Megacity Pollution Effects from Urban to Global Scales: Overview of the new EC 7FP Project "MEGAPOLI" and Initial Results on Comparing Emissions, Pollution Levels and Pollutant Export from Megacities Worldwide

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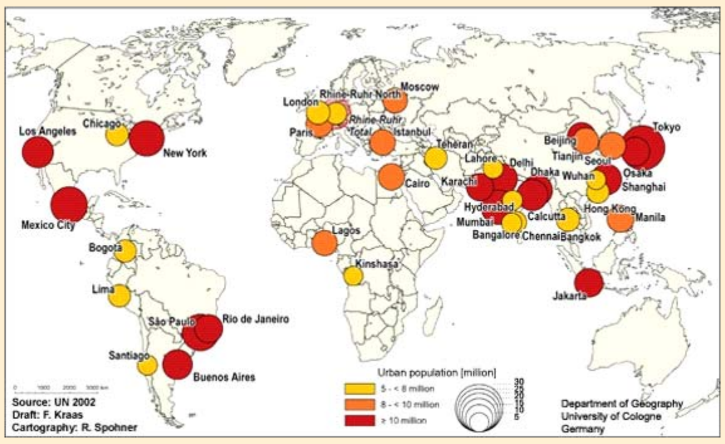
Abstract

An important concern for the emergence of increasing numbers of megacities is the high level of pollution within many of these cities, along with the impacts of the emissions from these urban agglomerations on downwind regions and on regional and global climate. The new European project **"MEGAPOLI" (Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation)**, scheduled to start in Fall, 2008, brings together over 20 partners specializing in urban air quality and population exposure forecast and control, regional and global atmospheric pollution, and meteorological and climate research, including leading European research groups from 12 countries, along with state-of-the-art scientific tools, 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.

The main objectives of MEGAPOLI are:

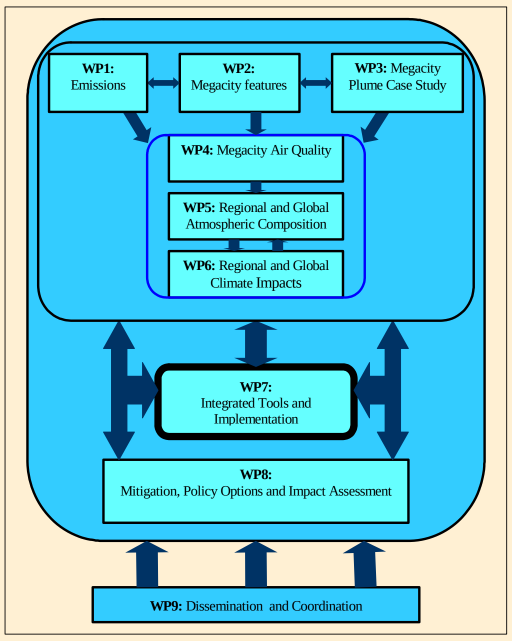
1. to assess impacts of megacities and large air-pollution hot-spots on local, regional and global air quality;
2. to quantify feedbacks among megacity air quality, local and regional climate, and global climate change; and
3. to develop improved integrated tools for prediction of air pollution in megacities.

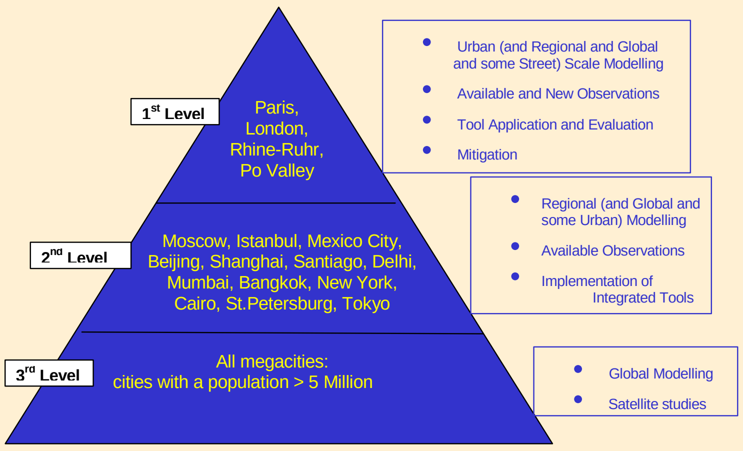
In order to achieve these objectives we will follow a pyramid strategy of undertaking detailed measurements in one European megacity, Paris, performing detailed analysis for a limited set of megacities with existing air quality datasets, and investigating the effects of all megacities on climate and global atmospheric chemistry. Here we provide an introduction to the plans and approach within MEGAPOLI. Furthermore, we show results from three recently published studies on a worldwide comparison of megacity emissions, pollution levels and pollutant export, which will feed in as key initial results to MEGAPOLI.



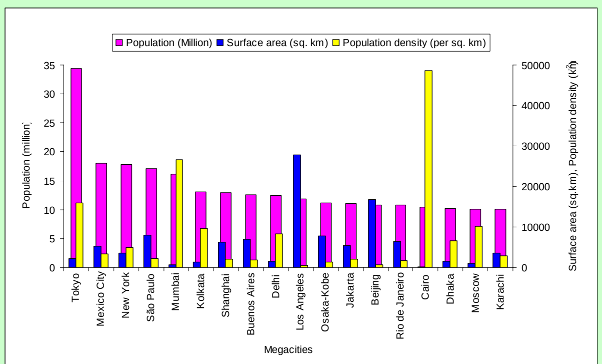
"Megacities" are coherent urban areas with a population of more than about 5 or 10 million people (there is no clear threshold or formal definition of a megacity at present). At present, there are about 20 cities worldwide with a population exceeding 10 million, and about 30 with a population of 7 million or greater. The rate of growth of megacities has been tremendous; for example those with populations exceeding 10 million have grown from only 3 in 1975 to an anticipated 22 in 2015. The figure shows a snapshot for 2002.

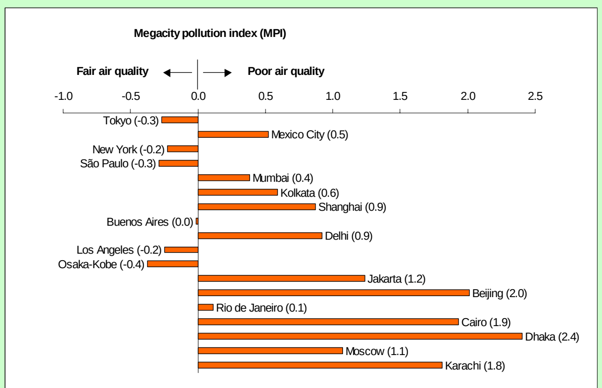
The *MEGAPOLI* organizational structure:





The ***pyramid*** of megacities to be examined within ***MEGAPOLI***: The project will address practically all major megacities around the globe at three different levels of detail.

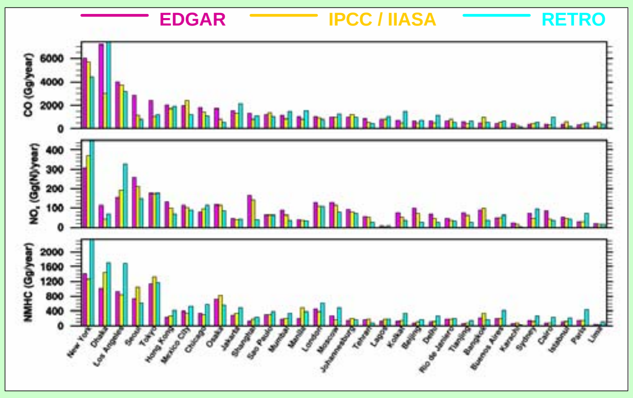


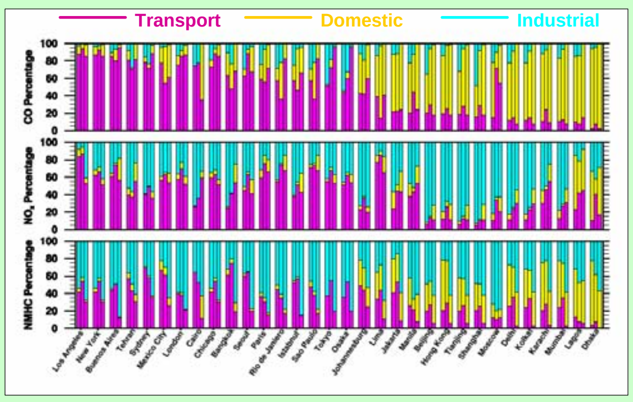


From Gurjar et al., Atmos. Env., 2008

Top: Characteristics of the 18 largest cities in the world.

Bottom: This study introduced a new way to characterize the overall pollution levels in various cities for comparison amongst each other, called the "Megacity Multi-Pollutant Index (MPI)", which is computed as: MPI = (1/n) [? (AC_i - GC_i) / GC_i], where i = the pollutants included in the computation (here TSP, SO_2, and NO_2), n = the number of pollutants considered, AC_i = ambient concentration (observed), and GC_i = guideline concentration (WHO). The MPI is found to be inversely correlated with economic and education-level indices such as the knowledge intensity ratio (KIR).

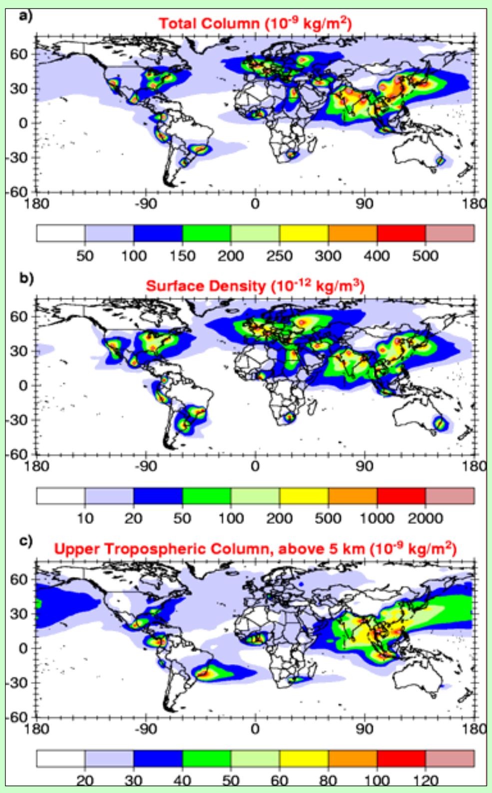




From Butler et al., Atmos. Env., 2008

Top: Comparison of the total emissions of CO, NOx and NMHCs from 32 of the largest cities in the world, based on the EDGAR, IPCC/IIASA, and RETRO emissions databases.

Bottom: Comparison of the relative emissions atrributed to three major sectors – transport, domestic, and industrial – for CO, NOx and NMHCs from the same 32 cities, with the three bars for each city showing the information from the three emissions databases: EDGAR (left bar), IPCC/IIASA (middle bar), and RETRO (right bar). Relatively clear regional signatures show up, e.g., for the contribution of transport versus domestic emissions.



From Lawrence et al., Atmos. Chem. Phys., 2007

Tracer simulation results (computed with the model MATCH-MPIC) to classify the regional pollution potentials of 36 selected megacities and major population centers worldwide. The tracers shown here are emitted at a constant rate of 1 kg/s from each megacity gridcell, and have an atmospheric exponential decay lifetime of τ = 10 days. The panels show the annual mean sum of all of the tracers for **(a)** the total column mass density (10^{-9} kg/m²), **(b)** the model surface layer density (10^{-12} kg/m³), and **(c)** the column above 5 km (10^{-9} kg/m²). The figures exemplify some of the tradeoffs between local pollution buildup, long-range export to downwind surface regions, and transport to the upper troposphere.