Energy, Air Quality and Health: A Clearer Picture Emerging

Ted Russell, Georgia Tech
and a cast of hundreds from GIT, Emory and elsewhere)

ROLLINS SCHOOL OF PUBLIC HEALTH
EMORY

Georgia Institute of Technology

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant # R83479901

Special Thanks

- Colleagues Professors and students at Georgia Tech and Emory (and beyond)
- Sources of support
  - Southern Company & Georgia Power
  - US EPA, DoT, NIH, USDA, NSF
  - Georgia EPD/DNR and DoT
  - ConocoPhillips and Phillips66
  - Health Effects Institute
- Atmospheric Research and Analysis (ARA)
  - Much of the data and insightful discussion

Impacts of Energy Sectors on Air Quality

- Can we directly quantify the health impacts of different energy sources for each sector on air quality and health?
- How should the impacts of energy use on air quality and health guide policies and selection of energy sources?
- Approach:
  - Consider emissions-air quality-health relationships
    - Present
      - Have controls been achieving their goal?
    - Future
      - What can we expect
      - How does it link with climate

Issues

- Air pollution is a leading factor in premature death worldwide, as well as asthma and other respiratory and cardiovascular disease
  - Primary pollutants of concern are particulate matter and ozone
  - PM small particles, range of health impacts, visibility impairment, …
  - Ozone: respiratory irritant
  - Other criteria pollutants tend to be less of a problem
    - Though tightening standards are making them an issue
      - Near-road NO_2 looming issue
      - SO_2

	Canada	United States
Dietary risks	1	1
Smoking	2	2
High body-mass index	3	3
High blood pressure	4	4
Physical inactivity	5	6
High fasting plasma glucose	6	5
High total cholesterol	7	8
Alcohol use	8	7
Drug use	9	9
Occupational risks	10	11
Ambient PM pollution	11	10
Childhood sexual abuse	12	12
Intimate partner violence	13	13
Iron deficiency	14	18
Low bone mineral density	15	15
Lead	16	14
Radon	17	16
Ozone	18	17
Zinc deficiency	19	19
Childhood underweight	20	21
Vitamin A deficiency	21	22
Unimproved water	22	20
Sanitation	23	23

Disability Adjusted Life Years Lost
Global Burden of Disease

http://vizhub.healthdata.org/irank/heat.php

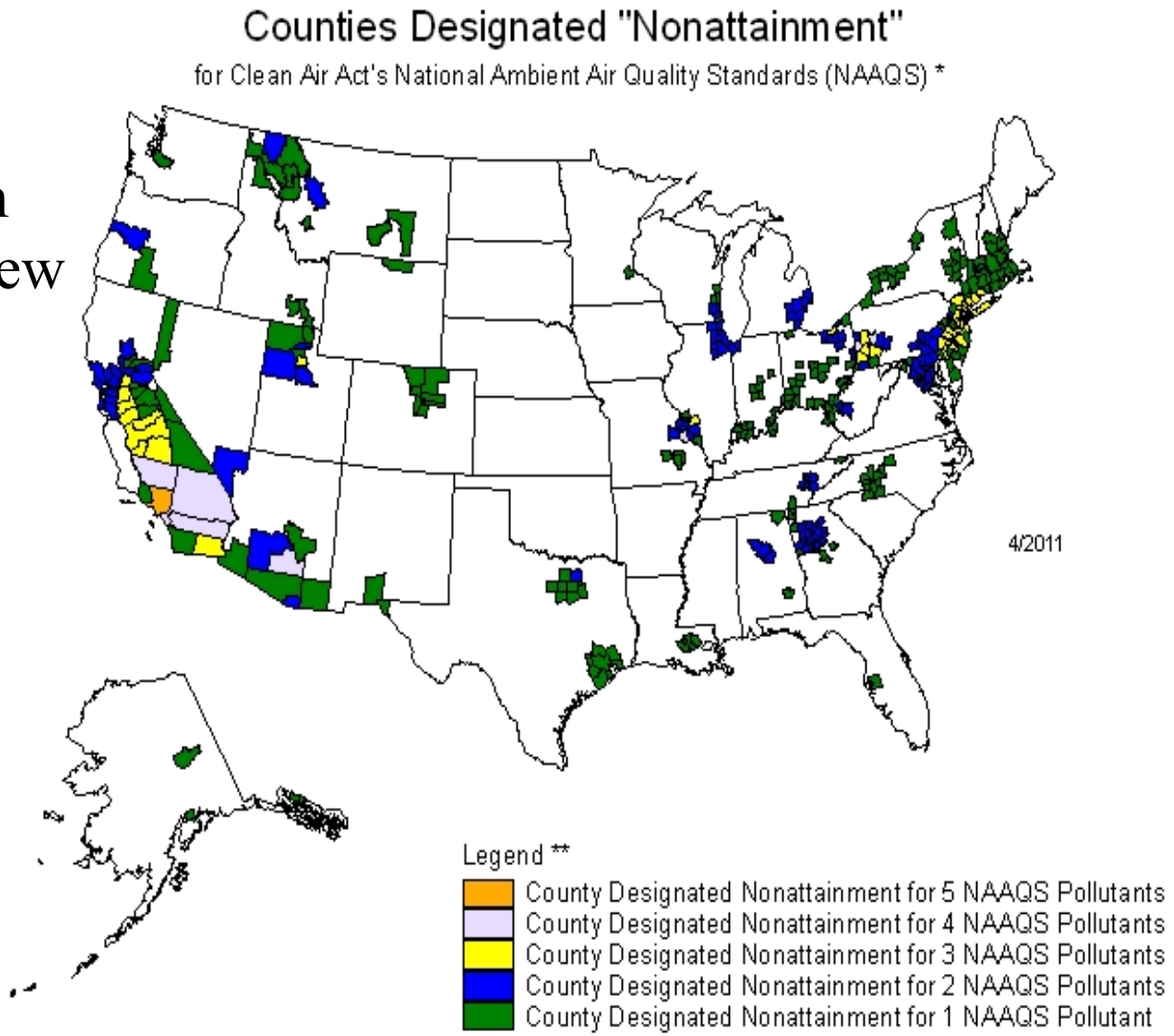
US Non-Attainment Areas

O_3: 0.075 ppm

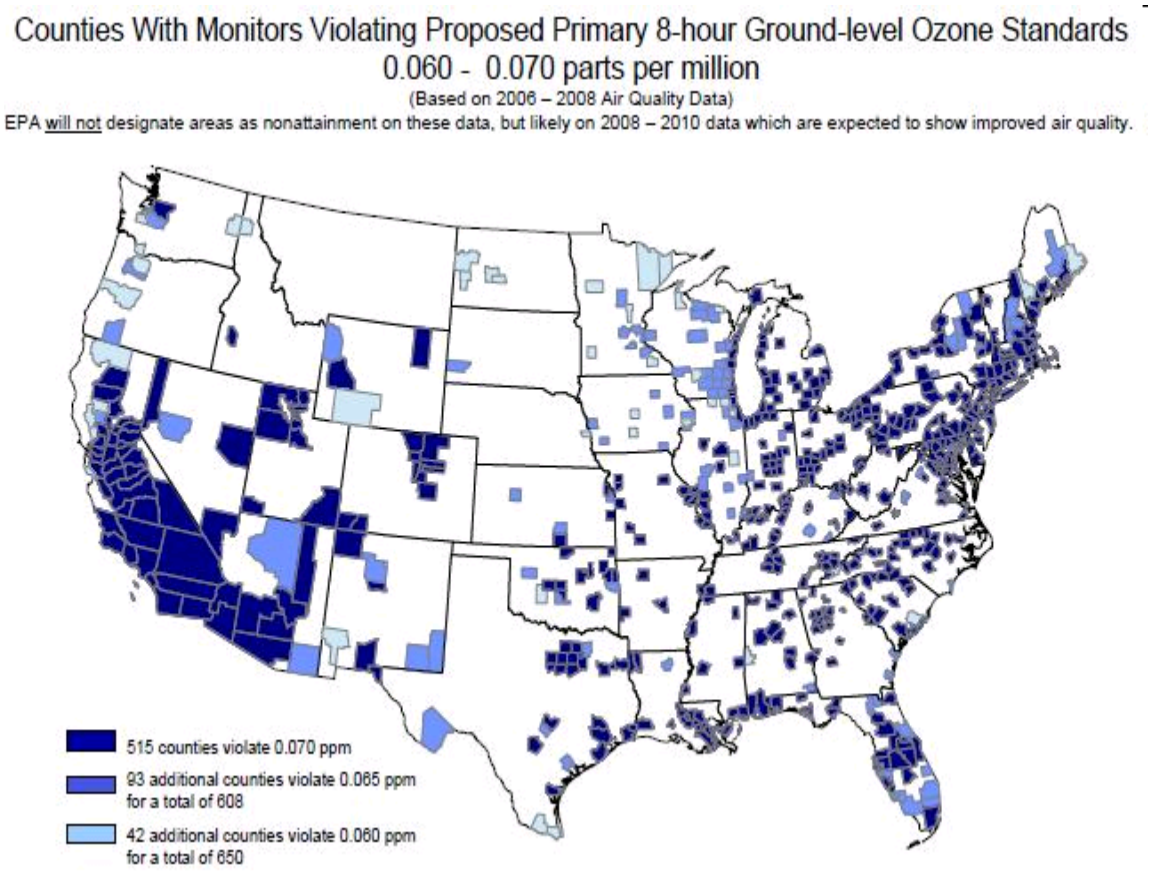
➔ Under review

PM: 15 ug/m^3

PM recently tightened to 12



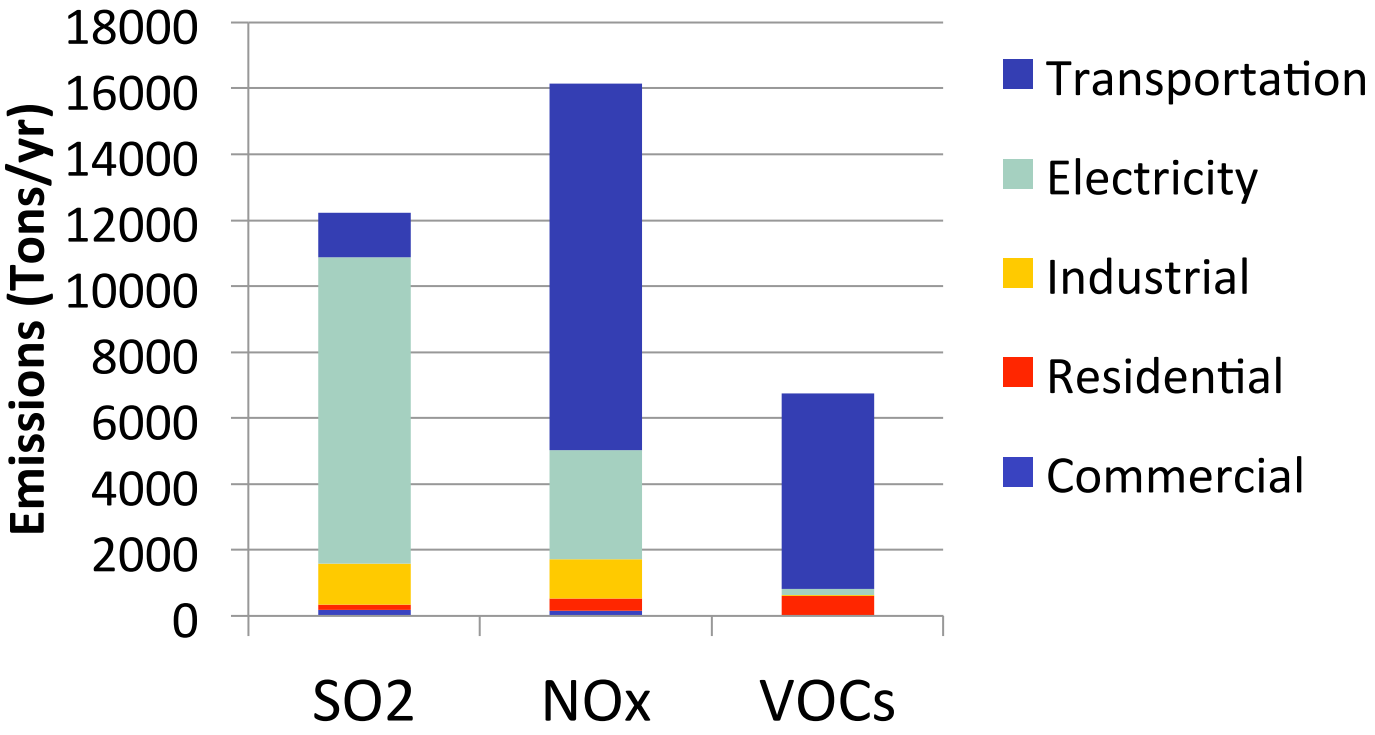
Ozone Evaluation (0.075➔0.070, 0.065 or 0.060 ppm)



That said…

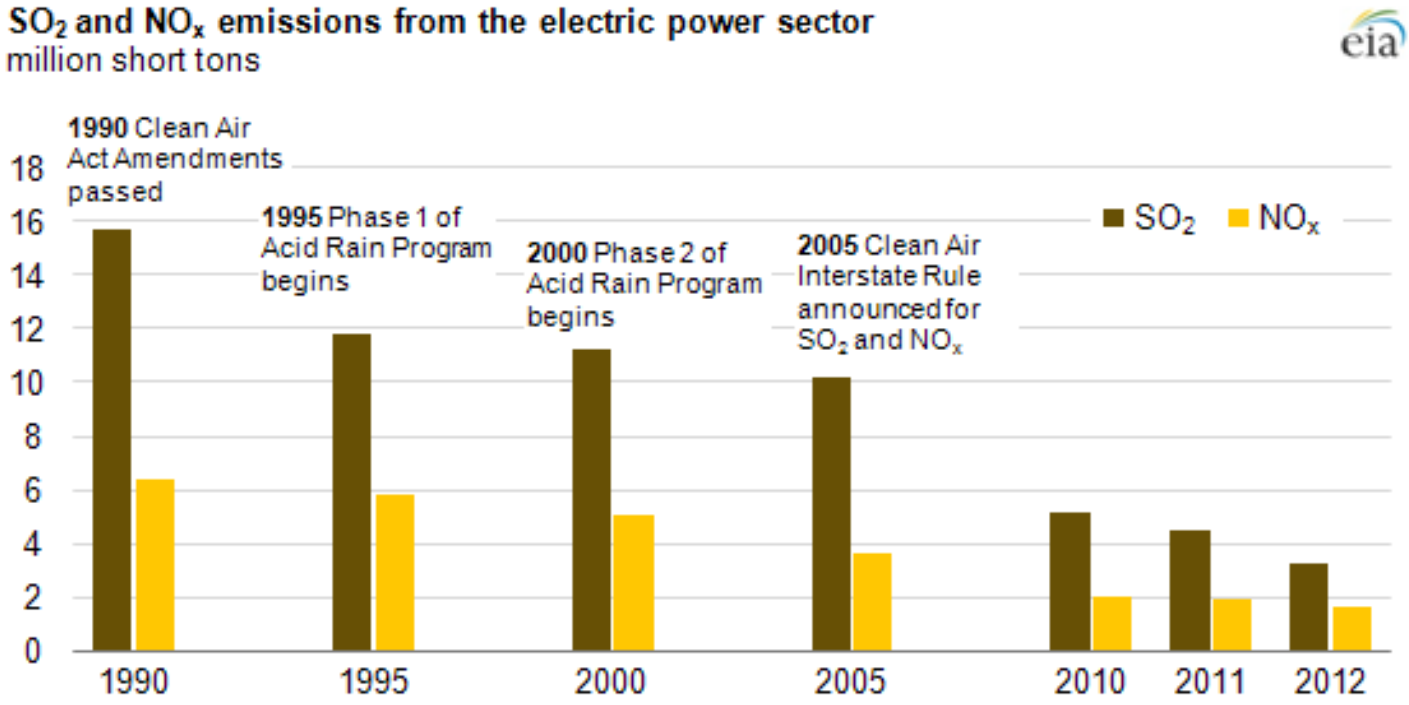
- While a tight ozone standard might be more difficult to attain
  - Background ozone increasing
  - Stratospheric intrusion
  - Less favorable response to controls
- PM tends to dominate current health discussions

Ozone and PM Precursor Emissions

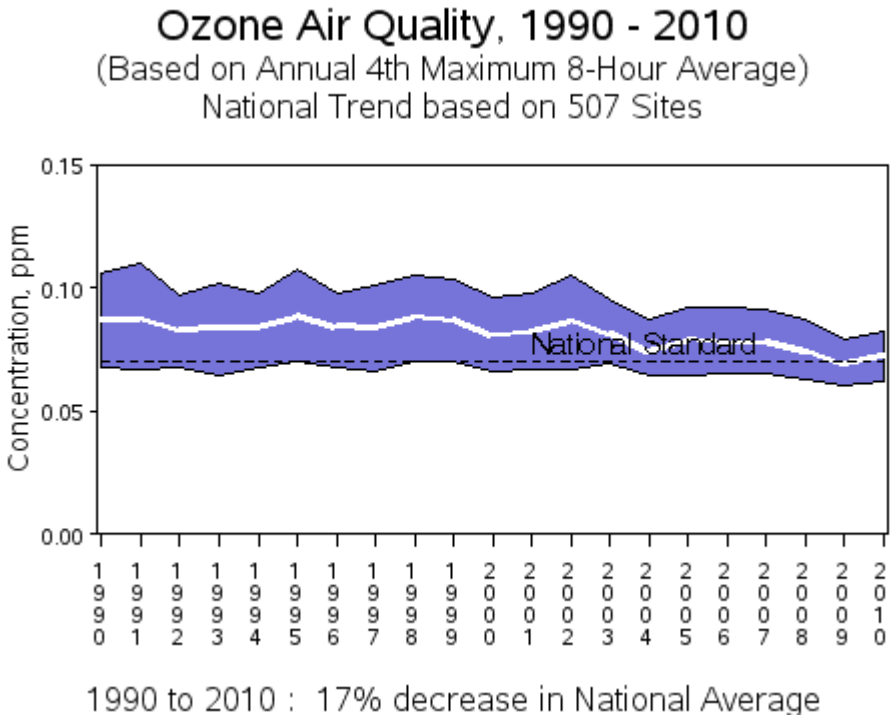


- SO2, NOx and VOCs all contribute to PM formation
  - To differing degrees
- NOx +VOCs ➔ Ozone

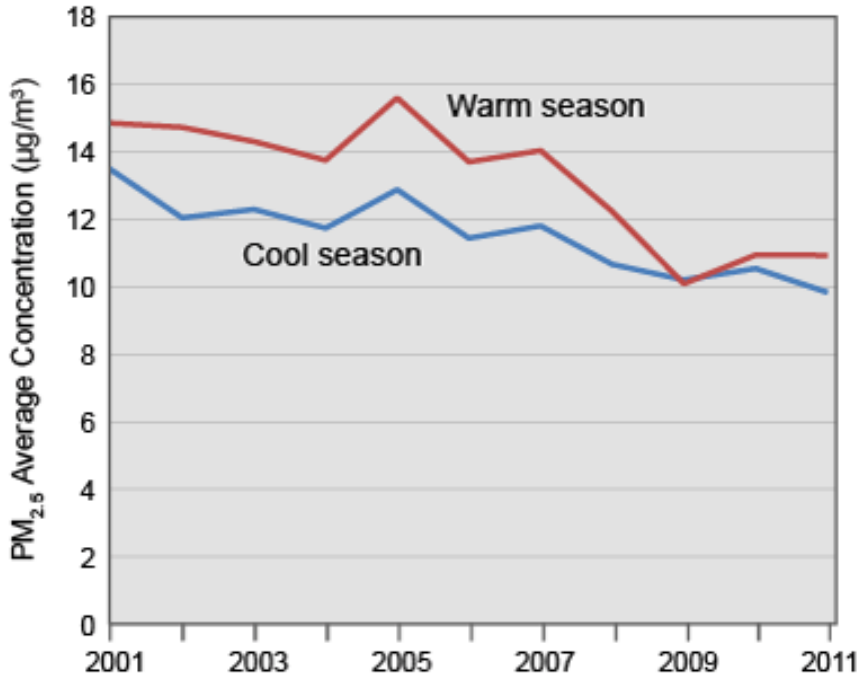
Recent SO_2 and NOx Emissions Reductions Really Impressive



Is it working?



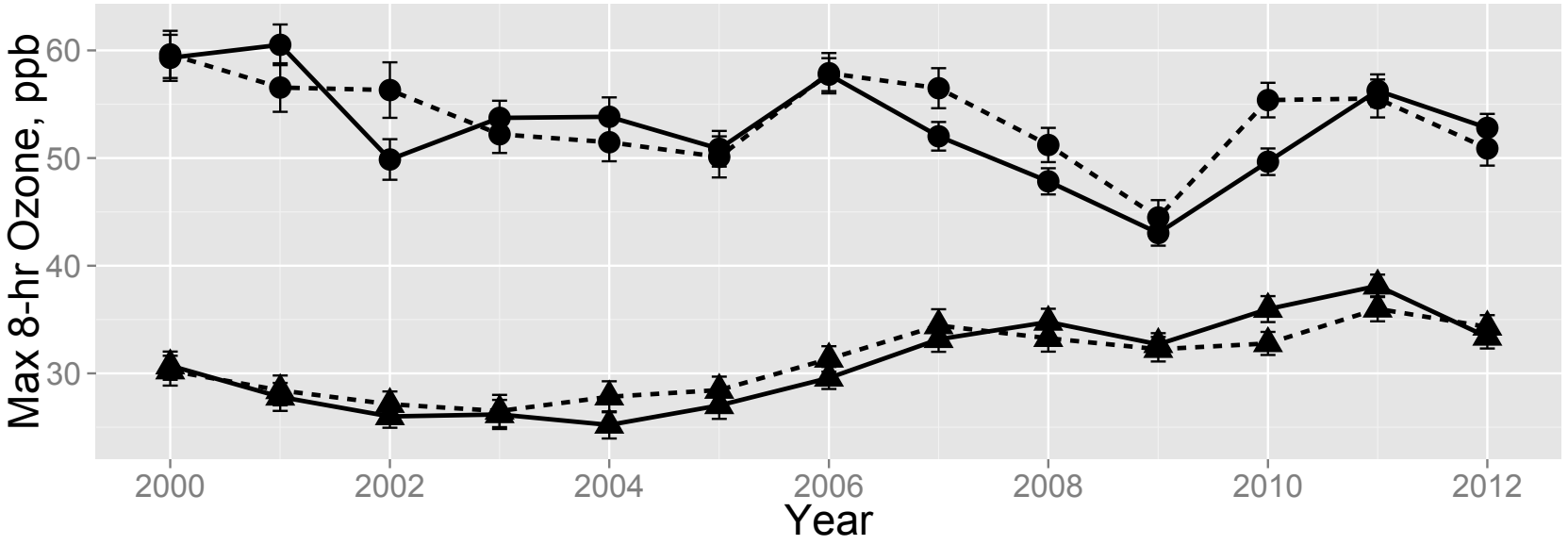
$PM_{2.5}$



http://www.epa.gov/airmarkets/progress/ARPCAIR11_02.html

Ozone is Complex

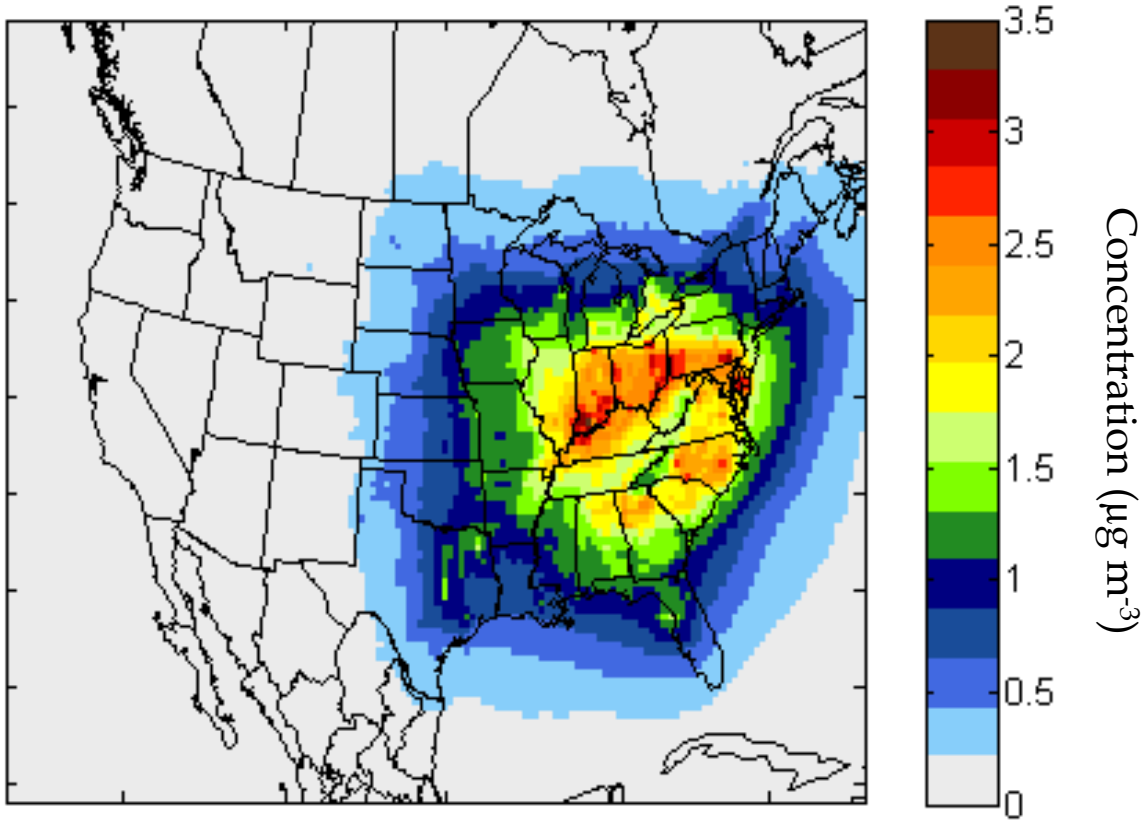
- NOx controls reduce peak ozone, but…
- Increase lower ozone levels



Source Impacts

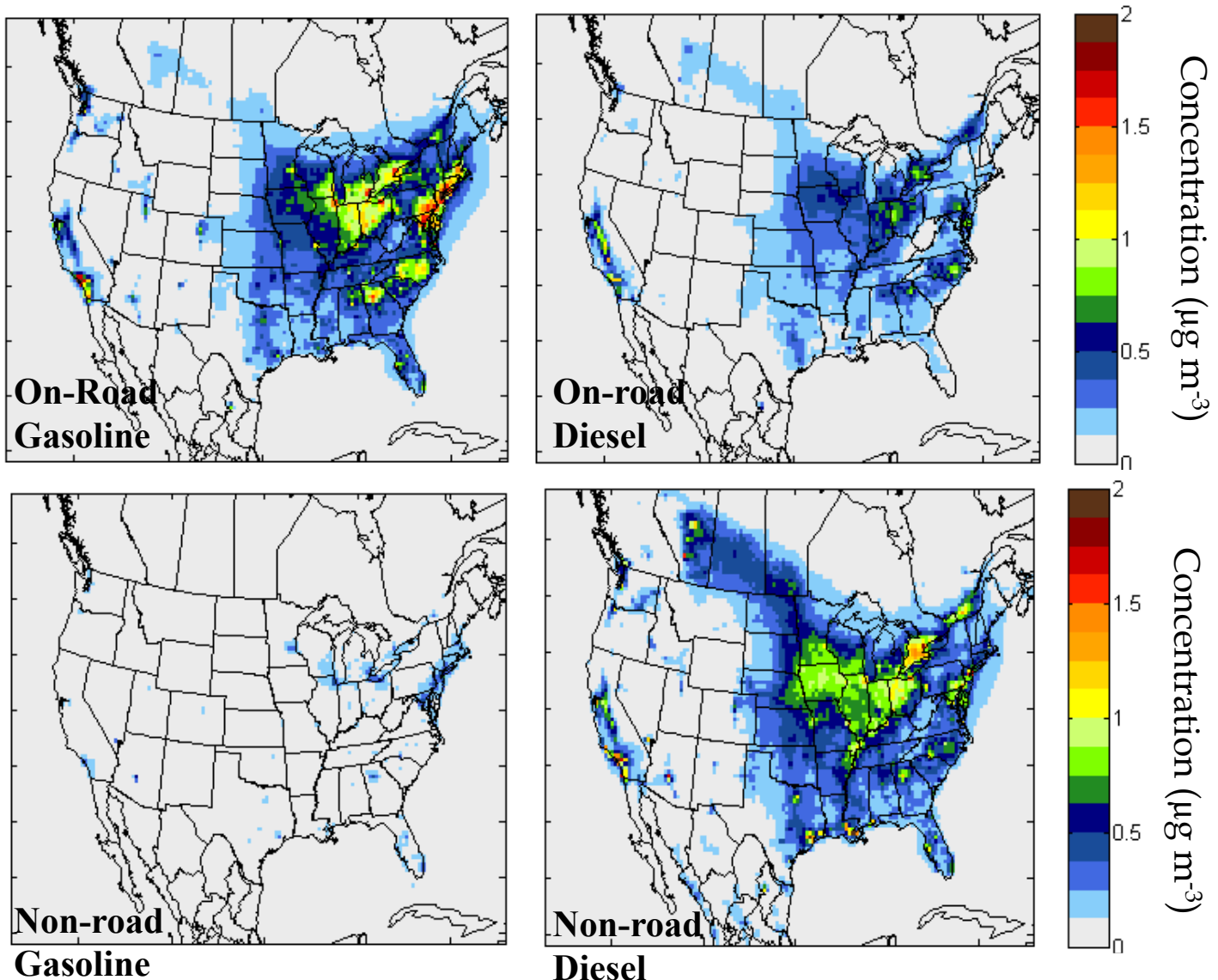
Annual Average Impacts on PM2.5

Coal Combustion (2006)



Annual Average Impacts on PM2.5

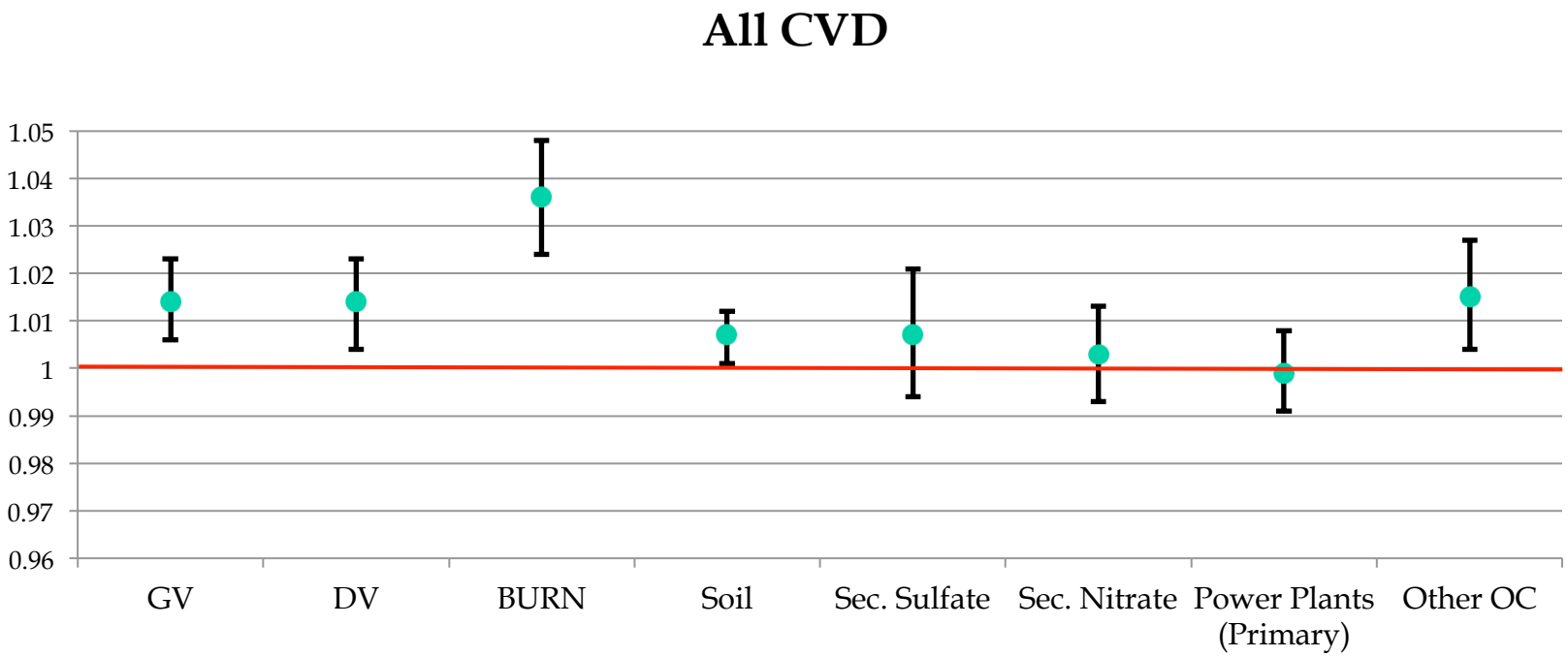
2006 Annual Average



Can we differentiate health impacts by source?

- Can develop (reasonably accurately) source air-quality relationships
  - Ozone by source
  - Particulate matter
    - By species
    - By source
- Hypothesis: Different PM types have different impacts:

Risk Ratios for cardiovascular in Atlanta by source



- Biomass burning tends to be high in most studies
- Uncertainties tend to overlap
- Different endpoints (e.g., respiratory) respond differently

Can we differentiate health impacts by source? Not well/yet

- Hypothesis: Different PM types have different impacts:
  - However, Health Effects Institute's National Particle Component Toxicity (NPACT) studies found mixed results, leading to:
  - "Overall, this comprehensive and ambitious research program has shown that research on the toxicity of PM components is not likely to easily identify a single culprit component or source category… We need the results of such research before we can definitely determine which components of PM2.5, if any, are responsible in whole or in part for the observed health effects associated with PM2.5."

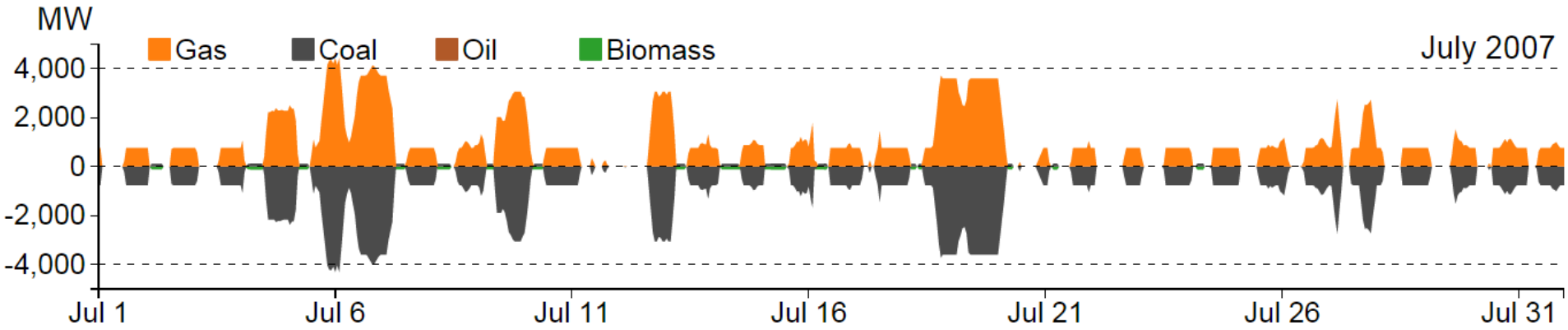
"Hidden Costs of Energy" NRC Report

- National Research Council report estimated "hidden" (largely health from air pollution) costs from various energy sectors
  - Coal electricity generation: $62 billion ($0.035/kWh)
    - Natural gas: $0.0016/kWh
  - Transportation: $76 billion ($0.29/gal)
  - Gas heating: $1.4 billion
  - Assumed all PM was created equal
  - Did not include ozone increases at low levels

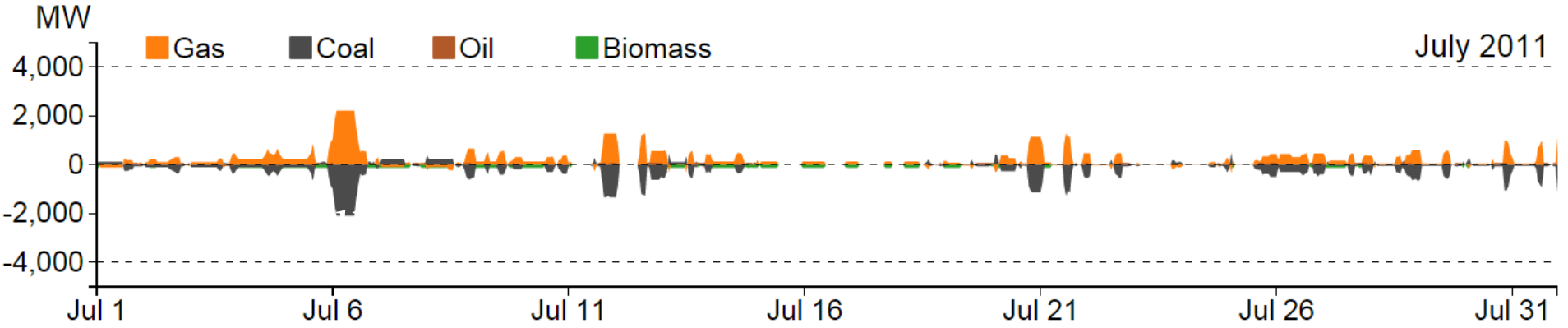
National Academies Press, Washington DC, 2010.

Impact of Controls on Optimization 2007 vs. 2011

Assessed the impact of including health costs on generation mix in Georgia

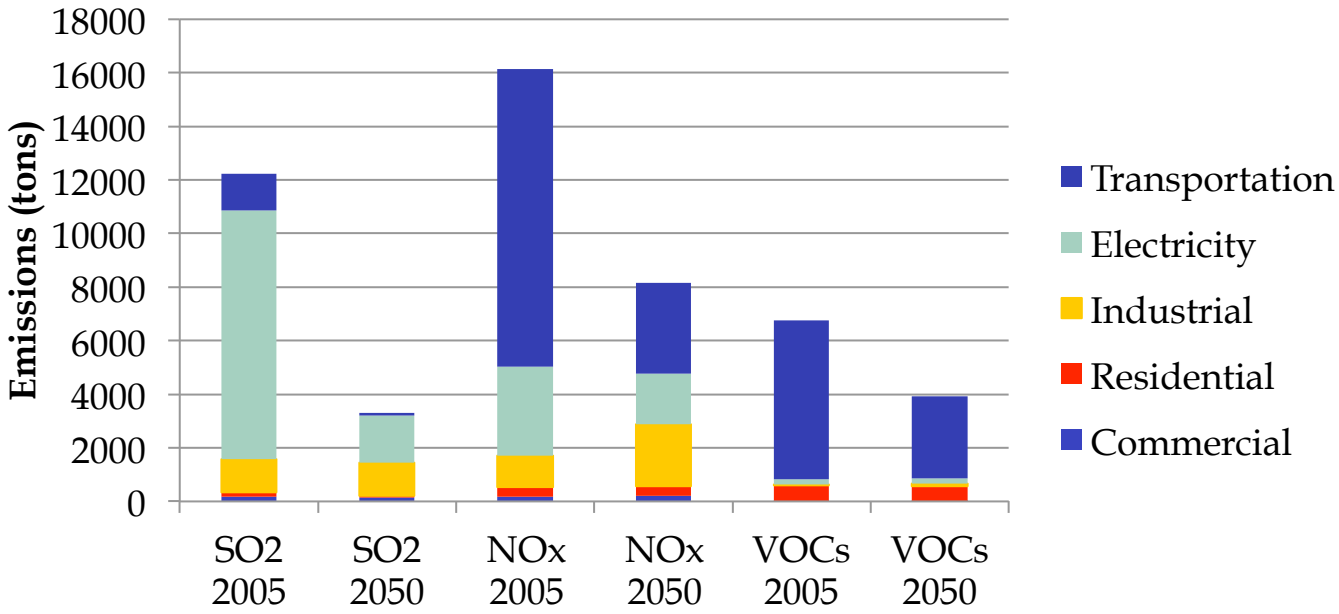


Including costs would lead to increased natural gas use (2007), but the impact of SO2 controls (2011 vs. 2007) lead to less switching:

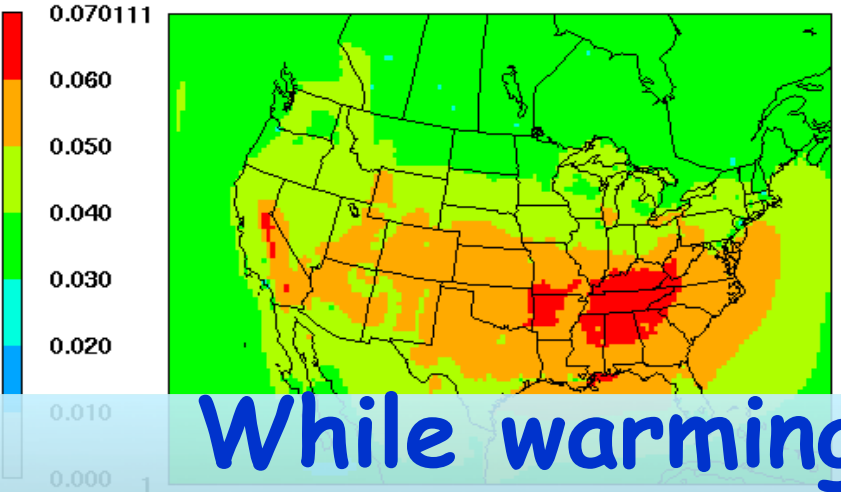


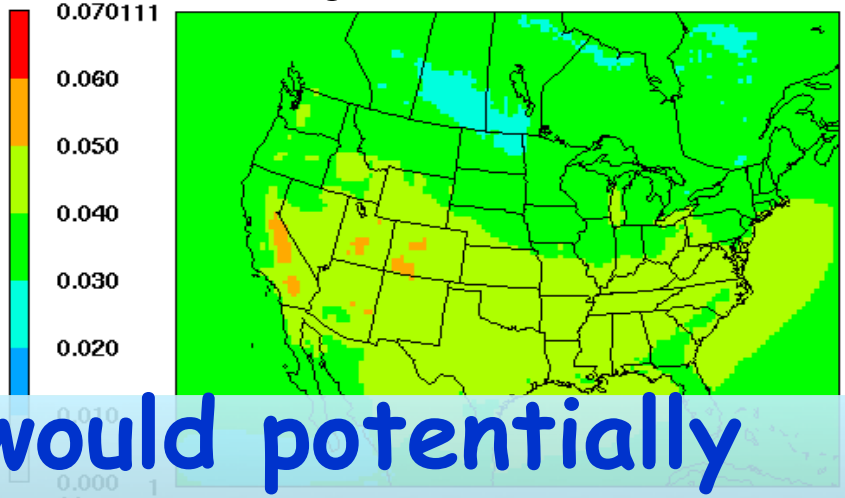
What about the future

- Emissions should keep going down
  - Except for ammonia (?) and biogenic (inc. fires)
- Climate change could make things worse
  - Climate penalty (0-~10 ppb)

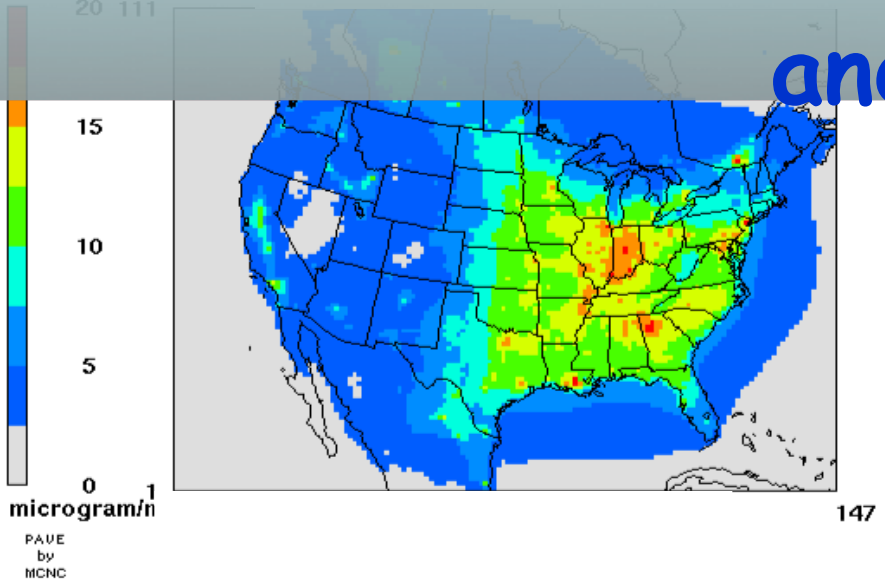


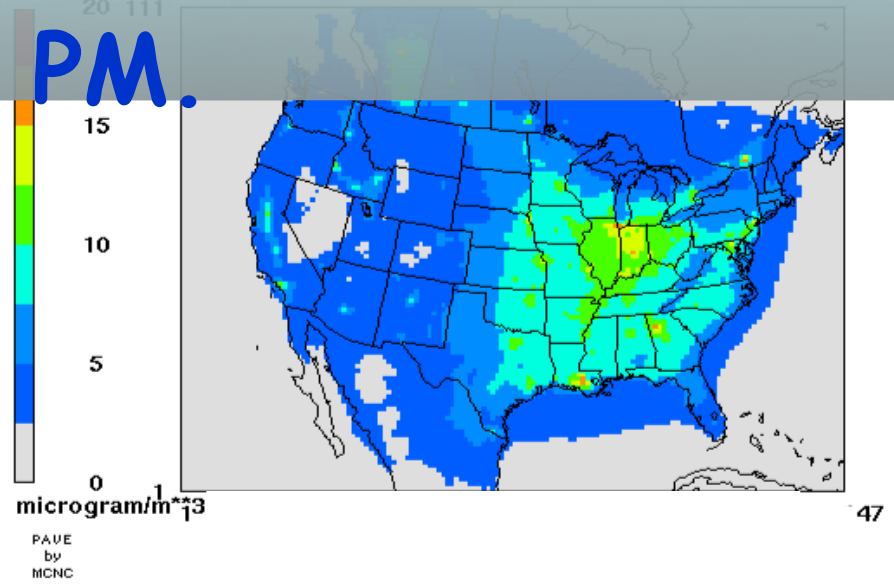
SUMMER O_3





While warming would potentially enhance ozone formation (0-10 ppb), controls will continue to reduce ozone and PM.





Summary

- Air pollution is a (relatively) unrecognized major source of a long term health burden in the US and worldwide
- Controls have led to dramatic improvements in the US which will continue in to the future
  - Future reductions in ozone will be small and accompanied by increases in low levels
    - Important if exposure to low levels of ozone have similar health impacts as higher levels (e.g., on a ppb basis)
- Can develop source specific relationships between emissions and air quality
  - Air quality to health more uncertain
  - There is mixed evidence of varying health impacts of PM derived from different sources
- How should the impacts of energy use on air quality and health guide policies and selection of energy sources?
  - Answer might change as emissions/activity drop