Columbia Climate and Health Program
at the Mailman School of Public Health

Urban Warming and Air Pollution

Patrick L. Kinney Sc.D.
Professor of Environmental Health Sciences
Director, Columbia Climate and Health Program
Mailman School of Public Health
Columbia University

July 9, 2014
UCI Meeting, Atlanta, GA

Outline

- How is air pollution affected by climate?
- What analytical tools can be used to assess future air pollution-related health effects in a changing climate?
- What do recent studies suggest about future health impacts of ozone and $PM_{2.5}$?
- Brief intro to pollution-related health co-benefits of climate mitigation
- Summary of what we do and do not know

How might Climate Change affect Air Pollution?

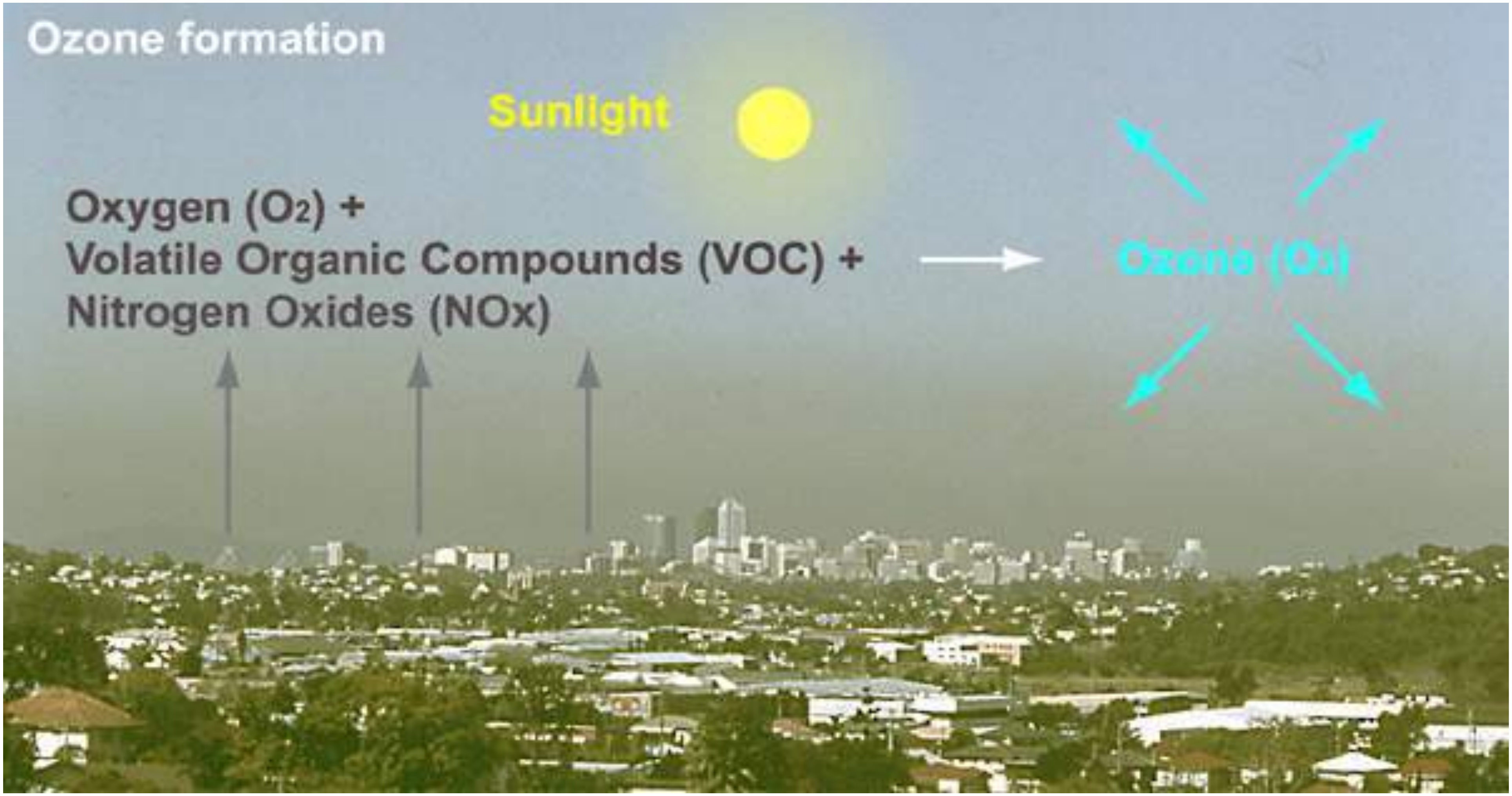
- Formation reactions for secondary pollutants generally happen faster at high temp and with greater sunlight
- Biogenic emissions increase at higher temp (highly important for ozone)

- Some particle species may volatilize at higher temperatures, reducing $PM_{2.5}$ concentrations.

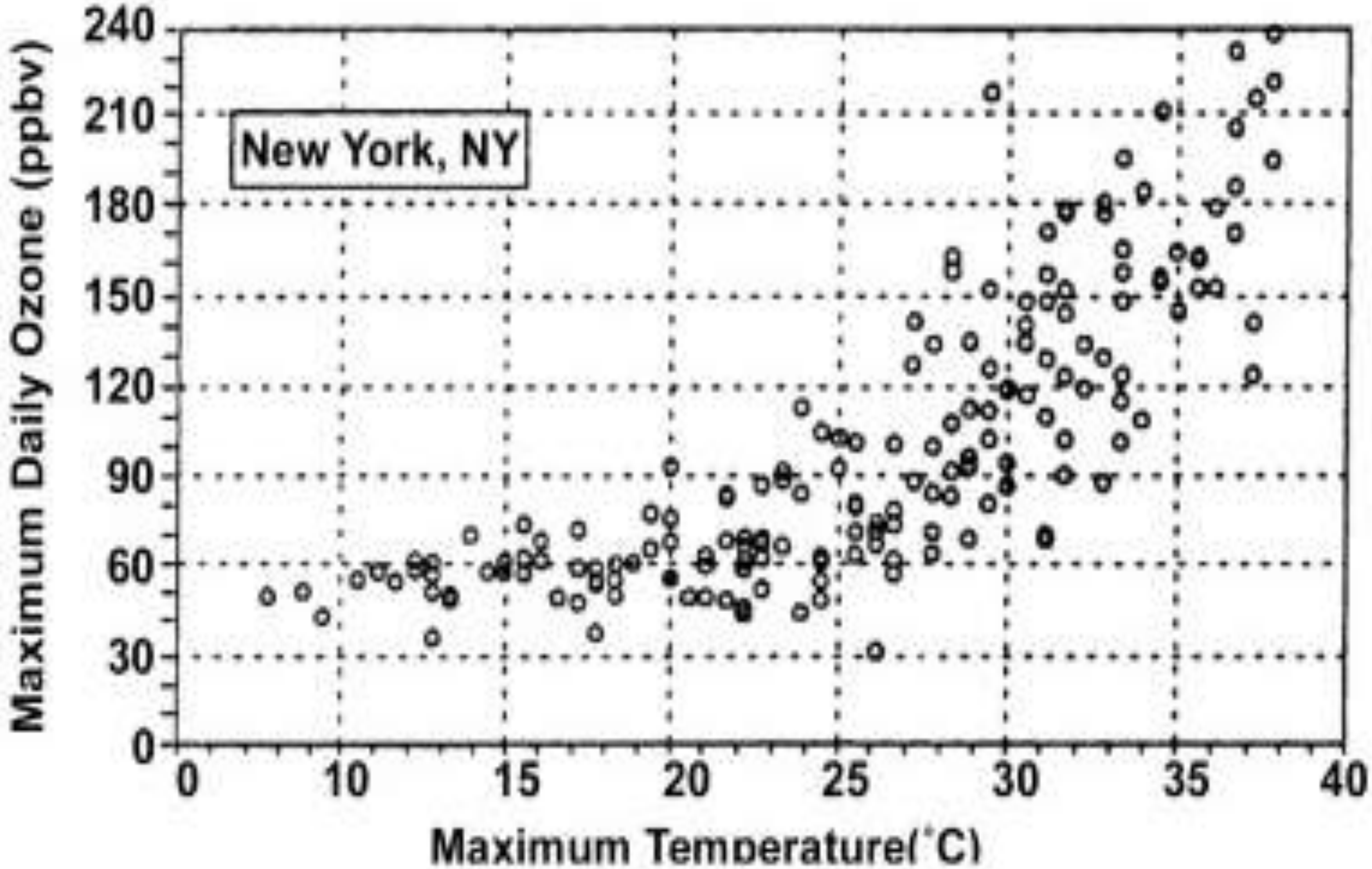
- Regional air mass patterns over time and space may change, altering stagnation and clearance events
- The mixing height of the lower atmosphere may change, affecting dilution of pollution emitted at the surface

→ But keep in mind that future anthropogenic air pollution emission trajectories are even more important

Ozone Formation



Queensland Government Environmental Protection Agency, 2006



Source: US EPA (1991); in Kleinman and Lipfert, 1996.
Note threshold~90°F (32°C)

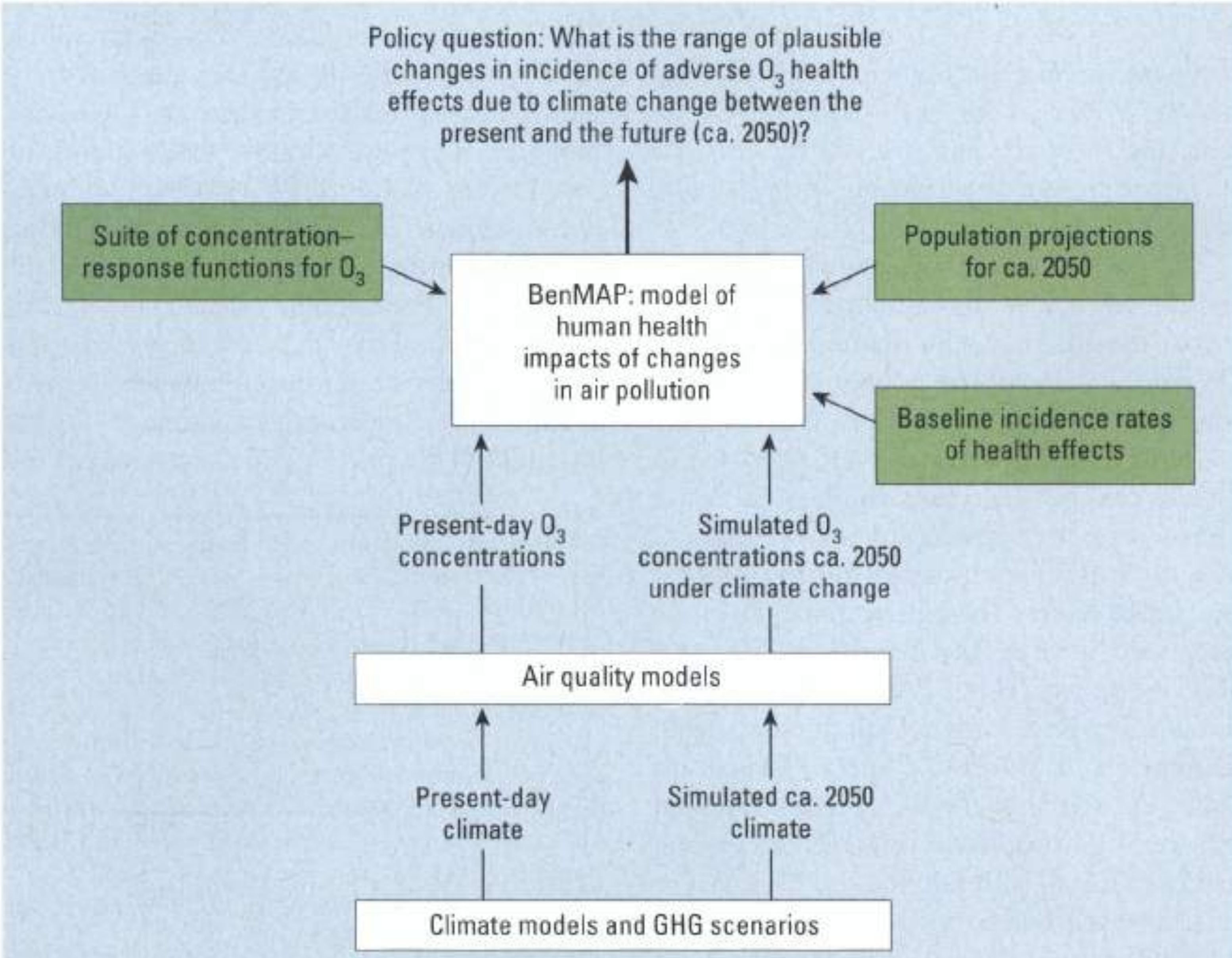
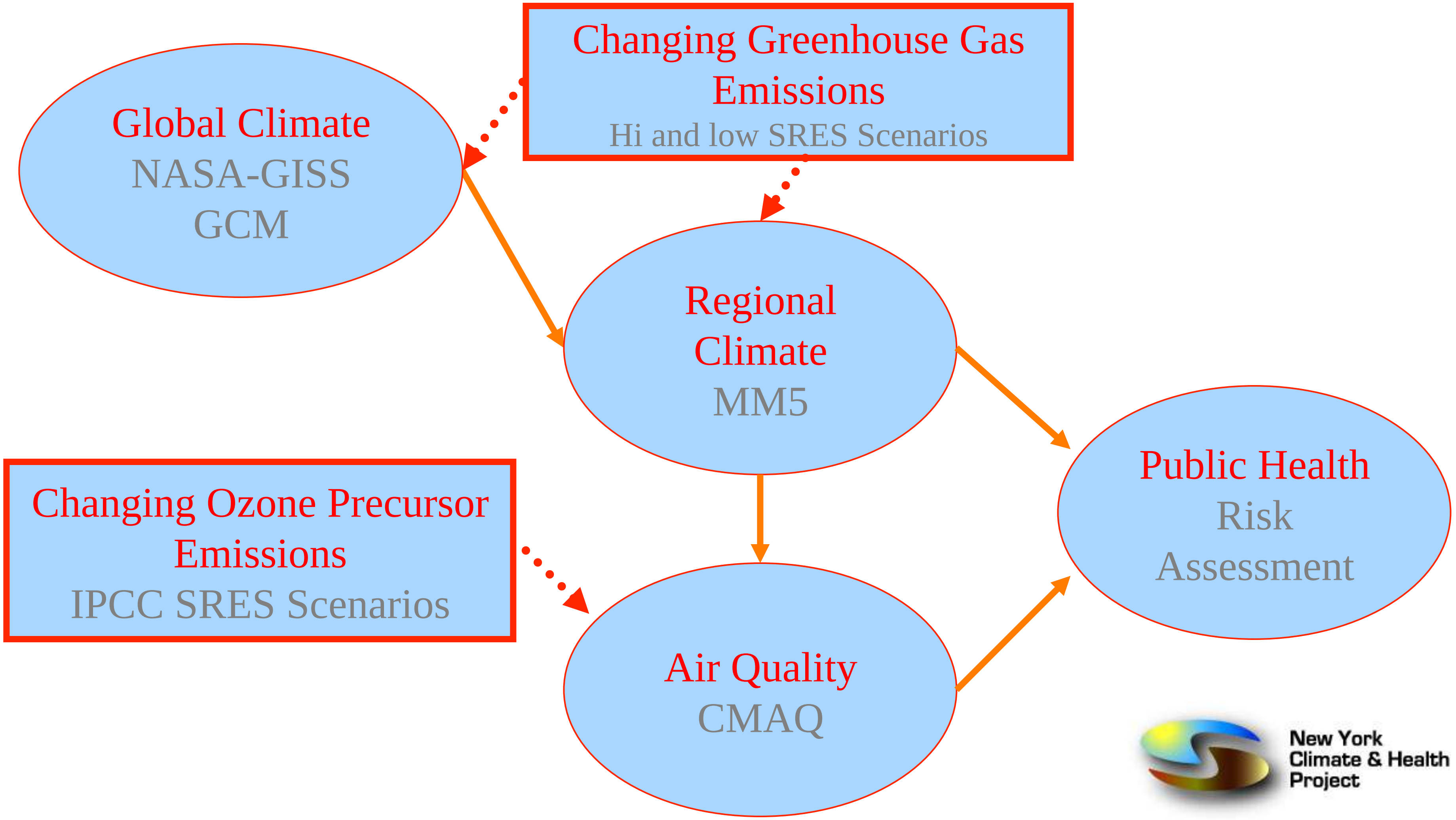


Figure 1. The structure of the analysis of O_3-related impacts on human health attributable to climate change. GHG, greenhouse gas.

From Post et al., EHP 2012

For example, the New York Climate and Health Project



Impact of Climate Change on Summertime Ozone Concentrations

Hogrefe et al., 2004

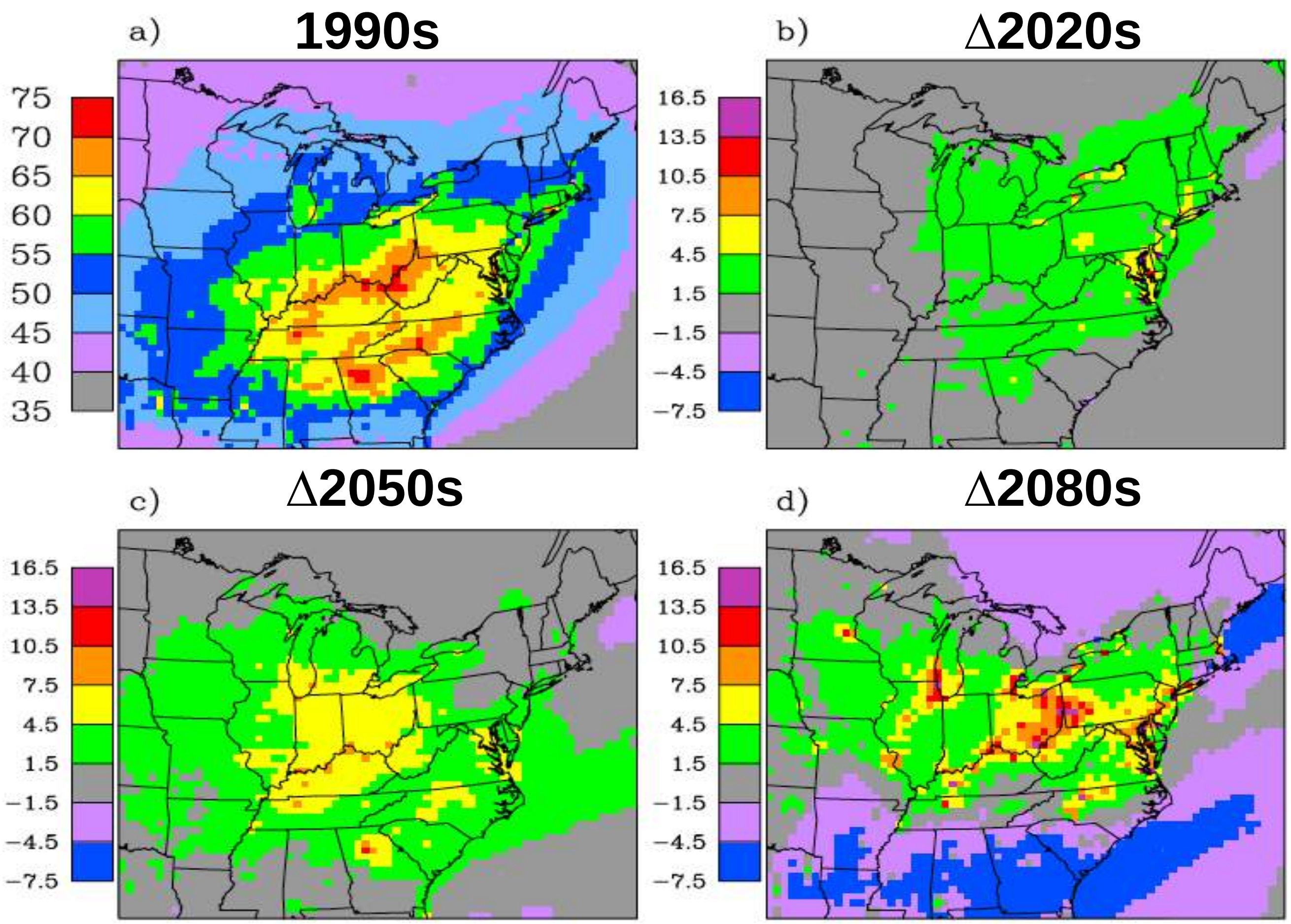


Figure 2. (a) Summertime average daily maximum 8-hour O_3 concentrations for the 1990s and changes in summertime average daily maximum 8-hour O_3 concentrations for the (b) 2020s, (c) 2050s, and (d) 2080s A2 scenario simulations relative to the 1990s, in parts per billion. Five consecutive summer seasons were simulated in each decade.

Modeled changes in:

Mean 1-hr max O3 (ppb) O3-related deaths (%)

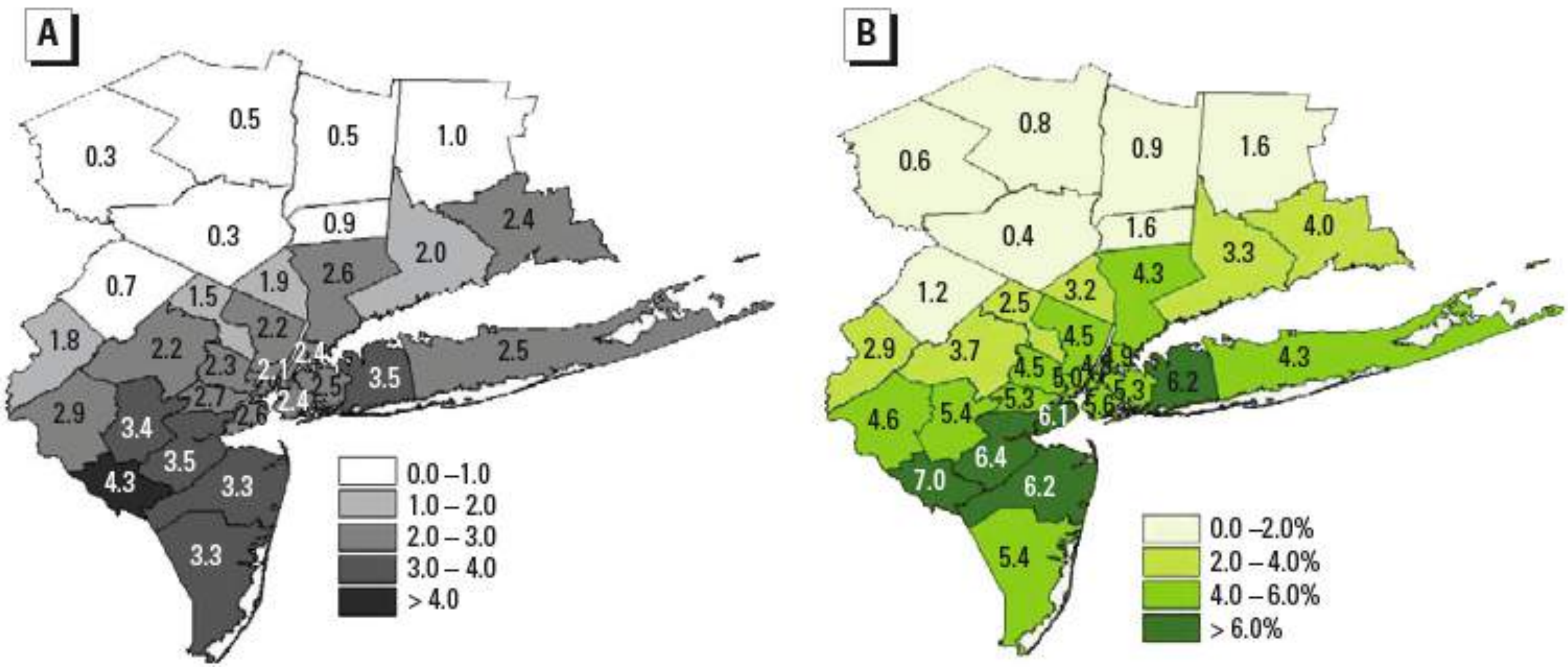
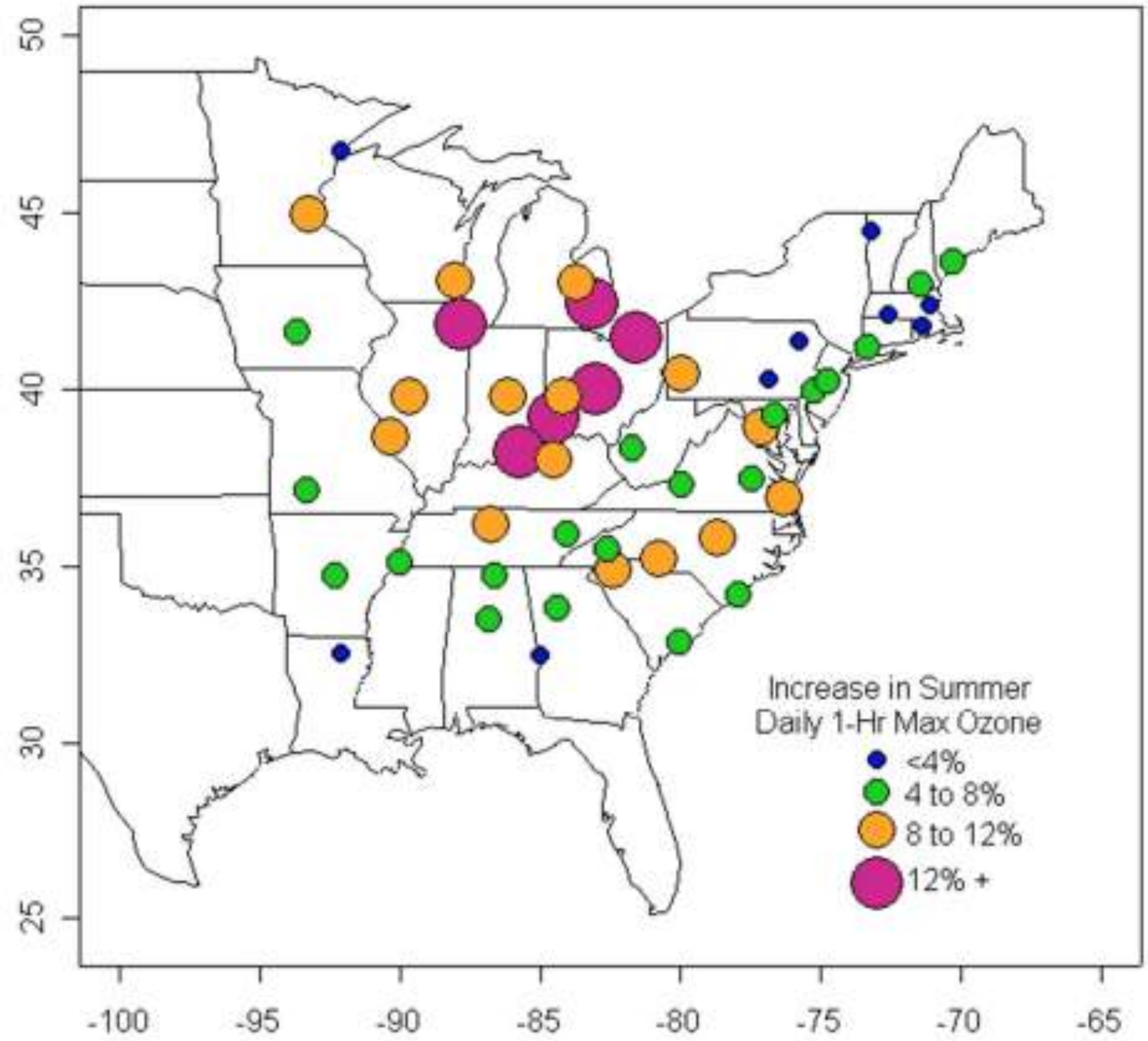


Figure 2. Estimated changes in O_3 and associated summertime mortality in the 2050s compared with those in the 1990s for M1, where climate change alone drives changes in air quality. (*A*) Changes in mean 1-hr daily maximum O_3 concentrations (ppb). (*B*) Percent changes in O_3-related mortality.

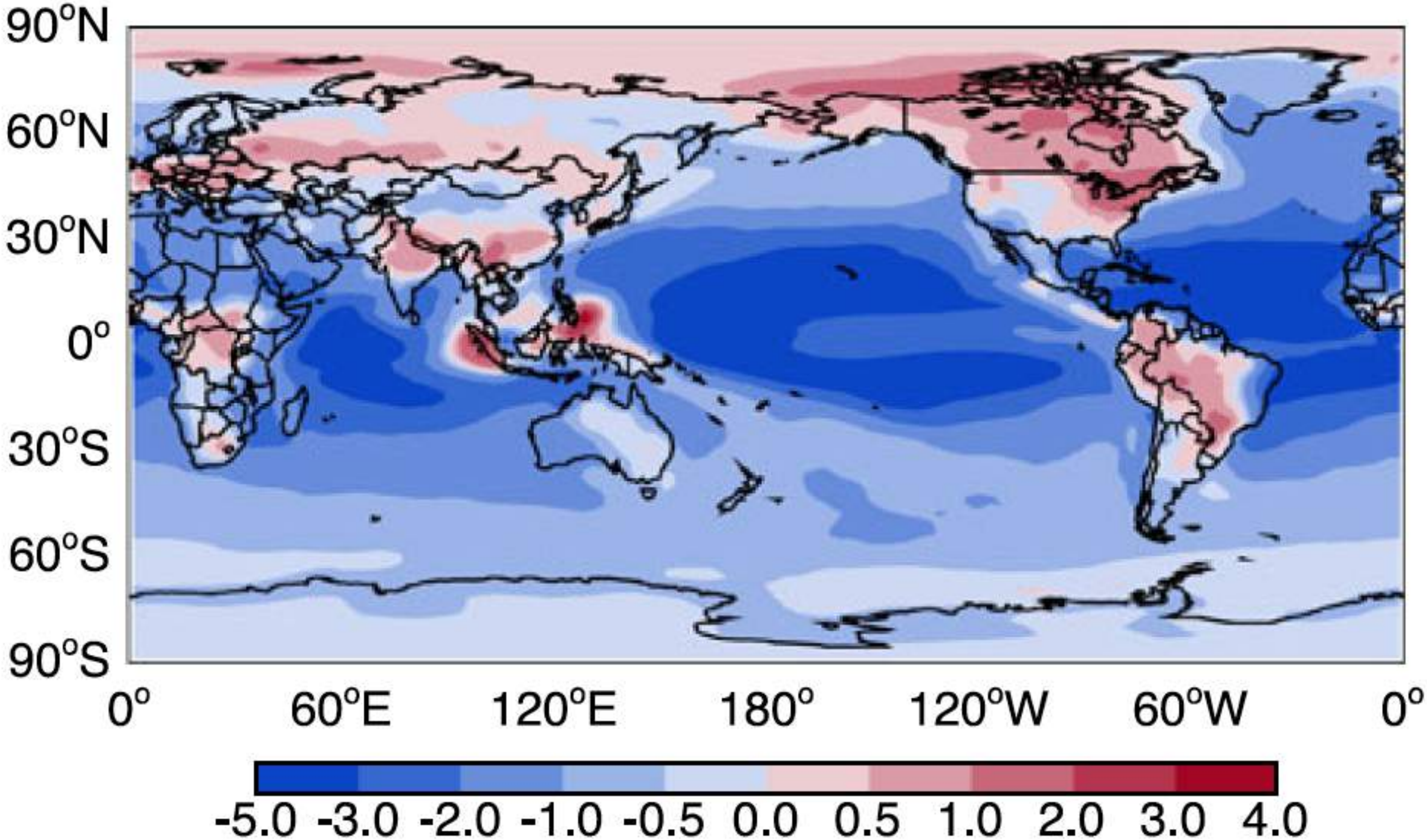
Knowlton et al., Environ Health Perspec, 2004

Increase in Ozone (1990s to the 2050s)



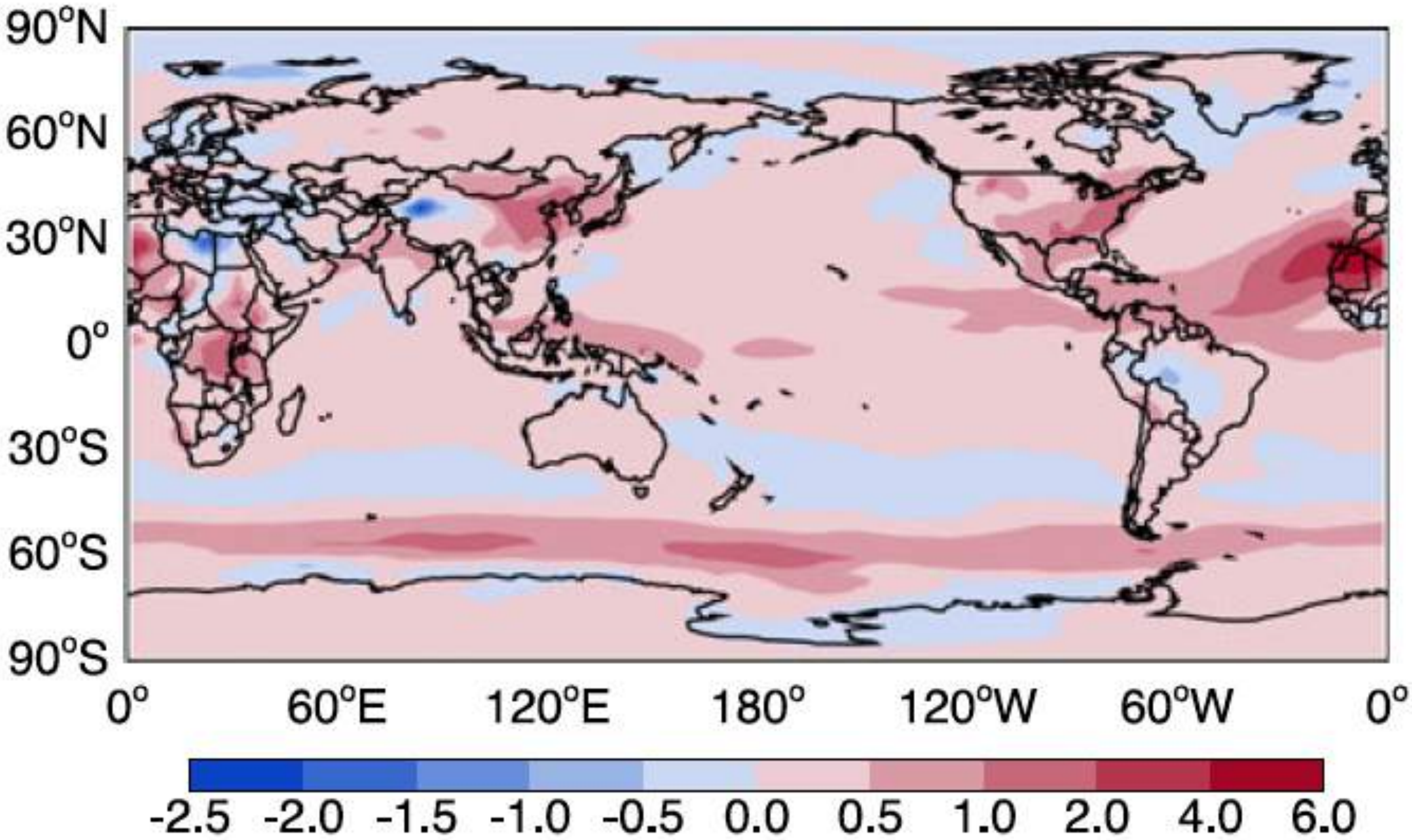
Bell et al.
Climatic Change 2007

Climate-induced changes in Ozone (ppb) from late 20th to late 21st century



Fang et al., Climatic Change, 2013

Climate-induced changes in PM2.5 (ug/m3) from late 20th to late 21st century



Fang et al., Climatic Change, 2013

Key Inputs and Assumptions in Assessing Future Climate-Air Quality-Health Impacts

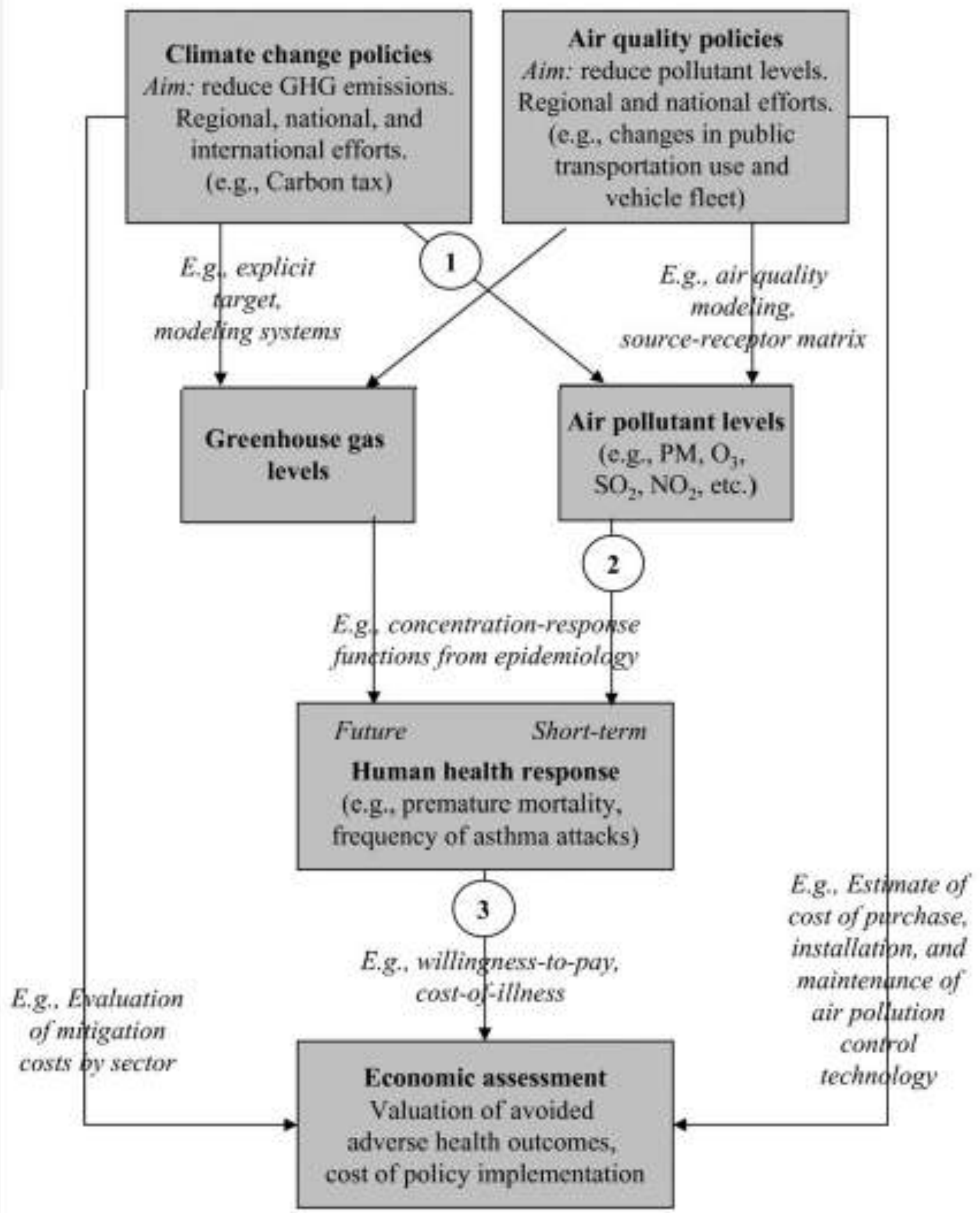
- Baseline and Future Time Windows
- Climate models
  - Which models?
  - At what spatial scale? Downscaling?
- Greenhouse gas emission scenarios
  - SRES; RCPs
- Air pollution models and emission scenarios
  - Which models? Downscaling?
- Exposure-response functions
- Population projections

Health Co-Benefits of Climate Change Mitigation Actions:

Mitigation of climate change generally involves reducing emissions of greenhouse pollutants, such as:

CO_2, methane, ozone, black carbon, …

The sources that emit these pollutants often emit pollutants that are directly harmful to public health



Relationship between Climate Change and Air Quality Policies

Bell et al. *Environmental Health 2008*

Emerging knowledge

- Climate change will make it harder to achieve future air quality goals – the "climate penalty"
- Holding pollution emissions constant, ozone could rise up to 10% or more around urbanized areas
- $PM_{2.5}$ is more complicated; fewer studies and less consistency in results than for ozone; but mortality impacts dominate those of ozone
- Pollution emission reductions can more than compensate for these effects
- Urban climate and air pollution mitigation actions can bring direct health benefits while reducing global climate impacts

Knowledge gaps

- We lack climate/air quality/health information at fine spatial scales relevant to local decision makers
- We need ensembles of multiple models to better characterize uncertainties and expected values, as has become the norm in climate impact modeling
- Health co-benefits assessments need to be developed at local scales to inform mitigation policy options
- To the extent possible, air pollution and climate mitigation should be planned in a coordinated way