MILAGRO

Megacity Initiative - Local and Global Research Observations

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INTEX-B

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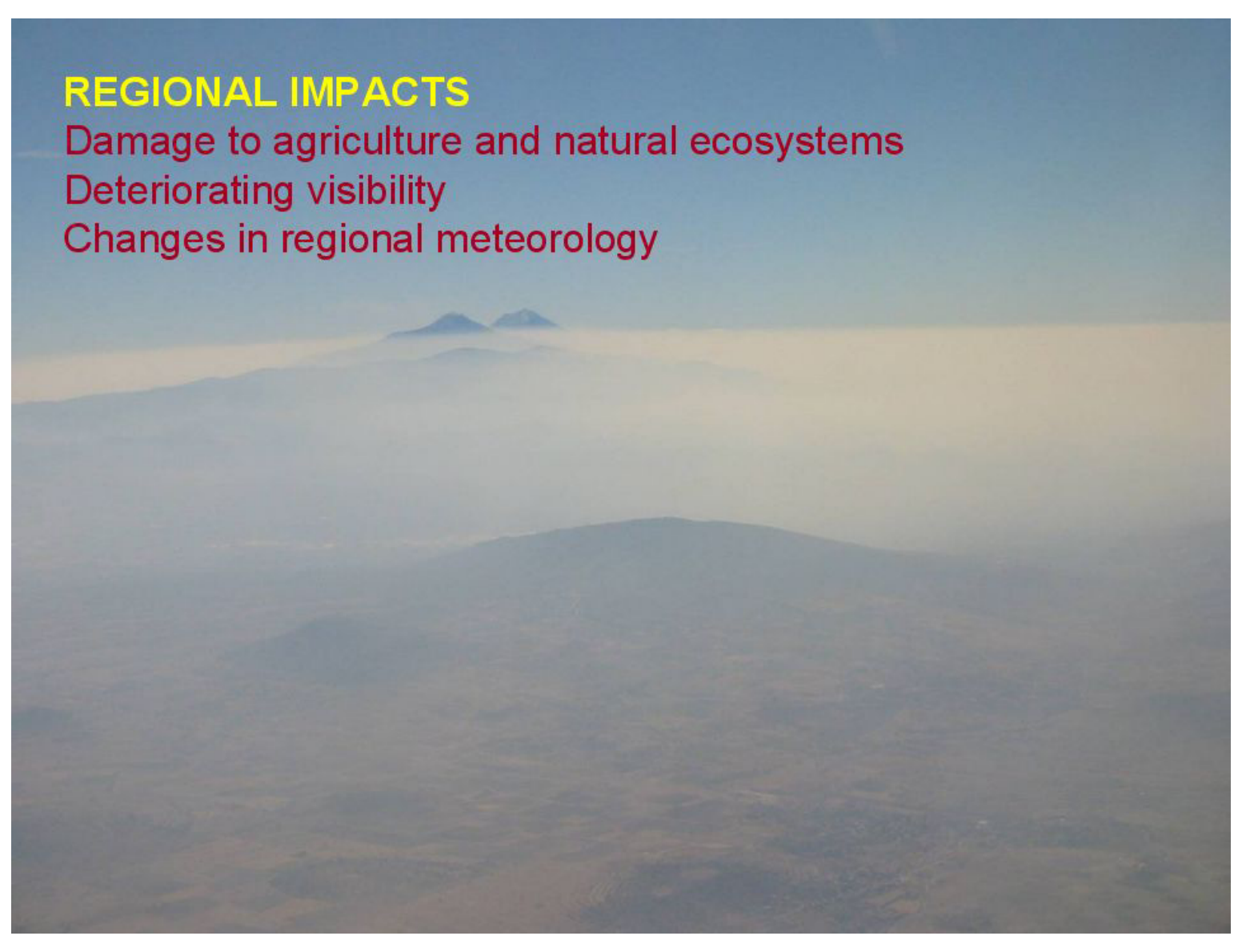
MEGACITIES AND THEIR LOCAL, REGIONAL AND GLOBAL IMPACTS

Increased energy usage in urban areas including motor vehicles and industrial activities leads to high levels of gases and aerosols.

Urban air quality degradation, eye-irritation both chronic and acute health effects along with visibility reduction are all associated with urban areas – especially those in valleys or basins where the meteorology acts to trap pollutants.



Many of the pollutants emitted from urban areas can react in sunlight to form other products downwind of the cities. Some of these can lead to secondary aerosols such as acidic sulfates and nitrates that contribute to "acid rain". Regional impacts can also include ecosystem impacts and impacts on regional weather and climate.

Global impacts from trace gases and aerosols can lead to weather modification and global climate change.

Population growth is a primary force driving environmental problems. More than 60 million people are added to cities each year. Most of this immense expansion occurs in the urban areas of developing countries, aggravating already enormous backlogs in housing and infrastructure development such as increasingly overcrowded transportation systems, insufficient water supplies, deteriorating sanitation, and environmental pollution. In spite of this, people continue to migrate to cities in hope of a better quality of life.

In recent decades air pollution has become one of the most important problems of megacities. The main air pollutants of concern until recently were sulfur compounds generated mostly by burning coal and other fuel such as gasoline and diesel.

A crowded street in Bangkok.
L. T. Molina

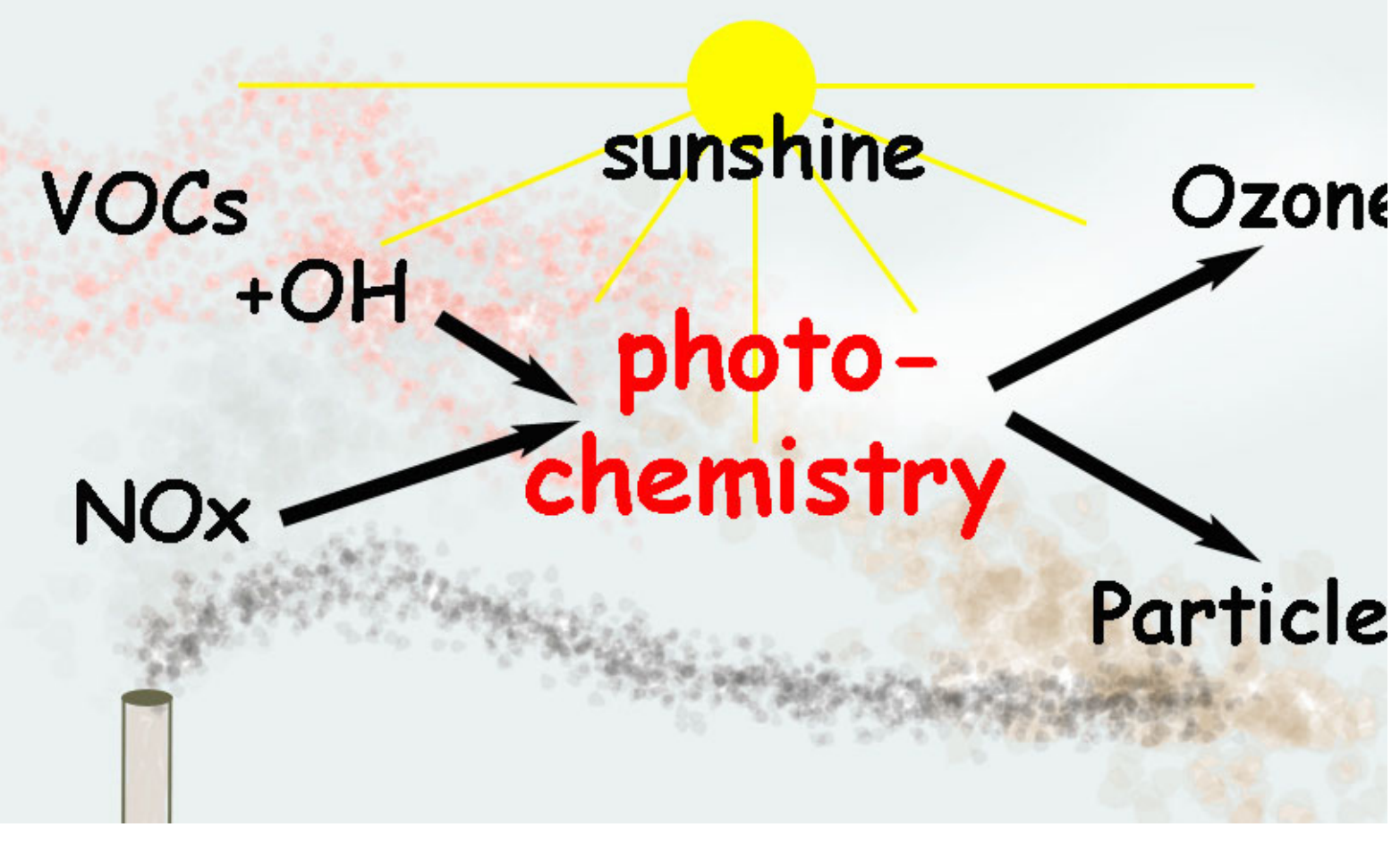
Air Pollution in Megacities

The air pollution problems of megacities differ greatly and are influenced by a number of factors, including topography, demography, meteorology, and the level and rate of industrialization and socio-economic development. These problems are of increasing importance because the projected growth in the urban population worldwide increases both the sources of urban air pollution and the number of people exposed to harmful air pollutants.

Air pollution has serious impacts on public health, deposits on surfaces, causes urban and regional haze, and has the potential to contribute significantly to climate change. Yet, with appropriate planning megacities can efficiently address their air quality problems through measures such as application of new emission control technologies and development of mass transit systems. Such planning must consider the local, urban, regional, and global effects of pollutants. It must treat gas and particle emissions from a variety of sources as a single entity, rather than as separate pollutants. It must recognize and address urban emissions that cross jurisdictions and international borders.

The influence of large urban areas on atmospheric pollution must also be balanced against that of non-urban contributors (such as forest and agricultural fires) to determine optimal emission control strategies.

Photochemical smog induced primarily from traffic, but also from industrial activities, power generation, and solvents, has now become the main source of concern for air quality, while sulfur is still a major problem in many cities of the developing world.



A major component of smog is ozone created by the interaction of nitrogen oxides (produced by combustion sources, cars, heaters, etc.) and VOCs (from evaporation of gasoline and solvents used in products such as paints). These two pollutants in the presence of sunlight (ultraviolet radiation) produce ozone at ground level.

London "Killer Fog"

The occurrence of serious health effects from air pollution in large cities is well documented, the most devastating being the 1952 "Killer Fog" in London, which claimed 4000 lives. These effects were most likely a consequence of burning sulfur-rich coal in the presence of a dense fog, releasing sulfur dioxide that lead to the formation of toxic sulfuric acid particles. This type of air pollution has been called "London smog."

Central London during the killer smog, December 1952.
http://www.npt.org/templates/story/story.php?storyId=873954

Photochemical Smog in Los Angeles

The city of Los Angeles during the 40's and 50's covered with smog.
http://www.npt.org/templates/story/story.php?storyId=873954

Significant air pollutant "episodes" were also reported in many cities in the United States. In the summer of 1943, California recorded its first episode of smog. Visibility was only three blocks and residents suffered from eye irritation, respiratory discomfort, nausea, and vomiting. In contrast to London smog, it is generated on hot, sunny days, and not on cool, foggy days. It is characterized by the presence of strongly oxidizing chemicals in ambient air that cause watery eyes and respiratory discomfort.

Atmospheric Fate of Air Pollutants

The atmosphere is a shared resource that respects no boundaries. Air pollutants do not stop when they reach city or country boundaries. The type of influence or impact an air pollutant can produce - whether local, regional or global - depends upon how long the chemical remains in the atmosphere and, therefore, how far it can travel from its source.

There are various processes by which chemicals are removed from the lower atmosphere, i.e., the troposphere, where people reside. These removal processes can be divided into two types:

1. Physical removal: Removal of a chemical from the atmosphere by rain is called "wet deposition," i.e., the chemical dissolves in a raindrop and falls to the earth with the drop.
2. Chemical removal: The second type of removal process, loss by chemical reaction, destroys the original species, converting it into another species.

There are, however, compounds such as the chlorofluorocarbons (CFCs), which remain in the atmosphere for several decades. These compounds are chemically very inert and practically insoluble in water, thus they are not removed by the cleansing mechanisms available in the troposphere. These compounds are able to persist in the atmosphere long enough to diffuse upward to the stratosphere, where they are eventually decomposed by high-energy short wavelength solar radiation to yield radicals that can destroy ozone through a catalytic process.

In contrast, compounds such as ammonia and hydrogen chloride are rapidly removed by rain, the average time scale for removal being weeks. From a global perspective, hydrocarbons and nitrogen oxides are also removed quickly: hydrocarbons are not soluble in water, but are first oxidized by various species such as the hydroxyl radical (OH), which converts them to soluble compounds that are then removed by rain. The predominant fate of nitrogen oxides is also removal by rain, after conversion to nitric acid that contributes to acid deposition.

From a local and regional perspective, hydrocarbons and nitrogen oxides are responsible for the degradation of air quality by forming ozone and secondary particulate matter. In places like Los Angeles and the MCMA, surrounding mountains often trap the pollutants long enough for them to undergo chemical transformations while still in a relatively concentrated form. Under such circumstances, strong measures must be implemented to prevent the accumulation of unacceptable levels of harmful air pollutants.

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