use as a starting point the corresponding emission inventories developed by local administrations for major urban areas. These will be improved when necessary, adjusted to the appropriate model scale and integrated into larger scale datasets for their use in regional and global scale atmospheric composition modelling. This approach will allow the exploitation of former investments and available information, and will build connections between local air quality management authorities and the air quality and climate research community. Emissions are the focus of WP1 (Fig. 3). WP2 is focusing on the megacity features (e.g. morphology), along with processes taking place in the urban canopy and boundary layer, which are responsible for the airborne transport and transformation of pollutants and urban climate effects. This WP is aimed at development of databases of morphology/land-use classifications for megacities, databases and sub-grid parameterisations of urban layer processes for megacity, regional and global scale models. Pollutant emissions impact chemical composition of the atmosphere on different scales. This in turn influences climate through radiative transfer and effects on clouds and hydrological cycle. These issues will form the core of the project, and will be analysed by WPs 3-6 (Fig. 3). WP3 will focus on characterization of aerosols and relevant precursors at urban and surrounding areas.
**Megacities in Focus**

The project will address, at different levels, practically all major megacities around the globe. Three levels of detail will be used in MEGAPOLI (Fig. 4). The lowest level of detail (3rd level) will include all megacities and the corresponding investigation will have a global perspective looking at their effects on global air quality and climate. The corresponding tools will include global Chemical Transport Models (CTMs), Global Climate Models (GCMs) and satellite studies. For cities in the 2nd level a regional perspective will be added to the global one. These cities (Moscow, Istanbul, Mexico City, Beijing, Shanghai, Santiago, Delhi, Mumbai, Bangkok, New York, Cairo, St. Petersburg, and Tokyo) have been selected because they are a representative subset of the full megacity set, they have been the locations of air quality studies and there are available observation datasets. The MEGAPOLI team includes local collaborators from these 2nd level megacities who will help in achieving the project objectives and will benefit from our results. MEGAPOLI will combine the available datasets in these megacities with regional models (including selected urban scale model applications) and also apply there the Integrated Modelling Tools that will be developed and evaluated in the project. The tools of the 3rd level will also be applied to the 2nd level megacities. Finally, for the 1st level megacities an urban and street scale perspective will be added to the regional and global ones. These megacities are the four major European Union population areas (Paris, London, Rhine-Ruhr, and Po Valley). New air quality observations will be collected for Paris closing some of the important gaps in the existing measurements.

The resulting dataset in Paris together with existing datasets in the other areas will be used for the evaluation and improvement of the modelling tools in MEGAPOLI. Finally our mitigation and policy analysis activities will focus on these 1st level megacities. Paris and London are the only two cities within the European Union that strictly correspond to the definition of a megacity (i.e. population larger than 5 mln people). The Rhine-Ruhr and Po Valley areas have megacity features even if they can be better described as urban conglomerations than as a single metropolitan area.

**Consortium**

The MEGAPOLI consortium consists of 23 full main partners from 11 European countries (Fig. 5), 12 international research non-funded partners and multiple end-users from Canada, Egypt, India, Chile, China, France, Mexico, Russia, Thailand, Turkey, UK, Ukraine, USA.

**Main Partners**
- Danish Meteorological Institute; DMI (Denmark)
- Foundation for Research and Technology, Hellas, University of Patras; FORTH (Greece)
- Max Planck Institute for Chemistry; MPIC (Germany)
- ARIANET Consulting (Italy)
- Aristotle University Thessaloniki; AUTH (Greece)
- Centre National de Recherche Scientifique (incl. LISA, LaMP, LSCE, GAME, LGGE) – CNRS (France)
- Finnish Meteorological Institute; FMI (Finland)
- Joint Research Center, Ispra, JRC (Italy)
- International Centre for Theoretical Physics; ICTP (Italy)
- King’s College London; KCL (UK)
- Nansen Environmental and Remote Sensing Center; NERSC (Norway)
- Norwegian Institute for Air Research; NILU (Norway)
- Paul Scherrer Institute; PSI (Switzerland)
- TNO-Built Environment and Geosciences; TNO (The Netherlands)
- UK MetOffice; MetO (UK)
- University of Hamburg; UHam (Germany)
- University of Helsinki; UHel (Finland)
- University of Hertfordshire – Centre for Atmospheric and Instrumentation Research; UH-CAIR (UK)
- University of Stuttgart; USTUTT (Germany)
- World Meteorological Organization; WMO (Switzerland)
- Charles University Prague; CUNI (Czech Republic)
- Institute of Tropospheric Research; IfT (Germany)
- Centre for Atmospheric Science, University of Cambridge; UCam (UK)

**Collaborators and End-Users**
- MCE2: Moline Center for Energy and the Environment.
- UI-CGER: University of Iowa, Centre for global and regional Environmental Research.
- YU-amDAL: York University-Atmos. Mod. & Data Assimilation Laboratory.
- SJSU: San Jose State University, Department of Meteorology.
- ASU: Arizona State University, Department of Mechanical & Aerospace Engineering, Environmental Fluid Dynamics Program.
- NSoEES: Nicholas School of the Environment and Earth Sciences, Duke University.
Collaborators and End-Users (continued)

- UoC-ESRL: University of Colorado, Earth Systems Research Systems (CIRES)
- IIT: Indian Institute of Technology, Department of Civil Engineering
- GKSS: GKSS-Research Centre, Institute for Coastal Research
- AIT: Asian Institute of Technology
- IIT-B: Indian Institute of Technology, Bombay
- San Jose State University, USA
- MSU: Moscow State University, the Geographical Faculty
- SRMC: Shandhai Regional Meteorological Center
- ITU: Istanbul Technical University
- GLA: Greater London Authority
- HRCCF: Hydrometeorological Research Center of Russia
- KMSA: Kiev's Municipal State Admin., Dept. of Environ.
- AIRPARIF: Association de Surveillance de la Qualité de l’Air en Ile de France
- CU: Cairo University-Astronomy and Meteorology Dept.
- DDEEEE: Direction des Etudes Economiques et de l’Evaluation Environnementale
- PUCC: P. Universidad Catolica de Chile
- RSHU: Russian State Hydro-Meteorological University
- University College London, UK
- AEROCOSMOS Scientific Centre for Aerospace Monitoring, Russia

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and present the MEGAPOLI Project results and findings:

- International Scientific Congress on Climate Change
  Copenhagen, Denmark, 10 - 12 March 2009
  http://climatecongress.ku.dk/
- 7th International Conference on Air Quality - Science and Application
  Istanbul, Turkey, 24-27 March 2009 (with special MEGAPOLI session)
  http://www.airqualityconference.org
- European Geosciences Union General Assembly (EGU-2009)
  Vienna, Austria, 19 - 24 April 2009 (with special MEGAPOLI session)
  http://meetings.copernicus.org/egu2009/
- 7th International Conference on Urban Climate
  Yokohama, Japan, 29 Jun – 3 Jul 2009
  http://www.ide.titech.ac.jp/~icuc7/
- 17th Intern. Conf. on Modelling, Monitoring and Management of Air Pollution
  Tallinn, Estonia, 20 - 22 July 2009
  http://www2.wessex.ac.uk/09-conferences/air-pollution-2009.html
- European Meteorological Society Annual Meeting (EMS-2009)
  Toulouse, France, 28 Sep - 2 Oct 2009 (with special MEGAPOLI session)
  http://www.emetsoc.org/annual_meetings/annual_meetings_2009.php
Welcome to the second issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 2nd issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon - Apr 2009 – special session on "Megacity Impacts on Regional and Global Scales" and Meetings (CityZEN, MEGAPOLI, MILAGRO participants) at the European Geosciences Union General Assembly (EGU-2009), Vienna, Austria, 19-24 April 2009; http://meetingorganizer.copernicus.org/EGU2009/session/247
- Coming soon - Mar 2009 – special session organized in cooperation with the EUCAARI, MEGAPOLI, CityZen, COST-728 - "Air Quality and Climate/ Meteorology Interactions and Feedbacks" and the Modelling Teams meeting at the 7th International Conference on Air Quality - Science and Application, Istanbul, Turkey, 24-27 Mar 2009; http://www.airqualityconference.org/programme.html
- 4 Mar 2009 – working meeting of the MEGAPOLI partners and collaborators participating in the COST-728, Madrid, Spain;
- 22 Feb 2009 – starting collaboration with the EC FP7 "Atmospheric Planetary Boundary Layers: Physics, Modelling and Role in Earth System" (PBL-PMES) Project (leader Prof. S. Zilitinkevich; Finish Meteorological Institute, Helsinki, Finland); http://pbl-pmes.fmi.fi/;
- 7 Jan 2009 – Telephone Conference with the sister CityZen Project. Participated - Michael Gauss, Maria Kanakidou, and Øystein Hov (from CityZen) and Alexander Baklanov, Mark Lawrence, Spyros Pandis, and Alexander Mahura (from MEGAPOLI).

Telephone Conference with our sister CityZen Project

- Identification of collaboration between CityZen and MEGAPOLI projects - differences and overlaps;
- Collaboration on the International Global Atmospheric Chemistry (IGAC) "Assessment on Impacts of Mega-cities on Air Quality and Climate";
- Establish links to each other’s projects web sites;
- Emission inventories - future emission scenarios and present day emissions;
- Coordinated model studies;
- Exchange of measurement data;
- Common data base;
- Exchange and use of each other’s mailing lists;
- Future conferences, where MEGAPOLI and CityZen should meet:
  - Air Quality, Istanbul, Turkey, 24-27 March, 2009;
  - European Geosciences Union (EGU), Vienna, Austria, 19-24 April 2009;
  - European Meteorological Society (EMS), Toulouse, France, 28 Sep - 02 Oct 2009;
  - European Geosciences Union, Austria, April 2010;
  - IGAC + Commission for Atmospheric Chemistry and Global Pollution (CAGCP) Joint Conference, Canada, July 2010;
  - European Geosciences Union, Austria, April 2011.
- Action items;
- Research questions of MEGAPOLI and CityZen projects.

See more details at: https://wiki.met.no/cityzen/meetings - in section “1st MEGAPOLI/CityZen phone conference, January 7, 2009”
The CityZen project (megaCITY - Zoom for the ENvironment) is funded through the 7th Framework Programme of the European Commission and focuses on the role of megacities and other emission hot spots on regional air quality and climate. The project has a total budget of about 4 million Euros for a duration of 3 years (1 Sep 2008 – 31 Aug 2011) and involves 16 partners from Europe, Africa and Asia. Air pollution and change are determined for the last decade and during the course of the project using extensive satellite and in-situ observations, and a series of different scale atmospheric composition models (local-regional-global). The Eastern Mediterranean, the Po Valley (Italy), the Benelux/Ruhr area, and the Pearl River Delta (South-East China) have been chosen for intensive case studies. Emissions, transport and transformation of pollutants in the troposphere are analyzed with focus on ozone, particulate matter, and their precursors. A set of chemical transport models connecting the different spatial and temporal scales is developed and used to quantify how the observed air pollution arises. Climate change may cause changes in air pollution in and around emission hotspots, and hotspot pollution can change precipitation, temperature and albedo. These feedbacks are studied in the scale-bridging model system based on global climate model scenarios, and in two coupled chemistry-climate models. Potential future changes are calculated for various climate scenarios (including mitigation options) by the model system evaluated in the project. Best available technologies and sectoral changes are studied. CityZen and MEGAPOLI have very similar objectives, which is why the European Commission strongly encourages collaboration between the two projects. First steps towards this end have been agreed upon by the coordinators. The first, informal, joint meeting will take place during the EGU General Assembly in Vienna on 22 April 2009. Several joint meetings will be organized. More detailed information about CityZen (list of partners, project objectives, publications, etc.) can be found on the web pages of the project at http://wiki.met.no/cityzen/.

An important idea in the project is to use hotspot regions to further develop and apply model systems that bridge together the processes occurring on the spatial scales spanning from the urban to the global: “An integrated zooming system to analyse air pollution impacts and climate effects from hotspots/megacities.” This concept is illustrated in Figure 1. The integrated system proposed here is a combination of models in different scales, earth observation and in-situ data. The modelling system is an ensemble of models zooming from global - regional - urban scales and capable to link to climate models. The scale bridging capability of this system is necessary to characterise adequately the exchange of pollution from hotspots/megacities and the impact in affected areas/regions.

The project will provide a lasting semi-operational structure of nested models and methods applicable for the underpinning of policy development for hotspots/megacities and extending to the regional and global spatial scales.

CityZen project partners:
- Meteorologisk institutt (met.no), the Coordinator;
- Peking University (PKU);  
- Centre National de la Recherche Scientifique (CNRS);
- Institut National de l’Environnement Industriel et des Risques (INERIS);
- Universitaet Bremen (1UP-UB);
- Foerderverein des Rheinischen Instituts fuer Umweltforschung an der Universitaet zu Koeln e.V. (FRIUK);
- Forschungszentrum Juelich GmbH (FZJ);
- University Of Crete (ECPL);
- Consiglio Nazionale delle Ricerche (CNR-ISAC);
- Norsk institutt for lufsforsknings (NILU);
- Universitetet i Oslo (UIO);
- Middle East Technical University (METU);
- University Of Leicester (ULEIC);
- International Institute for Applied Systems Analysis (IIASA);
- National Observatory of Athens (NOA);
- Cairo University, Center for Environmental Hazard Mitigation (CEHM).

WorkPackages:
- WP1 - Megacities & Air Quality (Laurence Roul, INERIS);
- WP2 - Megacity Air Quality and Climate Change (Martin Schultz, FZJ);
- WP3 - Megacity in the Future – Mitigation options for a sustainable Atmosphere (Paul Monks, ULEIC);
- WP4 - Integration of tools and support to policy (Leonor Tarrason, met.no).

Coordinator: Dr. Michael Gauss
Norwegian Meteorological Institute
Niels Henrik Abelsvei 40
NO-0313 Oslo, Norway
Phone: +47 22 96 33 02
Fax: +47 22 96 30 50
E-mail: Michael.Gauss@met.no

EC Scientific Officer: Dr. Wolfram Schrimpf
European Commission
Phone: +32-2-2971504
Fax: +32-2-2995755
E-mail: Wolfram.Schrimpf@ec.europa.eu
This project aims to systematically revise the planetary-boundary-layer (PBL) physics accounting for the non-local effects of coherent structures (long-lived large eddies especially pronounced in convective PBLs and internal waves in stable PBLs). It focuses on the key physical problems related to the role of PBLs in the Earth system as the atmosphere-land/ocean/biosphere coupling modules: the resistance and heat/mass transfer laws determining the near-surface turbulent fluxes, the entrainment laws determining the fluxes at the PBL outer boundary, the PBL depth equations, and turbulence closures. In this project the first round of revision will be completed, the advanced concepts/models will be empirically validated and employed to develop new PBL parameterization for use in meteorological modelling and analyses of the climate and Earth system. The new parameterizations and closures will be implemented in state-of-the-art numerical weather prediction, climate, meso-scale and air-pollution models; evaluated through case studies and statistical analyses of the quality of forecasts/simulations; and applied to a range of environmental problems. By this means the project will contribute to better modelling of extreme weather events, heavy air pollution episodes, and fine features of climate change. The new physical concepts and models will be included in the university course and new textbook on PBL physics. This project summarises and further extends our last-decade works in the PBL physics: discovery and the theory of the new PBL types of essentially non-local nature: “long-lived stable” and “conventionally neutral”; quantification of the basic effects of coherent eddies in the shear-free convective PBLs including the non-local heat-transfer law; physical solution to the turbulence cut off problem in the closure models for stable stratification; and discovery of the stability dependences of the roughness length and displacement.

Objectives

1. Advancing the key chapters of PBL physics

Completing the non-local RH/MT laws, prognostic PBL-height and turbulent entrainment equations, and surface-flux algorithms applicable to all PBL types, with particular attention to shallow, long-lived stable (LS) PBLs and sheared convective PBLs. Advancing the concepts of the momentum and scalar roughness lengths for very rough surfaces. Developing a hierarchy of turbulence closure models based on the concept of TTE and accounting for the internal wave mechanisms.

2. New data analyses required by theoretical developments

Empirical validation of and determining empirical constants in new theoretical models. Innovative field experiments parallel with real-time LES addressing “white spots” in the external parameter space. Analysing the outcomes from numerical experimentation using new PBL and turbulence closure schemes. Formulating recommendations to modellers for improved PBL parameterizations.

3. New tools for modelling and monitoring PBL height

Assessing remote-sensing methods applicable to all basic PBL types including shallow LS PBLs. Inter-comparison of the outcome from different instruments (ceilometers, other lidars, sodars). Refining the methodology for determining PBL parameters from practically usable instruments. Verification of the recommended PBL height models against observational data. Providing recommendations for operational monitoring of the PBL height, and estimating its added value for NWP, AQ and climate modelling.

4. Advancing the Earth-system modelling tools

Implementing the prognostic PBL height equation in NWP system HIRLAM and introducing corresponding changes in the model architecture. Creating principal linkages between the advanced HIRLAM and the PBL-height monitoring. Implementing and testing new PBL and turbulence closures schemes in the NWP, meteorological pre-processors for AQ, and coupled atmosphere-ocean models. Evaluation of the performance of new PBL schemes via direct (HIRLAM vs. meteorological observations) and indirect (SILAM and CAR-FMI vs. AQ observations) model-measurement comparisons.

5. Summarising result from numerical experimentation with improved environmental models

Analysing improvements and remaining difficulties with emphasis on (i) extreme weather events, (ii) heavy air-pollution episodes, and (iii) fine features of the climate change. Performing pilot studies of wind-energy resources using new modelling tools.
National Urban Database and Access Portal Tool, NUDAPT

Jason Ching
E-mail: Ching.jason@epamail.epa.gov
Atmospheric Modelling Division, National Exposure Research Laboratory, Office of Research and Development, United States Environmental Protection Agency
http://www.epa.gov/asmdnerl/

Based on the need for advanced treatments of high resolution urban morphological features (e.g., buildings, trees) in meteorological, dispersion, air quality and human exposure modelling systems for future urban applications (Figure 1), the U.S. Environmental Protection Agency (USEPA) launched a project in 2006 called the National Urban Database and Access Portal Tool (NUDAPT). Contribution to this effort also included collaboration efforts and in-kind contributions from many federal and state agencies and from private and academic institutions both here and in other countries. NUDAPT is a web served community-based urban database system designed to be a resource to facilitate implementations of new generations of advanced urban meteorological, air quality and climate modelling systems.

This initial effort produced a prototype of NUDAPT for Houston Texas. This Prototype included unique sets of gridded fields of urban canopy parameters (UCPs) for various new and advanced descriptions of model physics (sample UCPs are shown in Figure 2). These processed data are derived from high resolution building and vegetation measurements from airborne lidar system, obtained from the National Geospatial Agency, NGA, responsible for collecting such data for 133 major urban areas in the USA. Additional information included in the prototype system are gridded anthropogenic heating and daytime and nighttime population data incorporated to their specific models and applications.

The model sensitivity studies already performed have shown that both meteorological and air quality forecasts will significantly benefit from this next generation of models and database. Additional applications such as mitigation of urban heat island intensity studies are now also possible with NUDAPT. Future support will allow NUDAPT to extend its database coverage beyond the current Houston prototype to provide a modelling infrastructure for models including WRF and CMAQ to be applied to all major urban areas in the USA and elsewhere for which the high resolution urban data is now becoming available. The important custom-design feature and utilization of web portal technology enables NUDAPT to be a “Community” based system to facilitate customizing of data handling and retrievals (http://www.nudapt.org) for these urban applications (Ching et al., 2009).

The fundamental concepts in NUDAPT are consistent with MEGAPOLI’s WP2. Task 1 of WP2 focuses on creating a database of megacity features (e.g., morphology), along with processes taking place in the urban canopy and boundary layer, which are responsible for the airborne transport and transformation of pollutants and urban climate for supporting megacity, regional and global scale model studies COST Report. Model parameters for urban morphology, land-use and surface structure are to be derived from satellite, aerial and in situ data, e.g., height of structures will be determined using satellite images, stereography, laser scanning and SAR-interferometry for Paris, and other MEGAPOLI cities. We envision a partnership with principals from FMI, the responsible party for Task 1 of WP2; jointly the inclusion of the MEGACITY morphological databases into NUDAPT can serve to stimulate involvement and collaborations by the broad urban modelling community in various modelling applications if this function is not already built into the work plan; likewise the various tools in NUDAPT can be utilized by MEGAPOLI modelling partners to facilitate utility of this database to their specific models and applications.

References

Figure 1: Schematic of urban canopy parameterization concept and methodology for NUDAPT. Here, sky view factor is the ratio of the radiation received in the street canyon to the hemispheric radiation above the canopy.

Figure 2: Selected urban canopy parameters (UCPs) in NUDAPT derived for 1-km2 cells for Harris County, TX, as used in the urbanized MM5 modelling system. PAD is plan area density, and FAD is frontal area density of the buildings in each cell. Note that each cell has a unique combination of UCPs.
**Integrated Chemical Weather Modelling: On-line Coupled Enviro-HIRLAM System**

**Alexander Baklanov**

E-mail: alb@dmi.dk

Research Department, Danish Meteorological Institute (DMI)

http://www.dmi.dk/

A major share of anthropogenic sources of pollutants originated from conurbations, especially from megacities. These pollutants have not only local effects (on human health, material, ecosystem, urban climate), but may impact all the way to the regional (acidification, eutrophication, weather) and global scales (atmospheric composition, climate changes). The MEGAPOLI project (http://www.megapoli.info) is considering how megacities, air quality and climate interact, a schematic description of which is presented in Figure 1. Understanding and quantifying these links, feedbacks and chains request a new generation of integrated models with online two-way coupled meteorological processes, radiation, clouds, from one side, and atmospheric chemistry and aerosols from other side.

**Figure 1**: Main effecting links between megacities, air quality & climate.

The realisation of such on-line integrated models, using in MEGAPOLI, is demonstrated here using the Environment – HIgh Resolution Limited Area Model (Enviro-HIRLAM) integrated system (Baklanov et al., 2008; Korsholm et al., 2008; 2009). It was recently developed by DMI and other collaborators, joining the HIRLAM community, from the University of Copenhagen (Denmark), Tartu University (Estonia), Russian State Hydro-Meteorological University, Tomsk State University (Russia), Odessa State Environmental University (Ukraine), and Vilnius University (Lithuania).

The Enviro-HIRLAM (Figure 2) is an online coupled model for research and forecasting of both meteorological and chemical weather. It includes two-way feedbacks between air-pollutants and meteorological processes. Atmospheric chemical transport (ACT) equations are implemented inside the meteorological corner on each time step. To make the model suitable for urban areas, where most of population is concentrated, the meteorological part is improved by implementation of urban sublayer modules and parameterisations. The aerosol module in Enviro-HIRLAM comprises two parts: (i) a thermodynamic equilibrium model (NWP-Chem-Liquid) and (ii) the aerosol dynamics model CAC based on the modal approach. Parameterisations of the aerosol feedback mechanisms and several chemical mechanisms could be chosen in the model depending on the specific tasks: well-known RADM2 and RACM or new-developed economical NWP-Chem.

The Enviro-HIRLAM ten-year development history is outlined as the follows:

- 1999: Started as an unfunded initiative at DMI;
- 2001: On-line passive multi-tracer pollutant transport and deposition mechanisms are included in HIRLAM-Tracer;
- 2003: Aerosol and chemistry model tested, at first, as 0D module in off-line CAC model;
- 2004: Testing of different formulations for advection of tracers including cloud water;
- 2005: Urbanisation of the meteorological model (within EC FP5 FUMAPEX project);
- 2005: Studying of aerosol feedbacks (COGCI, PhD study);
- 2006: Test of CISL advection scheme;
- 2007: First version for pollen studies;
- 2008: New computationally efficient chemical solver NWP-Chem;
- 2008: First version with indirect aerosol feedbacks;
- 2008: Testing new advection schemes in Enviro-HIRLAM (Univ Copenhagen, PhD and MSc studies);
- 2008: Decision to build HIRLAM Chemical Branch (HCB) with the Enviro-HIRLAM as a baseline system;
- 2008: Enviro-HIRLAM becomes the international project;
- 2009: Opening of the HCB at http://hirlam.org;

Validation and sensitivity tests of the on-line versus off-line integrated versions of Enviro-HIRLAM showed that the online coupling improved the results. Different parts of Enviro-HIRLAM were evaluated versus the ETEx-1 experiment, Chernobyl accident and Paris study datasets and showed that the model performs satisfactorily.

The HIRLAM Community (http://hirlam.org) organized the HIRLAM Chemical Branch, where the Enviro-HIRLAM model is considered as the baseline system for the branch. The strategy of integration of the HIRLAM NWP and ACTM within the HIRLAM consortium is described by Baklanov (2008). The Enviro-HIRLAM model is using for studies of megacity effects on different scales in MEGAPOLI’s WPs 2, 4, 5, and 6.

**References**


Korsholm U. 2009: Integrated modelling of aerosol indirect effects - development and application of a chemical weather model. PhD thesis University of Copenhagen and DMI.
Integration of Different Emission Inventories for Po River Basin

Paola Radice
E-mail: p.radice@aria-net.it
ARIANET srl
http://www.aria-net.it

To reduce air pollution is necessary to control emission sources, and for this reason a deep knowledge of emissions of air pollutants is one of the requirements to check historical trends, to understand how secondary pollutants (e.g. ozone and particulate matter) are formed and to develop environmental management tools.

In MEGAPOLI project, the aim to estimate megacities emissions impact at local, regional and global scale can be reached integrating high resolution inventories available at local scale within national and continental scale ones. The first step in this direction is the evaluation of different inventories available for the European megacities and hotspots target areas.

The Po Valley extends some 600 km in an east-west direction, running from the Adriatic Sea to Western Alps. It hosts about 30% of Italian population, it accounts for 40% of national GDP, it is home to 37% of the country’s industry, about 55% of livestock, and 35% of the agricultural production. Milan metropolitan area with its extended road network is located in the central part of the Po river basin. The core of Milan urban area, roughly coincident with its province, accounts for about 3.7 millions inhabitants, while its commuting area is evaluated around 7 million people.

Integration of Different Emission Inventories

Two different kinds of emission inventories are available over the Po Valley area for the reference year 2005: a national one with province level spatialization (Figure 1) and a group of local inventories characterized by a municipal level spatialization.

The national emission inventory ISPRA2005 has been developed by the national environmental agency applying a top-down approach to computed provincial (NUTS3) estimates. Total national emissions have been disaggregated using measures of activity data directly or indirectly related to the emissions in each province. According to the national inventory, the Po Valley produces a large fraction of total Italian pollutants: PM10 and NOX (42%), NMVOC (39%) and NH3 (64%) (Figure 2). The first three pollutants are mostly linked to traffic and industrial activities, while the last one is produced by cattle-breeding and agriculture. The space resolution of ISPRA-2005 inventory is insufficient to properly define urbanized areas emissions. A better space distribution of pollutant sources is provided by regional inventories with municipal level spatialization (Figure 3), which are presently available for reference year 2005 for 3 regions: Piemonte, Lombardia and Friuli Venezia Giulia.

These latter inventories have been produced applying INEMAR methodology, that is based on the bottom-up approach and takes into account emissions from different sources (point, area, biogenic, road transport), organizing all information needed for their estimation: activity indicators, emission factors, and statistical data necessary for spatial and temporal distribution of emissions (Caserini et al., 2002).

Before merging the different inventories available over the Po valley, a comparison of regional versus national inventories is being performed at different space aggregation level: NUTS2 (regional) and NUTS3 (provincial). This verification is aimed to identify possible differences and mismatches between pollutants total emissions and their distribution among different sectors. Even if INEMAR totals agree well with national inventory, the composition of these emissions can be different, possibly causing unequal concentration scenarios after further space disaggregation and time modulation. Merging inventories characterised by relevant differences can cause space discontinuities in the emission load. After the cited verification, a reference inventory for the Po valley area will be built and made available for the reference year 2005. Figure 4 shows a preliminary evaluation of Milan and Po Valley NOx emissions in comparison with other megacities.

References and Acknowledgements

Caserini et al., 2002: Integrated Assessment and Decision Support, Proceedings of the 1st Biennial Meeting of the iEMSs “The INEMAR database: a tool for regional atmospheric emission inventory”

We thank National and Regional Environmental Protection Agencies of Piemonte, Lombardia and Friuli Venezia Giulia for providing emission inventories.
ARIANET recent projects concerning regional and urban air quality include: 1) support to ENEA and Italian Environmental Ministry in the development of the national air quality modelling system and the related RAINS-Italy; 2) cooperation with Italian Regional and Local Environmental Agencies to implement modelling systems at regional and urban scale for yearly air quality assessment and policies evaluation; 3) participation in EU FP5 project FUMAPEX, as WP leader, developing an urban air quality forecasting system for the Turin urban area, 4) collaboration to the development and implementation of the air quality forecasting modelling systems of Turin, Rome and Milan, 5) collaboration with CGER (Univ. of Iowa) to the realisation of air quality forecast for MILAGRO and ARCTAS campaigns.

Role and contribution
The ARIANET role and contribution into the MEGAPOLI project include: Multiscale emission modelling, integration of different emission inventories and up-scaling of high resolution regional and city scale emissions (WP1). Nested air quality modelling system applications to upscale megacities and hotspots pollution and evaluate their local to regional air quality impact (WP5 and WP7). Development, application and demonstration of prototype modelling system for case studies and scenarios evaluation on the Po-Valley urban conglomeration area and Mexico City (WP7 and WP8).

Researches involved
Sandro Finardi  
s.finardi@aria-net.it

Giuseppe Calori  
g.calori@aria-net.it

Alessio D’Allura  
a.dallura@aria-net.it

Paola Radice  
p.radice@aria-net.it

ARIANET expertise include: meteorological and air quality modelling from regional to local scale; air quality forecasting; real-time pollution control for industrial sites; development of emission inventories; integration between simulation models and geographic information systems (GIS), reconstruction of traffic flows and evaluation of their impact on air quality, statistical treatment and presentation of environmental data.
This includes air pollution modelling problems such as smog and ozone arising from emissions from industry, power plants, house warming, urban traffic, nuclear emergency, and pollen forecasting. The AQRG has been involved in several international research projects on atmospheric dispersion and chemistry relevant to the present application. Mostly these projects have been funded by EU, e.g. arctic surface ozone depletion (ARCTOC), DMS and aerosol impact on the climate (ELCID), forecasting of urban environment (FUMAPEX), Arctic Risk (AR-NARP), create a new European operational system for global monitoring of atm. chemistry and dynamics, and an operational system to produce improved medium-range and short-range air-chemistry forecasts (GEMS), and in several projects on nuclear emergency preparedness (ENSEMBLE, RODOS, RTMOD, ETEx, Enviro-RISKS, Enviro-HIRLAM).

Role and contribution

The DMI role and contribution into the MEGAPOLI project include: overall coordination of the project (WP9); improvement and evaluation of parameterization for the urban-regional meteorology (WP2); modelling the interaction between air-quality and meteorology/climate using on-line coupled model ENVIRO-HIRLAM (WP4); regional air quality and inverse (source determination) modelling using ENVIRO-HIRLAM/ CAC (WP5), regional climate modelling using HIRHAM (WP6); and will be one of the key-developer of the integrated urban-regional-global tool (WP7).

Researches involved

Alexander Baklanov
alb@dni.dk

Allan Gross
agr@dni.dk

Alexander Mahura
ama@dni.dk

Ulrik S. Korsholm
usn@dni.dk

Roman Nuterman
ron@dni.dk

Jens H. Christensen
jhc@dni.dk

Synne H. Svendsen
shs@dni.dk

The Danish Meteorological Institute (DMI, http://www.dmi.dk) is the national meteorological service for Denmark, Greenland and Faeroe Islands. DMI has a long-lasting experience in atmospheric environment and climate modelling including development, running and analysing 3D atmospheric models for both operational use and research in weather forecast, climate change and long-range dispersion, transformation and deposition of pollutants. The Meteorological Research Division, MRD (HIRLAM and atmospheric pollution) and the Danish Climate Centre, DCC (HIRHAM) at DMI involves about 40 scientists. The DCC has extensive experience in climate modelling research. The regional climate model HIRHAM which has been developed jointly by DMI and Max Planck Institute for Meteorology in Hamburg has been extensively employed in resolutions down to 12 km. DMI is furthermore involved in the regional model inter-comparison study PIRCS, under which extensive simulations using GCM boundary conditions from the Hadley Centre for present day climate and climate change simulations over USA have been conducted. The DCC has been involved in several international research projects on global and regional climate modelling funded by EU, including "Regionalization of Anthropogenic Climate Change", RACCS; TUNDRA; "Global implications of Arctic climate processes and feedbacks", GLIMPSE; "Prediction of Regional scenarios and Uncertainties for Defining EuropeAN Climate change risks and Effects", PRUDENCE; and ENSEMBLES projects.
Role and contribution
The MPIC role and contribution in the MEGAPOLI project includes coordination of the project and participation in WPs 1, 3, 5, 6 and 8, providing global model simulations of the impacts of megacities on atmospheric composition and climate, collaborating on the development of emissions datasets for sensitivity and scenario studies, interpretation of scenario runs for evaluating mitigation strategies, assessing the impact of megacity emissions using satellite observations, participation in the Paris field campaign, and working actively towards the dissemination of the results to the scientific community and stakeholders (public and policy makers).

Researchers involved
(not pictured - Paul Crutzen and Thomas Wagner)

Mark Lawrence
lawrence@mpch-mainz.mpg.de

Tim Butler
tmb@mpch-mainz.mpg.de

Steffen Beirle
beirle@mpch-mainz.mpg.de

Reza Shaiganfar
shaigan@mpch-mainz.mpg.de

Stephan Borrmann
borrmann@mpch-mainz.mpg.de

Frank Drewnick
drewnick@mpch-mainz.mpg.de

Johannes Schneider
schneider@mpch-mainz.mpg.de

Stephane Gallavardin
gallavas@mpch-mainz.mpg.de

The Max Planck Institute for Chemistry (MPIC, http://www.mpch-mainz.mpg.de/mpg/english/) was established in Mainz, Germany in 1949, and focuses on the chemistry of the atmosphere, particle chemistry, biogeochemistry, remote sensing for Earth systems sciences, and chemistry of the geosphere. Prof. Jos Lelieveld leads the atmospheric chemistry department (http://www.atmosphere.mpg.de/).

The atmospheric modelling group, led by PD Dr. Mark Lawrence, has many years of experience in global chemistry-transport and coupled chemistry-climate modelling. Our research focuses on a variety of topics, including gases and aerosols, both tropospheric and stratospheric, and our approaches range from theoretical developments and model tool development to applications such as process studies and providing support such as chemical weather forecasts for field campaigns. Below is an example plot of a simulation of the global surface layer distribution of outflow tracers emitted from megacities and other major population centers around the world.

The remote sensing group, led by Prof. Thomas Wagner, retrieves global data sets of tropospheric and stratospheric trace gases, aerosol and cloud properties from novel UV/Vis satellite instruments. These observations allow us to quantify the emissions of pollutants from Megacities and their export on regional and global scale. The group will also participate in the MEGAPOLI Paris summer field campaign using mobile MAX-DOAS instruments.

The particle chemistry department, led by Prof. Stephan Borrmann, has extensive expertise in aerosol measurements, characterization and interpretation, especially in urban regions. The department will be participating (using MPIC funding) in the MEGAPOLI Paris summer field campaign with a mobile laboratory, additional ground measurements and instrumentation aboard the SAPHIRE aircraft.

Brochures and reports about the institute’s research are available at http://www.mpch-mainz.mpg.de/mpg/english/reports.html
Nansen Environmental and Remote Sensing Center (NERSC; http://www.nersc.no/) is an independent non-profit research institute affiliated with the University of Bergen, Norway. The Nansen Center conducts basic and applied environmental research funded by national and international governmental agencies, research councils and industry.

NERSC's vision is to make a significant contribution to the understanding, monitoring and forecasting of the world's environment and climate on regional and global scales. This is done through coordination and participation in national and international research programs focusing on:

- Studies of global and regional climate processes using numerical models together with observations from earth-monitoring satellites and field experiments.
- Modelling of the global and regional marine ecosystem and carbon cycle combined with use of satellite ocean color observations.
- Studies of ocean disposal of the greenhouse gas CO2 as an option for reducing the rapid increase in atmospheric CO2 concentration.
- Studies of coastal zone processes and ecosystem dynamics by integrated use of high resolution ocean circulation models and observations through advanced data assimilation systems.
- Studies of sea ice processes using coupled numerical models and observations from satellite.
- Operational monitoring and forecasting of the coastal zone as a tool for management and risk assessment.
- Operational monitoring and forecasting of ice conditions as a service to offshore industry, ship traffic and fishing industry.

NERSC's research strategy is to integrate the use of remote sensing and field observations with numerical modelling through the use of advanced data assimilation techniques.

NERSC is an independent non-profit research institute affiliated with the University of Bergen, Norway. NERSC conducts basic and applied environmental research funded by governmental agencies, research councils and industry. NERSC's research strategy is to integrate the use of remote sensing and field observations with local-, regional- and global-scale numerical modelling. NERSC staff teaches university courses and hosts graduate students and postdoctoral fellows from several nations. Faculty members at the University of Bergen and senior staff at the Nansen Center hold adjunct positions at the two institutions.

NERSC is a head institution of the Nansen Group, which includes establishments in Russia (Nansen Centre in St.-Petersburg), China (Nansen-Zhu Centre), India, South America and Africa to provide an impetuous for globally-oriented research in support of sustainable development of the earth's resources. In 2005, NERSC was awarded the prestigious European Descartes Prize for the best integrated research.

The center teaches university courses and hosts graduate students and postdoctoral fellows from several nations. In 2002 the Nansen Group hosts 10 PhD candidates in Bergen and 15 PhD candidates in St. Petersburg. Cooperation in research and education are established with several universities world-wide. Faculty members at the University of Bergen and senior staff at the Nansen Center hold adjunct positions at the two institutions.

Role and contribution

In this project NERSC will be the co-leader of WP2 and the leader of its Task 2.4 – urban atmospheric boundary layer features, simulation, and parameterization. The primarily tools in operation will be turbulence-resolving models, namely, the NERSC LES code and parallelized LES code of the Meteorological Institute at Hannover University. With these tools, NERSC will contribute in understanding and simulations of the Paris plume (WP3) and the development of improved UABL parameterizations for WP4-6. Ultimate contribution will aim at representation of the urban climate and pollution through a 3D visualization of urban atmospheric dynamics in WP7

Researches involved

Igor Esau
igor.ezau@nersc.no

Sergey Zilitinkevich
sergej.zilitinkevich@nersc.no

Marwan Khalil
marwan.khalil@nersc.no

Svetlana Sorokina
svetlana.sorokina@nersc.no
Coming Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

• MEGAPOLI Project to be presented at the Session - AS3.8: Megacities: Air Quality and Climate Impacts from Local to Global Scales. European Geosciences Union General Assembly (EGU-2009), Vienna, Austria, 19-24 April 2009 - by Mark Lawrence (MPIC Team) "Megacity Pollution Effects from Urban to Global Scales: An Overview of the MEGAPOLI Project";

• MEGAPOLI Project to be presented at the Italian National Meeting of the Piemonte Regional Environmental Protection Agency, 24-27 Mar 2009, Piemonte, Italy – by Sandro Finardi (ARIANET team) "European initiatives on air quality modelling to support air quality management";


• MEGAPOLI Project to be presented at the International Alliance of Research Universities (IARU) International Scientific Climate Congress, 10-12 Mar 2009, Copenhagen, Denmark – by Alexander Baklanov (DMI team) "Megacities: Emissions, urban, regional and Global Atmospheric Polluion and climate effects, and Integrated tools for assessment and mitigation";

• MEGAPOLI Description of Work (DoW) – in Press; available at http://megapoli.dmi.dk/nlet/MEGAPOLI_DoW.pdf

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and present the MEGAPOLI Project results and findings:


• 7th International Conference on Urban Climate Yokohama, Japan, 29 Jun – 3 Jul 2009 http://www.ide.titech.ac.jp/~icuc7/

• 17th Intern. Conf. on Modelling, Monitoring and Management of Air Pollution Tallinn, Estonia, 20 - 22 July 2009 http://www2.wessex.ac.uk/09-conferences/air-pollution-2009.html


Welcome to the third issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 3rd issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – Jul 2009 – Paris Plume Study (WP3) – measurement campaign in the Paris metropolitan area and surroundings
- 19-24 Apr 2009 – special session on "Megacity Impacts on Regional and Global Scales" and Meetings (CityZen, MEGAPOLI, MILAGRO participants) at the European Geosciences Union General Assembly (EGU-2009), Vienna, Austria; joint MEGAPOLI and CityZen meeting and discussions
- 7-8 Apr 2009 – WP3: Megacity Plume Study - campaign planning meeting in Paris, France - discussions among participants about chemical and meteorological measurements, lidars, remote sensing, mobile ground based platforms, etc. practical involvement of other French research teams and authorities (AirParif)
- 24-27 Mar 2009 – MEGAPOLI special session organized in cooperation with the MEGAPOLI, CityZen, EUCAARI, COST-728 - "Air Quality and Climate/ Meteorology Interactions and Feedbacks" and the MEGAPOLI Modelling Teams meeting at the 7th International Conference on Air Quality - Science and Application, Istanbul, Turkey

EGU-2009 (Apr 2009, Vienna, Austria)

MILAGRO/ MEGAPOLI/ CityZen special session and Meetings (MEGAPOLI and CityZen participants) during the European Geosciences Union Assembly:
- Special Session on "Megacity Impacts on Regional and Global Scales"; joint meeting with the MEGAPOLI-CityZen projects participants; CityZen and MEGAPOLI Projects presentations; discussions on IGAC-sponsored “Assessment on Impacts of Mega-cities on Air Quality and Climate: Outline and Activities”; discussion of possible collaboration with NOAA on WP1 and WP8 for emission datasets; discussions on joint session for EGU-2010 with contributions from the MEGAPOLI, CityZen, and MILAGRO projects with presentations by continents (e.g. Europe, America, Asia, and other); as well 2nd splinter meeting between the MEGAPOLI and CityZen projects will be organized.

AQ7-2009 (Mar 2009, Istanbul, Turkey)

Additionally to MEGAPOLI, CityZen, EUCAARI, COST-728 special session and MEGAPOLI modelling teams meetings during the 7th International Conference on Air Quality, partners and collaborators had short working meetings on the following research topics:
- Po Valley focus group; Istanbul megacity study group; Up-scaling (from city to regional and to global scales) modelling; Two-way nesting for street- and city scales; Paris datasets (emission, land-use, monitoring, modelling) and experiment plans; Meteo-measurements for the Paris plume study; Remote sensing and data assimilation; Integrated modelling; Air pollution and ecosystem impact indexes; Urban planning and future scenarios; TNO emission inventory for MEGAPOLI.
Two one month campaigns are scheduled in July 2009 and in January/February 2010.

Figure 2. Example of flight plan with the French ATR-42 aircraft in the western sector. Flights will be performed at about 500 to 800 m altitude during afternoon. Similar flight plans are made for 5 other sectors.

A very large suite of state of the art instruments will be set-up during the campaign (see Table 1), allowing for fast measurement of aerosol chemical composition and physico-chemical properties, and of related precursor gas concentrations. Conjoint airborne and ground based measurements of the chemical SOA composition and of (oxidised) VOC will offer the opportunity to document gas phase aerosol interaction at various stages of the aging of polluted air masses.

In addition, the modification of optical and hygroscopic parameters during plume aging will be addressed. Data from these campaigns will allow for a detailed assessment, for one case study, of how megacity emissions impact on air quality, regional scale atmospheric composition and regional climate. They will also allow for in depth model evaluation and improvement.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Instrument</th>
<th>Time of acquisition</th>
<th>Urban site</th>
<th>Suburban site</th>
<th>Aircraft (peripheral site)</th>
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Table 1. List of instruments for gas and aerosol phase measurements to be deployed during the 2 intensive field experiments (summer/winter).

An airborne segment with dedicated flights with the French ATR-42 aircraft in the Paris plume during one summer month will permit documenting the evolution of the megacity plume (Figure 2). In addition to the observations funded within MEGAPOLI, several mobile laboratories (from PSI and MPIC) will allow aerosol and gas phase characterisation at various locations in the region (upwind of the agglomeration, within the plume). Aerosol backscatter measurements at three fixed locations and from one mobile platform will give information on the vertical aerosol distribution and on spatio-temporal variations of the boundary layer height. Meteorological and dynamical parameter measurements (wind, temperature, turbulence.) will also be performed at the peri-urban IPSL-SIRTA site.
French Mobile Observatory of Atmospheric Physico-Chemical Processes and Climate

Juan Cuesta1,2, Patrick Chazette1,3, Pierre Flamant1, Bernard Bonsang1, Dimitri E dovart1, Lætitia Estevan1, Fabien Gibert1, Valérie Gros3, Fabien Marnas1, Jean-Christophe Raut1,3, Joseph Sanak3 and Cyrille Flamant1

1 LMD/IPSL-CNRS, Ecole Polytechnique, 91128 Palaiseau, France, 2 LATMOS/IPSL, 4 Place Jussieu, 75252 Paris, France, 3 LSCE/IPSL, CEA-CNRS-UVSQ, F-91191 Gif-sur-Yvette, France

E-mail of Presenting Author: cuesta@lmd.polytechnique.fr
Institut Pierre Simon Laplace, LMD-LATMOS / CNRS
http://www.ipsl.jussieu.fr/
http://admweb.lmd.polytechnique.fr/LiMAG/

The ATMOS Mobile Observatory

A new ATMospheric Mobile ObServatory, so called "ATMOS", has been developed by the LiMAG "Lidar, Meteorology and Geophysics" team of the Institut Pierre Simon Laplace (IPSL) in France, in order to contribute to international field campaigns for studying atmospheric physico-chemistry, air quality and climate (i.e. aerosols, clouds, trace gasses, atmospheric dynamics and energy budget) and the ground-based validation of satellite observations. The deployment of ATMOS is an essential for complementing the fixed sites and a potential alternative of airborne platforms.

Instrumental Payload

ATMOS payload is modular, accounting for the different platforms, instruments and measuring techniques. It comprises both the remote sensing platform MOBILIS ("Moyens mOBiles de télédétection de l’IPSL") and the in-situ physico-chemical station SAMMO ("Station Aérosols et chimié MObile"). MOBILIS is an autonomous and high-performance system constituted by a full set of active and passive remote sensing instrumentation (i.e. Lidars and radiometers), whose payload may be adapted for either i) long term fixed monitoring in a maritime container or a shelter [Cuesta et al., 2008], ii) ground-based transect observation onboard a small car and ii) an airborne deployment in an ultra-light airplane (ULA) [Chazette et al., 2007]. SAMMO is a fully equipped in-situ sensor payload, oriented to pollution monitoring (i.e. particles and trace gasses), onboard a truck.

International Field Campaigns and Observations

ATMOS has been first deployed in the framework of LISAIR "Lidar pour la Surveillance de la qualité de l’AIR" [Raut and Chazette, 2007], for monitoring air quality in 2005. The platform enabled the characterization of local anthropogenic aerosols in the atmospheric boundary layer (ABL, up to 1 km above ground level agl in the example of Figure 1) and the long range transport overflowing the Paris region in the free troposphere of biomass burning aerosols (from 1 to 3.2 km agl) and desert dust (at 3.5 km agl). Their interactions are illustrated at 2100 h when the biomass burning plume subsides down to the ABL and produces a significant increase in the surface black carbon concentration.

In 2006, ATMOS contributed to the AMMA "African Monsoon Multidisciplinary Analysis", in Tamanrasset and in Niamey for observing the aerosols and the atmospheric boundary layer in the Sahara [Cuesta et al., 2008] and in the Sahel [Chazette et al., 2007]. It documented for the first time the development of the Saharan convective boundary layer which gains steadily ~1 km per hour during summer until nearly 6 km agl at 1300 UTC (see example of Fig. 2). In the afternoon, a continuous cumulus cloud deck typically formed with vertical recirculation depicted by the alternating occurrence of virga and dust updrafts from the surface (between 1600 UTC and 1830 UTC).

In 2007, ATMOS was deployed for the COPS "Convectively and Orographycally driven Precipitation Study" in the Rhin Valley and the validation of the spatial mission CALIPSO.

Upcoming Field Campaigns

In the coming years, ATMOS will be deployed i) in the Paris Megacity, in the framework of MEGAPOLI (2009-2010), ii) in southern France for the Chemistry-Aerosol Mediterranean Experiment CHARMEX (2011-2012) and iii) the validation of ADM-Aeolus in 2010-2011 and Earth-Care in 2012.

References


Figure 1. Multi-wavelength Lidar observations: attenuated backscatter (at 532 nm) and the surface black carbon concentration (in red and white points), in the Paris region (48.7°N 2.2°E) on May 26th 2005.

Figure 2. Mini-Lidar observations in Tamanrasset (22.8° N 5.5° E 1370 m) on June 25th 2006. White curves correspond to radiosounding potential temperature profiles.
Combined Use of Car Based and Satellite Observations for Characterization and Quantification of Large Emission Sources Like Megacities

Megacities constitute important emission sources of atmospheric pollutants. These emissions affect not only the air quality in the urban areas but can also be transported over large distances. We aim to quantify megacity emissions in particular of NO\textsubscript{2} using (a) satellite observations and (b) mobile based remote sensing instrumentation like Multi-AXis-(MAX-)DOAS mounted on a car.

At first, the satellite observations show enhanced levels of pollutants over many megacities; by combining these observations with model simulations, the emissions can be quantified and existing emission inventories can be improved.

Satellites provide long time series with global cover. In the Figure 1, the average tropospheric NO\textsubscript{2} VCD over Europe is shown. Enhanced values are found over densely populated emission sources. We will analyze time series of tropospheric NO\textsubscript{2} columns from SCIAMACHY, as well as from GOME2 and OMI, for various megacities.

At second, from MAX-DOAS observations, the vertically integrated trace tropospheric gas concentration above the instrument can be determined. These observations are used to validate the satellite observations. In addition, by making measurements in circles around large emission sources, the total emissions of these sources can be quantified.

If MAX-DOAS observations are performed from moving platforms, also integration along the driving route can be performed. Together with information on wind speed and direction, this allows to determine the complete trace gas flux through the plane above the route. If emission sources are encircled, even the complete trace gas emission of the sources can be determined.

For the Paris campaign within the MEGAPOLI project in July 2009 we plan to encircle Paris on ring roads of different diameter. This will allow determining the emissions of different parts of the city.

References
This time-resolved dataset of carbonaceous aerosols (EC+POM) and inorganic salts (ions) are reported in Figure 2.

Figure 2. Temporal variations of PM2.5, Carbonaceous (EC+POM) aerosols, and inorganic salts (ammonium, nitrate, sulphate).

This allowed investigating the factors controlling the levels of PM2.5 and showed that polluted periods with PM2.5 > 40µg/m³ were characterized by air masses of continental (European) origin and chemical composition made by 75% of ions (periods I and III, see Figure 2). By contrast, clean marine air masses have shown the lowest PM2.5 concentrations (typically of about 10 µg/m³); carbonaceous aerosols contributed for most of this mass, i.e. typically 75% (period II, see Figure 2).

The rather stable levels of carbonaceous aerosols observed during this study suggest that the region of Paris is a major contributor to this fraction. By opposite, long-range transport from European continent is proposed as the main contributor for ions measured in Paris during springtime. All these conclusions are supported by modelling results performed with the CHIMERE model (Q. Zhang, M. Beekmann, and co-workers; Sciare et al., 2009). This model is a multi-scale model primarily designed to produce daily forecasts of ozone, aerosols and other pollutants and make long-term simulation (http://www.lmd.polytechnique.fr/chimere/).

The use of artefact-free measurements of PM2.5 made by TEOM-FDMS has shown here to amplify the contrast between periods with low (respectively high) PM2.5 concentrations.

Although carbonaceous aerosols showed to be mainly produced at regional scale, our results also suggest that almost 2/3 of organic carbon measured in Paris is of secondary origin, pointing out the high reactivity of organic aerosols and gas precursors, in the few hours following their formation and/or transformation.

References
Morphology Database: How It Is Created

Pauli Sievinen
E-mail: pauli.sievinen@tkk.fi
Helsinki University of Technology/Department of Radio Science and Engineering
http://radio.tkk.fi/en/

Pauli Sievinen, Jaan Praks, Antti Hellsten, Jarkko Koskinen, and Jaakko Kukkonen

The transport of momentum, heat and pollutants over urban areas take place within a layer known as atmospheric boundary layer (ABL), also known as the mixed layer. The mixing properties of the ABL depend strongly on the ground-air interactions, and thus on the surface morphology. Computational Fluid Dynamics (CFD) models of various degree of description of involved physical processes are used in studies of the ABL processes over urban areas.

In large-scale models the surface morphology is typically modelled by means of simple scalar measures of surface roughness such as the roughness length. This is a highly simplified approach and cannot provide new insight into the details of the ground-air interaction processes taking place in the lowest part of urban ABL, the roughness layer. To understand these processes and to assess and further develop better simplified models for them, so called obstacle resolving numerical simulations are needed. This means that a morphology model of the urban area must be created.

In this project, morphology models for Paris are developed. In the present work, we decided to create a fine-resolution model covering a rectangular area in central or southern central Paris with Place d’Italie in the centre point of the rectangle. The rest of Paris will be in coarser resolution. We included most blocks, streets, squares, parks, water-areas and trees in this fine-resolution model. From the CFD-point of view, the blocks and buildings form the most important part of the morphology data. The ground projections of the blocks and buildings can be obtained with 1 meter resolution, but the variation of the building height within a block, and the roof shapes are difficult to handle with same accuracy. Hence a flat roof assumption.

The quickest way to gather city morphology related information over wide areas is remote sensing. Remote sensing provides variety of space borne and airborne instruments, capable to measure different properties of the target. Optical images can provide high resolution classification of land use, Synthetic Aperture Radar (SAR) interferometry can provide terrain elevation models, infrared sensors measure heat flux etc. In this project, several remote sensing instruments and several image analysis methods are combined in order to produce a morphology database of the study area.

Database consists of following layers: water, trees and vegetation, streets, roads and railroads, buildings and average block heights, digital elevation model (DEM).

Three of them are shown below (streets, blocks and trees) from the Paris fine resolution test area.

Database is created using optical images, street maps and SAR interferometry. Optical images and street maps are acquired from public sources in the internet (Google Maps, Microsoft Virtual Earth etc.). SAR images are obtained by European Space Agency’s ENVISAT ASAR instrument. The DEM of Paris area was acquired from NASAs Shuttle Radar Topography Mission (SRTM).

We extracted streets, parks and water bodies from street maps. This is done simply by manipulating colour histograms. Optical images are used to extract buildings and trees using supervised classification. In supervised classification samples are collected to represent classes. These classes represent the whole spectrum of that image and they are named after what they represent, e.g. roofs, roads, water, trees, grass etc. After the selection classified image is computed. In this case buildings and trees are extracted from the optical image. Classified images are masked using thematic road, park and water maps to avoid misinterpretation, e.g. some roofs and pavement have similar spectrum. After masking, images are filtered for noise reduction. Fine tuning of supervised classification process is time consuming because of potential misinterpretation.

Interferometric SAR images provide information regarding height and coherence. Topographic elevation model is acquired from the SRTM database. Envisat SAR is used to explore the possibility to derive building height using SAR interferometry. Additionally, interferometric coherence is used to estimate variance in building height thus providing a coarse height of building.

All thematic layers are combined to unified morphological database which can be used in the modelling of urban micro-meteorology and dispersion.

References

The Question of Scale: Large Eddy Simulation in Urban Research

Igor Esau
E-mail: igor.esau@nersc.no
Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research
http://www.nersc.no/

Introduction
Cities are interesting for an atmospheric physicist and modeller as “hot-spots” of anthropogenic impact on the Earth’s system. The impact is measurable through a number of physical (the surface heat/moisture balance), chemical (urban emissions), and dynamical (surface roughness) effects. Strong heterogeneity and patchiness of the urban features on relatively small scales introduces formidable difficulties into urban research. Meteorological models resolve only a limited interval of scales and that interval usually misrepresents the natural scales of emissions and dynamically related meteorological phenomena. This is illustrated on a sketch in Fig.1. Large-eddy simulations (LES) is a potent technique to resolve critical turbulent dynamics and thus to link small- and large-(regional)-scale atmospheric processes. Important feedbacks (Objectives 1, 2) are observed between turbulent motions and non-turbulent phenomena, e.g. street canyon effects and aerosol inhibition of urban cloudiness just to mention a few of them. In the project proposal, we suggested that the LES may serve as key, flexible and inexpensive instrument to investigate those feedbacks.

Heterogeneity as Modified Homogeneity
At present, the most popular approaches consider heterogeneous planetary boundary layer (PBL), as a special case of the homogeneous PBL. Two, not necessary excluding, approaches exist. The blending height approach defines a minimal mixing scale at which the traditional homogeneous parameterizations are still applicable. It is particularly useful under strong wind conditions and for relatively small heterogeneities. The mosaic PBL approach defines a minimal spatial scale at which the surface could be represented as a mosaic of independent homogeneous conditions. It is particularly useful under weak wind conditions and for relatively large patches of surface heterogeneities. The approaches require monotonic, but not necessary linear, modification of the transport and mixing properties from the homogeneous state, which is usually also determined incorrectly (Cuxart et al., 2006), to the state of no mixing. E.g. the flux-mosaic method gives the total flux A (see Fig.1) as a weighed sum of fluxes A1 (green area) and A2 (urban area).

Resonance-Like Response on Heterogeneity
The abovementioned approaches are widely used in models but generally speaking they are incorrect (Pielke et al. and others). The heterogeneity creates secondary circulations. Those circulations are produced by the horizontal pressure gradients (Esau, 2007), omitted in homogeneous PBL. It has been overlooked however that the secondary circulations interact with large-scale turbulence, which is represented by convective cells (slow wind conditions) or rolls (strong wind conditions). Fig.2 shows the effect of these interactions over the heterogeneously heated terrain. In this case, the heterogeneity is created by the open water leads in the sea ice surface with the horizontal temperature difference of 8K. The interactions on the PBL depth scale can enhance the fluxes by several times.

LES as an Instrument for Urban Research
LES are well established tool in the PBL research. Nevertheless, to establish LES in the urban research, one ought to overcome at least two difficulties. First, a data assimilation technique must be introduced to nudge the simulated profiles to observed mean profiles of meteorological quantities/concentrations without the loss of consistency in the simulated turbulent fluctuations and secondary flows. Fortunately, for high Re 3D turbulent fields, the downscale energy cascade and turbulence diffusion dominate. Thus, the mean wind and temperature measured in few points provide severe constrains on the simulated turbulent fields. To narrow constrains, the method of artificial neural network could be used. The idea is that the surface heterogeneity and emission sources do not change their location and therefore introduce phase-locked perturbations into the turbulent fields.

Heterogeneity of the Earth’s Climate System
Heterogeneity of the Earth’s Climate System

Urban PBL – Part of the Earth’s Climate System
Having the proper turbulence dynamics, the data assimilation and the urban relief treatment in place, the LES would be ready to answer the scientific questions on the material of specific urban campaigns, and hopefully for further theoretical generalizations. In particular, it is expected to quantify how megacities affect air quality and the transport and transformation rates of the major air pollutants from their scattered local sources to regional mesh scales (Q2 and Q3). Perhaps the least developed problem is the PBL-feedback mechanisms in megacities (Q8). It is trivial to notice that the change of meteorological conditions result in changes in the PBL and therefore in the megacity impact. It is less trivial to recognize that the response is strongly asymmetrical and scale differential. The local conditions will experience the strongest changes under stably stratified PBL where the pollutants, aerosols, and to some degree heat and moisture are trapped in the urban sub-layer. If the megacity climate change favors the increasing stability conditions, the local megacity impact, including hazardous near-surface concentrations, will increase. If the convective conditions favored, the opposite effect, i.e. the regional- to global impact will increase. At least in theory those feedbacks can be rationally manipulated via landscape planning.

More Detailed isn’t More Optimal
Obviously, the urban features depend heavily on the urban relief. Street canyon experiments revealed the mesh with at least 4 to 8 nodes per cube placed in the turbulent flow is required. Thus, a straightforward approximation of the urban relief is not an option for the megacity LES. The blending height approach may help for low built areas. More prospective approach has been proposed in oceanography (Wunsch et al.). It use functional cost minimization to obtain the approximate resolved-scale urban relief as the surface where the LES produce the most realistic turbulent flow.

References

Figure 1. Schematic representation of urban relief on large- and fine-scale model meshes. At any feasible mesh, the relief and surface features remain to be under-resolved as building to PBL scale ration 1:500 is currently can be resolved only in street canyon models but not on the megacity scales.

Figure 2. The effect of the resolved interactions between secondary flow and turbulence field. Insertions show 3D mean flow structure corresponding to certain aspect ratio of horizontal heterogeneity and PBL depth scales (unpublished analysis; Esau, 2007).
To assist in comparing the models, each was classified based on a number of characteristics including their modelling of vegetation, anthropogenic heat fluxes and the urban morphology, the facets and orientation assumed, number of urban canopy reflections, albedo and emissivity assumptions and handling of the storage heat flux.

In spite of participants being aware of the observations their models would ideally output, the relative performance of each model was found to vary significantly. This variability, assessed in terms of the root mean squared error (rmse) when compared with observed data, depended on: the specific fluxes being compared, the time period being examined (i.e. day-time, night-time or the whole period) and/or the assumptions of the models themselves. Such variability, in terms of Q* for the entire period, is shown in Fig. 1.

![Figure 1. Range of rmse values for the Q* flux for all 27 models involved. Models are identified by an anonymous, random number known only to that particular participant.](image)

Following the commencement of later phases of the project, modellers were given the opportunity to re-run their models for this initial phase, perhaps utilising model improvements they had made. The effect of this was significant, with rmse for the final model runs falling for all fluxes (Fig. 2). This result alone highlights the importance of this work as it has, in just one short phase, facilitated modellers in improving the performance of their models.

![Figure 2. RMSE values (maximum, minimum and mean) for first and final runs, derived using all 27 models and for particular fluxes noted.](image)

Other general observations from this phase include that the models have best overall capability to model Q*. Additionally, no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes. Additionally, no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes. Additionally, no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes. Additionally, no model appeared to perform best or worst for all fluxes and no model appeared to perform best or worst for all fluxes.

It is important to stress that these results are based on the evaluation of a short time series and for one particular urban location. Later stages evaluate the same models but using a longer data set (Grimmond et al. 2009, in preparation).

References


Many land surface schemes exist to model energy balance fluxes but for use in urban regions significant modification is needed. Urban features such as: additional sources of energy (Q_F), presence of built and natural surfaces, the bluff body nature of buildings and existence of urban canyons, each combine to change energy partitioning in urban areas. These models actually form the ‘urban’ component in meso-scale and global scale meteorological models that are needed to model the impact of mega-cities on air quality and climate change.

Of the numerous urban energy balance schemes which have been developed, each makes different assumptions about the features of the surface and exchange processes that should be considered. No comprehensive examination of such models has yet been conducted and this work aims to do this. In the initial phase of the project, 27 models have been compared involving participants from 17 institutions in 13 different countries.

The requirement for models to be included in this comparison is that they utilise forcing data (incoming short- (K_i) and long-wave fluxes (L_i) and meteorological observations) and in turn, simulate energy balance fluxes including: outgoing radiative fluxes (K_t, L_t), net all wave radiation (Q*), turbulent sensible heat flux (Q_h), turbulent latent heat flux (Q_l) and net heat storage fluxes (∆Q_s).

The comparison follows the methodology used in the Project for Intercomparison of Land-Surface Parameterization Schemes (PILPS) (Henderson-Sellers et al., 1993). In the initial phase, modelling groups were supplied with 14 days of data from an industrial area in Vancouver (VL92) (Voogt and Grimmond, 2000) which included forcing and observed data: Q*, Q_h, Q_l, ∆Q_s, K_t, L_t, wind-speed, wind direction, relative humidity, air temperature, station-pressure, rainfall and soil temperature. The models were then run ‘offline’ so that their performance could be evaluated independent of larger scale model performance or forcing.

First Results from the International Urban Energy Balance Model Comparison: Model Complexity


1King’s College London, UK, 2UK Met Office, UK, 3Univ. Reading, UK, 4Seoul National Univ., Korea, 5Laboratoire de Mécanique des Fluides UMR 9016, France, 6Norman Research, Inc., USA, 7Laboratoire d’Hydrologie et de Géomatique, UMR 5236, France, 8University of Athens Greece, 9Univ.Lodz, Poland, 10Royal Meteorological Institute, Belgium, 11National Institute of Advanced Industrial Science and Technology, Japan, 12Univ. of British Columbia, Canada, 13ICMAT, Spain, 14JAM, China, 15Meteo France, France, 16Ben Gurion Univ., Israel, 17Wageningen Univ., Netherlands, 18Univ. Western Ontario, Canada, 19Nanjing Univ., China.

E-mail: matthew.blackett@kcl.ac.uk

UrbanMet Team, Department of Geography, King’s College London

http://geography.kcl.ac.uk/micromet/ModelComparison/index.htm

NewsLetters of the FP7 EC MEGAPOLI Project
Large-Eddy Simulation Experiments with Nudging to Observed Mean Meteorological Profiles

Igor Esau
E-mail: igor.esau@nersc.no
G.C. Rieber Climate Institute at the Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research
http://www.nersc.no

Introduction
Turbulent mixing in the planetary boundary layer (PBL) is organized in large-scale structures (LS) as seen in Fig.1 with scales (U~10 m/s; T~10⁴ s; L~10³ m) comparable to typical meso-meteorological scales. The LS dominate the PBL mixing as their eddy viscosity $K_m \sim U L / T \sim 10^2$ m²/s) is large relative to the Kolmogorov’s mixing $K_m \sim 1$ m²/s. Thus, the observed meteorology in the PBL and the large-scale turbulence are inherently related. PBL simulations require recovery of LS consistent with observed mean profiles. This requirement dictates the need for turbulence-scale data assimilation.

Approach
The data assimilation in LES (turbulence-resolving large-eddy simulation model) has been attempted in [1] for chemicals and aerosols and in [2] for dynamics. Variants of the Newtonian relaxation (nudging) method was used as $d\Phi / dt = RHS(\Phi) + (ct)^{-1}(\Phi_{obs} - \langle\Phi_{LES}\rangle)$, where $\Phi$ is a meteorological variable (temperature or velocity), $ct$ is the relaxation time scale, and the angular brackets denote the mean value. Nudging is essentially diffusive process distorting the turbulence energy cascade [3] in LES. This distortion is analysed in the study through comparison of two Ekman PBL LES runs. One (CTR) run is integrated without the nudging term. Another (NDG) run uses the mean profiles from CTR in assimilation.

Results
Fig.2 presents the relative difference in the frequency spectrum of the horizontally averaged streamwise velocity, i.e. $(CTR-NDG)/CTR$. Generally, the difference is rather small, which reassures the proper turbulence recovery in the NDG run. However, certain damping at any height is found on lower frequencies corresponding to the longer scales. The damping is also observed above the PBL at any frequency. This is certainly due to elimination of the inertial oscillation in the flow and corresponding turbulence suppression. Nudging also pumps some energy at frequencies of the turbulence spectral maxima. It suggests that the nudging acts as a forcing for the energy cascade toward LS increasing available energy for the LS development.

The profiles of 2nd order turbulent statistics are very similar in both NDG and CTL runs (not shown). However, the surface stress and integral turbulent kinetic energy are about 20% less in NDG than in CTL runs. One obvious problem is the distortion of the energy exchange between components of the horizontal stress. The components of the stress are free but those of the mean velocity are prescribed. This distortion is observed for any relaxation time scale significantly less than the inertial oscillation time scale and should be studied in more details.

Figure 1. LS in the PBL visualized by Cu hum (cloud streets) under strong on-shore wind over west Sweden coast 5th April 2009.

Figure 2. Difference in the frequency spectrum of horizontally averaged streamwise velocity. Spectrum presented as altitude-frequency plot of $(CTR-NDG)/CTR$ (red – nudging damps energy; blue – nudging supplies energy)

Conclusions
Nudging is a simple and robust method of the modelling with observational data assimilation. It has been used with LES in [1,2] but its impact on the turbulent energy cascade and statistics has not been clarified before. This work suggests that the simplest nudging is not suitable for the LES. It damps a broad spectral range of energy containing turbulence. It distorts turbulent fluxes in the lower PBL and effectively filters out turbulence in the upper PBL. The distortions are however rather small. So for some practical applications this type of nudging could be acceptable. Additional studies, not discussed here, suggest that the simplest nudging might work better in the stratified PBL where the scale separation between meso- and LS-scales is larger. Probably more selective nudging as in [3] may serve better for the data assimilation in the realistic LES.

References
The MILAGRO (Megacity Initiative: Local and Global Research Observations) Campaign is a large, international, multi-agency, collaborative project to assess the outflow of emissions from a megacity. Specific goals of the campaign include quantifying the spatial and temporal extent of the urban plume, analyzing pollutant chemical and physical transformation in the plume, examining the interaction of the urban plume with surrounding sources and evaluating the regional and global impacts of the plume. The Mexico City Metropolitan Area (MCMA, 19°25'N latitude and 99°10'W longitude) is North America’s most populous city and one of the world’s largest megacities with an estimated 20 million inhabitants living in an elevated basin at an altitude of 2240 m asl and confined on three sides by mountain and volcanoes (Figure 1). The MCMA experienced a huge increase in population and urbanized areas during the 20th Century as it attracted migrants from other parts of the country and industrialization stimulated economic growth. Population growth, increasing motorization and industrial activities, a constrained basin and intense solar radiation combined to cause severe air quality problems of both primary and secondary pollutants. High concentrations of all criteria pollutants were recorded in the late 1980s. Ozone exceeded the air quality standards more than 90% of the days, and peaked above 300 ppb about 40-50 days a year, among the worst in the world [Molina and Molina, 2002]. During the past two decades, the Mexican government has made remarkable progress in improving air quality by developing and implementing comprehensive air quality management programs. As a result of regulatory actions combined with technology change, concentrations of criteria pollutants have been decreasing over the past decade despite the continuing increase in population and economic activity. The combination of meteorology, topography, population and multi-pollutant emission density of the MCMA has attracted a number of field studies. The MCMA-2002/2003 campaigns provided detailed measurements of many oxidant precursors and photochemical intermediates including radicals, as well as meteorology and emissions [Molina et al., 2007]. The observation phase of MILAGRO took place during March 2006 and included a wide range of instruments at ground sites, on aircraft, and satellites that provided extensive measurements of gas and aerosol chemistry, aerosol microphysics and optics, radiation and meteorology [Molina et al., 2009]. Major findings are being published in two special issues of Atmospheric Chemistry and Physics as well as in other journals.}

The MCMA motor vehicles produce abundant amounts of primary PM, elemental carbon, particle-bound polycyclic aromatic hydrocarbons, CO and a wide range of air toxics, including formaldehyde, acetaldehyde, benzene and toluene. Figure 2 compares the total annual emissions from light-duty gasoline vehicles estimated from fuel sales records and fuel-based emission factors obtained from on-road measurements during MILAGRO and available data from remote sensing measurements against the corresponding mobile emissions estimates in the 2006 official emissions inventory (sma.df.gob.mx). The comparison shows reasonable agreement for CO and NOx, an overall underprediction of about 1.4 to 1.7 for VOCs and a factor of 4 for PM2.5 emissions from gasoline vehicles in the inventory with respect to the measurements.

The response of urban O3 to precursors VOCs and NOx remains a topic of interest. Both measurements and chemical transport model simulations during 2003 and 2006 suggest that O3 production in the source region is VOC limited in the photochemically active periods. The pollution plume from Mexico City can be observed several hundreds of kilometers downwind. Aircraft-based measurements show ongoing production of secondary organic aerosols and O3 for several days downwind, added to the O3 and aerosols produced in the city and exported with the plume. We anticipate new results from MILAGRO will continue to contribute to our understanding of Mexico City air pollution and its potential impacts on human health, ecosystem viability, and climate change. This information will facilitate the decision makers in Mexico City to craft effective policies as well as provide insights to other megacities around the world.

**References**

The Risk Habitat Megacity research initiative reflects the joint work of about forty natural and social scientists and engineers from five research centres of the German Helmholtz Association – the German Aerospace Centre (DLR), the Karlsruhe Institute of Technology (KIT-Campus North / Forschungszentrum Karlsruhe), the Helmholtz Centre for Infection Research (HZI), the GeoForschungsZentrum Potsdam (GFZ), and the Helmholtz Centre for Environmental Research – UFZ, and four partner organizations in Latin America – Universidad de Chile, Pontificia Universidad Católica de Chile, Pontificia Universidad Católica de Valparaíso and Economic Commission for Latin America and the Caribbean (ECLAC/CEPAL) in the United Nations.

The research plan adopts an integrative research approach that combines basic theoretical and conceptual considerations with empirical and application-oriented analysis. The underlying notion of integration is a broad one, taking different dimensions of integration into account and making them explicit. To implement the integrative and interdisciplinary research approach and to offer a common framework for orientation, the research initiative applies three well-established, theory-based analytical concepts:

- **The concept of Sustainable Development** formulates the target dimension of the initiative. It provides orientation towards basic goals by defining specific sustainability criteria in close cooperation with the Chilean partners. The aim is to identify the desired future mega-urban development and to provide guidelines for both research and urban policy.

- **The Risk concept** focuses on the extent of the problems and their severity. In addition, it helps to identify and analyse the conditions for and impact of the emergence of risks that pose a potential threat to future sustainability.

- **The Governance concept** concentrates on the actions to be undertaken. This will be achieved by analysis of current efforts to enhance sustainability in megacities, and by the provision of knowledge and recommendations relevant to the appropriate solutions to specific problems and their potential for implementation.

The initiative applies these analytical concepts to several typical megacity issues, such as Land use management, Socio-spatial differentiation, Energy, Transportation, Air quality and health, Water resources and services, and Waste management (see Figure 1). The program comprises ten topics: three “cross-cutting concepts” – Sustainable Development, Risk, and Governance – and seven “fields of application”.

Air Quality and Health as one of application fields has become a serious problem in metropolitan areas and is most pronounced in topographically structured areas (Molina/ Molina 2004; Gurjar/ Lelieveld 2005). Major contributors to air pollution are traffic emissions, domestic heating and industrial sources.

In the face of the expected growth of urban populations, rise in standards of living, expansion of the economy and urban sprawl in megacities, air pollution will reach intolerable levels in the future, with serious socio-economic and ecological implications. Health problems specific to megacities can be caused by chemical and physical environmental exposure, contagious germs (intensified by extremely high population densities) and socio-economic conditions. Primary and photochemically produced pollutants create fundamental human health risks (Peters et al. 1997; Phalen 1998; Pope et al. 2006; WHO 2002, 2006). Therefore a detailed knowledge of the air quality situation is a basic requirement for the development of feasible strategies to improve air quality and the concomitant health status. The definition and implementation of measures for mitigation and adaptation requires a sound understanding of the current pollution situation. This is not available and must be established through the coordinated and integrated efforts of the scientists, stakeholders, and local authorities.

Therefore only such an interdisciplinary and holistic project can develop and give solutions in order to improve the air quality and quality of life in urban agglomerations in a sustainable way.
The COST Action ES0602 action “Towards a European Network on Chemical Weather Forecasting (CWF) and Information Systems “provides a forum for benchmarking approaches and practices in data exchange and multi-model capabilities for chemical weather forecasting and near real-time information services in Europe. The action includes approximately 30 participants from 19 countries, and its duration is from 2007 to 2011 (http://www.chemicalweather.eu/).

Major efforts have been dedicated in other actions and projects to the development of infrastructures for data flow. We have therefore aimed for collaboration with ongoing actions towards developing near real-time exchange of input data for air quality forecasting.

We have collected information on the operational air quality forecasting models on a regional and continental scale in a structured form, and inter-compared and evaluated the physical and chemical structure of these models. We have also constructed a European chemical weather forecasting portal that includes links to most of the available chemical weather forecasting systems in Europe (Kukkonen et al., 2009a,b).

The collaboration also includes the examination of the case studies that have been organized within COST-728, in order to inter-compare and evaluate the models against experimental data. We have also constructed an operational model forecasting ensemble. Data from a representative set of regional background stations have been selected, and the operational forecasts for this set of sites will be inter-compared and evaluated.

The Action has investigated, analysed and reviewed existing chemical weather information systems and services, and will provide recommendations on best practices concerning the presentation and dissemination of chemical weather information towards the public and decision makers (Karatzas and Kukkonen, 2009).

The key areas and tasks of WP1 are:
- identification of requirements for data exchange (all kinds of data needed for CWF);
- investigation of infrastructure needed to meet the identified demands.

The key areas and tasks of WP2 are:
- existing operational forecasting tools;
- air quality tools, methods, criteria, experience, requirements for measurement data;
- ensembles (single- / multi-model), existing / developing, experience;
- data assimilation into air quality models;
- experience in short-term emission abatement, possible network contribution;
- boundary conditions for meso- or local-scale applications.

The key areas and tasks of WP3 are:
- assess how various organisations or systems select the data and information on display, and by which means, platforms and format;
- identify which data collection protocols to use and which models and data are readily available;
- delineate relevant temporal and spatial resolution: hourly data, rural and urban data, next day ozone forecasts; details about used models.

The main Work Packages of Action are the following:
WP1 - Exchange of air quality forecasts and input data;
WP2 - Multi-scale forecasting, multi-model ensemble, boundary data;
WP3 - Dissemination and visualization.

References
Monitoring Urbanization in China and Modelling its Sustainability Under Future Climate Change

Garik Gutman
E-mail: ggutman@nasa.gov
NASA HeadQuarters (HQ)
Washington, DC USA
http://lcluc.hq.nasa.gov

The NASA Land-Cover/Land-Use Change (LCLUC) program consists of about 60 projects. Relevant to MEGAPOLI, the program includes a couple of projects on urbanization in China, which aim at improving our understanding of China’s extraordinary social, economic and environmental transformation and its impact on urbanization across the country. Given the size and scale of China’s urban development - urban populations have more than doubled during the last 30 years, and more than 70% of economic activity in now located in cities - urban environments are playing an increasingly important role in daily quality-of-life issues, ecological processes, climate, flows of materials, and land transformations. These NASA LCLUC international studies are conducted at University of Wisconsin (Principal Investigator: Dr. Annemarie Schneider) and at Michigan State University (Principal Investigator: Dr. Peilei Fan) in the United States with collaborators in China. The main objectives of the studies are to: characterize the rates and patterns of urban expansion; document the driving forces of urban expansion; analyze the causal linkages between urbanization and climate change; build scenarios of future urbanization; simulate local scale IPCC climate scenarios and provide adaptation recommendations for these scenarios. These studies use Landsat data as input to advanced data mining algorithms to derive new datasets on the rates and amounts of land-cover change in cities across China. The satellite observational period for analysis spans the 1980 to 2005 period both before and after economic reforms took effect. Using econometric modeling techniques, the science teams integrate satellite-based maps of urban growth with detailed socioeconomic data and policy variables to quantify the factors responsible for variations in the rates, amounts and patterns of urban expansion. The assessment of urban development is developed using a sustainability index, which encompasses three key aspects of sustainable urban development: economic development, environment, and equity. Shanghai and Urumqi cities are used in case studies, in which the causal linkage between urbanization and climate change are evaluated with a Driving force-Pressure-State-Effect-Feedback model using socio-economic, environmental, land use, and climate indicators. Future LCLUC scenarios and climates are based on the Dyna-CLUE models and the Regional Atmospheric Modeling System, respectively. Simulations explore how urban areas respond to scenarios such as business-as-usual, increased economic growth and policy-based stimulus. The primary outcome of these studies is a series of reconstructions of past land-cover change and projections of future urban expansion in China under different political and economic scenarios. Using IPCC emission scenarios, the regional climate simulations are being conducted for current, near-term (2021-2030) and the mid-range (2051-2060).

The teams use a suite of remotely sensed parameters to parameterize and validate their modelling results. These projections can help improve our understanding of the dynamics of land use transformations, the relative importance of the drivers that foster/impede land conversion, and the complex interactions between urban change and sustainable systems. The teams will also evaluate current adaptation strategies and illustrate a range of possible adaptation measures that the respective city governments can use to cope with the impacts of various future climate changes. This multi-institutional, international effort represents the first comprehensive study of Chinese metropolitan development based on empirical results from satellite imagery, socioeconomic data and field surveys. It will improve our understanding of China’s urbanization and regional climate changes and have a practical policy dimension for selected cities.

Figure 1. Satellite-derived land-cover change map for the province of Chengdu, China, for the 1990-2000 period.

Above (Fig 1) is an illustration of satellite-derived land-cover change map for Chengdu, China, for the 1990-2000 period (courtesy of Dr. Schneider, University of Wisconsin). Changes from agriculture to water are rendered in light blue, from water to land in light green, from agriculture to urban in red. The stable agriculture is rendered in light yellow, stable urban in purple, and natural vegetation in deep green.

The projects will continue for another couple of years and, if successful, may be selected for continuation. They may be expanded to other cities in the world to support the MEGAPOLI project. More on the LCLUC projects, announcements, brochures, etc. can be found on the program web site: http://lcluc.hq.nasa.gov.

The LCLUC program includes projects on aerosol, emissions and effects on the environment and society also relevant to MEGAPOLI but this is beyond the scope of the current newsletter contribution focused on the urbanization studies.

The NASA Land-Cover/Land-Use Change Program:
Program Manager:
Dr. Garik Gutman, NASA HQ
Program Scientist:
Dr. Chris Justice, University of Maryland
Coming Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

- MEGAPOLI project to be presented (by Alexander Baklanov, DMI Team) at the United Nations Framework Convention on Climate Change (UNFCCC) talks, "Air pollution and climate change: EU research activities to protect the planet and its inhabitants", 5 Jun 2009, Bonn, Germany;
- MEGAPOLI project to be presented (by Ari Karppinen, FMI Team) for the Air and Waste Management Association (AWMA-2009) Conference, 16-19 Jun 2009, Detroit, Michigan, USA;
- MEGAPOLI project to be presented (by Alexander Mahura, DMI Team) International Conference on Computational Information Technologies for Environmental Sciences (CITES-2009), 11-15 Jul 2009, Krasnoyarsk, Russia;

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present the MEGAPOLI Project results and findings:

- International Workshop «Atmospheric Composition Changes: Climate Chemistry Interactions» Lecce, Italy, 2-4 Nov 2009 Contact Ashraf Zakey (ICTP Team), azakey@ictp.it
- WMO, COST-728, MEGAPOLI End-user Workshop Geneva, Switzerland, 8-10 Dec 2009 Contact Liisa Jalkanen (WMO Team), LJalkanen@wmo.int
- European Geosciences Union General Assembly (EGU-2010) Vienna, Austria, 2-7 May 2010 (special MEGAPOLI, CityZen, MILAGRO session) [http://meetings.copernicus.org/egu2010/]
Welcome to the 4th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 4th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon - 24-25 Sep 2009 – 1st Annual Meeting of the MEGAPOLI Project (DMI, Copenhagen, Denmark)
- Aug 2009 – Mitigation, Policy Options and Impact Assessment (WP8) - megacity interview protocols distributed for obtaining information on the MEGAPOLI Pyramid megacities with details on scenarios and emissions
- 30 Jul 2009 – MEGAPOLI WP Leaders Telephone Conference
- Jul 2009 – Paris Plume Study (WP3) – measurement campaign including ground, mobile, and airplane observations for meteorology and chemical species in the Paris metropolitan area and surroundings
- Jul 2009 – Emissions (WP1) - TNO European emission database (year 2005) is available for the MEGAPOLI Partners
- Jun 2009 – daughter project MEGAPOLIS (involved MEGAPOLI external collaborators - AEROCOSMOS Scientific Center for Aerospace Monitoring, Lomonosov Moscow State University, and Institute of the Atmospheric Physics of the Russian Academy Sciences) supported for funding by the Ministry of Education and Science of the Russian Federation

WP3 – Paris Summer Campaign (1-31 Jul 2009)

Within the MEGAPOLI project, an intensive measurement campaign was realised in the Paris region during July 2009. The general objective is to better quantify primary and secondary aerosol sources in a large urban agglomeration and in its plume. A particular focus was put on the build-up of secondary organic aerosol and its relation to precursor gases. The second part of the campaign will be held in winter from mid-Jan to mid-Feb 2010.

Primary objective: quantify sources of primary and secondary carbonaceous aerosol in a large agglomeration (Paris) and its plume

Four major tasks:
- Document aerosol composition variability near source region,
- Source apportionment,
- Aerosol and SOA evolution in plume,
- Integrated data set for model evaluation and improvement.

Participants:
- Coordination:
  - Overall: Matthias Beekmann (LISA-CNRS), Urs Baltensperger (PSI),
  - Ground based segment: Jean Sciare, Valerie Gros (LSCE-CNRS),
  - Airborne segment: Agnès Borbon (LISA-CNRS),
- Funded measurements: CNRS, LISA, LSCE, GAME, LaMP, LGGE, SAFIRE, PSI, IIT, FORTH, Univ. Helsinki;
- Additional non-funded contributions, or supported by national funding: PSI, MPIC, Univ. Dütsburg /Essen, LGGE/LCP/ LCMC, SIRTA / LMD/ IPSL, Airparif, INERIS, Ecole de Mines de Douais, LATMOS, CEREA.

Measurement data are right now treated by partners, but quick looks are already available at the local CNRS/LISA campaign website. Pollution conditions during the campaign were rather clean, with several days of stronger photochemical activity within the agglomeration and the plume. Even for clean cases, the pollution plume was still well defined at more than hundred kilometres downwind from the agglomeration. This will give a “save” framework for later studying secondary organic aerosol build-up in plume.

The Paris campaign programme included: (i) 11 SAFIRE aircraft flights (~3.5h each) in 6 sectors on a constant altitude (within PBL) and for vertical profile up to 3 km; (ii) 5 ground fixed sites: LHVP, SIRTA, Golf de la Poudrière, Jussieu and Créteil, (iii) 5 mobile platforms: 2 aerosol vans, 1 backscatter lidar + MAX-DOAS van, 1 gas measurements van.

Measurements included: (i) Aerosol chemical composition (fast measurements); (ii) Detailed organic speciation (12 h filter samples); (iii) Size distribution; (iv) Optical properties (scattering and absorption coefficient); (v) Hygroscopic growth factor and CCN concentration; (vi) Backscatter lidar (aerosol extinction + PBL height, depolarisation); (vii) Detailed gas phase measurements: O₃, NOy, NOx, CO, OH, NMHCs, OVOC, etc.; (viii) Gas phase column measurements (NO₂, HCHO, O₃, CO, etc.); (ix) C-14 measurements (24 h); (x) Meteorological measurements (wind profile, turbulence, radiation, precipitation, etc.).
The SAFIRE ATR42 performed 11 successful scientific flights (43 flight hours) during July 2009. Each 4 hours flight was following the scenario:

- Round around Paris to study the initial conditions in all directions;
- Legs moving away from Paris and in the downwind area to study the evolution of the pollution plume.

The aircraft instrumental set was composed of aerosols sizers and analyzers (2 mass spectrometers) and air chemical analyzers; in addition to the core instrumentation (positioning, pressure, temperature, humidity, etc.). The European labs who operated the aircraft instrumentation were: IPSL (Paris, F), LaMP (Clermont-Ferrand, F), LISA (Creteil, F), Météo-France / CNRM (Toulouse, F), and MPI (Mainz, Germany).

2 ground inter-calibration exercises have been performed with the mobile labs coming close to the aircraft at Pontoise airport (Figure 1).

Summary of the aircraft activity:

<table>
<thead>
<tr>
<th>Flight type</th>
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<th>Flight duration [h]</th>
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<tr>
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<td>9/7/09 MEGAPOLI 3</td>
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<tr>
<td>10/7/09 MEGAPOLI 3</td>
<td>13:00</td>
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<tr>
<td>11/7/09 Ground intercomparison with 3 mobile labs from 12H00 to 17H30</td>
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<td>13/7/09 MEGAPOLI 5</td>
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<td>15/7/09 MEGAPOLI 4</td>
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<td>29/7/09 MEGAPOLI 5</td>
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<td>30/7/09 Ground intercomparison with the MPI mobile lab</td>
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</table>

Figure1: The ATR 42 and the mobile labs during the intercomparison exercise at Pontoise (11/07/2009). Credits: SAFIRE.

Figure2: Ozone concentration during the first scientific flight (01/07/2009, flight n° 25). One can clearly identify the pollution plume in the south area. Credits: SAFIRE.

SAFIRE Team
E-mail: desk@safire.fr
Service des Avions Français Instrumentés pour la Recherche en Environnement
http://www.safire.fr
The first critical step in improving our understanding of how megacities impact air quality, atmospheric composition and climate on different scales is the development of high-quality emission inventories (EI) of relevant gases and aerosols and their precursors, and determining how these are anticipated to change in the mid-term future, as well as how these change under various scenarios. Generation of such high resolution emission inventories (EI) is the focus of MEGAPOLI WorkPackage 1. The MEGAPOLI WP1 EI’s at local, regional and global scale build, where possible, on currently available state-of-the-art emission inventories and aim to merge these into consistent datasets suitable for modelling and policy support.

Current Status
In the first year of MEGAPOLI we focused on preparing gridded emission maps for the base year 2005. This "default" base year EI is ready and delivered to model partners in WP5 and WP6 (Fig. 1).

MEGAPOLI has a pyramidal structure of megacities in focus. The 1st level cities (Fig. 2) have a MEGAPOLI WP1 partner as counterpart: Paris (CNRS), London (KCL), Rhine-Ruhr (IER) and Po-valley (ARIANET). TNO interacts with these counterparts to collect local emission data that match closest with what local policy makers use. The spatial domains of the level 1 cities are now accurately defined. Note the large differences in spatial domain and population of 4 MCs as well as in population (Fig. 2, Tab. 1). Based on the selected domains emissions have been removed from the default base year emission database. This results in default European emission maps for 2005 with and without MC emissions.

The final merged year 2005 European emissions, including the megacities at high resolution, are expected to become available in October 2009 to MEGAPOLI partners.

Global Emissions
The global emission inventory to be used in MEGAPOLI will be based on the EDGAR v4.0 emission inventory (http://edgar.jrc.ec.europa.eu), but major changes between v4.0 and the updated version for air pollutants are expected to occur. This EDGAR version, with a resolution of 0.1°x0.1°, will be completed in autumn 2009. The resolution matches well with the high resolution European inventory. It allows nesting of MC’s outside of Europe in the future, if proper emission inventories become available.

Upcoming work
In the next months the focus of WP1 will be on understanding the differences between the bottom-up and top-down emission estimates for the European level 1 cities and subsequently composing the final base year emission map. Next, a nesting of local or continental inventories in the EDGAR v4.0 base grid is foreseen. When these tasks have been completed the preparation of emission scenarios will be started in cooperation with WP8 to further address the scientific questions of the MEGAPOLI project.

Acknowledgements
We thank the local Megacity Emission inventory authorities in Paris, London, Rhine-Ruhr, and Po valley for their cooperation. The EDGAR team of JRC Joint Research Centre (Joan van Aardenne, Ulrike Doering et al.) is thanked for cooperating with the MEGAPOLI project.
Thermal and Dynamical Urban Effects of Saint-Petersburg Metropolitan Area

Yulia Gavrilova
E-mail: gavrilova@rshu.ru
Russian State Hydrometeorological University (RSHU), St. Petersburg
http://www.rshu.ru

As a part of the MEGAPOLI activities within WP2 “Megacity Features” and development of the Enviro-HIRLAM (Environment – High Resolution Limited Area Model) system, the RSHU as the MEGAPOLI Collaborator and End-User has focused on evaluation of urbanized areas influence on formation of meteorological patterns. In this study, the spatial and temporal variability of meteorological fields due to influence of the thermal and dynamical urban effects of the metropolitan area was estimated on example of St. Petersburg (Russia). The selected case study is associated with the winter period. Dependence of these fields on the temporal variability of meteorological variables in the lower surface layer (wind at 10 m and air temperature at 2 m fields) was estimated as a function of modified parameters – roughness, anthropogenic heat flux, and albedo. The urban modifications were made in the Interaction Soil-Biosphere-Atmosphere (ISBA) land surface scheme of the numerical weather prediction model (NWP). As NWP model a research version of the Environment – High Resolution Limited Area Model (Enviro-HIRLAM; Korsholm et al., 2008; Korsholm, 2009) was used in simulations. The Enviro-HIRLAM model (chosen domain called –S01, with St. Petersburg Metropolitan area in the domain center, extending with 144 vs. 170 grids along latitude vs. longitude, with a horizontal resolution of 1.4 km, and 40 vertical levels) was run with modified land use and corresponding climate generation files. The meteorological fields’ simulations were driven using initial and boundary conditions from operational HIRLAM models of lower resolutions (at first, 15 km, and then – 5 km).

The runs were performed for 48 hour forecast length, taking into account a spin up of the model during the first day. The diurnal cycles of key meteorological variables such as the temperature at 2 m and wind at 10 m were analyzed comparing outputs (i.e., difference fields at each UTC term) from the control run with those where changes made (Figs. 1-2). The simulation results were compared with observations at urban/sub-urban synoptical stations: Sosnovo, Ozerki, St. Petersburg, Oranienbaum, Belogorka, Shlisselburg, Vyborg, Kronshtadt, Volosovo, and Sosnovyy.

In our study, we found that urbanization of the model with modified roughness, anthropogenic heat fluxes and albedo allowed showing urban areas effects. For winter dates (with dominating low wind conditions and inversion/isothermal layers), the differences between control vs. urbanized runs over the metropolitan area and surroundings were the following: wind at 10 m up to 2 m/s (with a maximum up to 2.9 m/s, at nighttime) and air temperature at 2 m is more than 1°C (with a maximum up to 2.7°C, at nighttime).

References

To select an urban case study for the modelling domain, meteorological conditions for 2008-2009 were analyzed based on available archived synoptical maps, vertical sounding diagrams, ground stations observations; and several specific dates – with low and typical wind conditions – in more details. The winter period of 29 Jan – 1 Feb 2009 (characterized by dominating low wind conditions and prevailing strong deep inversion and isothermal layers extending even up to almost 700 Mb) was chosen for evaluation of the thermal and dynamical effects of the St. Petersburg metropolitan area.

For selected specific dates several independent runs were performed for: (i) no modifications in scheme (control run) and (ii) modified run. In the later, the combined effects of the anthropogenic heat flux (ranging from 50 up to 200 W/m²), urban roughness parameter of 2 m, and albedo increased were included. These modifications were done only for the urban cells taking into account the urban class fractions in each cell. Due to presence of a snow cover in urban areas the albedo was also increased up to 0.65 comparing with other free snow seasons.

Figure 1. Difference plots (between the control vs. urban runs) for the wind at 10 m at 00 UTCs on 29 January 2009.

Figure 2. Difference plots (between the control vs. urban runs) for the wind velocity at 10 m at 00 UTCs on 29 January 2009.
EUCAARI: Integrated Project on Aerosol, Cloud, Climate and Air-Quality Interactions Contribution

Markku Kulmala
E-mail: markku.kulmala@helsinki.fi
Division of Atmospheric sciences and Geophysics, University of Helsinki
www.atm.helsinki.fi/indexeng.html

First 24 month results
The EUCAARI results for the first 24 months are ranking from observations of neutral clusters to establishment of global measuring networks. The studies range from new aerosol modules in GCMs (General Circulation Model) to quantum chemical calculations of effect of ammonia to nucleation and field measurements of long-range transport. The main part of the results is published in EUCAARI special issues of Atmospheric Chemistry and Physics www.atmospheric-chemistry-and-physics.net.

EUCAARI has a comprehensive network of high-quality experiments in Europe together with EUSAAR and has established selected observation sites outside Europe: Brazil, South Africa, China, and India.

Coordinator:
Markku Kulmala
Helsinki University
P.O. Box 64 (Gustaf Hällströminkatu 2a)
FI-00144 University of Helsinki
Tel: +358 9 191 50600
Fax: +358 9 191 50610
E-mail: markku.kulmala@helsinki.fi

Project Office:
Ari Asmi
Hanna Lappalainen
E-mail: eucaari-office@helsinki.fi

EC Scientific Officer:
Jose M. Jimenez Mingo
European Commission
Research Directorate General (RTD)
Environment Directorate
Unit 1.5 - Climate Change and Environmental Risks
B-1049 Brussels, Belgium
Tel. +32-2-2976721
E-mail: jose.jimenez-mingo@ec.europa.eu

EUCAARI partners

EUCAARI: Integrated Project on Aerosol, cloud, climate and air-quality interactions is funded by an EU Sixth Framework Programme project targeted for the period 2007 – 2010. Altogether 48 partners from 25 countries are in EUCAARI.

Objective
The EUCAARI work plan is designed to reduce of the current uncertainty of the impact of aerosol particles on climate by 50%. In the end EUCAARI will estimate the side effects of European air quality interactions on global and regional climate and provide tools for future quantifications for different stakeholders like for the EU-ESA Global Monitoring for Environment and Security (GMES) Program.

Approach
EUCAARI applies both experimental (laboratory and field experiments, including development of novel instrumental techniques) and theoretical (basic theories, simulations, model development) methodologies. The scientific achievements of EUCAARI can be described using a research chain that aims to advance our understanding of climate and air quality through a series of connected activities beginning at the molecular scale and extending to the regional and global scale. Fundamental aerosol and carbon cycle processes need to be understood in order to quantify aerosol radiative properties and the influence of aerosols on cloud microphysics and dynamics at the scale of individual clouds, and to understand changes in carbon uptake dynamics.

A hierarchy of complementary models, at the molecular, process, meso-, regional and the global scale will be applied in a coordinated way in EUCAARI. Ultimately, improvements in global and regional process models will be used to evaluate the reliability of highly parameterised schemes used in global climate models, with improvements made as necessary.

Figure 1. EUCAARI Model and Data Integration Philosophy.

EUCAARI (Integrated Project on Aerosol, cloud, climate and air-quality interactions) is funded by an EU Sixth Framework Programme project targeted for the period 2007 – 2010. Altogether 48 partners from 25 countries are in EUCAARI.

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Figure 1. EUCAARI Model and Data Integration Philosophy.
Russian-European Partnership Project - MEGAPOLIS

Valery G. Bondur
E-mail: vgbondur@aerocosmos.info

“AEROCOSMOS” Scientific Center for Aerospace Monitoring
http://www.aerocosmos.info

The MEGAPOLIS project aims to develop integrated technologies of megacities air-pollution assessment based on remote sensing and in-situ monitoring for mitigation purposes. This issue is very important, because in the Russian Federation there are 11 large cities having population of more than 1 million people. Moreover, within the Moscow metropolitan area, which is the biggest European agglomeration, there are more than 13 million people.

The project (duration 2.5 year) is funded in a scope of the Federal Framework Programme of the Federal Science and Innovations Agency / Ministry of Education and Science of the Russian Federation: “Priority Research and Development in Science and Technology Complex of Russia in 2007-2012. Action 2.7 Realization of research and development works in collaboration with foreign scientific organizations”.

The MEGAPOLIS project is a partnership project complementary to the FP7 European Commission MEGAPOLI Project (http://megapoli.info) - Megacities: Emissions, urban, regional and Global Atmospheric POLLution and climate effects, and Integrated tools for assessment and mitigation - on the Programme’s priority area “Environmental management” - FP7-ENV-2007.1.1.2.1.

The projects are focused on the scientific integration of the Russian (MEGAPOLIS) and the European Union (MEGAPOLI) scientists and partners towards the above goal of solving the multi-disciplinary and multi-scale problems of megacity air pollution and impact assessment on the regional-to-global scale climate change.

The leading organization of the MEGAPOLIS project is the “AEROCOSMOS” Scientific Centre of Aerospace Monitoring under Ministry of Research and Education, and Russian Academy of Sciences (RAS).

The project is implemented together with a group of scientific organizations represented by:

(i) Faculty of Geography, Lomonosov Moscow State University;
(ii) Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences;
(iii) Hydrometeorological Center of Russia (Federal Service for Hydrometeorology and Environmental Monitoring).

The main objectives of the MEGAPOLIS Project are the following:

- to develop methods, algorithms and programming tools for processing of remote sensing and in situ data from air monitoring in megacities;
- to assess impacts of megacities on air pollution and hot-spots having an effect on the air quality, local and regional climate by means of remote sensing and in situ monitoring;
- to simulate meteorological regimes and routes of air pollutants distribution within megacity and surroundings;
- to produce informational products for scientifically based recommendations on air quality assessment in megacity;
- to develop, based on integrated technologies, methods and recommendations to evaluate air quality in megacities (European part of Russia);
- to elaborate measures and recommendations to reduce risks of air pollution to life and health quality for population in large cities.

The decision of tasks is based on the integration and joint analysis of the remote sensing data, in-situ data and modeling results.

Such an approach that used combination of results from remote sensing of atmosphere and landscapes allows avoiding wrong estimations and forecasts caused by irregular network of ground-based measurements.

Complex analysis methodology of megacity environmental parameters provided by various sensors and modeling results is based on integration of data on different spatio-temporal scales and topological levels of studied area. The project provides for information products and services development based on modern organization and presentation methods of spatial information about megacity state-of-the-environment.

Cooperation between Russian and European projects - MEGAPOLIS and MEGAPOLI - is planed within the following activities:

- Anthropogenic and natural emission inventories;
- Development of database of surface characteristics, calculated parameters of models, the description and quantification of the effective emissions, transformation and removal of air pollutants, air quality information, etc.;
- Development innovative remote sensing data processing methods for megacity environmental assessment;
- Creation and improvement of models for megacity air pollution assessment and its effect on atmospheric composition and climate;
- Preparation recommendations for evaluation of air quality in megacity based on the tools and technologies developed in the international cooperation with MEGAPOLI project.

MEGAPOLIS/MEGAPOLI collaboration and projects results exchange will support scientific contacts between European and Russian research organizations and allow getting viable solutions for air pollution control, environmental monitoring policy, and improvement of life quality in the megacities.

Project Leader:
Valery G. Bondur
Prof., Academician RAS
E-mail: vgbondur@aerocosmos.info
AEROCOSMOS Scientific Center for Aerospace Monitoring
http://www.aerocosmos.info
**Air Quality in Istanbul: In the Past and Today**

**Selahattin Incecik**  
E-mail: incecik@itu.edu.tr  
Istanbul Technical University  
Department of Meteorology  
Istanbul, Turkey

**Ulás İm**  
E-mail: ulasim@boun.edu.tr  
Bogazici University  
Environmental Sciences Institute  
Istanbul, Turkey

### Introduction

Istanbul is one of the megacities in the world with more than 12.5 million inhabitants according to the 2007 figures. The city (41°N, 29°E) is located on both continents, Asia and Europe with a total area of 5714 km². The climate of Istanbul is usually Mediterranean, being warm and dry in summer and cold and wet in winter. The predominant wind directions are N/NE and SSW/SW in the city.

### History of Air Pollution in Istanbul

Air quality issues are a major concern in Istanbul. Within the last four decades, the city has experienced a rapid growth in urbanization and industrialization. Increased migration in 1960s from less developed regions of the country caused a rapid increase in the population and expansion of built-up areas in Istanbul. Low quality fuels with high sulfur content were mainly the most commonly used fuel types in both domestic heating and the industrial activities. Under these dense and variety of industrial activities, the region experienced very complicated air quality conditions in the late 1980s and early 1990s especially during the heating seasons (Ayap, 1976; Incecik, 1986, Incecik, 1996; Gülsoy et al., 1999; Tayanc, 2000; Topcu et al., 2003). Furthermore, in January 1991, 24-hr average SO₂ and TSP levels in the several parts of the city were exceeded 3000 and 2000 µg/m³ respectively (Batuk et al.,1997). The main reason for these dramatic episodic levels was use of very poor quality local lignite for heating having with high sulfur and ash under the anticyclonic pressure patterns over Istanbul and surrounding areas. Then, following the gradually fuel switching in the early years of 1990s from coal to natural gas for domestic heating led to a gradually decrease in the concentrations of primary pollutants. Today the natural gas usage ratio in the city has reached to 95%. The number of vehicles in the city is increasing with a fast ratio. Every day about 400 new cars are attending to the city traffic. There are also over 2.7 million cars registered in the city according to latest figures. Through the emissions from the transport sector, a big portion of ozone precursors and aerosols are emitted to the atmosphere. As a result of this developing, secondary pollutants such as ozone and aerosols have been gradually increased in the most parts of the city (Topcu and Incecik, 2002; Topcu and Incecik, 2003; Īm et al.,2006;2008).

### Air Quality Modeling Studies in Istanbul

There have also been modelling studies to understand the nature of these pollutants and their spatial and temporal variations in the city. The episodic levels of surface ozone have been studied using SAIMM/UAM-V (Antepilöğlu, 2000; Antepilöğlu et al., 2003), MM5/CAMx system (Antepilöğlu et al., 2004; 2007). They have showed the local circulations over the southern parts of the city leading to episodic conditions.

Recently, a MM5/CMAQ modelling system has been used for a selected high ozone period in Istanbul (Īm et al., 2009). PM10 levels have also been studied in a number of studies. Long range transport of aerosols from Europe to Istanbul have been studied by Kindap et al. (2006), using the 50 km EMEP emissions. Īm (2009) studied PM10 levels as well as the sulfate, nitrate and ammonium levels using a high resolution MM5/CMAQ modelling system and showed that local anthropogenic emissions contribute to episodic levels of PM10. In order to support air quality studies in the area an emission processing kernel was developed aiming to the compilation of a high spatial and temporal resolution emission inventory for anthropogenic sources for the Greater Istanbul Area (GIA) (Markakis et al., 2009). The emissions are spatially allocated on the cells using a grid spacing of 2 km over the GIA. The pollutants considered are NOx, CO, SOx, NH3, NMVOCs, PM10 and PM2.5. The NMVOCs emissions are chemically specified in 23 species based on Olivier et al.(2002) and Visschedijk et al.(2005) source sectoral profiles (CARB, 2007). PM10 emissions were chemically specified in organic and elemental carbon, nitrates, sulfates, ammonium and other particles.

### References

Im, U., Tayanc, M., Yenigün, O., 2009. An investigation of high summertime ozone levels in Istanbul with MM5/CMAQ modelling system. NATO/ITM Air Pol. and its Application, San Francisco  
**Partner: Foundation for Research and Technology Hellas/ Institute of Chemical Engineering and High Temperature Chemical Processes**

The Foundation for Research and Technology Hellas/ Institute of Chemical Engineering and High Temperature Chemical Processes (FORTH; [http://www.iceht.forth.gr](http://www.iceht.forth.gr)) is one of the MEGAPOLI Partners and Prof. Pandis is one of the project co-coordinators. The Institute of Chemical Engineering and High Temperature Chemical Processes (ICE-HT) was established in 1984, and is one of the seven research institutes that constitute FORTH (Foundation for Research and Technology Hellas; [http://www.forth.gr](http://www.forth.gr)). Currently, ICE-HT runs 50 RTD projects in cooperation with numerous industrial enterprises, universities and research institutes from all over the world. ICE-HT has more than 115 staff members and Res. Assoc. (40 - PhD holders). The Institute has well-equipped laboratories that have been used in a variety of research and technology problems involving physicochemical phenomena. ICE-HT is in close cooperation with Department of Chemical Engineering in the University of Patras. The work in this project will be performed by Air Quality Laboratory of ICE-HT.

**Figure 1.** The ICE-HT campus in Patra, Greece.

This research team has approximately 20 years of experience in the study of urban, regional, and global air quality and has a Greek and a US branch in Carnegie Mellon University ([http://caps.web.cmu.edu](http://caps.web.cmu.edu)). In ICE-HT and University of Patras there are three faculty members (Spyros Pandis, Christodoulos Pilinis, and Thanos Nenes), two postdocs (Christos Fountoukis and Pavan Racherla) and seven PhD students (Alexandra Tsipidou, Vlassis Karydis, Evangelia Kostenidou, Dhurata Koraj, Michalis Pikridas, Magda Psichoudaki, and Athanasios Megaritis). All of these are involved with either the modelling or measurement activities in MEGAPOLI. The US branch of the team includes two postdocs (Ilona Riipinen and Akua Asa-Awuku) and six PhD students (Kristina Wagstrom, Gabriella Engelhart, David Lee, Lea Hildebrandt, Sal Farina, and Ben Murphy). Some of the US students participated in the Paris field campaign funded by US National Science Foundation. The team is currently also participating in the EUCAARI project.

The ICE-HT Mission Statement includes:
* Forefront scientific research.
* Cooperation with industrial companies in EU and other countries.
* Development of innovative technological products and production processes.
* Participation in the creation of spin-off companies.
* Cooperation with other research & development organizations.

**Figure 2.** PMCAMx predicted average ground PM$_{2.5}$ concentrations ($\mu$g m$^{-3}$) for May 2008.

Current research topics of the ICE-HT/CMU groups include investigations of:
- Air quality in urban and regional scales
- Effects of climate change on air quality
- Development of instrumentation for in-situ automatic aerosol measurements
- Source-receptor relationships for PM
- Organic aerosol formation
- Formation, emission, and removal of nanoparticles
- Aerosol-water interactions
- Mercury chemistry, transport, and deposition

During MEGAPOLI the team will use extensively the PMCAMx Chemical Transport Model developed through a collaboration of Carnegie Mellon, FORTH and ENVIRON. PMCAMx is the research version of the publicly available CAMx ([http://www.camx.com](http://www.camx.com)). Its strength is the state-of-the-art description of the aerosol size-composition and especially the organic components. The model will be applied to the full European domain with high resolution (3x3 km) over the urban areas of interest (Paris, London, Po Valley, etc). PMCAMx will also be used in the Eastern US with high resolution in the Northeastern Coast, Mexico City, and Santiago.

**Researches Involved**

Spyros Pandis
[spyros@chemeng.upatras.gr](mailto:spyros@chemeng.upatras.gr)

Christos Fountoukis
[cfountoukis@iceht.forth.gr](mailto:cfountoukis@iceht.forth.gr)
The Norwegian Institute for Air Research, NILU (http://www.nilu.no) is an independent research foundation specialising in air pollution research from global to local problems and today is one of the largest European institutes in this field. NILU is the Chemical Co-ordinating Centre for EMEP and coordinates the work under the Convention on Long-Range Transboundary Air Pollution on particulate matter. NILU is a member of the European Environment Agency’s Topic Centre on Air Quality and Climate Change. NILU has 30 years experience in ambient trace gas measurements. NILU has been involved in several recent or current EC-research projects relevant to the MEGAPOLI proposal, such as EUCAARI, EUSAAR, CREATE, EARLINET-ASOS, Retro, SCOUT-O3, GMES-GATO, FORMAT, ASSET, FUMAPEX, Air4EU and ACCENT. NILU is also a member of the Nordic Centre of Excellence CBACCI (Biosphere – Atmosphere - Clouds – Climate – Interactions).

Role and contribution
The NILU role and contribution into the MEGAPOLI project include: Implementation and application of sub-grid emission parameterisations for selected megacities for use in air quality and exposure assessment. Participation in urban scale ensemble model analysis using the AirQUIS-EPISODE model. Application of the FLEXPART model at the global scale to compute the dispersion of emission tracers from megacities to study their transport characteristics and to discriminate between surface and upper tropospheric effects. Impact of North American megacity plumes, in particular from the New York megalopolis, onto European atmospheric composition by evaluation using the existing measurement data from European background stations (e.g., EMEP stations) and previous airborne campaigns combined with FLEXPART simulations to identify periods influenced by transport from North American megacities. The frequency and impact of such episodes on European air quality and chemical composition will be studied. NILU will co-ordinate WP5 and participate in WP2 and WP4.

Researches involved

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruce Denby</td>
<td><a href="mailto:bde@nilu.no">bde@nilu.no</a></td>
</tr>
<tr>
<td>Andreas Stohl</td>
<td><a href="mailto:ast@nilu.no">ast@nilu.no</a></td>
</tr>
<tr>
<td>Dhurata Koraj</td>
<td><a href="mailto:dhuratakoraj@chemeng.upatras.gr">dhuratakoraj@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Massimo Cassiani</td>
<td><a href="mailto:mc@nilu.no">mc@nilu.no</a></td>
</tr>
<tr>
<td>Andreas Stohl</td>
<td><a href="mailto:ast@nilu.no">ast@nilu.no</a></td>
</tr>
<tr>
<td>Bruce Denby</td>
<td><a href="mailto:bde@nilu.no">bde@nilu.no</a></td>
</tr>
<tr>
<td>Magda Psichoudaki</td>
<td><a href="mailto:mpsichoudaki@chemeng.upatras.gr">mpsichoudaki@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Gabriella Engelhart</td>
<td><a href="mailto:gje@andrew.cmu.edu">gje@andrew.cmu.edu</a></td>
</tr>
<tr>
<td>Michalis Pikridas</td>
<td><a href="mailto:mpikridas@chemeng.upatras.gr">mpikridas@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Evangelia Kostenidou</td>
<td><a href="mailto:v_kostenidou@chemeng.upatras.gr">v_kostenidou@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Vlasis Karydis</td>
<td><a href="mailto:vikarydis@chemeng.upatras.gr">vikarydis@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Psichoudaki</td>
<td><a href="mailto:mpsichoudaki@chemeng.upatras.gr">mpsichoudaki@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Athanasis Megaritis</td>
<td><a href="mailto:athmegaritis@chemeng.upatras.gr">athmegaritis@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Alexandra Tsimpidi</td>
<td><a href="mailto:tsimpidi@chemeng.upatras.gr">tsimpidi@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Dhurata Koraj</td>
<td><a href="mailto:dhuratakoraj@chemeng.upatras.gr">dhuratakoraj@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Massimo Cassiani</td>
<td><a href="mailto:mc@nilu.no">mc@nilu.no</a></td>
</tr>
<tr>
<td>Andreas Stohl</td>
<td><a href="mailto:ast@nilu.no">ast@nilu.no</a></td>
</tr>
<tr>
<td>Bruce Denby</td>
<td><a href="mailto:bde@nilu.no">bde@nilu.no</a></td>
</tr>
<tr>
<td>Magda Psichoudaki</td>
<td><a href="mailto:mpsichoudaki@chemeng.upatras.gr">mpsichoudaki@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Gabriella Engelhart</td>
<td><a href="mailto:gje@andrew.cmu.edu">gje@andrew.cmu.edu</a></td>
</tr>
<tr>
<td>Michalis Pikridas</td>
<td><a href="mailto:mpikridas@chemeng.upatras.gr">mpikridas@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Evangelia Kostenidou</td>
<td><a href="mailto:v_kostenidou@chemeng.upatras.gr">v_kostenidou@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Vlasis Karydis</td>
<td><a href="mailto:vikarydis@chemeng.upatras.gr">vikarydis@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Athanasis Megaritis</td>
<td><a href="mailto:athmegaritis@chemeng.upatras.gr">athmegaritis@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Alexandra Tsimpidi</td>
<td><a href="mailto:tsimpidi@chemeng.upatras.gr">tsimpidi@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Dhurata Koraj</td>
<td><a href="mailto:dhuratakoraj@chemeng.upatras.gr">dhuratakoraj@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Massimo Cassiani</td>
<td><a href="mailto:mc@nilu.no">mc@nilu.no</a></td>
</tr>
<tr>
<td>Andreas Stohl</td>
<td><a href="mailto:ast@nilu.no">ast@nilu.no</a></td>
</tr>
<tr>
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<td><a href="mailto:bde@nilu.no">bde@nilu.no</a></td>
</tr>
<tr>
<td>Magda Psichoudaki</td>
<td><a href="mailto:mpsichoudaki@chemeng.upatras.gr">mpsichoudaki@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Gabriella Engelhart</td>
<td><a href="mailto:gje@andrew.cmu.edu">gje@andrew.cmu.edu</a></td>
</tr>
<tr>
<td>Michalis Pikridas</td>
<td><a href="mailto:mpikridas@chemeng.upatras.gr">mpikridas@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Evangelia Kostenidou</td>
<td><a href="mailto:v_kostenidou@chemeng.upatras.gr">v_kostenidou@chemeng.upatras.gr</a></td>
</tr>
<tr>
<td>Vlasis Karydis</td>
<td><a href="mailto:vikarydis@chemeng.upatras.gr">vikarydis@chemeng.upatras.gr</a></td>
</tr>
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</table>
Role and contribution

The KCL role and contribution into the MEGAPOLI project include: coordination of WP2 "Megacity Features" and participation in WP1 "Emissions", involved in urban processes parameterisations and urban surface energy budget modelling, studies for the megacity of London.

Submitted by: Simone Kotthaus

Researchers involved include

Sue Grimmond
sue.grimmond@kcl.ac.uk

Sean Beevers
sean.beevers@erg.kcl.ac.uk

Martin Wooster
martin.wooster@kcl.ac.uk

Matthew Blackett
matthew.blackett@kcl.ac.uk

Nutthida Kitwiroon
Nutthida.Kitwiroon@erg.kcl.ac.uk

Mario Iamarino
mario.iamarino@unibas.it

Duick Young
duick.young@kcl.ac.uk

Thomas Smith
thomas.smith@kcl.ac.uk

Simone Kotthaus
simone.kotthaus@kcl.ac.uk
This team developed (jointly with RIVM, Netherlands) the LOTOS-EUROS model (www.lotos-euros.nl), one of Europe’s well-established regional air quality models (Fig. 2).

TNO is responsible for improving the user orientation of the research in several FP research projects and networks and participates in international working groups on policies and abatement strategies. The knowledge on abatement policies can be translated again into emission distributions (e.g., Fig. 3) and feed back into the DPSIR framework.

**Role and contribution**

In MEGAPOLI TNO focuses on the highlighted sections “Pressures”, “State” and “Responses” (Fig. 1). The TNO role and contribution include: leadership of WP1 “Emissions”. This WP will provide high resolution emission data at various scales to the modelling and mitigation WPs. TNO’s expertise on regional air quality modelling is used in WP5 and WP6 through application of its LOTOS-EUROS model. The expertise on mitigation, policy options, scenario development and stakeholder involvement is brought into WP8.

**Researches involved**

Peter Builtjes
peter.builtjes@tno.nl

Hugo Denier Van der Gon
hugo.deniervandergon@tno.nl

Dick Van den Hout
dick.vandenhout@tno.nl

Martijn Schaap
martijn.schaap@tno.nl

Antoon Visschedijk
antoon.visschedijk@tno.nl

Jeroen Kuenen
jeroen.kuenen@tno.nl

Hans van der Brugh
hans.vanderbrugh@tno.nl
SAFIRE (http://www.safire.fr/) - the Service des Avions Français Instrumentés pour la Recherche en Environnement (SAFIRE, UMS 2859) is a joint service unit of Météo-France, CNRS and CNES. It is providing several research aircraft including default measurement devices for several species. The SAFIRE aircraft have the following core instrumentation performing typical measurements onboard:

- Thermodynamics: High speed and sonic thermometers, lyman-alpha, dew-point hygrometers'
- Turbulence and wind: 5 holes modified radome or boom with pressure sensors, high sensitivity Inertial Navigation System + GPS;
- Air Chemistry: CO, NOx, O3;
- Aerosols: specific air-inlets;
- Microphysics: underwing pods for standard Particle measurement Systems (0.3 to 6000 mm);
- Radiative measurements: down and up visible, IR and UV radiations, radiance temperature;
- Remote sensing: large openings with quartz/BK7 windows (optionnal) for Lidars, Radiometers, etc.;
- Video (Nadir camera);
- Data real-time acquisition.

Role and contribution

The SAFIRE role and contribution into the MEGAPOLI project include: run the French ATR-42 aircraft for flights in the Paris pollution plume during summer 2009 (24 flight hours in a 14 day period).

Research personnel involved

The SAFIRE Team
Director: Marc Pontaud
Contact: desk@safire.fr

Operations team (pilots)
Alain Butet
alain.butet@safire.fr

Instrumentation team
Thierry Perrin
thierry.perrin@safire.fr

Jean Sciare
jean.sciare@lsce.ipsl.fr

Valérie Gros
valerie.gros@lsce.ipsl.fr

Nicolas Bonnaire
nicolas.bonnaire@lsce.ipsl.fr

Cristina Dolgorouky
cristina.dolgorouky@lsce.ipsl.fr

Patrick Chazette
patrick.chazette@lsce.ipsl.fr

Bernard Bonsang
bernard.bonsang@lsce.ipsl.fr

Roland Sarda-Esteve
roland.sarda-esteve@lsce.ipsl.fr

Jean-Christophe Raut
jean-christophe.raut@lsce.ipsl.fr

Jose Nicolas -
jose.nicolas@lsce.ipsl.fr

Morgan Lopez
morgan.lopez@lsce.ipsl.fr

Yohann Trolliet
The Institute of Environment and Sustainability (http://ies.jrc.ec.europa.eu/) at the Joint Research Center, Ispra has long been involved in the study of atmospheric processes at all scale and in all their forms as well as air quality in Europe. More in particular it has long been involved in the process of assisting the Commission in the definition of air-quality related policies by providing scientific and technical advice.

The mission of the Institute for Environment and Sustainability is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment.

Located in Ispra (Lake Maggiore, Italy), the Institute for Environment and Sustainability (IES) is one of seven institutes that constitute the Joint Research Centre (JRC), which is a Directorate-General of the European Commission providing customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies.

The IES was created in 2001 through a merger of the former Environment Institute of the JRC with the Space Applications Institute, giving life to a scientific structure covering the entire environmental sciences with particular competences in the field of earth observation and remote sensing. With over 400 staff, the IES is one of the largest interdisciplinary environmental research institutes in Europe. Its institutional budget of approx. 45 million Euro per year (staff costs and research credits) stems from direct funding through the EU Framework Research Programme and competitive income.

Being structured into six scientific Units, the Institute at present is engaged in seven main fields of activity:

- Sustainable Use of Natural Resources: Water, Soils, Forests
- Sustainable Agriculture and Rural Development
- Climate Change Mitigation and Adaptation
- Environmental Risks and Natural Hazards
- Sustainable Transport and Air Quality
- Environmental Dimension of Development Co-operation
- Environmental Monitoring and Information Systems: GMES and INSPIRE

Through its research actions, the IES supports a large number of European policies and programmes related to the environment including, among others, the Water Framework Directive, the Thematic Strategies of the 6th Environment Action Programme, the Global Monitoring for Environment and Security (GMES) and the Infrastructure for Spatial Information in Europe (INSPIRE).

The main customers of the work of IES are the Policy Directorates-General of the European Commission and other European bodies, such as the European Environment Agency (EEA) and the European Space Agency (ESA), as well as global organisations such as the United Nations Environment Programme (UNEP) and the United Nations Food and Agricultural Organisation (FAO).

The IES works in close collaboration with research partners in the Member States of the European Union and beyond. Since 2002, the Institute participates in the Partnership for European Environmental Research (PEER), which combines Europe's largest environmental research centres.

The IES runs several large-scale research infrastructures and hosts a large number of unique pan-European and global databases. The Institute actively supports the enlargement and integration process of the European Union through targeted activities. Being a European reference centre for environmental science and technology, it is also engaged in international standardisation efforts and provides calibration services to the private sector and the scientific community at large.

The IES puts strong emphasis on the public dissemination of its research results through publications and media activities, thus strengthening the link between EU policies and the European citizen.

**Role and contribution**

The JRC role and contribution into the MEGAPOLI project include: leading the Task 5 in WP 2 that relates to the parameterization of sub grid scale emission to upper atmospheric concentration levels. This will be performed by means of high resolution models and simulation of the atmospheric boundary layer and emission scenarios, try to mimic what a large scale model would see of sources with different emission intensities. The competences present in the team are going to be use extensively for carrying out the task. Coordination of the contribution to the activity from the University of Thessaloniki will also be carried out by the JRC team.

**Figure. Example of high resolution simulation of dispersion of two passive tracers in the atmospheric boundary layer**

**Researches involved**

Stefano Galmarini
stefano.galmarini@jrc.it
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

- Book “Air Pollution: Health and Environmental Impacts” (CRC Press, Taylor & Francis, USA) to be released in Feb 2010 – news by Bhola Gurjar, MEGAPOLI Collaborator, ITR, India

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present the MEGAPOLI Project results and findings:

- European Meteorological Society Annual Meeting (EMS-2009)
  Toulouse, France, 28 Sep - 2 Oct 2009  (*special MEGAPOLI session*)
  [http://www.emetsoc.org/annual_meetings/annual_meetings_2009.php](http://www.emetsoc.org/annual_meetings/annual_meetings_2009.php)
- ACCENT/GLOREAM Workshop on tropospheric chemical transport modeling
  Brescia, Italy, 26-27 Nov 2009
  [http://automatica.ing.unibs.it/gloream/index.html](http://automatica.ing.unibs.it/gloream/index.html)
- WMO, COST-728, MEGAPOLI End-user Workshop
  Geneva, Switzerland, 8-10 Dec 2009
  Contact Liisa Jalkanen (WMO Team), LJaalanen@wmo.int
- American Meteorological Society (AMS-2010) Annual Meeting
  Atlanta, Georgia, USA, 17-21 Jan 2010
- European Geosciences Union General Assembly (EGU-2010)
  Vienna, Austria, 2-7 May 2010
  (*special MEGAPOLI, CityZen, MILAGRO session*)
- 13th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes; Paris, France, 1-4 June 2010
  [http://www.harmo.org/harmo13](http://www.harmo.org/harmo13)
- International Aerosol Conference
  Helsinki, Finland, 29 Aug – 3 Sep 2010
Welcome to the 5th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 5th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dpi.dk).

Latest News

- **Coming soon** – End-User Workshop “Mesoscale modelling for air pollution applications - achievements and challenges” (24-26 Feb 2010, Geneva, Switzerland) - organized together with WMO, GURME, COST-728 and MEGAPOLI in cooperation with CityZen, COST ES602, ACCENT, and MACC Projects - contact Liisa Jalkanen (LJalkanen@wmo.it)
- **Coming soon** – COP15 United Nations Climate Change Conference (7-18 Dec 2009, Copenhagen, Denmark)
- **26-28 Nov 2009** – MEGAPOLI Intercomparison Workshop (WP3: Paris Plume Case Study) – discussions on Paris Campaigns (IfT, Leipzig, Germany)
- **2-4 Nov 2009** – International Workshop on Atmospheric Composition Changes: Climate-Chemistry Interactions (Lecce, Italy)
- **28 Sep – 2 Oct 2009** - MEGAPOLI relevant presentations at the AW11 Session "Environmental Meteorology (from local to global)" at the European Meteorological Society (EMS-2009) Annual Meeting (Toulouse, France)
- **24-25 Sep 2009** – 1st Annual Meeting of the MEGAPOLI Project (DMI, Copenhagen, Denmark)

MEGAPOLI 1st Annual Meeting (24-25 Sep 2009)

See details on the next page

Danish Meteorological Institute (DMI)
The 1st Annual MEGAPOLI meeting attended in total - 65 persons
From 31 Research Institutions/ Organizations
From Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, The Netherlands, Norway, Russia, Spain, Switzerland, UK, USA.

During the meeting the presentations were given on Day 1:
23 Oral + 1 Poster for MEGAPOLI WPs 1-9 & Megacities in Focus;
Day 2:
4 Oral – FP7 EC PBL-PMES and Russian partners of MEGAPOLIS.

Followed by discussions
WP3 – Paris Plume Study – Winter 2010 Campaign
  - lead by Matthias Beekmann (CNRS)
WP8 – Mitigation, Policy Options, and Impact Assessment
  - lead by Jochen Theloke (USTUTT)

and discussions in Thematic groups on different scale studies:
  Local – lead by Alexander Baklanov (DMI)
  Regional – lead by Spyros Pandis (FORTH)
  Global – lead by Mark Lawrence (MPIC)
followed by summary presentations on thematic groups.

1st MEGAPOLI Annual Meeting
24-25 Sep 2009, Copenhagen, Denmark

24 Sep 2009
09.00–09.30 - Registration
09.30–09.40 - Welcome from the Host DMI
  - Leif Laursen, DMI
09.40–10.00 - MEGAPOLI: General Outlook
  - Alexander Baklanov, DMI

Progress for the MEGAPOLI Work Packages (WPs)

10.00–10.20 - WP1: Emissions
  MEGAPOLI WP1 Emissions: Progress in year 1
  - Hugo van der Gon, TNO
10.20–10.40 - WP2: Megacity Environments
  Features, Processes, Effects: Status and Progress Report
  - Igor Esau, NERSC
  Paris Morphology Database, Preliminary Version
  - Antti Heilsten, FMI
10.40–11.00 - Coffee Break
11.00–11.15 - WP3: Megacity Plume Case Study
  MEGAPOLI Paris Campaign - Overview
  - Matthias Beekmann, CNRS-LISA
11.15–11.25 - Meteorology Measurements During
  MEGAPOLI Remote Sensing of Vertical Profile
  - Martial Haefelin, CNRS-SIRTA/LMD/IPSL
11.25–11.35 - Airborne Measurements - First Overview
  - Agnès Borbon, CNRS-LISA
11.35–11.45 - MoLa: Measurements During MEGAPOLI
  2009 Paris Intensive Campaign
  - Mark Lawrence, MPIC
11.45–11.55 - Ground Based Gas Phase Measurements
  - Valérie Gros, CNRS-LSCE
11.55–12.10 - Aerosol Measurements at Ground Stations
  - Jean Sciare, CNRS-LSCE
12.10–12.20 - Mobile Measurements: Preliminary Examples
  - André Prevot, PSI
12.20–12.30 - Combined Use of car MAX-DOAS and Satellite Data for Estimation of Megacity Emissions
  - Mark Lawrence, MPIC
12.30–13.40 - Lunch
13.40–14.00 - WP4: Megacity Air Quality
  - John Douros, AUTH
14.00–14.20 - WP5: Reg & Global Atmospheric Composition
  - Regional – Jaakko Kukkonen, FMI
  - Global – Andreas Stohl, NILU
14.20–14.40 - WP6: Regional and Global Climate Effects
  - Regional – Filippo Giorgi, ITP
  - Global – Bill Collins, UK MetO
14.40–15.00 - WP7: Integrated Tools and Implementation
  - Ranjeet Sokhi, UH-CAIR
  - Jochen Theloke, USTUTT
15.20–15.40 - Coffee Break
15.40–16.00 - WP9: Dissemination and Coordination
  - Alexander Baklanov, DMI
16.00–16.50 - Overview of Megacities in Focus
  Paris and the Ile-de-France Region
  - Veronique Gherzi, AIRPARIF
  Po Valley: Emission Inventory and Preliminary Analysis of Pollutant Export
  - Sandro Finardi and Paola Radice, ARIANET
  London Case Study Preparations
  - Ranjeet Sokhi, UH-CAIR
  The Rhine–Ruhr Region
  - Melinda Uzbasich, USTUTT

First Results on Summer 2009 Paris Campaign
11.00–11.15 - WP3: Megacity Plume Case Study
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  The Rhine–Ruhr Region
  - Melinda Uzbasich, USTUTT
1st MEGAPOLI Annual Meeting  
24-25 Sep 2009, Copenhagen, Denmark

24 Sep 2009 (continued)

16.50–17.00 - Break
17.00–17.45 - Discussions:
  WP3: Paris Plume Study Winter 2010 Paris Campaign Discussions
    (lead by Matthias Beekmann, CNRS)
  WP8: Mitigation, Policy Options and Impact Assessment
    (lead by Jochen Theloke, USTUTT)
17.45–18.15 - MEGAPOLI Steering Group Meeting
    (lead by Alexander Baklanov, DMI)
19.00 – Dinner

25 Sep 2009

09.00–10.30 – Discussions:
  Thematic Groups on Different Scale Studies
    – Global, HIRLAM Meeting room
      (lead by Mark Lawrence, MPIC)
    – Regional, Auditorium Meeting room
      (lead by Spyros Pandis, FORTH)
    – Local, Drivhuset Meeting room
      (lead by Alexander Baklanov, DMI)
10.30–10.50 - Coffee Break
10.50–11.20 - Discussions in Thematic Groups on Different
  Scale Studies (continued)
11.30–12.20 - Summary presentations from each group and
  linkage between groups
12.20–12.30 - Collaborative FP7 EC Project PBL-PMES
  – Sergey Zilitinkevich, FMI
12.30–13.30 – Lunch
13.30–14.00 – MEGAPOLIS Russian Project, General Info
  – Valery Bondur, AEROCOSMOS
  – Nikolay Kasimov & Galina Surkova, MSU
  – Georgy Golitsyn, IFRAN RAS
14.00–14.30 - Discussions/ linkage with tasks and activities of the
  MEGAPOLI (MEGAPOLIS and other projects)
14.30–15.00 - Items/ topics of the 1st year MEGAPOLI reporting
  (deliverables, milestones, dissemination, management reporting)
  – Alexander Mahura, DMI
15.00–15.30 - Discussions of plans for the 2nd year
  – Alexander Baklanov, DMI
15.30–15.50 - Coffee Break
15.50–16.30 - Discussions of plans for the 2nd year (continued)
16.30–17.00 - Summary of the 1st MEGAPOLI meeting
17.00 - Adjourn
18.00 – Signing joint memorandum on collaboration between the
FP7 EC MEGAPOLI and Russian MEGAPOLIS projects in the Russian
Cultural Center (Copenhagen)
Global Radiative Forcing from Megacity Emissions of Long-Lived Greenhouse Gases

William Collins
E-mail: bill.collins@metoffice.gov.uk
Met Office Hadley Centre, UK
http://www.metoffice.gov.uk

Abstract
The contribution to climate change from the emissions of long-lived greenhouse gases (carbon dioxide, methane and nitrous oxide) from Megacities is given as Deliverable 6.1 of the MEGAPOLI Project. Megacities are found to contribute around 10% of the anthropogenic emissions of these gases. The climate impacts are calculated in terms of surface temperature change using a simple analytical climate model. For an emission pulse, the long-term temperature is driven by solely by CO\textsubscript{2}, for a step change in emissions methane and nitrous oxide contribute about 12% of the temperature change.

Emissions
To determine the climate impact of greenhouse gas emission from megacities we took the emissions of carbon dioxide, methane and nitrous oxide from the EDGAR v4.0 database at 1 degree resolution. These 3 gases were chosen as they are the most important for climate forcing. We neglected halo-carbons as individually they make only a small contribution even though in total their magnitude is significant. The carbon dioxide emissions are shown in Fig. 1. Note that the emissions are very localised.

Climate Impacts
To determine the climate impact of the 3 gases we used the method of Boucher and Reddy (2008) to calculate the surface temperature change. This method uses a simple analytical model to relate radiative forcing to temperature, and to describe the carbon cycle.

We conducted two experiments, in both cases starting from conditions with no megacities. In the first case megacity emissions were turned on for a 1 year pulse and then switched off. In the second case megacity emissions were turned on, and left on as a step change. The results of these are shown in Fig. 3.

For the pulse emissions, the methane concentrations grow very rapidly, but then decay with a ~12 year e-folding time, whereas the carbon dioxide and nitrous oxide concentrations maintain their levels. For the first 5 years after the pulse about half the temperature rise is due to the methane emissions. After 60 years the methane contribution is negligible.

For the step change in emissions the methane concentrations plateau whereas the carbon dioxide and nitrous oxide concentrations continue to rise. The increase in surface temperature after 100 years of megacity emissions is 225 mK, of which 200 mK is due to the CO\textsubscript{2} emission, 22 mK due to the methane emissions and 3mK due to the nitrous oxide emissions.

Conclusions
Megacities account for 12% of the anthropogenic CO\textsubscript{2} emissions and lesser fractions of the methane and nitrous oxide emissions. Even maintaining a constant 2005 level of emissions, megacities will be responsible for a 225 mK warming over the next 100 years. Just under 90% of this warming is due to the CO\textsubscript{2}. Methane emissions have a larger impact in the short term.

References

William Collins
E-mail: bill.collins@metoffice.gov.uk
Met Office Hadley Centre, UK
http://www.metoffice.gov.uk

Figure 2. Emissions from 34 megacities. Emissions of CO\textsubscript{2} are in Pg/yr, CH\textsubscript{4} and N\textsubscript{2}O are in Tg/yr, although values for CH\textsubscript{4} have been divided by 10 to keep them on the same scale.

Figure 3. Evolution of the concentration changes (top) and temperature changes (bottom) resulting from (left) --- a 1 year pulse of megacity emissions; and (right) --- a step change of megacity emissions.

Figure 1. CO\textsubscript{2} emission map on a 1 degree grid from EDGAR.
Regional Climate-Chemistry (RegCM-CHEM) Coupling: 1st Year Preliminary Results

Ashraf Zakey
E-mail: azakey@ictp.it
The Abdus Salam International Center for Theoretical Physics, Italy
http://www.ictp.trieste.it

ICTP-RegCM Model (RegCM-CHEM) Developing
Chemistry plays an important role in determining current and predictions of the future state of earth’s climate, because a large number of agents that force earth’s climate are chemically active. Chemical processes in the atmosphere determine the abundances and properties of atmospheric forcing agents. From an atmospheric chemistry perspective, changes in the atmospheric composition, which force the climate system, are of primary interest. It is precisely the composition changes—natural or anthropogenic—that also forces the climate system to change, above and beyond the forcing by other natural factors such as the Earth’s orbit, solar activity, etc. In some sense, other long-term changes such as those in ocean circulation can be treated as “natural” variations that are beyond human control.

The ICTP contribution is mostly linked with model development, and the following steps have been accomplished so far: 1) Determined a regional model domain to develop climate-chemistry feedback over European mega cities; 2) Developed an emission pre-processor for RegCM-CHEM which takes into accounts all of the available global emission inventories. 3) Coupled an online biogeo: VOC emission module (MAGEN) to the land surface model of RegCM-CHEM, enabling an interactive treatment of natural emissions and climate; 4) coupled a suite of gas phase chemical mechanisms to RegCM-CHEM and evaluated the model during the heat-wave over Europe. Based on the comparisons with an observational network of ozone data from EMEP, the results indicate that the gas-phase mechanisms accurately simulate ozone, an important greenhouse gas. Fig. 1 shows the technical schematic of the chemical processes coupled in RegCM-CHEM. The abundance of ozone in the atmosphere is completely determined by chemical processes; both their production and loss are chemical in nature. Of course, transport is responsible for redistribution of these species.

Chemical Solvers: The Kinetic Pre-Processor (KPP)
Current atmospheric chemistry mechanisms include hundreds of reactions and dozens of chemical species. For example, the condensed chemistry mechanism developed by Collaborator Sanford Sillman (from Michigan University, USA) (GEOS_SILL) has 533 reactions and 157 species. In order to derive solutions to these chemical reactions, this would require solving corresponding large systems of ODE, requiring highly efficient numerical integrators and costly code developments and updates. Automatic Code generation has become widely used tool to approach above problems, and one such generation is the Kinetic Pre-Processor (KPP; Sandu and Sander, 2006). The KPP solver needs only three files (user defined), including one for the set of mechanism equations, one for definitions of species and the last one for initialization and inline code. The KPP will process such files and produce a complete package for simulation of such mechanisms. KPP used to produces the chemical mechanisms for the gas-phase (RADM2, CBM-Z, and RACM).

Coupled Chemical Mechanism and Chemical Solver Options
In RegCM-CHEM, we plan to have several chemical mechanisms coupled to the climate model, so that the user can select the appropriate chemical mechanism for their application. To date, we have tested several chemical mechanisms and several chemical solvers within RegCM-CHEM. These include the following: (a) Updated GEOS-CHEM (SILL), using Sanford Sillman box model code; and (b) Updated GEOS-CHEM (GEOS_KPP), (c) CBMZ (CBMZ_KPP), and (d) RACM (RACM_KPP) using KPP to produce the code.

Case Study of Heat-wave over Europe, 2003
In August 2003, Europe has been suffered from a heat wave lasted 15 days; this heat wave was accompanied by a high level of ozone. We chose this period as a case study to evaluate the coupled climate-gas phase chemistry model. We used EMEP stations (Fig. 2) network for ozone to validate the outputs. EMEP (European Monitoring and Evaluation Programme) is a scientifically based and policy driven programme under the convention on Long-range Transboundary Air Pollution for international co-operation to solve transboundary air pollution problems (http://www.emep.int).

- Three gas-phase mechanisms are coupled on-line with RegCM-CHEM (updated GEOS-CHEM, KPP_GEOS-CHEM, KPP_CBMZ and KPP_RACM), each of them include different solver.
- Global emission inventories from RETRO, POET, EDGAR, and GFED are re-gridded and interpolated to the model grid spacing (60 km) using bi-linear interpolation.
- The numbers of transported species are 19; number deposited (dry) - 14 out of 19 using a new gas-dry deposition scheme which is on-line coupled with RegCM-CHEM recently.
- RegCM-CHEM is validated using EMEP ozone measurement during the heat wave over Europe (1-15) August 2003.
- The result shows that the model captures the same feature of the observed ozone one spatial and temporal distribution over the studied domain as shown in Fig. 2. The modelled maximum of ozone concentration shows underestimation, which may be due to the lack of some ozone precursor sources.

Figure 1. Technical schematic of chemical processes coupled in RegCM-CHEM

Gas-Phase Mechanisms and Organic species lumping techniques in RegCM-CHEM
Most inorganic (inorganic photolysis and inorganic oxidation reactions) use approximately the same representation in all mechanisms. However, due to extremely large number of organic chemical species in the atmosphere, there are several approaches used in chemical mechanisms to describe wide range of organic compounds. There are 2 major approaches to deal with hundreds of organic species: Lump molecule (RADM2, RACM, GEOS, GEOS-SILL) - (a) Surrogate species have similar reactivity range; (b) Does not conserve carbon mass; and Lump structure (CBM-IV, CBM-Z) - (a) Surrogate species base on carbon bonds single bond species, double bond species; (b) Relatively fewer categories are needed to represent organic species; (c) Conserve carbon mass.

Figure 2. ICTP-RegCM-CHEM simulated ozone concentration output vs. observations at 88 measurement stations on 8 Jul 2003.
Evaluation of Zooming Approaches Describing Multiscale Physical Processes

Nicolas Moussiopoulos

E-mail: moussio@eng.auth.gr
Aristotle University Thessaloniki (AUTH), Laboratory of Heat Transfer and Environmental Engineering, Greece
http://lhte.meng.auth.gr

Moussiopoulos N., Tsegas G., Douros I., Barmpas Ph.
Aristotle University Thessaloniki (AUTH), Laboratory of Heat Transfer and Environmental Engineering, Greece

The treatment of physical effects across multiple spatial scales has been one of the long-standing issues in numerical weather prediction (NWP) and climate modelling. As part of the MEGAPOLI WP4 activities, zooming approaches are being evaluated for simulating the effect of local forcings in regions of strongly structured topography and within the urban canopy. Zooming approaches, in a variety of implementations, are increasingly applied as part of a strategy for establishing consistent numerical treatment of multiscale dynamical effects, while maintaining a small computational resource footprint. In essence, the aim of such approaches is to improve the parent model’s skill in simulating small-scale features through the use of dynamical downscaling (usually in the form of model coupling), introduction of multiple parameterisations for scale-specific processes and support for flexible nesting of computational grids. At the same time, the WP4 collaborating teams have been seeking out ways to minimize uncertainties and cope with the main sources of error arising in modelling of cross-scale interactions.

In a typical implementation of dynamical coupling, the smaller scale model is driven by introducing parameter fields, extracted from larger-scale calculations in specified intervals, as boundary conditions. Major design issues for any zooming methodology involving dynamical downscaling, particular in the urban-to-street scales, include:

- the treatment of incompatible physical parameterisations across different scales
- modelling errors inherent to the various scale-specific parameterisations
- minimisation of spatial discretisation errors, a particularly problematic source of uncertainties due to the fact that characteristic scales of various processes, and therefore the grid resolutions required to resolve them, often need to be determined by numerical experiment.

Current modelling strategies attack these problems by incorporating multiple alternative approaches, either used in a complementary fashion or provided to the model user in a modular form as selectable options.

The European Zooming Model (EZM) (Moussiopoulos, 1994) is a comprehensive model system developed for simulating wind flow and pollutant transport and transformation in subregions of the European region. It is one of the most widely tested and verified European air pollution models and is especially suited for urban air quality studies. EZM evolved to be a stand-alone model system which may be driven with measurement data. Recent enhancements to EZM provide a mechanism for enabling two-way interaction of the mesoscale model with a local-to-microscale model simulation of urban flows in- and over built-up areas, as well as the estimation of feedback effects on the mesoscale induced by the presence of the urban-scale structure (Tsegas et al., 2009). A preliminary validation of the system for an urban test case in Athens, Greece has indicated a significant reduction of the low-level wind speeds compared to the reference mesoscale calculation. The presence of the urban structures induces a distinctive modification of the vertical turbulent kinetic energy profile, extending to a height of up to 2.5 times the average roof height.

An integrated set of meteorological model forms the foundation of the Enviro-HIRLAM integrated system (High Resolution Limited Area Model, Baklanov et al, 2009) aimed at coupled meteorological and chemical transport simulations on the regional to urban scales. In order to cope with the heterogeneity of parameterisations across scales, a multi-approach strategy is implemented, combining the use of field downscaling, modification of the mesoscale parameterisations over urban areas and explicit modelling of the urban sublayer. In the latter case, an increased vertical resolution in the NWP model becomes necessary for an accurate estimation of the urban surface energy budget. Numerical evaluations of the integrated model indicate a significant reduction of average wind speeds up to 2.5 m/s in the urbanized case, while the combined thermal effects in the urban canopy typically induce a temperature increment of up to 2 °C, particularly pronounced during the late evening and night hours.

In the oncoming months, WP4 groups will seek to finalise a concrete performance assessment of the proposed zooming approaches, while ideas and suggestions are continuously being tested and challenged through application in urban test cases. We expect that the ongoing work on validation cases involving the “1st level” MEGAPOLI regions will provide significant benefits on the improvement of methodologies, as well as the necessary calibration of existing parameterizations.

References
One of the main objectives of MEGAPOLI is to investigate the influence of Megacities on regional air quality. A Megacity is characterized by large emissions of primary and secondary pollutants such as NOx, O3, organic compounds as well as particles. However, the direct influence of the emissions is not the only way the city affects air quality. In particular, the interaction between soluble particles and clouds may be of importance. Particles may be transported downwind in the urban plume into cloudy environments where they activate and contribute to an increase in cloud droplet number concentration. Such an increase leads to enhanced cloud-top reflectance through the first aerosol indirect effect (Twomey, 1974) and modification of precipitation development through the second aerosol indirect effect (Albrecht, 1989). This is of importance to air quality because cloud cover (actinic fluxes) and temperature may change downwind and thereby influence photolysis and chemical reaction rates. Additionally, such changes may lead to dynamical redistributions of the chemical species due to local thermally induced circulation cells, changes in wind and boundary layer structure. In this study we investigate the effect of particle emissions in the greater Paris area on the regional thermal structure. Model simulations with and without the first and second aerosol indirect effects in a single meteorological case were compared to two-meter temperature measurements (T2m).

The meteorological setting was governed by deep convection and rain in the days prior to the forecast period. During runtime (covering June 30 to July 1 2005) the domain was governed by cloudiness and convectively unstable air, with westerly winds and small amounts of rain. Such a setting has been chosen to optimise the second aerosol indirect effect. The investigation comprised four model runs under identical settings except for the inclusion of the first aerosol indirect effect (1IE), the second aerosol indirect effect (2IE), both effects (12IE) and neither effects (REF).

In general, inclusion of the indirect effects led to decreased temperature during daytime and slightly increased temperature during night time at stations where cloud cover changed (Fig. 1). At individual points the temperature change may be up 5°C. From run 2IE it was found that the second indirect aerosol effect led to increased cloud cover through suppression of auto-conversion. The 1IE run showed that the first indirect effect had only negligible influence in this meteorological case. Large influence of the first indirect effect is only expected for thin cloud layers. Comparing to measurements of T2m (using 31 standard WMO stations evenly distributed in the modelling domain with three hourly updates) shows that run 12IE performs better than REF during late afternoon and early evening on most stations (Fig 2.).

The results present a consistent physical picture where the presence of anthropogenic sulphate aerosols increase cloud droplet loading leading to increased cloud lifetime and corresponding changes in temperature. The fact that comparison with two meter temperature improves when including the effects lends credibility to the results. However, a sensitivity study to determine whether the model atmosphere was in a particular nonlinear regime has not been conducted. This will be included in further experiments with larger temporal coverage, during the MEGAPOLI project.

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Urbanization Related Studies in India: An Overview

Bhola Ram Gurjar, PhD
E-mail: bholaface@iitr.ernet.in
Department of Civil Engineering, Indian Institute of Technology Roorkee http://http://www.iitr.ac.in/~CE/bholaface

Due to rapid urbanization and industrialization in India, several Indian researchers are focusing their works on the urban related studies. A few of them are briefly described hereinafter.

**Max Planck Partner Group for Megacities & Global Change**

In South Asia one third of the 15 largest megacities are found, with a combined population of about 70 million, which is more than combined population of several countries of Europe. The economies of the Indian subcontinent are growing rapidly, and megacities are playing crucial roles as their relatively better infrastructure and skilled workers attract international businesses and investments, which enhance the overall employment capacity of these cities. The improving employment opportunities attract the rural population to migrate into the cities. Because of the growing industrial activities and energy use, the burgeoning megacities are growing into huge conglomerates of air pollution sources with local and global consequences for air quality and climate. The Max Planck Partner Group for Megacities & Global Change (http://www.iitr.ernet.in/outreach/web/mppgroup/), which is a joint research group of MPIC Mainz (Germany) and IIT Roorkee (India) with financial support from the Max Planck Society (Germany), is conducting local-to-regional-to-global air quality and climate studies of South Asian megacity air pollution with a focus on quantifying the emission sources, their impacts and potential control options.

**Regional atmospheric environment and intercontinental transport of pollutants**

A three-year (2008-2010) project by Indian and Italian scientists, which is being carried out at Indian Institute of Tropical Meteorology (IITM), will help determine the amount of air pollutants that are being transported to India from different parts of the world and vice-versa. The major contributors to the deterioration of air quality are pollution from vehicles and the burning of fossil fuels. The project has been selected in the framework of the Indo-Italian programme of scientific and technological co-operation for by the Department of Science and Technology (DST). IITM is the only institute in Asia which has the mandate for tropical meteorology research. More details are available at: http://timesofindia.indiatimes.com/home/environment/pollution/Now-a-project-to-nail-global-air-polluters/articleshow/4253648.cms

**Urban study related projects at IIT Delhi**

There are several research projects (http://web.iitd.ac.in/~tripp/rp/R_PTarace.html) being carried out at IIT Delhi which focus on sustainable transport systems in Indian cities.

**Urban Air Pollution Control**

Research undertaken by Central Pollution Control Board (CPCB) indicates that tentacles of vehicular pollution have also extended to small cities and towns. The CPCB is reviewing action plans of various cities/towns of the country before the vehicular pollution becomes a major problem there.

**Inventory of Evaporative Emissions of Hydrocarbons from various sources in Delhi, Kolkata, Mumbai and Chennai**

This study was executed by NEERI Zonal Laboratory, Mumbai. The study has been completed and report is being published.

**Monitoring and inventory of Volatile Organic Compounds (VOC) in Urban Air of Delhi & Mumbai**

This study was executed by National Environmental Engineering Research Institute (NEERI) Zonal Laboratory, Mumbai. The study has been completed and the report is being published.

**Estimation of Emission Load from Vehicular Sources under Various Scenarios**

The exercise involves calculation of vehicular emission load in major cities using various scenarios like completely/partially switching over to cleaner alternate fuels, leapfrogging emission norms for new vehicles etc.

**Ambient Air Quality Status of Kolkata with reference to Ozone and VOCs**

The study is being executed by NEERI Zonal Office, Kolkata. The objective of the study is to provide background information to research workers, policy makers and other stakeholders on the following areas: Ambient levels of NOx, carbonyl, ozone and speciated VOCs. These levels are characteristics of source emission impacts.

**Nation-Wide Assessment of Vehicular Pollution Control Measures**

The vehicular pollution control has been emphasized in megacities until recently. However, in the recent few years the tentacles of vehicular pollution have also extended to small cities and towns. Thus, the requirement to look upon the problems of vehicular pollution at local level has been visualized to curb this menace throughout the country. The CPCB is attempting to assess the status of vehicular pollution in terms of problems, steps taken and required to be taken in various cities/towns of the country before the vehicular pollution becomes a major problem there.

**Assessment of Aldehydes, Ketones and Methane emissions in Vehicle exhaust, using different fuels (Petrol, Diesel, LPG, CNG, Ethanol in Petrol, Biodiesel and Hythane)**

This study is being undertaken by CPCB in association with ICAT, Manesar with the objective to characterize Aldehydes, Ketones and Methane emissions in vehicle exhaust of 2-wheelers, 3-wheelers, 4-wheeled passenger vehicles, 4-wheeled light duty commercial vehicles & 4-wheeled heavy duty commercial vehicle engines operating on different fuels i.e. Petrol, Diesel, LPG, CNG, Ethanol (5%) in Petrol (BS III) and Biodiesel (10%) in Diesel (BS III) & Hythane.

**Evaluation of Performance and Durability of Catalytic Converters and Development of Short Test Procedure for checking Performance of such Converters fitted on in-use vehicles**

The study is proposed to be undertaken by CPCB in association with suitable executing agency with following objectives and terms of references. Evaluation of long term performance & durability of catalytic converters in on-road vehicles Development of short test procedure for checking performance of catalytic converters in on-road vehicles Improvement in existing PUC procedure to have better co-relation with standards mass emission system.

**Comparative risk assessment for interventions aimed at reduction of Indoor air pollution associated with biomass fuel use in rural and urban settings of Andhra Pradesh, India - An integrated evaluation based on health risks and greenhouse gas emissions**

The objectives of this study include: Assess emission and exposure potentials for pollutants associated with combustion of solid fuels in rural Andhra Pradesh; Develop integrated environmental strategies to address indoor air pollution associated with combustion of biomass fuels through the assessment of co-benefits of reduction of emission of health damaging pollutant as well as greenhouse gas emissions; Evaluate cost-effectiveness of possible interventions based on co-benefits.

http://www.srmc-ehe.org.in/3_Ongoing_projects.php
Is a Kuznets Paradox on the Horizon for Developing Megacities?

Benjamin Gibson
E-mail: ben.gibson@iea.org

International Energy Agency
– Currently on secondment from the U.S. Environmental Protection Agency

This work was prepared independently and does not necessarily reflect the views of the IEA or US EPA.

The United Nations estimates that since 2008, and for the first time in human history, a majority of the world’s population is now living in urban areas. This long-term demographic shift shows no signs of abating, and holds profound implications for environmental and energy policymakers at all levels of government.

Broadly speaking, where you have more people, you will often find more pollution. A lack of access to affordable clean-energy technologies or effective emission controls often leads to even higher concentrations of health-damaging pollutants such as particulate matter in developing urban areas. Basic activities for human survival such as cooking and heating are often enabled out of sheer necessity only by means such as open burning of fossil fuels, biomass (e.g., wood, straw), and even highly toxic materials such as tires.

Figure 1 uses coarse particular matter (PM\(_{10}\)) to illustrate the disparities in air quality levels between OECD and Non-OECD megacities. The chart shows nearly twice as many people living in the Non-OECD megacities, roughly in line with the relative number of cities for which data were analyzed. What is more alarming is the disparity in PM\(_{10}\) levels between OECD and Non-OECD. The population-weighted average for Non-OECD cities is approximately 90 micrograms-per-meter-cubed, almost three times higher than that of OECD megacities, and more than four times the limit recommended by the World Health Organization.

The high PM\(_{10}\) levels in Non-OECD megacities paint a grim picture, but are not particularly surprising if one believes there is some truth to the Environmental Kuznets Curve. As shown in Figure 2, the curve predicts that in the early growth stages of economic development, environmental degradation increases up to a point, after which it reverses course once a certain standard of living is achieved and social priorities shift (blue solid line). Developing urban centres can be thought of as falling somewhere along the upper end of the left-hand side of the curve, looking to make it over the turning point and begin moving along a downward slope that represents continued economic growth paired with improving environmental conditions.

However, even with significant reductions in traditional non-greenhouse-gas pollution, it is possible that environmental gains may be offset if severe climate change scenarios are realized (red dashed line). The actual outcomes would vary by city, and depend on a complex array of spacial and temporal variables, but significant negative impacts would be expected in most locations around the world.

The prospect of severe climate change presents a unique two-fold dilemma for developing urban areas. Firstly, the vast majority of greenhouse gases (GHGs) already in the atmosphere were emitted by developed countries, which are likely to remain relatively high-volume GHG emitters for some time. In other words, even if developing megacities control what they can (localized air pollution), they may still be negatively impacted by an environmental phenomenon that cannot be fully controlled on a local or even national level (rising atmospheric GHG concentrations).

Secondly, developing megacities will remain much less well equipped than their developed counterparts to deal with climate change impacts for the foreseeable future. Adaptation may necessitate shifting limited resources away from the control of traditional pollutants, and in a sense sliding backwards along the Kuznets curve.

The MEGAPOLI project aims to assess climate change and air quality issues in megacities, with the ultimate goal of informing smarter and more integrated policies in the future. As MEGAPOLI moves its focus beyond E.U. cities to emerging urban areas such as Cairo and Moscow, unique considerations such as a Kuznets paradox may be useful in shaping project-related policy objectives.

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Regional Air Pollution Research Network for Improving Air Quality in Asian Developing Countries

Nguyen Thi Kim Oanh
PI of AIRPET
E-mail: kimoanh@ait.ac.th
Environmental Engineering and Management, SERD
Asian Institute of Technology
http://www.ait.ac.th

AIRPET (Regional Air Pollution Research Network for Improving Air Quality in Asian Developing Countries; [http://www.serdl.ait.ac.th/airpet]) addresses integrated air quality management issues in Asian countries. The research project is coordinated by the Asian Institute of Technology (AIT) and is jointly conducted by 6 national research institutions from Asian developing countries, namely AIT, China, Indonesia, India, Philippines & Vietnam.

The major objectives of first 2 phases (2001-2009) are to: (1) establish comprehensive assessment of air pollution status, (2) develop appropriate control technologies for developing countries, (3) apply modelling tools for integrated air quality management, and (4) develop integrated air quality management for target sources as demonstration cases. The major outputs of these first 2 phases are highlighted below.

AIRPET has created a long-term monitoring database of 7000 PM$_{2.5}$ and PM$_{10}$ samples collected in 2001-2008 with necessary QA/QC in 6 cities. In each city (Bangkok, Beijing, Chennai, Bandung, Manila, and Hanoi) PM monitoring was conducted at 3-5 characteristic urban sites and one remote site (outside the city). Samples were analyzed for mass and compositional data (EC/OC and/or BC, selected metals, and inorganic and organic ions). Higher levels of PM were observed during the dry season with daily PM$_{2.5}$ exceeded the WHO (2005) 24h PM$_{2.5}$ guideline of 25 μg/m$^3$ in all six cities for most of the monitoring periods (Kim Oanh et al., 2005). The levels of carcinogenic pollutants (BTEX, PAHs, pesticides and PCBs) were also found high in urban areas as compared to remote areas.

Receptor models (CMBB, PMF, FA, COPREM, ME-2) revealed that diesel vehicles, biomass burning and secondary inorganic particles are the largest contributors to PM$_{2.5}$ in the cities, collectively contributed up to 80-90% of the PM mass.

3D air quality models (CMAQ/MM5, CAMx/MM5, and CHIMERE) were successfully evaluated and applied to analyze the efficacy of emission reduction scenarios on urban/regional ozone air quality in Bangkok, Hanoi, Jakarta and Hochiminh City and the whole Southeast Asia region. Simulated ozone levels were high around large urban areas. The risk of surface ozone exposure on ecosystem/crops in Southeast Asia was assessed using AOT40 maps which show 3-month AOT40 significantly exceeding the WHO guideline (3000 ppb-h) over large parts of the region which suggest substantial reductions in agricultural crops yield.

Several lab-scales devices were developed and their performance was successfully evaluated with cost-benefit analysis.

These include the systems for BTEX, SO$_2$ and NOx (India), NOx and CO (Indonesia), VOC (China), and VOC & NOx (AIT). Two devices have been successfully scaled-up to pilot application in industries, namely for VOC control (China) and NOx control (India).

Integrated air quality management was developed for four target sources/source categories including open field rice straw field burning (AIT), brick making community (Vietnam), VOC industrial emission (China), and vehicle exhaust focusing on leaded gasoline (Indonesia). Recommendations from the demonstration cases study are also relevant for other countries where similar situations exist.

The AIRPET team actively involved in the result dissemination to public and policy makers. AIRPET regional workshops/trainings and national workshops were organized regularly. The team has produced over 70 peer-reviewed international journal articles, 100 peer-reviewed papers in international conference proceedings and conference presentations. The AIRPET team is in the process to publish a book “Air Pollution Management in Asia” based on the scientific output of the project.

Young researchers and graduate students involved actively in the project activities in all national partners. The research capacity of the involved NRIs had been improved substantially by human resource development and laboratory equipment. Networking was actively conducted with international networks (UNEP, World Bank, US-AEP, CAI-Asia, etc.) and national partners.

AIRPET phase 3 is planned for 2010-2011 with the overall goal to secure the remaining research results and continue research momentum, capacity building and networking. Main objectives are to (1) obtain long term trend of PM and BC, (2) apply satellite monitoring tool to assess the interaction between local and long range transport (LRT) and effects on urban air quality, and (3) promote co-benefit approach for air quality and climate change in Asia. One of the outputs of AIRPET phase 3 is a proposal of a new regional research project focusing on co-benefit for air quality and climate in Asia.

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AIRPET website, 2009: [http://www.serdl.ait.ac.th/airpet]
Urban metabolism considers a city as a system and distinguishes between energy and material flows. "Metabolic" studies are usually top-down approaches that assess the inputs and outputs of food, water, energy, etc. from a city (Ngo and Pataki, 2008), or that compare the metabolic process of several cities (Kennedy et al., 2007). In contrast, bottom-up approaches are based on quantitative estimates of urban metabolism components at local scale, considering the urban metabolism as the 3D exchange and transformation of energy and matter between a city and its environment. Recent advances in bio-physical sciences have led to new methods to estimate energy, water, carbon and pollutants fluxes. However, there is poor communication of new knowledge to end-users, such as planners, architects and engineers.

The FP7 project BRIDGE (Sustainable Urban Planning Decision support accountinG for urban mEtabolism) aims at illustrating the advantages of considering environmental issues in urban planning. BRIDGE will not perform a complete life cycle analysis or whole system urban metabolism, but rather focuses on specific metabolism components (energy, water, carbon, pollutants). BRIDGE’s main goal is to develop a Decision Support System (DSS) which has the potential to propose modifications on the metabolism of urban systems towards sustainability (Chrysoulakis et al., 2009).

BRIDGE is a joint effort of 14 Organizations from 11 EU countries. Helsinki, Athens, London, Firenze and Gliwice have been selected as case study cities. The project uses a “Community of Practice” approach, which means that local stakeholders and scientists of the BRIDGE meet on a regular basis to learn from each other. The end-users are therefore involved in the project from the beginning.

The energy and water fluxes are measured and modelled at local scale (Offerle et al., 2006). The fluxes of carbon and pollutants are modelled and their spatio-temporal distributions are estimated (Borrego et al., 2006). These fluxes are simulated in a 3D context and also dynamically by using state-of-the-art numerical models, which normally simulate the complexity of the urban dynamical process exploiting the power and capabilities of modern computer platforms (San Jose et al., 2008).

The output of the above models lead to indicators which define the state of the urban environment. The end-users decide on the objectives that correspond to their needs and determine objectives’ relative importance (weighting). The objectives weights reflect the central priorities of the project. Once the objectives have been determined, a set of associated criteria are developed to link the objectives with the indicators. BRIDGE integrates key environmental and socio-economic considerations into urban planning through Strategic Environmental Assessment (Donnelly et al., 2006).

The BRIDGE DSS evaluates how planning alternatives can modify the physical flows of the above urban metabolism components. A Multi-criteria Decision Making approach based on cost-benefit analysis has been adopted in BRIDGE DSS. To cope with the complexity of urban metabolism issues, the objectives measure the intensity of the interactions among the different elements in the system and its environment. The objectives are related to the fluxes of energy, water, carbon and pollutants in the case studies. The evaluation of the performance of each alternative is done in accordance with the developed scales for each criterion to measure the performance of individual alternatives.

Several studies have addressed urban metabolism issues, but few have integrated the development of numerical tools and methodologies for the analysis of fluxes between a city and its environment with its validation and application in terms of future development alternatives, based on environmental and socio-economic indicators for baseline and extreme situations. The innovation of BRIDGE lies in the development of a DSS integrating the bio-physical observations with socio-economic issues. It allows end-users to evaluate several urban planning alternatives based on their initial identification of planning objectives. In this way, sustainable planning strategies will be proposed based on quantitative assessments of energy, water, carbon and pollutants fluxes.

For more information: http://www.bridge-fp7.eu
Urbanisation has arguably been the most significant process of land use change in Europe since the Second World War. Over 70% of Europe’s population now lives in urban areas, which in turn have grown in area by almost 80% over the last fifty years (EEA, 2006). The most obvious signs of this shift towards urbanisation are urban sprawl and the emergence of peri-urban areas, characterised by scattered built-up residential, industrial or commercial areas and dense transport networks, but also by the establishment in some places of green belts, recreational facilities, urban woodlands and golf courses, the conversion of farmstead complexes into housing and changes from conventional agricultural land uses into hobby farms and rural areas within easy reach of the city.

The different spatial patterns, cultures, planning policies, and various driving forces of urban growth or decline, result in changes of land use and functional linkages between urban and rural areas. The changing nature of the relationships between rural and urban land uses has deep consequences both for people’s quality of life, for the environment and ecosystem services. These changes are most dynamic, intense and visible in the peri-urban zones which are therefore the main object of study. To understand the processes that drive land use changes, it is necessary to analyse the causes and effects, to improve knowledge, and to create better methods and tools to assess the future social, environmental and economic impacts of these changes. Only then can effective planning strategies to achieve sustainable land use systems be identified.

The PLUREL Project

The EC-funded research project, PLUREL, aims to achieve a deeper understanding of the changing relationships between urban and rural land use with an emphasis on the most dynamic portion, that of peri-urban areas. It develops methods and tools to assess the environmental, social and economic impacts of land use changes. Potential strategies and good practice examples will be identified in order to promote the sustainable development of land use systems in Rural-Urban Regions, especially the peri-urban.

A multi-level approach is essential, both to identify driving forces and pressures, and to explore policy responses and opportunities. Thus the results will be targeted to the pan-EU, national and regional levels of governance.

For the pan-European level typologies of Rural-Urban Regions and future scenarios for spatial development are developed. These scenarios are assessed for effects on land-use change, peri-urban land use relationships, as well as wider sustainability impacts, delivering outputs at NUTS2/3 level across the EU.

For the case study level detailed collaborative case studies and stakeholder scenarios for peri-urban development pressures, planning and governance systems – are combined with the development of quantitative land use scenarios, for the assessment of peri-urban land use relationships and sustainability impacts, both from regional policies and external driving forces.

End-Products

As its main end-products PLUREL will provide information and tools for analysis of peri-urban land use relationships and their sustainability. The end-products should provide outlook and inform decision making on peri-urban development at regional, national, and EU level.

The key end-product of the project will be the PLUREL Xplorer – a platform providing structured access to state-of-the-art knowledge on rural-urban land use relationships; and to a range of more interactive tools allowing exploration and analysis of sustainability impacts, land use dynamics, Quality of life effects; as well as access to maps produced in the project.

The web-based and interactive tools will be supplemented by a book and a topical policy brochure for reference and support in policy development for the peri-urban.

International Conference in 2010

In 2010 - last year of the 4 year project – PLUREL will organise an international conference from October 18-21st in Copenhagen. The purpose is to present the status of scientific approaches for assessment of peri-urban land-use relationships and their sustainability effects; as well as setting the agenda for future research in the field. Abstract submissions are welcome until March 1st 2010.

Photo by UFZ in Leipzig, General Project meeting Fall 2007. The PLUREL team consists of 33 research institutions and SMEs from 15 European countries and China; as well as practitioners from 7 case study regions. Well over 100 researchers and practitioners have been working in PLUREL until date.

References:

PLUREL website: www.plurel.net

International Conference, Managing the Urban-Rural Interface www.plurel.net/conference Deadline for abstracts is March 1st 2010.

PLUREL is financed by the European Commissions sixth framework programme for research (EC FP6 036921)
EC FP6 Project CECILIA

Tomas Halenka

E-mail: tomas.halenka@mff.cuni.cz

Charles University, Prague, Department of Meteorology and Environment Protection, Faculty of Mathematics and Physics


Partners
1) Charles University, Czech Republic, 2) The Abdus Salam ICTP, Italy, 3) Météo-France, France, 4) Danish Meteorological Institute, Denmark, 5) Aristotle University of Thessaloniki, Greece, 6) Czech Hydrometeorological Institute, Czech Rep., 7) Institute of Atmospheric Physics, Czech Rep., 8) Swiss Federal Institute of Technology Zurich, Switzerland, 9) University of Natural Resources and Applied Life Sciences, Austria, 10) National Meteorological Administration, Romania, 11) National Institute of Meteorology and Hydrology, Bulgaria, 12) National Institute of Hydrology and Water Management, Romania, 13) Hungarian Meteorological Service, Hungary, 14) Forest Research Institute, Slovakia, 15) Warsaw University of Technology, Poland, 16) Eötvös Loránd University, Hungary

The aim of the CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment) project is to assess the impact of climate change at the regional to local scale for CEE using very high resolution in order to capture the effects of the complex terrain of the region. This goal is achieved using very high resolution RCMs run locally for targeted areas. Changes in weather patterns and extreme events are addressed within the project as they affect the important sectors for the economies and welfare of individual countries in the region. The selected applications of the CECILIA outputs are supposed toward water resources and management, agriculture, forestry, air quality and health.

Key issues
Emphasis is given to application of regional climate modelling studies at a resolution of 10 km for local impact studies in key sectors of the region, with selected domains for simulations committed by the partners as shown in Fig. 2. From the viewpoint of climate change scenario production two periods of time are planned, for 2020-2050 and 2070-2100. This CECILIA high spatial resolution of regional model experiments will feed into investigations of weather extremes in the region. Statistical downscaling methods for verification of the regional model results will be developed and applied, and assessments of their use in localization of model output for impact studies is performed. The objectives will be achieved through the tasks with the overall structure and dependencies within the project presented in Table 1.

Figure 1. Simulation domains of individual targeted regions (partners).

Figure 2. Climate change signal in surface temperature of CUNI A1B simulation at 10km resolution (annual mean) in mid-century time slice (2021-2050, left panel) and end-of-century time slice (2071-2100, right panel), against control run 1991-1990

Figure 3. Climate change signal in number of days with ozone concentration above 120 μg/m3 per year based on CUNI A1B simulation at 10km resolution in mid-century time slice (2041-2050, left panel) and end-of-century time slice (2071-2100, right panel), against control run 1991-2000

Figure 4. Climate change signal in average maxima of ozone concentration based on CUNI A1B simulation at 10km resolution in mid-century time slice (2041-2050, left panel) and end-of-century time slice (2091-2100, right panel), against control run 1991-2000

Results
Example of regional climate change simulations is presented in Fig. 2. These high resolution simulations are at the final stage of the project used as a basis for further localisation effort, final scenarios construction and application in selected impact studies. In Fig. 3 and 4 we present examples of impacts on air-quality, which is of relevance to MEGAPOLI project. Not so substantial changes are seen in the mid-century decade, but end-of-century decade brings quite significant increase of days per year above the limit of 120 μg/m3 in Po Valley region, while the view in terms of average maxima shows the increase in Ruhr and Benelux region as seen in Fig. 4.

Project Info
CECILIA - Central and Eastern Europe Climate Change Impact and Vulnerability Assessment, http://www.cecilia-eu.org
Contract No. 037005, 1.1.6.3.13.3.2 - Climate change impacts in central-eastern Europe, 1 June 2006 – 31 December 2009

Table 1. Organization of individual tasks in workpackages.
Role and contribution

The AUTH/LHTEE role and contribution into the MEGAPOLI project include: coordination and strong involvement in WP4 as well as a significant role in WP2 and WP7. In WP4, AUTH/LHTEE will lead the investigation and testing of advanced physical and chemical parameterisations developed in WP2, and will describe the dispersion, transformation and removal processes of the pollutants across the mesoscale and urban scales. The coupled MEMO/MARS modelling system will also be used to relate meteorological patterns to urban air pollution episodes and to identify and quantify the contribution of the main local emission sources to the urban air quality. In WP2, numerical RANS and LES CFD simulations will be performed by AUTH/LHTEE for the systematic study of small-scale features in the urban canopy and their effect on the air flow, as well as for the description of the urban energy balance. In WP7, simplified approaches will be utilised for the assessment of interactions between megacities and climate change, leading to a hierarchy of models, depending on the detail of input data availability. A number of megacities will then be selected for implementation of the integrated framework, spanning multiple scales, from city to global.

Researchers involved

Nicolas Moussiopoulos
moussio@eng.auth.gr

John Douros
jdouros@aix.meng.auth.gr

Photios Barmpas
fotisb@aix.meng.auth.gr

Lia Fragkou
lia@aix.meng.auth.gr

George Tsegas
gtseg@aix.meng.auth.gr

The Laboratory of Heat Transfer and Environmental Engineering (LHTEE; http://aix.meng.auth.gr/lhtee/) belongs to the Energy Section, Mechanical Engineering Department of the Aristotle University Thessaloniki (AUTH; http://www.auth.gr/home/index_en.html). It has a long record of research and consulting activities, both at national and international level. Most of the research funds of the Laboratory originate from competitive programmes of the European Union. In the last years, the total annual turnover of the Laboratory has been of the order of 1 million €. The Laboratory has significant experience and expertise in meteorological and air quality modelling and air quality assessment. The Laboratory’s research work focuses on the simulation of transport and chemical transformation of pollutants in the atmosphere with the use of advanced air quality models, with main focus on the urban air quality assessment. The Laboratory is also involved in Air Quality Management through the assessment of various measures for reducing air pollution levels, and the analysis of the impact of industrial activities and major public works on air quality. The Laboratory also provides practical support to public authorities and the private sector within this area of activities through the development of integrated environmental assessment tools with the use of informatics technologies. In the frame of its consulting services, LHTEE is also significantly involved in the various activities of EEA’s European Topic Centre on Air and Climate Change.

Figure 1. Numerically predicted TKE field calculated for a densely built urban area.

Figure 2. Modelled PM$_{10}$ concentrations ($\mu g/m^3$) during an air pollution episode in Thessaloniki, Greece.
CNRS-GAME (http://www.cnrm.meteo.fr/present/cahier.htm) - the Groupe d'étude de l'Atmosphère Météorologique (GAME) is a joint research unit of the CNRS and the Centre National de Recherches Météorologiques (CNRM) of Meteo-France. The laboratory activities cover six main research topics including water cycle (processes, modelling, and assimilation), climate and climate change, ocean-atmosphere exchange, physics and chemistry of the atmosphere, urban meteorology, modelling and instrumental development.

The main objectives of CNRM are:
• making weather forecast more reliable and finer, in particular regarding early warning of high impact weather, and enriching weather forecast with an evaluation of its uncertainty and an assessment of the impacts to be expected;
• improving the performance of our Earth System model to reduce uncertainties on global and regional climate projections in order to deliver the knowledge which is necessary to mitigate climate change and to identify the best strategies for the adaptation of the territories.

One of the major areas of activity of CNRM-GAME concerns cloud and aerosol microphysics, the impact of aerosol on climate and health, the development of new airborne instrumentation, processing methods, parameterization of aerosol and cloud microphysics in multidimensional models, and of their effects for radiative transfer and precipitation formation.

CNRM has contributed to a number of EU projects within FP5-FP7 and is present in steering committees of several national, European and international programmes. CNRM is presently coordinating the EUFAR FP6 integrated infrastructure initiative aiming at integrating the activities of the European fleet of instrumented aircrafts in the field of environmental research.

Role and contribution
The CNRS-LGGE role and contribution into the MEGAPOLI project include airborne aerosol measurements in WP3 (chemistry). We were also part of the ground measurements at LHVP and SIRTA, in collaboration with people from LCP-Marseille (lead : Nicolas Marchand) (http://www.univ-provence.fr/lcp-ira) and LCME-Chambéry (lead: JL Besombes) (www.lcme.univ-savoie.fr).

Researches involved
Nicolas Marchand
nicolas.marchand@univ-provence.fr
Jean-Luc Jaffrezo
jaffrezo@ujf-grenoble.fr
Thierry Bourrianne
thierry.bourrianne@meteo.fr
Julie Cozic
julie.cozic@ujf-grenoble.fr
Laurent Gomes
laurent.gomes@meteo.fr
Jean-Michel Etcheberry
jean-michel.etcheberry@meteo.fr
Benjamin Aouizerats
benjamin.aouizerats@cnrm.meteo.fr
Benjamin Aouizerats
benjamin.aouizerats@cnrm.meteo.fr
The Abdus Salam International Centre for Theoretical Physics, ICTP (http://www.ictp.trieste.it/) has been founded in 1964 by Abdus Salam (Nobel Laureate). The ICTP operates under the aegis of UNESCO (United Nations Organization for Education, Science and Culture) and is regulated by a three-party agreement between UNESCO, the IAEA (International Atomic Energy Agency) and the Government of Italy, which provides the major part of the Centre's funding. The main mission of the ICTP is to foster the growth of advanced studies and research in physical and mathematical sciences, with particular emphasis on the developing countries. ICTP acts as an international forum for scientific contacts between scientists from all countries. It provides facilities to conduct original research for its visitors, associates and fellows and to organize schools, workshops and conferences (approximately 60 per year). On average, ICTP welcomes 3600 scientists a year. Over 50% of the scientists who have attended the ICTP activities since 1964 came from developing countries; until now, 150 nations and 45 international organizations have been represented. The main research fields of interest at ICTP are: Mathematics, Physics of Condensed Matter, Physics of High and Intermediate Energies, Earth System Physics, Physics of the Living State, Digital Communications and Computer Networking.

The Physics of Weather and Climate group was established in 1998 and then it was enlarged and became the Earth System Physics section (ESP) in 2005. It conducts research and educational activities on regional and global climate modelling, anthropogenic climate change, natural climate variability, predictability at seasonal to interannual and interdecadal scales, chemistry-climate interactions, biosphere-atmosphere interactions, seismology, physics of the lithosphere, earthquake prediction. The ESP maintains and develops a state-of-the-art regional climate model (RegCM). This model was developed and upgraded during the last two decades and has been used for a wide variety of applications, including paleo climate, land-atmosphere feedbacks, chemistry-climate interactions, air sea interactions, and future climate simulations at the regional scale. The RegM has been applied to most land regions in the globe (Europe and Mediterranean Basin, US, Africa, Central, East and South Asia, Central and South America) and has been run at horizontal grid intervals of 10-100 km. It has capability of interactive coupling to an aerosol model, different chemistry modules, a one dimensional lake model, a three dimensional ocean model (the MIT GCM) a dynamical vegetation scheme (CLM) and a biogenic emission module (MEGAN). The RegCM is currently used by a large community of users, including many from developing countries. They form the Regional Climate Research Network (RegCNET, Fig. 1), a community of scientists worldwide that regularly interacts through email and workshops. The ESP organizes 8-10 workshops and conferences per year on Earth Sciences, both at ICTP and abroad. It also organizes a one year diploma program in Earth System Physics.

It currently participates in EU projects (ENSEMBLES, CECILIA, WATCH, ACOWA), international projects (PIRCS, NARCCAP, CORDEX) and projects within the Italian National Climate Research Program (CMCC). The ESP has access to the supercomputing facilities of CINECA.

**Role and contribution**

The ICTP role and contribution into the MEGAPOLI project include the use RegCM3 (Regional Climate Model Version 3) both in uncoupled and coupled (with aerosol module) mode. The top-of-atmosphere radiative direct and indirect forcings and related climatic effects induced by megacity emissions will be calculated both off-line and on-line by RegCM3. The analysis of climate effects will include variables such as temperature, clouds, precipitation, circulation and the surface hydrological cycle, as well as radiation-aerosol interactions and cloud-aerosol interactions. The regional model simulations will focus on the European region and one extra-European domain, either Asia or Central America. Sets of regional simulations are planned, each of 10 to 20 years in length for present day and future climate conditions. The simulation period will include the special observing period planned in WP5. Each set will include three simulations, one without aerosol effects (control run), and the others including aerosol effects in uncoupled and coupled mode. Lateral chemical boundary conditions will be obtained from corresponding global model simulations (WP5 and WP6).

**Researchers involved**

Filippo Giorgi

giorgi@ictp.trieste.it

Ashraf Zakey

azakey@ictp.it

Ahmed Shalaby

ashalaby@ictp.it
Aerosol Index for July 2001

Recent research work (funded by NERC/NCAS) concerns the use of WRF and CMAQ to understand the dynamical processes affecting exchange of air pollutants between urban canopy and the free tropospheric. Detailed evaluation of the performance characteristics of the models is assisting the Environmental Agency to make an informed decision on how complex models can be employed for regulatory applications. Outcome of this work is also relevant for the wider decision-making and policy formulation process related to air quality and health impact and European sustainable development action plans and strategies.

Role and contribution
The UH-CAIR role and contribution into the MEGAPOLI project include: (i) Integration of UK higher resolution emissions inventories into regional emission inventory and the influence of up-scaling of megacity emission to regional/global scales; (ii) Use of WRF with CMAQ to improve the treatment of downscaling processes for megacities from regional to urban scales and finer and evaluate their local to regional air quality impact; (iii) Application and demonstration of prototype modelling system for case studies and scenarios evaluation focusing on London and Paris megacities and (iv) Synthesising the main project outcomes to develop a framework for integrating models for the purpose of quantifying the impacts on and of megacities over regional to global scales.

Researches involved

- Ranjeet Sokhi
  r.s.sokhi@herts.ac.uk
- Charles Chemel
  c.chemel@herts.ac.uk
- Xavier Francis
  x.francis@herts.ac.uk
- Rong-Ming Hu
  r.hu@herts.ac.uk

CAIR expertise include: Modelling of weather and air quality, Satellite remote sensing and multi-scale modelling, characterisation and source apportionment of air pollutants, air quality science for health and policy, and megacities and trends in air quality. A special emphasis is being placed on the dynamical, physical and chemical processes that affect air quality on scales ranging from global down to turbulence scales. Nationally CAIR coordinates the UK’s mesoscale modelling network MESOMAQ which is an activity under the NCAS/Weather Directorate. It is also running other national projects including MESO-NET (funded by NERC) and CREMO (funded by the Environment Agency within the UK) both of which focus on modelling air quality on multiple scales.
The Department of Physics, Division of Atmospheric Sciences at the University of Helsinki (UHel; http://www.helsinki.fi/university/) has over 25 years tradition in atmospheric research. 80 scientists and doctoral students are currently engaged in this area. The main research subjects are aerosol dynamics (nucleation, condensation, coagulation, and deposition), formation and growth of atmospheric aerosol particles and cloud droplets, atmospheric chemistry, urban aerosols, forest-atmosphere interactions (fluxes, photosynthesis, water transport), aerosol-cloud-climate interactions, atmospheric boundary-layer theory, modelling and parameterization and satellite remote sensing. The basic theoretical resources consist of detailed computer codes describing basic phenomena such as multi-component nucleation and condensation, photosynthesis, and extensive models for aerosol dynamics, atmospheric chemistry and cloud microphysics.

The basic experimental resources consist of three field stations (SMEAR: I, II, III) and a state-of-art aerosol laboratory. In the field stations e.g. aerosol dynamics, atmospheric chemistry, micrometeorology, gas exchange between forest and atmosphere, soil chemistry and forest growth are measured continuously.

The Division (http://www.atm.helsinki.fi/) focuses on:

- Atmospheric aerosols: climate change and health effects
- Micrometeorology: interactions between ecosystem and the atmosphere, carbon sinks
- Meteorological modelling: climate research, development of weather forecast models, Martian gas sphere
- Weather radar - development of radar measurements

The scientists of the Division participate in international research projects such as:

- EUCAARI (European Integrated project on Aerosol Cloud Climate and Air Quality Interactions)
- iLEAPS (Integrated Land Ecosystem - Atmosphere Processes Study)
- CBACCI (Biosphere-Carbon-Aerosol-Cloud-Climate Interactions)
- PBL (Planetary-Boundary-Layer)
- ABS (Atmosphere-Biosphere-Studies Nordic Master Programme)
- Finnish Centre of Excellence (Physics, Chemistry, Biology and Meteorology of Atmospheric Composition and Climate Change)
- ICOS (Integrated Carbon Observation System)
- EUSAAR (European Supersites for Atmospheric Aerosol Research)
- IMECC (Infrastructure for Measurements of the European Carbon Cycle)
- GEOnom (Global Earth Observation and Monitoring)

**Role and Contribution**

The role and contribution of the University of Helsinki in the MEGAPOLI project include: responsibility for the aerosol science aspects including aerosol-climate interaction, ground based observations and remote sensing, and development of improved parameterization of the turbulent and mean structures of urban atmospheric boundary layers (UABLs) for use in climate and air quality models. Contribution also includes using eco-indications in MEGAPOLI: to update the concept of water eco-indices; to participate in elaboration of characteristics combining in integral indexes (Environmental Quality Indexes) for the system air-water.

**Researches Involved**

Markku Kulmala
markku.kulmala@helsinki.fi

Sergej Zilitinkevich
sergej.zilitinkevich@fmi.fi

Gerrit de Leeuw
gerrit.leeuw@fmi.fi

Michael Boy
michael.boy@helsinki.fi

Pasi Aalto
pasi.p.alto@helsinki.fi

Iryna Bashmakova
iryna.bashmakova@helsinki.fi
Charles University (CUNI) founded in 1348 is one of the oldest universities in Europe and nowadays belongs to the most eminent educational and scientific establishments in the Czech Republic. CUNI now contains 17 faculties, 3 collegiate institutes, 6 additional establishments for educational, scientific, research and developmental activities and other creative activities and for information service, 5 university-wide facilities and the vice-chancellor’s/ rector’s office as an executive establishment for Charles University management. There are more than 7000 University employees, 4000 of them are academic and research workers. Over 42,400 students study at CUNI (approximately one fifth of all the students in the Czech Republic) in more than 270 accredited academic programs with 600 departments. 7200 students are studying for bachelor’s degrees, 29,000 students are studying for master’s degrees, and over 6200 students are in PhD programs. There are more than 4300 foreign students—750 of which study in English language academic programs. CUNI is an accredited public university, it is an autonomous scientific and educational establishment. The rector is head of CUNI; the Academic Senate is the supreme self-regulating academic organ. The deans are heads of faculties which are independent to a large extent. CUNI aims to be recognized as a competitive research university on the world stage. The scope of CUNI can be characterized also by its income amount which is cca 5 billion Czech crowns per year. 41% of this amount comes from educational funding, 27% from competitive research grants, and 26% is its own income.

The Department of Meteorology and Environment Protection (located in building Troja, see below) is a part of the Faculty of Mathematics and Physics of Charles University in Prague. The department provides training of students in subject field of meteorology and climatology in all degree programmes - bachelor, master and doctorate. In addition to training of experts in the field of atmospheric physics, the department contributes significantly to research focused on the weather, climate system or urban pollution.

The graduates of Department have a wide knowledge of basic physics, especially physics of the atmosphere, and essential mathematical methods. They are able to deal with tasks in both basic and applied research or in wide meteorological practice (e.g., weather service). In particular, their knowledge consists of atmospheric dynamics, energetics and circulation and it can be used especially in numerical weather prediction, modelling of air-pollution transport, dispersion and transformation of air-pollution, modelling of climate, climate changes and anthropogenic impact on it. Alumni have a good knowledge of atmospheric optics, acoustics and electricity which allows them to participate in many technical applications, both research and operational ones.

**CUNI Team**

The team from the Department of Meteorology and Environment Protection (http://kmop.mff.cuni.cz/en/main) of the Charles University (CUNI; http://www.cuni.cz/UKENG-1.html) in Prague, have expertise in a range of climate-related research topics including regional climate modelling and statistical evaluation of the reliability, sensitivity and uncertainty of model results comparing both with gridded climatology and station data. One of the main experiences of the team is in air-quality studies as well, mainly working on air-pollution modelling. Recently, mainly for EC FP6 IP QUANTIFY and EC FP6 STREP CECILIA, CTM CAMx has been coupled to RegCM model used for regional climate simulations and studies on interactions of chemistry and climate in high resolution on regional scale. CUNI has participated and coordinated in several EU, international and national projects, respectively. In addition, it has provided numerous consultations to local and national governmental authorities and Organizations in its field of expertise. In relation to the MEGAPOLI project mainly participation in FP6 projects ENSEMBLES, QUANTIFY and coordination of project CECILIA could contribute to the progress in the envisaged studies.

**Role and contribution**

The CUNI role and contribution into the MEGAPOLI project include: participating in WP6, CUNI will share the expertise in regional climate modelling in high resolution, impact of land use changes as well as the skill with coupling of air-quality CTM model to the regional climate model.

**Researchers Involved**

**Tomas Halenka**, doc.RNDr. CSc., (Associate Professor, Deputy Head of the Department). Experience and expertise in numerical modeling of the atmosphere, regional climate modelling, air quality modelling in local and regional scales, ozone, reading lectures on NWP, Dynamic Meteorology and others topics, supervisor of many diploma and doctoral student. Participation and coordination in several EU, international and national projects, coordinator of EC FP6 project CECILIA, participating in project FP6 EC ENSEMBLES, QUANTIFY, FP5 EC SOLICE. President of the Czech Meteorological Society, Vice-President and Treasurer of European Meteorological Society (2005-2007), Chairman of educational committee of EMS.

*tomas.halenka@mff.cuni.cz*
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:


See more MEGAPOLI Publications/ Presentations at [http://megapoli.info](http://megapoli.info)

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present the MEGAPOLI Project results and findings:

- WMO, COST-728, MEGAPOLI End-user Workshop
  Geneva, Switzerland, 24-26 Feb 2010
  Contact Liisa Jalkanen (WMO Team), Ljalkanen@wmo.int
- European Geosciences Union General Assembly (EGU-2010)
  Vienna, Austria, 2-7 May 2010
  [special MEGAPOLI, CityZen, MILAGRO session](http://meetings.copernicus.org/egu2010/)
- 13th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes; Paris, France, 1-4 June 2010
  [http://www.harmo.org/harmo13](http://www.harmo.org/harmo13)
- International Aerosol Conference
  Helsinki, Finland, 29 Aug – 3 Sep 2010
- 10th European Meteorological Society (EMS-2010) Annual Meeting and 8th European Conference on Applied Climatology (ECAC)
  Zurich, Switzerland, 13-17 Sep 2010
  [special MEGAPOLI session](http://meetings.copernicus.org/ems2010/)

IMPORTANT NOTICE

If you do not wish to receive this newsletter, send an e-mail to the following address - news.megapoli@dmi.dk - and you will be removed from the mailing list.

We apologise for any inconvenience caused.
Welcome to the 6th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 6th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – MEGAPOLI Paris Campaign Measurements Workshop (Paris, France, end May 2010)
- Coming soon – special MEGAPOLI, CityZen, MILAGRO session & joint meeting at European Geosciences Union General Assembly, EGU-2010 (Vienna, Austria, 2-7 May 2010)
- Coming soon – 4th MEGAPOLI WP Leaders telephone conference (27 Apr 2010)
- Mar 2010 – MEGAPOLI Mid-Term Assessment reporting has started
- 24-26 Feb 2010 – International Workshop "Mesoscale modelling for air pollution applications - achievements and challenges" (Geneva, Switzerland)
- 17 Feb 2010 – 3rd MEGAPOLI WP Leaders telephone conference

MEGAPOLI Paris Winter 2010 Measurement Campaign

See details on the next pages

LHVP Urban Site

SIRTA Suburban Site

AirField SAFIRE Site
WP3: Paris Winter 2010 Measurement Campaign

PhD Students are very busy ... as always

Instrumentation for measurement

PSI and IFT Teams at SIRTA Site

Early morning telephone conference and up-date

PSI and FORTH Teams at SIRTA Site

CNRS-LISA Team at SIRTA Site

Not always we are lucky ... Snowing

Laboratory chemical analysis

Running models

and analysing pollution from Paris agglomeration
Partners and Collaborators at LHVP Urban Site in Paris

VIP-instrument

Ideas are coming in a different way

SAFIRE Team / Piper Aztec Aircraft

LSCE, IIT, and UCC Teams at LHVP Site

Winter campaign weekly research seminars
MEGAPOLI Winter 2010 Paris Campaign

Matthias Beekmann
E-mail: beekmann@lisa.univ-paris12.fr
Laboratory Inter-universitaire des Systèmes Atmosphériques (LISA), Centre National de Recherche Scientifique (CNRS)

M. Beekmann (1), U. Baltensperger (2), A. Borbon (1), J. Sciare, V. Gros (3), and the MEGAPOLI Paris- campaign team (4)

(1) Laboratoire Inter-universitaire des Systèmes Atmosphériques (LISA), Université Paris Est et 7, CNRS, Créteil, France, (2) Paul Scherrer Institut, Villigen, Switzerland, (3) Laboratoire des Sciences du Climat et de l’Environnement (LSCE), Gif sur Yvette, France, the MEGAPOLI Paris-campaign team : L. Gomes, P. Tulet (Game-CNRM), A. Wiedensohler A. Held, W. Birmli (IfT), P. Lavé, K. Sellegri, A. Schwarzenbock (LaMP), J.L. Jaffrezo (LGGE), A. Colomb, I. Coll, F. Doussin, H. MacLeod, Q. Zhang *(LSCE), P. Chazette (LSCE), S. Birmeli (MPIC), P. DiCarlo, A. Prevot, E. Weingartner. (PSI), M. Kulmala, (Univ. Helsinki), S. Pandis (Univ. Patras), Ph. Lameloise, O. Sanchez, A. Kaufman, H. Marfaing, V. Gherbi, C. Honoré (AIRPARIF), S. Kukui, F. Ravetta (LAMOS), Y. Le Mouel (LHVP), M. Hasefein (LMD), * also ARPA-Technologie.

The intensive (MEGAPOLI WP3 – Paris Plume Study; http://megapoli.lisa.univ-paris12.fr/) measurement campaign had continued in the Paris region starting 15 Jan until 15 February 2010. In total 25 research teams/ institutions have participated with involvement of more than 50 researchers from different countries. The general objective of the campaign is related to better quantification of primary and secondary aerosol sources in a large metropolitan area, such as Paris agglomeration, and their interactions and distribution in the plume. A specific objective was on building-up of secondary organic aerosol and its relations to precursor gases.

A ground segment of observations at an urban (Laboratoire de l’Hygiéne de la Ville de Paris, LHVP) and two suburban sites at IPSL/SIRTA-Ecole Polytechnique (Palaideau) and Golf de la Poudrérie (Livry Gargan) during winter could allowing to study aerosol’s composition and their properties, spatial and temporal variability, near primary emission sources, and likewise in air masses passing through the Paris agglomeration (Figure 1).

Figure 1. Location of primary (fully equipped) urban (LHVP) and suburban (SIRTA) measurement sites for the campaign; secondary sites (at Jissieu and Créteil) - spectroscopic and lidar measurements; mobile vans - in-situ aerosol measurements; MAXDOAS and aerosol lidar measurements.

An airborne segment of observations (dedicated flights with the French Piper Aztec aircraft through and around the Paris plume during winter allow studying an evolution of the megacity related plume (Figure 2). Flights are performed at about 300 m altitude; at first, a circular flight at 11.30h LT, and then a flight into the plume sector at 14h LT.

A mobile segment of observations (1 and 2 vans from PSI and MPIC teams, respectively) allows studying aerosol and gas phase characterisation at various locations (by driving radial/along within plume sector, measurements at fixed positions, upwind of the agglomeration).

Aerosol backscatter measurements at 6 fixed locations within the agglomeration allow studying vertical distribution of aerosols and spatio-temporal variations of the boundary layer height. Meteorological and dynamical parameters measurements (wind, temperature, turbulence) were also performed at the suburban IPSL/SIRTA site.

A very large suite of state of the art instruments was used during the campaign, which allowed for fast measurement of aerosol chemical composition and phyisico-chemical properties, and of related precursor gas concentrations. Combined airborne and ground based measurements of the chemical SOA composition and of (oxidised) VOC offered an opportunity to study gas phase aerosol interaction at various stages of the aging of polluted air masses. The modification of optical and hygroscopic parameters during plume evolution and aging could be addressed.

Daily campaign planning for measurements (for ground, mobile, airborne) for the upcoming days was done in advance on early morning and included:

- 07.30h – starting telephone conference among parties involved (airborne and mobile; if needed – ground based);
- 08.00h – up-date of plans for the Piper Aztec aircraft;
- 08.30h – up-date of plans for mobile (MPIC + PSI) measurements;
- 09.00h– up-date/alert of winter campaign news (weather and pollution forecasts for the next 3+ days);
- contacts/ visits with/of working teams during the day;
- 19.00h – up-date of plans for mobile (MPIC + PSI) measurements for the next day;
- 20.00h – drafting for the next morning up-date/alert of winter campaign news.

Forecasting of meteorological conditions (air temperature, winds characteristics, cloudiness, precipitation type and their patterns, possibility of slippery road conditions, etc.) had been done using input from METEO-FRANCE; METEOCIEL (GSF, multimodel); Laboratoire de Météorologie (Paris Île de France); weather forecasts from several models with focus on expert maps, including ensemble forecast, frontal analysis; cloud animation /visible and infrared/; radar real time precipitation.

Forecast of chemical conditions (first of all, surface concentration fields of PM2.5 and POA) had been done using input from PREVAIR; AIRPARIF; Laboratoire de Météorologie Dynamique.

Moreover, every Wednesday research seminar among the campaign participants was organized with presentations and discussions on status of on-going measurements, experienced problems, etc.

During the winter campaign, particulate matter levels were much larger than during summer, reaching up and beyond 100 µg/m 3 PM2.5 at several occasions. Both local sources with a major OC fraction, and continental sources with a large nitrate fraction, contributed to these levels. A surprise was the major contribution of wood burning to local OC.

It is important to note that data obtained from both summer and winter Paris campaigns will allow a detailed assessment (on example of this long-term case study) to study on how megacity emissions could impact on air quality, atmospheric composition at regional scale, and influence on regional climate. Such data are also valuable contribution for in depth evaluation of models and their improvement.
Programme of Measurements at SIRTA Suburban Site in MEGAPOLI Winter Campaign

During summer (Jul 2009) and winter (Jan-Feb 2010) MEGAPOLI campaigns the Site Instrumental de Recherche par Télédétection Atmosphérique (SIRTA) (http://sirta.ipsl.polytechnique.fr/) - provided support to several participants in order to deploy many equipments and instruments to monitor suburban pollution over the site.

SIRTA Hosting

The SIRTA team, lead by Dr. M. Haeffelin (Fig. 1), involved 8 people during the winter campaign. The SIRTA team was quite busy at the campaign setup to get all teams powered up, and to establish comfortable work spaces for everybody. The SIRTA team took also care that all participants were able to work in safe conditions, and observed necessary safety rules. For the purpose of MEGAPOLI, the team operated a backscatter UV lidar (owned by LMD) to monitor the mixing layer depth and aerosol layers aloft, a Doppler wind lidar (owned by CEREA) to measure the vertical profile of wind speed and direction between ground and 200m height (Fig. 2). In addition, the team is in charge on a continuous basis of operating about 40 different sensors to monitor cloud properties, surface radiation and heat balance, dynamics and turbulence in the surface layer, and basic meteorological instruments. The SIRTA team made a report every morning to the campaign PIs about the observed meteorological conditions in the column above the site (wind profile, mixing layer height).

PSI Team

The PSI team (Fig. 3) in total involved 15 people who monitored chemical and microphysical properties of aerosol along with some gas phase species. Aerosols were sampled from the PSI trailer at SIRTA and using the PSI mobile van. The stationary measurements (Fig. 4, 5) included in detail: Aerosol chemical composition [Aerosol Mass Spectrometer, Rotating Drum Impactor]; black carbon properties [Aethalometer, Single Particle Soot Photometer]; size distribution [Scanning Mobility Particle Sizer, Aerosol Particle Sizer]; optical properties [Nephelometer, Aethalometer]; volatility, hygroscopicity and cloud condensation nuclei number [Volatility/Hygroscopicity Tandem Differential Mobility Analyzer; Cloud Condensation Nuclei Counter].
FORTH Team

The FORTH team performed continuous measurements of the volatility of organic aerosol and aerosol size distribution measurements. The system, located in the PSI trailer at SIRTA (Fig. 6), consisted of a variable residence time thermodenuder combined with a Scanning Mobility Particle Sizer and the PSI Aerosol Mass Spectrometer.

CNRS Team

The team contribution is similar to programme of aerosol measurements performed at the urban LHVP site.

CNRS-LISA Team

During MEGAPOLI winter campaign, the CNRS-LISA team (Fig. 7; including C. Afif., W. Ait-Helal J. Bechara, A. Borbon, A. Colomb, V. Michoud, K. Miet, S. Perrier) was responsible for trace gases measurements on its fixed platform MILEAGE. Target trace gases are air quality regulated pollutants (CO, ozone, NOx) and other photochemical species: NOy (sum of total reactive nitrogen incl. speciated HONO and PAN) and a large set of VOCs. Measurements consist in on-line and off-line techniques. Collected samples are transferred and analyzed at the laboratory at Lisa and Ecole des Mines de Douai) by various chromatographic techniques (HPCL UV, GC-FID and GC-MS). Additional measurements include frequency photolysis measurements (JNO2 sensor and Licor 1800 spectroradiometer and meteorological data (pressure, wind speed and direction, temperature, RH). During her PhD, Warda Aït-Helal (Fig. 8-left) will identify and quantify factors (emission and chemistry) controlling the spatial and temporal evolution of primary and secondary gaseous organic carbon within megacities plume and its impact on Secondary Organic Aerosol formation. Her work begins with measurements collected during the two MEGAPOLI campaigns. During MEGAPOLI campaigns, Warda was in charge of several ground-based instruments dedicated to VOC measurements. Thus, two on-line GC-FID provide complementary on-line measurements of hydrocarbons C2-C9) at hourly frequency. Besides, off-line instruments complete the VOC measuring range. While AMOVOC traps airborne formaldehyde into a DNPH solution at hourly frequency, an automatic sampling system (SASS-Tera Environnement) catches every 3 hours oxygenated carbonyl VOC onto DNPH cartridges (C1-C6) and heavy hydrocarbons (C6-C16: BTEX, alkanes, aldehydes, terpenes) onto cartridges coated with activated charcoal. Then collected samples are analyzed with various chromatographs (HPLC or GC-FID). Finally, the large database obtained will be used in a statistical model, in order to predict evolution and fate of gaseous VOC whether in the gas phase or and their interaction with the particulate one.

Figure 6 : FORTH Team – Evangelia Kostendidou – measurements and analysis of volatility of organic aerosol and aerosol size distribution.

Figure 7 : Members of the LISA Team – (Front L->R: Matthias Beekmann, Sebastien Perrier, Agnes Borbon; Back – see Fig. 8).

Figure 8 : LISA PhD students (Warda Ait-Helal, Vincent Michoud).
SIRTA (http://www.sirta.fr/) stands for Site Instrumental de Recherche par Télédétection Atmosphérique. It is a French national atmospheric observatory dedicated to cloud and aerosol research. SIRTA is located in Palaiseau (49°N, 2°E), 20 km south of Paris (France) in a semi-urban environment (Fig. 1).

The observatory gathers and operates a suite of state-of-the-art active and passive remote sensing instruments from a large community to document and monitor an ensemble of radiative and dynamic processes in the atmosphere. The detailed description of the state of the atmospheric column is archived and made accessible to the scientific community. The primary applications are to improve our understanding of atmospheric processes, to test the performance of atmospheric models, and to develop new remote sensing methods for future space-borne observations.

SIRTA is an observatory of Institut Pierre Simon Laplace (IPSL), a French research institute in environmental sciences. It is hosted by École Polytechnique and supported by Institut National des Sciences de l’Univers (INSU/CNRS), Centre National d’Etudes Spatiales (CNES), and Météo-France.

**Infrastructure**

The SIRTA infrastructure is composed of four zones (Fig. 2) located on the campus of Ecole Polytechnique. Zone 1 is a 1000 m² concrete surrounded by land equipped with a 30 m pylone. Zone 2 is a roof platform with direct link to the lab, acquisition room. Zone 3 is a 15 m wooden tower. Zone 4 is land area equipped with a 30 m pylone. All zones have power and network for easy instrumental deployment. On top of the permanent instruments, SIRTA regularly hosts national and international field experiments (e.g. ParisFog 2006-2007 http://parisfog.sirta.fr; MEGAPOLI 2009-2010).

**Role and Contribution**

The SIRTA contributed to the MEGAPOLI project by hosting nearly 100 sensors or instruments from CMU/Forth, LCP/LGGE, LISA, LSCE, INERIS, Météo-France, PSI and U. Duisburg to monitor suburban pollution South-West of Paris during the summer 2009 (Fig. 3) and winter 2010 campaigns. SIRTA also provided physical measurements of the state of the atmosphere, with, among other parameters, vertical profiles of wind speed and direction (by Sodar and Lidar – CEREA), monitoring of the mixing layer depth and aerosol vertical distribution (by Lidar – LMD). These measurements were used every day of the campaign at the morning briefing to validate the main wind direction in the first 500m of the boundary layer and to follow the depth of the mixing layer, two key parameters to plan the deployment of the airplane and mobile vans.

SIRTA also hosted mobile van intercomparison experiments in summer and winter.

SIRTA staff involved in 2009/2010 campaigns were:
- Mahdi Belaid, Christophe Boitel,
- Jean-Charles Dupont, Ludmila Klenov,
- Florian Lapouge, Yohann Morille,
- Christophe Pietras, and Bernard Romand.

The SIRTA team will provide support to MEGAPOLI researchers in two main areas: the analysis of mixing layer estimation and analysis of atmospheric dynamics (wind and turbulence).
Programme of Measurements at LHVP
Urban Site in MEGAPOLI Winter Campaign

During summer (Jul 2009) and winter (Jan-Feb 2010) MEGAPOLI campaigns the Laboratoire d’Hygiène de la Ville de Paris (LHVP; http://www-address/) – provided support to many participants (Fig. 2) in order to deploy many equipments and instruments to monitor urban pollution over the site. Among described here contributions from different research teams involved into measurement programme at the LHVP site, the CNRS-LSCE and –LISA teams are also planning to contribute to the next newsletter.

LHVP Hosting
The Laboratoire d’Hygiène de la Ville de Paris (LHVP; Fig. 1) is a municipality service whose mission is to study the quality of the urban environment. It focuses on air quality of outdoor and indoor microenvironments regularly frequented by Parisians such as residential buildings, schools, day-care centers, swimming pools, offices or transportation modes. With the collected data, LHVP assesses the exposure of city residents to chemical, physical and microbiological contaminants. LHVP also works in partnership with epidemiologists on research relating to environmental health impacts.

University College Cork (UCC) Team
The UCC team (Fig. 3) has deployed an aerosol time-of-flight mass spectrometer (ATOFMS, TSI Model 3800) to measure the size and chemical composition of single particles in the size range 100-3000 nm (aerodynamic diameter). The instrument uses 2 sizing lasers to measure aerodynamic diameter, a desorption/ionisation laser to ionise particle-bound species, and 2 collinear time of flight mass spectrometers to measure the resulting positive and negative ions. The instrument provides useful data on the internal and external mixing state of ambient airborne particles. The core composition of single particles, for example elemental/organic carbon and transition metals, as well as secondary species such as nitrate and sulfate can be determined. This information is particularly useful when combined with meteorological data to identify local and regional sources of PM2.5. The ATOFMS sampled continuously for 4 weeks and over 1,700,000 single particle mass spectra were successfully collected. These spectra will now be analysed using the K-means algorithm in order to identify the various particle types or “classes”. Comparisons with other on-line and off-line measurements of PM2.5 composition will also be very interesting, and will hopefully help to resolve the various local and regional sources of PM2.5 impacting air quality at the site.
The Leibniz Institute for Tropospheric Research (IFT Team) is the member of the MEGAPOLI WP3. Our measurements took place in a container (Fig. 4) located in the garden of the LHVP. The container was deployed during the summer 2009 and winter 2010 campaigns. Measurements were focused on the particle characterisation using high-end scientific instruments in order to study:

(i) physical aerosol properties using an Aerodynamic Sizer (APS) and Tandem Differential Mobility Analyser (TDMPS) for particle number size distributions from 3 nm to 10 µm, and a Humidifying Differential Mobility Particle Sizer (HDMPS) for the hygroscopic growth of the particles;

(ii) optical properties using a nephelometer and an absorption photometer to measure the particle light scattering and absorption coefficients, respectively; and

(iii) particle chemical composition using a High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS) for the non-refractory PM$_1$.

Figure 5 shows first preliminary results (time-series of particle size distribution and chemical composition) obtained during the winter campaign. The quick-looks at results of the campaign are very promising and obtained data will be analysed in the coming months.

The main implication of our groups (Fig. 6) in the framework of the MEGAPOLI project is to characterize deeply the chemistry of PM (PM$_{2.5}$, 12h) at both LHVP and SIRTA sites. About one hundred of organic compounds (including Levoglucosan and isomers, hopanes, PAH, n-alkanes, tetrols.) and 40 metals will be analysed as well as major ions, EC/OC, HULIS and $^{14}$C in order to provide source apportionment of PM. PTRMS measurements are also performed at LHVP (40 m/z in the SIM mode, temp. resol. 2.5 min) with the aim to better understand the links between gas and particulate phases.

Figure 7 shows the strong correlation between PTRMS m/z 33 (MeOH) and preliminary Biomass Burning Organic Aerosol (BBOA) factor derived from AMS measurements (IFT Team). Fragments occurring in the drift tube of the PTRMS have to be checked carefully, but such correlations suggest residential wood burning as a major source of MeOH in urban atmosphere during winter.
The LSCE team (Fig. 8) has deployed different on-line analysers to characterize the chemical composition of the PM2.5 aerosol (including an aethalometer for black carbon, a SUNSET instrument for EC/OC, a PILS-IC for ions, a PILS-TOC for water soluble organic carbon) along with instruments characterizing the aerosol mass (TEOM-FDMS) and size distribution (GRIMM instrument). A detailed gas-phase instrument set-up was also deployed by LSCE to characterize ozone, nitrogen oxides, carbomonoxyde, speciated non-methane hydrocarbons and OH total reactivity. All these instruments will allow a fine characterization of the different regional and trans-frontier pollution events observed during the winter campaign (Fig. 9 and 10).

Major compounds are dichloromethane (1.60 ppb), benzene (0.35 ppb), toluene (0.88 ppb), acetaldehyde (2.47 ppb), ETBE (0.21 ppb), acetone (1.47 ppb), ethanol (8.68 ppb), isopropanol (0.41 ppb), butanol (0.26 ppb). Representative profiles of these compounds are shown in Fig. 11 from January 13th to 21st. Upper profiles show the strong correlation between toluene/benzene and CO, indicator of primary anthropogenic origin (combustion source). Some OVOC incl. acetaldehyde, ETBE, isopropanol and ethanol have similar profiles indicating their primary anthropogenic origin related to human activities rush. Others show distinct profiles such as acetone, hexanal (anticorrelated to toluene), isobutanol/ butanol and dichloromethane due to different lifetime (contribution of background pollution vs local pollution) and/or other additional primary and secondary sources. This will be further investigated. During this period, most of air masses originate from western (oceanic) and southern sectors. Profiles are expected to reflect regional pollution contribution.
Lidar and Spectroscopic Measurements during Winter 2010 Paris Campaign

LEOSPHERE – Lidar Environmental Observations

Lolli Simone
E-mail: slolli@leosphere.fr
LEOSPHERE, 76 Rue Monceau, 75008, Paris, France
http://www.leosphere.com

Simone Lolli¹, Patrick Chazette³, Sébastien Conil², Sophie Loaec¹, Martial Haeffelin¹ Michel Ramonet³, Laurent Sauvage¹

¹ LEOSPHERE, 76 Rue Monceau, 75008 Paris, France
²ANDRA1/7, rue Jean Monnet, .Parc de la Croix-Blanche, 92298 Châtenay-Malabry France
³LSCE, Laboratoire des Sciences du Climat et de l’Environnement, Laboratoire mixte CEA-CNRS-UVSQ, CEA Saclay, 91191 Gif-sur-Yvette, France
⁴SIRTA, Ecole Polytechnique, Palaiseau, France

In the frame of Megapoli campaign, four ALS(Aerosol Lidar System) Elastic Lidars produced by Leosphere were deployed in the outskirts of Paris, following the four cardinal points, and a Doppler wind lidar was deployed downtown (Jussieu), in order to monitor and detect the aerosol load and transit (Fig. 1). Als Lidar, operated by Andra, was deployed in MeteoFrance premises, at CDG airport. LSCE Als Lidar was deployed at Inra premises, in the west outskirts of Paris. An Als Lidar operated by Leosphere was deployed in the east part, at ENPC(Ecole Nationale). The south side of Paris was covered by Sirta Als lidar, that run continuously from 2007, being part of several aerosol watch projects.

The data from each instrument are automatically stored and analyzed in quasi-real time in order to retrieve range corrected backscattered power, planetary boundary layer height, backscattering coefficient and aerosol optical depth.

The algorithm produces as first output, the 2D colour plot of the range corrected backscattered signal, that permit a real-time qualitative analysis of the aerosol load measured by the four instruments, as shown in Fig. 2.

Moreover, a Doppler wind lidar was available in Jussieu, in the center of Paris. The lidar outputs are both wind profiles up to Planetary Boundary Layer and Carrier to noise ratio, a quantity proportional to the aerosol load. Some CNR data are displayed in Fig. 3.

In Fig. 3, a Doppler wind lidar was used to monitor the aerosol layer and its transition. The CNR data are displayed for two different days in Jussieu.

Figure 1: ALS Lidar deployed around Paris.

Figure 2: Intercomparison for the 4 als lidar systems deployed in the four cardinal point of Paris.

Figure 3: WLS70 Carrier to noise ratio for two different days in Jussieu.

The data availability near to 100%. These measurements, in synergy with other sensors, permit to track the aerosol layers transiting over Paris, and to identify the local pollution sources.
MOBILIS Platform Measurements at the Creteil Observatory, University Paris 12
LMD – Laboratoire de Météorologie Dynamique
and LISA – Laboratoire Interuniversitaire des Systèmes Atmosphériques

Juan CUESTA
E-mail: cuesta@lmd.polytechnique.fr
LMD/IPSLS-CNRS, Ecole Polytechnique, 91128 Palaiseau, France
http://www.lmd.jussieu.fr

Juan Cuesta1,2, Pascale Chelin3, Patrick Chazette4, Pierre H. Flamant1, Dimitri Edouart1, Laetitia Estevan1, Cyrille Flamant5, Jean-Christophe Raut2, Mokhtar Ray3, Philippe Royer4, Joseph Sanak4, Camille Viatte3 and Matthias Beekmann6

1 LMD/IPSLS-CNRS, Ecole Polytechnique, Palaiseau, France
2 LATMOS/IPSLS, Université Paris 6, Paris, France
3 LISA/IPSLS-CNRS, Université Paris 12, Créteil, France
4 LSCE/IPSLS, CEA-CNRS-UVSQ, Saclay, France

In the framework of MEGAPOLI summer 2009 and winter 2010 field campaigns, MOBILIS "Moyens mOBIles de télédetection de l'IPSL" has been deployed in the southeast suburbs of Paris, at the Creteil Observatory (48.78°N 2.45°E). MOBILIS is a new atmospheric mobile observatory developed by the "Lidar, Meteorology and Geophysics" team of the French Institut Pierre Simon Laplace, in order to contribute to international field campaigns on air quality and climate research and validation of satellite observations. MOBILIS is composed by a full set of lidars (Fig. 1a), radiometers (Fig. 1b) and complementary in situ instrumentation.

As shown in Fig. 2, for 4 Feb 2010, MOBILIS lidar observations enable a thorough characterization of atmospheric aerosols vertical distribution (orange-red below 1.5 km of altitude) and meteorological situation (clouds above 3.5 km). A detailed description of the evolution of the atmospheric boundary layer shows dilution in the convective boundary layer (from 200 m at 1200 LT to 800 m at 1600 LT) and accumulation in the residual layer (up to 1 km high before 1200 LT). Aerosol optical properties are retrieved for tracing changes in their composition and assessing their radiative impact.

Figure 1: Créteil site: (a) Multi-wavelength aerosol backscatter lidar, (b) Sun photometer, (c) Observatory’s Fourier transform spectrometer.

Figure 2: MOBILIS lidar profile time series of attenuated backscatter coefficient at 1064 nm on 4 Feb 2010 at Créteil.
MEGAPOLI Summer 2009 Campaign – Paris Plume Study

Matthias Beekmann
E-mail: Matthias.Beekmann@lisa.univ-paris12.fr
1 Laboratoire InterUniversitaire des Systèmes Atmosphériques (LISA), Université Paris Est et 7, CNRS, Créteil, France

M. Beekmann 1, U. Baltensperger 2
2 Paul Scherer Institute (PSI), Villingen, Switzerland

An intensive MEGAPOLI measurement campaign was performed during July 2009 in the Ile-de-France region. This campaign aimed at better quantifying primary and secondary organic aerosol sources on an example of a large European megacity (the Paris metropolitan region), according to the MEGAPOLI WP3 objectives O3.1-O3.4. During the 1st year, the campaign was prepared, with a coordination meeting held in Paris in April 2009.

The campaign design included 3 primary and 4 secondary fixed ground measurement sites, an aircraft and 5 mobile platforms (Figure 1 - shows the location of the primary and secondary ground based sites, mobile platforms and one aircraft). This set-up was much bigger than initially planned and funded by the European Commission, due to a large number of additional volunteering contributions by the MEGAPOLI partners and other research groups. The campaign was carried out from 1 to 31 July 2009.

In total, more than 20 research laboratories participated: i.e. FP7 funded research laboratories:
- GAME-CNRM (Météo-France/CNRS), France,
- Institut für Troposphärenforschung, Leipzig, Germany,
- LaMP (CNRS / Université Blaise Pascal), France,
- LGGE (Université Joseph Fourier / CNRS), France,
- LISA/IPSL (CNRS/Universités Paris-Est et Paris 7), France,
- LSCE/IPSL (CEA / CNRS / UVSQ), France,
- Paul Scherer Institute, Villingen, Switzerland,
- SAFIRE (CNRS / Météo-France / CNES), France,
- Université de Patras, Greece,
- Universität d’Helsinki, Finnlend;

and additional research laboratories (or non-funded groups of funded laboratories):
- AIRPARIF, France,
- CEREA (Ecole des Ponts et Chaussés / EDF), France,
- Département Chimie & Environnement (Ecole des Mines de Douai), France,
- Finnish Meteorological Institute, Finland (ceilometer measurements),
- INERIS, France,
- LATMOS/IPSL (CNRS / UVSQ / UPMC), France,
- LCME (Université de Savoie), France,
- LCP-IRA (CNRS / Université de Provence), France,
- LMD/ IPSL (CNRS / ENS / Ecole Polytechnique / UPMC), France,
- Max-Planck Institut für Chemie à Mayence, Germany, Aerosol group and MAX-DOAS group,
- Paul Scherer Institute, Villingen, Switzerland, (mobile measurements),
- SIRTA/ IPSL (CNRS, Ecole Polytechnique), Université Essen-Duisburg, Germany

The campaign was coordinated by a coordinating committee:
- M. Beekmann (CNRS /LISA) - WP3 co-leader,
- Borbon (CNRS/LISA) - airborne segment coordinator,
- J. Sciare (LSCE/CNRS) - ground segment coordinator (aerosol),
- V. Gros (LSCE/CNRS) - ground segment coordinator (gases, LHVP site responsible),
- S. Pandis (FORTH), A. Baklanov (DMI), M. Lawrence (MPI), MEGAPOLI coordinators (one of three presented during the whole campaign),
- M. Haeffelin (IPSL/CNRS) - SIRTA site responsible,
- Schwarzenboeck (LaMP/CNRS) - airborne instruments PI,
- L. Gomes (Game/CNRS) - airborne instruments PI.

Major tasks included: to activate predefined aircraft flight plans, and to decide on target sectors for mobile labs. For this the chemical forecast from the PREVAIR system (http://www.prevair.org) was provided by INERIS in a specific format defined for the campaign and uploaded each day at 06 of Local Time (LT) on the local WP3 website (http://megapoli.lisa.univ-paris12.fr) and partly by DMI. Regular, weekly science meetings were organized where all groups presented measurements performed so far, and common campaign issues were also discussed. A particular focus was put on specific intercomparison exercises covering all major instruments or parameters measured by different groups. This activity was coordinated by IfT (A. Wiedensohler and A. Held). A specific Intercomparison workshop took place in Leipzig, Germany in November 2009.

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- Finnish Meteorological Institute, Finland (ceilometer measurements),
- INERIS, France,
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Figure 2 : Set-up of aerosol measurement at the three primary measurement sites

At three primary sites, a very complete set-up of instruments was deployed (Fig. 2, Tab. 1) allowing for detailed characterisation of aerosol properties, including size distribution, volatility, hygroscopicity,
In total 11 successful flights in the Paris agglomeration pollution plume were performed with the ATR-42 aircraft of SAFIRE.

A extensive instrumentation was set-up on the aircraft (Tab. 3) combining aerosol property and chemical composition measurements (by AMS) and gas phase measurements (NOx, NOy and VOC). A typical flight pattern is given in Fig. 3. The plume is crossed by aircraft several times to document its evolution up to distance of 150 km from the town center. Flying around the agglomeration also allows for characterising air masses entering the agglomeration.

### Aerosols

**Physical properties and hygroscopicity**

**Optical properties**

**Chemical composition**

### INSTRUMENTS

- **Aerosols**
  - **Physical properties and hygroscopicity**
  - **Optical properties**
  - **Chemical composition**

### GASES

A fleet of 5 mobile vans was deployed in the plume or for characterising upwind air masses:
- **PSI** van and **MOLA** vans with extensive aerosol and gas phase measurement facilities (Figs. 4-5):
- **MPI** MAX-DOAS van allowing for column measurements of NO2, HCHO and other VOCs;
- **CEA** van with backscatter lidar measurements including a polarized channel;
- **University Duisburg** van allowing for aerosol mass and gas phase measurements.

The campaign was clearly a success, with measurement coverage above 90%. Now the measurements are analyzed and quality checked by partners.
For the task “Examination of the evolution of aerosols and gas-aerosol interactions in the urban outflow of Paris” (lead by CNRS-LAMP; with contributions from CNRS-GAME, LGGE, and LISA, and PSI, FORTH, CNRS-LSCE, IFT, UHel for flight planning and exploitation) all data gathered will serve as input, and especially data gathered by the French ATR-42 aircraft in the plume and by mobile platforms, but also at fixed sub-urban sites when downwind of the agglomeration will give a huge database allowing the examination of the evolution of aerosols and gas-aerosol interactions in the urban outflow of Paris. For the task “Set-up of an integrated data base and use for model evaluation” (lead by CNRS-LISA; with contributions from UHel, FORTH, CNRS-LISA+LGGE+GAME+LGGE, PSI, IFT, NERSC teams) a first database of measurements quick looks and chemical weather forecast simulations has been set-up at CNRS-LISA at http://megapoli.lisa.univ-paris12.fr/.

Main Findings

One of the interesting results from airborne primary pollutant measurements was that the pollution plume was still well defined at more than 100 kilometres downwind from the agglomeration. This will give a “safe” framework for later studying secondary organic aerosol build-up in the plume.

The mobile measurements (using mobile ground-based laboratories) including the concept of assessing upwind and downwind conditions of the Paris plume worked well. The setup of the stationary instrumentation allowed for a successful separation between internally and externally mixed particles.

Significant new particle formation events were observed in the Paris area during the whole month of the campaign. These events were assisted by the relatively low particulate matter concentration levels and resulting low surface area during most of July 2009.

Very preliminary attribution of organic aerosol (OA) from AMS mass spectrometer urban and peri-urban measurements shows a large fraction of oxidised organic aerosol (OOA), comprising both chemically processed (oxidized) primary organic aerosol and classical secondary organic aerosol (from aromatic and biogenic VOC precursors), and a smaller fraction of un-oxidised organic aerosol (HOA) of primary origin. Another aspect is water solubility of OA available from PILS-TOC measurements. At the urban LHVP site, about half of OA is water soluble, corresponding probably to primary and chemically processed primary OA.

Acknowledgements

The MEGAPOLI project is very warmly thankful and acknowledged the Laboratoire d’Hygénie de Paris (LHVP), SIRTA/IPSL, Golf de la Poudrière à Livry-Gargan for hosting the campaign. Without this help, the campaign would not have been possible.

References


A first data base of measurements quick looks and chemical weather forecast simulations has been set-up at CNRS LISA (http://megapoli.lisa.univ-paris12.fr/). The campaign fostered a large public awareness of urban pollution problems and scientific needs and activities to tackle them. Large national and regional televisions, radios, and newspapers provided reports on the campaign.

Taking into account the data gathered during the campaign, it is clear that the MEGAPOLI WP3 "Paris Plume Study" objectives have been met, i.e.:
• O3.1: To characterize atmospheric aerosol and relevant precursors at two urban and suburban sites in Greater Paris area;
• O3.2: To provide a source apportionment of PM (separately for ultrafine particles, PM1, and the coarse mode);
• O3.3: To examine the evolution of aerosols and gas-aerosol interactions in the urban outflow of Paris;
• O3.4: To provide additional data for the evaluation of Chemical Transport Models.

The key milestone of WP3 “Preparing the measurement programme, instrumental base, equipment calibration and test measurements” had been achieved by successfully performing the summer 2009 intensive campaign. The second campaign (winter intensive) was planned in the Paris agglomeration from mid January to mid February 2010.

The work on task on “Characterization of the atmospheric aerosol and relevant precursors” (lead by CNRS-LSCE; with contributions from PSI, IFT, FORTH, UHel, CNRS-LISA + LAMP, NERSC teams) showed that aerosol and gaseous species measurements gathered during the summer 2009 campaign will allow an extensive characterisation of urban aerosol and precursors. As said before the geographical coverage and detail of aerosol and gaseous precursors were much beyond of what has initially been proposed in MEGAPOLI DoW, due to many additional contributions from volunteers.

The task on “Source apportionment of PM” (lead by PSI; with contributions from FORTH, CNRS, IFT, UHel teams) uses data gathered during the summer campaign as input for source apportionment studies. Preliminary analysis showed a mixture of primary and secondary sources for organic aerosol at both urban and sub-urban sites. Due to advection of rather cleaner marine air masses during most of July, the origin of organic aerosol was often local.
Mobile MAX-DOAS Observations around Paris

Reza Shaiganfar
E-mail: r.shaiganfar@mpic.de
Max-Planck Institute for Chemistry
Mainz, Germany
http://www.mpch-mainz.mpg.de

Daily mobile MAX-DOAS observations were carried during the Paris winter campaign from 14 Jan to 14 Feb 2010. The observations were usually made on large circles (diameter ~60 km around the center of the city). Mobile MAX-DOAS observations (Wagner et al., 2010, see also Fig. 1) have important advantages over MAX-DOAS observations at fixed locations: i.e. they yield not only the vertically integrated tropospheric trace gas concentration above that location, but allow the determination of the complete emissions of the surrounded emission sources (in combination with the wind direction) (Ibrahim et al., 2010). From the measured spectra, the absorptions of NO₂, HCHO and Glyoxal can be analysed. In Fig. 2 results of MAX-DOAS NO₂ observations on 11 Feb 2010 (10:00 – 12:45) are shown. High values are found south-west of the center, which is in agreement with the prevailing wind direction on that day (from north-east).

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In Fig. 3 the daily maximum values of the integrated tropospheric NO₂ concentration is shown for both MEGAPOLI campaigns. Systematically higher values are measured in winter indicating probably a combination of a) higher emissions and b) longer atmospheric lifetimes of NO and NO₂.

Acknowledgements
We want to thank the car drivers (Thierry Marbach, Steffen Dörner, Christoph Hörmann, Tobias Tröndle, Bastian Jäcker, Swen Krautwurst) for their great commitment during two long measurement campaigns.

References
Mobile Aerosol and Trace Gas Measurements in the greater Paris Area during the MEGAPOLI 2009 Campaign

Frank Drewnick
E-mail: frank.drewnick@mpic.de
Max Planck Institute for Chemistry
Particle Chemistry Department
Mainz, Germany
http://www.mpch-mainz.mpg.de

During the MEGAPOLI 2009 summer field campaign in the greater Paris area the recently developed Mobile Laboratory (MoLa) of the Max Planck Institute for Chemistry (MPI-C) was used to systematically investigate the spatial distribution of various pollutants in the emission plume of the agglomeration. MoLa is a modern aerosol research laboratory capable of performing truly mobile measurements of 25 atmospherically relevant parameters with high temporal resolution. Physical aerosol parameters like particle number concentration and size distribution (size range 5 nm – 32 µm) are measured as well as the chemical composition of the fine aerosol fraction. In addition, the concentrations of several trace gases and typical meteorological parameters are continuously monitored.

To investigate the emission plume three different measurement approaches were used (Fig. 1, right): Mobile measurements driving MoLa on a circular route around the city to measure a cross section through the plume (blue, green); radial measurements along the plume transport direction to perform quasi-Lagrangian measurements in the plume and to investigate aging of the plume (red); stationary measurements either to measure the atmospheric background or within the plume over extended time intervals with minimized local contamination (green points).

To minimize contamination by emissions of other vehicles on the same street during mobile measurements routes were planned selecting roads with low traffic density (Fig. 1, left). Stationary measurements (Fig. 2, right) were performed at locations with negligible traffic.

To avoid contamination from the own exhaust the electrical power for these measurements was generated using an external generator set up 80-100 m downwind of the mobile laboratory (Fig. 2, right). In some situations the wind shifted, and it was possible to measure both, the atmospheric background as well as the emission plume from the Paris agglomeration during a single stationary measurement (Fig. 2, left). In altogether 10 mobile and 11 stationary measurements the emission plume was characterized under various meteorological conditions. An example of a cross section measurement is shown in Figure 3. Here, the lower pollutant concentrations during the second cross section (at larger distance from the city) clearly show the dilution of the plume on its transport away from the sources.

Additional measurements performed by MPI-C with an extensively equipped measurement container in the North-East of the agglomeration and a single particle aerosol mass spectrometer on a research aircraft provide the opportunity to compare pollutant concentrations at different distances from the source or to compare concentrations within the plume with background values to extract further information on plume development and particle transformation processes.

Acknowledgements
This work was financed by internal MPI funds and logistically supported by the MEGAPOLI campaign team. Special thanks to Thomas Böttger and Johannes Fachinger for technical help and support before and during the measurements.

Figure 1: Planning of routes for mobile measurements (left). The map shows the tracks of the mobile measurements during the field campaign, the green dots are locations where stationary measurements were performed (right).

Figure 2: Stationary measurement, operating MoLa at a location without significant local contamination (right). Shifting wind directions cause the Paris emission plume to pass over the site (left).

Figure 3: Data from mobile measurements: In this measurement trip the Paris emission plume was crossed twice at different distances (25 and 40 km) from the city centre.

Drewnick, Frank1, von der Weiden, Sarah-Lena1, Zorn, Sören1,2, Diesch, Jovana1,3, Borrmann, Stephan1,2

1 Max Planck Institute for Chemistry, Particle Chemistry Dept., J.J.Becherweg 27, D-55128 Mainz, Germany
2 now at: School of Engineering and Applied Sciences, Harvard University, Cambridge, MA 02138, U.S.A.
3 Institute for Atmospheric Physics, Johannes-Gutenberg-Universität, D-55099 Mainz, Germany

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**Role and Contribution**

One of the contributions of Paul Scherrer Institut (PSI), Switzerland to the MEGAPOLI Project is the quantification of primary and secondary aerosol sources in and around a large agglomeration (Paris) and the analysis of their evolution in the megacity plume. The combination of high time resolution measurements by the Aerodyne Aerosol Mass Spectrometer (AMS) and statistical models will allow a more detailed source apportionment.

**Introduction**

Mobile measurements allow the description of the spatial variability of the aerosol chemical composition and physical properties in different emission scenarios (rural and urban roads, highways, etc.). In order to study the evolution of aerosols and gas-aerosol interactions in the urban outflow of Paris, concurrent up-wind and down-wind measurements have been performed during summer 2009 by two mobile labs, the PSI mobile van (Fig. 1) and the mobile laboratory of the Mainz group (MoLa).

**Material and Methods**

High Resolution Time of Flight Aerosol Mass Spectrometer (HR-TOF-AMS) measurements have been performed downwind the megacity plume during two different drives from the South of Paris to the Northern sector (Figs. 2-3).

In order to identify the main sources which contribute to the atmospheric aerosol concentration a preliminary source apportionment technique based on characteristic mass fragments was applied. The organic fraction of the aerosol was characterized in terms of HOA (Hydrocarbon-like Organic Aerosol) and OOA (Oxygenated Organic Aerosol) (Weimer et al., 2009).

**Preliminary Results**

Figure 2 shows the AMS measurements performed downwind Paris during drive on 13 Jul 2009. The largest contribution to PM1 mass concentration comes from organics (50-80%), mostly of secondary origin (SOA). Constant background sulphate levels are measured during the whole drive (around 0.8 μg/m³) and high HOA levels (57%) are identified on the highway, as expected. Preliminary comparisons with model and aircraft data indicate agreement in terms of plume location.

**References**


**Conclusions**

Successful mobile AMS measurements were performed in Paris. Plume transport and its evolution have been measured downwind of Paris. A first source apportionment of organics was performed. The combination of HR-ToF-AMS, aircraft and wind profile measurements with more sophisticated statistical techniques will allow identification of more specific aerosol sources.
**Airborne Measurements on-board ATR-42 during MEGAPOLI Summer 2009 Campaign**

Agnès Borbon

E-mail: borbon@lisa.univ-paris12.fr

LISA-Laboratoire Interuniversitaire des Systèmes Atmosphériques
Universités Paris 12 et 7, CNRS
31 av. Du Gal de Gaulle, Créteil, France


A. Colomb1,2, C. Aff,1 L. Gomes3, A. Schwarzenboeck4, K. Sellignet5, M. Brands5, J. Schneider6, Stephan Bormann7, J. L. Jaffrezo8, V. Michoud1, N. Amaroche9, S. Chevailler10, R. Durand11, N. Grand4, T. Bourriane3, JM Pichon5, F. Doussiére9, and SAFIRE team7

1 – LISA/Univ. Paris 12 and 7/CNRS, Créteil, France
2 – LaMP, Univ. Blaise Pascal Clermont Ferrand 2, CNRS, Aubière, France
3 – CNRM/CNRS/GAME, Toulouse, France
4 – MPIC, Particle Chemistry Department, Mainz, Germany
5 – LGGE, Univ. Joseph Fourier, CNRS, Grenoble, France
6 – DT INSU/CNRS, Neudon, France
7 – Base 101 Francalaz, Cugnaux, France

**Objectives:** The MEGAPOLI summertime campaign took place in July 2009 in the greater Paris area. This campaign is part of MEGAPOLI WP 3. The objective of the aircraft campaign is to characterize the evolution of aerosol and gas-aerosol interactions within the urban plume. The questions are (1) **To which extent is a larger scale area impacted by megacity emissions?** (2) **What are the major processes involved in pollution export and aerosol build-up?**

To answer these questions, three major tasks are planned:

(1) Describe secondary organic aerosol (SOA) formation from aircraft related to ground based measurements
(2) Derive kinetics of SOA formation as a function of SOA precursors abundance (anthropogenic and biogenic VOC) and the chemical age of the plume under different meteorological conditions
(3) Evaluate the impact of aerosol aging processes on optical and hygroscopic aerosol properties

**Flight patterns:** To fulfill the objectives, pseudo Lagrangian flight patterns have been retained. Six 90°-sectors depending on the most frequent wind direction in summer were defined before the campaign started (from South-West to East). For each sector, several transects perpendicular to plume axis at increasing distances from Paris urban centre (50 to 150 km) were performed during 4-hour flights. Flights were performed in the afternoon (take off at 01:00 – 03:00 PM LT) in well developed boundary layer at constant altitude (1500-2000 ft). One vertical sounding was performed at the end of the last transect between 500 – 10000 ft. The choice of the flying sector was based on meteorological and chemical forecast by the CHIMERE model.

**Instrumentation:** The instrumentation deployed on-board provided a fine characterization of both gas-phase and aerosol phase at high temporal frequency.

**Gas-phase characterization:** Ozone, CO (MOZART UV and IR photometer), VOC (on-line PTR-MS and AMOVOC) and NOx, species (MONA)

**Aerosol phase characterization** through the Community Aerosol Inlet: particle number/size distribution (CPC, SMPS, OPC), optical properties (PSAP, nephelometer), hygroscopic (CCNC) properties and size resolved chemical composition (filters, aerosol mass spectrometers ALABAMA and AMS).

**Two intercomparison exercises** between aircraft and mobile vans (PSI, U Duisburg, MPIC) were carried out on the 11th and 31st of July as illustrated in Figure 2 for NOx/NOy chemiluminescence instruments and AMS. For all data, the variability of the compounds seems to be reproduced quite well by all instruments but there are still some differences in quantification. For AMS, higher deviation is observed for organic component with a 30%-difference in mass but remains reasonable. Further analysis is needed to explain error factors.

**Missions:** Eleven successful flights were performed with high recovery rate for all instruments (> 90%). Aerosol tracers (BC) and gas phase air quality tracers (CO and ozone) distributions indicated a large range of pollution levels from very high pollution levels (1st of July, continental inflow) to low pollution levels (20th and 25th of July, westerly wind regimes). Figure 2 reports the aircraft trajectory code-coloured by the some tracer distributions for flight #25 (1st of July) in the SW sector. The plume is well captured as predicted by the forecast for all displayed tracers. Generally, the plume is well-defined independent of pollution levels and instrument responses are consistent.

**Figure 1:** MEGAPOLI team at the airport and intercomparison exercise with mobile vans of PSL, U Duisburg, and MPIC.

**Figure 2:** Intercomparison for NOx instruments and AMS (courtesy M. Crippa) between ATR-42 and mobile vans.

**Figure 3:** Chemical forecast with flight sectors and 2D distribution of anthropogenic tracers (NOy from MONA, toluene from PTRMS and BC content derived from PSAP).
Ground-Based Gas-Phase Measurements during the MEGAPOLI Summer Campaign

Valérie Gros
E-mail: valerie.gros@lsce.ipsl.fr

CNRS / LSCE / Experimental Atmospheric Chemistry Group
http://www.lsce.ipsl.fr

A. Borbon², A. Colomb³, N. Marchand⁴, A. Kukui², F. Freutel², F. Drewnick⁶, S. Borrmann⁶, M. Lopez², C. Aff², K. Miet⁷, V. Michoud², W. Ait-Helal², B. Termine⁴, N. Bonnaire², B. Bonsang¹, S. Perrier², R. Durand-Jolibois²

1- Laboratoire des Sciences du Climat et de l’Environnement (LSCE), unité mixte CNRS-CEA-UVSQ, Gif sur Yvette, France
2- Laboratoire inter-universitaire des Systèmes Atmosphériques (LISA), Univ. Paris7, Univ. Paris 12, CNRS, Créteil, France
3- Laboratoire de météorologie physique (L.A.M.P), Université Blaise Pascal Clermont Ferrand 2, Aubière, France
4- Laboratoire de Chimie-Provence (LCP), Université de Provence CNRS, Marseille, France
5- LATMOS, Vérières le Buisson, France
6- Max Planck Institute (MPI), Particle Chemistry Department, Mainz, Germany
7- Institute for Atmospheric Physics, University of Mainz, Mainz, Germany

During the MEGAPOLI summer campaign (July 2009), gas-phase measurements were performed at the two main measurement sites (LHVP: urban background station in Paris; SIRTA: peri-urban station in the south west of Paris). An additional station (GOLF: north-east peri-urban station) was instrumented by MPI for Chemistry. All sites were equipped with in-situ measurements of CO, NO, NOx and O₃. LHVP (LSCE and LCP) and SIRTA (LISA) sites were equipped with instruments (including on-line GCs and PTR-MS) dedicated to speciated volatile organic compounds (VOCs) measurements. In addition OH, RO₂ and H₂SO₄ have been measured with chemical ionisation mass spectrometry at the SIRTA site (LATMOS).

At the beginning of the campaign (July 1-3), north-easterly winds were encountered which brought continental pollution to the LHVP site as seen on long-lived compounds. CO values up to 800 ppb and ozone values up to 120 ppb (Fig. 1) were monitored during those days. During the rest of the campaign, mostly westerly winds were observed, associated with low continental concentrations. The end of the campaign was characterised by high levels of local /regional pollution as can be seen in concentrations of short lived tracers as ethylene (Fig. 1). The Benzene/Toluene ratio can be used to determine the photochemical age of the air mass and the low value observed at the end of the campaign (except for a short peak) of this ratio (Fig. 2) confirms the local origin of this event. When the Paris pollution plume was observed at the SIRTA site, it could be easily identified with elevated concentrations of primary and secondary pollutants (Fig. 3).

Primary and secondary sources of pollutants along with OH radical (Fig. 4.) budget will be examined in details.

Specific sources have also been identified as seen on the GOLF site measurement of 14 Jul fireworks (Fig. 5).

Figure 1: Ozone and ethylene time series at LHVP (LSCE).

Figure 2: Benzene and toluene measured at the LHVP site by PTR-MS (LCP). Series are coloured according to the benzene/toluene ratio.

Figure 3: PAN, O₃, JNO₂ measured at the SIRTA site (LISA). Green circles mark the periods where the Paris plume was observed.

Figure 4: J(O1D) and OH radical time series at the SIRAT site (LATMOS).

Figure 5: Time series of gas-phase measurements at the GOLF site (MPI).
During MEGAPOLI and at both ground sites, HCHO was measured hourly. Once collected, the vials were transferred to the laboratory. A total of 30 specimens per site are collected daily, including those for QC/QA and blanks. Over 1000 samples were taken in each campaign which made the analysis procedure hard. Analysis was driven by High Performance Liquid Chromatography – HPLC coupled to a UV/Vis detector. Figure 2 presents the temporal variation of HCHO at SIRTA during the 26th and 27th of January 2010. Those two days had very good meteorological conditions with a clear and sunny sky. As observed, formaldehyde concentrations reached ~3 ppb during these 2 days.

As for the flights during the summer campaign, not only formaldehyde was monitored by means of AMOVOC, but also VOCs. 15 multisorbent tubes were collected and analyzed from each flight at the LISA by short-path thermal desorption coupled with gas chromatography and mass spectrometry (TDAS-GC-MS). Figure 3 presents the analytical system used.

When large field campaigns are conducted, offline techniques present a hard work to be executed and are often time consuming in order to get high quality results.

References
Simulation of PM2.5 in Large Urban Agglomeration of Ile-de-France

Qijie Zhang
E-mail: zhang@lisa.univ-paris12.fr

Laboratory Inter-universitaire des Systèmes Atmosphériques (LISA), Centre National de Recherche Scientifique (CNRS)

Q. J. Zhang1, M. Beekmann2
1 Laboratoire InterUniversitaire des Systèmes Atmosphériques (LISA), Université Paris Est et 7, CNRS, Créteil, France

In the framework of the FP7 EU project MEGAPOLI, an intensive campaign for air pollutant measurements (both ground-based and airborne) was launched in the Greater Paris Region during July 2009 and January-February 2010. The main objective is to quantify different sources of organic aerosol (OA) within a megacity and to better understand the interaction of secondary aerosol formation with the gas phase.

The CHIMERE is a multi-scale chemistry transport model, and it is primarily designed to produce daily forecasts of ozone, aerosols and other pollutants and make long-term simulations (entire seasons or years) for emission control scenarios. CHIMERE runs over a range of spatial scale (several thousand kilometers) to the urban scale (100-200 Km) with resolutions from 3 Km to 50 Km. The CHIMERE model simulations for near real-time analysis at LISA were performed every day during the summer campaign and the winter campaign. These simulations were also compared to the quick-look measurements such as Black Carbon and O3 on flight and PM of ground AMS data.

A same localisation of SOA plume from Paris was also simulated (two-product SOA scheme) by CHIMERE on this photochemically-polluted day. Comparisons of PM concentrations between the CHIMERE simulations and AMS measurement at GOLF (ground site) as below showed that the CHIMERE model is able to produce a good structure of PM concentration. In contrast, SOA concentration is too low in simulations with a traditional two-product scheme (Fig. 2).

The Volatility-basis-set (VBS) approach has been integrated into the regional chemistry transport model CHIMERE, in order to improve simulations of primary and secondary aerosol formation within the Greater Paris region. The simulations are compared with HOA (hydrocarbon like organic aerosol) and OOA (oxidised organic aerosol) fractions derived from AMS measurements. Based on first preliminary results of the summer campaign, we found more quantitative agreement with measurement data when using VBS approach for POA than when considering POA as non-volatile.

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References
CHIMERE website: http://www.lmd.polytechnique.fr/chimere/


Figure 2: Comparisons of PM concentrations between CHIMERE simulations with AMS measurements at GOLF (by MPI, MEGAPOLI science meeting).

Figure 1: Comparison of O3 concentration between temporal interpolated CHIMERE results and measurements for flight 30, MEGAPOLI science meeting.

A same structure of O3 concentration was simulated by CHIMERE (Fig. 1, left-above) on the flight way as measured during flight 30 (Fig. 1, right) on 16 July 2009.
Global Modelling Activities at the Max Planck Institute for Chemistry

Tim Butler

E-mail: tim.butler@mpic.de

Max Planck Institute for Chemistry, Department of Airchemistry, Germany

http://www.mpic.de

Tim Butler 1, Mark Lawrence 2

1 Max Planck Institute for Chemistry, Mainz, Germany

The fundamental approach of the MEGAPOLI project is the bridging of spatial scales, from the street scale to the global scale, in the study of megacities and their influences on air quality and climate. This approach requires the use of a heirarchy of models, from fine-scale turbulence-resolving models able to compute the flow deformation due to elements of the urban canopy, to regional models, which simulate the detailed effects of individual urban centres or agglomerations on their local surroundings, all the way up to global models, which can simulate the combined effects of all megacities on large-scale pollutant plumes and on the global climate system.

The Max Planck Institute for Chemistry in Mainz, Germany (MPI-C) is one of the four MEGAPOLI partners involved in the global modelling efforts of the MEGAPOLI project. Our major contribution to the MEGAPOLI project will be to Work Package 5: Regional and Global Atmospheric Composition, in which we will be heavily involved in Task 5.4.2: Determination of the impacts of megacities on global atmospheric composition. The results of this task are deliverable in month 33 of the project. Some key steps (Butler and Lawrence 2009, see below) have already been completed.

The MPI-C component of this task will be performed using two different global models: MATCH-MPIC and EMAC.

MATCH-MPIC is a semi-offline CTM (Chemical Transport Model) which uses input fields (wind speed and surface fluxes) to compute the hydrological cycle and the transport and chemistry of atmospheric trace constituents. MATCH-MPIC has already been used for two different studies of the global impacts of emissions from megacities (Lawrence et al. 2007, Butler and Lawrence 2009, see below).

We have already provided output from MATCH-MPIC as boundary conditions to the ensemble of regional models involved in the MEGAPOLI project.

EMAC (the ECHAM5/MESSy1 Atmospheric Chemistry general circulation model, Jöckel et al. 2006) is a fully coupled, highly modular, global three dimensional chemistry-climate model, which will be used in addition to MATCH-MPIC in the suite of models performing global simulations under the MEGAPOLI project. The use of a larger suite of models allows better estimation of the between-model uncertainty.

The MPI will also cooperate closely with Work Package 6: Regional and Global Climate Impacts, which is led by the UK Met Office. Our cooperation will involve a two-way exchange of information; fields of atmospheric composition, calculated using models at the MPI-C will be used as input to the global climate models of the UK Met Office, and online, fully coupled approaches will be compared and contrasted with offline CTM approaches.

Our previous work examining the emissions from, and transport of tracers away from megacities is summarised below.

Lawrence et al. (2007) performed idealised simulations using passive tracers and found that the degree of vertical transport of trace constituents away from megacities plays a crucial role in both the amount of pollutants in the cities themselves, as well as their amounts in regions downwind of the cities (Fig. 1).

Butler and Lawrence (2009) performed simulations with a full suite of gas phase chemical reactions, using the emissions from megacities described by Butler et al. (2008). We found that the influences of megacities on global oxidising capacity (through the OH radical) and ozone mixing ratios were generally in proportion to or smaller than the total percentage of global emissions which are due to megacities. The effects of megacities on the reactive nitrogen cycle, however, were generally larger than the percentage of the emissions of reactive nitrogen due to megacities, with potentially important consequences for deposition of reactive nitrogen onto terrestrial and oceanic ecosystems (Fig. 2).

The new emissions inventories and scenarios from WP1 of MEGAPOLI will allow improvement upon this previous work.

References


leads to an intensification of the primary plumes at the regional scale, and to an increase of the ozone production rate by a factor of 1.5-2 in the most condensed scenario, with low geographical variability. In this last case, the model calculates particularly worrisome ozone values, which exceed 180 ppbv in numerous plumes. From a geographical point of view, the main impact of megacities is local as plumes are very concentrated in the vicinity of megacities, and then fast dilute in the continental atmosphere. However, differences between the scenarios have been calculated for all grid cells and they indicate that the distance of megacity impact increases with their size.

The tendency to produce more ozone with higher production rates has to be studied into more details, this is why we are currently working on the implementation of a refined chemical module, on the production of more realistic urban areas (derived from real current shapes instead of geometric shapes), and on the implementation of flux calculation in the model so as to quantify the megacity pollution export in all those configurations. This will be studied at a refined grid scale, and more chemical species will be included in our budget analysis, in particular secondary species.

Conclusions
What is remarkable in this study is the fact that European pollution has its own structures, which last independently of our scenarios. These results raise the question of the importance of all the highly urbanized areas (Benelux, South of England, maritime lanes, Po valley...), sort of “super-megacities”, in the continental-scale pollution.

It appears that the intensification of urban emissions has different local and continental impacts on air composition, and the increase of photochemical reactivity in the megacity plumes needs further investigation. In particular, we need to bring quantitative answers to the questions presented in the introduction. At the local scale, the plume composition and the intensity of pollution export will be finely calculated. At a larger scale, the whole quantity of ozone present in the simulation domain will be an important element for the evaluation of the impact of the different scenarios.

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Waste heat produced by human activities is one important contributor to the altered climate found in urban areas. While this anthropogenic heat flux (Q_F) varies spatially and temporally under certain conditions it can exceed energy receipt from net all-wave radiation. Typical values range from 20 and 70 W m\(^{-2}\) but values of greater than 1000 W m\(^{-2}\) under extreme localised conditions, for example in the densest part of Tokyo at the peak of air conditioning demand have been calculated (Ichinose et al. 1999). Q_F is commonly omitted from climate models despite its local importance. Sources of Q_F include heat generated by the combustion process in motor vehicles, heat created by industrial processes, the conduction of heat through building walls or emitted directly into the atmosphere by air conditioning systems, and the metabolic heat produced by humans. The aim of this project is to develop methods and models to estimate the different components of Q_F in urban areas at different temporal and spatial scales. The main focus area is Greater London (GL) but attempts to model global Q_F are also being undertaken. The methods and models developed are also compared with already existing models to estimate Q_F in cities. Three separate models are currently being developed and analysed within the scope of this project using different approaches to estimate all, or some of the different components of anthropogenic energy fluxes (traffic, buildings and metabolism) at different spatial scales.

The ERG Q_F calculator
This tool produces anthropogenic heat estimations generated from road transport in GL. This model has the capability to provide vehicle emissions between 1995 and 2025 and produces Q_F outputs that are for 1 x 1 km area. It can provide an average hourly value for ~6500 roads separately and for a typical 24 hour period during each year, and hourly estimates for ~1750 major roads for the year 2008. All Q_F values are separated into nine vehicle types, including petrol and diesel vehicles. The hourly Q_F calculation is undertaken for a subset of roads, selected by the user using ArcGIS.

GreaterQF v2.0
This software is using statistical information to estimate all the components of Q_F for GL. The inventory covers the years 2005 to 2007 and provides estimations from human metabolism, transportation sector and buildings. The temporal resolution starts from half-hourly values that can be aggregated to daily, monthly and yearly profiles. Variation with respect to space is accomplished on the basis of a geographical hierarchy introduced by the Office for National Statistics (ONS) for the 2001 Census to report small area statistics. The smallest areas for which data are collected by ONS are called Output Areas (OA) and, in England, they have a minimum size of 100 residents and 40 households corresponding to an average size of 0.065 km\(^2\).

The Global Q_F Model
This is a global model for urban areas that estimates hourly values of Q_F at a spatial resolution of 2.5 x 2.5 arc-minute resolution (about 21 km\(^2\) at the equator). The model is based on various statistical information at global scale based for the year 2005 such as population density, number of vehicles, energy consumption statistics etc.

Ongoing work
Comparison between the different models is currently occurring. Preliminary results show good agreement between the three Q_F models. A more detailed spatial & temporal model comparison is currently being done.

References
In this contribution, UCP. We considered that a necessary condition for natural complement of the effort done to obtain detailed real morphologies and building materials. This work is the (respectively) of the idealized morphologies based on values of expressions can be derived to estimate the basic morphological simplified morphology must also respond to solar forcing in a same in the two morphologies. Building material used in the in the estimation of the surface energy budget) must also be the parameterization for mesoscale models (UCP). The nature of the UCP depends on the purpose of the simulation, available computer power, and scientific knowledge. Since all these factors are continuously evolving, UCPs are also evolving. In this contribution, UCP evolution’s lines followed at CIEMAT are presented.

2. Idealized vs. Real Urban Morphologies
At the basis of most of the UCPs there is an idealization of the urban morphology needed, for example, for the calculation of radiation trapping and shadowing in street canyons. It is assumed that the real morphology is equivalent to a 2D or 3D regular array of buildings, with uniform building materials (idealized morphology). The criteria adopted for the equivalence, is again dependent on the purpose of model use. Focussing on air quality and urban climate, we decided that urban morphologies are equivalent if they have the same vertical profiles of the spatially averaged mean variables, momentum and heat fluxes. We considered that a necessary condition for this equivalence is that roads, walls, and roofs surfaces (respectively) must be the same in the real and the idealized morphologies. Moreover, sky-view factors (an important element in the estimation of the surface energy budget) must also be the same in the two morphologies. Building material used in the simplified morphology must also respond to solar forcing in a similar way to the weighted average of the building materials of the real morphology. Based on these assumptions, a series of expressions can be derived to estimate the basic morphological parameters (Martilli, 2009), and thermal properties (Salamanca et al., 2009) of the idealized morphologies based on values of real morphologies and building materials. This work is the natural complement of the effort done to obtain detailed databases of real urban morphologies (NUDAPT; Ching et al., 2009).

3. Microscale Models
Urban morphologies generate atmospheric structures (turbulent and not) at scales smaller than the typical grid size of a mesoscale model (e.g. 1 km). This has two consequences: a) point measurements in the UCL are not representative of spatially averaged variables, and cannot be directly used to validate mesoscale models with UCPs, and b) the small scale structures affect the spatially averaged variables, and their effect need to be parameterized. To shed light on this problem, we used a microscale CFD-RANS (Reynolds Averaged Navier Stokes) model that runs on domains smaller than the mesoscale (hundreds of meters), but with resolutions high enough to explicitly resolve the building induced non-turbulent structures. RANS was selected as the best compromise between accuracy and CPU time, after a validation against wind tunnel and Direct Numerical Simulations (DNS) data (Santiago et al., 2007; Martilli & Santiago, 2007; Santiago et al., 2008). The advantage of microscale CFD is that spatial averages can be performed and compared to the outputs of the UCPs. In this way it was possible, for example, to estimate the dependency of the drag coefficient and the turbulent length scales with the packing density. Once the values of the parameters derived with the CFD models were introduced in a UCP based on BEP (Building Effect Parameterization, Martilli et al. 2002), and run in 1-D, vertical profiles of the mean wind were in good agreement with the spatially averaged profiles (Fig. 1). This technique can also be used to find the most appropriate idealized urban morphology that represents a real one (see section 2).

4. Building Energy Models
Following the same philosophy of idealize the urban structure, a simplified Building Energy Model (BEM) has been built to estimate the energy exchanges between the buildings’ interior and the atmosphere. BEM accounts for heat generation inside the buildings due to occupants and equipments, solar radiation through windows, heat diffusion through walls and air conditioning systems (Salamanca et al., 2009) and it allows estimating the energy consumption due to air conditioning. BEM has been linked to BEP, and tested against the BUBBLE dataset (Basel Urban Boundary Layer Experiment), showing an improvement compared to the previous version (Salamanca & Martilli, 2009). BEP+BEM have been implemented in the Weather and Research Forecast model (WRF) and run over Houston (Fig. 2). The energy consumption estimated for two days in August 2000 is comparable with values obtained using bottom-up and top-down approaches (Salamanca et al., 2010).

5. Conclusions
This work is a step toward a tool to evaluate the impact of a change on urban structure on air quality, urban climate, and meteorologically related (air conditioning, heating) energy consumptions. This tool can be helpful in evaluate urban development scenarios.

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The issue of sub-grid scale process modelling becomes more and important as the complexity at the surface increases at the scales smaller than the model grid size as in the case of an urban environment (see MEGAPOLI NewsLetter n.3: “The Question of Scale: Large Eddy Simulation in Urban Research” by I. Esau).

One of the issues that are being addressed within the MEGAPOLI project is the development of a sub-grid model that would allow accounting for the variability of emission intensities with a model grid. In an urban environment emission of primary pollutants are produced by sources of very different nature, from vehicle moving along streets (line sources), to households more or less sparsely distributed (area sources), point sources such as stacks of industrial areas. Not only these are heterogeneously distributed in space but they account for varying amounts of mass emitted. The classical approach consists in considering one emission term per species per unit time that would account for the grid volume average. This approach neglects completely the variability produced by the fact the individual emitting elements are actually contributing to the total amount and that this variability has a physical significance.

Two approaches have been developed one presented in Galmarini et al. (2008) and the other by Cassiani et al. (2009). The approaches tackle the very same problem with two completely different modeling philosophies, respectively second-order closure and stochastic fields modeling. While the first considers a model for the transformation of emission variability into concentration variability, therefore transforming the emission variance around the mean value into concentration variance; the second applies a modeling technique that would transform a probability distribution function (pdf) of sub-grid emissions into a concentration pdf. Through this approach all moments other then the second can be extracted form the concentration pdf. Through this approach all moments other then the second can be extracted from the concentration pdf thus allowing a more complete representation of the variable and of the effect of the sub-grid emission variability on the final result. Both methodologies have been applied to controlled academic cases and both have demonstrated the capability to reproduce the expected result. Future investigation will concentrate to more complicated cases and will consider also the problem of chemically reactive compounds that is the ultimate scope for MEGAPOLI research.

References
**MEGAPOLI Megacity in Focus: The Rhine-Ruhr Region**

Melinda Uzbasich

E-mail: mu@ier.uni-stuttgart.de

Institute of Energy Economics and Rational Use of Energy (IER), University of Stuttgart (USTUTT), Germany

http://www.ier.uni-stuttgart.de/

Introduction

The Rhine-Ruhr region is the most populated, largest urban and industrial agglomeration, and the only megacity in Germany. The concept of a European Metropolitan Rhine-Ruhr region was first suggested in the North-Rhine-Westphalia Regional Development Plan of 1995 (LEP – Landesentwicklungsplan Nordrhein-Westfalen) (see Blotevogel et al., 2006).

In order to statistically define the region, we use the LEP delineations at the county (Kreis) and city (Kreisfreie Stadt) level. According to Blotevogel et al. (2006), with 20 cities and a population of more than 100,000 inhabitants as well as 11 counties (Kreise) with a population over 250,000 inhabitants, the area is a classic example of a polycentric region without a clear hierarchy, with a highly developed transportation network and a diversified export economy. The high industrial and residential density in this region resulted in a degree of regional air pollution.

Geography and Population

The Rhine-Ruhr region has more than 10 mio. inhabitants (2008 census) and an area of 7110 km². It is named after the Rhine and Ruhr rivers, which are both the regions defining geographical features and historically its economic backbone (Blotevogel, 2006). The region lies entirely within the federal state of North Rhine-Westphalia. The official defines borders are: Hamm in the east, Mönchengladbach in the west and Bonn in the south. The northern border is similar to the border of the Ruhr Area.

Economy and Transportation

Present characteristic of this region is the deindustrialisation and structural change. There is a trend to a new regional division of labour. The main industrial centres (for example, the large plants of the chemical and steel industry) are located along the Rhine River from cities of Cologne to Duisburg. Coal mining, chemical industry and metal processing are concentrated in this region. The industrial density of the Rhine-Ruhr Region is still far dropped (Blotevogel, 2006). The region accounts today for roughly 15% of the GDP (Gross Domestic Product) of the German economy. This fact would place it as the 3rd largest GRP (Gross Regional Product) of metropolitan area in the European Union and the 16th largest GDP in the world. The largest economic centres are Düsseldorf and Cologne, with specialization in financial and insurance, high tech and multi media services, respectively. Bonn, Dortmund and Essen are other major economic centres.

Emissions and Air Quality

With frequent west and south-west winds, the region is downwind of other European megacities as London or Paris and impacted by air pollutants transported from the Netherlands. Local climate and air pollution are heterogeneous and quite locally influenced due to the mostly hilly terrain.

The most important emission sources are traffic, industry, small combustion plants and agriculture. The Rhine-Ruhr region is characterized by high emissions, like the PM$_{10}$-emissions as shown in Fig. 1.

The concentrations of fine particles are higher than values discussed in the European Union. The main sources of these pollutants are road traffic, certain industries and secondary aerosol precursors, especially NH$_3$ from agricultural activities. A combined reduction strategy of the emissions of road traffic, industry and agriculture is necessary to achieve lower pollutant concentrations. The annual mean of PM$_{10}$ are shown in Fig. 2.

The mean annual concentrations of many pollutants in this region are still higher than in many other urban agglomerations in Germany.

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During most of the trips our international colleagues joined us: scientists from Germany, USA, Austria, and Finland. We would welcome other colleagues on the future journeys and scientific studies. Normally trip across Siberia takes about two weeks. The equipment used belongs to the Observatory of Geography Department at the Moscow State University. Researches work in a wagon-car laboratory (see photos above) and are accommodated in special passenger coupes. The Figures 1 and 2 present results of CO2 and VOC measurements around the Moscow megapolis. The detailed description and results of the TROICA Project can be found at http://www.ifaran.ru/troica/biblio/ troica-en.pdf /to find material in Russian replace -en.pdf. to -ru.pdf/.

**Conclusions**

We hope that TROICA Project connected now with the Russian MEGAPOLIS Project could be a useful contribution into EU MEGAPOLI Project.

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Evaluating the Regional Impact of Santiago de Chile on Air Quality, Meteorology and Climate

Marcelo Mena-Carrasco
E-mail: mmena@unab.cl
School of Environmental Engineering/Universidad Andrés Bello, Santiago, Chile

Scott Spak1, Gregory R. Carmichael2, Luisa T. Molina2
1 – University of Iowa Center for Global and Regional Environmental Research.
2 – Molina Center for Energy and Environment

Megacities (MC) continue to be attractive to people despite growing environmental concerns in terms of air quality and health. Their environmental footprint can be quite large due to the amount of resources they consume. Recent studies have focused on analyzing air quality impacts from emissions from MC (Mena-Carrasco et al., 2009; Mena et al., 2009). This project integrates the results from projects in North America and Asia (which collected high quality unique chemical and meteorology datasets using aircraft) and new data (C-130 aircraft data from VOCALS campaign) to answer basic questions regarding MC impacts, and allows inferring what makes cities in Asia, North America and South America different. The lower background pollution in the southern hemisphere makes it easier to observe long range transport, and anthropogenic pollution tends to be from the continent nearby, and not from intercontinental transport (Figs. 3, 4).

It will combine observations from the C-130 aircraft, photochemical models data assimilation (4DVar), to determine megacity influence on air quality (tagging modeled contributions to observed values), photochemistry (sensitivity runs that remove effect of aerosol on calculation of photolysis frequencies), meteorology (correlating observed and model chemical parameters to changes in cloud properties) and climate (calculating direct and indirect effect of MC emissions on radiate forcing through a radiative transfer model).

This research is very relevant as it builds on previous work on MC impacts, and allows inferring what makes cities in Asia, North America and South America different. The lower background pollution in the southern hemisphere makes it easier to observe long range transport, and anthropogenic pollution tends to be from the continent nearby, and not from intercontinental transport (Figs. 3, 4).

The project will also focus on obtaining relationships between urban plumes and changes in cloud properties as observed by GOES (Fig. 3). Finally the project will focus questions that are more policy oriented questions such as how will future Santiago growth increase or decrease concentrations of PM2.5, O3 exposure and health effects. Also the effect of a changing climate (represented by meteorological conditions for 2050 from a regional climate model) will be assessed on future air quality scenarios. To conclude, the effectiveness of smart growth on reducing emissions, concentrations, and health effects will also be evaluated.

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Spak S., M Mena, G R Carmichael (2009): Influences of land-ocean-atmosphere dynamics and emissions sectors on atmospheric chemical transport during VOCALS-REX. AGU Fall Meeting.
The results of surface ozone observations have a local nature but can serve to develop a method of control for ozone concentrations with a help of mathematical modeling and use of observation data. For studying the surface ozone formation in the Kiev metropolitan area, the UAM-V model is used, which combines calculations of emission flows of O₃ forming species, their transfer and turbulent motions, formation of urban plume of primary pollutants, their photochemical transformations and production of secondary pollutants, including surface ozone. The result of the modeling of enhanced O₃ episode (Shavrina et al., 2008) for 18-22 Aug 2000 with cloud-free weather, negligible diurnal variations of pressure, weak transfer of air mass and lack of precipitations is shown in Fig. 2.

Two days simulation of this ozone episode were performed scaling emission data averaged daily and hourly on a basis of annual volumes and further hourly scaling of car emissions. Fig. 3 shows the comparison of calculated with UAM-V ozone concentrations and data of measurements in National Botanic Garden for these days. Ozone concentrations show non-linear variation depending on average hourly NOₓ emission data (curves 2 and 3). The comparison of ozone modeled vs. measurements shows a necessity of temporal modulation of VOC and NOₓ emissions taking into account diurnal and specific weekday traffic intensity variations (curve 4).

It was revealed that situations of nocturnal decrease of O₃ to minimum value (about zero) were almost not observed. On the contrary, at night as a rule it is observed the secondary maximum of surface ozone, which for the lack of photochemical processes, is probably formed in the result of ozone sinking from boundary level. As it is known, for the regions of enhanced anthropogenic impact, the troposphere ozone production takes place not only near the earth surface, but also in the boundary level.

References

Acknowledgments
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The Night Time Lights of Urban Areas

Daniel Ziskin

E-mail: Daniel.Ziskin@noaa.gov
NOAA/National Geophysical Data Center
University of Colorado/ Cooperative Institute for Research in Environmental Sciences
http://www.ngdc.noaa.gov/dmsp/dmsp.html

Ziskin D, Elvidge C, Baugh K, Tuttle B, Ghosh T
1 - National Geophysical Data Center, NOAA, Boulder, CO
2 - Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder
3 - Geography Dept, University of Denver, Denver, CO

Introduction
One of the most obvious characteristics of the human-built environment is lighting at night. It is so prominent that cities can be confidently mapped by the light they emit to space at night (Fig. 1). The Defense Meteorological Satellite Program (DMSP), run by the United States Air Force, has been monitoring the Earth at night and producing digital data for almost two decades. These data are archived at the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC). The useful data record stretches back to 1992 and is on-going. The DMSP satellites that have contributed to this data record have three shortcomings that have limited their utility in the study of mega-cities. These limitations are poor spatial resolution, lack of calibration, and saturation at urban light levels. The spatial resolution is ~30 arc seconds (or about 1 km depending on latitude), which is fine enough to discern large-scale structure. But much of the detail that is easily obtainable from day lit imagery is blurred (Fig 2).

The second two limitations are being actively addressed by the NGDC staff in hopes of creating exciting new applications for a familiar dataset. We are in the process of calibrating the DMSP imagery using reflected moonlight off of selected desert surfaces in order to compare observations to modelled absolute radiances. Secondly we are blending unsaturated observations of the urban cores with operational data to effectively extend the dynamic range of the instrument. These soon-to-be-implemented enhancements will greatly increase the scientific value of these data. Absolute calibration will allow more accurate comparisons from year to year and across satellite platforms. Blending in low gain unsaturated observations will provide detailed imagery where the observational data merely indicated the presence of bright light.

Absolute Calibration
The DMSP is comprised of a series of satellites, staggered in time to achieve continuous coverage. Each satellite has an Operational Linescan System (OLS) instrument that has the ability to resolve light levels a million times lower than a typical daytime imaging detector. The local overpass time of each satellite drifts as its orbit degrades (Fig. 3). Unfortunately for scientific applications, the visible channel of the OLS does not have an absolute calibration function. Relative calibration is further confounded by factors such as the drift of satellite overpass times, instrument degradation, and changes in anthropogenic light sources. These hurdles can be addressed by devising a system of absolute calibration based on geophysical observations. By observing reflected moonlight off of high-albedo desert surfaces, it is possible to model the absolute radiance impinging on the instrument. The efficiency of the OLS can be estimated as the ratio of observed to modeled radiance.

In order to determine the radiance observed by the OLS, it must be deconvolved from the Digital Number (DN) in the data stream taking into account DNmax (maximum value) and Rs (saturation radiance, which is a function of the instrument’s gain setting). The gain setting varies frequently both with scan angle of the detector (across track) and with latitude (along track). The gain setting is not recorded in the data stream and must be calculated as a function of instantaneous solar and lunar elevations and lunar phase relative to the satellite. Furthermore the gain is a function of pre-loaded onboard constants which are particular to each satellite. A selection of several desert locations was made to model the reflected moonlight. These sites are all Landsat calibration locations, chosen for our use because of factors including high reflectance, limited vegetation, snow cover, or standing water, limited anthropogenic lighting, and representation from both northern and southern hemispheres (Fig. 4).

This method of calibrating the data have not been yet completed, but it shows great promise for adding scientific value to the DMSP night lights data set.

Urban Saturation
The OLS instrument in standard operational mode saturates over most urban areas. This is useful for determining if there is or is not a city present at a particular location. On selected occasions the US Air Force collects "Fixed Gain" data. Data is collected with the gain of the instrument set at a specified value for the night time period of the orbit. It is typically set to run through a series of values over consecutive nights during the dark portion of the lunar phase. The three fixed gains that are cycled through are FG55, FG35, and FG15. FG55 is very close to the gain setting that the OLS normally functions under so FG55 resembles the operational data. FG35 is reduced in sensitivity by a factor of 10, and so many pixels that would normally saturate at FG55 remain unsaturated. FG35 is able to resolve the edges of cities, but still saturates in bright urban cores. FG15 is reduced in sensitivity by another factor of 10 or 100 times less sensitive than operational data. FG15 rarely saturates and is able to resolve most urban data.

Conclusion
The DMSP Night Lights dataset has created a time series of unique observations. Two soon-to-be-implemented enhancements will greatly increase the scientific value of these data. Absolute calibration will allow more accurate comparisons from year to year and across satellite platforms. Utilizing the fixed gain observations will provide detailed imagery where there were previously saturated pixels.

References
The Finnish Meteorological Institute (FMI: http://www.fmi.fi/en) has the mandate of producing reliable scientific information on the state of the atmosphere, as well as contributing to scientific ends. FMI employs about 550 people, about 250 of which are involved in research.

The main contributions up to date
FMI coordinates WP5 in collaboration with NILU. We have informed the participants on the details regarding the construction of the European model ensemble, and archived the required input data for this model exercise. The fire assimilation model, describing the emissions and dispersion of plumes from wild-land fires, is now operational (http://silam.fmi.fi). The model structure has also been recently published in ACP. An archive has been generated for general use in MEGAPOLI that contains global and European inventories of fire emissions and concentrations for numerous years.

We have also evaluated the use of satellite data (CALIOP level 2 aerosol subtypes) for the purposes of MEGAPOLI. A new sea salt emission model has been constructed and evaluated (included in the SILAM dispersion model) against experimental data. This emission sub-model is also available to be used by the participants of MEGAPOLI.

The first version of the morphological database for Paris was released in September 2009. This work is collaboration with the Helsinki University of Technology. An area of 6 x 3 km around Place d’Italie has been surveyed in detail. The database contains selected thematic layers on water, parks, trees, streets, buildings, average height of blocks, digital elevation model of the terrain, so-called coherence, and the surface heat flux. A larger area, covering the interior of the beltway around Paris, has also been surveyed with lesser detail and lower resolution. The building-block height data still needs to be verified and possibly calibrated. This will be completed by the end of 2009.

We are currently finalizing the merge of the SILAM dispersion model and the detailed aerosol process model SALSA. This combination of models will allow a substantially improved investigation of various science questions regarding the formation and transformation of atmospheric aerosols, in collaboration especially with the University of Helsinki.

A Vaisala ceilometer was sent by the FMI team to be used in the Paris experimental campaign at the Laboratoire d’hygiène de la Ville de Paris (LHVP) site. This instrument is used for the determination of mixing height. The processing of the data is in progress.

Methods have also been developed for the evaluation of population exposure, and several journal articles have been published in this area. The aim is to apply the methodologies in Paris and London, in collaboration with the University of Hertfordshire and CNRS/Lisa.

Role and contribution
The FMI role and contribution into the MEGAPOLI project include: co-coordination of WP5, lead of the Task 1.2: Biogenic and natural global emission inventory; the Task 2.1: The classification and database for urban surface and morphology, and the Task 3.5: Exposure estimates.

Researchers involved

From left: Michael Boy (UHel), and FMI Team - Jukka-Pekka Jalkanen (jukka-pekka.jalkanen@fmi.fi), Jaakko Kukkonen (jaakko.kukkonen@fmi.fi), Antti Hellsten (antti.hellsten@fmi.fi), Mikhail Sofiev (mikhail.sofiev@fmi.fi)
Role and Contribution

The CNRS-LISA role and contribution into the MEGAPOLI project include:

- campaign planning and organization (dedicated campaign in Paris region, WP3);
- extensive gas phase measurements during the summer and winter campaign;
- urban / regional / continental scale modelling with the CHIMERE model for Paris and several megacities.

Airborne gas phase measurements (VOC, NOy species CO) have been performed during ATR-42 flights during the summer campaign, extensive gas phase measurements have also been performed at the SIRTA site during both summer and winter campaign, specific oxygenised VOC measurements also at LHVP.

Modelling is both performed for campaign interpretation and for scenario simulations (WPs 5, 8).

Researches Involved

Matthias Beekmann
beekmann@lisa.univ-paris12.fr

Isabelle Coll
icoll@lisa.univ-paris12.fr

Agnès Borbon
sorbon@lisa.univ-paris12.fr

Aurélie Colomb
colomb@lisa.univ-paris12.fr
(now at CNRS-LaMP)

Warda Ait-Helal
warda.ait-helal@lisa.univ-paris12.fr

Guillaume Siour
siour@lisa.univ-paris12.fr

Qijie Zhang
zhang@lisa.univ-paris12.fr

Charbel Afif
aff@lisa.univ-paris12.fr

Vincent Michoud
Vincent.michoud@lisa.univ-paris12.fr

Sebastien Perrier
Sebastien.Perrier@lisa.univ-paris12.fr

Killian Miet
Killian.Miet@lisa.univ-paris12.fr

Catherine Schmechtig
schmechtig@lisa.univ-paris12.fr

Not Pictured:

Helene Mac Leod
macleod@lisa.univ-paris12.fr

Noel Grand
grand@lisa.univ-paris12.fr

Pascale Chelin
chelin@lisa.univ-paris12.fr

Servanne Chevaillier
chevaillier@lisa.univ-paris12.fr

Régine Jolibois
jolibois@lisa.univ-paris12.fr

Joelle Bechara
bechara@lisa.univ-paris12.fr

Jean-François Doussin
doussin@lisa.univ-paris12.fr

Hervé Petetin
herve.petetin@lisa.univ-paris12.fr

Laetitia Scotti
scotti@lisa.univ-paris12.fr
The Institute for Geography covers all fields of geography including economic and social effects (e.g. regional accounts of environmental risks). Since the early nineties indicators of sustainable urban development, planning strategies and scenarios for urban restructuring are elaborated at the institute. More recently basic and applied research on urban growth strategies has been included within a frame of concepts of ecological modernization in urban governance. Currently the Geographers are involved in projects of recent trends of re-urbanisation and a new meaning of compact city strategies. The empirical work is based on GIS technologies.

Role and contribution
The University of Hamburg is involved in WP2, WP5, WP7 and WP8 with a focus on mesoscale modelling. Within WP2 the Meteorological Institute will improve an existing parameterisation for sub-grid-scale urban surface fluxes. The improved calculation will be implemented in M-SYS and validated for the Rhine-Ruhr region. The influence of anthropogenic heat on mesoscale meteorology will be tested in the mesoscale model system for an exemplar region and will be evaluated.

M-SYS participates in ensemble runs on different scales performed in WP5. The special regional focus will be on the Rhine-Ruhr region. Furthermore, evaluations will be performed for the Paris field experiments.

The Meteorological Institute will co-lead WP7 and additionally contribute by leading task 7.3, developing a joint evaluation method for the MEGAPOLI project and apply it to the various models and applications. This will result in the framework of integrated tools for air quality modelling. Later on the evaluated M-SYS will be implemented for Shanghai, and studies on the Shanghai impact on the surrounding air quality will be performed.

The Institute for Geography contributes to WP8 by developing scenarios of possible evolutions of megacities (Paris, London, Rhine-Ruhr, Shanghai, Mexico City, Shanghai) by qualitative descriptions of the possible development of settlement structure and infrastructure. This will support assumptions about the effect of these scenarios on transport, energy supply and emissions of air pollutants. Based on these assumptions the future paths of air quality and climate impact of megacities can be investigated.

Researchers involved

K. Heinke Schlünzen  
heinke.schluenzen@zmaw.de

Jürgen Oßenbrügge  
oessenbruegge@geowiss.uni-hamburg.de

Ole Roß  
ole.ross@zmaw.de

Ursula Bungert  
ursula.bungert@zmaw.de

David Grawe  
david.grawe@zmaw.de

Malte Uphoff  
malte.uphoff@zmaw.de

Not Pictured:

The Institute of Geography has its 38000 students Germany's 5th largest university. Structured in six faculties, the Faculty of Mathematics, Informatics and Natural Sciences is one of the largest and includes the Earth Sciences Department with the Meteorological Institute and the Institute for Geography.

The Meteorological Institute is part of the Centre for Marine and Atmospheric Sciences (ZMAW), where researchers and PhD students jointly work in marine, climate and earth system research. Institute members collaborate in more than 100 national and international projects, and contribute to or coordinate several EU projects and COST actions.

Since October 2007 the cluster of excellence “CiICAP” (Integrated Climate System Analysis and Prediction, www.cisap.de) brings together about 900 scientists from seventeen disciplines on the “KlimaCampus” (www.klimacampus.de) not only working on the physical basis of climate change but on social, economic and political implications. The research focuses on climate analysis, climate variability, climate and humans, and regional effects and risks. The MEGAPOLI Principal Investigators K. Heinke Schlünzen and Jürgen Oßenbrügge (Institute for Geography) coordinate the working group on urban systems within CiICAP.
To investigate this area we are using the UK Met Office Unified Model coupled to the recently-developed UKCA chemistry and aerosols module, both at the typical climate resolution (1.875x1.25 degrees ~200km) and at a higher resolution, normally used for global weather forecast (0.56/0.37 degrees ~40 km). In these studies we will focus on assessing how megacity emissions affect the surrounding region: the ‘Megacity enhancement’ of different pollutants relative to the background in the region is calculated and we show how this quantity varies for each Megacity with increased model resolution.

We will also perform sensitivity studies on the effect of removing Megacity emissions, or re-distributing Megacity emissions to a larger ‘sub-urban area’, which can inform policy makers on the efficiency of different Megacity planning policies. The novel aspect of this work is the use of a high resolution global model and comparison to previous studies which have used lower horizontal and vertical resolution.

Additional work will involve comparison with higher resolution regional CTM results and therefore provide a better assessment of uncertainty in the representation of export processes and fast chemistry in global models.

Our high resolution global model can also provide an alternative set of lateral boundary conditions for modelling studies over London (as part of WP7).

**Researchers involved**

Prof. John Pyle  
Chemistry Dept, University of Cambridge  
john.pyle@atm.ch.cam.ac.uk

Dr. Maria Russo  
NCAS Research Scientist  
Chemistry Dept, University of Cambridge  
maria.russo@atm.ch.cam.ac.uk

Zadie Stock  
PhD student  
Chemistry Dept, University of Cambridge  
zadie.stock@atm.ch.cam.ac.uk

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The Centre for Atmospheric Science (CAS: [http://www.atm.ch.cam.ac.uk/](http://www.atm.ch.cam.ac.uk/)) is a joint venture between the Departments of Chemistry, Geography and Applied Mathematics and Theoretical Physics at the University of Cambridge, Cambridge, UK (UCam; [http://www.cam.ac.uk/](http://www.cam.ac.uk/)).

CAS pursues fundamental research into the chemical and physical processes controlling the structure and composition of the Earth’s atmosphere. The research programme comprises laboratory studies, field measurements, modelling and theoretical analysis, and a major strength of CAS is in the strong interactions between these various disciplines. Researchers at the Centre for Atmospheric Science have been actively developing and applying a range of chemistry-transport models and chemistry-climate models to numerical studies of the troposphere and stratosphere for more than 20 years, and have particular expertise in the areas of tropospheric oxidation processes, long-range transport, stratosphere-troposphere coupling, chemistry-climate feedbacks, stratospheric ozone hole development and recovery, and evaluation of models against atmospheric measurements. CAS has been a major contributor to national, European and international research projects, recently including ACTO, EXPORT, ITOP, MOZAIK, POET, RETRO, THALOZ, TRADEOFF, ACCENT, HTAP, AMMA, ACTIVE, SCOUT-O3 and OP3.

**Role and contribution**

The UCam Team contribution to the MEGAPOLI project is mainly on WP5 and focuses on exploring the regional and global effects of megacities on atmospheric composition and climate, with particular emphasis on the importance of model resolution for a correct representation of Megacity emissions and transport processes.
Role and contribution

The USTUTT role and contribution into the MEGAPOLI project include the responsibility for the Rhine-Ruhr Area. For this megacity USTUTT has compiled a highly spatially resolved emission inventory. Furthermore, USTUTT leads and coordinates the compiling of emission scenarios for future years until 2050 for Europe and selected megacities (WP1). USTUTT co-leads the WP8 “Mitigation, policy options and impact assessment”. This workpackage deals with the beginning and end of the full chain or impact pathway approach of integrated assessments to be carried out in the project. In this project it is important to define policy questions to be answered in the assessment, and to create scenarios, at the beginning of the project, while towards the end it becomes important to assess the impacts of different policy options and prepare recommendations for specific actions in cooperation with policy makers, in particular the megacity administrations and the EC. WP8 is linked with WP7 “Integrated tools and implementation”. Therefore, USTUTT contributes also to WP7.

Researches involved

Rainer Friedrich
rf@ier.uni-stuttgart.de

Jochen Theloke
jt@ier.uni-stuttgart.de

Ulrike Kugler
uk@ier.uni-stuttgart.de

Melinda Uzbasich
mu@ier.uni-stuttgart.de

The Institute of Energy Economics and the Rational Use of Energy Use, USTUTT (http://www.ier.uni-stuttgart.de) has been engaged in research work in the fields of air pollution control for many years. Research on “Air Pollution Control” and “Technology Assessment” has focused on generation of emission inventories, identification of emission reduction strategies, technology assessment, environmental economics, quantification and assessment of environmental damage and risks to human health and estimation of external costs of energy and transport systems. USTUTT is involved, as co-ordinator or participant, in a wide range of EU research projects and has a long experience in international research cooperation within both EU and Eastern European countries as well as developing countries. Results of USTUTT research have been actively disseminated through close links to public institutions, politicians, industry and private households. The areas of interest are the following:

- the development and application of methods and models for the calculation of anthropogenic emissions of air pollutants and greenhouse gases preparation of emission scenarios for future years;
- theoretical and experimental determination of uncertainties of calculated emission data;
- identification of efficient strategies for the reduction of emissions and ambient concentrations of air pollutants and greenhouse gases;

Figure 1: Integrated Assessment Modelling System.
Currently FG MSU develops modern methods of integration of the observation data and nested modelling system (e.g. Fig.2) results for meteorological and pollution regimes for megacity. We fruitfully study an impact of air pollution on public health. The environmental geochemical assessment is other direction of FG MSU research for MEGAPOLI/MEGAPOLIS. In particular, the pollutant concentrations within soils and snow cover are one of the essence signatures of the cumulative air quality. Study of their seasonal and long-term changes is also a part of FG MSU contribution to MEGAPOLI/MEGAPOLIS.

Researchers Involved

Nikolay Kasimov
secretary@geogr.msu.ru

Alexander Kislov
avkislov@mail.ru

Svetlana Malkhazova
sveta_geo@yahoo.com

Natalja Chubarova
chubarova@imp.kiae.ru

Natalja Sokolikhina
nsokolikhina@mail.ru

Natalja Kosheleva
natalik@mail.ru

Victor Stepanenko
vstepanenko@meister@gmail.com

Galina Surkova
galina.surkova@gmail.com

Pavel Konstantinov
kostadini@mail.ru

Pavel Toropov
tormet@inbox.ru

Natalia Shartova
shartova@yandex.ru

As well as (not pictured), Elena Nikiforova, Elena Baldina, Irina Labutina

Submitted by: Galina Surkova

System «Megapolis – air pollution – public health»

ASSESSMENT MODELLING MAPPING PREDICTION

ANALYSIS SYNTHESIS RESULTS VERIFICATION PRESENTATION OF RESULTS

SYSTEM DESCRIPTION SYSTEM MANAGEMENT

Figure 1: Integrated tools for atmospheric pollution and public health assessment.

Figure 2: The technology for high resolution modelling of meteorological conditions and pollution in megacity.
The action fields of the ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) are “research, innovation technology and advanced services in the fields of energy - especially nuclear energy - and sustainable economic development”. In this framework, ENEA’s activities are particularly focused on: sustainability of energy, the natural risks in which the national territory is exposed due to the effects of Climate Change, the adaptation and mitigation policies, the environmental balance and territory. The ATMOSFERA TEAM activities are included in these last targets.

**ATMOSFERA Team**

The expertise of the ATMOSFERA Team is in the urban air quality investigation and in the air pollution modeling as well as in the realization and application of the environmental tools and in the project coordination in the industrial areas. The team had realized an automatic intelligent system ATMOSFERA for predicting urban pollution concentrations (CO, SO2, O3, PM10, NO2 and C6H6) hourly at 24, 48 and 72 in advance. The first version of this computer system was developed in 1998 based on remote sensing experiments and micrometeorological campaigns results inside the city of Rome. Following further researches, specifically designed for air pollutant predicting, neural networks were developed for the Milan application, where ATMOSFERA system has been used by the city governments for the decision-making on the air pollution, and after its functionality was demonstrated in the city of Naples.

**ATMOSFERA Project**

During followed path of studies and experimentation on deterministic and statistical models, a solution, based on a neural-network model, has been adopted for ATMOSFERA. The neural network applications for predicting and monitoring urban air quality have generally concerned instances limited in space and time and in which convective components, such as the Planetary Boundary Layer (PBL) in particular, are not considered in a specific way. ATMOSFERA is a complex computer system integrating software, sophisticated equipments, mathematical models, communications networks, monitoring and prediction functions and operational procedures (Fig. 1). ATMOSFERA features are also:

- **Operational**: in supporting decision-makers to prevent and manage acute air pollution events and define strategies to fight pollution;
- **Automatic**: in learning process, in forecasting more detail meteorological data and in pollution prediction;
- **Replicable**: in any urban area where there is a knowledge base of the meteorological conditions.

ATMOSFERA is a valuable tool for preventing worse air quality or mitigating critical pollution situations in the city and for estimating the effectiveness of preventive actions at a later stage.

The scope of the ATMOSFERA performance is aimed as a support for local decision-makers, responsible for protecting public health.

**Role and Contribution**

The ATMOSFERA role and its contribution into MEGAPOLI project include: (1) providing to local administrations a tool for preventing, averting and mitigating critical situations linked to air quality into the city, (2) giving researchers the opportunity to open new frontiers for studies to understand air pollution transport and accumulation phenomena in cities, (3) forecasting pollutant concentrations and Planetary Boundary Layer height dynamics.

**Researchers Involved**

Maria Cristina Mammarella  
maria.cristina.mammarella@enea.it

Giovanni Grandoni  
giovanni.grandoni@enea.it

Pasquale Fedele  
pasquale.fedele@enea.it
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

- Baklanov A. et al. - Invited talk on MEGAPOLI at WMO, COST-728, MEGAPOLI End-user Workshop, Geneva, Switzerland, 24-26 Feb 2010
- Beekmann M. et al. - Invited talk on MEGAPOLI at European Geosciences Union General Assembly (EGU-2010), Vienna, Austria, 2-7 May 2010

See more MEGAPOLI Publications/ Presentations at http://megapoli.info

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present the MEGAPOLI Project results and findings:

- European Geosciences Union General Assembly (EGU-2010)
  Vienna, Austria, 2-7 May 2010
  (special MEGAPOLI, CityZen, MILAGRO session)
  http://meetings.copernicus.org/egu2010/
- 5th ICTP Workshop on the Theory and Use of Regional Climate Models;
  Trieste, Italy, 31 May - 11 Jun 2010
  Contact Filippo Giorgi, ICTP Team, giorgi@ictp.it
- 13th Urban Environment Symposium
  Gothenburg, Sweden, 9-11 Jun 2010
  http://www.hues.se/
- 10th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes; Paris, France, 1-4 June 2010
  http://www.harmo.org/harmo13
- International Conference and Early Career Scientists School on Environmental Observations, Modeling and Information Systems (ENVIROMIS-2010); Tomsk, Russia, 5-11 Jul 2010
- International Aerosol Conference
  Helsinki, Finland, 29 Aug – 3 Sep 2010
  http://www.iac2010.fi
- 10th European Meteorological Society (EMS-2010) Annual Meeting and 8th European Conference on Applied Climatology (ECAC)
  Zurich, Switzerland, 13-17 Sep 2010
  (special MEGAPOLI session)
  http://meetings.copernicus.org/ems2010/
Welcome to the 7th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 7th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users. Contributions to newsletters and news at the website as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – MEGAPOLI 2nd Annual Meeting (1-2 Nov 2010; Hamburg, Germany)
- Coming soon – 5th MEGAPOLI WP Leaders telephone conference (14 Jul 2010)
- Coming soon – MEGAPOLI Paris Plume Study Workshop (14-15 Jun 2010; Paris, France)
- Coming soon – Database from the Paris summer (Jul 2009) measurement campaign became available (10 Jun 2010)
- 31 May 2010 – MEGAPOLI Mid-Term Scientific (coordination, management, dissemination and deliverables/ reports) Periodic Reporting to EC - finalized through the newly established ECAS portal system
- 3-4 May 2010 – special MEGAPOLI, CityZen, MILAGRO session & joint meeting at European Geosciences Union General Assembly, EGU-2010 (Vienna, Austria)
- 27 Apr 2010 – 4th MEGAPOLI WP Leaders telephone conference
- 19 Mar 2010 – working meeting of MEGAPOLI and Russian MEGAPOLIS projects’ collaborators; progress report of the daughter project

MEGAPOLI Periodic Reporting to EC

The FP7 EC MEGAPOLI project has reached the mid-term point. Just recently the MEGAPOLI Project Office has finalised contributions from all partners/teams as a joint Mid-Term Periodic Report and sent it together with 16 Deliverables/Reports, Description of Work (DoW), 6 NewsLetters, etc. to the EC Scientific Officer through a new ECAS reporting web-portal. The first 18 months of research performed since the beginning of the project have been focused on the following:

- Field measurement campaigns in the Paris metropolitan area (France):
  (i) Summer - July 2009;
  (ii) Winter - January/February 2010;
  (iii) Analysis and modelling;
- Emissions database and future megacity scenario development;
- Continued model development from urban to global scales, analysis and interactions;
- Bringing these various activities together with first steps towards integrated modelling and mitigations scenarios;
- Modelling to quantify feedbacks among megacity air quality, local and regional climate, and global climate change.

The MEGAPOLI WPs status and progress during the first reporting period were up-dated at the public MEGAPOLI web-site (http://megapoli.info) in section “Project Results” including:

- Summary and progress toward objectives;
- Summary details for each WP deliverables, milestones, and tasks;
- Significant results: methodologies and scientific achievement related to WP including partners’ contributions;
- Socio-economic relevance and policy implications;
- Discussions and conclusions;
- List of WP reports, publications, presentations.

See details on the next pages
The FP7 EC MEGAPOLI project has reached the mid-point of its duration and it is time to make first overall view on realisation of project tasks and first scientific achievements. Recently we finalised Mid-Term Periodic Report based on contributions from all MEGAPOLI teams and sent it to the EC. Here, only a very short statement of the MEGAPOLI current results is presented.

MEGAPOLI is contributing to the strategic goal of promoting sustainable management of the environment and its resources by advancing our knowledge on the interactions between air quality, climate and human activities related to large urban centres and hotspots. The main MEGAPOLI objectives are:

(i) to assess impacts of megacities and large air-pollution “hot-spots” on local, regional, and global air quality and climate;

(ii) to quantify feedbacks between megacity emissions, air quality, and local, regional and global climate;

(iii) to develop and implement improved, integrated tools to assess the impacts of air pollution from megacities on regional and global air quality and climate and to evaluate the effectiveness of mitigation options.

The main scientific results achieved during the reporting period include the following:

1. Two intensive measurement campaigns were performed around Paris during summer and winter month periods. The campaigns aimed at better quantifying primary and secondary organic aerosol (SOA) sources for a European megacity, and included 3 primary and 7 secondary fixed ground measurement sites, an aircraft and 5 mobile vans. More than 25 research laboratories participated. We found that the pollution plume was still well defined at more than 100 km downwind from the agglomeration, which gives a clear framework for later studying SOA build-up in the plume. Significant new particle formation events were observed in the area during the whole month of the campaign. During the winter campaign, large PM levels were observed both due to a strong local wood burning source and due to continental advection.

2. Prototype inventories for anthropogenic (base year of 2005, 6 km resolution) and natural (e.g., fire, sea salt) emissions were compiled. For the 1st level megacities (Paris, London, Rhine-Ruhr area, Po Valley) high-resolution emission data have been collected, for integration with the final European scale emission map. An anthropogenic heat flux (AHF) model (0.25 x 0.25 arc-minute resolution) was developed and used to compute the AHF inventories for Europe and London.

3. A morphology database for Paris has been developed, along with a hierarchy of urban canopy and energy bud get parameterisations for different scale models, which are being used to evaluate the surface flux balance modelling and urban features needed for climate and air quality models.

4. New physical and chemical parameterisations and zooming approaches have been implemented and are being tested for several megacities (e.g., Paris, Mexico City, and Po Valley), providing information about the relative importance of the various parameterisations when examining megacity air quality and especially its relation to meteorology. Coupled ACT-NWP models with two-way feedbacks were used to classify meteorological patterns favouring development of urban air pollution episodes in European megacities as well as to study effects of megacity emissions on meteorological processes. Urban aerosols were found to significantly affect several meteorological variables (temperature, inversion layers, radiation budget, cloud processes, precipitation, fog, etc.) in and far from the megacities due to the direct and indirect effects.

5. Substantial progress was made in developing and evaluating the satellite-based methods for the measurement of tropospheric gases and aerosols, especially NO2 in and around megacities. For construction of a regional model ensemble the harmonization of European domain parameters, input data and other modelling details was realized.

6. The radiative forcing from megacity emissions on the global scale was examined. Generally, megacities contribute about 2% to 5% of the total global annual anthropogenic emission fluxes for various compounds. Megacity pollutants were found to contribute a radiative forcing of +6.3±0.4 mW/m2 from an increase in the ozone burden, while the impact on CH4 contributes a forcing of -1.0±0.5 mW/m2. The aerosol forcing from megacity pollutants amounts to -15.3±0.6 mW/m2 in the short-wave spectrum and +2.0±0.1 mW/m2 in the long-wave spectrum. Combined this gives -8.0±1.6 mW/m2 under present-day conditions.

7. Progress has been made on producing a European framework for online and offline coupling of meteorological and atmospheric chemical transport models.

The achieved results have been reported in 15 scientific reports, 7 Newsletters and in a number of journal publications (see the next page and the MEGAPOLI project web-site: http://megapoli.info).

References

http://megapoli.dm.dk/publ/MEGAPOLI_sr09-03.pdf

Baklanov et al. (2010): MEGAPOLI Mid-Term Periodic Report (internal).

Are the cities to blame for climate change/global warming?

- On the city and meso-scale (AGH), "Yes" contributions via UHI and emissions.
- On regional and continental scale, UHI extends up to thousands km, so it could offset CC.
- On global scale: probably "No" due to UHI, but "Yes" due to GHG emissions (anthropogenic CO2, CH4, N2O and tropospheric ozone)
- Source of aerosols which have both direct and indirect (radiation effects cooling or warming)
- Currently to make conclusions, new multi-scale studies are necessary!

Measures to reduce urban drivers of climate change, e.g.:

- Reducing GHG and aerosol emissions
- Reducing traffic congestion
- Switch in traffic & less GHG scale effects
- Connecting energy and water
- Greater use of passive heating and cooling technology
- More compact city design and greater use of buses/transportation
- Intelligent use of trees to shelter or shade
- Increased use of light colored surfaces in hot cities.
http://megapoli.net/MEGAPOLI_Dw.pdf

http://megapoli.dmi.dk/publ/MEGAPOLI_sr09-01.pdf

http://megapoli.dmi.dk/publ/MEGAPOLI_sr09-02.pdf

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http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-12.pdf
Numerical Experiments for Central Paris with Urbanized Large-Eddy Simulation Model PALM (MEGAPOLI Del 2.4)

Igor Esau
E-mail: igor.esau@nersc.no
Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research
http://www.nersc.no

Problem Formulation
Meteorological models require modifications of the surface layer parameterization to account for urban effects. In this limited presentation, we discuss only the simplest modification introduced through \( z_0 \) - surface roughness, \( d_0 \) - displacement height and \( h_b \) - the height of the urban canopy (Britten & Hanna, 2003). In a near-neutral flow, the velocity profiles \( u(z) \) at heights \( z > h_b \) reads \( u = u_0 \kappa^{-1} \ln((z - d_0)/z_0) \) (1) where \( u_0 \) is the friction velocity, \( \kappa = 0.4 \) is the von Karman constant. Free parameters \( z_0 \) and \( d_0 \) characterize the aerodynamic surface roughness on sub-grid scales and the aggregated displacement height of the grid cell. Those parameters must be fitted either to measured or the simulated in much finer resolution model profiles. The latter approach is the subject of this study. The Ekman boundary layer (EBL) over Paris morphology is simulated with the urbanized PALM large-eddy simulation code. Fine resolution model data are aggregated on scales 0.5 km, 1.0 km and 2.0 km and parameters’ dependence on the urban canopy height is investigated.

Urbanized City-Scale Turbulence-Resolving Model
The parallelized code PALM was urbanized as described in Letzel et al. (2008). The method introduces block-cubic surface where boundary conditions, including Monin-Obukhov surface layer, can be prescribed on each of 5 facets. The CRAY-XT4 computer of the Bergen University Parallab was used to compute the experiments over the entire central Paris domain as defined by the MEGAPOLI Paris morphology database. In this study, the run resolution was 50 m x 50 m x 25 m, which require ~1 hour x 32 CPU to complete the run. Figure 1 shows the composite surface elevation used for this study. The model was run for 11 hours over the rural surface (Paris without buildings), then the surface map was changed by urban one and the model run for another 3 hours. With the prescribed westerly geostrophic wind of 5 m/s, it means ~50 km of an average air particle path over urban surface, which correspond to the megapolis extension.

Results
The vertical cross-section of the instant wind speed in the urban simulations with PALM is given in Figure 2. The wind profiles from the PALM run were aggregated (averaged) within 0.5 km (100 profiles), 1.0 km (400 profiles) and 2.0 km (1600 profiles) squares covering the experiment domain. Each averaged profile was used to fit theoretical profile (1) using the least square minimization in the 2D \( (z_0, d_0) \) parameter space. Figure 3 exemplifies the procedure. The best fit maps at resolution 1 km (suitable for Enviro-HIRLAM domain P01 studies) are given for \( z_0 \) in Figure 4 and for \( d_0 \) in Figure 5. The average \( z_0 \) over the entire domain is 1.7 m and \( d_0 = 47 \) m whereas \( h_b = 60 \) m. By comparison, Garratt (1992) relationship \( d_0 = 2/3h_b \) (2) predicts \( d_0 = 40 \) m.

Discussion
The obtained LES data are compared with empirical relationship (2) given in Garratt (1992) and often utilized in model urbanization. Figure 6 reveals that urban data do not support (2) as such. It is general shape of the large-scale surface morphology, obtained in “rural” simulations without buildings, which fits (2) while with some non-negligible offset. Simulations with buildings on the top of the digital elevation model morphology actually deteriorate the agreement suggesting that the surface roughness becomes less dependent on \( h_b \). This is also supported by increasing number of squares with no dependence on the building height whatsoever. Their relative fraction increases for small aggregation scales. Generally, the proportionality coefficient of unity seems to be satisfactory for both datasets and all scales of aggregation. One should recognize, the building height itself (about 50 m) is only a small fraction of the surface height differences (about 180 m), it is obvious from Fig. 2.
MEGAPOLI Paris Plume Study (WP3)
See more details at http://megapoli.lisa.univ-paris12.fr

SAFIRE Team at work

LHVP site

SIRTA site

Seminars and Discussions

Work on the MEGAPOLI WP3 Database

Figure 6: Dependence between the displacement height and the averaged surface height within the aggregation area. Small dots – data aggregated over 1 km scale; large dots – data aggregated over 2 km scale. Gray dots – rural surface experiment (without buildings); green dots – urban surface experiment. Red line – Garratt empirical relation (2); black and green lines – correspondingly the best LSM fits for rural and urban data; dashed line – 1:1 fit.

Preliminary Conclusions

The available computer resources allow for simulations of the central Paris area with resolution of 10 m and ever finer. The result aggregation on different scales can provide the optimal values \( (z_0, d_0) \) for urbanization of the coarse resolution models. Although the values of \( d_0 \) linearly correspond to the surface elevation model, the obtained proportionality coefficient (~1) is different from that one (2/3) suggested earlier. Moreover, significant fraction of the area does not show any dependence between the urban canopy height and the displacement height. Preliminary we can conclude that it is the large-scale elevation variations, but not the urban building height variations, that have the largest effect on the urban surface layer at least in the central Paris area. The roughness length does have expected dependence \( z_0 = \gamma_0 (h_b - d_0) \), \( \gamma_0 = 0.2-0.4 \) (Garratt, 1992) (not shown) albeit with somewhat large scatter. \( z_0 \) does not show obvious dependence on the surface morphology but it looks to have some dependence on surface steepness on large-scales.

Future Work

The work will progress in two general directions: (A) completing and analysis of the fine resolution PALM experiments; introduction of the urban heat flux and the atmospheric stability; and (B) urbanization of LESNIC code (Esau, 2004) using another, more flexible and accurate, method from Pourquie et al. (2009). Figure 7 gives a flavour of fine resolution PALM run (10 m mesh), which has been now completed for rural type surface using 5000 CPU hours.

Figure 7: Anomalies of the wind speed at 3 model levels in the high resolution PALM run on 10 m mesh. The grid points under the surface are white areas.

References

Letzel, M. O., Krane, M. and Raasch, S., 2008: High resolution urban large-eddy simulation studies from street canyon to neighbourhood scale, Atmos. Environ., 42, 8770-8784.


QualAir is a joint remote-sensing observation platform from LATMOS and LPMAA, located in Paris city centre. It addresses the need for information about pollutant vertical distributions to improve our understanding of pollution peak processes and assess ground-based air quality measurements representation. Moreover, it offers possibilities for satellite validation over urban areas.

The station measures integrated columns of NO₂ (SAOZ UV-visible zenith-sky spectrometer), atmospheric pollutants (infrared Fourier transform spectrometer) and aerosols (AERONET sun photometer). An elastic backscatter lidar provides aerosol extinction profiles and observations of boundary layer (BL) height variability. Here, BL depth is determined from lidar data on an hourly basis. BL top is defined as the altitude of minimal signal gradient or as the cloud base, if a cloud is capping the BL. The same treatment is applied to SIRTA lidar data to show regional variability of BL depth. Results are presented in Figure 2 for both MEGAPOLI campaigns, together with ECMWF forecasts. In summer during daytime, the effect of solar radiation and convection is predominant and there is no noticeable difference between Paris centre and suburbs. In winter, as the solar flux is lower, BL depth over the city tends to be higher due to the heat island effect. ECMWF forecasts agree reasonably well to observations given their low temporal resolution.

The very high resolution Fourier transform spectrometer of the LPMAA records the infrared solar spectra from QualAir roof. The spectral region (3.1-5.1 µm) is selected to monitor atmospheric pollutants like CO, CO₂, N₂O, O₃, H₂O, CH₄, HCl, HF. The spectral signature of those gases allows to retrieve their abundances in the atmosphere using a radiative transfer algorithm. Figure 3 shows the P(8) CO absorption line (located at 2111.543 cm⁻¹) that is used to determine the CO concentration vertical profile for July 1st 2009 (Figure 4). Fluctuating signals around 35500 s are due to the thin clouds presence. The CO volume mixing ratio obtained by the FTIR at ground level (on average, 0.31 ± 0.05 ppmv) compared well to the CO in-situ measurements from QualAir CO11M analyzer (on average, 0.27 ± 0.10 ppmv).

Acknowledgements
Thanks to the SIRTA team for their lidar data.

References
Té, Yao et al., 2008, The Fourier transform spectrometer of the QualAir platform, 8th Atmospheric Spectroscopy Applications Proceedings, 6-9.
During summer campaign, an instrument called MONA was deployed into the French aircraft (ATR-42). MONA consists of three NO commercial analysers (Ecophysics). It measures NOx (NO+NO\textsubscript{2}) and NOy (sum of NOx and its oxidation products) concentrations (one minute frequency and 10 pptv detection limit) by ozone chemiluminescence. NO is directly detected. NO\textsubscript{2} is converted into NO by a photolytic converter. NOy is converted into NO by a gold converter heated at 200°C with H\textsubscript{2}. An example of results obtained by this instrument is shown in Fig 2.

**Figure 2:** NO\textsubscript{y} measurements during the flight of July the 16th 2009. This flight took place in the north sector of Paris with high pollution levels. Paris plume was well defined with high NO\textsubscript{y} concentrations. The high ozone concentrations can be noted near the plume with a decrease in the plume center due to NO titration (Fig 2).

Exposure of pollutants to atmospheric processing is quantified using the ratio of NOx to NOy as a photochemical age. NOx are mainly emitted as NO which rapidly reacts with O\textsubscript{3} to form a steady state mixture of NO and NO\textsubscript{2}. Subsequent oxidation reactions form HNO\textsubscript{3}, PAN, and organic nitrates. Photochemical age of the air mass is defined as: 

\[-\log_{10}(\text{NOx}/\text{NOy})\]

Just after emission, \(-\log_{10}(\text{NOx}/\text{NOy}) = 0\) because NOx=NOy and \(-\log_{10}(\text{NOx}/\text{NOy}) = 1\) when 90% of NOx has been oxidized. In the daytime, oxidation of NOx is mainly due to their reactions with OH; so:

\[-2.303 \log_{10}(\text{NOx}/\text{NOy}) = k[\text{OH}]t\]

where: \(k\) is the constant rate for the reaction between NO\textsubscript{2} and OH, and \(t\) the photochemical age (Kleinman et al., 2008).

**Figure 3:** Ozone evolution with photochemical age inside the plume. -log10 ([NOx]/[NOy]) is used as a photochemical clock to estimate the age of air masses. Color scale represents NOy concentration to discriminate dots inside and outside the plume. The ozone production into the plume and an ozone background outside the plume of about 50 ppbv (Fig 3) were observed.

### References


To study characteristics of reactive nitrogen species NO\textsubscript{y} in and around Paris, ambient mixing ratios of NO, NO\textsubscript{2}, NO\textsubscript{y}, PAN, NMHCs (C\textsubscript{3}-C\textsubscript{10}), HCHO, HONO, O\textsubscript{3}, photolysis frequency of NO\textsubscript{2} (JNO\textsubscript{2}), and usual meteorological parameters were measured at the SIRTA site, located south-west of Paris. In addition, NO, NO\textsubscript{2}, NO\textsubscript{y}, HCHO and NMHCs measurements were performed on board ATR-42, the French research aircraft operated by SAFIRE. Flights were designed to study urban plume: perpendicular flight legs to the wind direction were performed and gave pollutants gradient in and around the city plume.

**Figure 1:** Relevant trace gases measurements and meteorological parameters at SIRTA site during summer & winter MEGAPOLI campaigns.

A few situations with wind coming from North-East sector (approximately 13% in summer and 21% in winter) were encountered. Nevertheless, some episodes of high pollution during both campaigns have been observed (secondary pollution in summer and primary pollution in winter) (Fig 1).

### Measurements of Reactive Nitrogen Compounds and other Relevant Trace Gases (O\textsubscript{3}, CO) in Paris Plume during MEGAPOLI Campaigns

Vincent Michoud E-mail: vincent.michoud@lisa.univ-paris12.fr

Laboratory Inter-universitaire des Systèmes Atmosphériques (LISA), Université Paris Est Créteil, Centre National de Recherche Scientifique (CNRS)


Vincent Michoud\textsuperscript{1}, Aurélie Colomb\textsuperscript{2}, Agnès Borbon\textsuperscript{1}, Warda Ait-Helal\textsuperscript{1}, Charbel Afif\textsuperscript{1,3}, Jean-François Doussin\textsuperscript{1}, and the LISA Team

1 – LISA, Université Paris Est, Université Paris 12 & CNRS, Créteil, France
2 – LaMP, Clermont Université, Université Blaise Pascal, CNRS, Aubière, France
3 – Department of Chemistry, Faculty of science, Saint Joseph University, Beirut, Lebanon

To study characteristics of reactive nitrogen species NO\textsubscript{y} in and around Paris, ambient mixing ratios of NO, NO\textsubscript{2}, NO\textsubscript{y}, PAN, NMHCs (C\textsubscript{3}-C\textsubscript{10}), HCHO, HONO, O\textsubscript{3}, photolysis frequency of NO\textsubscript{2} (JNO\textsubscript{2}), and usual meteorological parameters were measured at the SIRTA site, located south-west of Paris. In addition, NO, NO\textsubscript{2}, NO\textsubscript{y}, HCHO and NMHCs measurements were performed on board ATR-42, the French research aircraft operated by SAFIRE. Flights were designed to study urban plume: perpendicular flight legs to the wind direction were performed and gave pollutants gradient in and around the city plume.

**Summer 2009**

**Winter 2010**

A few situations with wind coming from North-East sector (approximately 13% in summer and 21% in winter) were encountered. Nevertheless, some episodes of high pollution during both campaigns have been observed (secondary pollution in summer and primary pollution in winter) (Fig 1).

### References

First results on reactivity

During the MEGAPOLI winter 2010 Paris campaign two contrasted periods were identified:

- 26-27 Jan 2010 - a high OH reactivity episode corresponding to air masses originating from the N-E part of Europe (air charged in pollutants);
- 3-5 Feb 2010 - a low OH reactivity episode corresponding to air masses originating from the Atlantic Ocean (clean air).

(a) Comparison OH reactivity – primary VOC

Figure 2: Influence of the air masses origin on Paris OH reactivity.

(b) Comparison OH reactivity – secondary VOC

Figure 3: OH Reactivity and toluene measurements by PTR-MS (LCP).

No covariation was observed between the OH reactivity and toluene (compound characterising local pollution).

Figure 4: OH Reactivity & acetaldehyde measurements by PTR-MS (LCP).

Better covariation reactivity – acetaldehyde was observed.

Conclusion

The preliminary OH reactivity results show that the Paris OH reactivity is mainly impacted by regional scale pollution episode rather than direct local emissions. Also, first OH reactivity quantification suggests values up to 100 s⁻¹. Additional tests are performed for final quantification.

References

Megacities emit large amounts of gaseous and particulate pollutants, the primary aerosols. Particulate matter (PM) has both direct emission sources and is also formed in the atmosphere from chemistry involving several organic (VOC) and inorganic species. These species are an important factor in the Earth’s climate system: PM plays a role through the scattering and absorption of radiation and by nucleation of cloud droplets. The formation and evolution of organic aerosol (OA) is still poorly characterized at urban and regional scales. Recent campaigns have indicated that much of the organic aerosol in urban areas is likely formed in the atmosphere (secondary organic aerosol or SOA) rather than directly emitted (primary organic aerosol or POA) and that SOA is formed more efficiently than predicted (de Gouw et al., 2005; de Gouw et al., 2006). Several studies, including the U.S. and Mexico City, showed that the observed SOA formation could not be explained quantitatively from the measured VOCs and their laboratory-determined particulate yields (de Gouw et al., 2005; de Gouw et al., 2008). But the reasons are still unknown. Because of the close connection between VOCs and SOA, there is an increasing interest and need to complete studies that address the budget and speciation of total organic carbon in the combined gas and aerosol phases. This leads to better constraints on emissions and chemistry that govern organic carbon formation and evolution.

VOCs present different diurnal variations, according to the origin of the air mass. Primary and secondary compounds have higher mixing ratio when the air mass comes from Paris. As the 4th July is also characterized by high temperatures and radiation, and anticyclonic conditions, implying low wind speed, not only background mixing ratios are higher, but biogenic compounds emission is promoted and photochemical processes are enhanced. When the air mass is oceanic, even if their profiles are smoother, the primary compounds also show a decrease in the middle of the day, because of photochemical depletion and the evolution of the boundary-layer height.

Finally, after identifying the factors affecting the VOCs concentrations (emissions, chemistry and height of the boundary-layer), the database will be used in a statistical model, to predict evolution and fate of gaseous VOC whether in the gas phase or and their interaction with the particulate one.

References


Improved urban meteorological forecasts could provide information to city management regarding additional hazardous or stressing urban climate (e.g. urban runoff, flooding, icing/ snow accumulation, high/gusts urban winds, heat or cold stress in growing cities, warming climate). Moreover, availability of reliable urban scale weather forecasts could be a relevant support for emergency management of fires, accidental toxic emissions, potential terrorist actions.

Results of testing of different models with implemented different urbanizations were presented (see for details the MEGAPOLI Del 2.2) for simple modifications of land surface schemes (Fig. 1b); Medium-Range Forecast Urban Scheme (MRF-Urban; Fig. 1a); Building Effect Parameterization (BEP; Fig. 2b); Soil Model for Sub-Meso scales Urbanised version (SM2-U; Fig. 2a); UM Surface Exchange Scheme (MOSES); Urbanized Large-Eddy Simulation Model PALM (see MNL-7; Esau, 2010); and others (Grimmond et al., 2010).

Model Urbanization Strategy

The available urban canopy modules, models and parameterisations are very different in terms of the sophistication of process descriptions, computing resources required and in the associated difficulties in implementing in meteorological models. Many publications consider separate aspects of urban features but none provide necessary algorithms and steps required. Summaries, discussions and recommendations on the best practice and strategy for urbanisation of different types of meteorological and air quality models are given in the MEGAPOLI Del 2.2.

Hierarchical models for urban areas have different requirements (e.g. relative importance of the urban boundary layer and urban surface sublayer structure) depending on:

(i) scale of models (global, regional, city, local, micro, etc.);

(ii) functional type of the models, e.g.:

- Forecasting or assessment;
- Urban or regional climate models;
- Research meso-meteorological models;
- Numerical weather prediction models;
- Atmospheric pollution models;
- Emergency preparedness models;
- Meteo-preprocessors (or post-processors).

The model urbanization strategy recommendations and requirements should be based on detailed evaluation of the (i) urban physiographic data classification and utilisation of surface satellite data; (ii) parameterisations and models of urban soil/heat, roughness sublayer and internal boundary layers; (iii) urbanisation of existing meso-meteorological models including the numerical weather prediction models, (iv) urban sublayer models, parameterisations and meteo-preprocessors for urban air quality and emergency preparedness models, and (v) incorporation of urban effects into regional climate models.

**References**

Meteorological Conditions Favoring Development of Urban Air Pollution Episodes (MEGAPOLI Del 4.3)

Alexander Baklanov
E-mail: ab@dni.dk
Danish Meteorological Institute (DMI), Research Department, Copenhagen, Denmark
http://www.dmi.dk

The MEGAPOLI WP4 Task 4.3: “Interactions between air quality and meteorology/climate” (lead by DMI) has two main focuses to study: (i) effects of meteorology on air pollution, and (ii) urban aerosol/gases feedbacks on meteorology (to be presented by Korsholm (DMI) in the next newsletter).

first focus is to describe and quantify the influence of meteorological patterns on urban air pollution especially high-level concentrations air pollution episodes in megacities. The findings can be further used for risk assessment closely related to decision and policy making. This task also carries out analysis of meteorological patterns leading to urban air pollution episodes by the development of suitable indicators linking particular meteorological conditions/parameters to increased air pollution levels in the urban areas. These indicators constitute a useful tool for regulators in suggesting effective policies and mitigation measures.

Introduction into the Problem

An air quality (AQ) episode is defined as a situation, during which air pollution concentrations exceed a specified threshold value. Such pollutants as PM10, PM2.5, O3 and NO2 can cause the worst air quality problems in European cities. These pollutants are regulated by both the EU limit values and the national guidelines. The guidelines are applied as practical objectives in environmental policy, while the limit values are considered as strict limits. If the limit value is exceeded, the city or municipality has to take measures, in order to ensure that the limit value will not be exceeded again in the future. The EU Directives require practical measures to be taken, if the air quality limits are exceeded.

The ability to reliably forecast air pollution episodes will be invaluable to minimise the health impact on the citizen, in particular, children and the elderly. If episodes can be forecasted reliably, local authorities can implement strategies and practical measures to reduce the impact on public health and the environment. Time warnings makes it possible to target local air quality management actions specifically to reduce population exposures and thus to minimise adverse health effects caused by episodes. However, it is not always possible to forecast episodes, when the pollutant concentrations are high, the performance of dispersion models is commonly worst.

The causes of air pollution episodes are complex and depend on various factors, including emissions, meteorological parameters, urban features, topography, atmospheric chemical processes and solar radiation. The relative importance of such factors is dependent on the geographical region, its surrounding emission source areas and related climatic characteristics, as well as season of the year.

Air Quality in Selected European Urban Areas

The MEGAPOLI Del 4.3 on “Interactions between Air Quality and Meteorology” (Baklanov & Mahura (Eds.), 2010, Part I) provides analysis (based also on FP6 EC FUMAPEX project; http://fumapex.dmi.dk) of the air quality in selected European cities, including an analysis of time-series of chemical species and corresponding meteorological situations. The selected MEGAPOLI megacities such as London (UK), Paris (France), Po Valley (Italy; Fig. 1), and Moscow (Russia) are presented there in more details considering existing national air quality monitoring networks, special measurement campaigns, dominating meteorological conditions leading to air pollution episodes, etc.

Classification of Air Pollution Episodes

Identification and classification of various types of air pollution episodes in cities located in different European climatic and geographical regions and identification the key meteorological parameters leading to air pollution episodes in various European climatic regions were done based on FUMAPEX data and latest MEGAPOLI analysis. A classification of air quality episodes in European cities is presented in Tabs. 1-2 (see MEGAPOLI Del 4.3).

The measured concentrations are compared with the currently applicable EU limit values; the hourly limit value for nitrogen oxides (NOx) is 200 µg/m3, while for ozone (O3) the hourly average limit is 180 µg/m3 and for carbon monoxide (CO) the 8-hourly gliding average limit value is 10 mg/m3. For suspended particles (PM10) the hourly limit value is 50 µg/m3 and 70 µg/m3 over 24 hours.

Table 1: Classification of European AQ episodes for local scale.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Season</th>
<th>Meteorological characteristics</th>
<th>Source and scale</th>
<th>European region</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10, PM2.5</td>
<td>Winter</td>
<td>Inversion, stable ABL</td>
<td>Local traffic</td>
<td>N, S, Central</td>
</tr>
<tr>
<td>NO2, CO</td>
<td>Winter</td>
<td>Inversion, low wind</td>
<td>Local traffic</td>
<td>N, S, Central</td>
</tr>
<tr>
<td>&quot;Spring dust&quot; episodes</td>
<td>Spring, Autumn.</td>
<td>Dry, melting snow</td>
<td>Suspended dust</td>
<td>N, Central</td>
</tr>
</tbody>
</table>

Table 2: Classification of European AQ episodes for regional and long-range transport scale.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Season</th>
<th>Meteorological characteristics</th>
<th>Source and scale</th>
<th>European region</th>
</tr>
</thead>
<tbody>
<tr>
<td>O3, photochemical pollutants</td>
<td>Summer, Spring</td>
<td>High pressure, recirculation, thermal low pressure</td>
<td>Precursor, Regional</td>
<td>S, Central</td>
</tr>
<tr>
<td>PM10</td>
<td>Winter, Spring</td>
<td>Stable ABL</td>
<td>LRT, regional</td>
<td>N, S, Central</td>
</tr>
</tbody>
</table>

The various episodes according to pollutant and prevailing meteorological conditions were classified. The episodes can also be categorised according to the scale of the main source areas, i.e. those originating from local emissions and those from regional and long-distance sources.

The so-called "spring dust episodes" refer to the episodes caused by particulate matter (PM) suspended from the road and street surfaces. These are characteristic especially for Northern parts of the Europe.

The larger scale episodes can be schematically classified as those involving photochemical pollution from both local, and regional and LRT sources, and the episodes caused by long range transported air masses. The photochemical episodes are especially relevant in Southern European cities. These may characteristically involve re-circulation of air masses, caused by meso-scale meteorological effects (such as land-sea breeze) and orographic flows.

Acknowledgements

MEGAPOLI Del 4.3 also acknowledges partial contributions from the COST-715, FUMAPEX, IGSP: summaries of the MEGAPOLI, ESOEP, and LISAIR measurement campaigns; AirParif (France), regional ARPA’s(Italy), Moscow City Eco-Monitoring (Russia), and London (KCL, UK) air quality monitoring networks.

References


Po Valley Base Year Emissions

Paola Radice
E-mail: p.radice@aria-net
ARIANE srl
http://www.aria-net.it

After the release of European scale reference emission inventory (EI) for base year 2005 (see van der Gon (TNO) in MEGAPOLI NewsLetter #4), local emissions started to be developed for MEGAPOLI 1st level European megacities. As it’s described in the MEGAPOLI NewsLetter #2, ARIANET defined the Po Valley emission data set starting from bottom-up regional inventories with municipal level space resolution, which are presently available for reference year 2005 for the following Italian regions: Piemonte, Lombardia, Trentino Alto Adige and Friuli Venezia Giulia. For the Po valley Regions that have not yet released their high resolution inventories (Veneto and Emilia-Romagna) the top-down national emission inventory, available at province level space resolution, has been used. Gridded emissions of area sources subdivided in SNAP classes have been made available at the two following resolutions: a) 0.125 x 0.0625 degrees (~ 7 x 7 km); b) 0.0511 x 0.036 degrees (~ 4 x 4 km). Point sources emissions and stack features are provided separately. Emission data cover the spatial domain defined for MEGAPOLI applications (see van der Gon (TNO) in MEGAPOLI NewsLetter #4). The coarse resolution dataset employs the same grid system used for the European emissions, to allow an easy merge of data, while fine resolution emissions are directed to support high resolution model simulations over the Po river basin.

Po Valley emissions have been compared with MEGAPOLI European scale inventory over different areas, showing a general coherence and limited differences for total emissions when we consider the whole megacity area or even Italian Regions, which are characterised by different original bottom-up EIs. Larger differences are detected when smaller areas characterised higher urbanisation are considered.

Fig. 1 shows the comparison between major pollutants emissions provided by European and Po Valley datasets within Milan Province area (outlined in Fig. 2), which encloses the core and largest portion of Milan conurbation (about 3.5 millions inhabitants). Total emissions are not comparable for all the pollutants. Large differences are observed for CO and SO2, with Po Valley total emission values lower than half of those provided by the European inventory. The opposite situation is observed for NMVOC, with larger emission in the local megacity inventory. Other species, like NOx, CO, VOC and PM10, show more comparable total emission values, but large differences in contributions from diverse macro-sectors. Relevant variations can be noticed in the weight of dominant emission sectors for considered pollutants, e.g. energy production for SO2, transport for CO, solvent use for VOC and agriculture for NH3. This latter aspect can have consequences in the space disaggregation and time modulation of emissions and therefore on air quality modelling.

The space distribution of PM10 emissions over the Po Valley area, as described by the different MEGAPOLI emission datasets, is illustrated in Fig. 2. The intensity and space distribution of emissions are comparable for European (Fig. 2a) and Po valley (Fig. 2b) inventories. A lower concentration of emissions around the major sources (cities and road network) can be noticed for the Po Valley emission dataset. This feature can be attributed to the influence of the different macro-sectors, in particular to wood-burning and agriculture contributions. Emissions are more spread out around Milan conurbation, and less intense in its city core. Opposite condition is observed for Turin metropolitan area (western Po Valley), where the local inventory provides higher emissions concentrated over the most urbanised region. The higher resolution dataset (Fig. 2c) allows a better confinement of emissions within the Po river plain area and encloses them within the major Alpine valleys over the mountain area. It can also be observed much better emission localization in the eastern Po Valley (Veneto and Emilia-Romagna Regions) where no large conurbation is located, but the population is distributed among a large number of mid-size cities.

Acknowledgement
We are thankful to the Environmental Protection Agencies of Piemonte, Lombardia, Friuli Venezia Giulia and Trentino-Alto Adige Regions for providing local emission inventories and for their cooperation with MEGAPOLI activities.
Global-Scale Radiative Forcing from Megacity Pollutant Emissions (MEGAPOLI Del 6.2)

Gerd Folberth

E-mail: gerd.folberth@metoffice.gov.uk
Met Office Hadley Centre, Atmospheric Composition and Climate
http://www.metoffice.gov.uk

Folberth G., 1, Rumbold S., 1, Collins W.J., 1, Butler T., 1, Lawrence M., 2
1 – Met Office Hadley Centre, Exeter, UK
2 – Max Plank Institute for Chemistry, Mainz, Germany

Air pollutants from megacities such as NOx, VOC and particulates have the potential to impact the climate. NOx and VOC contribute to tropospheric ozone formation and affect the lifetime of long-lived greenhouse gases such as methane. The sign of the impact is determined by the NOx/VOC ratio and is highly localised and variable.

Anthropogenic aerosols comprise sulphate (predominately SO2 which is chemically transformed to sulphate particles), black carbon (BC) and particulate organic matter (POM). Aerosols impact climate directly by either absorbing (BC) or backscattering (sulphate, POM) radiation but also have indirect (cloud) effects.

The climate impact of megacity pollutants has been studied with the Met Office Hadley Centre Earth System Model HadGEM2, with contributions from the MATCH-MPIC chemistry-transport model operated by the Max Plank Institute for Chemistry in Mainz. Two simulations were carried out, a control and an "annihilation" scenario in which anthropogenic emissions of short-lived species (excluding methane) from megacities were removed using the mask from Butler et al. (2008).

Methane radiative forcing as caused by pollutant emissions from megacities is computed from the change in the methane chemical lifetime applying the simplified expressions outlined in Butler et al. (2008). Ozone radiative forcing has been determined from the change in the ozone burden by scaling the forcing published in Gauss et al. (2006).

Direct radiative forcing (DRF) from megacity aerosols is diagnosed in HadGEM2 by differencing net radiative fluxes obtained by calling the radiation scheme twice (Bellouin et al., 2007). Figure 1 shows the short-wave forcing from megacity aerosols which is mostly driven by changes in sulphate. These show a cooling effect around the megacity locations.

Combining the gas-phase and aerosol impacts, the model simulations indicate an overall climate impact of short-lived species from megacities resulting in a slight cooling at present-day conditions as summarised in Table 1. This cooling effect amounts to a DRF of -8.0±1.6 mW/m² and is due to the dominance of the aerosol backscattering over a positive forcing by the increase in tropospheric O3 and additional absorption of LW-radiation by BC aerosols.

The results from MPI-Chemistry Mainz are similar, with a DRF due to change in ozone of +9.9 mW/m² and -3.1 mW/m² as a consequence of the change in the methane chemical lifetime. Even though the results from the two groups are consistent it has to be noted that they are based on a different emission dataset (EDGAR 3.2 Fast Track 2000; Olivier et al., 2005) and were derived with chemical mechanisms that are similar in complexity but not identical.

Methane emissions result in an indirect forcing due to increased O3 formation. As methane emissions were not changed in this study this is not included in Table 1. We estimate this effect would add an additional radiative forcing of roughly +3.5 mW/m² to the ozone forcing in Table 1.

In a previous scientific report for MEGAPOLI Collins (2009) reported on the climate impact of greenhouse gas emissions from megacities. In those simulations the impact of direct emissions of CO2, CH4 and N2O has been analysed. These gave direct radiative forcings of +120.0 mW/m², +28.4 mW/m² and +3.3 mW/m², respectively after 100 years of emission. Clearly, on centennial timescales the climate impact of air quality pollutant emissions from megacities is small when compared to the direct impact of megacity GHGs. However these pollutants will have a larger relative effect on shorter timescales.

Table 1. Current best estimate of the present-day annual global mean direct radiative forcing (mW/m²) due to megacity pollutant emissions.

<table>
<thead>
<tr>
<th>Species</th>
<th>HadGEM2 (mW/m²)</th>
<th>MATCH-MPIC (mW/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔO3 (tot. TOA)</td>
<td>+6.3±0.4</td>
<td>+9.9</td>
</tr>
<tr>
<td>ΔCH4 (tot. TOA)</td>
<td>-1.0±0.5</td>
<td>-3.1</td>
</tr>
<tr>
<td>ΔPM (sw all-sky)</td>
<td>-15.3±0.6</td>
<td>-(-15.3)</td>
</tr>
<tr>
<td>ΔPM (lw clear-sky)</td>
<td>+2.0±0.1</td>
<td>-(+ 2.0)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-8.0±1.6</strong></td>
<td><strong>-6.5</strong></td>
</tr>
</tbody>
</table>

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References


Bellouin, N. et al. (2007): Improved Representation of Aerosols for HadGEM2, Hadley Centre Technical Note 73.


SAFAR – System of Air quality Forecasting and Research for CWG-2010 in India

Gufran Beig
E-mail: beig@tropmet.res.in
Indian Institute of Tropical Meteorology, Dr. Homi Bhabha Road, Pashan, Pune- 411 008, India
http://www.tropmet.res.in/beig

SAFAR (http://safar.tropmet.res.in) which stands for System of Air quality Forecasting And Research is one of the most ambitious scientific projects of India in the year 2010. For the first time, India will be having a system for forecasting pollutants in air. This is undertaken in view of the Common Wealth Games which will be held at Delhi during October 2010. This project on pollutant monitoring and forecasting, is being developed and executed by the Indian Institute of Tropical Meteorology, Pune, an autonomous body under the Ministry of Earth Sciences, Government of India. In this project, air quality monitoring and forecasting for pollutants is being done. The weather monitoring and forecasting will be done by the India Meteorological Department. Till date, only a few developed countries have demonstrated the strength towards developing such kind of system for air quality forecasting during major game events. After successful implementation of this SAFAR project, India will be among the few developing nations to take a big leap in environmental research.

In the meeting of the GURME (Global Atmospheric Watch Urban Research Meteorology and Environment) Scientific Advisory, a programme of World Meteorological Organization (WMO), which was held on 23rd February 2010, the project “System of Air Quality Forecasting And Research (SAFAR) for Commonwealth Games 2010 of Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Govt. of India, has been recognized as a pilot activity of WMO-GURME. This recognition implies that GURME considers SAFAR as an important activity in the region and will make all efforts to get international visibility to the project. GURME-SAG further states that the experience gained will serve as an example within India, in large region of South Asia and globally, provided that appropriate documentation on the project design, experience and results are provided by the SAFAR project office.

SAFAR will provide and display the information about air quality in near real time basis (hourly) and forecast the future level of pollution a day in advance at various key locations of Common Wealth Games (CWG)-2010 through wireless true colour display panels. The information about pollutant levels provided on day-to-day basis and the forecast will be helpful in deciding the mitigation strategies towards controlling the pollution levels. SAFAR system will have the following air pollutants: ozone, Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Particulate Matters (PM2.5, PM10), Black Carbon, Benzene, Toluene and Xylene. For the current information, 10 monitoring stations are being set up in and around the Games venues in Delhi. The monitoring station is one room facility, which is equipped with several automatic Air Quality (AQ) analysers to measure the above mentioned pollutants and one Automatic Weather Station (AWS) which record parameters like temperature, pressure, wind speed, wind direction, rainfall, radiation, heat and humidity.

The air quality forecasting will be made using the Atmospheric chemistry-transport model. This model will run on high performance computer on daily basis. The HPC system is recently commissioned in IITM, Pune. The above data collected on a particular day along with meteorological parameter data will be processed. In addition several other data base viz. Emission inventory, terrain, vegetation, etc is being prepared under this project using GIS based statistical modelling. This data will be processed as an input to the air quality forecasting model. Model will predict the air quality of Delhi 24 hours in advance in 1.67 km x 1.67 km grid resolution.

The pollutant and weather related data from all the stations will be collected through GPRS network and stored in a centrally located SAFAR server and IMD server respectively. Once the near real time and forecasted data is checked for quality assurance, it will be transferred to the display server for converting to public friendly format in terms of Air Quality Index (on Delhi’s geographical map, bar chart, color animated diagrams etc.). The Air Quality Index (AQI) will be calculated as per the latest standards released for India. Once it is done, it will be available to the common public through LED and LCD digital display boards installed in several locations in national capital region of Delhi. The display boards will also display environmental friendly messages along with the advisory on how to keep the environment clean. In addition, the current and forecasted AQI data of the CWG venues will also be made available online on SAFAR website, specially developed and dedicated to this project.

Figure 1: Schematic diagram of SAFAR. Pollutants generally originate from industries, hence surveys and climatic flow studies have been carried out. In addition, the emission sources are also identified, and information on emission levels and patterns has also been gathered in advance by the involved scientists. Accordingly meteorological data for pollutant monitoring and prediction have been generated which will prove to be extremely important during the forecasting.

Thus, in conclusion, the data collected during SAFAR project will greatly help and guide in planning the mitigation strategies to achieve the motto of CWG i.e. Green Games, as we will be in a position to identify the major sources of air pollutants and can take immediate measure to improve the air quality. The system is planned to be commissioned at least 2 to 3 months in advance so that advance mitigation recommendations can be provided to the executing authorities. The data collected will be further utilized to study several interesting emerging scientific research problems.
**Role and contribution**

The IfT is member of the MEGAPOLI WP3. Our measurements took place in a container located in the garden of the LHVP. The container was deployed during summer 2009 and winter 2010 campaigns. Our measurements were focused on the particle characterisation using high-end scientific instruments in order to study:

(i) Physical aerosol properties (APS, TDMPS, HDMPS);
(ii) Optical properties (nephelometer and MAAP);
(iii) Particle chemical composition (AMS).

**Researches involved**

- Alfred Wiedensohler
  ali@tropos.de
- Wolfram Birmili
  birmili@tropos.de
- Andreas Held
  andreas.held@uni-bayreuth.de
- Andreas Nowak
  andreas.nowak@tropos.de
- Laurent Poulain
  laurent.poulain@tropos.de
- Kay Wienhold
  wienhold@tropos.de
- Katharina Kamilli
  kamilli@tropos.de
- Maik Merkel
  merkel@tropos.de
HadGEM2 (Hadley Centre Global Environment Model 2) is a fully coupled Earth System Model. In the standard configuration N96L38 the model’s horizontal resolution is roughly 1.9°x1.3° (~200 km x 140 km) and it comprises 38 vertical levels extending up to 39 km altitude. The model is run with a 30-minute time step. Extended Tropospheric Chemistry is inline and provided by the United Kingdom Chemistry and Aerosol (UKCA) model (UKCA-ExtTC). The mechanism includes 89 chemical species, 63 are tracers. Mechanism development has recently focused on BVOC chemistry and formation of SOA. Primary BVOC include isoprene, terpenes, methanol and acetone and are provided to UKCA-ExtTC interactively at every time step by iBVOC. Primary and secondary inorganic aerosols are determined by the HadGEM2 mass-based “Classic” scheme with two-way feedback to the chemistry.

So far, HadGEM2 has been used to assess the effect of megacities on the surface concentration and radiative forcing of gas and particulate pollutants at regional and global scales. This work will be extended to investigate the impact of megacities under climate change scenarios.

### Researches involved

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bill Collins</td>
<td><a href="mailto:bill.collins@metoffice.gov.uk">bill.collins@metoffice.gov.uk</a></td>
</tr>
<tr>
<td>Gerd Folberth</td>
<td><a href="mailto:gerd.folberth@metoffice.gov.uk">gerd.folberth@metoffice.gov.uk</a></td>
</tr>
<tr>
<td>Steve Rumbold</td>
<td><a href="mailto:steven.rumbold@metoffice.gov.uk">steven.rumbold@metoffice.gov.uk</a></td>
</tr>
</tbody>
</table>

The UK Met Office (http://www.metoffice.gov.uk/) has well over 20 years of world-leading expertise in climate modelling. Currently 150 scientists research climate science in the Met Office’s Hadley Centre for Climate Change. The fields represented include climate monitoring, climate modelling, climate variability, quantifying uncertainty, understanding climate change, and climate-chemistry-ecosystem feedbacks. Research on atmospheric composition and climate includes global modelling of aerosol and gas-phase reactive chemical constituents.

The focus here is on the direct and indirect radiative and climate impacts of these constituents through their interactions with clouds, terrestrial and ocean ecosystems and the land surface. The atmospheric composition team are currently participating in the EU projects EUCAARI, ACCENT and GEMS.

### Role and contribution

The UK MetO role and contribution into the MEGAPOLI project include: The Met Office will co-lead WP6 and will contribute significantly to WP5. In WP6 the Met Office will lead the work on global climate effects of megacities and will contribute with its HadGEM2 climate model which includes the UKCA package of interactive aerosols and reactive gases. In WP5 the Met Office will contribute to Tasks 5.5 and 5.6.
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

- Invited presentation of the MEGAPOLI Project at the EU-China Science and Technology Week, WORLD EXPO-2010 (Shanghai, China, 18 Jun 2010) – by Alexander Baklanov (DMI Team)
- See more MEGAPOLI Publications/ Presentations at [http://megapoli.info](http://megapoli.info)

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:

- International Aerosol Conference
  Helsinki, Finland, 29 Aug – 3 Sep 2010
- 10th European Meteorological Society (EMS-2010) Annual Meeting and 8th European Conference on Applied Climatology (ECAC)
  Zurich, Switzerland, 13-17 Sep 2010
- 31st NATO/SPS International Technical Meeting on Air Pollution Modelling and its Application
  Torino, Italy, 27 Sep – 1 Oct 2010
  [http://www.int-tech-mtng.org](http://www.int-tech-mtng.org)
- 2nd Annual MEGAPOLI Project Meeting
  Hamburg, Germany, 1-2 Nov 2010
  [Contact: Heinke Schluenzen, UHam (heinke.schluenzen@zmaw.de)](mailto:heinke.schluenzen@zmaw.de)
- European Geosciences Union (EGU-2011) General Assembly
  Vienna, Austria, 3-8 Apr 2011
  (special MEGAPOLI, CityZen, MILAGRO session)
Welcome to the 8th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 8th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – 6th MEGAPOLI WP Leaders telephone conference (Jan 2011)
- Coming soon – 2nd Annual MEGAPOLI Meeting (1-2 Nov 2010; Hamburg, Germany)
- Sep-Oct 2010 – 2nd year reporting on Deliverables (sci. reports) and Annual Dissemination Report of the MEGAPOLI project
- 17 Aug 2010 – 5th MEGAPOLI WP Leaders telephone conference
- 18 Jun 2010 – MEGAPOLI project presented at the WORLD EXPO-2010 EU-China Science and Technology Week (14-19 Jun 2010, Shanghai, China)
- 14-15 Jun 2010 – MEGAPOLI WP3 “Paris Plume Study” and French ANR MEGAPARIS joint meeting (Paris, France)

Joint Meeting of the MEGAPOLI WP3 “Paris Plume Study” and French ANR MEGAPARIS

Took place: 14-15 Jun 2010, Paris, France

Attended: about 40 participants representing all groups participating in the MEGAPOLI WP3, some groups from other MEGAPOLI WP’s, the MEGAPOLI coordination, and from most of the additional other research groups involved into MEGAPOLI measurement campaigns

Agenda included:

Day 1: objectives of the meeting and overall general information; overview of scientific questions; individual and research groups presentations followed by discussions; details on instruments deployed, parameters measured during campaign, highlights; major questions to be answered, what additional data will be needed;

Day 2: WP3 coordination group meeting; plenary meeting and discussion on common exploitation activities and common papers (in Science, Atm. Chem. & Phys.); database issues: overview of existing database at CNRS-LISA; open questions and plans for final database

(note, all given presentations are available at the MEGAPOLI internal website)

Major conclusions and action points:

- Publication strategy (Science, sci. journals, special issue);
- Common analysis tools and data (trajectory simulations and emission data);
- Database issues (hosting; data formats; data protocol; deadlines) - contact Catherine Schmechtig, CNRS-LISA team; Catherine.Schmechtig@lisa.u-pec.fr);
- Expected Deliverables of WP3:
  - D3.1 - Database of chemical composition, size distribution and optical parameters of urban and suburban PM and its temporal variability (hourly to seasonal);
  - D3.2 - Source appointment of major urban aerosol components (OC, BC, inorganic ions), including primary and secondary PM sources;
  - D3.3 - Effective emission factors for OC and BC for urban type emissions;
  - D3.4 - Database of the impact of megacity emissions on regional scale PM levels.

(see also details in the summary notes at the MEGAPOLI internal website)

Content

1 Editorial, Latest News
2 Evaluation of Zooming Approaches Describing Multiscale Chemical Transformations
3 Utilizing ATOFMS Measurements for Long-Range Pollution Events
4 Anthropogenic Heat Fluxes over Moscow Agglomeration
5 MEGAPOLI Teams: CNRS-LaMP, WMO
6 MEGAPOLI Project Office

Coming Presentations, Publications, Conferences

NOx emission intensity in year 2005 (TNO Team; D. 1.1)

Predicted average ground concentration of fine grids for nitrate in July 2001 and Jan 2002 (μg m⁻³) (FORTH Team, D. 4.2)
In this work we investigate the importance of zooming in the description of aerosol chemical processes and transformations in megacities. The Eastern US area was chosen for this application, because of the availability of a wide range of measurements for the model evaluation. PMCAMx, a detailed 3-dimensional chemical transport model (CTM) was used to simulate air quality focusing on the PM$_{2.5}$ aerosol mass concentration and composition in the north-eastern US States using two grids: a uniform 36 x 36 km (coarse) grid and one that has a nested subdomain with 12 x 12 km (fine grid) resolution. The performance of the model was evaluated against PM$_{2.5}$ aerosol mass concentration and composition in the Eastern United States for all four seasons. J. Geophys. Res. 112 D14211.

PMCAMx uses the framework of the CAMx air quality model (Environ, 2003) describing the processes of horizontal and vertical advection, horizontal and vertical dispersion, wet and dry deposition, and gas-phase chemistry. For the aerosol processes, three detailed aerosol modules are used. These aerosol modules use a sectional approach to dynamically track the size evolution of the aerosol mass across 10 size sections spanning from 40 nm to 40 μm. The aerosol species modeled include sulfate, nitrate, ammonium, sodium, chloride, potassium, calcium, magnesium, elemental carbon, primary and secondary organics.

Two simulations were performed for the same modeling domain in the Eastern US: one using the traditional coarse modeling domain that has been used in previous applications of PMCAMx in the area (Karydis et al. 2007) and one with a multi-scale grid “zooming” in the northeastern US (Fig. 1). Emission and meteorological input fields for the fine grid (12 x 12 Km) were created via interpolation from the respective parent (coarse) grid.

It was found that during Jul 2001 average concentrations of main chemical species predicted by the fine and coarse grid simulations were quite similar. During Jan 2002, the model performance for sulphate and nitrate was better for the fine grid (Tab. 1).

The coarse grid simulation predictions are characterized by a general smoothing of the concentrations throughout the domain. During July, the fine grid simulation captured the maximum concentration value of organic mass and elemental carbon with elevated peaks in the polluted areas of Boston and New York. The coarse grid overpredicts organic mass concentrations in urban sites, with an average predicted concentration of 5.2 μg m$^{-3}$ while the average predicted concentration in the nested grid is 4.13 μg m$^{-3}$ and the average measured value is 4.5 μg m$^{-3}$. For organics and elemental carbon, the model performs the best with the fine grid during Jan 2002. The coarse grid simulation overpredicts the average organic mass concentrations at the urban sites during winter, while the fine grid simulation reproduces better the observed values.

Refining the model grid size can improve its ability in simulating physical and chemical processes. However, nesting should not be taken as a simple grid refinement for selected areas. It has to be accompanied by the use of appropriately resolved and structured input data sets for emissions, land use, and meteorology, otherwise the gain of accuracy by nesting may remain low considering the disadvantage of a large computational cost required.

Future work includes the application of a similar zooming approach in various Megacities of Europe (e.g. the Greater Paris area) with the use of appropriate emission and meteorological fields for the coarse grid as well as the fine grids of selected sub-domains.

References
Utilizing ATOFMS Measurements for Long-Range Pollution Events

Eoin McGillicuddy

E-mail: e.j.mcgillicuddy@mars.ucc.ie

Centre for Research into Atmospheric Chemistry, Department of Chemistry and Environmental Research Institute

http://crac.ucc.ie/

McGillicuddy, E.J.1,2, Healy, R.M.1,2, O’Connor, I.P.1,2, Wenger, J. C.1,2, Sodeau, J. R. 1,2

1Centre for Research into Atmospheric Chemistry, Department of Chemistry, University College Cork, Ireland
2Environmental Research Institute, University College Cork (UCC), Ireland

As part of the MEGAPOLI winter 2010 monitoring campaign in Paris (France) the UCC deployed an Aerosol Time-of-Flight Mass Spectrometer (ATOFMS, TSI Model 3800) at the LHVP urban site. This instrument measures the size and chemical composition of single particles with aerodynamic diameters in the range 100-3000 nm. The core composition of single particles, for example elemental/organic carbon and transition metals, as well as secondary species such as nitrate and sulphate can be determined. When combined with meteorological data, local and regional sources of particulate matter can be identified.

During a long-range transport event on 27 Jan 2010 elevated signals were observed (Fig. 1) for lithium (m/z = 7; Snyder et al., 2009). It has been previously suggested that lithium is a useful marker for coal combustion (Guazzotti et al., 2003). The HYSPLIT (http://www.arl.noaa.gov/ready/hysplit4.html) air mass back trajectory analysis for this period shows that the air mass arriving at the measurement site originated in the Eastern Europe (an example of the HYSPLIT trajectory calculations is shown in Fig. 2).

A coincident increase in the ATOFMS signal for aged sulphate (m/z = -195; Moffet et al., 2008) was also observed for the same period of time. As seen in Fig. 3, the integrated signals for both m/z = 7 and m/z = -195 have a strong north-easterly wind dependence, which is indicative of a common source. It is possible that particles containing internally mixed lithium and sulphuric acid arise from coal combustion in the Eastern Europe and are transported to the site.

Future Work

During the campaign, in total 1.74 million dual ion single particle mass spectra were collected. Cluster analysis has been applied with Environmental Chemistry Through Intelligent Atmospheric Data Analysis (ENCHILADA) software using the K-means algorithm (K=80) (Gross et al., 2010). These 80 clusters will be reduced to much fewer final ATOFMS classes and compared with other on-line and off-line particle measurements made during the campaign. The overall secondary composition of particles will be compared to PILS and AMS measurements in particular. Individual ion signals for individual metals will also be compared with off-line XRF analysis.

Acknowledgements

The CRAC / UCC participation in MEGAPOLI was facilitated by The Higher Education Authority Ireland (HEA) and the Irish Research Council for Science Engineering and Technology (IRCSET) embark initiative.

References


Urbanization is a great challenge for the most regions of the world. It influences on soil, hydrology, air pollution and human health, as well as on local, regional and even global climate. One of particular urban effects is so called anthropogenic heat flux (AHF) or thermal pollution. Globally, AHF is very small (about 0.3 W/m²) but over the continental United States and Western Europe AHF reaches 0.4 and 0.7 W/m², respectively (see at http://www.cgd.ucar.edu/tss/ahf/).

The LUCY model estimates the global mean urban AHF with a diurnal range from 0.7 to 3.6 W/m² (see Allen et al., 2010). The energy consumption in different countries more or less reflects the national per capita income. Anthropogenic heat fluxes depend on both energy consumption and population density. The simple formula for AHF was proposed (Ginzburg & Raspletina, 2008):

\[ AHF = k \times PD \times EC, \quad (1) \]

where: PD is urban population density and EC is average national total energy consumption per capita. Anthropogenic heat fluxes for selected world urban areas were calculated (see Table 1) applying Eq. (1) and using demographic data (see at http://www.demographia.com) and The 2006 Little Green Data Book. Seoul and Moscow are the two world capitals with the highest values of AHF. Taking into account the revised density. The simple formula for AHF was proposed (Ginzburg & Raspletina, 2008):

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<table>
<thead>
<tr>
<th>City</th>
<th>AHF (W/m²)</th>
<th>Population (min.)</th>
<th>Area (sq. km)</th>
<th>Population density (*)</th>
<th>Energy consumption**</th>
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Table 1. Anthropogenic Heat Fluxes (AHF) over world urban areas
(* - habitants/sq. km, ** - kg of oil equivalent per capita).

Baklanov et al. (2008) varied AHF from 50 (for small/medium cities) up to 200 W/m² (for large megacities in industrially developed countries). According to Allen et al. (2010) across the Greater London area the mean heat emissions are 24 and 16-17 W/m² during winter months and from spring till autumn, respectively. Heat emissions in Tokyo are greater than for London. The highest average AHF of 70 W/m² can be reached in January. The lowest average heat emissions from LUCY model is estimated 47 W/m² in November. Saitoh et al. (2005) estimated that a lower heat emission (combustion of electricity, gas and petrol consumption) in Tokyo is equal to 28 W/m². It means that average AHF for London is around 20 W/m² and for Tokyo - 50 W/m². Given calculations in Table 1 for London and Tokyo show 26 and 32 W/m², respectively.

As for the high Moscow City AHF, the main reasons are relatively high energy consumption per capita in Russia and relatively small area of Moscow City situated mostly within the Moscow circle motor road (MCMR). Many of densely populated towns and other residential suburbs situated just outside MCMR boundaries are not included in the boundaries of the Moscow city administrative area. In order to compare AHF within the Moscow agglomeration against the thermal pollution in other world cities, the six Moscow agglomeration circles (MAC) were constructed. These were centered at Kremlin and equal by area to world cities such as Rio, San Paulo, Paris, London, Tokyo, and New York (see Fig. 1).

Because population density of Moscow suburb towns and other settlements is not published regularly, the only data presented in the Russian regions (2008) were used, which contains information about Russian cities and town with population more than 100 thousands habitants. Smaller towns and settlements are not taken into consideration and the lower boundaries of AHF are estimated. The MAC 1 (Rio like; radius of 21 km) includes Moscow City and 7 suburb towns (Reutov, Luberseys, Krasnogorsk, Kolomna, Khimki, Dzerzhinsky, and Mytischi) and its AHF is 51 W/m² which is much more than over Rio and less than over Moscow. The AHF within the MAC VI (New York like) is only 9.8 W/m² and lower than New York City - 21.1 W/m² (Belova & Ginzburg, 2010).

The Figure 2 underlines that Moscow city and Moscow agglomeration circles equal by area to Tokyo and New York have AHF less than Moscow, Tokyo, and New York. At the same time Moscow regional AHF higher than the thermal emission for London, San Paulo, Paris and some other cities analysed.

References
Saitoh et al. (2005): A grand design of future electric vehicle to reduce urban warming and CO2 emissions in urban area. Renewable Energy, 30: 1847-1860

Figure 1. Moscow City, suburb towns and agglomeration circles.

Figure 2. AHF over Moscow City and Moscow agglomeration circles (MAC) equivalent by area to different world cities (W/m²).
CNRS-LaMP (http://wwwobs.univ-bpclermont.fr/atmos/) – the Laboratoire de Météorologie Physique (LaMP) is a joint research unit of CNRS and Université Blaise Pascal. LaMP has a long-standing experience in the experimental and modelling studies of clouds and their interactions with solar radiation and atmospheric gaseous and particulate compounds. The main research activities deal with the role of aerosols and clouds in the oxidation capacity of the troposphere and the impact of iced and mixed-phase clouds on the Earth’s radiative budget. LaMP has developed new tools for characterising radiative and chemical properties of aerosols and cloud elements. It implements the cloud observation site of Puy-de-Dôme and manages activities for the French network of free-tropospheric research stations. In addition, LaMP has a long-standing experience with airborne characterization of cloud and aerosol optical, physical and chemical properties. LaMP has co-ordinated a number of EU projects within FP4 and FP5 and is present in the steering committees of several national and international programmes. LaMP is presently coordinating the EUSAAR FP6 Infrastructure program for monitoring of aerosol properties over Europe.

Role and contribution
The CNRS-LaMP role and contribution into the MEGAPOLI project include: airborne aerosol characterization of physical-chemical and optical properties of aerosol particulate matter in WP3 (microphysics and chemistry).

Researchers involved
Alfons Schwarzenboeck
a.schwarzenboeck@opgc.univ-bpclermont.fr

Karine Sellegri
k.sellegri@opgc.univ-bpclermont.fr

Jean-Marc Pichon
j.m.pichon@opgc.univ-bpclermont.fr

Suzanne Crumeyrolle
s.crumeyrolle@opgc.univ-bpclermont.fr

Boris Quennehen
b.quennehen@opgc.univ-bpclermont.fr

The World Meteorological Organization, WMO (http://www.wmo.int) is a specialized United Nations (UN) Organization that has the mandate for weather, climate, operational hydrology, and related geophysical sciences within the UN system. It is the UN system’s authoritative voice on the state and behaviour of the atmosphere, its interaction with the oceans, the climate it produces, and the resulting distribution of water resources. WMO plays a leading role in international efforts to monitor and protect the environment through its Programmes and is instrumental in providing advice and assessments to governments on matters related to these issues and in contributing towards ensuring the sustainable development and well-being of nations. The Global Atmosphere Watch (GAW) of the Atmospheric Research and Environment Programme (AREP) department is the only global long-term atmospheric chemistry and air pollution programme. The measurement variables of GAW include greenhouse gases, stratospheric and tropospheric ozone, aerosols, UV radiation, reactive gases, and precipitation chemistry. The principal goal of GAW implementation is to contribute to efforts in reducing environmental risks to society and meeting the requirements of environmental conventions; to strengthen capabilities to predict climate, weather and air quality; and to contribute to scientific assessments in support of environmental policy; through maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere; emphasizing quality assurance and quality control; and through delivering integrated products and services to users.

The GAW Urban Research Meteorology and Environment (GURME) was established in 1999, it is the GAW activity most closely focused on air quality. This project bridges over a wide variety of Organizations and authorities, including environmental agencies that collaborate under the WMO GURME umbrella in order to improve their citizens’ environment. GURME addresses the end-to-end aspects of air quality that link observational issues, data assimilation techniques, numerical models, dissemination methods, and capacity building. GURME is on one hand applying the latest research and developments in modelling, forming good collaboration between research and operational communities, and on the other building capacity in developing countries, for instance through pilot projects.

Role and contribution
The WMO role and contribution into the MEGAPOLI project include: provide the link to megacities outside of Europe and developing countries through GURME. WMO will participate in WP8 as a Task Leader.

Researchers involved
Lisa Jalkanen
l.jalkanen@wmo.int
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:


- Saarnio K.; M. Aurela; H. Timonen; S. Saarikoski; K. Teinilä; T. Mäkelä; M. Sofiev; J. Koskinen; P. Aalto; M. Kulmala; J. Kulikonen, R. Hillamo (2010): Fine particles in fresh smoke plumes from boreal forest-fires. Science of The Total Environment, 408 (12), 2527-2542


- See more MEGAPOLI Publications/ Presentations at http://megapoli.info

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:

- 2nd Annual MEGAPOLI Project Meeting Hamburg, Germany, 1-2 Nov 2010
  Contact: Ole Ross (ole.ross@zmaw.de) and Heinke Schluenzen (heinke.schluenzen@zmaw.de), UHam team

- American Geophysical Union (AGU-2010) Fall Meeting session "Urban Areas and Global Change" San-Francisco, California, USA, 13-17 Dec 2010
  http://www.agu.org/meetings/fm10/

  http://www.ametsoc.org/meet/annual/

- European Geosciences Union (EGU-2011) General Assembly Vienna, Austria, 3-8 Apr 2011 (special MEGAPOLI, CityZen, MILAGRO session)
  http://meetings.copernicus.org/egu2011

- European Meteorological Society (EMS-2011) Annual Meeting Berlin, Germany, 12–16 Sep 2011
Welcome to the 9th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 9th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – special MEGAPOLI, CityZen, MILAGRO session "Megacities: Air Quality and Climate Impacts from Local to Global Scales" at the European Geosciences Union (EGU-2011) General Assembly, Vienna, Austria; 3-8 Apr 2011
- Coming soon – 6th MEGAPOLI WP Leaders telephone conference (mid-Jan 2011)
- Coming soon – Merry Christmas and Happy New Year 2011
- 1-2 Nov 2010 – 2nd Annual MEGAPOLI Meeting (UHam; Hamburg, Germany)
- Oct 2010 – access /sign agreement/ to MEGAPOLI database on Paris campaigns
- Sep-Nov 2010 – 2nd year reporting on WPs progress, milestones and deliverables (sci. reports) and Annual Dissemination Report of the MEGAPOLI project

MEGAPOLI 2nd Annual Meeting (1-2 Nov 2010)

See details on the next pages

Content

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12 MEGAPOLI Project Office Coming Presentations, Publications, Conferences
2nd Year MEGAPOLI Achievements

The FP7 EC MEGAPOLI project has passed into the 3rd year and it is time to make summary overview on realisation of project tasks and scientific achievements during the 2nd year. As reported in the 7th Newsletter the project successfully passed the Mid-Term Assessment (the results were discussed at the 2nd MEGAPOLI annual meeting in Hamburg, Germany). Here, only a very short statement of the MEGAPOLI results achieved during the 2nd year is presented.

MEGAPOLI is contributing to the strategic goal of promoting sustainable management of the environment and its resources by advancing our knowledge on the interactions between air quality, climate and human activities related to large urban centres and hotspots. The main MEGAPOLI objectives are:

(i) to assess impacts of megacities and large air-pollution "hot-spots" on local, regional, and global air quality and climate;

(ii) to quantify feedbacks between megacity emissions, air quality, and local, regional and global climate;

(iii) to develop and implement improved, integrated tools to assess the impacts of air pollution from megacities on regional and global air quality and climate and to evaluate the effectiveness of mitigation options.

The main scientific results achieved during the 2nd year of the project include the following:

1. Intensive winter (15 Jan – 15 Feb 2010) measurement campaign was successfully completed in the Paris metropolitan area. The campaign aimed at better quantifying primary and secondary organic aerosol (SOA) sources for a European megacity. Measurements were performed at primary and secondary fixed ground sites, an aircraft and mobile vans. During the winter measurements, large PM levels were observed due to both a strong local wood burning and continental advection. Database has been setup at CNRS-LISA website with login & password access. The Paris measurement campaign database was prepared including measurement results from the summer 2009 and partly from the winter 2010 campaigns.

2. Prototype inventories for anthropogenic (base year of 2005, 6 km resolution) and natural (e.g., fire, sea salt) emissions were compiled. For the 1st level megacities (Paris, London, Rhine-Ruhr area, Po Valley) high-resolution emission datasets were prepared and integrated into the final European scale emission map. An anthropogenic heat flux (AHF) model (0.25 x 0.25 arc-minute resolution) was developed and used to compute the AHF inventories for Europe and London.

3. A morphology database for Paris has been developed, along with a hierarchy of urban canopy and energy budget parameterisations for different scale models, which are being used to evaluate the surface flux balance modelling and urban features needed for climate and air quality models.

4. New physical and chemical parameterisations and zooming approaches have been implemented and are being tested for several megacities (e.g., Paris, Mexico City, and Po Valley), providing information about the relative importance of the various parameterisations when examining megacity air quality and especially its relation to meteorology. Coupled ACT-NWP models with two-way feedbacks were used to classify meteorological patterns favouring development of urban air pollution episodes in European megacities as well as to study effects of megacity emissions on meteorological processes. Urban aerosols were found to significantly affect several meteorological variables (temperature, inversion layers, radiation budget, cloud processes, precipitation, fog, etc.) in and far from the megacities due to the direct and indirect effects.

5. Substantial progress was made in developing and evaluating the satellite-based methods for the measurement of tropospheric gases and aerosols, especially NO2, in and around megacities. For construction of a regional model ensemble the harmonization of European domain parameters, input data and other modelling details was realized.

6. The radiative forcing from megacity emissions on the global scale was examined. Generally, megacities contribute about 2% to 5% of the total global annual anthropogenic emission fluxes for various compounds.

7. Progress has been made on producing a European framework for online and offline coupling of meteorological and atmospheric chemical transport models.

After Mid-Term Assessment the achieved results have been reported in a series of scientific reports, Newsletters and in a number of journal publications (see more at http://megapoli.info).

References
Day 1 - 1 Nov 2010

Location: KlimaCampus, Grindelberg 5, seminar room, Gr.Floor

09:00–09:25
- Heinke Schluenzen, UHam
  “Welcome: KlimaCampus, University of Hamburg & Center for Climate Research”

09:25–09:50
- Alexander Baklanov, DMI
  “MEGAPOLI: General Outlook and Mid-Term reporting results”

Status/ Progress for the MEGAPOLI Work Packages (WP)

09:50–11:10

WP1: Emissions
- Hugo Denier van der Gon, TNO - MEGAPOLI WP1 Emissions: Progress in Year 2, Deliverables
- Jochen Theloke, IER/ USTUTT - The baseline scenario results, Del 1.3
- Thomas Loridan, KCL - Anthropogenic heat flux inventory: the LUCY model
- Thomas Wagner, MPIC - Determination of Megacity Emissions from Satellite and Car MAX-DOAS observations

11:30–12:20

WP2: Megacity Environments: Features, Processes and Effects
- Igor Esau, NERSC - “Megacity Features & Urbanized turbulence-resolving model of Paris & Improved urban parameterizations based on prognostic equations, utilizing LES results”
- Antti Helsten, FMI - “Morphology database for a target megacity”
- Thomas Loridan, KCL - “The International Urban Energy Balance Models Comparison Project: overview of Phase 1 and 2”
- Alexander Mahura, DMI - “Hierarchy of Urban Canopy Parameterisations for Different Scale Models”
- Stefano Galmarini, JRC - “Stochastic fields method for sub-grid scale emission heterogeneity in mesoscale atmospheric dispersion models”

12:20–13:00

WP3: Megacity Plume Case Study
- Andre Prevot, PSI - “The Paris MEGAPOLI campaign to better quantify organic aerosol formation in a large agglomeration: Results of the winter campaign”
- Matthias Beekmann, CNRS-LISA - “WP3 general overview”

13:00–14:00
Lunch

Location: ZMAW, seminar room 022/23, Gr. Floor

14:00–14:30

WP4: Megacity Air Quality
- Nicolas Moussiopoulos, AUTH - “Megacity air quality: progress report and current status”
- Alexander Baklanov, DMI - “Interactions between Air Quality and Meteorology/ Climate Aerosol Feedbacks”
- Jaakko Kukkonen, FMI - “Exposure maps for selected megacities”

14:45–15:15

WP5: Regional and Global Atmospheric Composition
- Jaakko Kukkonen, FMI - “Regional atmospheric composition: progress report and current status”
- Andreas Stohl, NILU - “Global atmospheric composition: boundary conditions, global dispersion" characteristics, annihilation scenario”
- Steve Rumbold, UKMetO - “Megacities impact on global composition”

15:20–15:55

WP6: Regional and Global Climate Effects
- Bill Collins, UK MetO - “Climate impacts of megacities - global”
- Steve Rumbold, UK MetO - “Comparison of coupled and uncoupled models”
- Fabien Salmon, ICTP - “Regional climate modeling effects”
- Tomas Halenka, CUNI - “Urban impact on air quality in REGCM/CAMx couple for MEGAPOLI Climate Change Study in High Resolution”

16:20–16:45

WP7: Integrated Tools and Implementation
- Heinke Schluenzen, UHam - “Integrated Tools and Implementation: progress report and current status”

Figure: WP1: Nesting the Paris inventory (TNO).

Figure: WP5: PM10 yearly concentrations in Po Valley vs. comparison with background observations (ARIANET).

Figure: WP6: PM10 yearly concentrations in Po Valley vs. comparison with background observations (ARIANET).
1 Nov 2010 (continued)

16:45–17:25
**WP8: Mitigation, Policy Options and Impact Assessment**
- Jochen Theloke, USTUTT –
  “Mitigation, Policy Options and Impact Assessment: progress report and current status”
- Rainer Friedrich, USTUTT –
  “Integrated assessment of policies”

17:25–17:35
**WP9: Dissemination and Coordination**
- Alexander Baklanov, DMI –
  “Reporting on WP9 tasks, m/ls, dels, dissemination and coordination”

17:35–18:15
**Overview of Megacities in Focus**
- Sandro Finardi, ARIANET –
  “Status of Po Valley Activities & Italian emission scenarios at national and sub-national scale”
- Melinda Uzbasich, USTUTT –
  “The Rhine – Ruhr region”
- Xavier Francis, UH-CAIR –
  “Effect of Megacities on Air Quality and Climate – London and Paris”

18:15–18:45
**MEGAPOLI Steering Group Meeting**
- lead by Alexander Baklanov, DMI -

Day 2 – 2 Nov 2010
Location: ZMAW, seminar room 022/23, Gr. Floor

09:00-09:15
Morning gathering and announcement of parallel sessions
ZMAW, seminar room 022/23 & 101, Geomatikum 1729

09:15–10:45
**Parallel/Specific WPs Meetings and Discussions (lead by WP leaders)**

Meeting of WP5: Regional and global atmospheric composition
- lead by Mikhail Sofiev, FMI -
  MEGAPOLI European Ensemble (status, expected results, outcome)

Meeting of WP7: Integrated Tools and Implementation
- lead by Heinke Schluenzen, UHam -
  Synthesis of outcomes of WPs, Integration framework, Evaluation of integrated methods, Implementation of integrated tools to megacities, Recommendations on sci. analysis of megacity impacts

Meeting of WP8: Mitigation, Policy Options and Impact Assessment
- lead by Rainer Friedrich, USTUTT -
  Tasks to do / Questions - overview

10:45-11:15
**Coffee break**

11:15–12:30
**Discussions in Thematic Groups on Different Scale Studies**

**Global Group**
- lead by Mark Lawrence, MPIC -
  Emissions, Simulations, Impact on Climate, Publications

**Regional Group**
- lead by Spyros Pandis, FORTH & Mikhail Sofiev, FMI -
  Regional modeling specifics (scientific questions; comparison with observations: representativeness issue; communication with WP7)

**Local Group**
- lead by Alexander Baklanov, DMI/ Nicolas Moussiopoulos, AUTH -
  Megacity Scales Study: questions to answer from the 1st year meeting, and questions for the 2nd year meeting; Calculation of the urban increment

Location: ZMAW, seminar room 022/23, Gr. Floor

12.30–13.15
**Summary Presentations from each group & linkage between groups**
- Mikhail Sofiev, FMI -
  Groups: WP5 & Regional Modelling
- Heinke Schluenzen, UHam -
  Group: WP7: Integrated Tools and Implementation
- Rainer Friedrich, USTUTT –
  Group: WP8: Mitigation, Policy Options and Impact Assessment
- Mark Lawrence, MPIC -
  Group: Global Modelling
- Alexander Baklanov, DMI –
  Group: Local Modelling – Megacity scales study
- Nicolas Moussiopoulos, AUTH –
  Group: Local Modelling – Calculation of urban increment

13:15-14:15
Lunch

14:30–15.15
**MEGAPOLI Third Year Plans: Overview and Discussions**
- lead by Mark Lawrence, MPIC -
  Deliverables by main topics (Emissions; Campaign Data & Analysis; Modelling – Urban, Regional, Global; Integration; Mitigation)

15:15–15:45
**Collaborative Projects / External partners presentations**
- Bob Bornstein, San Jose State University, USA -
  MEGAPOLI & my research on observation & simulation of polluted coastal urban PBLs in a changing change
- Liisa Jalkanen, WMO, Switzerland -
  GURME connections: WMO GAW Urban Research Meteorology and Environment project

16:20–16:30
- Alexander Mahura, DMI -
  Items/ topics of the 2nd year MEGAPOLI reporting (deliverables, milestones, dissemination reporting)

16:30–16:45
- Alexander Baklanov, DMI -
  Publications: planned/written articles, special issues, meetings, etc.

16:45–16:50
- Heinke Schluenzen, UHam -
  Conclusions/ summary of the 2nd MEGAPOLI meeting; End

Figure: WP3: Determination of the Paris emissions from car MAX-DOAS measurements (MPIC).
MEGAPOLI workpackage 1 (lead by TNO) provides emission data for various modelling WPs of the project. A previous article in newsletter by van der Gon et al., (2009) describes the activities in WP1 for the regional (European) emissions. In this newsletter the focus is on the global emissions used by the modellers in MEGAPOLI. A short deliverable report describing the global emission data was prepared and it is available from the MEGAPOLI website (van der Gon et al., 2010).

**Global Emissions**

WP1 focuses on emission inventories at local, regional and global scale. Emission inventories are created, using where possible currently available state-of-the-art emission inventories at local, regional and global level. At the global level, the initial plans were to use the EDGAR v4.0 emission dataset, which should provide global emissions at 0.1°x0.1° (longitude x latitude). However, the release of this dataset was delayed and not available in time for MEGAPOLI. A good alternative is the gridded emission dataset developed in support of the IPCC Fifth Assessment Report (AR5) by Lamarque et al. (2010). The resolution of this dataset is 0.5°x0.5°. The most recent year is 2000. However, the IPCC Representative Concentration Pathways (RCPs) provide emission projections for future years. In MEGAPOLI the RCP8.5 scenario (Riahi et al. 2007) was selected to derive global emissions for 2005. Fig. 1 shows an example of the emission map for year 2005.

**Emissions from Megacities**

In total 36 megacities (MC) were identified in the global emission dataset using the 1x1° MC emission mask by Butler et al. (2008). Emissions from these megacities were extracted and combined with population data to derive MC emissions per capita. A weighted average of the emissions per capita from the megacities in each continent shows significant differences between continents (Fig. 2). The high emissions per capita in Oceania are related to Sydney, Australia (the only megacity on this continent) and suggest that emissions in this city are relatively high. However, this conclusion may be preliminary since the allocation of emissions from the global dataset may lead to a bias, or the spatial distribution of emissions may allocate too big share of the Australian emissions in Sydney.

Emissions of CO, NMVOC and SO2 are higher for Asia and Africa compared to other continents, reflecting the use of older technologies and less clean fuels. In European megacities the NH3 emission per capita is remarkable, but it is likely to be explained by the inclusion of non-urban areas in the MC domain (Rhine-Ruhr area and Po Valley), especially the latter has substantial animal husbandry.

With regard to sources, emissions from residential combustion are a major source, especially in African and Asian megacities. This reflects the use of coal and mainly wood as well as less advanced combustion installations in this sector (Fig. 3). The highest emissions from the transport sector and the use of solvents occur in North American megacities.

**Acknowledgements**

We thankful to Lamarque et al. (2010) and Riahi et al. (2007) for the possibility to use their data in the MEGAPOLI project.

**References**


MEGAPOLI Database of Chemical Composition, Size Distribution and Optical Parameters of Urban and Suburban PM and its Temporal Variability & of the Impact of Megacity Emissions on Regional Scale PM Levels (MEGAPOLI Dels 3.1 & 3.4)

Matthias Beekmann
E-mail: beekmann@lisa.u-pec.fr
LISA, UMR7583, CNRS, Université Paris-Est, Université Paris-Diderot

M. Beekmann1, U. Baltensperger2, Catherine Schmechtig1, and the MEGAPOLI campaign team

1 Centre National de Recherche, Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), 2 Paul Scherrer Institut (PSI), Switzerland

This contribution describes two MEGAPOLI Deliverables accomplished by autumn 2010, which presents the description of the measurements set-up performed during the MEGAPOLI Paris campaigns and the set-up of a local database at the CNRS-LISA website for their storage and distribution. Del. 3.1 deals with measurements at fixed locations/sites; Del. 3.4 - with measurements performed on mobile platforms (i.e. vans and aircraft).

Two intensive measurement campaigns were performed in the Ile-de-France region during a one-month summer and a one-month winter period (July 1 – 31, 2009 and January 15 to February 15, 2010, respectively). The campaigns aimed at better quantifying primary and secondary organic aerosol sources for the example of a big European Megacity (the Paris region) according to the MEGAPOLI WP3 core objectives. The campaign design included 3 primary and 7 secondary fixed ground measurement sites, an aircraft and 5 mobile platforms. This set-up was much bigger than initially planned and funded by the European Commission, due to a large number of additional volunteers’ contributions by the MEGAPOLI partners and other research groups, and due to additional national (French) funding. The research groups reports published in previous newsletters have already given an overview over these activities.

The organisation of the campaign database at the CNRS-LISA is described. In this database, measurement data are now available to FP7 project partners and to campaign participants (listed in Appendix 1 of the Deliverable), after signature of a data exchange protocol which can be downloaded at http://megapoli.lisa.univ-paris12.fr/DATA/data.php. For other groups, data can be available upon a request. The campaign database for the Paris MEGAPOLI campaign has been set-up by Catherine Schmechtig, research engineer at CNRS-LISA. It is accessible via the CNRS-LISA MEGAPOLI website (http://megapoli.lisa.univ-paris12.fr/), which also gives general information about the campaign and is linked with the general public MEGAPOLI project website. The database is file oriented, which means that files are stored and can be downloaded as they come in, with the exception of a format control. The common campaign data base format is NASA / Ames for 1D data (time series). This format is in common use also for other campaign databases (for example, for the FP6 EUCAARI project). Lidar data will be distributed as netCDF or HDF format.

The data base can be accessed at: http://megapoli.lisa.univ-paris12.fr/ Data and Measurements To DATABASE

To enter the site, a username and a password are required. These are provided by the database administrator Catherine Schmechtig (1), research engineer at CNRS-LISA, after signature of the data protocol, which should be sent to her. The data base is organised in the following way. An entry page shows the different fixed primary and secondary sites, and gives access to mobile sites. From this page, sub-pages for the different sites can be reached. On each site page, a list of the performed measurements is displayed. A different list of data files is then available for the summer and winter period on a click. The database coverage for contractual data is good for the summer campaign (about 90%), but slightly less for the winter campaign (about 80 %), for which time for data reduction was less. Also non-contractual data have already been submitted by many groups. At a later stage, in the middle of year 2011, data will be transferred from the local CNRS-LISA to the CNRS / CNES topical center Ether data base (http://ether.ipsl.jussieu.fr/) for longer term storage and distribution. This data base will be active also after the formal end of the FP7 project.

(1) Catherine Schmechtig, Laboratoire InterUniversitaire des Systèmes Atmosphériques (LISA), Faculté des Sciences, 61, avenue du Général de Gaulle, 94140 Créteil, Cedef, France E-mail: catherine.schmechtig@lisa.u-pec.fr

http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-16.pdf
http://ether.ipsl.jussieu.fr/


Figure: Entry page of the CNRS-LISA campaign data base
During MEGAPOLI Winter (January-February 2010) measurement campaign the SAFIRE Piper Aztec airplane performed successful scientific flights. The field team of SAFIRE included 4 persons: Philippe Pohar (pilot), Remi Caillou and Marc Laurens (experimenters), and Pierre Vitupier (mechanic).

Each flight was following the same scenario: (i) Round around Paris to study the initial conditions in all directions; (ii) Legs moving away from Paris and in the downwind area to study the evolution of the pollution plume.

The labs who operated the aircraft instrumentation were: CNRM (Toulouse, F; PI: L. Gomes), LaMP (Clermont-Ferrand, F; PI: A. Schwarzenboeck), and LISA (Creteil, F; PI: A. Borbon).

**SAFIRE Team for Paris Winter 2010 Campaign**

<table>
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<th>Date</th>
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<th>Trace gases pollution level</th>
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<td>Paris turn around</td>
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<td>Paris turn around</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Table 1.** Airborne measurements on Piper Aztec aircraft operated by SAFIRE during the winter campaign.
Satellite Observations of Aerosol Properties over European Megacities and Surroundings

Edith Rodriguez
E-mail: edith.rodriguez@fmi.fi
Finnish Meteorological Institute, Climate Change Unit, Helsinki, Finland
http://ilmatieteenlaitos.fi/en/

Satellite observations of aerosol optical depth (AOD) are used to estimate the contribution of emissions from European Megacities to the regional aerosol load. In this study data from the Advanced Along Track Scanning Radiometer (AATSR), flying on the ENVironmental SAtellite (ENVISAT), are used together with AERONET Sun photometer level 2.0 data for validation.

Instrument
The AATSR is designed for monitoring land and sea surface temperatures. The special feature of the AATSR instrument is that it provides measurements at two viewing angles, at 55° forward and about two minutes later at nadir. The spatial resolution is approximately 1x1 km² at nadir and its swath width is 512 km. The AATSR instrument has seven wavelengths in the visible and infrared regions, centred at 555, 659, 865, 1610, 3700, 11000, and 12000 nm. AATSR reaches global coverage in about five days, while at mid-latitudes the return time is about three days.

Method
The radiance measured by AATSR at the top of the atmosphere is due to reflectances by the surface, clouds, gases and aerosols. For cloud-free pixels the path radiance has to be separated from the surface contribution. This is accomplished with the AATSR Dual View Algorithm (ADV) which uses the two AATSR views for retrievals over land. The path radiance is retained and compared with radiative transfer model results, at three wavelengths, to determine the spectral AOD. These comparisons are made for a range of aerosol model components and mixing ratios of two models to determine the most appropriate wavelength dependence and aerosol mixing ratio. ADV is based on the ATSR-2 algorithm (Veefkind et al, 1998a) and is described in Curier et al, 2009. For application over water the Single View Algorithm (ASV) (Veefkind and de Leeuw, 1998) is used. ADV results are validated by comparison with ground-based measurements from the AERONET network. The retrieved parameters include the AOD at three different wavelengths (555, 659, and 1610 nm) and the Ångström coefficient which describes the AOD wavelength dependence. The aerosol mixing ratio can optionally be made available.

Results
To retrieve the AATSR data over Europe a combination of a non-absorbing model for coarse particles (geometric radius 0.51 μm) and an absorbing model for fine particles (geometric radius 0.11 μm) was used.

Figures 1 and 2 show the AOD at 555nm and the Ångström Exponent (555-675) (AE), respectively, aggregated from all retrievals in 2009 over NW Europe. Aggregates are shown rather than averages because AATSR overpasses this region every third day and aerosol retrieval is only possible in clear sky. The aggregate AOD over London for 2009 was 0.28±0.14 and over Paris 0.24±0.25. The large standard deviation in Paris is due to alternate periods with clean and polluted air associated with circulation patterns.

During clean air episodes the AOD is clearly enhanced with respect to its surroundings as opposed to episodes with more polluted air when cities can less clearly be identified from the AOD pattern. The AE re-enforces this conclusion because high values are associated with the occurrence of fine particles. It is noted that the high AOD over the North Sea is an artefact due to the occurrence of sediment in the water which is not properly accounted for in the AATSR aerosol retrieval algorithm.

Conclusions
Satellites provide aerosol properties over larger areas. From the regional distribution sources can be identified in the aggregates provided that they are strong enough to locally enhance the column aerosol concentrations and thus the AOD.

References
General Approach

This study is devoted to elaboration of general methodology for adjustment of original land-use dataset (CORINE Land Cover 2000; CORINE, 2000) for urban scale modelling in numerical weather prediction (NWP) and environmental applications. Three metropolitan areas – Paris (France), Copenhagen (Denmark), and Bilbao (Spain) – of different spatial sizes and population were considered. The CORINE and Basque Government land use (UDALPLAN, 2009) databases of different details and resolutions were selected. Several approaches were suggested for treatment of selected databases multilayer content using Geographic Information System (GIS) tools, depending on the data available in each case. It is applied to an operational online coupled numerical weather prediction and atmospheric chemical transport modelling system Enviro-HIRLAM (Environment-High Resolution Limited Area Model; Baklanov et al 2008; Korsholm, et al., 2009). The interaction Soil-Biosphere-Atmosphere (ISBA) land surface scheme was modified to include urban effects using the Building Effect Parameterization (BEP, Martilli et al., 2002) module and Anthropogenic Heat Fluxes (AHF) extracted from LUCY model (which considers energy fluxes from traffic, metabolism and energy consumption, Allen et al., 2010).

The methodology is based on the extraction of the modelling domain from the ENViro-HIRLAM climate files. By processing the grid in GIS environment it was possible to convert the irregular grid points into regular polygons. Then, they were integrated with the regional/European database and finally, performed the urban classification into different types of districts over the domain (Table 1).

High resolution short-term runs (2.4 km) for specific dates (summer 2009 and winter 2010) with variable wind conditions were performed for the Bilbao metropolitan area, based on different urban scenarios generated by means of this approach. Several scenarios were generated with AHF= 40 W/m² modifying the size of the city: firstly, the area considered in CORINE 2000 (16 urban grids); then the double size city expansion (30 urban grids) and the triple size city expansion (48 urban grids). Other scenario considers an increased of AHF in double (80 W/m²) with the original size of the city (16 urban grids). The last scenario combined the triple size city expansion (48 urban grids) plus the increased AHF in double (80 W/m²). The goal was to evaluate the urbanized (with BEP module and AHF) Enviro-HIRLAM and to estimate the influence of the city on formation of the air temperature at 2 m and wind velocity at 10 m. Three nested domains were selected with spatial grid resolution of 15, 5 and 2.4 km which contain 1.5x148, 130x116 and 130x116 cells, respectively. There were performed two simulations for each urban scenario: 1) control runs, without any modifications and 2) urban runs including BEP+AHF within the corresponding modification for scenarios.

![Comparison of output of Urbanized and Control Runs for Air Temperature at 2 m](image)

As it was found, for the urban area considered with 16 urban cells and AHF=40 W/m², on average, for air temperature at 2 m the difference was 1.3°C between 3-6 UTC (with a maximum of 1.9°C at 6 UTC) (Fig. 2a). For wind velocity at 10 m the difference was 1 m/s between 3-6 UTC (with a maximum of 1.5 m/s at 6 UTC). However, for the scenario combining triple size city expansion and double increased in AHF, on average, for temperature at 2 m the difference was 1.8°C between 3-6 UTC (with a maximum of 3.15°C at 6 UTC) (Fig. 2b). For wind at 10 m the difference was 1.9 m/s between 3-6 UTC (with a maximum of 2.9 m/s at 6 UTC).

Acknowledgements

Thanks to Dr. M. Mendizabal for the constructive discussions related to GIS processing.

References

CORINE, 2000: CORINE Land Cover Dataset 2000. European Environmental Agency. http://dataservice.eea.eu.int/dataservice/UDALPLAN, 2009 at 6:00 am for urban area (as (a) considered in CORINE (i.e. 16 urban grids) and AHF=40 W/m²); and (b) based on triple size city expansion (48 urban grids) and double AHF=80 W/m²).

![Comparison of output of Urbanized and Control Runs for Wind Velocity at 10 m](image)

![Comparison of output of Urbanized and Control Runs for Air Temperature at 2 m](image)

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<td>1.4x1.4</td>
<td>6522</td>
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</table>

Figure 1: Urban districts classification for metropolitan areas of: (a) Paris, (b) Bilbao, and (c) Copenhagen.

Figure 2: Difference plots between outputs of the urbanized ENVIRO-HIRLAM (BEP module and AHF fluxes modified in the ISBA land surface scheme) and control runs for the air temperature at 2 m on 12th Aug 2009 at 6:00 am for urban area as (a) considered in CORINE (i.e. 16 urban grids) and AHF=40 W/m²; and (b) based on triple size city expansion (48 urban grids) and double AHF=80 W/m².

Figure 2: Difference plots between outputs of the urbanized ENVIRO-HIRLAM (BEP module and AHF fluxes modified in the ISBA land surface scheme) and control runs for the air temperature at 2 m on 12th Aug 2009 at 6:00 am for urban area as (a) considered in CORINE (i.e. 16 urban grids) and AHF=40 W/m²; and (b) based on triple size city expansion (48 urban grids) and double AHF=80 W/m².

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Table 1: Information of the climate files extracted from Enviro-HIRLAM to be processed in GIS tools for the three cities studied.
Multi-Scale Air Quality Forecast: Downscaling from Regional to Street Scale

Roman Nuterman
E-mail: ron@DMI.DK
Danish Meteorological Institute, Research Department, Copenhagen, Denmark
http://www.dmi.dk

Nuterman R.1, Baklanov A.1, Mahura A.1, Zakey A.1, Korsholm U.1, Bjarne A.1, Gonzalez-Aparicio I.2
1Danish Meteorological Institute, Copenhagen, Denmark
2Environmental Unit, TECHNALIA research and innovation, Bilbao, Spain

Due to increasing supercomputer power modern nested numerical meteorological and air pollution models realise model nesting/down-scaling from the global to the local scale and approach the necessary horizontal and vertical resolutions to provide weather and air quality forecasts for urban and local scales. Most of urban simulations for real conditions consider only a small part of the urban area in a micro-meteorological model and urban heterogeneities outside the simulation domain affect the micro-scale processes. Therefore, it is important to build a chain of models of different scales with nesting of high resolution models into larger scale lower resolution models.

Figure 1. Urban-Street downscaling system for Copenhagen, DK.

Usually, the up-scaled city-scale (sub-meso) or meso-scale models consider parameterisations of urban effects or statistical descriptions of the urban building geometry, whereas the micro-scale (street canyon) models are obstacle-resolved and consider a detailed geometry of the buildings and the urban canopy. The first element in the downscaling chain is ensemble forecast from regional/meso-scale models as input for DMI’s downscaling system (Fig. 1).

After that two nested domains are used for downscaling from the regional- to meso- and city-scale using Enviro-HIRLAM (Environment - High Resolution Limited Area Model, Korsholm et al., 2008). Several levels of urban parameterisation are used in the chain depending on considered scales (Baklanov and Nuterman, 2009): for regional scale urban parameterisation is based on the roughness and flux corrections approach; for urban-scale on the Building Effects Parameterisation (Martilli et al., 2002). For local- and micro-scale nesting the Micro-scale Model for Urban Environment (M2UE) is used. This is a comprehensive CFD-type obstacle-resolved urban wind-flow and dispersion model (based on the Reynolds averaged Navier-Stokes approach and different two-equation turbulence closures, Nuterman et al., 2008).

Figure 2. Micro-scale Model run for Urban Environment (M2UE) downscaling for the selected Copenhagen area (Jagtvej street; top – figure extracted from http://sketchup.google.com); Results (bottom) of the M2UE model run for: grid cells number: 107 x 162 x 38, domain size: 280 x 400 x 60 m, maximum inflow speed - 5.5 m/s)

Boundary and initial conditions for the nested M2UE model are used from the Enviro-HIRLAM model with corresponding interpolation (like Radial Basis Function or bilinear techniques).

In some cases, when it is switch from the roughness to the obstacle-resolved approach in the nested model (Fig. 2), the interpolation procedure can be difficult for meteor/chemical fields between buildings and will lead an increase of the computation time due to necessary additional iterations. In such cases, as a possible alternative, the perturbation approach can be recommended, where the main meteorological variables (or chemical species) are considered as a sum of two components: background (large-scale) values, described by the coarse-resolution model, and perturbations due to micro-scale features, described by the nested fine resolution model.

References


The Russian MEGAPOLIS project aims to develop integrated technologies of megacities air-pollution assessment based on results of remote sensing and in-situ monitoring for mitigation option. The project is funded in the scope of the Federal Framework Program of Ministry of Education and Science of Russian Federation. The MEGAPOLIS project is a partnership project with the European FP7 MEGAPOLI project (http://megapoli.info).

Head organization of the MEGAPOLIS project is “AEROCOSMOS” Scientific Centre of Aerospace Monitoring. The project is carried out together with a group of scientific organizations representing:
(i) the Faculty of Geography, Lomonosov Moscow State University;
(ii) the Institute of Atmospheric Physics, Russian Academy of Sciences;
(iii) Hydrometeorological Centre of Russia (Federal Service for Hydrometeorology and Environmental Monitoring).

MEGAPOLIS project runs for more than a year now. The following results have been achieved during that time:

- Ground and remote sensing data for the Moscow area were collected and analyzed; these included meteorological (temperature, humidity, pressure) and chemical (concentration of ground-level ozone, nitrogen oxide, nitrogen dioxide, sulfur dioxide, carbon monoxide, total hydrocarbons, PM10) data. Statistical analysis of concentration of chemical species distribution over the Moscow area showed that concentrations of some pollutants depend on a distance from pollution sources.
- Studies of snow cover properties in the eastern district of Moscow have allowed getting an objective picture of its pollution, reflecting the atmospheric pollution during the winter season.
- Atmospheric boundary layer and urban surface properties were investigated using ground-based and remote data for episodes of extreme events (such as -30 degrees of frost in the winter of 2010 and the strong heat in the summer of 2010). Results of the data processing confirmed the importance of meteorological conditions and the properties of the underlying surface in the assessment of air pollution in megacity like Moscow, especially in periods of extreme weather conditions.---

References
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:

- Baklanov A. and the MEGAPOLI Team (2010): MEGAPOLI: concept of multi-scale modeling of megacity impact on air quality and climate. Advances in Science and Research, 4, 115-120; doi:10.5194/asr-4-115-2010
- Oral presentations given at the 2nd Annual MEGAPOLI Meeting (1-2 Nov 2010; Hamburg, Germany) (2010) – available at the MEGAPOLI project internal website (http://megapoliforum.dmi.dk)
- See more MEGAPOLI Publications/ Presentations at http://megapoli.info

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:

- European Geosciences Union (EGU-2011) General Assembly Vienna, Austria, 3-8 Apr 2011 (special MEGAPOLI, CityZen, MILAGRO session) http://meetings.copernicus.org/egu2011
- Urban Air Quality and Climate Change Workshop (UAQCC) Hamburg, Germany, 16-18 Aug 2011 contact: Heinke Schluenzen, UHam (heinke.schluenzen@zmaw.de)
- European Meteorological Society (EMS-2011) Annual Meeting Berlin, Germany, 12–16 Sep 2011
- 3rd Annual MEGAPOLI Project Meeting/ Workshop Paris, France, 26-28 Sep 2011 contact: Matthias Beekmann, CNRS-LISA (beekmann@lisa.univ-paris12.fr)
Welcome to the 10th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 10th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – workshop on "Planetary Boundary Layer (PBL): Science, Education and Urban Applications" organized by the FP7 EU MEGAPOLI, Russian MEGAPOLIS, EU TEMPUS and FP7 EU PBL-PMES projects (30 Apr - 3 May 2011; Dubrovnik, Croatia)
- Coming soon – special MEGAPOLI, CityZen, MILAGRO session "Megacities: Air Quality and Climate Impacts from Local to Global Scales" and Splinter Meeting with sister FP7 EC CityZen project at the EGU-2011 General Assembly (3-8 Apr 2011; Vienna, Austria)
- 21 Feb 2011 – starting submission of MEGAPOLI related papers to 2 special issues of the Atmospheric Chemistry and Physics (ACP) Journal
- 23-27 Jan 2011 – MEGAPOLI project presented (invited talk) at the AMS 91st Annual Meeting (Seattle, USA) and working meetings with MEGAPOLI US collaborators
- 13 Jan 2011 – 6th MEGAPOLI WP Leaders telephone conference
- Dec 2010 – Second Year MEGAPOLI Dissemination Report is publicly available

MEGAPOLI-NL10-11-03


"The project is organised into several WPs in which there have been the following developments:

- The project has integrated emission inventories from local administrations into larger datasets. This has built connections between existing information and bridges between the air quality and climate change research communities.
- Researchers have developed a classification of megacity features, such as land use, and features of the atmosphere above the city.
- Using measurements from Paris, the project has characterised different aerosols (tiny airborne particles) and their behaviour above megacities. Results indicate that a large cloud of pollution is still well-defined more than 100km from its source in Paris, providing a spatial framework for future study of aerosols.
- New methods have been developed to model local and urban scale impacts of megacity emissions on air quality and on the feedback loops between air quality and climate change. The results indicate that urban aerosols affect several weather conditions, such as temperature and rainfall.
- Progress has been made in developing modelling tools at the continental and global scale and findings indicate that megacities contribute about 2 to 5 % to total global fluxes of emissions caused by humans.
- Finally, the results of modelling are being used to estimate the financial impact of megacity emissions on human health, ecosystems and climate change. Using this information, various mitigation options will be evaluated."
European and Megacity Baseline Scenarios for 2020, 2030 and 2050 (MEGAPOLI Del 1.3)

Jochen Theloke
E-mail: jochen.theloke@ier.uni-stuttgart.de
USTUTT, Institute of Energy Economics and Rational Use of Energy (IER), Stuttgart, Germany

Jochen Theloke1, Markus Blesl2, Tatjana Kampffmeyer3, Konstantin Schenk1, Susanne Wagner1, Ulrike Kugler1, Rainer Friedrich1, Hugo Denier van der Gon1, Dick van den Hout2
1 USTUTT, Institute of Energy Economics and Rational Use of Energy (IER), Stuttgart, Germany
2 TNO, Environment Health and Society, Utrecht, The Netherlands

Introduction
The development of a baseline emission scenario is a crucial basis for the assessment of mitigation and policy options to efficiently reduce health effects and climate change impacts caused by releases of substances to air in megacities. The aim of Work Package 1.3 is therefore to provide a baseline scenario for Europe and the MegaCities (MC) for the years 2020, 2030, and 2050. Scenarios have been provided for air pollutants (CO, NH3, NMVOC, NOx, PM10, PM2.5 and SO2) and greenhouse gases, GHG (CO2, CH4 and N2O).

Methodology
The scenarios have been compiled on base of a consistent European Energy model, which models the development of energy related sectors. In addition the development of non-energy related sectors has been assessed on base of the GAINS model (http://gains.iiasa.ac.at) and other assumptions.

The demand of energy was determined by application of several sector specific data bases and models (TREMOVE, GAINS) and own assumptions. The development of the emission factors is mainly driven by technical developments and air quality policies. The emission factors are based on assumptions from the European energy system model (Blesl et al., 2010). The Pan-European TIMES energy system model (short TIMES PanEU) is an energy model of 30 regions which contains all countries of EU-27 as well as Switzerland, Norway and Iceland. The model covers on a country level all sectors connected to the energy supply and demand, for example the supply of resources, the public and industrial generation of electricity and heat and the industrial, commercial, household and transport sectors.

Figure 1 shows the development of the total final energy consumption for EU-30 in the baseline scenario from the TIMES-Energy Model.

A climate policy for the European countries with a mitigation of GHG gases of about 50% until 2050 in comparison to 1990 GHG emissions has been assumed. That means we assumed a moderate climate policy, which give options of applying further mitigation strategies. The model-intrinsic policies have mainly impacts on the activities (e.g. fuel use) in our model. The assumptions include the use of more air conditioning, which means an increase in electricity demand. They do not explicitly estimate a reduced energy demand for heating (room heating and water heating), although the demand for heating is decreasing in our data due to improved insulation. We however estimate that the effect would be small and partly or fully compensated by the rebound effect (increase of required indoor temperature).

The emission factors are mainly based on assumptions from the European energy system model and other models (TREMOVE, GAINS) and own assumptions. The development of the emission factors is mainly driven by technical developments and air quality policies. The emission factors for 2050 have been mainly projected from 2030 to 2050 assuming them as constant or taking into account a technological or/and efficiency development.

Results
In Figure 2 the future development of NOx emissions from 2005 to 2050 in Europe is shown. The main reduction of NOx emissions are expected between 2005 and 2020 due to current legislation (e.g. Euro 5 / 6) in the transport sector. After 2020 emissions will increase slightly due to assumed growing activities.

Megacities specific scenarios
A survey about the availability of megacity specific scenario information has been conducted in the four 1st level MC. It showed that assumptions about the development of future emissions until 2050 are only available for London (Williams, 2007). For the Po valley emission projections until 2020 exist on base of the GAINS-Italy model (http://www.pbl.nl/images/RAINS_Ill_{Italy {Project} tcm 60-21207.pdf}). Thus, the emission scenarios for future years for the 1st level MC have been generated by downscaling the emissions to the city areas from the European data base.

References
Table 1: Ratio of the MC emission from the Regional European scale inventory over the local MC emission inventory.

<table>
<thead>
<tr>
<th></th>
<th>NOx</th>
<th>PM$_{10}$</th>
<th>PM$_{2.5}$</th>
<th>NH$_3$</th>
<th>SO$_2$</th>
<th>NMVOC</th>
<th>CO</th>
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<tr>
<td>London</td>
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<td>3.9</td>
<td>na</td>
<td>9.4</td>
<td>1.5</td>
<td>3.6</td>
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<tr>
<td>Paris</td>
<td>1.1</td>
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<td>Po Valley</td>
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<td>0.9</td>
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<td>1.0</td>
<td>1.2</td>
<td>0.8</td>
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na = not available

Since the MC domains were accurately defined (see MEGAPOLI Newsletter N4) we can “cut-out” the MC emission from the regional inventory and compare them to the local MC emission estimates (Tab.1). The differences can be quite dramatic. The discrepancy for NOx is limited but not for uncertain pollutants like PM, NMVOC and CO. For example, the PM$_{10}$ emission allocated to London or Paris by the down-scaled regional inventory is a factor 3-4 higher than the local inventories. The smaller the domain, the larger the discrepancies are. The 10 fold overestimating of SO$_2$ emission from London (Tab.1) was due to uncertainties of the exact location of some point sources. Such misplacements can be understood and repaired but some more complex discrepancies need further study.

The first critical step in improving our understanding of how megacities impact air quality, atmospheric composition and climate on different scales is the development of high-quality emission inventories (EI) of relevant gases and aerosols and their precursors. The generation of a European EI with nested high resolution EIs for selected European megacities is one of the main deliverables of MEGAPOLI WorkPackage 1. In the first year of MEGAPOLI the focus was on preparing gridded emission maps for the base year 2005. This “default” base year EI was delivered to project partners in 2009. The next step was nesting local high resolution inventories in the European emission inventory in a consistent way (Fig.1).

Comparison of the down-scaled and bottom-up inventories MEGAPOLI has a pyramidal structure of megacities in focus. The 1st level cities have a MEGAPOLI WP1 partner as counterpart: Paris (CNRS), London (KCL), Rhine-Ruhr (IER) and Po Valley (ARIANET).
Method
The block heights are retrieved using a multi-baseline approach based on an algorithm for automatic Digital Elevation Model (DEM) reconstruction (Ferretti et al., 1997). The height of each pixel in a single complex interferogram is considered as a random variable. Using the information from multiple observations at different perpendicular baselines, for each pixel a Probability Density Function (PDF) for the height can be computed from interferometric phase difference and coherence. Mean and standard deviation of this PDF give the estimated height value of the pixel and an estimate for the reliability of the result. Both a height map and a height error map for the Paris region of interest were obtained.

Results
A Digital Surface Map of central Paris, providing the roof-top height, has been generated. The height map in slant range coordinates is shown in Figure 1. Some errors in low coherence areas are visible, which still need to be masked out. The corresponding height error is presented in Figure 2. The standard deviation of the height PDF does not exceed 1 m, which yields a height error of less than 2 m with 95% confidence interval, in most of the central Paris area. The unwrapped phase image was transformed from slant-range to ground-range coordinates and re-projected into UTM geo-coordinates (as seen in Figure 3).

Conclusion
In this study, good and reliable estimates for the roof-top elevation of most building-blocks in the Paris urban area were obtained. In a case of very tall blocks no elevation is found due to the effect of multiple phase wraps and strong layover. To obtain the block heights over ground a Digital Terrain Map (DTM) needs to be subtracted. Generation of a DTM from the same data by finding scatterers at street level will be the next step in the on-going study.

References

Instrument
The ASAR is a C-band Synthetic Aperture Radar (SAR). In Image Mode (IM), the ASAR provides images in single polarization (VV or HH) at multiple incidence angles (from IS1 to IS7). Coverage ranges from 100 km (IS1) to 56 km (IS7) at an azimuth resolution from 4 to 5 meters and a range resolution from 9 to 18 meters (Rosich, 2002).

Data
In this study, the Single Look Complex (SLC) IS2 images are used. 13 images of the Paris urban area were available for this study. Using the InSAR processor DORIS, developed by the Delft University of Technology, 27 complex interferograms with perpendicular baselines ranging from 8 to 337 meters were generated. For each interferogram phase difference and coherence were computed. Observations were taken in the period from 16 December 2006 to 29 May 2010.
Evaluation of Methodologies for Exposure Analysis in Urban Areas and Application to Selected Megacities (MEGAPOLI Del 4.4)

Joana Soares
E-mail: joana.soares@fmi.fi
Finnish Meteorological Institute
Air Quality Division
http://www.fmi.fi

Denby B.1,2, Kangas L.1, Karpipinen A.1,2, Kukkonen K.1,3, Finardi S.1, Cassiani M.1,3, Radice P.1,3
1 - Finnish Meteorological Institute
2 - Norwegian Institute for Air Research
3- National Agency for New Technologies, Energy and Sustainable Economic Development

Any modeling analysis has a number of limitations and uncertainties. An example of these limitations is the resolution inadequacy of the modelled air concentrations. A study has been carried out to quantify the effect of sub-grid variability (SGV) of concentrations and population on exposure. The discretized population weighted concentration ($C_{pw,j}$) over any defined area $A_j$ for a given period of time can be written as (Karpipinen et al., 2010):

$$C_{pw,j} = C_j(1 + COV_{CP,j})$$

Where: $C_j$ is mean concentration for each grid square $j$ and $COV_{cp,j}$ is the correction factor. $COV_{cp,j}$ was assessed and parameterised based on empirical data, applying spatial statistical methods. The method was applied to nitrogen dioxide ($NO_2$), coarse particulate matter ($PM_{10}$) and the ozone ($O_3$) indicator SOMO35 using data from the year 2006. The SGV and its impact on European scale indicate that significant errors in the population weighted concentrations can occur due to the use of finite grid sizes:

i. $NO_2$ $COV_{cp,j}$ is more strongly dependent on grid resolution than is the $PM_{10}$ factor. This is due to the relatively high correlation between $NO_2$ concentrations and population density;

ii. $PM_{10}$ $COV_{cp,j}$ shows a weak dependence on grid resolution. This is due to the spatial homogeneity of $PM_{10}$ concentrations;

iii. SOMO35 shows a negative correlation, likely due to $NOx$ titration in urban areas, and as such $O_3$ exposure estimates will be overestimated by 15% when finite grids of 50 km or more are used.

Karvosenoja et al. (2010) assessed population exposure caused by the emissions of primary fine particulate matter ($PM_{2.5}$) originated from road traffic and domestic wood combustion in Finland in 2000 and 2020. Their general implication was that the exposure values evaluated using integrated assessment models can be sensitive to the methodology, especially these can substantially increase with an increasing spatial resolution.

This study led us to conclude that:

Table 1: The relative change in exposures calculated using hourly vs. daily temporal resolution, by cross-correlating concentrations measured at downtown locations and activities.

<table>
<thead>
<tr>
<th></th>
<th>work</th>
<th>home</th>
<th>traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre</td>
<td>17 %</td>
<td>-8 %</td>
<td>12 %</td>
</tr>
<tr>
<td>Traffic/bg</td>
<td>10 %</td>
<td>-6 %</td>
<td>17 %</td>
</tr>
<tr>
<td>Residential</td>
<td>-6 %</td>
<td>0</td>
<td>9 %</td>
</tr>
</tbody>
</table>

Figure 1: Correction factor for total exposures for $PM_{2.5}$ at the Helsinki Metropolitan Area as function of effective grid resolution (m).

i. traffic exposure is the most sensitive component, and the maximum correction factor for $PM_{2.5}$ exposures was found out to be 10%;

ii. total exposure the correction factor was $\sim$4 %. This lower sensitivity to resolution can be explained by the negative correlation of home locations and high-concentration areas, which counters the effect of stronger and opposite resolution dependence of traffic exposure;

iii. $PM_{2.5}$ exposures are expected to be much less sensitive to resolution changes, as the spatially smoothly distributed $PM_{2.5}$ background concentrations dominate the exposures;

iv. temporal resolution can also have a major effect on the relative contributions

The results of the small scale exposure modeling studies seem to be very much in line with the large scale correction factor analyses, although the small scale studies are based on one specific city area and one specific pollutant, and it is to be expected that in other cities and for other pollutants the exact values for correction factors may differ from this case study. However, we have demonstrated here a simple method for estimating these resolution effects in smaller scales, which can be readily utilized in any city and for every pollutant.

The methodology described and implemented here accounts for the SGV of concentrations and their spatial correlation with population distribution. This enables improved estimates of the population weighted concentrations, which are used in long term health impact studies. The potential of the method is that large grid sizes, i.e. low resolution models, can be used for fast multiple scenario or sensitivity calculations whilst retaining their ability to calculate population exposure. The only requirement in regard to input data to the parameterisation is that emission data must be available at a suitably high resolution. Since the parameterisation includes the emission population covariance any changes in emission, or population, distributions in future scenarios will be implicitly included in the parameterisation.

References
An efficient air quality management policy should aim to ensure that legal pollution limits are not exceeded and that the economical and social costs of poor air quality are controlled and minimised. A prerequisite for the successful application of mitigation measures and the development of efficient pollution abatement strategies is the accurate identification of pollution sources and of their individual contributions to ambient pollutant concentrations. As part of the MEGAPOLI WP4 activities, project partners have been involved in Task 4.4 on source apportionment and the identification and quantification of relevant source contributions. Several modelling methodologies have been reviewed and tested in the apportionment of ambient pollutants, including receptor-based models, methods based on advanced chemical dispersion modelling, as well as a combination of both. In addition, a comprehensive review of source apportionment modelling methodologies as used in the EU member states has led to an assessment of current state-of-play regarding source apportionment efforts as well as the strengths (Figure 1) were analysed in parallel with concentration fields calculated using variable emissions source strengths (Figure 1) were analysed in parallel with concentration fields calculated using variable emissions source strengths. The approach in the analysis of diverse measurement datasets in conjunction with different model configurations. Further validation will be required to investigate the suitability of the approach in the analysis of diverse measurement datasets in conjunction with different model configurations.

The first part of the survey involved the application by the FORTH team of the latest version of PMCAMx, a detailed chemical transport model (CTM), introducing a state-of-the-art chemical transport model (CTM), introducing a state-of-the-art advanced chemical dispersion modelling, as well as a combination of both. In addition, a comprehensive review of source apportionment modelling methodologies as used in the EU member states has led to an assessment of current state-of-play regarding source apportionment efforts as well as the strengths and loadings with specific source types. The proposed method aims to deal with this issue by supplementing the factor contributions and enabling their interpretation as specific source types. The proposed method aims to deal with this issue by supplementing the factor contributions and enabling their interpretation as specific source types. The approach was tested using a zero-out method for emissions, respectively, was accurately determined. A key benefit of the use of this approach is that it can be applied with a limited computational cost as the runs required for a successful interpretation need only cover limited time periods. Further validation will be required to investigate the suitability of the approach in the analysis of diverse measurement datasets in conjunction with different model configurations.

### References


### Figure 1

**Figure 1.** Difference map for O₃ concentrations in the Paris metropolitan area, calculated with baseline and the zeroed out traffic emissions.

### Figure 2

**Figure 2.** NMF factor loadings obtained from concentration time-series calculated for the Aubervillers station using the full-emissions (left) and zero-traffic (right) scenarios.

During May 2008, the model predicted a relatively flat average diurnal profile in London, Athens, Po Valley and Ruhr area, and a strong diurnal variation of OA concentrations in Paris. The predicted source contributions to OA in Paris showed a strong diurnal variation of fresh POA with increases during the rush hours and relatively flat profiles for the other OA components. During the winter period a more distinct diurnal variation was predicted in most of the cities following the diurnal variation of emission rates mainly due to combustion.

The second part of the investigation has focused on exploring and improving upon existing receptor modelling methodologies, which are essentially based on statistical evaluations of ambient concentration measurements at different times and locations. As established practice, Chemical Mass Balance (CMB) models are applied when emission sources are known and detailed information on source profiles is available, whereas in case the sources are unknown or information on source profiles is limited, the Principal Component Analysis (PCA), Positive Matrix Factorisation (PMF) or Non-negative Matrix Factorisation (NMF) methods are usually preferred. A known limitation of receptor modelling techniques is the difficulty in identifying the resulting factors and loadings with specific source types. The proposed method aims to deal with this issue by supplementing the factor analysis of measurements with results of dispersion simulations. Concentration fields calculated using variable emissions source strengths (Figure 1) were analysed in parallel with measurements providing a more accurate identification of factor contributions and enabling their interpretation as specific source types. The approach was tested using a zero-out method for traffic emissions in the Paris metropolitan area where the relative contributions of the two principal factors (leftmost bars in Figure 2), identified as traffic and secondary pollutant emissions, respectively, was accurately determined. A key benefit of the use of this approach is that it can be applied with a limited computational cost as the runs required for a successful interpretation need only cover limited time periods. Further validation will be required to investigate the suitability of the approach in the analysis of diverse measurement datasets in conjunction with different model configurations.
The assessment of human exposure usually requires the integration of different models including estimation of emissions and atmospheric dispersion and transformation of air pollutants. To estimate the overall exposure of the population to a certain pollutant, the exposure is modelled by combining concentration and population in a certain period of time. The following equation shows how the exposure \( E \) is computed for this study:

\[
E = n \times t \times C \quad \text{(µg.s/m³)}
\]

where \( n \) is the number of people per grid cell, \( t \) is the time period [s] and \( C \) is concentration \([\text{g.m}^{-3}]\) for the pollutant. The final results will be shown as annual average exposures. The exposure for \( \text{PM}_2.5, \text{PM}_{10} \) and \( \text{NO}_2 \) was computed for the Greater London (GL) (United Kingdom) and Po Valley Region (PVR) (Italy) population. The choice of these two cases was based on the availability of concentration and population gridded data. The human exposure for the GL was estimated for the year 2001 and for PVR for the year 2005 (due to data availability). The population and concentration data for GL was provided by the Cambridge Environmental Research Consultants. These data were available as yearly averages in a regular grid of points with a spatial resolution of 1 km for population data and 50 m for concentration data (CERC, 2001). In the P case, the annual average concentration and population distribution was provided by the National Agency for New Technologies, Energy and Sustainable Economic Development (Zanini et al., 2005). The data was available for a regular grid of points with a spatial resolution of 4 km. The results obtained were compared with the results by Karppinen et al. (2010) study to have an order of magnitude of the values for population averaged concentrations, since these two studies were conducted for different years.

The main results of the \( \text{PM}_{10} \) exposure calculation are described in Table 1.

### Table 1: Summary of \( \text{PM}_{10} \) exposure results. 

<table>
<thead>
<tr>
<th>Population (millions)</th>
<th>GL</th>
<th>PVR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td>Annual average exposure ((\text{µg.s/m}^3))</td>
<td>2.5\times10^{10}</td>
<td>1.6\times10^{10}</td>
</tr>
<tr>
<td>Maximum value exposure ((\text{µg.s/m}^3))</td>
<td>2.6\times10^{10}</td>
<td>6.7\times10^{10}</td>
</tr>
<tr>
<td>Total exposure ((\text{µg.s/m}^3))</td>
<td>2.5\times10^{10}</td>
<td>2.4\times10^{10}</td>
</tr>
<tr>
<td>Population weighted concentration ((\text{µg/m}^3))</td>
<td>24.5</td>
<td>27.1</td>
</tr>
<tr>
<td>( pw ) in Karppinen et al. (2010) ((\text{µg/m}^3))</td>
<td>11.5</td>
<td>16.5</td>
</tr>
</tbody>
</table>

The population averaged concentrations obtained from the exposure study are 24.5 µg/m³ and 27.1 µg/m³ for the GL and PVR, respectively. The difference in population weighted concentration estimates (and exposures) are 1.5-2 times higher in the high resolution study.

For this particular domain, only one grid cell form EMEP calculations and a completely different reference year was considered in the regional scale resolution study, which is enough to explain the differences. For the Po PVR case, the values obtained by these two different modelling studies for \( \text{PM}_{10} \) are much closer to each other and more comparable since the years studied are nearer (emissions are similar) and the gridding for PVR study for the regional scale calculations is much more representative for the whole area than in the GL case study.

Exposure is strongly spatially correlated with the population data. This is expected since emissions (traffic especially) and concentrations are highest where the population density is highest. In the case of Po Valley Region we also see a strong influence of the topography of the terrain. The Alps (northern part of the domain) create a specific situation in terms of dispersion of the pollutants, trapping the pollution within the valleys closer to the mountains and increasing the exposure to pollutants (Figure 1).
Processes involving nonlinear interactions and feedbacks between emissions, chemistry and meteorology require coherent and robust approaches using integrated/online methods. This is particularly important where multiple spatial and temporal scales are involved with a complex mixture of pollutants from large sources, as in the case of megacities. The impacts of megacities on the atmospheric environment are tied directly to anthropogenic activities as sources of air pollution. These impacts act on street, urban, regional and global scales. Previously there were only limited attempts to integrate this wide range of scales for regional and global air quality and climate applications. Indeed, progress on scale and process interactions has been limited because of the tendency to focus mainly on issues arising at specific scales. However the interrelating factors between megacities and their impacts on the environment rely on the whole range of scales and thus should be considered within an integrated framework bringing together the treatment of emissions, chemistry and meteorology in a consistent modelling approach. Numerical weather and air pollution prediction models are now able to approach urban-scale resolution, as detailed input data are becoming more often available. As a result the conventional concepts of down-(and up-) scaling for air pollution prediction need revision along the lines of integration of multi-scale meteorological and chemical transport models. MEGAPOLI aims at developing a comprehensive integrated modelling framework usable by the research community which will be tested and implemented for a range of megacities within Europe and across the world to increase our understanding of how large urban areas and other hotspots affect air quality and climate on multiple scales. The integration strategy in MEGAPOLI (Fig. 1) is not focused on any particular meteorological and/or air pollution modelling system. The approach considers an open integrated framework with flexible architecture and with a possibility of incorporating different meteorological and chemical transport models.

MEGAPOLI aims at developing a comprehensive integrated modelling framework usable by the research community which will be tested and implemented for a range of megacities within Europe and across the world to increase our understanding of how large urban areas and other hotspots affect air quality and climate on multiple scales. The integration strategy in MEGAPOLI (Fig. 1) is not focused on any particular meteorological and/or air pollution modelling system. The approach considers an open integrated framework with flexible architecture and with a possibility of incorporating different meteorological and chemical transport models.

**Figure 1**: Schematic showing the main linkages between megacities, air quality and climate. The connections and processes are the focus of MEGAPOLI. In addition to the overall connections between megacities, air quality and climate, the figure shows the main feedbacks, ecosystem, health and weather impact pathways, and mitigation routes which will be investigated in MEGAPOLI. The relevant temporal and spatial scales are additionally included.

**Figure 2**: Scheme of environmental risk assessment and mitigation strategy optimization basing on forward/inverse modelling.

Where required new or improved interfaces for coupling (direct links between emissions, chemistry and meteorology at every time step) are developing. Common formats for data exchange (such as GRIB, netCDF formats) is defined to ease the implementation and to help combine the different models via agreed data exchange protocols. The current chemistry schemes (tropospheric, stratospheric and UTLS) are examined as to their suitability for simulating the impact of complex emissions from megacities. The coupled model systems are applied to different European megacities during the development phases of the project. The framework will be used and demonstrated for selected models including UKCA (MetO), WRF-Chem (UH-CAIR), Enviro-HIRLAM (DMI), STEM/FARM (ARIANET), M-SYS (UHam) and ECHAM5/MESO on different scales. This part of the work is linked to the requirements and use of simpler tools for assessing air quality impacts within megacities (OSCAR - UH-CAIR, AIRQUIS - NILU, URBIS - TNO).

The D7.1 report was realised within the MEGAPOLI WP7 Task 7.2: Formulation of the components of an integration framework in a close collaboration with the COST Actions 728 and ES0602. It is also linked with a new COST Action ES1004: European framework for on-line integrated air quality and meteorology modeling (EuMetChem).

**References**


Influence of Urban Territories on Meteorological Parameters: Vilnius Case Study

Adomas Mažeikis
E-mail: adomas.mazeikis@geo.lt
Nature Research Center, Institute of Geology and Geography, Vilnius, Lithuania
http://www.geo.lt

The surface of urban areas differs from other territories in many parameters. These differences impact the boundary layer meteorological parameters which are especially important for dispersion of air pollutants. This study concentrates on main meteorological parameters (which are important for air pollution dispersion processes) sensitivity to urban areas surface parameters such as albedo, surface roughness and anthropogenic heat flux. The Vilnius agglomeration was selected because it is the largest urban area in Lithuania. The cases when air pollution dispersion conditions are good (i.e. high speed winds), poor (i.e. calm conditions), quick removal (i.e. heavy precipitation), and long stay in boundary layer (i.e. stable stratification of the atmosphere) are of importance in this study.

Methodology
The research version of numeric weather prediction (NWP) model Enviro-HIRLAM (Korsholm et al., 2008) was used in this study. The aerosol module was switched off to exclude the aerosols’ effects on meteorological fields. Different modeling domains were selected with the Vilnius urban area in the center of domain areas: LT1 (250 x 150 grids along longitude x latitude, and 1.4 x 1.4 km resolution) and LT3 (298 x 220 grids along longitude x latitude, and 2 x 2 km resolution). The NWP urbanization included modifications (in the ISBA surface scheme; Noilhan & Mahfouf, 1996) of roughness, albedo and anthropogenic heat flux only for grid cells having non-zero urban fractions. Note that all modified runs had same settings for roughness (2 m) and albedo (0.15).

Results and analysis
Two fields: air temperature at 2 m (Fig. 1) and wind speed at 10 m were compared and differences between control and modified runs had been estimated. The provided graphs (Figs. 2-3; see Tab. 1) illustrate the difference in temperature and wind speed at the urban grid cell of Vilnius city (measurement station is placed in the Žvėrynas urban district) where the urban fraction was the highest. Due to anthropogenic heat flux (AHF) the air temperature can increase, due to higher roughness the wind speed can become low. Even a small change in wind speed could lead to large changes in concentrations of air pollutants, and temperature changes might led also to changes in chemistry.

Table 1: Definition of computed experiments.

<table>
<thead>
<tr>
<th>Case</th>
<th>Date</th>
<th>Domain</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT1-0129C</td>
<td>2009 - 01.29</td>
<td>LT1</td>
<td>None</td>
</tr>
<tr>
<td>LT1-0129I</td>
<td>AHF 100W/m²</td>
<td>LT1</td>
<td>AHF 100W/m²</td>
</tr>
<tr>
<td>LT1-0129II</td>
<td>AHF 200W/m²</td>
<td>LT1</td>
<td>AHF 200W/m²</td>
</tr>
<tr>
<td>LT3-0314C</td>
<td>2009-03.14</td>
<td>LT3</td>
<td>None</td>
</tr>
<tr>
<td>LT3-0314I</td>
<td>AHF 100W/m²</td>
<td>LT3</td>
<td>AHF 100W/m²</td>
</tr>
<tr>
<td>LT3-0314II</td>
<td>AHF 200W/m²</td>
<td>LT3</td>
<td>AHF 200W/m²</td>
</tr>
<tr>
<td>LT3-0623C</td>
<td>2009 - 06.23</td>
<td>LT3</td>
<td>None</td>
</tr>
<tr>
<td>LT3-0623I</td>
<td>AHF 100W/m²</td>
<td>LT3</td>
<td>AHF 100W/m²</td>
</tr>
<tr>
<td>LT3-0623II</td>
<td>AHF 200W/m²</td>
<td>LT3</td>
<td>AHF 200W/m²</td>
</tr>
</tbody>
</table>

Conclusions
• The modifications of the surface parameters within the urban territories, such as the Vilnius metropolitan area, have impact on formation of meteorological fields that affect air pollution dispersion.
• The temperature at 2 m height is typically higher in urbanized simulation runs.
• The difference in wind speed between two types of runs can be up to 2.7 m/s.
• The impact of urban territories in simulations is of more local scale, i.e. up to 2.8 km from heavily urbanized territories and up to 40 m in height.
• To study the sensitivity of meteorological fields to modifications of every single surface parameter a more detailed study should be carried out. The effect of simultaneously combined modifications can give different feedback (positive/ negative) depending on dominating influence mechanisms.

References

Figure 1: Example of the Enviro-HIRLAM control (top) vs. urbanized (bottom) run: air temperature at 2 m at 17 UTC on 29 Jan 2009.

Figure 2: Temperature at 2 m difference (vertical axis, °C) between control and modified runs /solid line – LT3-0314II run and dashed line - LT3-0314I run/.

Figure 3: Wind speed at 10 m difference (vertical axis, m/s) between control and modified runs /solid line – LT3-0623II run and dashed line - LT3-0623I run/.
### NewsLetters of the FP7 EC MEGAPOLI Project

#### 10 Issue
March 2011

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**MEGAPOLI Project Office**

**WWW ADDRESS**
http://www.megapoli.info

**POSTAL ADDRESS**

**MEGAPOLI Project Office**  
Danish Meteorological Institute (DMI)  
Research Department  
Lyngbyvej 100  
DK-2100 Copenhagen  
DENMARK

**COORDINATOR**

Prof. Alexander Baklanov  
E-mail: alb@dmi.dk  
Phone: +45 3915-7441  
Fax: +45 3915-7400

**VICE-COORDINATORS**

Dr. Mark Lawrence  
E-mail: lawrence@mpch-mainz.mpg.de  
Phone: +49-6131-305331  
Fax: +49-6131-305511

Prof. Spyros Pandis  
E-mail: spyros@chemeng.upatras.gr  
Phone: +30-2610-969510  
Fax: +30-2610-990987

**MANAGER**

Dr. Alexander Mahura  
E-mail: ama@dmi.dk  
Phone: +45 3915-7423  
Fax: +45 3915-7400

**SECRETARY**

Britta Christiansen  
E-mail: brc@dmi.dk  
Phone: +45 3915-7405  
Fax: +45 3915-7400

**EC Scientific Officer**

Dr. Jose M. Jimenez Mingo  
E-mail: jose.jimenez-mingo@ec.europa.eu  
Phone: +32-2-2976721  
Fax: +32-2-2995755

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We apologise for any inconvenience caused.

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**Coming and Recent Presentations and Publications**

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:


See more MEGAPOLI Publications/ Presentations at [http://megapoli.info](http://megapoli.info)

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**Coming Conferences**

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:

- European Geosciences Union (EGU-2011) General Assembly  
  Vienna, Austria, 3-8 Apr 2011  
  [special MEGAPOLI, CityZen, MILAGRO session](http://meetings.copernicus.org/egu2011)

  Odessa, Ukraine, 3-9 July 2011  
  [http://atmos.physic.ut.ee/~muscaten/YSSS/1info.html](http://atmos.physic.ut.ee/~muscaten/YSSS/1info.html)

- Urban Air Quality and Climate Change Workshop (UAQCC)  
  Hamburg, Germany, 16-18 Aug 2011  
  contact: Heinke Schluenzen, UHam (heinke.schluenzen@zmaw.de)

- European Meteorological Society (EMS-2011) Annual Meeting  
  Berlin, Germany, 12-16 Sep 2011  

- 3rd Annual MEGAPOLI Project Meeting/ Workshop  
  Paris, France, 26-28 Sep 2011  
  contact: Matthias Beekmann, CNRS-LISA ([beekmann@lisa.univ-paris12.fr](mailto:beekmann@lisa.univ-paris12.fr))

- 14th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes  
  Kos Island, Greece, 2-6 Oct 2011  
  [http://www.harmo.org/harmo14](http://www.harmo.org/harmo14)
Welcome to the 11th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 11th issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments are always welcome (send to news.megapoli@dmi.dk).

Latest News

- Coming soon – Sep 2011 - Final Periodic Reporting to European Commission
- Coming soon – Final (3rd Annual Meeting) MEGAPOLI Project Symposium (Paris, France, 26-28 Sep 2011)
- Coming soon – Urban Air Quality and Climate Change Workshop (UAQCC) (16-18 Aug 2011, Hamburg, Germany)
- 25 May 2011 – "Megacities and GURME" meeting at the World Meteorological Congress
- 24 May 2011 – 7th MEGAPOLI WP Leaders Telephone Conference
- 30 Apr – 3 May 2011 – International workshop "Integration of geospheres in earth systems: Modern queries to environmental physics, modelling, monitoring & education" (Dubrovnik, Croatia)
- 26-28 Apr 2011 – WP3: "Megacity plume case study" workshop (Villigen, Switzerland)
- 4-5 Apr 2011 – MEGAPOLI related session at EGU-2011 and Splinter Meeting with CityZen and MILAGRO projects
- 8 Mar 2011 – MEGAPOLI presented in the "Eggs" (EGU NewsLetters)

EGU-2011: Megacities Session and Splinter Meeting

4-5 Apr 2011 – MEGAPOLI related session AS3.6 "Megacities: Air Quality and Climate Impacts from Local to Global Scales" at the European Geosciences Union General Assembly 2011 (EGU-2011, Vienna, Austria, 3-8 Apr 2011) with invited talk on MEGAPOLI by Spyros Pandis (FORTH Team); and Splinter Meeting with CityZen and MILAGRO
- 4 Apr 2011 - Mon, 08:30-17:00 - AS3.6 Session "Megacities: Air Quality and Climate Impacts from Local to Global Scales" (Oral presentations); Convener: Michael Gauss, Co-Conveners: Luisa Molina, Alexander Baklanov); with a number of MEGAPOLI project related presentations
- 4 Apr 2011 - Mon, 17:30-19:00 - AS3.6 Session "Megacities: Air Quality and Climate Impacts from Local to Global Scales" (Poster presentations)
- 5 Apr 2011 - Tue, 08:30-10:00 - MEGAPOLI/ CityZen/ MILAGRO joint splinter meeting of the MEGAPOLI, CityZen and MILAGRO projects (Introduction - by Alexander Baklanov; status and progress on projects - CityZen - by Michael Gauss, MEGAPOLI - by Alexander Baklanov, MILAGRO - by Spyros Pandis; and followed discussions lead by Mark Lawrence; summary notes of the meeting - by Alexander Mahura); Attended - 27 persons (MEGAPOLI - 16; CityZen - 8; MILAGRO - 1; other projects - 2) from 13 countries and from 22 research organizations/ institutions (list of participants); see details at the MEGAPOLI internal website
- 5 Apr 2011 - Tue, 10:30-12:00 - MEGAPOLI working meeting (progress and finalization of tasks, deliverables, and milestones have been discussed; separate WP6, 7, and 8 phone-conferences have been planned, in addition to the re-scheduled MEGAPOLI WP Leader phone-conference)
The fundamental approach of the MEGAPOLI project is the bridging of spatial scales, from the street scale to the global scale, in the study of megacities and their influences on air quality and climate. This approach requires the use of a wide range of models, from fine-scale turbulence-resolving models able to compute the flow deformation due to elements of the urban canopy, to regional models, which simulate the detailed effects of individual urban centres or agglomerations on their local surroundings, all the way up to global models, which can simulate the combined effects of all megacities on large-scale pollutant plumes and on the global climate system.

In general these models require emission data as boundary conditions, in order to correctly simulate the evolution of the chemical composition of their particular atmospheric domain. Within the MEGAPOLI project there are several different models covering each of the relevant scales. The use of a large suite of models allows better estimation of the between-model uncertainty. When all models use the same emission inventory it is easier to compare their results. The emission inventory used by the regional models in the MEGAPOLI project was described in the last MEGAPOLI newsletter (March 2011). This regional inventory includes nested high resolution data of the Paris region. Here we describe the emission inventory used by the global models in the MEGAPOLI project.

In consultation with the global modelling groups in the MEGAPOLI project it was decided to use an emission inventory which was already available to the scientific community; the CMIP 5 project global emission inventory (Coupled Model Intercomparison for the upcoming IPCC community; the CMIP 5 project global emission inventory which was already available to the scientific MEGAPOLI project it was decided to use an emission inventory used by the regional models in the MEGAPOLI project.

The emission data is based on a set of historical emission data produced by Lamarque et al. (2010), which extends from the year 1850 to the year 2000, with data available for each decade. Beyond the year 2000, emission data is obtained from a set of Representative Concentration Pathways (RCP) which describes a range of possible future development pathways and their associated emissions. These RCP are harmonised with the historical emission data using a “handshake” approach, as illustrated in Figure 1. RCP data are available for the year 2005 as well as for every decade up to the year 2100. The base year for the global model runs in the MEGAPOLI project is set as the year 2005, which is projected from the latest available historical emissions for the year 2000 through the RCP 8.5 pathway (van Vuuren et al., 2007).

Each global modelling group will perform simulations using this base year. Depending on the available resources, different global modelling groups will also perform simulations for a number of future scenario years drawn from several of the available RCP datasets.

An important aspect of the global modelling for the MEGAPOLI project is the use of a megacity “mask” in order to identify points in the grided global emission dataset which correspond with the geographical location of the megacities under consideration. Previous work had used a mask at a spatial resolution of 1 x 1 degrees. In order to take advantage of the higher resolution of these newer emission data, a new mask at a spatial resolution of 0.5 x 0.5 degrees was developed using a new procedure based on the emissions distribution. An example of the application of this new mask is shown in Figure 2. Since the emissions originating from the megacities are now identified, we can investigate what the impact of these emissions is on air quality and regional climate.

**Figure 1.** The handshake process, illustrating the link between historical and future emissions (Lamarque et al., 2009).

**Figure 2.** Zoom from the global emission map after applying the new megacity mask: NOx emissions from the European megacities in 2005.

**References**


Assembling the multi-model ensemble allowed to perform an objective inter-comparison of the predictions of the participating models (made within the scope of this WP5 and the WP7, deliverable 7.3) and to estimate the extent to which the predictions of the individual models can be improved by means of multi-model ensemble.

It was found that the individual models are performing generally similarly for well-verified gaseous pollutants, such as NO$_2$, SO$_2$, and O$_3$. Out of these, the most difficult pollutant to be modelled was SO$_2$, for which all models have shown very low correlation with the observed time series, being generally close to the mean values. A series of specifics of some of the models were identified and communicated to the model developing groups for investigation.

In addition to the general similarity of the patterns computed with the above-mentioned models, the inter-comparison showed systematic differences between the model predictions. The differences between the model predictions are of the same order of magnitude than the differences between the individual models and the observations. The reasons for the particular behaviour of each model are time-, region-, and model- specific and have to be analysed separately for each episode.

Contrary to previous findings with other multi-model ensembles, the results showed that vertical profiles of the models are quite comparable, so that the difference between the predicted fields does not increase significantly with height above the surface.

In line with the previous experience, the differences between the model predictions for the compounds not verified routinely can be very large. More efforts are evidently needed to better understand and verify the modelling systems for these species.

It was demonstrated that application of even simple ensemble based estimates leads to improvement of the predictions. However, the effect varies among the compounds. The strongest improvement was obtained for optimising ensemble treatment applied to PM$_{2.5}$ and PM$_{10}$ predictions where these methods eliminated the under-estimation and kept the predicted spatial pattern of the concentrations. Neutral impact was found for SO$_2$ whereas for O$_3$ the ensemble average appeared to be superior to the optimising methods. The reasons for such behaviour are under investigations.

Apart from the main multi-model ensemble analysis, the deliverable report includes a series of individual model studies, which are complementary to the main line. The analysis of the LOTOS-EUROS simulations with two versions of the emission inventory showed substantial changes of the PM concentrations over Paris. The experiment with the SILAM model showed the dependence of the results on the resolution and robustness of the area-totals to the computational setup. The analysis of the urban effects and aerosol feedbacks on the meteorology was made with the Enviro-HIRLAM model. The detailed analysis of the aerosol composition over Paris during the summer campaign and Mexico city was made with the PM-CAMx model. Finally, the report included an outlook of presently operational chemical weather forecasting systems in Europe.

### References

http://megapoli.dmi.dk/publ/MEGAPOLI_srr11-04.pdf
Using HadGEM2, the Hadley Centre has been addressing the differences in aerosol abundances and radiative effects between climate model runs with and without coupled chemistry for present day conditions. The target years for the study were the 10 years centred on 2005. The chemistry coupling was achieved by allowing radiative forcing from ozone, methane and aerosols. The coupled aerosols were also allowed to have indirect effects on clouds. The impact on aerosol distribution between coupled and uncoupled runs was found to be dependent on species with black carbon from fossil fuels having the more consistent signal away from the source.

The difference in clear sky radiative forcing between coupled and uncoupled model runs has a generally negative response in equatorial regions and a positive response in polar regions (Fig. 1). The global mean signal is negative at -0.339 W m\(^{-2}\) and is dominated by the equatorial response. This is largely due to the increased presence of scattering sulphate aerosol in the coupled runs at these locations. The positive response in the polar regions results from the increased presence of black carbon in the coupled run allowing more radiation to be absorbed over the bright surface than would otherwise be the case. The polar signal can be seen to be significant (not shown), with coupled mean being at least 4 standard deviations away from uncoupled mean. The surface concentration of aerosol is affected by chemistry coupling as the coupling has an impact on radiation and aerosol formation and removal mechanisms especially those connected with clouds and rainfall. The sign of the difference depends on location and aerosol type. However, averaged over the globe, there is more aerosol at surface level when coupled than uncoupled. The difference in magnitude is similar between the aerosol types (~0.03 μg m\(^{-3}\)) with sulphate showing the largest global change of 0.032 μg m\(^{-3}\). OCFF (organic carbon from fossil fuel use) is 0.026 μg m\(^{-3}\) larger when coupled and black carbon is 0.025 μg m\(^{-3}\) greater.

The signal is noisy for sulphate and OCFF with low significance in general. Although there appears to be large significance over Greenland and the polar regions, the signal strength is low. The effect on black carbon can be seen in Fig. 2 and demonstrates a much clearer positive signal. The remote signal appears significant (see Fig. 3) as the mean of the coupled runs is more than 4 standard deviations away from the mean of the uncoupled runs. This indicates that there is more long range transport of black carbon in the coupled runs and less deposition close to the source. This effect is a consequence of the experimental design and can be explained by cloud droplet number concentration (CDNC). This is held at fixed values (one value for sea and one for land) in the uncoupled run. In this model, when aerosols are coupled, it transpires that CDNC is lower than when uncoupled. This results in less removal by diffusional scavenging over the longer ranged transport.

From the analysis of the present day years, the differences in sulphate and OCFF do not appear significant between coupled and uncoupled runs. Black carbon surface concentration and burden however do show significant differences between coupled and uncoupled experiments regionally. The resultant impact on radiative forcing has a significant impact on the polar radiation budgets.

**References**


Steve Rumbold

E-mail: steven.rumbold@metoffice.gov.uk

Met Office Hadley Centre, Earth System and Mitigation Science.

http://www.metoffice.gov.uk

Steve Rumbold

E-mail: steven.rumbold@metoffice.gov.uk

Met Office Hadley Centre, Earth System and Mitigation Science.

http://www.metoffice.gov.uk
Mean values of temperature and wind are well represented, the hit rates reach values over 50% (see Figure 2) and thus in the range found for other meteorology model evaluations in literature. The differences found for the annual average of meteorological parameters are consistently found for different weather situations.

Figure 2. Hit rates of temperature $T$, wind speed $ff$, wind direction $dd$ for 2005. Note that the meteorological data evaluated are input data of CHIMERE, FARM, SILAM; they are not calculated in the AQ models themselves.

The AQ models reach a different agreement with observations for the different chemical components. Systematic underestimations (overestimations) were found for PM10 for CHIMERE and SILAM (FARM). This results in too low (high) frequencies of exceedance. For ozone the low concentrations were simulated too high, the high concentrations slightly high (CHIMERE, FARM) or too low (SILAM). The differences are not only visible in the annual average data but also in different weather situations and might therefore not be a result of the meteorology, but of chemical reactions, of emission data composition or of a model internal origin. The too low NO2 values can partly be explained by the too high ozone values found for many meteorological situations but not for all (Fig. 3).

Figure 3. Mean values of O3 concentration in dependence of weather types at LANUV stations.

From the evaluation study it can be concluded that the introduction of weather clusters and frequency distributions of model results and observations into the model evaluation can indeed help to better understand reasons for differences. The results already triggered investigations of the input and comparison data, as well as model internals. The model simulations will be extended and the method be applied in MEGAPOLI to analyse more model results for 2005 in additional European regions.

**References**
http://megapoli.dmi.dk/publ/MEGAPOLI_sr11-03.pdf
Short, Medium and Long Term Abatement and Mitigation Strategies for Megacities (MEGAPOLI Del 8.1)

Jochen Theloke
E-mail: jochen.theloke@ier.uni-stuttgart.de

USTUTT, Institute of Energy Economics and Rational Use of Energy (IER), Stuttgart, Germany

Introduction

The collection of mitigation measures and policy options for reducing the impact from Megacities to climate change and air pollution and vice versa is a crucial basis to collect mitigation measures and policy options distinguished by short term options and measures, that can be implemented more or less until ca. 2010 (e.g. traffic restrictions, city toll), medium term measures, that include changes of infrastructure and can thus be implemented in 2020. In addition long term mitigation and policy options (for 2030 to 2050) including structural changes, e.g. shift of industrial activities or living places to other areas are analysed; urban planning projects methodologies are used to develop scenarios of possible evolutions of the megacities London (centric structure) and Rhine-Ruhr (polycentric structure), i.e. a qualitative description of the possible development of settlement structure and infrastructure and development of assumptions about the effect of these scenarios on transport, energy supply and emissions of air pollutants have been developed.

Methodology

Relevant abatement measures for the sectors road traffic in cities, other mobile machineries, small and large combustions plants and industry have been identified and developed with focus to Megacities. The abatement measures have been developed for air pollutants and greenhouse gases. The abatement potential, cost and Synergies/interactions with other environmental objectives (e.g. climate change) and the implementation options of all measures have been assessed. The implementation of mitigation options was grouped into short (2010/2020), medium (2020/2030) and long (2050) term time scales.

Both technical measures (changing emissions factors, e.g., an additional filter) and non-technical measures (which change the decisions and the behaviour of users of emission sources, e.g., by implementing a charge on emissions) have been addressed.

The long (2050) term measures about the options and effects of long term city planning and urban management in the long run (including changes in the number of inhabitants and working places), how beneficial are these changes (e.g. better air quality, but higher energy demand, if population density decreases) and what is the potential of such changes are under development at moment.

Results

In our study - 9 measures related to road transport, 4 measures related to other mobile sources, 2 measures related to large combustion plants, 5 measures concerning small and medium combustion plants and 4 industrial related measures for the concerned megacities have been identified and described. Some of these measures can be applied only to the MC and others can be applied EU-wide, but also in MC areas.

For the sector “on-road traffic” has been developed the following measures:

- Enhanced use of bicycles in cities,
- Enhanced use of public traffic,
- Promotion of low emission vehicles (E-cars, hybrid vehicles),
- Traffic management (Green Wave, improvement of the operation of signalized intersections),
- Low emissions zones,
- City toll,
- Increase in fuel costs,
- Passenger car toll,
- Enhanced use of biofuels.

For the sector “other mobile machineries” has been developed the following measures:

- Differentiation of track access charges for rail transport,
- Further development of emission limits in inland waterway transport,
- Kerosene tax for aviation,
- Low emission zones for construction equipment.

For the sector “Large combustion plants” has been developed the following measures:

- Modernisation of the existing coal-fired Large combustion plants,
- Expansion of electricity generation from renewable resources in LCP.

For the sector “Small combustion plants” has been developed the following measures:

- Replacement of solid fuels fired small combustion plants with efficient combustion techniques,
- Replacement of old gas/oil boilers with modern condensing boilers,
- Energy-efficient modernisation of old buildings,
- Switch to renewable heat supply in residential sector,
- Expansion of district heating network.

For the sector “Industry” has been developed the following measures:

- Combined climate protection measures in cement industry,
- Iron & Steel production – Blast furnace - Injection of pulverized coal (PCI),
- Sinter plants – Heat recovery,
- Coke plants – Coke dry quenching.

Outlook

In addition two urban development reference scenarios for the Rhine-Ruhr area (polycentric structure) and London (centric structure) about the future development of settlement structure, population growth and land use statistics have been developed. On base of this will be modeled three hypothetical scenarios for future development of the different kind of urban structures: “The network model of the city”, “Re-urbanization” and “Urban Sprawl”/“Disperse development”. Another focus for further work is the investigation of future urbanisation effects to megacities on the global scale.

References

http://megapoli.dmi.dk/publ/MEGAPOLI_sr11-06.pdf
Ozone and Carbon Monoxide Signatures from Different Continents and the Bosnywash Area in the European Free Troposphere

Sabine Eckhardt
E-mail: sec@nilu.no
Norwegian Institute for Air Research (NILU), Kjeller, Norway
http://www.nilu.no

1 – Norwegian Institute for Air Research, Norway

In this study the influence of the large emissions of the North American East coast megalopolis (Boston, New York, Washington, collectively named Bosnywash in the following) on atmospheric composition over Europe is assessed.

Method
We used a large data set of carbon monoxide (CO) and ozone measurements from the MOZAIC program to examine the influence of Bosnywash, as well as total North American, European and Asian emissions on the chemical composition of the atmosphere over Europe. For 1 km vertical averages of the MOZAIC aircraft measurements taken during take-off and landing over Central Europe, the Lagrangian particle model FLEXPART (Stohl et al., 2005) is used to identify the modelled CO contribution of each of the 4 mentioned regions. For each measurement 40,000 particles were released and followed 20 days backward in time, anthropogenic CO emission inventories were used to model the estimated CO contribution. We define an air mass being influenced by a certain region if more than 70% of the modelled total CO is coming from this specific region. For the Bosnywash area, however, we request a contribution of only 20%, as much higher contributions are rare. The data series for ozone spans a period from 1995-2009 while CO was measured since 2002. The model also estimates the stratospheric contributions to each measurement. Samples with a higher than 5% stratospheric contribution are not used in this analysis.

Influence of different continents
As all the measurements were taken over Europe, there is a dominant influence of European emissions in the lowest 4 km (Fig.1, yellow line). North American dominated measurements become most abundant between 4 and 8 km (Fig. 1, blue line), with more than 5000 measured ozone values are used. Asian dominated air masses are most frequent at about 8 km but peak at only about 2000 cases.

Screening the dataset for all observations, which had an influence >70% from one continent or >20% from the Bosnywash area, it was found, that while 22% of the observations were dominated by North American emission, only 3.5 % are coming from the Bosnywash area. European emissions dominate with 66.5%, while the contribution of modeled CO from Asia is 10%.

In order to estimate how strong the European free troposphere is influenced by the specific source regions, modelled CO contributions for each continent, as well as seasonal deviation from the mean mixing ratios is calculated for each region respectively (Fig. 2).

Figure 1. Frequency of non-stratospheric ozone measurements dominated by one continent/Bosnywash area as a function of height. The period from 1998 to 2009 is used and the measurements were taken in a box over Europe extending from 45N to 55N and from 10W to 20E.

Figure 2. Seasonal averages for modelled CO due to emissions from the last 20 days before sampling, grouped by the dominating source region (upper panel) over an altitude between 3 and 8 km. Measurements of CO and ozone (lower two panels), averaged over times when a certain continent/region had a dominating influence. Positive values indicate that when the air mass is mainly influence by one continent the measured mixing ratios are above average. The statistic for ozone is performed over the same time period as Figure 1; for CO, data from 2002 to 2009 were available.

The modelled and measured CO (upper two panels of Figure 2) show that the highest measured/modelled CO values occur in air with dominant European emission influence. The model estimates somewhat more than 50% smaller mixing ratios when air is dominantly influenced by North American and Asian emissions, the measurements show a stronger Asian than North American enhancement. In summertime, air masses coming from the Bosnywash area have higher CO, but lower ozone than from other regions in North America. This is different in winter and spring, where air masses from the Bosnywash region have higher ozone values than North American influenced ones.

Acknowledgements
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References
Estimation of NOx Emissions from Delhi using Car MAX-DOAS Observations and Comparison with OMI Satellite Data

Reza Shaiganfar

E-mail: r.shaiganfar@mpic.de

Max Planck Institute for Chemistry, Mainz, Germany/ Satellite

http://www.mpic.de/Satellitenfernung.2050.0.html

R. Shaiganfar1, S. Beirle2, M. Sharma2, A. Chauhan2, R.P. Singh2, T. Wagner2

1 - Max-Planck-Institute for Chemistry, Mainz, Germany
2 - Research and Technology Development Centre, Sharda University, Greater Noida, India
3 - School of Earth and Environmental Sciences, Schmid College of Science, Chapman University, Orange 92866, USA

The first Multi-Axis- (MAX-) DOAS observations in Delhi (India) and nearby regions were performed during April 2010 and January 2011. The MAX-DOAS instrument was mounted on a car roof, which allowed to perform mobile measurements. From car MAX-DOAS observations along closed circles around Delhi, together with information on wind speed and direction, the NOx emissions from the greater Delhi area were determined. The total NOx emissions were derived from observations along closed circles around the city. Since the MAX-DOAS observations encircled only part of the entire Delhi area, the results obtained have been up-scaled. For that purpose, three different proxies were used - the spatial distribution of:

- NOx emissions from the EDGAR data base,
- population density,
- light intensity observed from satellite during night (Fig. 1).

Fig. 1. Spatial distribution of the night-time lights for the selected Delhi area, which is used to estimate the fraction of the encircled emission. Also shown are the driving routes for the different days.

Our emission estimation for Delhi, $3.7 \times 10^{25}$ molec/s, is slightly lower than the corresponding emission estimates using the EDGAR data base and substantially smaller compared to a recent study by Gurjar et al. (2004), (see Figure 2).

Fig. 2. Comparison of the up-scaled NOx emissions from the car MAX-DOAS measurements (using different proxies for the spatial distributions) and existing emission estimates.

Fig. 3. Comparison of the tropospheric NO2 VCDs on 14 April 2010 measured from OMI and car MAX-DOAS. MAX-DOAS observations were carried out between 5:20 and 10:57 UT; OMI overpass was at 7:50 UT. The large circle indicates MAX-DOAS observations during OMI overpass.

The MAX-DOAS observations of the tropospheric NO2 VCD were also used for validation of simultaneous satellite observations from the OMI instrument and a good agreement of the spatial patterns (see Figure 3) was found. OMI data tend to underestimate the tropospheric NO2 VCDs in regions with high pollution levels, and tend to overestimate the tropospheric NO2 VCDs in cleaner areas. These findings might indicate possible discrepancies between the true vertical NO2 profiles and the profile assumptions in the OMI satellite retrieval.

References


Shaiganfar, R., Beirle, S., Sharma, M., Chauhan, A., Sing, R.P., Wagner, T, 2011: Estimation of NOx emissions from Delhi using Car MAX-DOAS observations and comparison with OMI satellite data. Submitted to ACPD.
**Impact of Urban Parameterization on High Resolution Meteorological and Air Quality Simulations with the GEM/LAM-AQ Model**

Joanna Struzewska  
E-mail: Joanna.struzewska@is.pw.edu.pl  
Warsaw University of Technology, Department of Environmental Engineering, Warsaw, Poland

Struzewska J. 1, Kaminski J.W. 2

1 – Warsaw University of Technology, Department of Environmental Engineering, Warsaw, Poland  
2 – WxPrime Corporation, Toronto, Canada. York University, Toronto, Canada

**Introduction**

In meso-gamma scale simulations of atmospheric processes the differences between rural and urban areas indicate the need for using urban parameterizations. The aim of the study was to assess the impact of urban cover on the high-resolution semi-operational meteorological and air quality forecast calculated with the GEM/LAM-AQ model (http://www.EcoForecast.eu).

The forecasting system is based on the GEM-AQ model (Kaminski et al., 2008). GEM-AQ is a comprehensive chemical weather model in which air quality processes (chemistry and aerosols), tropospheric and stratospheric chemistry are implemented on-line in the operational weather prediction model, the Global Environmental Multiscale (GEM) model, developed at Environment Canada. The regional forecast is computed on a global variable grid with the uniform resolution of 25 km (0.22 deg) over Europe. Nested high-resolution forecast is calculated on a 100 by100 grid with the resolution of 0.0625 deg and the time step of 120 s.

**Urban cover description**

To represent urban effects the TEB (Town Energy Balance) parameterization (Masson, 2000) implemented in the GEM/LAM model (Lemonsu et al., 2008) was used. TEB parameterization distinguishes twelve categories of urban morphology (Table 1). In this study, due to relatively coarse resolution, the structure of the towns was described in a simplified way - only three urban cover categories were selected – representing city centre, middle suburbs and outer suburbs. The urban cover layers were constructed based on a fraction of towns in a grid cell. For most urban sites in the domain the fraction was ~30%. Two different datasets were prepared (Table 1).

**Table 1. Urban cover categories in TEB scheme – default average building height and anthropogenic heat flux. UF1/UF2 - two alternative approaches to describe urban cover**

<table>
<thead>
<tr>
<th>No</th>
<th>TEB urban cover</th>
<th>Build. height</th>
<th>Anth. heat</th>
<th>UF-1 %</th>
<th>UF-2 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High buildings</td>
<td>30</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mid-high buildings</td>
<td>25</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Low buildings</td>
<td>13</td>
<td>30</td>
<td>&gt;= 50</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Very low buildings</td>
<td>8</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Industrial areas</td>
<td>5</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sparse buildings</td>
<td>12</td>
<td>15</td>
<td>10-50</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Roads and parkings</td>
<td>9</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Road borders</td>
<td>5</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>High-density suburbs</td>
<td>5</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mid-density suburbs</td>
<td>5</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Low-density suburbs</td>
<td>8</td>
<td>15</td>
<td>&lt; 5</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Mix built / nature</td>
<td>8</td>
<td>0</td>
<td>&lt; 10</td>
<td></td>
</tr>
</tbody>
</table>

**Results**

Three one-day cases representing different meteorological condition were selected: 6 of November 2010 (frontal passage), 3 of January 2011 (low wind, clear sky conditions, cold air mass) and 29 of March 2011 (moderate wind and cloudiness).

Positive temperature anomaly over larger cities was reproduced in all modeled cases, however, the intensity of the UHI effect strongly depended on meteorological situation (wind speed and cloudiness) and the urban cover type. Anomaly of NO2 concentrations were most significant over cities characterized with high NOx emission. In most cases results calculated with urban parameterization taken into account showed the decrease of NO2 concentrations most probably due to enhanced mixing (UHI) (Figure 1). Modelling results were compared against measurement from the air-quality monitoring urban stations.

**Conclusions**

The GEM/LAM-AQ model was exercised in high resolution configuration with urban parameterization taken into account. Although the urban structure representation was very simple the model response was correct in terms of magnitude of the anomalies between "urban" and "non-urban" scenarios and the relation to meteorological situation. The differences between the two alternative surface description approaches were relative small.

Preliminary analysis of the differences in modelled pollutants concentration fields between "urban" and "non-urban" scenarios indicate the importance of proper description of urban areas for high resolution air quality simulations.

**References**


Air Quality Forecast Study with Enviro-HIRLAM in Istanbul

Hüseyin Toros
E-mail: toros@itu.edu.tr

Istanbul Technical University, Department of Meteorology, Istanbul, Turkey

http://www.itu.edu.tr

Introduction

The following study results from a partnership between KNMI (Royal Netherlands Meteorological Institute) and ITU (Istanbul Technical University). Here we report our preliminary results of the ongoing research for the modeling of an episode period in Istanbul, which was submitted to NATO ITM 2010, Turin (Toros et al., 2010). In the first phase of the study, predictions of meteorological variables during episode period were obtained. The second phase of this collaboration is to study chemical weather forecasting for this episode period using Enviro-HIRLAM.

Air Quality Levels and Episodes in Istanbul

Air quality levels in the urban area of megacities is a serious issue which usually depends on some meteorological condition. The strategy of new generation integrated Meso-Meteorological and Atmospheric Chemical Transport Model systems suggest considering the urban air quality as a combination and integration, at least, of the following factors: air pollution, meteorological/climatic conditions, and population exposure (Baklanov, 2008). Chemical weather forecasts of high quality will be highly valuable. For this purposes we considered an investigation of air quality in Istanbul.

Istanbul is one of the megacities in the world with more than 13 million inhabitants.

The city (41°N, 29°E) is located on both continents, Asia and Europe with a total area about 5400 km².

Istanbul has experienced serious air quality problem in the past due to the poor quality coal usage for domestic heating and industry. Two pollutants were of major concern in 1980s. They were Total Suspended Particulates and SO₂ at those years. Following fuel switching in the city in the beginning of 1990s, industrial emissions. Two pollutants were of major concern in 1980s. They were Total Suspended Particulates and SO₂ at those years.

Selection of Episode

An example for the air quality levels in the urban area of Istanbul is the time series of the daily and 3 day moving average PM10 concentrations for 10 urban air quality monitoring station. As can be seen in Fig. 1, there are several episodes in this one year period. The first episode starts in beginning of February, second beginning of March and third episode is started of late November 2009. The third episode is discussed here in more detail. The intention is to apply the model to similar episodic events in Istanbul as case studies. An anticyclonic high pressure prevailed over Istanbul and surrounding region that leads to low wind speeds and surface inversions during 18-20 November 2009.

Discussion

These conditions caused poor air quality, especially in the Istanbul Metropolitan Area. The high PM10 concentrations during the episode considered here possibly originated from the local sources such as heating of residences in the beginning of winter season. The numerical weather forecasting model HIRLAM serves as a basic tool for weather forecasts in several European countries (http://www.knmi.nl/hirlam). Simulations were executed with version 7.2.1 of the HIRLAM model with 2.5 km horizontal resolutions. The simulations were able to predict the temperatures, wind speeds and relative humidity at near surface (Fig.2).

Accuracy in forecasting air pollution levels depends critically on the ability of the numerical weather prediction models to compute the relevant meteorological parameters like pressure, temperature, wind speed and relative humidity. We have therefore tested the performance of the limited area weather forecasting model HIRLAM. This study showed that the 24 hours forecast from HIRLAM was able to forecast the high pressure, low wind speed, low temperature and high relative humidity.

References


Mapping and Monitoring Megacities from Space

Hannes Taubenböck

E-mail: hannes.taubenboeck@dlr.de
German Remote Sensing Data Center (DFD), German Aerospace Center (DLR)
Division: Land Surface
http://www.dlr.de/caf/desktopdefault.aspx/tabid-5412/10516_read-23315/

Taubenböck H. 1, Esch T. 1, Dech S. 1
1 German Remote Sensing Data Center, German Aerospace Center (DLR)

Introduction

Urbanization is a global phenomenon. And the United Nations expect that almost all population growth for the world in the next thirty years will be concentrated in urban areas (UN, 2009). Explosive, often uncoordinated growth frequently leads to a lack of data and information to measure, monitor, and understand urban sprawl processes. The analysis of such changes has become an important use of multi-temporal remote sensing data and applications.

Study sites “Mega cities”

The United Nations define mega cities quantitatively as conurbation having more than 10 million inhabitants (UN, 2009). Mega cities are the largest category of urban agglomerations and thus they can serve as good predictors of future urbanization processes in incipient mega cities.

The Value of Remote Sensing

Earth observation is an independent, consistent, area-wide and up-to-date data source. The capabilities of various sensors reach far beyond the obvious benefits available at platforms like Google Earth or Bing. They provide reflective responses all along the electromagnetic spectrum which enables detection of objects or patterns on the earth’s surface and their condition: The sensors cover many spatio-temporal dimensions, with a flexible repetition rate and in various scales ranging from spatially detailed analyses on single buildings or building block level to global studies on continental scale.

In combination with widely automated methods of data processing and image analysis, urban remote sensing provides multiple options to support decision makers such as resource managers, planners, environmentalists, economists, ecologists and politicians with accurate and up-to-date geoinformation.

In this study time-series data from the Landsat sensors as well as the TerraSAR-X satellite allow monitoring of cities for almost 40 years on a regional scale. Object-oriented classification algorithms facilitate the derivation of urban footprints from the optical Landsat data (Taubenböck et al., 2009). A pixel-based classification algorithm extracts urban footprints from the radar data of TerraSAR-X (Esch et al., 2010). The urban footprint is an abstract approximation of the particular city. Accuracy assessment with high detailed 3-D city models highlights that the urban footprint is closely related to the man-made environment of cities. Results show about 80 % correlation (Taubenböck et al., 2011).

Figure 1 illustrates one result of spatial megacity (Manila, Philippines) growth from 1975 until 2010. Using a pixel-based post-classification change detection, spatial urban growth can be identified. It enables to detect the spatial dimension of sprawl and the dynamics in dependence of time. Beyond that, processes such as redensification, leap frog development as well as patterns of growth such as axial, mono- or polycentric structures or satellite town evolution can be analysed.

The result of change detection is shown for the example of mega city Istanbul, Turkey. Figure 2 visualizes the growth of the metropolitan area along the Marmara Sea in four time steps since 1975.

Critical in the description, analysis, and modelling of urban form and its changes are spatial metrics. Methods such as landscape metrics, gradient analysis or zonal statistics allow quantifying the spatial patterns (Taubenböck et al., 2009). With the consistent data from remote sensing cross-city comparisons as well as comparisons over time become possible.

Outlook

The constantly increasing availability and accessibility of modern remote sensing technologies provides new opportunities. The German Aerospace Center (DLR) intends to provide as one example a consistent multi-temporal change detection product on urban footprint level since the 1970s for all current 27 mega cities of the world. Beyond that the German TanDEM-X mission will provide a global coverage of TerraSAR-X stripmap data. With it, DLR aims at classifying the current global urban footprint.

References

Megacities are an increasing source of pollution due to migration to urban areas. This is more pronounced in developing countries, where economical means for proper regional area planning are limited. Due to uncontrolled migration, new informal settlements are often established around the formal perimeter of cities. This is also the case in South Africa, where the Gauteng metropolitan conurbation (Johannesburg, Pretoria and the associated greater metropolitan areas) continuously grow (currently already more than 10 million people). Apart from its physical size, this conurbation is also the largest economical centre in Africa.

To study the global and regional effects of the Gauteng conurbation out-plume, a new comprehensive measurement station was started (Laakso et al., 2008, Vakkari et al., 2011) approximately 100 km west of Johannesburg in May 2010. The Welgegund measurement site (http://www.welgegund.org) is situated in a grazed savannah-grassland (Figure 1), with very little local pollution sources.

However, the area is regionally strongly impacted by the plumes from the Gauteng metropolitan conurbation, as well as the other important industrialized areas of the South African interior (e.g. Vereeniging, Secunda and other industrialized Mpumalanga) (Figure 2). The site also receives air masses from background areas with no major industrial developments due to a clean sector to the west.

The continuous measurements currently conducted at Welgegund include:

- Trace gases – SO2, CO, NOx, O3 and VOC’s
- Aerosol properties – air ion size distributions 0.4-40 nm, aerosol particle size distribution 10-840 nm, total PM1, black carbon, 3-wl aerosol scattering, aerosol chemical composition by online Aerosol Mass Spectrometer and some off-line aerosol composition measurements
- Solar radiation – direct and reflected PPFD (Photosynthetic Photon Flux Density) and global radiation, net radiation
- Meteorology – precipitation, wind speed and direction, temperature at different heights and relative humidity
- Ecosystem – sensible and latent heat fluxes, CO2 flux, soil temperature and moisture at different depths, soil heat flux

The first year of measurements revealed that the site selection (physical positioning) was scientifically sound, i.e. capturing the environmental impacts of the Gauteng metropolitan conurbation, as well as most of the other important industrialized areas of the South African interior.

During the prevailing easterly (Gauteng metropolitan conurbation impacts) and northerly winds (western Bushveld Igneous Complex impacts), concentration of particulates and trace gases reach very high values (e.g. O3 above 95 ppb), capable of affecting radiative balance and causing damages on the regional ecosystem.

One of the current aims of the research is to determine the oxidation of the megacity plume. Another research focus is the validation of regional water balance models, which almost completely lack continuous boundary layer measurements of water exchange.

References


Air Pollution in and around the South African megacity Johannesburg

Johannesburg is the largest city in South Africa with a population of approximately 3.8 million and increasing. This leads to an increase in anthropogenic emission sources, therefore posing a significant threat to human health, property and environment. Due to its remote location within the southern hemisphere, high altitudes and direct influences of surrounding industrial activities, Johannesburg holds a particular significance to photochemical modelling. The primary aim of this investigation is to use a box model with detailed gas-phase chemistry, along with new measurements of trace gases made at several locations in and around the city, to investigate the impact of surrounding industrial activities on the tropospheric photochemistry of Johannesburg. Model calculations are performed with the chemistry box model MECCA (Module Effective Calculating the Chemistry of the Atmosphere) developed and used by the Max Planck Institute for Chemistry in Mainz, Germany.

E-mail: sandra.lourens@mpic.de
Max-Planck Institute for Chemistry, Mainz, Germany
http://www.mpic.de

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Regional and global transport and deposition of pollutants from megacities worldwide

In global models megacities are represented as pollution point sources and detailed differences in the emissions distribution between individual megacities become small compared to the resolution applied. However, the regional and global impact of a single megacity depends strongly on the local meteorology which governs the transport and deposition of the megacity pollution plume. Using generic passive tracers with constant emission rates in an atmospheric chemistry global circulation model (EMAC) and applying metrics for transport and deposition allows a ranking of megacities in terms of their pollution potential. Aerosol and gas-phase passive tracers are used to characterize the pollution potential of each megacity and the impact on various land use types and on human populations. Transport into different atmospheric regimes, such as remote-low-level regions and the upper troposphere, is investigated, as well as the local build up of pollutants, and the distinction between dry and wet removal as components of the total local and remote deposition.

E-mail: daniel.kunkel@mpic.de
Max-Planck Institute for Chemistry, Mainz, Germany
http://www.mpic.de

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Comparison between the AOD derived from a global climate model HadGEM2 and from satellite observations

Aerosol optical properties influence the radiative balance of atmosphere. Aerosol Optical Depth (AOD) can be measured accurately by ground based instruments. Resources for this kind of measurements are, however, limited. Satellites provide regular, low maintenance measurements with global coverage. Satellite instruments AATSR (Along Track Scanning Radiometer) and MODIS (Moderate Resolution Imaging Spectrometer) covering globe in 3-5 and 1-2 days, respectively, measure reflected radiation, from which AOD can be retrieved. In this study, retrieval methods and results are under continuous evaluation and improvement. AODs retrieved from two satellite-based instruments are compared with HadGEM2 climate model 3D products is evaluated using ground based measurement network AERONET (AErosol RObotic NETwork; provides sun photometer data at approx. 400 stations in 50 countries). Preliminary results showed that satellite retrieved AODs are generally similar as regard their magnitude and spatial distribution. Differences are observed e.g. over regions with high surface reflectance. Other differences over various surfaces and in different situations and seasons are also observed, this needs further investigation.

E-mail: irina.hannukainen@helsinki.fi
University of Helsinki, Department of Physics
http://www.helsinki.fi/university

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NO₂ measurements in megacities

Multi-Axis-Differential Optical Absorption Spectroscopy is observing the scattered sunlight under various viewing directions. Mobile MAX-DOAS observations are conducted on circles around localized emission sources or even whole cities. These observations combined with meteorological information give us the possibility to estimate the total emission of trace gases like NO₂, HCHO or Glyoxal. The amounts of tropospheric trace gases and aerosols can be determined by mobile MAX-DOAS observations, which can be used to validate the satellite data.

Year of PhD Defence: 2011
Sci. Advisers: Ulrich Platt (Institute for Environmental Physics, Univ. of Heidelberg, Germany), Thomas Wagner, Steffen Beirle (Max-Planck Institute for Chemistry, Germany)

E-mail: r.shaiganfar@mpic.de
Max-Planck Institute for chemistry, Mainz, Germany/ Satellite http://joseba.mpch-mainz.mpg.de/index.htm

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Sci. Advisers: Tim Butler, Mark Lawrence (Max-Planck Institute for Chemistry, Germany), Paul Buekes, Kobus Plenaar, Pieter van Zyl (Northwest Univ, Potchefstroom, South Africa)

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Year of PhD Defence: 2012
Sci. Advisers: Mark Lawrence, Stephan Borrmann (Max-Planck Inst. for Chemistry, Germany)

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Year of PhD Defence: 2013
Sci. Adviser: Gerrit de Leeuw (Finish Meteorological Institute); Co-Advisers: Anu-Maija Sundström (Univ. of Helsinki), Edith Rodriguez, Pekka Kolmonen, Larissa Sogatcheva (FMI)
Stationary and mobile measurements of the chemical composition, sources and aging of aerosol particles

Stationary and mobile measurements have been performed during two measurements field campaigns in the Paris region, in order to study aerosol particles chemical composition, their physical properties and sources. Several instruments were deployed during the measurements and two "high resolution time of flight aerosol mass spectrometers" (HR-TOF-AMS) were used to investigate the evolution of the chemical composition of aerosol particles, their size distribution and source apportionment. In order to identify the main sources which contribute to the atmospheric aerosol formation different source apportionment techniques can be applied. The combination of statistical models with high time resolution measurements performed with the AMS allows a more detailed source apportionment, with discrimination of many sources. Positive matrix factorization (PMF) has been used to characterize organic aerosol in terms of HOA (Hydrocarbon-like Organic Aerosol), OOA (Oxygenated Organic Aerosol), BBOA (Biomass Burning), and other local sources, such as cooking (COA).

Year of PhD defence: 2012
Supervisor: Prof. Urs Baltensperger (PSI);
Co-Supervisors: Prof. Ulrike Lohmann (ETH-Zurich), Dr. Andre Prevot (PSI)

Characterisation of the cloud condensation nuclei properties of complex aerosols: from the smog chamber to the free troposphere

During the MEGAPOLI campaign (January-February 2010) in Paris (SIRTA site) a CCN counter (DMT) was operated parallel to a condensation particle counter in a SMPS (Scanning Mobility Particle Sizer) setup in order to measure at 10 different supersaturations (0.1-1%) the CCN number size distribution next to the total particle (CN) number size distribution from 10 to 440 nm. This measurement setup, combined with data inversion makes it possible to determine the number size distribution of CN and CCN at a defined supersaturation. These measurements contain useful information not only on the average hygroscopicity of the particles but also on the mixing state with respect to hygroscopicity of the aerosol population.

Year of PhD defence: 2010
Supervisor: Prof. Urs Baltensperger (PSI);
Co-Supervisors: Prof. Ulrike Lohmann (ETH-Zurich), Dr. Martin Gysel (PSI)

Investigation of black carbon properties using a single particle soot photometer

The measurements undertaken during MEGAPOLI will be part of my thesis that aims at measuring black carbon at its different state of ageing. The goal during Megapoli was to study the mixing state of black carbon and its evolution in the urban outflow of the megacity Paris in summer (July 2009) and winter (Jan/Feb 2010). Our stationary measurements took place at the sub-urban background site in SIRTA where I measured using a single particle soot photometer (SP2). This instrument allows measuring the mass of black carbon in individual particles independently of the amount or of the type of coating. We can also retrieve the coating thickness and therefore the mixing state of each particle and relate it to air masses for example. Black carbon properties have been measured continuously during winter 2010; however, only the mass concentration can be retrieved from the summer campaign.

Year of PhD defence: 2012
Supervisor: Prof. Urs Baltensperger (PSI)
Co-Supervisors: Prof. Thomas Peter (ETH-Zurich), Dr. Martin Gysel (PSI)

Hygroscopicity and volatility of aerosol particles

The measurements within MEGAPOLI are one part of my thesis about hygroscopicity and volatility of fresh and processed aerosols from different sources. The goal was to study the evolution of the chemical composition and physical properties of the aerosol in the urban outflow of the megacity Paris in summer (Jul 2009) and winter (Jan/Feb 2010). Our stationary measurements took place at the sub-urban background site in SIRTA and I focus here on the V/H-TDMA (volatility and hygroscopicity tandem differential mobility analyzer) measurements in the diameter range 35-265 nm. Volatility and hygroscopicity were continuously measured as volume fraction remaining (VFR) at 100°C and hygroscopic growth factor (GF) at 90% RH, respectively. From the GF scans (and sometimes also for volatility) we observed the mixing state of the aerosols.

Year of PhD defence: 2011
Supervisors: Prof. Urs Baltensperger (PSI), Dr. Ernest Weingartner (PSI)
--- Michoud Vincent

E-mail: Vincent.michoud@lisa.u-pec.fr
CNRS-LISA, Université Paris Est Créteil, Université Paris Diderot, Créteil

**Megacities emission impact on nitrogen species cycle and fast gas chemistry**

Within the FP7 EU MEGAPOLI project, two intensive field campaigns have been conducted in the Greater Paris region during summer 2009 and winter 2010 to evaluate the impact of Megacities on local and regional air quality. During these campaigns, particulate phase and gas-phase measurements have been performed. I was in charge of gas-phase measurements during MEGAPOLI campaigns, more precisely of nitrogen species (NOx, PAN, HONO) and Volatile Organic Compounds (VOCs). After the campaigns, the data obtained were validated. The aim of PhD is to study the radical chemistry as the driving force behind the oxidation of primary organic species into secondary pollutants. For that study, the photo-stationary state calculations are carried out for the radical and nitrous acid budget. This work will be completed by a 0D modelling study for the radical budget.

**Year of PhD defence: 2012**

**Supervisor:** Doussin Jean-François (CNRS-LISA)
**Co-Adviser:** Colomb Aurélie (CNRS-LaMPP, Clermont Université, Université Blaise Pascal, Aubière, France)

--- Q.Jie Zhang

E-mail: zhang@lisa.u-pec.fr / qzhang@aria.fr
CNRS-LISA, Université Paris Est Créteil, Université Paris Diderot / Aria technologies

**Simulation of Particulate Matter in grand agglomeration of Ile-De-France**

The aim of this thesis is to improve the simulation of particulate matter and especially organic aerosol in the chemical transport model CHIMERE (http://euler.lmd.polytechnique.fr/chimere), and to apply the model to simulate sources and evolution of (organic) aerosol in a large megacity. The example chosen is the Paris agglomeration, where an intensive measurement campaign was held in July 2009 and winter 2010 in the frame of the FP7/MEGAPOLI project. To improve simulation especially of organic aerosol, the Volatility-basis-set (VBS) approach has been integrated into CHIMERE and evaluated with MEGAPOLI observations. The advection versus local origin of particulate matter is evaluated, so as the aerosol build-up in the Paris plume. The thesis is supported by French CIFRE grant attributed to LISA and ARIA.

**Year of PhD defence: 2011**

**Supervisor:** Matthias Beekmann (CNRS-LISA)
**Co-Adviser:** Armand Albergel (Aria Technologies)

--- Guillaume Siour

E-mail: Guillaume.Siour@lisa.u-pec.fr
CNRS-LISA - INERIS

**Modeling and multi scale impact assessment of European megacities**

The main objective is to study relationship between the city-structure, air quality and pollutant transport over the continent. The main focus is on the continental scale and the export of pollutants from the megacities. To characterize as accurately as possible the composition and the intensity of the plumes exported by a megacity, a flux calculation was developed in the CHIMERE CTM, and the last version of the SAPRC chemical mechanism was implemented in order to obtain a more detailed VOC speciation during the plume aging. Moreover, a sensitivity study about the evolution of European megacity emissions was conducted. Two options were taken into account: a densification of urban emissions inside megacity cores, and a “city-spreading scenario” simulating the increase of megacity emissions in the suburbs. In addition a 1-year (2005) simulation for the MEGAPOLI modeling exercise was carried out using TNO emissions and MATCH boundary conditions. A number of global experiments are carried out for the year 2005 to identify sensitivity to changes in megacity emissions. A megacity mask, produced at 0.5x0.5 degree resolution, is used to create both annihilation and redistribution scenarios, in which changes are made to the spatial distribution of megacity emissions. In these studies particular attention is paid to the importance of model and emission resolution for correct representation of megacity emissions.

**Year of PhD defence: 2011**

**Supervisor:** Isabelle Coll (CNRS-LISA)
**Co-Advisers:** Alain Dutot (CNRS-LISA), Augustin Colette and Bertrand Bessagnet (INERIS)

--- Zadie Stock

E-mail: zss21@cam.ac.uk
Univ of Cambridge, Centre for Atmos. Science, Departm. of Chemistry, UK
http://www.atm.ch.cam.ac.uk

**Impact of megacities on regional and global atmospheric composition and climate**

Quantifying the effects of megacities, cities with population greater than 10 million, on regional and global air quality is a key objective of the EU project MEGAPOLI. The UK Met Office global climate-chemistry model (Unified Model version 7.3) is used coupled to the UK Chemistry and Aerosols module (UKCA) at both typical climate resolution (1.875 x 1.25 degrees, 200 km) and at a higher resolution (40-60 km) to explore megacity effects across different scales. A number of global experiments are carried out for the year 2005 to identify sensitivity to changes in megacity emissions. A megacity mask, produced at 0.5x0.5 degree resolution, is used to create both annihilation and redistribution scenarios, in which changes are made to the spatial distribution of megacity emissions. In these studies particular attention is paid to the importance of model and emission resolution for correct representation of megacity emissions.

**Year of PhD defence: 2012**

**Supervisor:** Prof. John Pyle, Centre for Atmospheric Science, University of Cambridge, UK
**Co-Adviser:** Dr Maria Russo, Centre for Atmospheric Science, University of Cambridge, UK
Aerosol properties comparison between Paris and other megacities, using satellite and sun photometer measurements

One of the main objectives of the MEGAPOLI project is to assess impacts of megacities and large air-pollution hot-spots on local, regional and global air quality. In this study the effects of air pollution generated in different megacities have been analyzed. The aerosol distribution around Paris and other megacities like Mexico City, New York and New Delhi was compared using satellites and ground-based remote sensing measurements (during 2009). The satellite instruments used for this study were the Advanced Along Track Scanning Radiometer (AATSR), flying on ENVISAT and MODIS flying on Terra. Ground-based measurements were obtained from the AERONET sun photometer network. AATSR and MODIS provide information on the regional distribution of aerosol properties; AERONET provides information on local aerosol properties which is used to validate the satellite data, and to study gradients in along-wind situations. To calculate the Aerosol Optical Depth (AOD) and Ångström Exponent (AE), with the AATSR data, a combination of coarse and fine mode aerosol models is used. The comparison between AERONET, AATSR and MODIS shows good agreement but with some overestimation of AOD retrieved from AATSR.

Post Doctoral Research
Supervisor: Prof. Gerrit de Leeuw (Finnish Meteorological Institute)

Mapping of urban topography with interferometric SAR

A cost efficient way to generate Digital Elevation Maps (DEM) is the use of space-borne Synthetic Aperture Radar (SAR). Large areas are covered and the data is freely available for scientific use. From the phase difference between a pair of SAR images information on the ground topography can be obtained. These images are subject to noise and phase ambiguities though. This can be overcome using multi-baseline interferometry from repeat-pass satellite observation. 13 ENVISAT-ASAR images obtained. These images are subject to noise and phase ambiguities though. This can be overcome using multi-baseline interferometry from repeat-pass satellite observation. 13 ENVISAT-ASAR images are used to form 53 phase interferograms. From this information a height map of Paris will be derived, with resolution down to building-block level.

Year of BSc Defence: 2011
Supervisors: Prof. Jarkko Koskinen and Dr. Antti Hellsten (Finnish Meteorological Institute)

Simulation of particulate matter in grand agglomeration of Ile-De-France

Aerosols are worth of studying because of their effect on climate and human health. In both cases, the most important qualities of aerosols are the size and the abundance of the particles making the aerosol. With a Differential Mobility Particle Sizer (DMPS) one can define an aerosol size distribution, which contains the information about these aerosol qualities. For the Megapol campaign, a flow-switching DMPS was built at Division of Atmospheric Sciences of University of Helsinki. The aim of building this instrument was to make a portable DMPS system with a performance similar to the twin-switching DMPS. A cost efficient way to generate Digital Elevation Maps (DEM) is the use of space-borne Synthetic Aperture Radar (SAR). Large areas are covered and the data is freely available for scientific use. From the phase difference between a pair of SAR images information on the ground topography can be obtained. These images are subject to noise and phase ambiguities though. This can be overcome using multi-baseline interferometry from repeat-pass satellite observation. 13 ENVISAT-ASAR images are used to form 53 phase interferograms. From this information a height map of Paris will be derived, with resolution down to building-block level.

Year of BSc Defence: 2010
Supervisors: Drs. Tuukka Petäjä and Pasi P. Aalto (Univ of Helsinki, Divis.of Atmos. Sciences)

Thermal and dynamical urban effects of Saint-Petersburg metropolitan area

The urban areas have significant influence on the meteorological processes and atmospheric flow, its turbulence regime, the microclimate, and, accordingly, modify the transport, dispersion, and deposition of atmospheric pollutions within these areas. In this study, the spatial and temporal variability of meteorological fields due to influence of the thermal and dynamical urban effects of St. Petersburg (Russia) urban area was evaluated using the Enviro-HIRLAM model (with horizontal resolution of 1.4 km). The selected case study is linked with winter period of 2009. Dependence of meteo.fields on temporal variability of meteorological variables in the lower surface layer (wind at 10 m and air temperature at 2 m) was estimated as a function of roughness, anthropogenic heat flux, and albedo. The differences between control vs. urbanized runs over the metropolitan area were: for wind speed - up to 2 m/s (max 2.9) and for air temperature - more than 1ºC (max 2.7). The simulation results were compared with observations at urban/ sub-urban synoptical stations within the metropolitan area. Results showed that urbanization can significantly improve the forecasting in urban areas, and combined urbanization effects have shown significant role of non-linear effects

Year of MSc Defence: 2010
Supervisors: Prof. Sergey Smyshlayev (Russian State Hydrometeorological University) and Dr. Alexander Mahura (Danish Meteorological Institute)
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:


- See more MEGAPOLI Publications/ Presentations at http://megapoli.info

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:

- Urban Air Quality and Climate Change Workshop (UAQCC) Hamburg, Germany, 16-18 Aug 2011 http://www.klimacampus.de/?id=1785
- Final MEGAPOLI Project Symposium (3rd Annual Meeting) Paris, France, 26-28 Sep 2011 contact: Matthias Beekmann, CNRS-LISA (beekmann@lisa.univ-paris12.fr)
- 8th International Conference on Air Quality Science and Application Athens, Greece, 19-23 Mar 2012 http://www.airqualityconference.org

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We apologise for any inconvenience caused.
Welcome to the 12th issue of the Newsletter

Editorial

The MEGAPOLI consortium is pleased to present the 12th FINAL issue of the MEGAPOLI Newsletter. Short contributions from Partners and Collaborators, as well as Research Teams introductions are given here. Details on the project progress can be found in public documents available at the project website (www.megapoli.info). The purpose of the newsletters is to inform about activities, progress, and achievements of the MEGAPOLI project as well as to establish a dynamic communication link with the Partners, Collaborators, and Users Community, to monitor the project activities and to exchange input and experiences. For these reasons your contributions to newsletters and news at the web-site as well as comments have been always welcome.

MEGAPOLI Project Office

Latest News

- Coming soon – Final (3rd Annual Meeting) MEGAPOLI Project Symposium (Paris, France, 26-28 Sep 2011)
- Coming soon – special session on “Environmental Meteorology” at EMS-2011 Annual Meeting (Berlin, Germany, 12-16 Sep 2011)
- Sep 2011 – MEGAPOLI Final Reporting to European Commission (finalization of all deliverables/reports; coordination, management, dissemination, financial reporting; periodic and final reporting to EC through the ECAS web-portal)
- 19 Aug 2011 – 8th MEGAPOLI WP Leaders Telephone Conference
- 16-18 Aug 2011 – Urban Air Quality and Climate Change Workshop (UAQCC) Hamburg, Germany
- Aug 2011 – testing functionality of the MEGAPOLI ETHER platform for accessing the Paris campaign data/measurements

UAQCC: 16-18 Aug 2011, Hamburg, Germany

16-18 Aug 2011 – Urban Air Quality and Climate Change Workshop, UAQCC (KlimaCampus; Hamburg, Germany) lead by the UHam team

- 40 researches from 16 countries – met to discuss current aspects and challenges in urban climate and air quality and their developments in climate change
- Sessions at Workshop:
  - Air pollution in urban areas – measurements and simulations;
  - Regional climate changes;
  - Climate and air quality interactions;
  - Impact of mitigation measures on air quality and urban climate;
  - Urban air quality and climate change - required accuracy for planners;
  - Required level of complexity for modelling urban AQ-climate change interactions.
- Urban areas in focus - Beijing, Cairo, Cape Town, Chicago, Delhi, Detroit/Windsor area, Hamburg, Istanbul, Lagos, London, Los Angeles, Melbourne, Mexico City, Moscow, Mumbai, New York, Paris, Pearl River Delta, Po Valley, Rheine-Ruhr, Santiago del Chile, Shanghai, St. Petersburg, Tokyo-Yokohama.
- Round Table Discussions:
  - Are there common unknowns when investigating regional climate change and urban air quality?
  - Are mitigation measures more relevant than climate changes for urban air quality?
  - What accuracy is needed, what accuracy can be delivered?
  - What do we know about necessary complexity for investigating urban air quality in climate change?
  - What do we know, and What do we need to know on urban air quality and climate change?
Overview of MEGAPOLI Project

Major Results

Alexander Baklanov
E-mail: alb@dmi.dk

1 Danish Meteorological Institute, Research Department, Copenhagen, Denmark
2 Max-Planck Institute for Chemistry, MPIC, Mainz, Germany
3 FORTH, University of Patras, Greece

http://www.dmi.dk

The EC FP7 Project MEGAPOLI is entering its final phase. It has brought together leading European research groups, state-of-the-art scientific tools and key players from non-European countries to investigate the interactions among megacities (MCs), air quality and climate. MEGAPOLI includes both basic and applied research, and bridges spatial and temporal scales connecting local emissions, air quality and weather with global atmospheric chemistry and climate.

The main MEGAPOLI objectives are:

(i) to assess impacts of MCs and large air-pollution hotspots on local, regional and global air quality,
(ii) to quantify feedbacks among MC air quality, local and regional climate, and global climate change,
(iii) to develop improved integrated tools for prediction of air pollution in MCs.

Examples of a few of the main scientific results achieved by the MEGAPOLI project are briefly mentioned below (additional details can be found in the final report, roughly 50 scientific reports, 2 books, 3 special issues and the corresponding journal papers on http://megapoli.info).

Several important scientific achievements of MEGAPOLI are based on the Paris measurement campaigns. Two intensive month-long measurement campaigns were performed around Paris during the summer of 2009 and winter of 2010. The campaigns aimed at better quantifying primary and secondary organic aerosol sources for a European MC, and included 3 primary and 7 secondary fixed ground measurement sites, an aircraft and 5 mobile vans. More than 25 research groups participated. The Paris pollution plume was still well defined at more than 100 km downwind from the agglomeration, which allowed the study of secondary pollutant build-up in the MC outflow. Significant new particle formation events were frequently observed during the campaigns.

Processes involving nonlinear interactions and feedbacks between emissions, chemistry and meteorology require coherent and robust approaches using integrated/online methods. MEGAPOLI has proposed a comprehensive integrated modelling framework. The framework has been tested for a range of MCs within Europe and across the world to increase our understanding of how large urban areas and other hotspots affect air quality and climate on multiple scales.

The integration strategy in MEGAPOLI is not focused on any particular meteorological and/or air pollution modelling system. The approach considers an open integrated framework with flexible architecture able to incorporate different meteorological and chemical transport models. This multi-scale modelling framework includes nesting of the following characteristics and processes from the global to street scale:

(i) Land-use characteristics and scenarios,
(ii) Anthropogenic heat fluxes,
(iii) Emission inventories and scenarios,
(iv) Atmospheric processes model down- and up-scaling (two-way nesting, zooming, nudging, parameterizations, urban increment methodology).

In MEGAPOLI a state-of-the-art regional European emission data base was combined and cross-checked with bottom-up emission inventories for Paris, London, Rhine-Ruhr area (Germany) and the Po-valley (Italy).

The allocation of the emission in the regional down-scaled inventory can deviate substantially (up to a factor of 4) from the MC bottom-up inventories. The major discrepancies caused by e.g. residential combustion and industry sectors were documented and explained. Emission inventories are not consistent across scales and this is likely to have significant impact on predicted air pollution and exposure levels. Comparing various MC emission estimates patterns provided better insight in per capita emissions and knowledge gaps for global MC-scale assessments.

The MC impacts are quite variable in space and time and are often in directions different than that of the average prevailing winds. The average transport distance (distance from the source area to the center of the pollution plume) for elemental carbon and other primary fine PM components are around 100 - 200 km for most MCs examined. On the other hand, the secondary PM species were found to be transported the furthest with sulfate and secondary organic aerosol often transported on average over 350 km. Maximum transport distances are significant higher, with secondary particulate matter impacts reaching as far as 2000 km away from the MC.

Megacities have strong so-called urban heat islands (UHI), due to differences in surface properties and waste heat from anthropogenic activity. The effects of UHI can be substantial. Anthropogenic heat fluxes for MCs can be very high: up to 50-500 W/m², locally reaching 1600 W/m². Hence, MCs can be warmer than surrounding rural environments by up to 10°C. This heating obviously impacts the local environment directly, but also affects the regional air circulation, which is changed additionally by an increase in the so-called roughness length due to the building height and density. High resolution simulations show that the boundary layer height (which is extremely important for air pollution) increases due to the UHI by up to several hundred meters.

Megacities impacts on regional and global climate are relatively small and mostly due to GHGs and aerosol emissions. However, the direct impact of climate change on air quality in MCs is significant. It was estimated that MCs contribute a warming of over 0.2 K after 100 years, with nearly 90% of this being due to carbon dioxide emissions, and most of the rest due to methane. Generally, the contribution of MCs to global pollutant emissions is of the order of 2% to 6% of the total global annual anthropogenic emission flux. There are four main direct radiative forcing impacts of MC pollutants:

(i) Ozone production: +5.7±0.02 mW/m²,
(ii) Reduction of the methane lifetime due to OH radical production: -2.1±0.13 mW/m²,
(iii) Short-wave direct forcing from aerosols: -6.1±0.21 mW/m²,
(iv) Long-wave direct forcing from aerosols: +1.5±0.01 mW/m².

The combined effect of all of these individual terms is a rather small negative forcing, that is a cooling, of -1.0±0.32 mW/m² under present-day conditions.

Megacities present a major challenge for the regional and global environment. Adaptation by humans to significant climate change in major metropolitan areas is possible. Well-planned, densely populated settlements can reduce the need for land conversion and provide proximity to infrastructure and services, but sustainable development must also include:

(i) appropriate air quality management plans;
(ii) adequate access to clean technologies; and
(iii) improvement of data collection and assessment.

A successful result will be to arrive at integrated control and mitigation strategies that are effectively implemented and embraced by the public.

Measures to reduce urban drivers of climate change can include:

(i) Reducing GHG and aerosol emissions,
(ii) Reducing traffic congestion,
(iii) Switch to fuels with less GHG side effects,
(iv) Conserving energy and water,
(v) Greater use of passive heating and cooling technology,
(vi) More compact city design and greater use of mass transportation,
(vii) Intelligently use of trees to shelter or shade,
(viii) Increased use of light colored surfaces in hot cities.

Alexander Baklanov, Mark Lawrence, Spyros Pandis

NewsLetters of the FP7 EC MEGAPOLI Project

12, September 2011
Analysis of Pollutants Exchange between the Po Valley and Surrounding European Region

Sandro Finardi

E-mail: s.finardi@aria-net.it
ARIANET srl
http://www.aria-net.it

Scenarios analysis has been performed to investigate the regional scale impact of the Po Valley (hereafter PV) emissions. The atmospheric physics and chemistry processes involving pollutants emitted in the PV have been studied by means of the chemical transport model FARM (Silibello et al., 2008) offline coupled with the meteorological model RAMS. Two nested domains have been used (Figure 1) to cover continental Europe with 16 km horizontal resolution and the Alpine region with 4 km resolution, in order to resolve the major topographic and emission features. MEGAPOLI European scale inventory has been integrated with high-resolution bottom-up data provided by local authorities to build a reference high resolution emission dataset. Air quality initial and boundary conditions for gas chemical compounds have been built from MPI-MATCH concentration fields made available to MEGAPOLI partners for the whole year 2005. The analysis has been extended to June and December 2005 to take into account the seasonal variation of both emissions and chemical processes. During MEGAPOLI reference year 2005, June and December recorded typical seasonal atmospheric circulation conditions over northern Italy and relevant long lasting summer and winter pollution episodes (Baklanov and Mahura, 2010).

Figure 1. Nested computational domains for RAMS (blue) and FARM (red) models. Green shaded area indicates Po Valley plains.

Sensitivity analyses have been performed modulating pollutants emissions within the PV to estimate their area of impact and the possible effect of their reduction. A full emissions reference model run has been compared with "annihilation" and 50% reduction scenarios to verify possible non-linearity effects of the chemical regime. The percent variation caused by reduction scenarios has been computed as:

$$\text{VAR}_{\%} = 100 \times \frac{C_{\text{base case}} - C_{\text{scenario}}}{C_{\text{base case}}}$$

where \( C \) indicates monthly average concentration of the considered specie. Positive variation indicates a decrease of concentration, while negative variation indicates an increase of concentration.

Figure 2 shows PM\(_{2.5}\) concentration variation caused by the 50\% PV emission reduction during June and December 2005. The PV impact on the regional air quality extends up to 500 km distance. The area affected is mainly the northern Mediterranean and the western Balkan Peninsula due to the prevailing anticyclonic circulation. The PV footprint is larger during the winter near the surface, while the mass injected in the free troposphere is bigger during the summer due to deeper vertical mixing. Transport of pollutants to the upper troposphere can be important for long-range transport, global pollution and climate (Lawrence et al., 2007). For most variates high variations of near surface concentration are limited to the PV and the northern Adriatic Sea. Longer lifetime species and secondary PM components show a larger area of impact. The influence of external sources on the air pollution within the PV has been evaluated from the fractional variation of concentrations inside the PV associated to the reduction scenarios:

$$\text{VAR} = \frac{\int_{0-1km} C_{\text{scenario}} \, dz}{\int_{0-1km} C_{\text{base case}}}$$

Figure 3. Fractional variation of column integrated PM\(_{2.5}\) concentration below 1 km due to 50\% reduction scenario of Po Valley emission, for months June (left) and December (right) (2005).

PM\(_{2.5}\) results (Figure 3) show a larger impact of remote sources during summer. A gradient is detectable between central PV and its western and eastern edges, with a minimum impact in the central area. The contribution of regional sources can be roughly quantified in a range of 60-80\% during summertime and 30-50\% during wintertime.

References

Aerosol direct radiative forcing is likely to induce regional climate responses through perturbation of local physics as well as global climate through remote effects (Rodwell & Jung, 2008). In the context of the MEGAPOLI multi-scale study, a regional climate model has been used in order to assess possible regional climatic effects of aerosol emissions by megacities (MCs) for present and future climatic conditions, focusing only on aerosol direct and semi-direct effects. This study is designed to complement the global scale approach (Del 6.6) using high resolution simulations over a limited domain. We used here the ICTP REGCM4 model (Giorgi et al., 2011) which basically accounts for sulphate, organic carbon, black carbon as well as natural dust and seas-salt aerosols radiatively coupled to model dynamics. We focused on an extended European domain including Grater London, German Ruhr, Po Valley and Paris megacities as identified in MEGAPOLI. We performed different sets of simulations for which the model was integrated over 10 years for present (2001-2010) and future (2041-2050) conditions at 40 km spatial resolution. The model was dynamically forced at its boundaries by ECHAM5 GCM outputs (which scenario) and we used a monthly climatology of oxidant prescribed using the TNO CTM for the sulphate scheme.

Emissions over the domain were prescribed using the TNO MEGAPOLI high resolution inventory for SO2 and PM (cf. Del 1.2) recalculated at 40 km resolution. PM emissions have been speciated into OC and BC according to activity sectors and country on a basis of information provided by TNO. For future emission scenario we used the country and activity sector scaling factors for year 2050 provided by TNO. Because domain is extended in order to encompass natural aerosol sources impacting Europe, anthropogenic emission outside the MEGAPOLI European domain were prescribed using the global MACcity emission inventory for 2005. In order to isolate MEGAPOLI specific contribution we performed different runs including: no aerosol (control run CTL), all aerosols (AER), anthropogenic only (ANTHRO), and MCs only (MEG). For later experiment the TNO megacity high resolution mask was also used to generate 40 km resolution emissions (cf. Fig. 1b). Fig. 1 displays preliminary results for present day summer conditions. Fig. 1c shows the average summer clear sky radiative forcing obtained with AER experiment. For comparison, Fig. 1d shows simulated forcing for MCs contribution only (note the scale difference). Aerosol radiative forcing is dominated by dust contribution over the southern part of the domain, with large negative values over sea and positive values over bright surface desert.

Evidence of a Regional Climatic Response?

A preliminary estimation of possible climatic response induced by aerosol radiative forcing over the domain is obtained by plotting differences between aerosol and control simulation for different fields. As an example, Figs. 1e and 1f present difference obtained on temperatures at 2 m. These plots do show some distinct patterns, however simulated responses are of similar magnitude despite large difference in the magnitude of the respective forcings (AER vs. MEG). This kind of responses could result from model internal variability triggered by small perturbations rather than a coherent physical signal and do not allow us to conclude on any robust aerosol induced effect over the domain at this stage. However, ongoing works are focusing on internal variability effects and filtering, in order to propose a deeper analysis of statistical significance of simulated signal for different variables, time scale (diurnal cycles, season), sub-regions as well as for future climate conditions.

References


Figure 1: Simulated anthropogenic emissions, radiative forcing and temperature response obtained for all aerosol (AER) and megacities only (MEG) experiment. Average JJA 2001-2010.
Environmental Impact of both Anthropogenic and Natural Aerosols over Cairo

Ashraf Zakey
E-mail: asz@dmi.dk
Danish Meteorological Institute Research Department, Copenhagen, Denmark
http://www.dmi.dk

Introduction
The Greater Cairo region suffers from severe air pollution problems. This region is densely populated with more than 20 million inhabitants. The major sources of air pollution in the region includes vehicle emissions, open burning of solid waste, emissions from industrial facilities and desert dust aerosols from Sahara. These sources contribute to particulate matter (PM) emissions in the region posing severe health risks to population. Every autumn, the farmers in the Nile Delta of Egypt are burning a rice wastes and causing a sever pollution episode over Cairo which is called the “Black-Cloud”.

Results: Meteorological and Chemical Conditions
Fig. 1 shows the frequency of PM\textsubscript{10} concentrations together with the wind direction during autumn season (2001). As seen the Fum El Khalig station receives more PM\textsubscript{10} from the southern sector and higher concentrations while Abbasseya receives more PM\textsubscript{10} from the northern.

According to the Head Quarter of the Egyptian Meteorological Authority, at the Abbasseya meteorological station during 2001-2002 most of time the wind speed was within a range of 2.5-5 m/s. Such speed is sufficient enough for dispersing air pollutants. Moreover, light winds were observed more frequently in winter than in autumn.

Spring Dust-Storm Episode in the Greater Cairo Area
Egypt has observed severe episodes for PM. Analysis of data (episode 12-13 May 2001) from 4 selected air quality stations operated by the Egyptian Environmental Affairs Agency and located inside the Greater Cairo area shows (see Fig. 5) that PM\textsubscript{10} concentrations were at a moderate level when wind was initially blowing from the east and then changed direction to from the west (i.e. from the western desert) with a slightly higher speed reaching 6.7 m/s (at Abbassia station). Such situation from western desert produced large amount of carried dust causing PM\textsubscript{10} increase at all stations.

References
The results suggest a potential overestimation of NOx emissions for all three inventories, as seen in Table 1 (average factor 1.5, range of 1σ uncertainty 1.0–2.2). BC emissions may be also overestimated by the EMEP-LA and MEGAPOLI inventories, but may be underestimated by MEGAPOLI-MC (factor 1.3, range 0.9–1.8), but may be underestimated by MEGAPOLI-MC factor (factor 0.6, range 0.6–1.1). Results show a high day-to-day variability, due the emission variability, but also the method itself. As a consequence, the emission correction factors are, in general, significant at approximately 1σ confidence level.

Several uncertainty sources have been investigated in order to evaluate on the one hand the emission variability, and on the other hand the uncertainties due to the method itself. Thus, emission correction factors are in general different from unity at approximately a one sigma confidence level.

The main uncertainty sources are:
(i) the wind speed that directly links the diurnal emission profile to the rate of decrease of concentrations in the plume,
(ii) the degree of vertical mixing that determines the representativeness of the airborne measured concentrations,
(iii) the wet and dry deposition of the tracers which can lead to discrepancies in the emission factors if these processes are not well simulated in the model, and
(iv) the boundary layer height and its horizontal variability over the aircraft trajectory which directly affects the level of concentrations.

The availability of evaluated and corrected emissions inventories is of great importance for assessing pollution transformation processes within the MEGAPOLI project. The developed methodology is of general interest for evaluating megacity emissions.


http://megapoli.dmi.dk/publ/MEGAPOLI_sr11-08.pdf
Evaluating Simple Mitigation Strategies of the Urban Heat Island with WRF

Francisco Salamanca

E-mail: fsalamanca@lbl.gov

1 Lawrence Berkeley National Laboratory, Atmospheric Sciences Department, USA

http://www.lbl.gov

Salamanca F. 1, Martilli A. 2

2 CIEMAT, Environment Department, Atmospheric Pollution Modelling Division. Ministry of Science and Innovation, Spain

Introduction

Nowadays, the impact of the anthropogenic heat (AH) on the air temperature, the relationships existing between the energy consumption (EC) and meteorological conditions, and the evaluation of simple strategies to mitigate the UHI phenomenon can be evaluated using detailed urban canopy parameterizations (UCP). In this work, a new UCP implemented (Salamanca et al., 2011) in the public WRF model (V3.2 release) has been tested over the city of Madrid (Spain) coinciding with the DESIREX (2008) campaign (http://www.uv.es/desirex).

Two days were simulated (Jun 30th and July 1st) and a high UHI intensity (5-6°C) was observed and modelled. The impact of the air conditioning (AC) systems and the EC were evaluated for the studied period. The heat fluxes coming from the AC systems were responsible of an increase in the air temperature up to 1.5-2°C in some dense urban areas during the night. Effects of modifications in the roof albedo and building material properties reduced the total EC by 4.8% and 3.6% respectively, affecting the intensity of the UHI. When the AC systems did not eject the heat fluxes out in the atmosphere, the EC was reduced on 2.5%.

Methodology

Three different urban classes were defined in the inner domain based on the CORINE land cover (http://www.eea.europa.eu) database (Fig. 1). All the simulations were run with the Bougeault & Lacarrère (1989) turbulent scheme, and the Noah LSM for the vegetated part.

Results

Assuming that the AC systems were working during the studied period, the AH was ejected into the atmosphere in the kh(AH) simulation, while in the other one kh(noAH) was eliminated. When the air temperature was analyzed, the best results were obtained with the kh(AH) simulation showing the importance of considering this AH in urban environments. For the majority of the urban stations the RMSE was below 1.5°C. The Fig. 2 shows the effect of the AC fluxes comparing the 2m air temperatures obtained with the two mentioned simulations (T2(AH)-T2(noAH)) at 1800 UTC (when this difference is maximum during daytime) for the 30th of June. The air temperature increased up to 1.25-1.5°C in the core of the city.

Only in the case kh(AH), the model was able to reproduce a nocturnal mixing layer over the city with a thickness of approximately 200m. Finally, three different strategies were analyzed to reduce the UHI and EC without analyzing the possible impacts in air quality; the first consisted in a change of the albedo of the roofs from 0.2 to 0.4 (kh(AH)_alb), the second, consisted in a modification of the thermal properties by introducing an insulating material (kh(AH)_insul), and finally the third case (kh(noAH)_alb_insul) groups the mentioned modifications into a single strategy. Comparing the kh(AH)_alb case against the previous kh(AH) simulation, the total EC was reduced by 4.8%. Comparing the kh(AH)_alb_insul with the previous kh(noAH) was eliminated. When the air temperature was analyzed, the best results were obtained with the kh(AH) simulation showing the importance of considering this AH in urban environments. For the majority of the urban stations the RMSE was below 1.5°C. The Fig. 2 shows the effect of the AC fluxes comparing the 2m air temperatures obtained with the two mentioned simulations (T2(AH)-T2(noAH)) at 1800 UTC (when this difference is maximum during daytime) for the 30th of June. The air temperature increased up to 1.25-1.5°C in the core of the city.

References


Figure 1. Urban classes in the inner domain (CORINE)

/31 - Discontinuous Urban Fabric (DUF), 32 - Continuous Urban Fabric (CUF), 33 - Other Urban Areas (OUA)/.

Figure 2. T2(AH)-T2(noAH) differences at 1800 UTC together with boundary line of the urban fraction.

The horizontal domain of the simulations was composed of five two-way nested domains with a grid spacing of 27, 9, 3, 1 and 0.333 km respectively. The simulations were conducted with the initial and boundary conditions obtained from NCEP with a grid and a time resolution of 40 km and 3h respectively. The simulations, during daytime, generated some spurious rolls-type structures within the central part of domain and horizontal diffusion coefficient (kh) was fixed to 300 m²s⁻¹ to filter them.
“Green Infrastructure” Approach and its Relevance with Climate Change and Urban Sustainability

Adnan Kaplan
E-mail: adnankaplan@gmail.com
Ege (Aegean) University Faculty of Agriculture Department of Landscape Architecture, Izmir, Türkiye (Turkey)
http://www.ege.edu.tr

Cities are vulnerable because of the complex and fixed nature of urban infrastructure. Urban areas’ dependency on complicated and extensive networks for transportation, communication and trade is a key factor in their vulnerability to climate impacts. Functioning urban infrastructure and a healthy environment not only provide the urban population with the necessary structure for carrying out economic and social activities, but are also prerequisites for ensuring the competitiveness of a city. Cities’ stability and prosperity rely on vast networks of provisional infrastructure – solid waste disposal; wastewater treatment; transportation; water, energy and sanitary provisional systems (Kamal-Chaoui and Robert, 2009).

Climate change (CC) and socio-environmental instability along with the lack of urban infrastructure force many cities to apply adopting policies for urban sustainability worldwide. This new era primarily calls for employing more emphasis on natural landscapes, CC effects and spatial planning domain for urban sustainability.

Understanding the impacts of CC on ecosystems, landscapes and land uses is an essential basis for well-grounded decisions on adaptation and mitigation strategies and politics at both regional and local scales. Spatial planning is expected to provide the instrumental framework for the implementation of these strategies and measures (Meyer et al., 2010).

Amidst these highly complex relations, the “green infrastructure” (GI) as a planning approach provides an efficient and viable medium for gathering together CC and spatial planning matters towards urban sustainability and consistent future cities scenarios. Indeed, this new aspect of GI has been recently explored in both theory and some sustainable urban development practices around the world.

As a comprehensive network of parks, streets, trails, shorelines, green- and blueways across (metropolitan) cities, GI provides a framework that can be used to guide urban growth and land development / conservation decisions to accommodate population growth and protect and preserve community assets and natural resources (Benedict and McMahon, 2006).

Such conversion in the planning paradigm helps to develop comprehensive adaptation and mitigation strategies against (likely) effects of CC for sustainability. Adversely, CC is changing the context of planning and shaping its priorities through introducing a systematic shift in spatial planning towards ecological priorities (Davoudi et al., 2009).

Most significantly, GI’s over-arching policy theme ensures that environmental priorities and objectives are, in particular, given equal policy attention with the social and economic agendas while supplying increased level of ecological services for the future prosperity of cities around the world.

The lack of understanding of a comprehensive GI has generally resulted in unsustainable urban growth (or urban sprawl) and destruction of natural resources. At this point, GI is being configured as a means to supplement its multi-scale aspect (in metropolitan-local continuum) against overriding ecological, socio-cultural and economic challenges (Kaplan, 2010) (Fig. 1).

Besides establishing a city-wide network that redefines and sustains a corporate urban infrastructure, the GI can play an important role in adapting cities for CC. This will be achieved through quantifying full environmental functions under both current and future climate scenarios, as well as with differing patterns of green cover to moderate CC impacts in towns and cities (Gill et al., 2007). Based on some evidences of socio-ecological concerns within the whole range of planning scheme, as depicted in Fig. 1, GI aims to combine and drive ecological networks, transportation, natural resource preservation, building, water policies to respond to CC and reduce the urban environmental footprint as well as to manage urban sustainability.

Hence, it is important to introduce strategies of GI at whether metropolitan, urban or local scales, not only for providing sustainable urban development provisions but also for effective climate adaptation responses. The innovative use of the GI is thus being considered one of the most promising opportunities for delivering adaptation and mitigation strategies that can be easily applied within sustainable planning and design scheme. Concisely, these two mainstreams (i.e. planning and CC) should be intertwined in GI planning realm to account for sustainable-future cities scenarios.

References
Kaplan, A., 2010. Green infrastructure as a means to deliver a multi-scale approach for urban sustainability. 3rd Fábos Conference on Landscape and Greenway Planning, 8-11 July 2010, Corvinus University Faculty of Landscape Architecture & University of Massachusetts Department of Landscape Architecture and Regional Planning, Budapest.

Figure 1: The coverage of metropolitan-wide green infrastructure (Kaplan, 2010)
Air pollution assessment is a key problem to parameterize urban air quality. About 66 mln people in Russia are permanently living under enhanced air pollution (Bedritsky, 2010). At present there is no common approach that would be valid for most of the world. Air pollution indexes in different parts of the globe are calculated based on local, national or municipal legislation. Air quality in Russia is regulated by the management directive of 1991 prepared by the Russian Hydrometeorological Service (Roshydromet) (Bezuglaya, 1991). According to this document to assess air quality individual and complex indexes can be used. Individual indexes are determined as:

\[ I_i = \left( \frac{q_{i}}{q_{\text{occ}}^i} \right)^{c_i}, \]

where: \( I_i \) - individual index for component \( i \), \( q_{i} \) - average concentration of component \( i \), \( q_{\text{occ}}^i \) - maximum permissible concentration for component \( i \), \( c_i \) - constant (that can be 1.7; 1.3; 1.0; 0.9 accordingly to 1\(^{\text{st}}\), 2\(^{\text{nd}}\), 3\(^{\text{rd}}\), and 4\(^{\text{th}}\) danger class that binds danger of component \( i \) to the one of \( \text{SO}_2 \)).

Complex indexes are determined as:

\[ I = \sum_{i=1}^{n} I_i \]

where: \( n \) - is a number of selected pollutants which are supposed to determine air quality in the region.

For instance, in Moscow has the most developed system of air quality monitoring. It has been established with a support of the Moscow government. Five components (\( \text{CO}, \text{NO}_2, \text{NO}, \text{O}_3, \text{and formaldehyde} \)) are used to calculate an integrated air pollution index including 4 possible pollution levels (http://www.mosecom.ru). In general, more than 600 air pollutants are regulated by the Russian legislation (Hygienic regulations, 2003), but in practice, only a few of them are controlled by up-to-date methods.

Within the MEGAPOLIS project (Russian partner of EU FP7 MEGAPOLI) a new system of air quality assessment for Russian megacities was elaborated. Such system should be:

- practical;
- applicable for all national megacities;
- with high level of automatization of data processing;
- commensurable with international methods;
- convenient for modelling and satellite data assimilation.

At the beginning, existing systems of air quality assessment have been analyzed. Most attention was paid for European (CAQI, ATMO, UK, and MEGAPOLI) and US (EPA) systems. Observational time-series for different pollution types during 2008-2010 were selected from the database of the OIAP monitoring station in Moscow. Air quality indexes (AQI) were calculated using European and US methods mentioned above.

| Table 1: Tested Air Quality Index (AQI) calculation system for Russia. |
|----------------------|------------------|------------------|------------------|------------------|------------------|
| AQI                  | \( PM_{10} \) µg/m\(^3\) | \( \text{NO}_2 \) µg/m\(^3\) | \( \text{CO} \) µg/m\(^3\) | \( \text{O}_3 \) µg/m\(^3\) | \( \text{SO}_2 \) µg/m\(^3\) | \( \text{NMHC} \) ppmm |
| 0-50 Low             | 0.36              | 0.25             | 0.05             | 0.15             | -                | -                |
| 50-100 Moderate      | 0.75              | 0.50             | 0.20             | 0.50             | -                | -                |
| 100-200 Poor         | 0.10              | 0.20             | 0.60             | 1.30             | 0.67-1.3         | -                |
| 200-300 Very poor    | 0.15              | 0.40             | 1.00             | 2.00             | 1.3-2.0          | -                |
| \( \geq 300 \) Critical | \( >300 \)       | \( >400 \)       | \( >1000 \)       | \( >240 \)       | \( >120 \)        | 2                |

Comparison of results revealed that no one of foreign systems is perfect for the Russian cities. It is because of differences in typical urban air composition and accepted pollution levels. For Moscow, concentration of aerosols is a representative indicator for air pollution in more than 95% of the cases. Contribution of \( \text{NO}_2 \) is also significant. \( \text{CO}, \text{O}_3 \) and volatile organic compounds can imply AQI only in very rare situations. \( \text{SO}_2 \) has never reached maximum permissible concentration (MPC) even under unfavorable conditions. In general, pollution structure in other Russian cities is similar (Elansky et al., 2009). Some oil-refining and chemical industrial regions (like Irkutsk-Angarsk) have high levels of organic pollution.

Nevertheless, a new method is proposed to calculate AQI in Russia on a base of hourly averaged observations that accounts for 6 components: \( PM_{10} \) as aerosol indicator, \( \text{NO}_2, \text{CO}, \text{O}_3, \text{SO}_2, \) and total NMHC as VOCs indicator (Table 1). AQI for every pollutant is calculated following Gurjar et al. (2008). The system was tested on data of Moscow maximal pollution episode occurred on 5-8 Aug 2010 (Fig. 1a). Even then, when almost all pollutants exceeded MPC, aerosol content was the most reliable pollution indicator.

**Figure 1**: Air Pollution in Moscow Megacity during extreme heat and smog from wild fires in early August, 2010: main pollutants concentrations (a) and calculated AQI (b).

According to this data AQI during maximal pollution was about 4 times higher than worst gradation break point (Fig. 1b). This looks reasonable for that really extraordinary situation. Additional options to account for heat and hypoxia effects are proposed. Original software to process both observational and modelling data for calculating AQI has been elaborated.

**References**


TRANSPHORM – Transport Related Air Pollution and Health Impacts

Nicholas Good
E-mail: n.good@herts.ac.uk
University of Hertfordshire, Centre for Atmospheric & Instrument Research, Hatfield, UK
http://strc.herts.ac.uk/cair

Good N.1 and Sokhi R.S.1
1 Centre for Atmospheric & Instrument Research, University of Hertfordshire, Hatfield, AL10 9AB, UK

TRANSPHORM (http://www.transphorm.eu) is the EU FP7 project designed to improve the scientific understanding of transport emissions and their impact on human health. The TRANSPHORM consortium consists of 21 partners from 14 European countries and run for 4 years starting 2010. The project is coordinated by Ranjeet Sokhi (University of Hertfordshire, UK), Dick van den Hout (TNO, The Netherlands) and Bert Brunekreef (University of Utrecht, The Netherlands). Over the lifetime of TRANSPHORM, the aim is to develop an integrated methodology for assessing the health impacts of air pollution with particular focus on the impact of pollution caused by transport.

Field Measurements
A series TRANSPHORM measurement campaigns in Rotterdam, Helsinki and Thessaloniki have already been completed. These targeted measurements are being performed for the purpose of source apportionment, exposure assessment and model evaluation. For example intensive measurement campaigns were performed in the Netherlands simultaneously at multiple sites up and down wind of Rotterdam harbour, Schiphol airport and a motorway site in order to assess their impact on local pollution levels. A campaign to measure ship emissions is also being undertaken and will provide new emissions data as a function of engine load and fuel type. TRANSPHORM will also utilise data from existing national and EU networks (e.g. ACCENT, http://www.accent-network.org and EMEP, http://www.emep.int) and projects (e.g. EUCAARI - http://www.atm.helsinki.fi/eucaari and MEGAPOLI - http://megapoli.info).

Transport Emissions
Work in TRANSPHORM will focus on improving emissions estimates from transport sources, in particular where existing data is uncertain or lacking. Road transport emission factors will be developed for example incorporating traffic situation scenarios. Obtaining improved emission factors for shipping, aviation and rail is also a key goal. The main focus of TRANSPHORM will be on particulate pollution; new and improved emission factors for particulate matter, PM10, PM2.5 and PM1 will be determined for key transport sources. The project will then develop future transport emission scenarios up to 2030, these will be used as the baseline for modelling the effectiveness of air pollution reduction strategies.

Pollution Modelling and Human Exposure
A key element of TRANSPHORM is the integration of air quality and exposure models in order to assess urban concentrations and human exposure to air pollution. State of the science models will be used to investigate regional- to micro-scale pollution phenomena using the up-to-date emissions inventories developed in TRANSPHORM. Modelling tasks will include source appor-

12 Issue 12, September 2011
Simulating the atmospheric primary and secondary organic aerosols

In Mexico City Metropolitan area half of the total fine aerosol mass (PM2.5) consists of organic aerosol (OA). However, contributions of primary and secondary OA have been difficult to quantify. In this study, new primary and secondary OA modules have been added to a three dimensional chemical transport model (PMCAMx) for use with the SAPRC99 chemistry mechanism. The new modeling framework is based on volatility basis-set approach: both primary and secondary OA are assumed to be semivolatile and photochemically reactive and are distributed in logarithmically spaced volatility bins. The model performance has been tested against Aerosol Mass Spectrometry (AMS) observations and Positive Matrix Factorization (PMF) analysis results taken during two major field campaigns: MCMA-2003 and MILAGRO-2006. The model reproduces well both the Hydrocarbonlike Organic Aerosol (HOA) and Oxygenated Organic Aerosol (OOA) concentrations and diurnal profiles. The model results also showed that transport of OA from outside city was a significant contributor to observed OA levels.

Year of PhD defence: 2009
Supervisor: Prof. Spyros N. Pandis; University of Patras, Greece

Measurement of the organic aerosol volatility in a suburban area

During the MEGAPOLI campaign continuous measurements of the organic aerosol (OA) volatility and the aerosol size distribution were performed at the suburban site SIRTA. The volatility of atmospheric OA is one of the most important aerosol physical properties which determines its ambient concentration. The volatility distribution provides indirect information about the OA chemical composition and can reflect its origin and history in the atmosphere. The goal in this project was to study the volatility of the OA in a background site of a Megacity (Paris) which is being influenced by a combination of fresh and processed OA, for both warm and cold periods (Jul 2009, Jan-Feb 2010). The system, located in the PSI trailer, consisted of a variable residence time thermodenuder combined with a Scanning Mobility Particle Sizer and PSI High Resolution Aerosol Mass Spectrometer. The system was run with a coarse resolution (36×36 km²) over the wide European domain while a fine grid nest was applied over MCs with a higher resolution (4×4 km²) in order to investigate the effect of grid size on simulation of gas and aerosol-phase chemical transformations. Model predictions are compared against high time resolution measurements of fine PM. Additionally, the Particulate matter Source Apportionment Technology (PSAT) code of PMCAMx was used to simulate directly contributions of different source types and source areas to concentrations of PM over Paris. The main advantage of PSAT is that it describes source contributions to secondary PM together with that of primary.

Post-Doctoral Researcher
Supervisor: Prof. Spyros N. Pandis; FORTH, Greece

City plume effect on nucleation

Even though the formation of new particles in the atmosphere is frequently observed at many different sites around the world and is of interest due to the particles’ effect on radiative forcing, cloud formation and lifetime, the processes that govern the phenomena remain unclear. During MEGAPOLI campaign ambient aerosol number size distributions, sub-micron chemical composition and volatile organic compounds were monitored at 3 different stationary stations along with mobile van and aircraft measurements. The combination of these measurements may provide insight on the effect of the city plume on nucleation. The effect of the plume on the surrounding regions with respect to aerosol number concentration will also be assessed.

Year of PhD defence: 2012
Supervisor: Prof. Spyros N. Pandis; FORTH, Greece
Quantification of the total atmospheric OH reactivity in urban area

The hydroxyl radical (OH) is the main oxidant of the troposphere and the main sink of most volatile organic compounds (VOCs). Despite the unique information that OH reactivity measurements can provide about atmospheric photochemistry (oxidant capacity of the atmosphere), few measurements are available due to the complex equipment required. The method used and developed during my PhD studies was the Comparative Reactivity Method (CRM) which represents a fast and promising method for measuring the OH reactivity (Sinha et al, 2008). The measurements within the MEGAPOLI winter 2010 campaign represent the most important applicative part of my thesis. The OH reactivity results show that the Paris OH reactivity is mainly impacted by regional/continental scale pollution episode rather than direct local emissions.

Year of PhD defence: 2012
Supervisor: Valérie Gros (LSCE), France

Improved methodology for simulating the dispersion of air pollutants in complex urban areas

Numerical modelling is an essential part of air pollution assessment and urban planning. A key factor in the application of numerical models is the domain scale, since different models apply to different spatial and temporal scales. Bridging the gap between mesoscale and microscale dispersion models is expected to improve simulations in complex urban areas by incorporating multiscale effects associated with atmospheric flow, pollutant emissions and transport, and chemistry. Such effects have a determining role in urban applications, where the geometry of the buildings is the major factor of turbulence. By providing an effective mechanism of exchanging flow and turbulence data between different model scales, the proposed approach aims to an improved depiction of urban air quality. The accuracy of the simulation results is then evaluated with regard to the additional computational cost associated with model coupling.

Year of PhD defence: 2012
Supervisor: Nicolas Moussiopoulos, AUTH, Greece

Anthropogenic heat fluxes in urban agglomerations

The heat generated during production and consumption of energy is the same climatic active admixture as greenhouse gases and aerosol released into the atmosphere. Scenarios of the development of power energetic and intensity of anthropogenic heat release from different sources first of all from urban and industrial territories, are needed to estimate the existing and future local, regional, and global climatic effects. In this work, we propose a method for estimating anthropogenic heat fluxes based on the statistical data about the gross energy consumption. The energy consumption in different countries more or less reflects the national per capita income. Anthropogenic heat fluxes (AHF) depend on both energy consumption and population density. To compare AHF within Moscow agglomeration with thermal pollution in other world cities were constructed six Moscow agglomeration circles (MAC) centred at Kremlin and equal by area to cities like Rio, Paris, London, Tokyo and New York.

Post-Doctoral Researcher
Supervisor: A.S. Ginzburg; A.M.Obukhov Institute of Atmospheric Physics Russian Academy of Sciences

Simulating formation and size distribution of inorganic atmospheric aerosols

In this work, the PMCAMx-2008 CTM, which includes the aerosol thermodynamic model ISORROPIA-II, is applied in the Mexico City Metropolitan Area in order to simulate the effect of mineral dust on semi-volatile partitioning and water uptake of inorganic aerosols. The hybrid approach for modelling aerosol dynamics is applied in order to accurately simulate the inorganic components in the coarse mode, assuming that the smallest particles are in thermodynamic equilibrium, while describing the mass transfer to and from the larger ones. The March 2006 (MILLAGRO campaign) and April 2003 (MCMA campaign) datasets are used to evaluate the inorganic aerosol module of PMCAMx-2008. The performance of the model for the major inorganic PM components is encouraging. In areas of high dust concentration, the associated alkalinity increases the concentration of nitrate, chloride and ammonium in the coarse mode. The predicted ammonium nitrate levels inside Mexico City are sensitive to the physical state (solid vs. liquid) of the particles during periods with RH less than 50%.

Year of PhD defence: 2009
Supervisor: Spyros N. Pandis; University of Patras, Greece
Development of assessing the air quality methodology for Russian cities

Air quality in large cities (megacities - MCs) gives concern. It depends on industry, transport, long-range and regional air transport from polluted areas. For each MC contributions of these factors are different due to unique location and infrastructure. That is why there is no standard methodology for urban air quality assessment. In this study, analysis of existing Russian and international methods to calculate Air Pollution Index (API) was made. A number of techniques (Russian Federal Service for Hydrometeorology and Environmental Monitoring, US-EPA, CAQI, ATMO, other European techniques including used in MEGAPOLI) have been tested for the Moscow urban area using measurements (2008-2010) of atmospheric composition at the ecological station of the Moscow State University. A proper method to calculate API, considering specific situation and sources of pollution in Moscow and other Russian cities, has been developed. Methodology is tested on data from maximum air pollution episodes in Moscow in summer 2010. The methodology contains 5 levels of pollution and uses 6 regularly measured components (PM_{10}, NO\_2, CO, O\_3, SO\_2, total non-methane hydrocarbons). The methodology allows taking into account an adverse effect of high temperature and oxygen deficiency.

Year of PhD defence: 2012
Supervisors: Nikolay Elansky, Andrey Skorokhod; A.M. Obukhov Institute of Atmospheric Physics, RAS, Russia

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Benzo[a]pyrene (B[a]P) derivatives characterisation in real and simulated atmosphere

PAH, and in particular BaP (whose atmospheric concentrations are limited to 1 ng/m³ by EU regulation on air quality 2004/107/CE), can undergo oxidative reactions once they are emitted in the atmosphere or sampled on filters. Very few is known on where reactions take place and, therefore, on subsequent negative artefact. The MEGAPOLI campaign (Jul 2009) had been a chance to study PAHs location degradation. Aerosols were collected with 2 high volume samplers: one equipped with a conventional PM_{10} head; other with a specific PM_{10} head with a MnO2 denuder trapping ozone upstream from the filter. PAHs were quantified by HPLC/UV-fluo, oxygenated and nitrated PAHs derivatives by GC/MS-NICI. A 12-stage Micro Orifice Uniform Deposit Impactor (MOUDI) was used to inform oxy-/nitro-PAHs size distribution and bring information on their origin (primary, secondary). These results will be completed with chambers experiments to characterize the reactions responsible for PAHs degradation.

Year of PhD defence: 2011
Supervisors: Eva Leoz-Garzialandia (INERIS), Hélène Budzinski (EPOC-LPTC/University of Bordeaux), Eric Villenave (EPOC-LPTC UMR 5805 CNRS)

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Algorithm & software for observations data processing & air quality assessment

About 66 million people in Russia live in conditions with high-polluted air. It concerns megacities with its industrial structure. Urban environment may become dangerous for human health. In order to control the situation and make decisions the software called “Air Quality” is developed. It is able to analyze large amount of data from environmental monitoring stations. The main features are: averaging with different time resolutions, statistical analysis, plotting data, and calculation of air pollution indices by several methods using WHO standards. It was successfully tested using measurements from the Moscow city monitoring stations. This work is also related to radiation processes in atmosphere and different impacts of gases and aerosols.

Year of PhD defence: 2012
Supervisors: Alexander Ginzburg (A.M.Obukhov Institute of Atmospheric Physics) and Boris Fomin (Central Aerological Observatory), Russia

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Urban aerosol budget in Ile-de-France – Chemical composition and physico-chemical properties

In the framework of both the MEGAPOLI and PARTICULES projects, the research work aims at better understanding urban aerosols through their chemical composition and physico-chemical properties. As MEGAPOLI gives a very detailed dataset during two short intensive campaigns (one month), the PARTICULES gives daily PM_{2.5} speciation data over a larger period (i.e. one year). This large amount of experimental data allows to evaluate the ability of the CHIMERE chemistry-transport model (used as official French air pollution forecast tool as well as scientific research model) to well simulate the urban aerosol in Paris. The main objectives are (i) to evaluate regional and local PM contributions in Paris, and (ii) to well simulate a link between chemical composition and physico-chemical properties.

Year of PhD defence: 2013
Supervisor: Matthias Beekmann (LISA) and Olivier Sanchez (AIRPARIF), France
Development of an integrated methodology for the assessment of urban population exposure to ultrafine particles

Atmospheric pollution constitutes one of the pressing problems that societies have to face in the 21st century, as an increasing portion of human population and activities are concentrated in dense urban conglomerations. One of the most dangerous pollutants in urban ambient air is particulate matter (PM), especially the ultrafine PM fraction, which is related to a wide range of respiratory and cardiovascular diseases. The main objective of the study is to develop an integrated methodology for the estimation of urban population exposure to ultrafine particle concentrations. The basic scientific approach includes the creation of a proper numerical module for calculation of ground-level ultrafine particle concentrations in urban areas, which will be incorporated in the Eulerian dispersion and chemical transformation model MARS-aero. Initially, the methodology will be applied in selected urban areas with available measurement data on ultrafine PM.

Year of PhD defence: 2014
Supervisor: Nicolas Moussiopoulos (AUTH, Greece)

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Eoin McGillicuddy
E-mail: e.j.mcgillicuddy@mars.ucc.ie
Department of Chemistry and Environmental Research Institute (ERI), University College Cork (UCC), Cork, Ireland
http://crac.ucc.ie

A study of airborne chemical aerosols in urban locations

An Aerosol Time-of-Flight Mass Spectrometer (ATOFMS, TSI Model 3800) was deployed at the LHVP measurement site during the MEGAPOLI winter 2010 measurement campaign in Paris. The instrument measures size and chemical composition of single particles with aerodynamic diameters in the range 100-3000 nm. The chemical information provides the core composition of single particles, for example, elemental/organic carbon and transition metals, as well as secondary species such as nitrate and sulfate ions. The collected spectra have been analysed using the K-means algorithm to identify different particle types present. The collected data is compared with other on- & off-line measurements of PM$_{2.5}$ composition. When combined with meteorological data, local and regional sources of PM can be identified. Preliminary results indicate contributions from traffic, biomass burning, oil combustion and highly aged transported particles amongst others.

Year of PhD defence: 2013
Supervisors: John Sodeau and John Wenaer (ERI & UCC, Ireland)
Coming and Recent Presentations and Publications

Dear colleagues, please, pay your attention to presentations and publications related to the MEGAPOLI Project:


- See more MEGAPOLI Publications/ Presentations at http://megapoli.info

Coming Conferences

Dear colleagues, please, pay your attention to conferences you might be interested to attend and/or present MEGAPOLI Project results and findings:


- 8th International Conference on Air Quality Science and Application Athens, Greece, 19-23 Mar 2012 http://www.airqualityconference.org

The MEGAPOLI project brought together 27 leading research groups from 11 European countries, state-of-the-art scientific tools and key players from countries outside Europe to investigate interactions among megacities, air quality and climate. The project included both basic and applied research, and bridged spatial and temporal scales connecting local emissions, air quality and weather with climate and global atmospheric chemistry.

This is collection (volume) of the MEGAPOLI Project NewsLetters published during 2008-2011.