Managing the Air: A Challenge for Sustainable Development

Noelle E. Selin
Assistant Professor of Engineering Systems and Atmospheric Chemistry
Massachusetts Institute of Technology

China's Leaders in Development (CLD) Program
22 May 2012

selin@mit.edu
http://mit.edu/selin
http://mit.edu/selingroup

MIT ESD
Massachusetts Institute of Technology
Engineering Systems Division

EAPS

Air Quality and Sustainable Development

- Air quality: what's the problem?
- Emissions, concentrations and trends
- Quantifying pollution health damages
- Issues for further research and policy

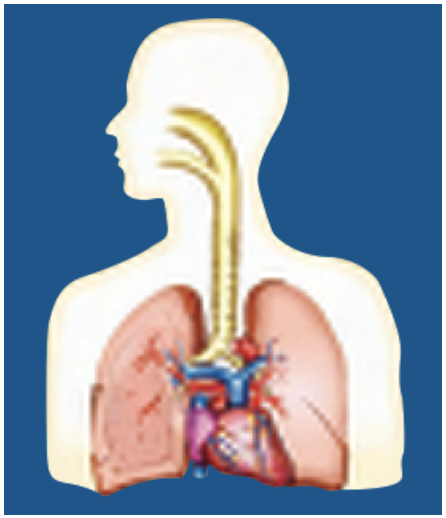
Air Quality: What's the problem?

- Growing economic activity leading to pollutant emissions
- Substantial air quality problems
- Health impacts
- Links to climate change and future regulatory challenges

Air Quality and Health Damages

NOx
VOCs
SO_2
BC
OC
Primary PM
Hg

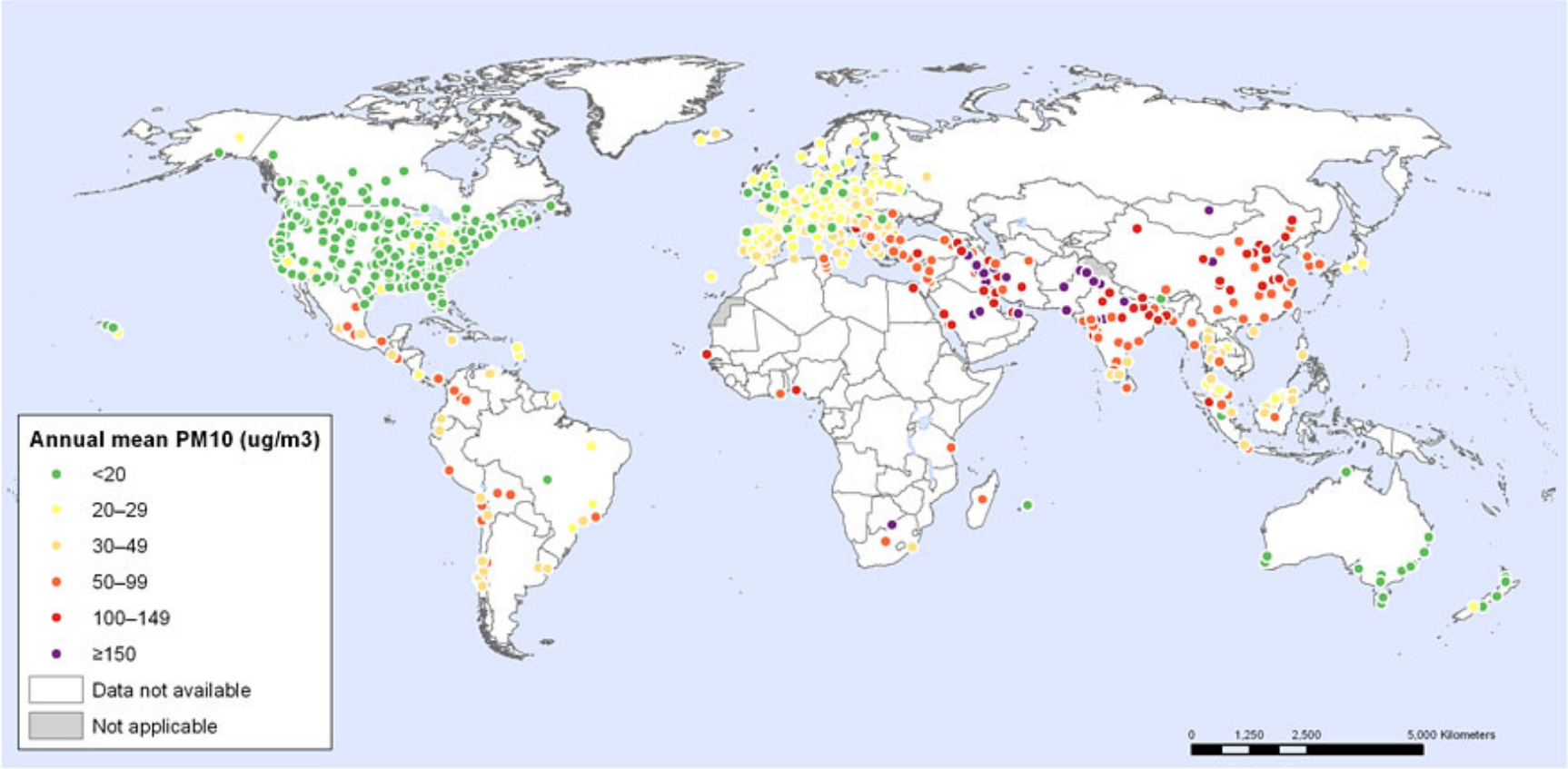
Ozone
Fine particulate matter
≤2.5μm, ≤10μm
($PM_{2.5}$, PM_{10})



Methylmercury

Global Exposure to PM_{10}

Exposure to particulate matter with an aerodynamic diameter of 10 µm or less (PM10) in 1081 cities, 2003–2010



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

World Health Organization

WHO Air Quality Guidelines for $PM_{2.5}$, PM_{10}

Table 1

WHOair quality guidelines and interim targets for particulate matter: annual mean concentrations[a]

	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Iinterim target-1 (IT-1)	70	35	These levels are associated with about a 15% higher long-term mortality risk relative to the AQG level.
Interim target-2 (IT-2)	50	25	In addition to other health benefits, these levels lower the risk of premature mortality by approximately 6% [2–11%] relative to theIT-1 level.
Interim target-3 (IT-3)	30	15	In addition to other health benefits, these levels reduce the mortality risk by approximately 6% [2-11%] relative to the IT-2 level
Air quality guideline (AQG)	**20**	**10**	These are the lowest levels at which total, cardiopul-monary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to $PM_{2.5}$

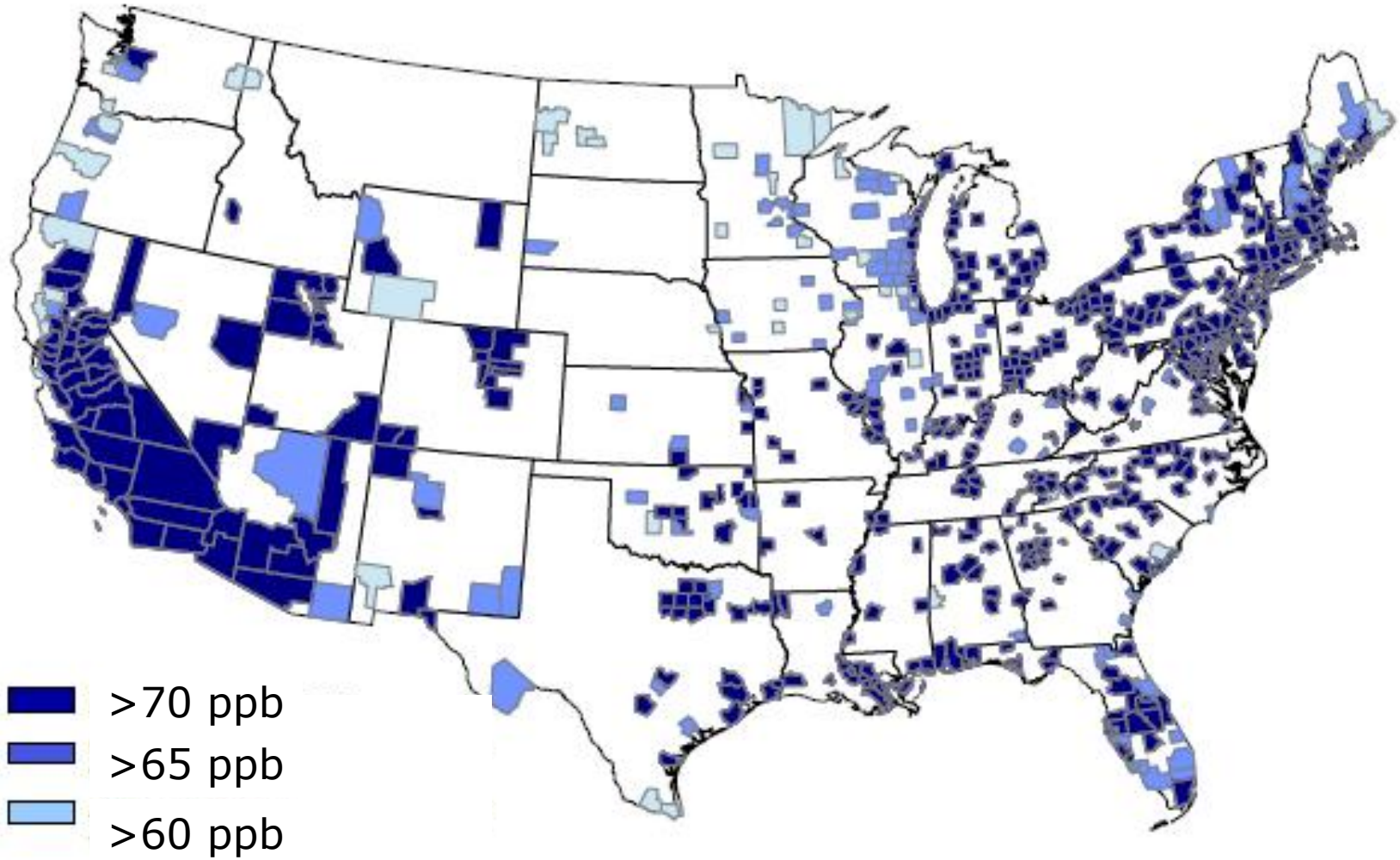
US annual standard: 15 μg m^{-3} for $PM_{2.5}$

Source: World Health Organization

US locations with high ozone

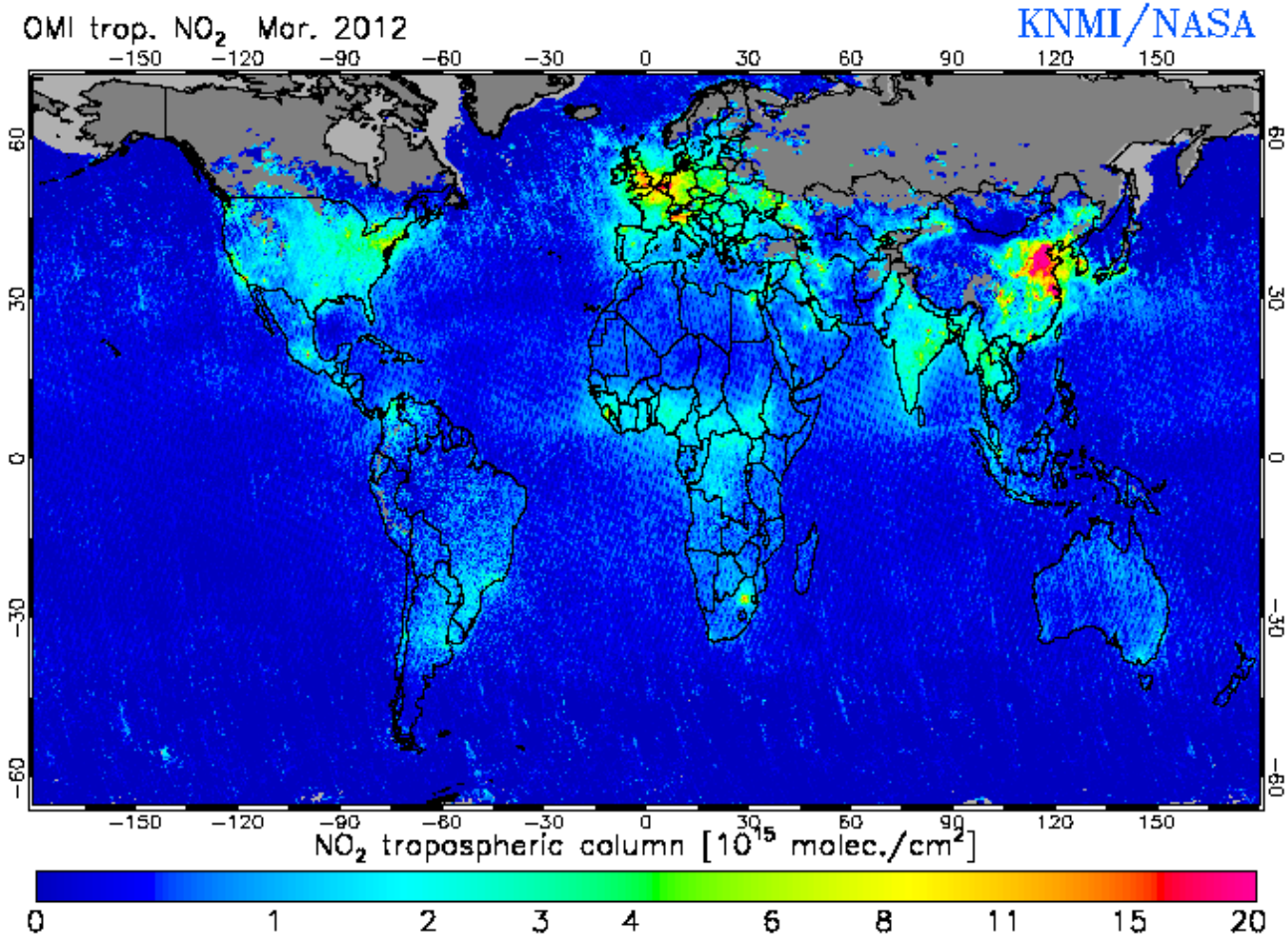
(Based on 2006 – 2008 Air Quality Data)

EPA will not designate areas as nonattainment on these data, but likely on 2008 – 2010 data which are expected to show improved air quality.



http://www.myfirecommunity.net/NeighborhoodPublic/Neighborhood279/ozone_nonattainment_70ppb_60ppb.jpg

Industrial Emissions from Satellite

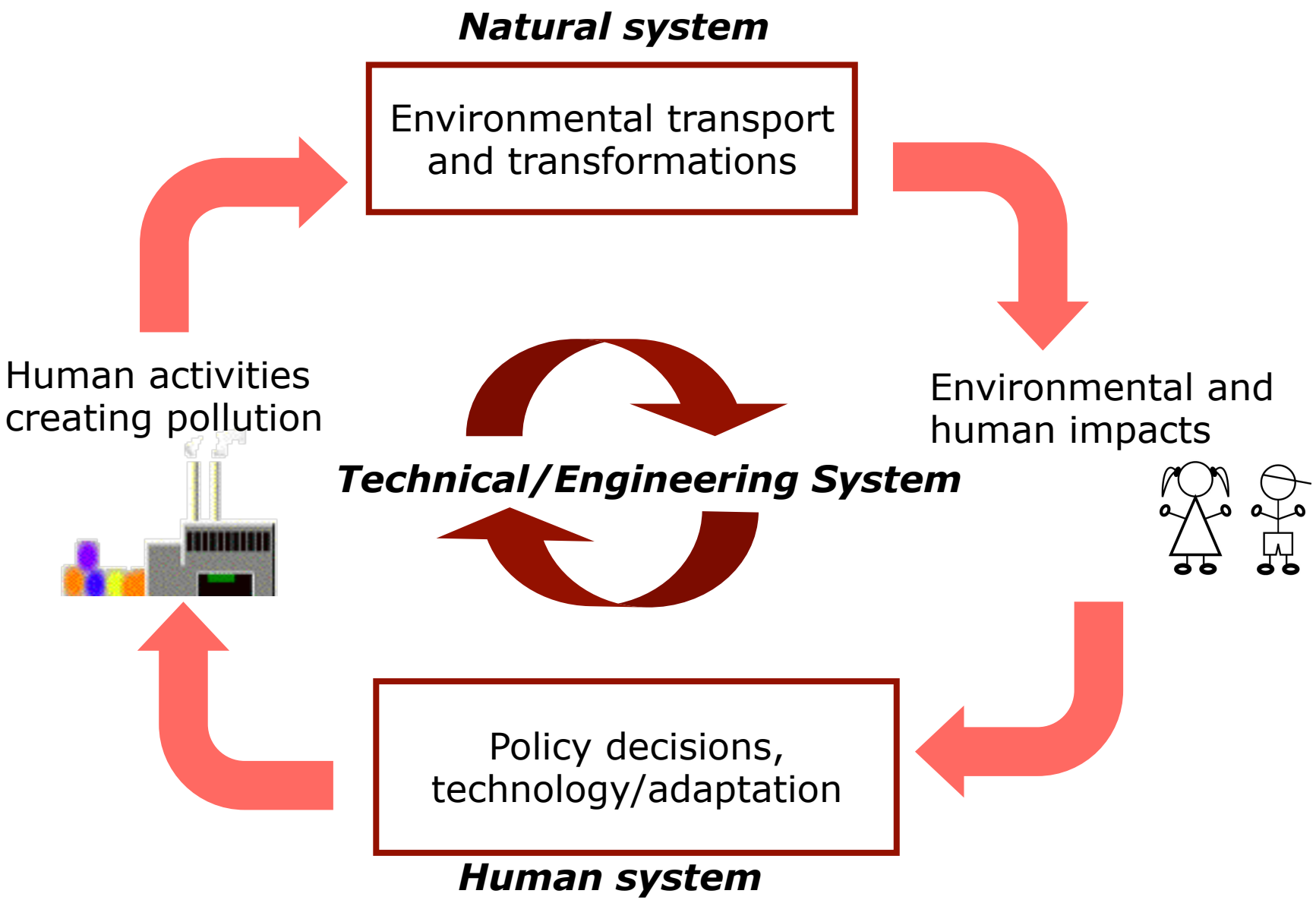


- NOx, precursor to O_3
- March 2012
- Shows industrial centers

Questions for Research

- How can we better understand the drivers, processes, and impacts of air pollution?
- Can we develop better tools to understand interactions between human, economic and atmospheric systems?
- How to inform better policy choices and tradeoffs (e.g. for climate vs. air pollution policies)

Integrated Assessment: Air Pollution Impacts



Economic Assessment of Health Damages

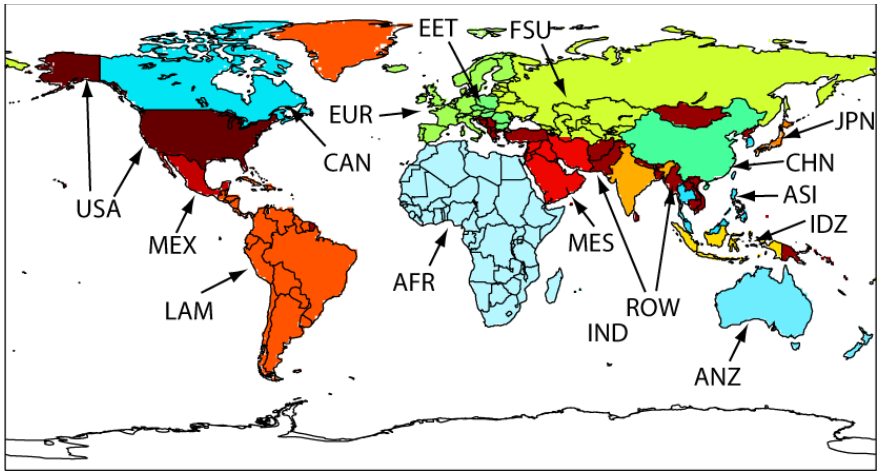
Concentration of O_3, particulate matter (data, model): Population-weighted concentration per region

↓

Morbidity and mortality outcomes and costs (from epidemiological literature)

↓

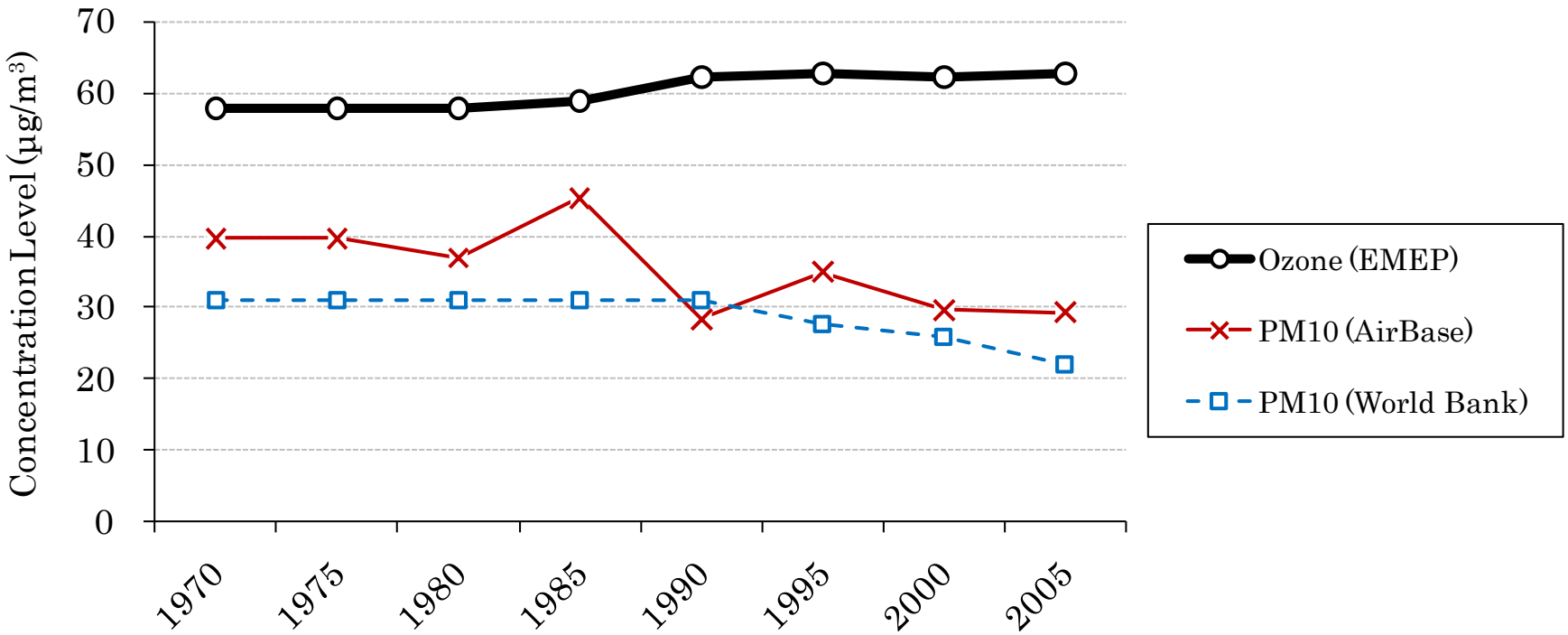
Loss of labor, capital and equilibrium economic effects over time; economic activity and emissions



MIT Emissions Prediction and Policy Analysis (EPPA) model

[EPPA-HE model: *Matus et al., Clim. Change, 2008; Selin et al., ERL, 2009*]

Health Costs of Air Pollution in Europe

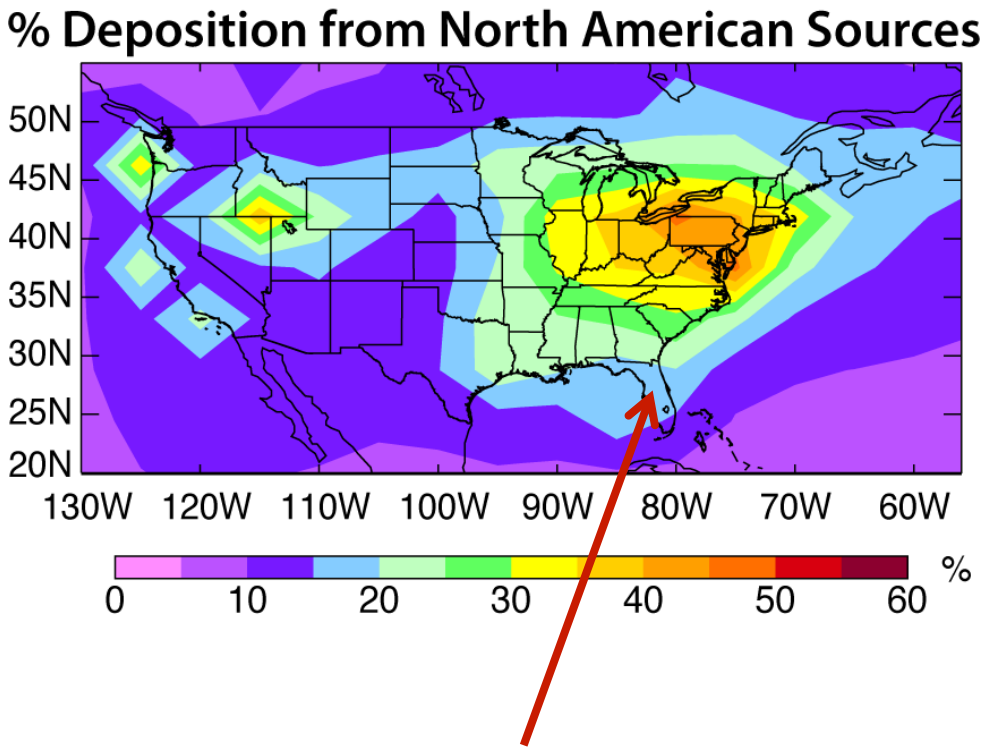


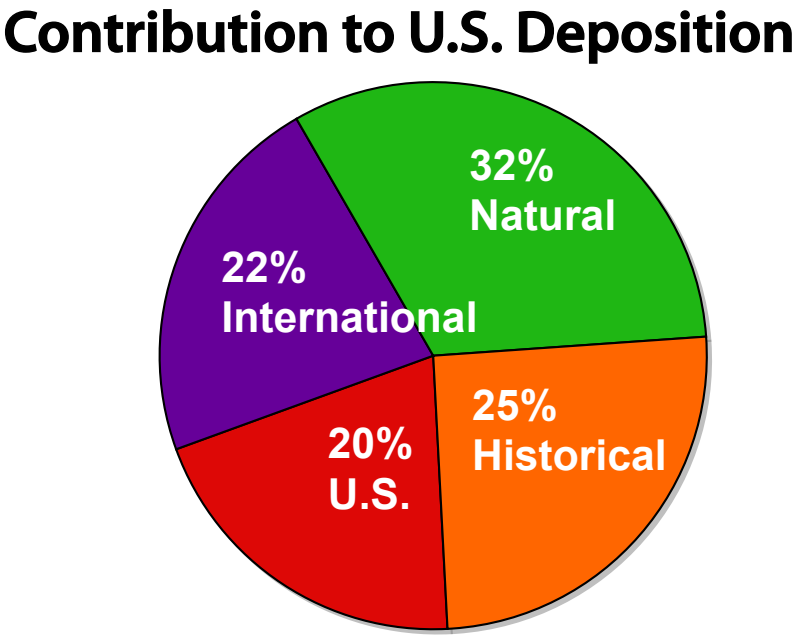
Air pollution in Europe results in **€370 billion** in economic losses

Uncertainty: €209-550 billion

[Nam et al., Energy Policy, 2010]

Global Hg emissions affect the U.S.





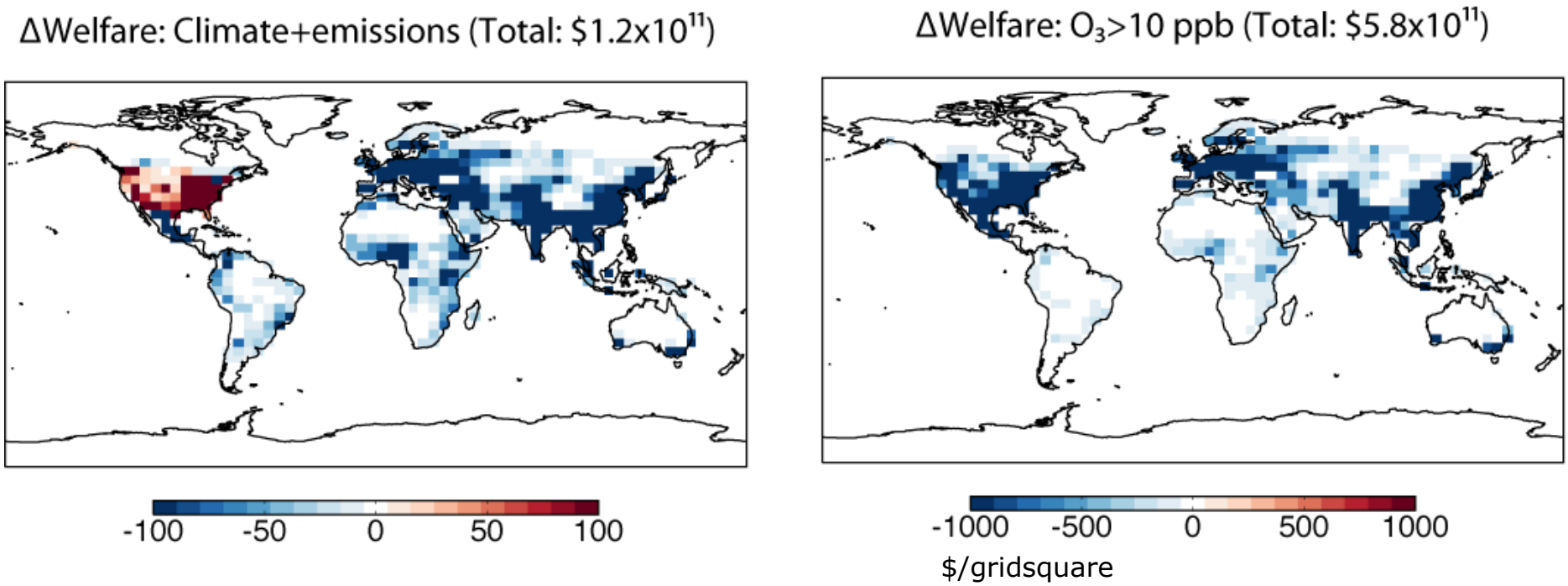
Southeast U.S. has high Hg deposition, mostly from outside U.S.

[*Selin et al., GBC 2008; Selin and Jacob, 2008*]

Linking Climate and Air Quality

- Climate change affects air quality (and vice versa)
  - Example: increased temperature, more ozone formation
  - Example: sulfate aerosols can cool climate; black carbon is warming

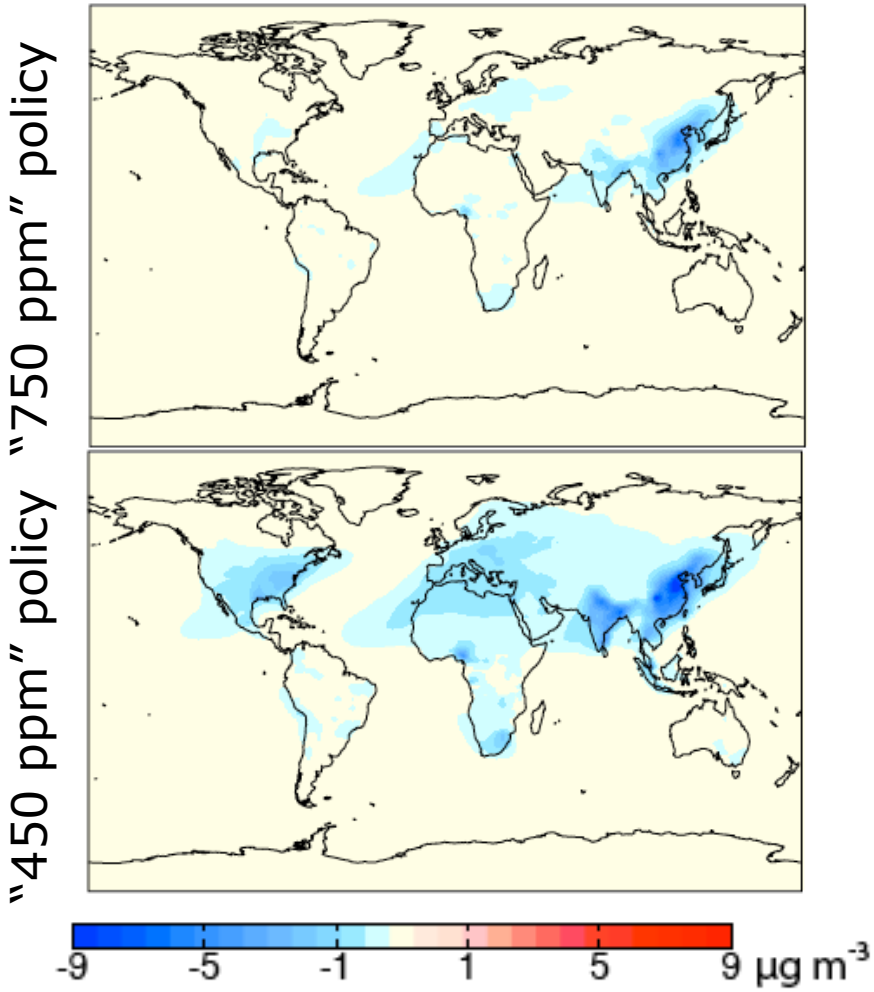
Impacts and Costs of Ozone in 2050



- In 2050, climate changes alone will result in a *$790 million* increase in ozone-related health costs (year 2000 $) [95% probability: $13 million – 190 billion]
- 2050 welfare loss from climate+precursor changes: *$120 billion* [95% probability: $100 billion – 1.5 trillion]
- 2050 welfare loss from all O_3 above background: *$580 billion*

[*Selin et al., Environmnetal Research Letters*, 2009]

Co-Benefits of Climate Policy (2050)



IPCC (2007): *high agreement and much evidence that health co-benefits from reduced air pollution as a result of climate action can be substantial, and* ***may offset a substantial fraction of climate mitigation costs***

Health-related "co-benefits" of BC, OC, SO_2 reductions valued at **0.03-0.09%** of global GDP in 2050

Climate change policies cost **0.4-6.7%** of global consumption in 2060

Relevant to policies for short-lived climate forcers (e.g. black carbon)

[Selin et al., in prep]

Acknowledgments

- **Funding:** NSF: Atmospheric Chemistry Program, "CAREER: Understanding Chemistry, Transport and Fate of Mercury and Persistent Organic Pollutants through Global Atmospheric Modeling,"; MIT Research Support Committee Ferry fund; U.S. EPA: Science to Achieve Results (STAR) Program, "Air Pollution, Health and Economic Impacts of Global Change Policy and Future Technologies: An Integrated Model Analysis," MIT Joint Program on the Science and Policy of Global Change and its consortium of government and industry sponsors, see http://globalchange.mit.edu

For more information, publication copies or comments:
http://mit.edu/selingroup

selin@mit.edu