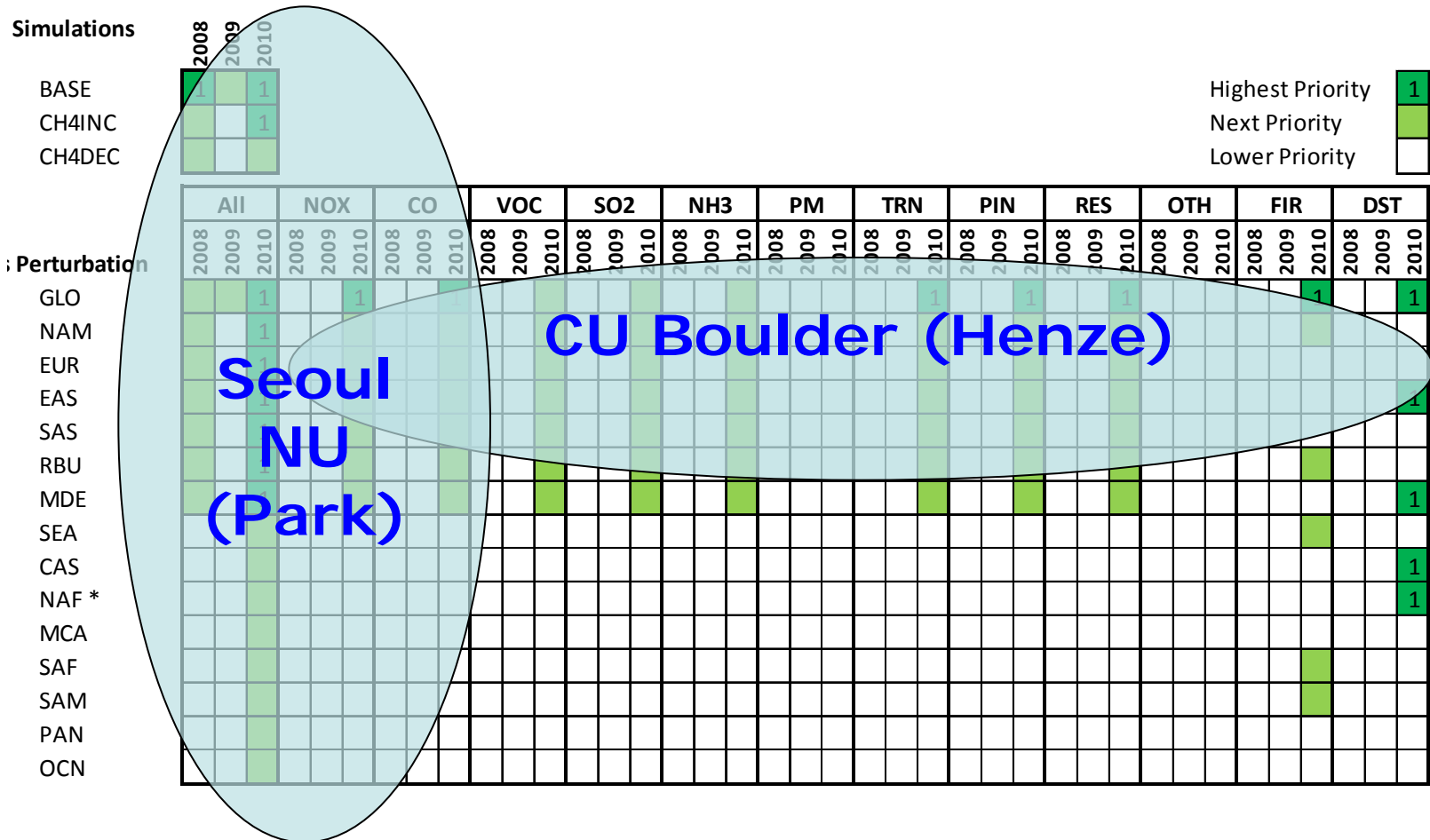


# GEOS-Chem *preliminary* HTAP results

Daven Henze, Yanko Davila, Kateryna Lapina (CU Boulder)  
Rokjin Park, Duseong Jo (Seoul National University)

# GEOS-Chem HTAP modeling



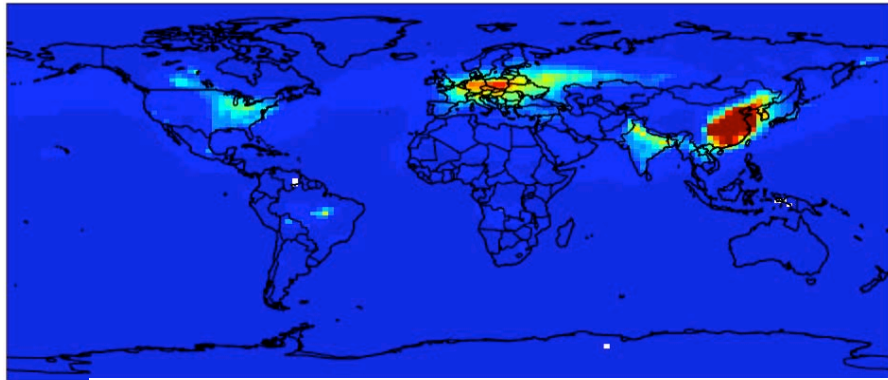
Also: POPs, Hg (Selin, MIT)

# GEOS-Chem configuration

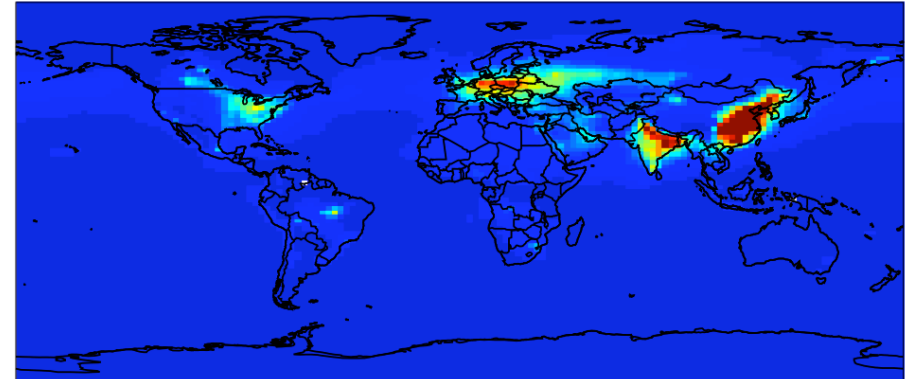
- GEOS-5 meteorology
- Standard set of HC, O<sub>3</sub>, NO<sub>x</sub>, aerosols
- HTAP recommended volcano, GFEDv3 burning...
- v9-01-02 gas-phase scheme
  - + PM<sub>2.5</sub> (other)
  - + PM<sub>10</sub> (other)
  - + transport tracers
  - + SOA (Park)
  - + adjoint sensitivities (Henze):
    - reaction rate constants
    - stratospheric prod / loss rates
    - emissions

# Impacts of NAM $\text{SO}_2$ emissions on $\text{SO}_4 + \text{NO}_3 + \text{NH}_4$

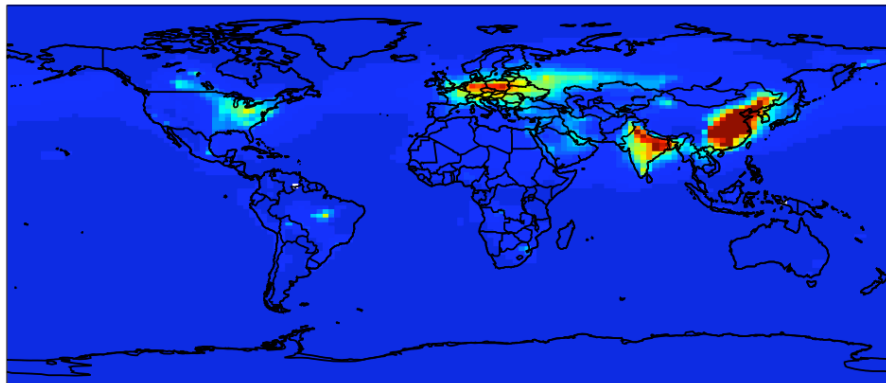
GEOS-Chem



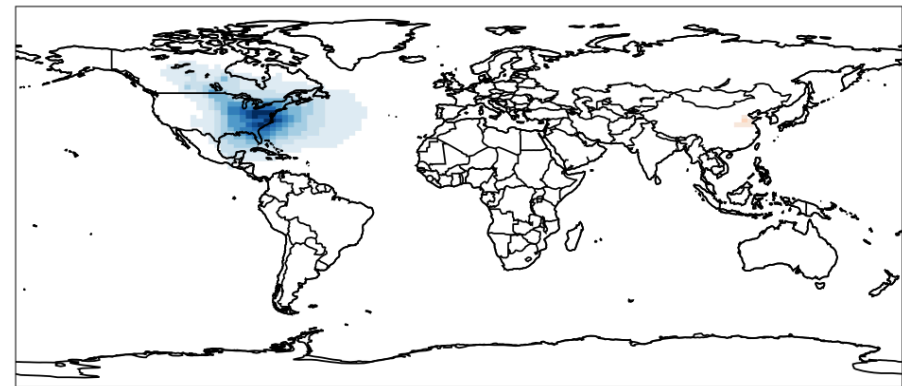
HTAP base



HTAP pert (GLB PIN ALL -20%)

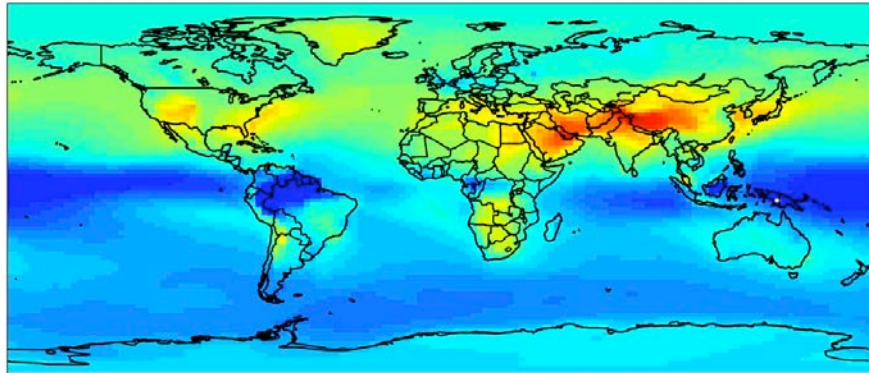


HTAP pert - base



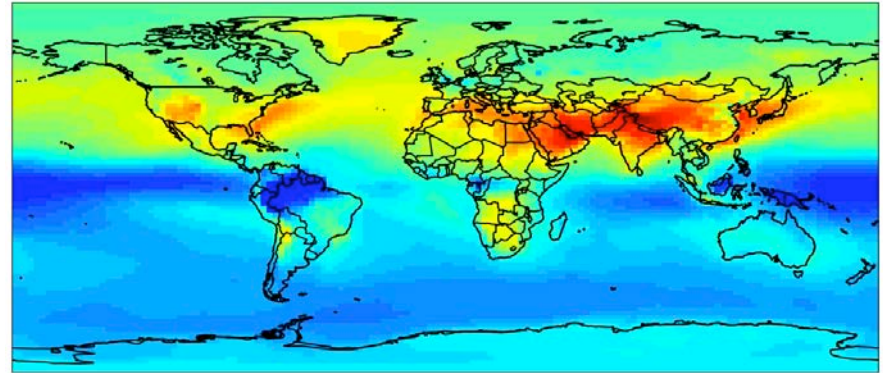
# Impacts of global TRANSPORT emissions on O<sub>3</sub>

GEOS-Chem



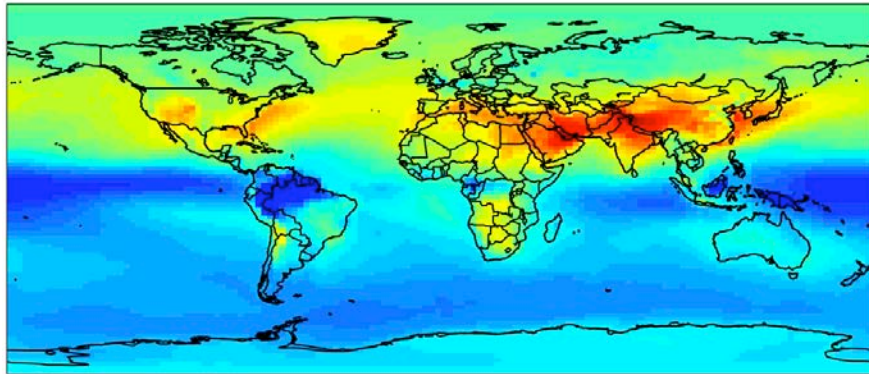
known ~15 ppb high bias in eastern U.S.  
summer e.g., Lapina et al., in press

HTAP base

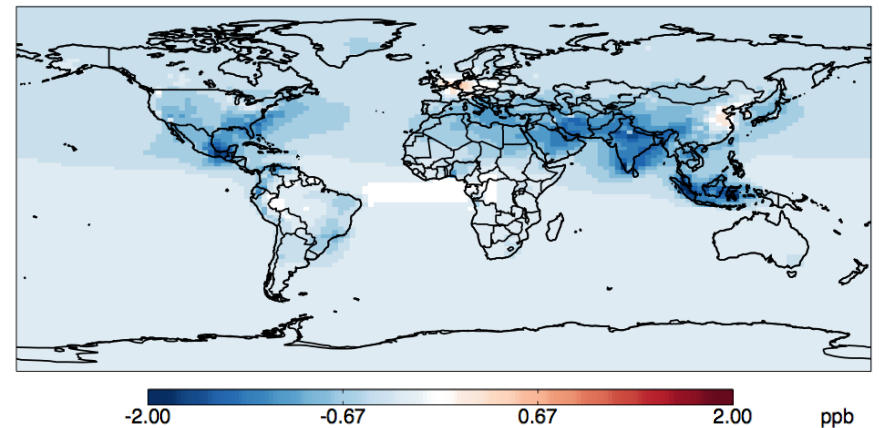


ppb  
HTAP is even higher! Which NEI  
for US NO<sub>x</sub> emissions?

HTAP pert (GLB TRN ALL -20%)



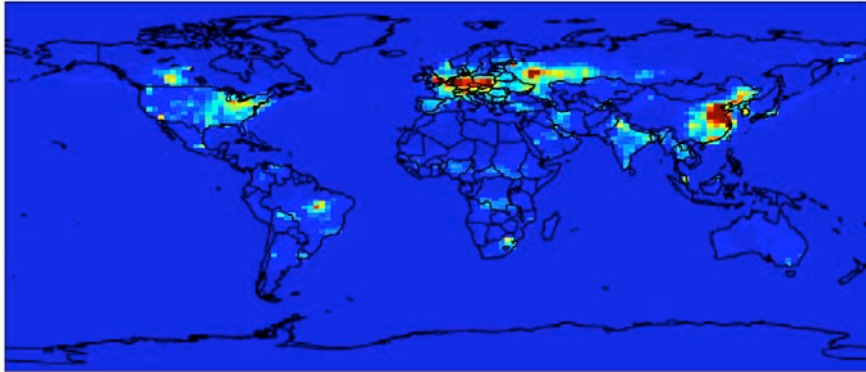
HTAP pert - base



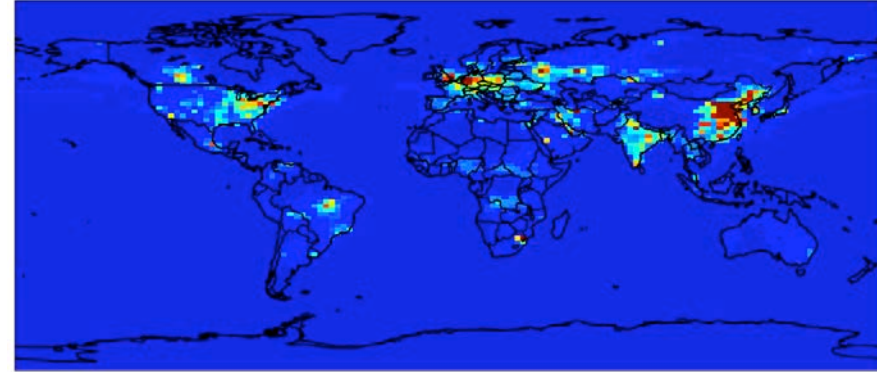


# Impacts of global POWER + INDUSTRIAL emissions on NO<sub>x</sub>

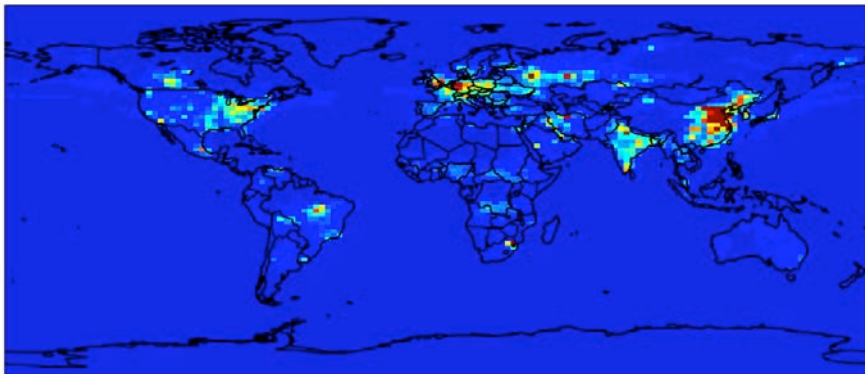
GEOS-Chem



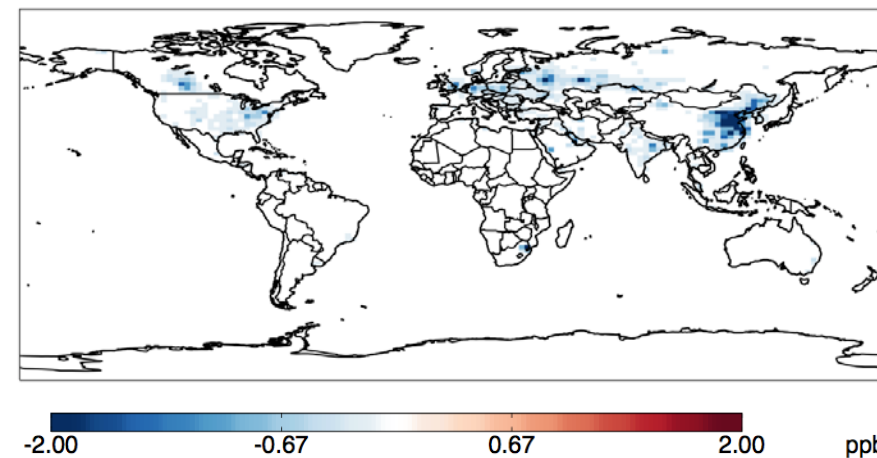
HTAP base



HTAP pert (GLB PIN ALL -20%)

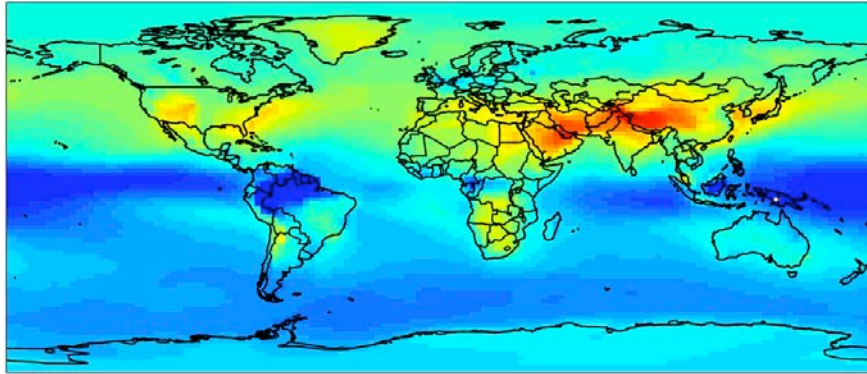


HTAP pert - base

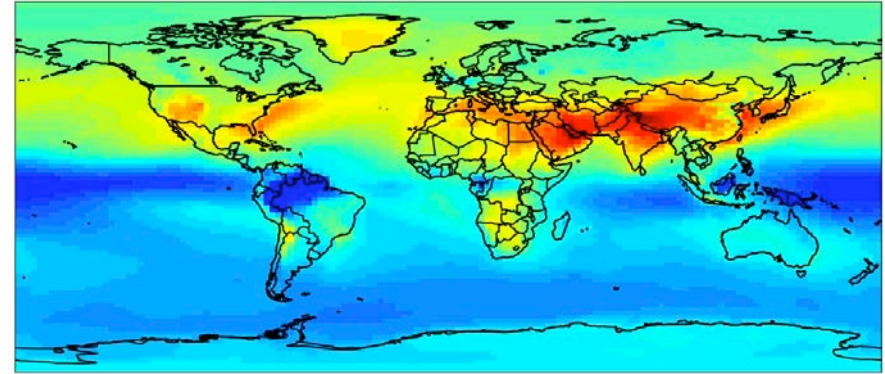


# Impacts of NAM $\text{NO}_x$ emissions on $\text{O}_3$

GEOS-Chem

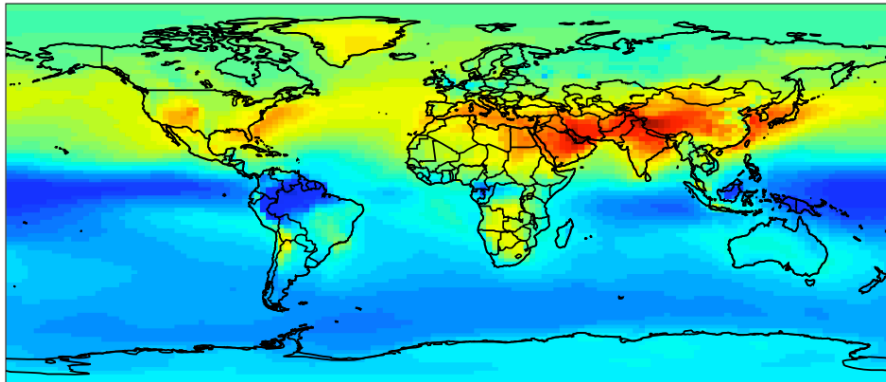


HTAP base

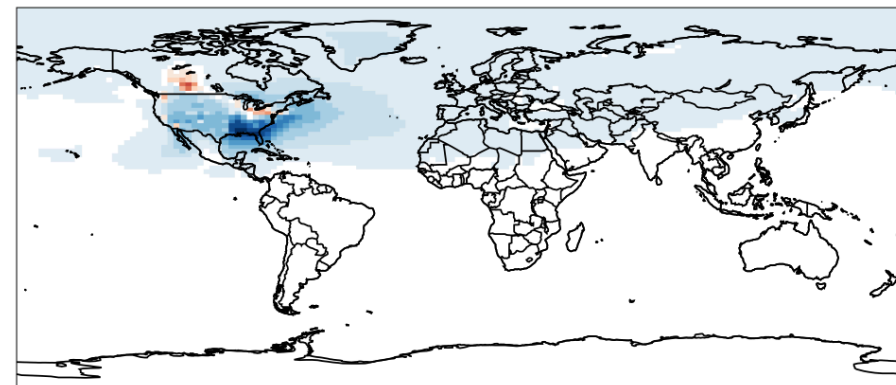


ppb

HTAP pert (GLB PIN ALL -20%)

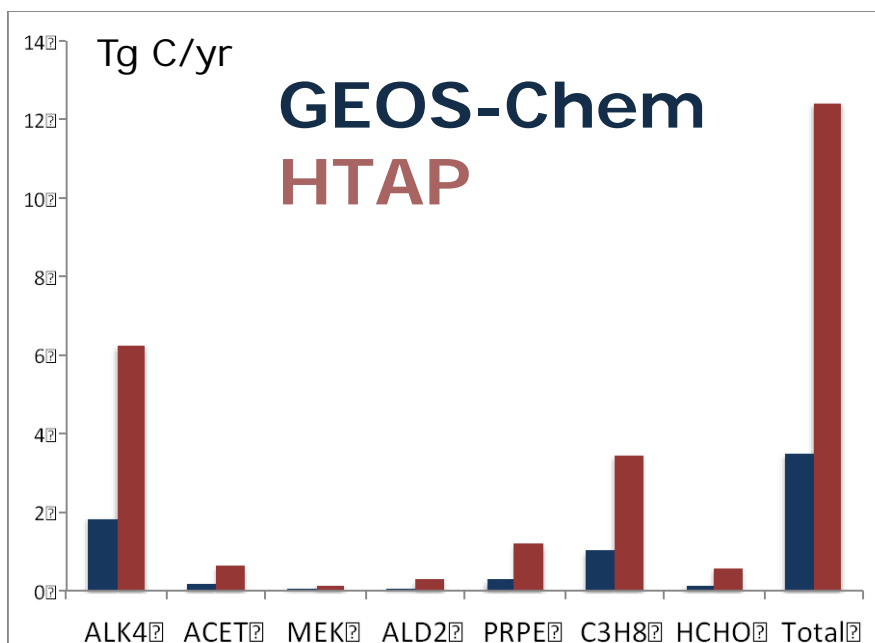
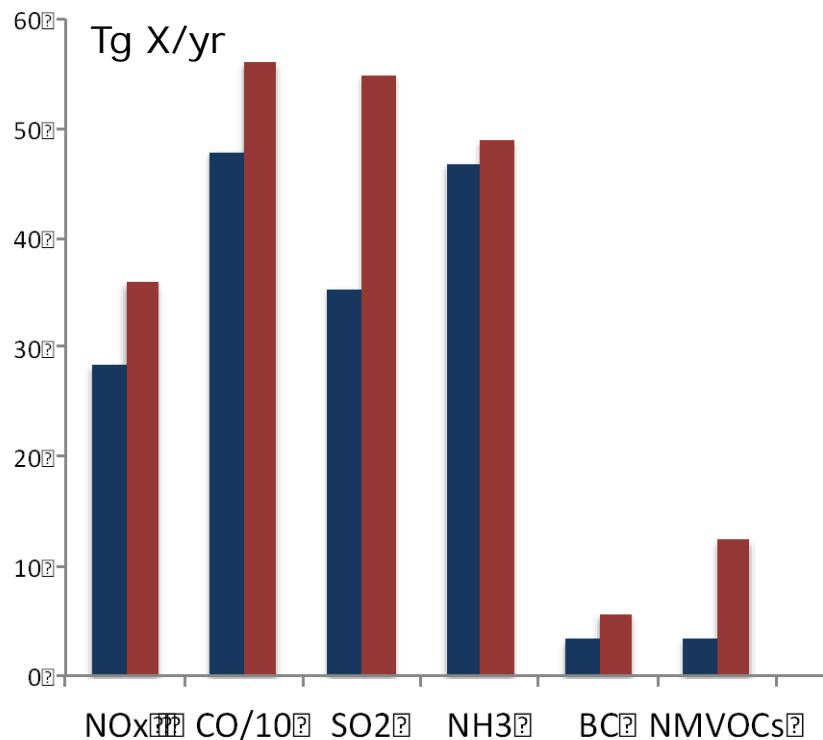


HTAP pert - base



ppb

# GEOS-Chem vs HTAP emissions



Total VOCs in GEOS-Chem scaled to match HTAP total VOCs, retaining diurnal / day-of-week variability...

...but set of species that are included is not the same!



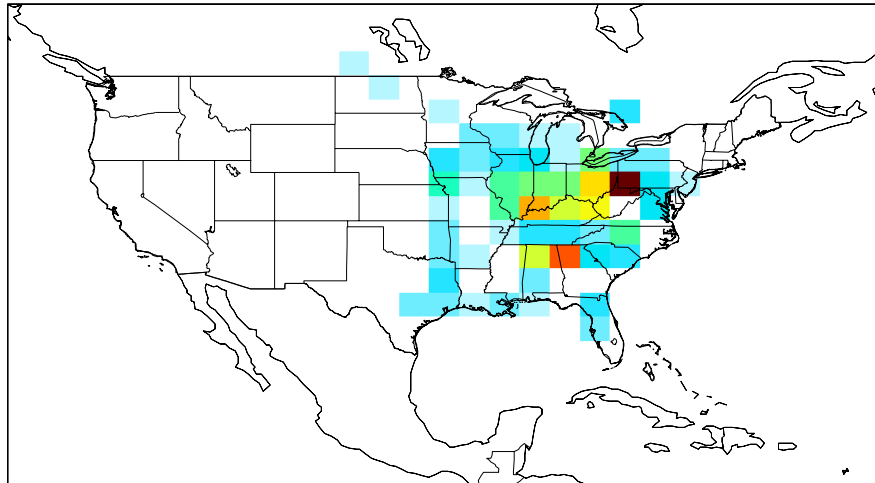
# Source attribution of PM<sub>2.5</sub> related mortality\*

Source contributions to US national mortality from PM<sub>2.5</sub> using population, mortality rates, and relative risk from BenMAP

- total estimated in forward model to be 140,000 / yr
- compare to 130,000 / yr from Fann et al. (2012)

Adjoint benefits by location / sector / species of 20% reduction:

From all anthro SO<sub>2</sub> (1330)



[deaths]

From all anthro NO<sub>x</sub> (11,051)



[deaths]

*\*preliminary analysis based on March alone*

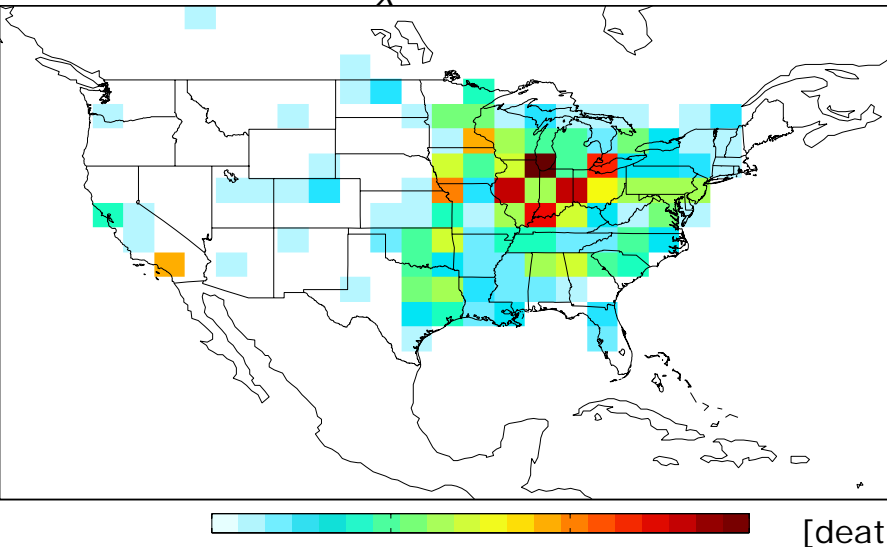
# Source attribution of PM<sub>2.5</sub> related mortality\*

Source contributions to US national mortality from PM<sub>2.5</sub> using population, mortality rates, and relative risk from BenMAP

- total estimated in forward model to be 140,000 / yr
- compare to 130,000 / yr from Fann et al. (2012)

Adjoint benefits by location / sector / species of 20% reduction:

Power NO<sub>x</sub>



Transportation NO<sub>x</sub>



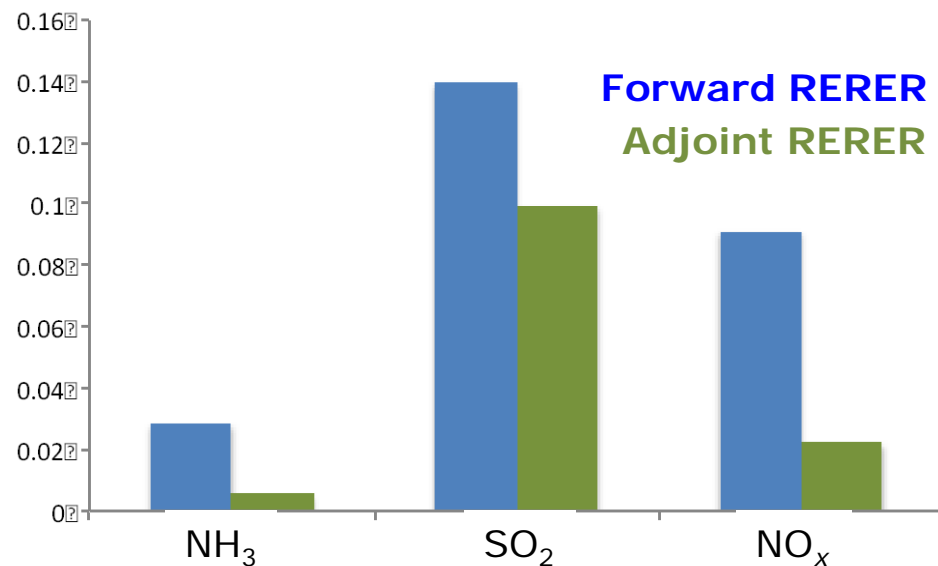
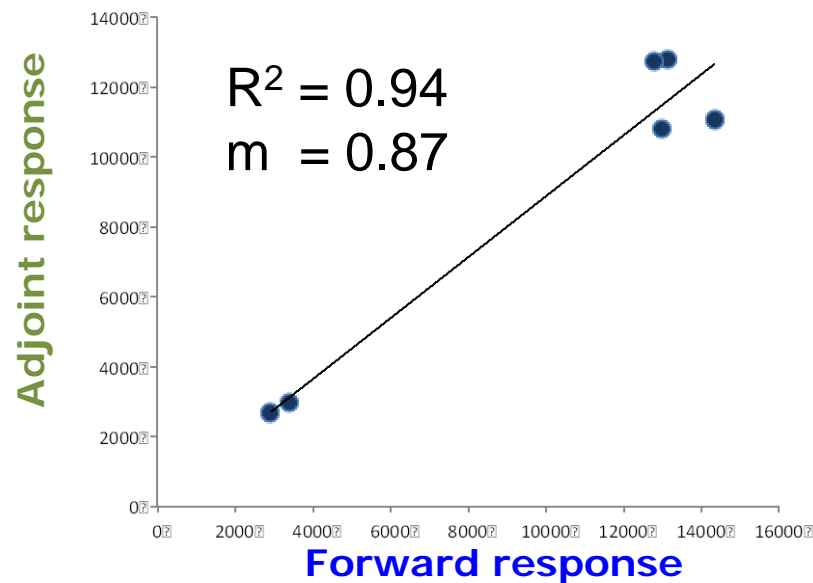
*\*preliminary analysis based on March alone*

# Source-Receptor / Source-Attribution Comparisons (WP 2.6)

Compute SIA-related mortality response in NAM to:

- GLB perturbations of  $\text{NH}_3$ ,  $\text{NO}_x$ , and  $\text{SO}_2$
- NAM perturbations of  $\text{NH}_3$ ,  $\text{NO}_x$ , and  $\text{SO}_2$

Compute RERER based on fwd and adjoint:



*Bonus slides!*

# Integrated Radiative Forcing

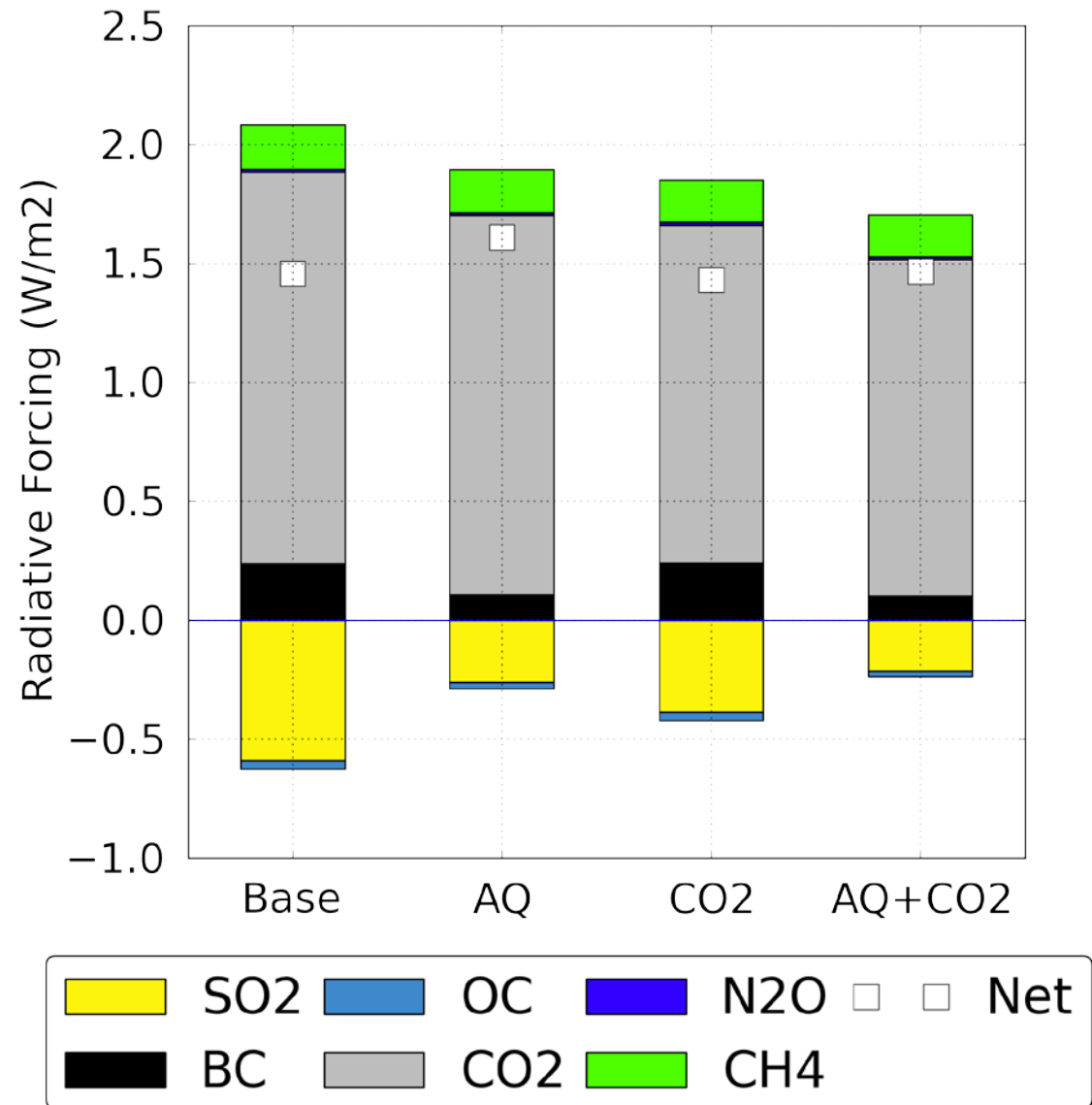
Reductions in light scattering  
aerosols from AQ regulations  
→ increase in near-term warming.

CO<sub>2</sub> cap reduces near-term  
warming, offsetting the climate  
effects of the air quality  
regulations.

- Emission scenarios are evaluated for *Total Integrated Radiative Forcing* effects within the 45 year modeling period only

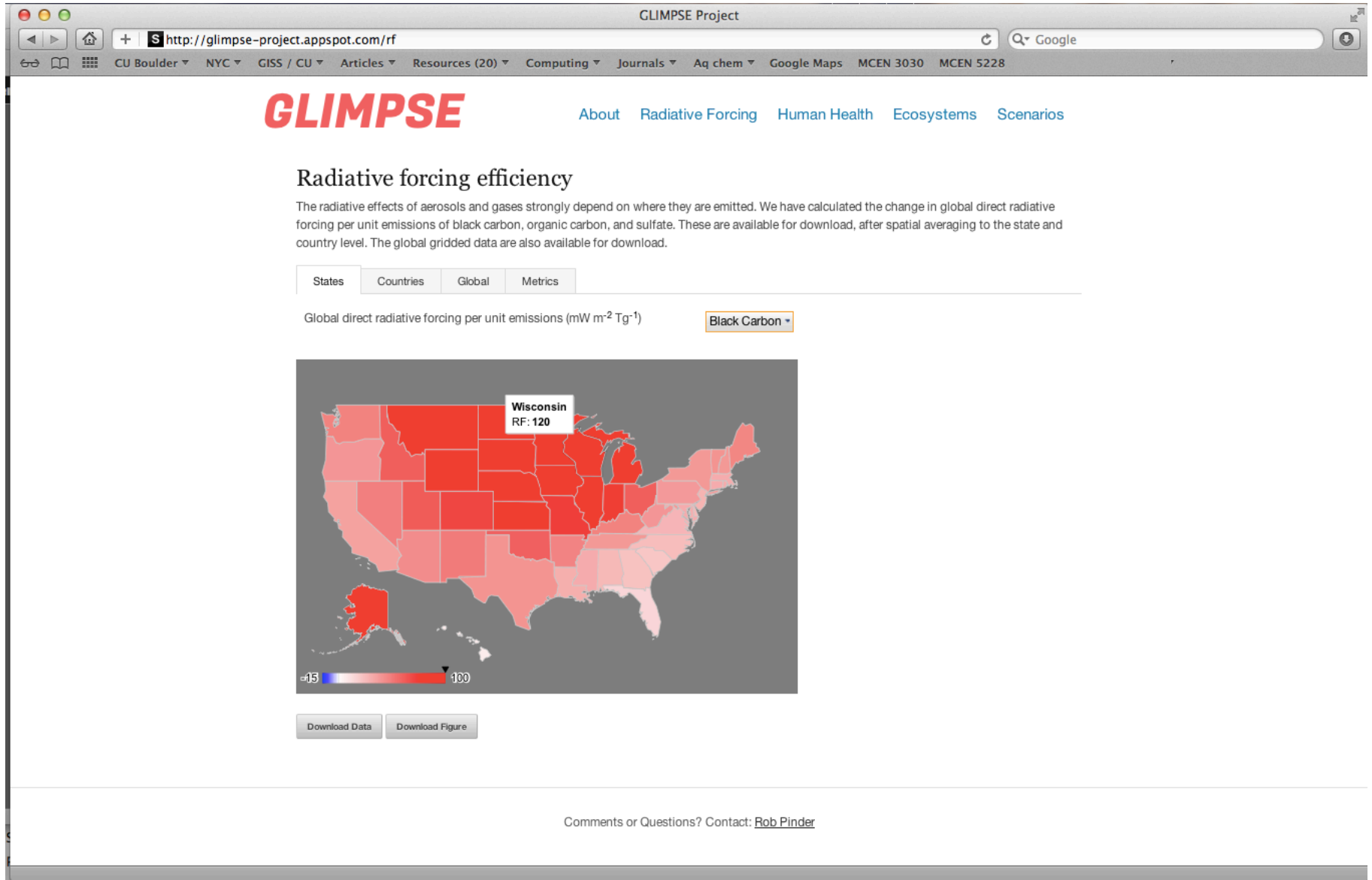
- Aerosols RF values from GEOS-Chem adjoint + LIDORT and applied regionally.

- GHGs RF effects from Shine et al. 2005 and applied nationally



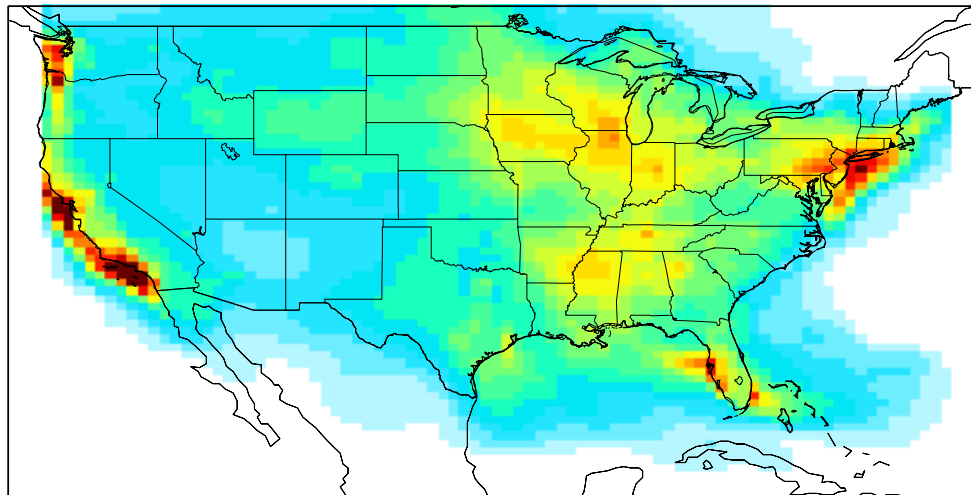


# GLIMPSE framework online



# Spatial heterogeneity in damages per unit change in emissions

Marginal damages of *any*  $\Delta\text{SO}_2$  emissions



0 10,000 20,000 30,000 [\$/ton]

*note: preliminary analysis, complete annual average results in progress*

Leads to damages being variable across sectors:

Ship > fossil fuel > bio burn

Marginal damages lower bound on impacts of total  $\text{SO}_2$  emissions

- based on \$6,000,000 per life (NRC, 2010)
- compare to other estimates:
  - average for all sources = \$1500/ton (Mendelsohn, 2007)
  - for EGUs = \$6000 / ton (NRC, 2010)
  - for EGUs = \$80,000 / ton in urban areas (Fann et al., 2009)