

Review of the Potential Health Impacts of Climate Change-Related Effects on Air Quality

Kristie L. Ebi, Ph.D., MPH
Exponent
Kebi@exponent.com

Climate Science in Support of Decision Making
14-16 November 2005

Outline

- Review of the impacts of poor air quality on human health
 - Air pollutants
 - Aeroallergens
 - Long-range transport of dust and other particles
- Projections of the potential health impacts of climate change-related effects on air quality

Climate Change Could Affect Air Quality

- Directly
 - Changes in chemical reaction rates
 - Boundary layer heights that affect vertical mixing of pollutants
 - Changes in synoptic air flow patterns
- Indirectly
 - Changes in biogenic emissions
 - Increased frequency and intensity of drought, leading to more dust and other fine particles

Ground-Level Ozone

- Primary constituent of urban smog
 - Secondary pollutant formed through photochemical reactions involving NO_x and VOCs in the presence of bright sunshine with high temperatures
- Exposure to elevated concentrations associated with
 - Increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, allergic rhinitis, other respiratory diseases
 - Increased mortality
- Outdoor ozone concentrations, activity patterns, and housing characteristics are the primary determinants of ozone exposure

Trends in Ozone Concentrations

- Background concentrations have risen since pre-industrial times, and this trend is expected to continue over the next 50 years
- Future concentrations depend on future emissions and weather patterns
 - Emissions depend on assumptions of population growth, economic development, and energy use
 - Fraction attributable to climate change is the portion that is the consequence of climate change on local temperature & UV
 - Assuming no change in the concentration of precursor emissions, the frequency of future ozone episodes will depend on the occurrence of the requisite meteorological conditions

Projections of Attributable Premature Mortality

| | | | | |
|--|---------------------------|---|---------------------------------------|--|
| New York Metro Region <i>Knowlton et al. 2004</i> | Ozone-attributable deaths | Concentration / response / function model | GISS GCM linked to RCM; A2 population | By 2050s under A2 climate, 4.5% increase in ozone deaths |
| England and Wales <i>Anderson 2002</i> | Ozone exceedance days | Statistical model based on met factors | UKCIP scenarios 2000s, 2050s, 2080s | Large decreases in days with high particulates |

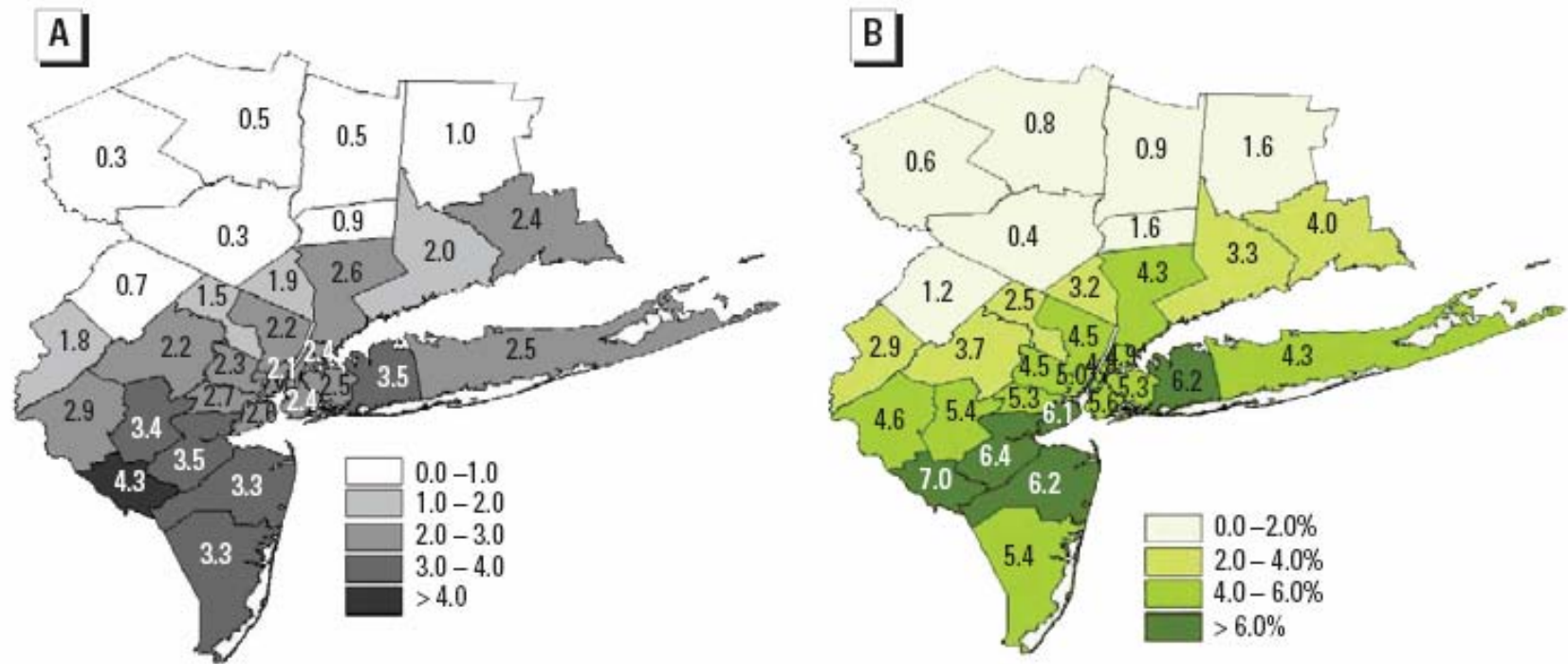


Figure 2. Estimated changes in O₃ and associated summertime mortality in the 2050s compared with those in the 1990s for M1, where climate change alone drives changes in air quality. (A) Changes in mean 1-hr daily maximum O₃ concentrations (ppb). (B) Percent changes in O₃-related mortality.

Other Air Pollutants

- Local conditions and emissions are of primary importance when determining human exposures
 - Transboundary transport also plays a significant role
- Some locations, because of their general climate and topographical setting, are predisposed to poor air quality
- Modeling results vary by region
 - US study projected an increase in the severity and duration of regional air pollution episodes in the Northeast and Midwest (Mickley et al. 2004)
 - UK study projected a large decrease in days with high particulate concentrations due to changes in meteorological conditions (UK Department of Health 2002)

Aeroallergens

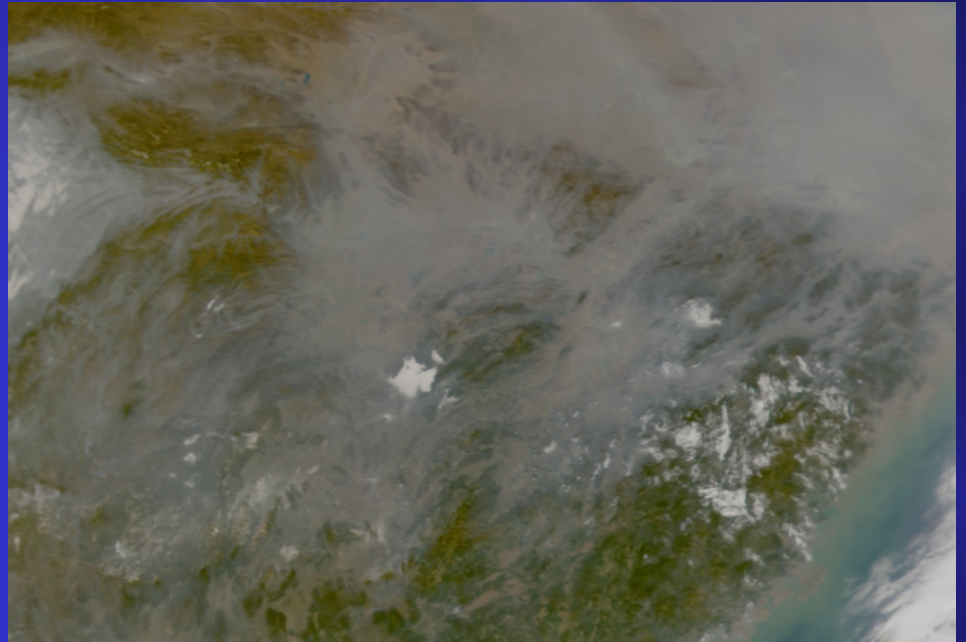
- Strong evidence that observed higher temperatures are associated with an earlier onset of spring in the Northern Hemisphere, with an earlier onset of pollen production, particularly for late-winter and spring flowering plants
- Trend is reversed at higher altitudes
- It is not known whether the allergenic component of pollen also is changing

Long Range Transport

- Under certain conditions, aerosols, carbon monoxide, ozone, desert dust, mold spores, and pesticides may be transported over large distances and over timescales of typically 4-6 days
- Dust can carry large concentrations of PM_{2.5-10}, trace minerals, fungal spores, and bacteria

China Haze 10 January 2003

- Windblown dust originating in desert regions of Africa, Mongolia, Central Asia, and China can affect air quality and population health over wide regions
- Mortality, particularly from cardiovascular and respiratory diseases, is increased on days following a dust storm



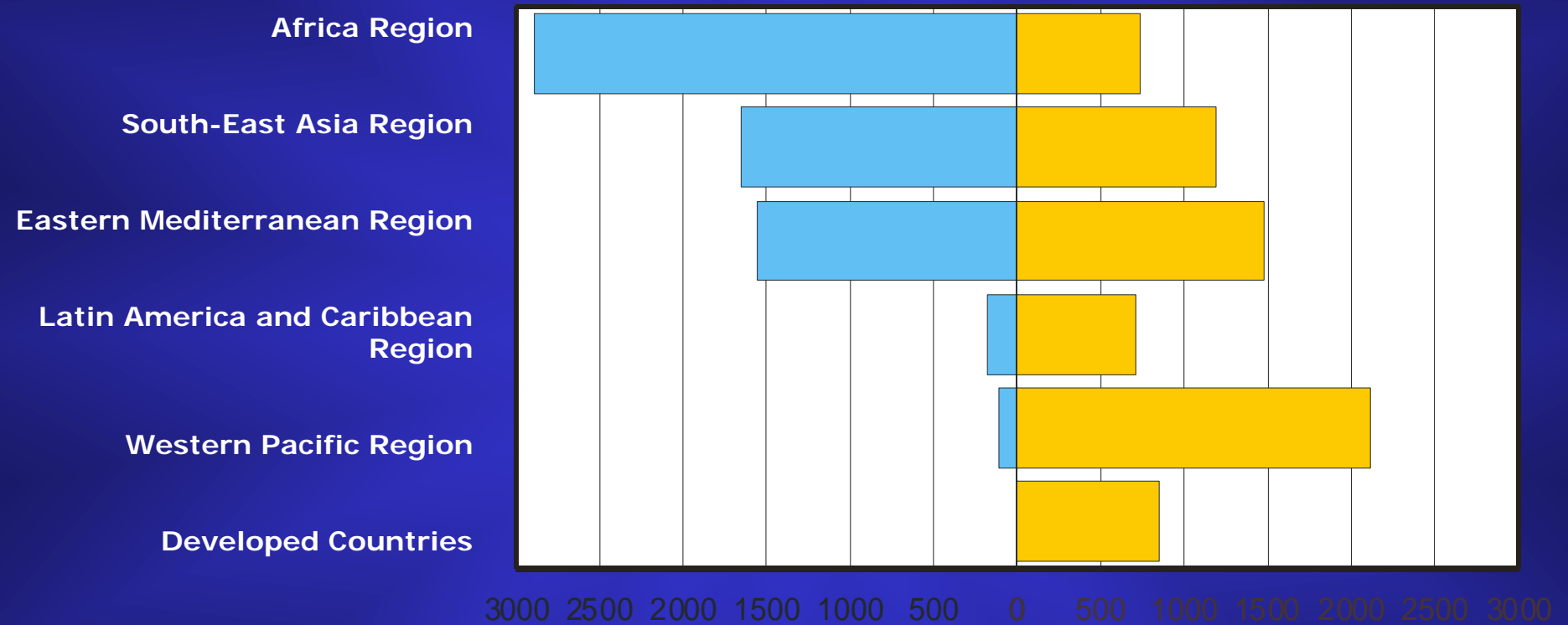
NASA

Climate Change vs. Urban Air Pollution

Millions of DALYs

Climate change

Urban Air Pollution



Burden of disease by region: Climate change and urban air pollution. Disability Adjusted Life Year per million. World Health Report 2002.

Key Areas for Further Research: Air Pollutants

- Extensive, and growing, literature on the health impacts of air pollutants in developed countries
 - Fewer studies on the health impacts in developing countries, which experience higher concentrations of air pollutants
- Better understanding is needed of how climate change might affect air pollution concentrations
 - Cloud cover particularly important for ozone formation
- Additional modeling studies, incorporating relevant factors, is needed to assess whether climate change could add to future disease burdens
 - For both ozone and other air pollutants

Key Areas for Further Research

- Aeroallergens:
 - Need projections of the seasonal distribution of pollen under a changing climate
 - Need to understand whether the allergenic components of pollen will change with changing phenology
- Long-range transport
 - Very little research has been conducted on health impacts

Thank you