MILAGRO

Megacity Initiative - Local and Global Research Observations

MIRAGE-Mex · MAX-Mex · MCMA · INTEX-B

MARCH 1-31
2006

MEGACITIES AND THEIR LOCAL, REGIONAL AND GLOBAL IMPACTS

Urbanization was one of the most striking developments of the twentieth century. About 70 percent of the population of North America, Europe, and Latin America now lives in cities. Worldwide, about 325 cities have population of more than one million, compared to 270 in 1990. Among the most serious environmental problems in cities are air and water pollution, solid waste accumulation and disposal (including toxic and hazardous wastes), and noise.

In recent decades air quality has deteriorated markedly in the large cities of the developing world. Millions of people are being exposed to harmful levels of air pollutants caused mainly by emissions from the combustion of fossil fuels in motor vehicles and for industrial processes, heating, and electricity generation. Other pollutants are produced by incinerators, petrochemical plants and refineries, metal smelters, and the chemical industries.

In principle, the problem can be solved to a large extent through the use of clean technologies. For example, new cars with three-way catalytic converters emit at most a few percent of the amount of pollutants emitted by cars without emission controls. In practice, there are large socioeconomic and political barriers to the transition to new technologies. Furthermore, other tenacious problems associated with unrestrained urban growth, such as traffic congestion are exacerbating air pollution throughout the world.

Air pollution can be natural or human-made. For example, air pollution occurs naturally during volcanic eruptions, forest fires, and dust storms. Such events have led to occasional problems for humans. However, during the past 100 years, air pollution of human origin has become a major, persistent problem in many urban areas around the world. Concentrations of pollutants emitted by human activities have often reached levels with clear adverse effects on the health of the plants, animals, and people. In the long term, the transport of pollutants across national boundaries and between continents could have potentially serious consequences to ecosystems and humans on a global scale.

The World Health Organization (WHO) lists six ‘classic' air pollutants: CO, lead, nitrogen dioxide (NO2), suspended particulate matter (SPM) –including dust, fumes, mists and smoke- SO2 and tropospheric ozone (O3).

The burning of fossil fuels and biomass is the most significant source of air pollutants such as SO2, CO, certain nitrogen oxides such as NO and NO2 (known collectively as NOx), SPM, volatile organic compounds (VOCs) and some heavy metals. It is also the major anthropogenic source of carbon dioxide (CO2), one of the important greenhouse gases.

Harmful substances emitted to the air affect both human health and ecosystems. Indoor and outdoor air pollutants are estimated to be responsible for nearly 5 per cent of the global burden of disease.

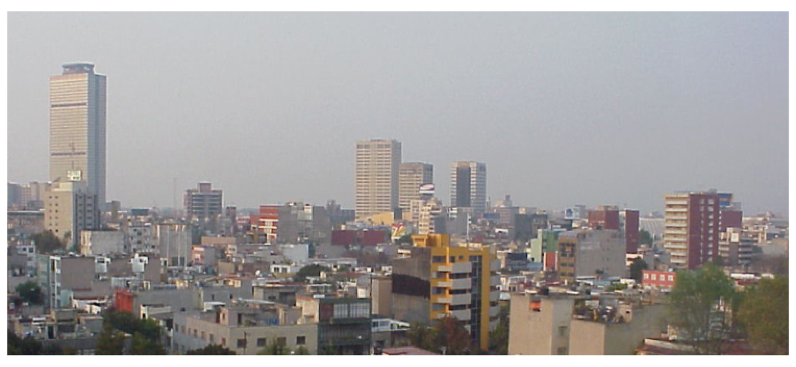
Acid deposition is one of the causes of acidification of soil and water that results in declining fish stocks, decreasing diversity in acid-sensitive lakes and degradation of forest and soil. Excessive nitrogen (as nitrate and/or ammonium) promotes eutrophication, particularly in coastal areas. Acid rain damages ecosystems, provokes defoliation, corrosion of monuments and historic buildings and reduces agricultural yields.

1. Health Effects

Air pollution aggravates and possibly even causes asthma and other allergic respiratory diseases. Adverse pregnancy outcomes, such as stillbirth and low birth weight, have also been associated with air pollution. It has been estimated that in developing countries about 1.9 million people die annually due to exposure to high concentrations of SPM in the indoor air environment of rural areas, while the excess mortality due to outdoor levels of SPM and SO2 amounts to about 500,000 people annually. Evidence is also emerging that particles with median aerodynamic diameter less than 2.5□m (PM2.5) affect human health significantly.

2. Impaired Visibility

Air pollution reduces the distance that you can see through the atmosphere. Although gases such as NO2 can also reduce the visibility, most frequently the reductions are due to suspended particles (liquid or solid). Impaired visibility reduces our enjoyment of nature, and in extreme cases can pose a hazard to aviation.



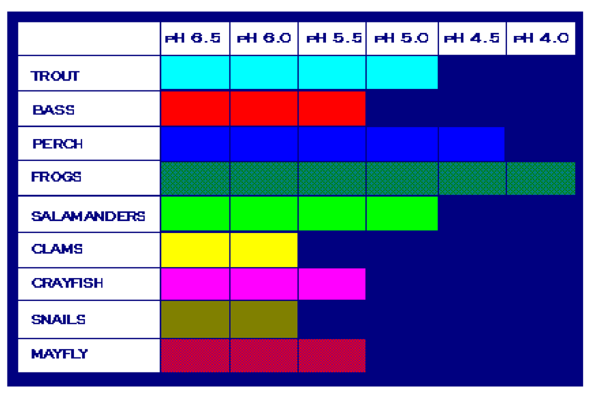


Figure 1:Tolerance levels of different animal species to water's acidity. A lower pH represents greater acidity (EPA, 2005).

3. Acid Deposition

Acid rain can damage vegetation by damaging the leaves through direct contact, and by making the soil more acidic. It can also damage building materials (particularly marble) and paints (for example, automotive paints). Acid snow, hail, fog and hazes can also occur and have similar effects on ecosystems when they are deposited on the Earth's surface (Fig. 1).

4. Regional Ozone

Ground-level ozone is toxic to plants and also makes them more susceptible to diseases, insect infestations, and harsh weather (Fig. 2). This causes damage to natural ecosystems and also reduces the productivity of economically important agriculture.

Figure 2: Ozone damage to the plant on the left, compared to a healthy plant. Photo courtesy of Gene Daniels/U.S. EPA

Ground-level ozone has increased substantially in the last century, and is expected to continue increasing in the next decades. Fig. 3 shows the long-term changes in ground-level ozone, computed with a numerical model of atmospheric chemistry and transport.

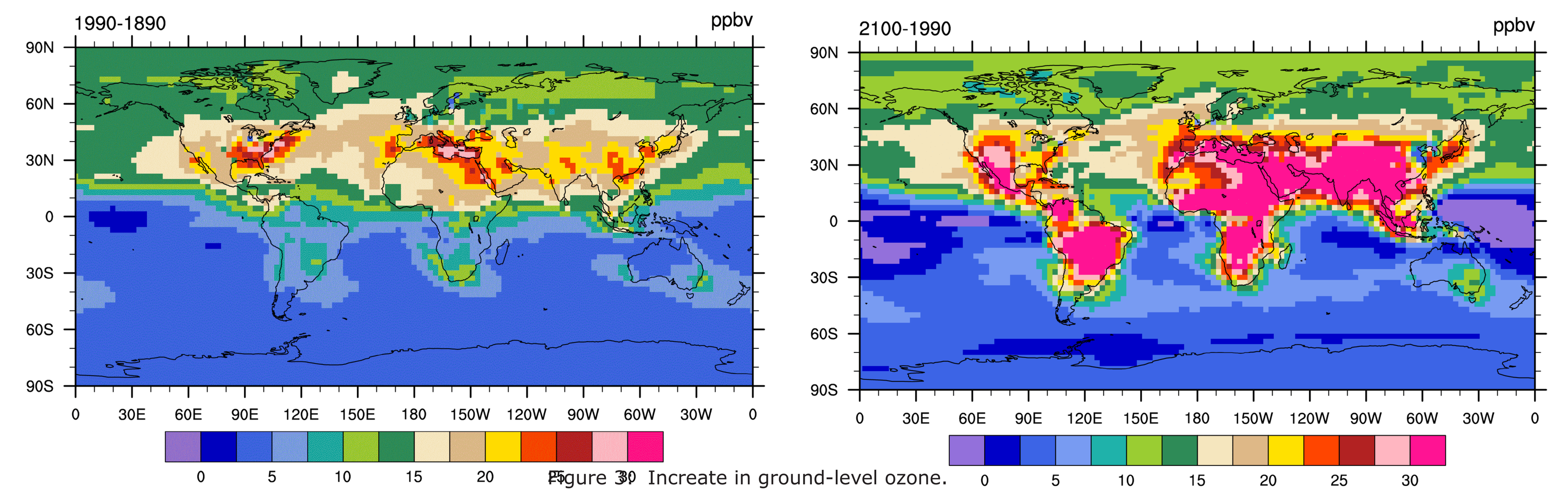


Figure 3: Increate in ground-level ozone.

5. Climate Change

Gaseous and particulate pollutants are major contributors to the so-called "greenhouse effect." Gases such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), various halocarbons, and ozone (O3) absorb infrared radiation that naturally cools the atmosphere and thus have a positive radiative forcing (Fig. 4). Suspended particles (aerosols) can cool or warm the atmosphere, depending on the type of particle. Soot particles absorb solar light and thus warm the atmosphere, while sulfate particles scatter incident solar light back to space (the so-called "direct effect"). The net effect of aerosols on climate is not well known. In the future, the effects of these pollutants are likely to increase because of increases in population, urbanization, and industrialization.

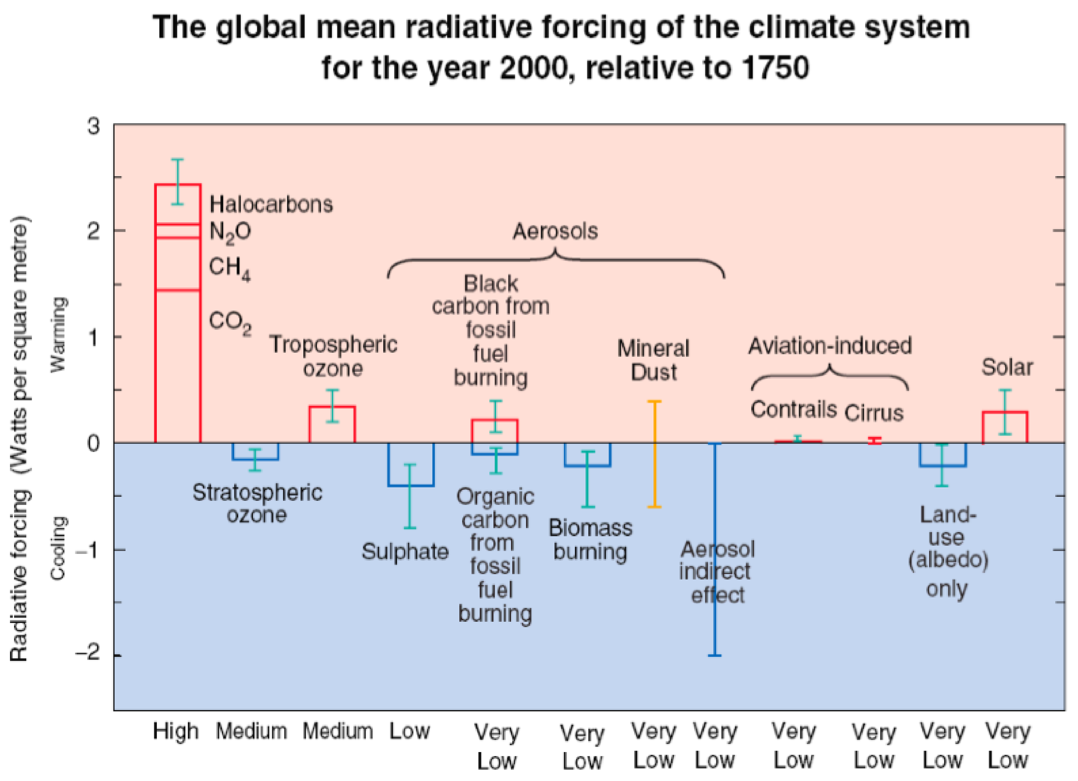


Fig. 4: Contribution to global warming from various factors, including gases, atmospheric suspended particles (aerosols), clouds induced by aviation, changes in land reflectivity, and solar variability. Gases and aerosols, both associated with pollution, are seen to have the largest effects. The largest uncertainties are due to aerosols: their atmospheric amount, geographical distributions, lifetimes, types, their interactions with clouds, and their effect on the atmospheric radiation budget. From IPCC, 2001.

6. The Cleaning Capacity of the Atmosphere

Years ago, when pollution was mainly a local problem, people believed that the problem could be solved by winds that ventilate the local atmosphere with clean air. Now, and even more so in the future, pollution from every continent extends across lands and oceans to create a global problem. Dilution is no longer the solution to pollution!

Measurements at remote locations, such as Antarctica, Greenland, and Hawaii, clearly show that significant amounts of air pollutants are arriving there form sources many thousands of kilometers away. How will the global atmosphere cope with this?

The long-term future of the atmosphere rests with the fate of a single type of molecule, the hydroxyl radical (OH). OH radicals are the main "cleaning agents" of the atmosphere. They react with pollutants such as CH4, volatile organic compounds (VOCs), SO2, and many others, to convert them to soluble compounds which are then more easily removed from the atmosphere by rain. If OH radicals decrease in the future, the atmosphere will be less able to cleanse itself, and pollutants will stay in the atmosphere for a longer time.

The amount of OH in the atmosphere is not fixed. OH is rapidly produced through photochemical processes during the day and also rapidly lost by various chemical reactions. Therefore the amount of OH in the atmosphere depends sensitively on many other atmospheric chemicals, including pollutants. Some pollutants, like hydrocarbons, destroy OH, while other pollutants, like NOx help to make it. The future of OH will depend on the total amount of pollution, and also on which pollutants increase most rapidly.

MCE²
Molina Center for Energy and the Environment
http://mce2.org