Analysis of climate drivers and mitigation options within the Energy, Transportation and Agriculture sectors using GISS ModelE2

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with

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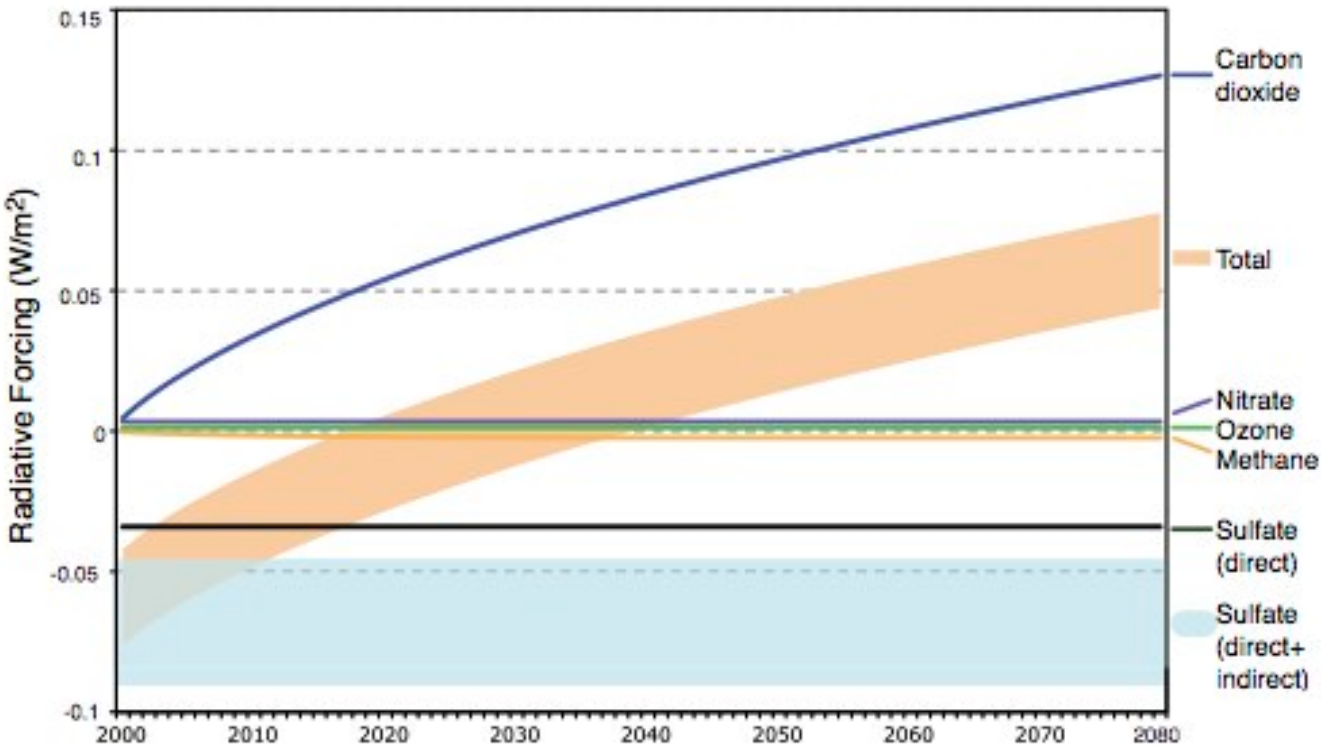
[Rob Pinder, Farhan Akhtar (US EPA)]

NASA National Climate Assessment

Context

Prior work showed balance between various pollutants time-dependent, impacts of emissions changes not always obvious

Radiative forcing due to coal-fired power plants



Shindell & Faluvegi, ACP, 2010

Project Goals

First phase:

- Study effects of US emissions by sector on climate and air pollution, impacts on human health and agriculture.
- Use same GISS model as in runs supporting IPCC AR5 (a well characterized model, both in terms of its own performance and context among other models).
- Exploration of emissions mitigation options (Obama Administration policies/goals)

In progress (extension):

- Analysis using alternate version of aerosol model (TOMAS with microphysics as in ACCMIP)
- Ozone-health impacts

Simulations with fixed-meteorology (short) and interaction (long)

Simulations Completed with Mass-based Aerosol Model

Standard scenario emissions trends

2050 conditions under RCP8.5 (control run; also 2010 for RCP8.5)

2050 conditions under RCP8.5 except 2010 US energy sector emissions

2050 conditions under RCP8.5 except 2010 US transportation sector emissions

2050 conditions under RCP8.5 except 2010 US agricultural sector emissions

Policy Interventions (Obama Administration proposals)

2030 control (RCP8.5)

2030 but US transportation emissions cut in half
(50% increase in fuel economy, all vehicles; assume fleet turnover by 2030)

2030 but US energy 70% from zero-emissions sources
(energy goal: 80% clean electricity by 2035)

Challenges

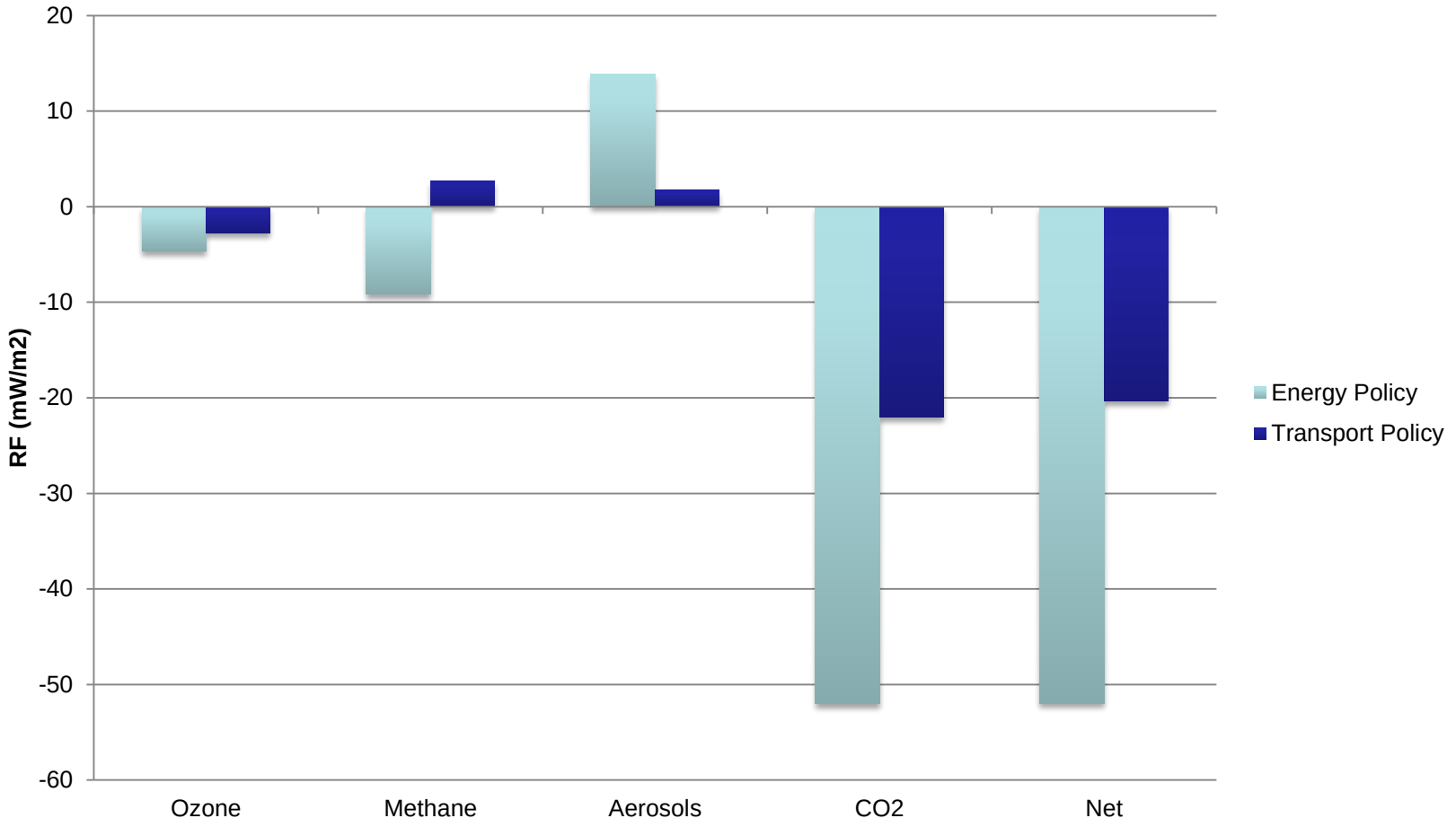
Aerosol indirect forcing very noisy!

Developed new cloud-albedo forcing diagnostic; compares well with full (ERF minus RF) for historical aerosol forcing

Used long-runs only for methane and indirect dynamical response analysis

Facilitates use of aerosol microphysics model (which is slow!)

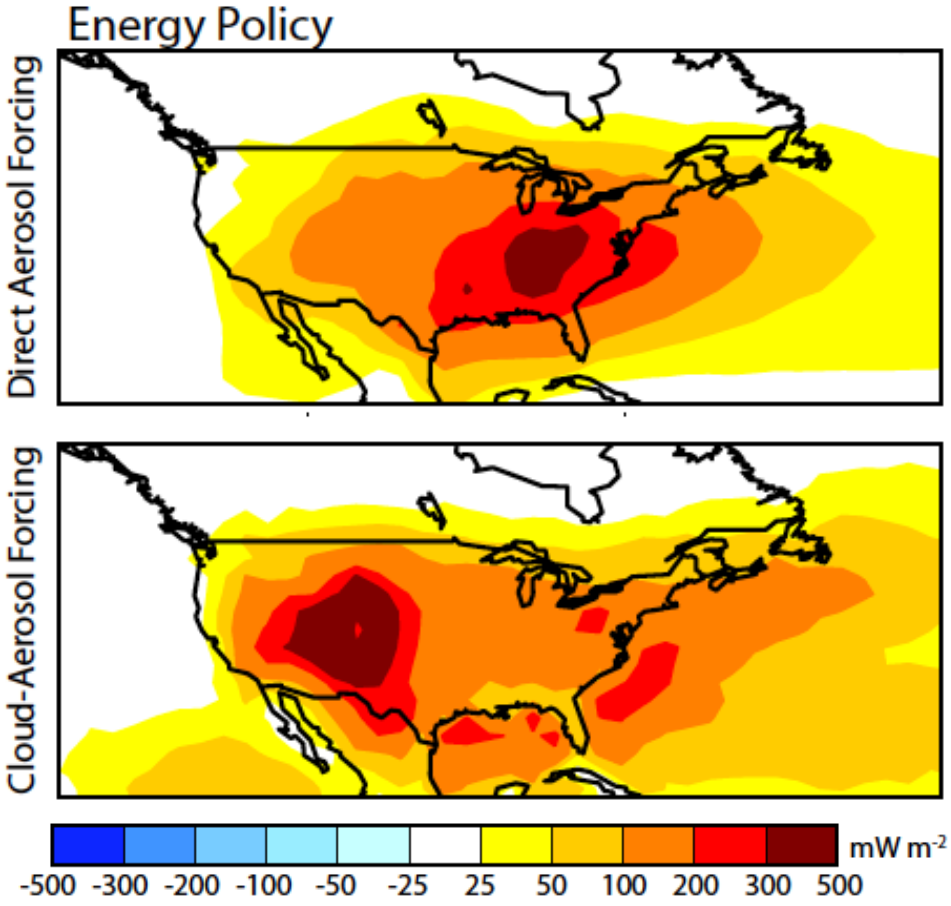
Global Average Radiative Forcing (2030)

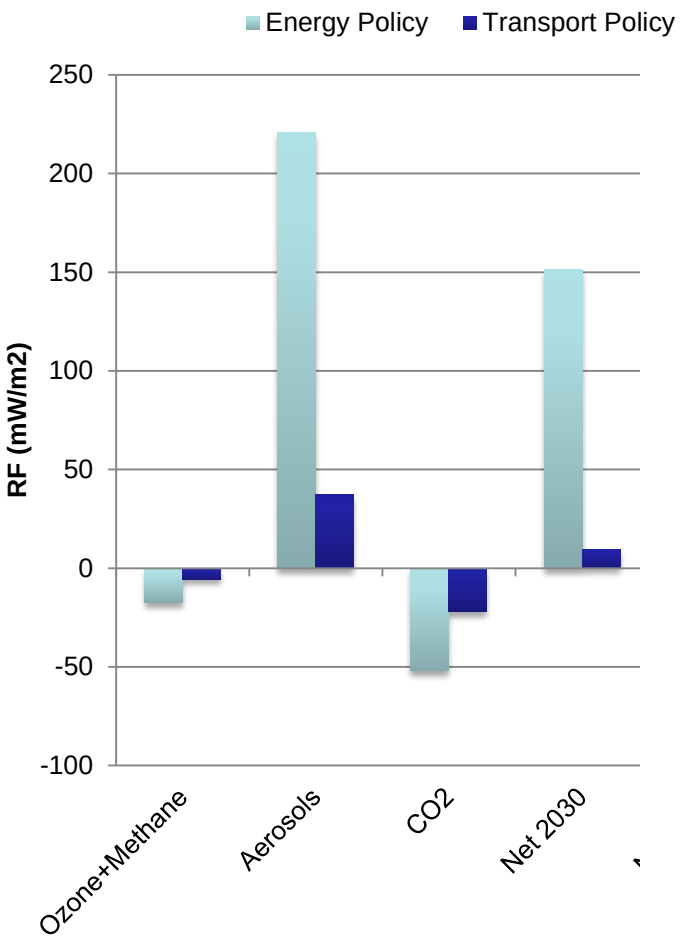


Transportation emissions reductions avoid ~0.03° C 2030 warming (0.1° C 2100)

Energy emissions reductions avoid ~0.08° C 2030 warming (0.25° C 2100)

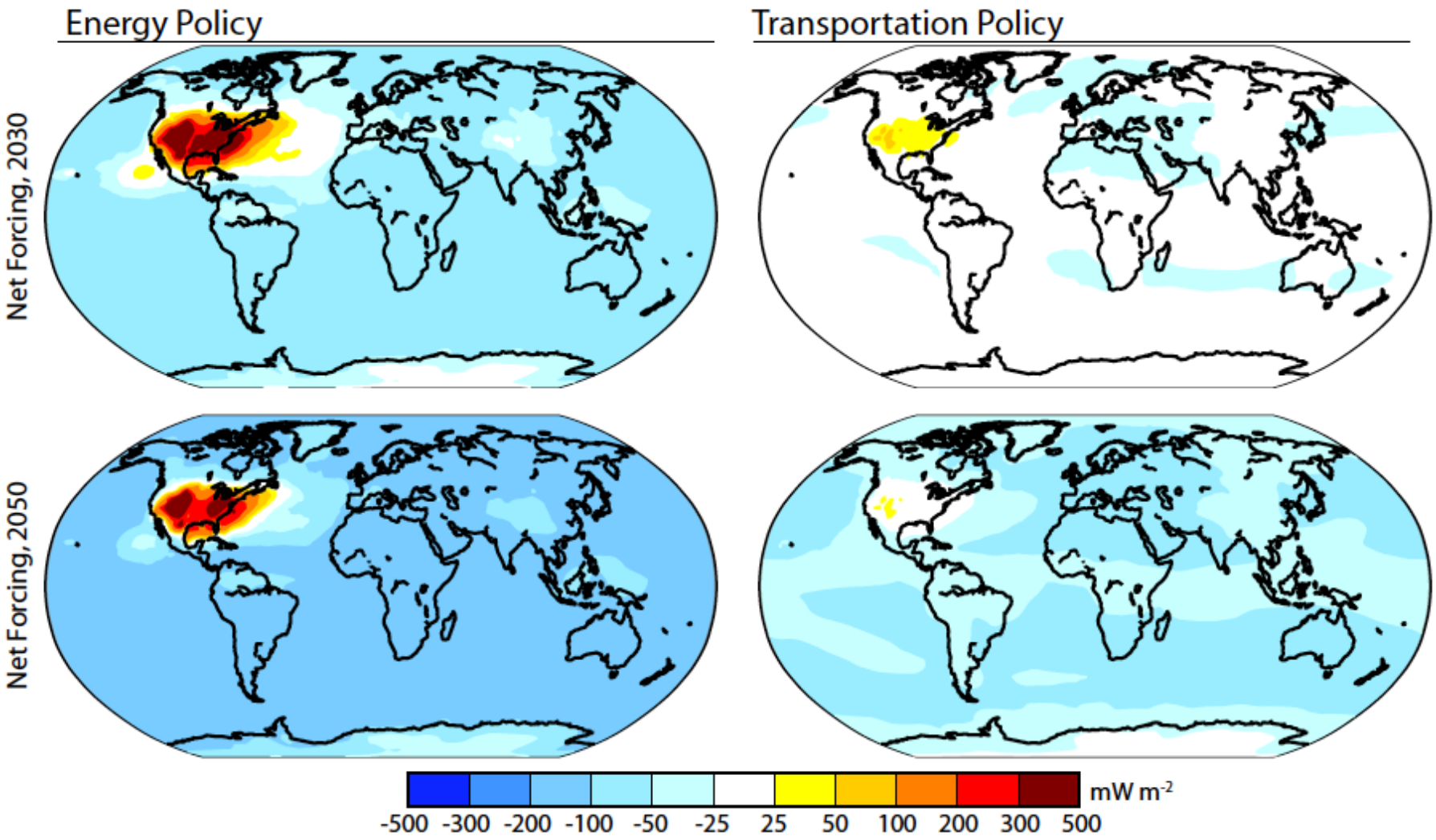
US Average Radiative Forcing





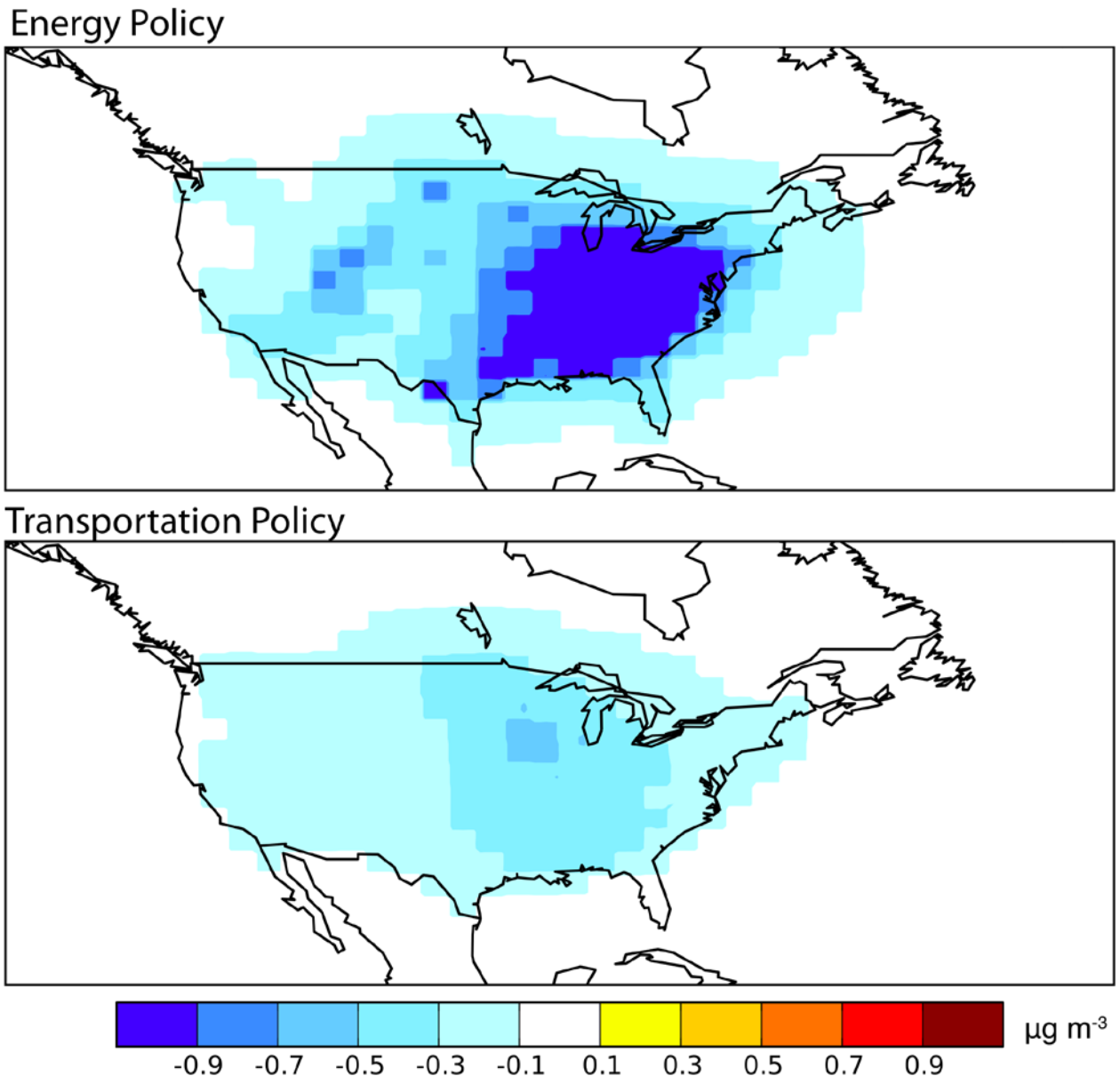
Sulfate reductions dominate US power-sector forcing (in 2030); comparable direct & indirect total but spatially distinct

Radiative Forcing



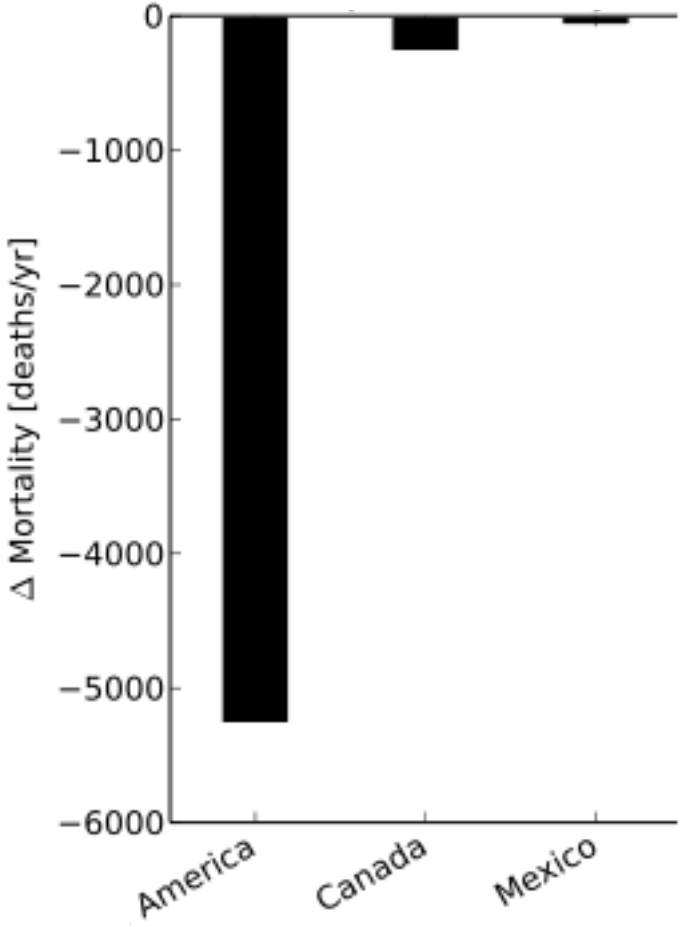
Energy benefits from international cooperation; Transportation benefits to all

Change in Surface $PM_{2.5}$

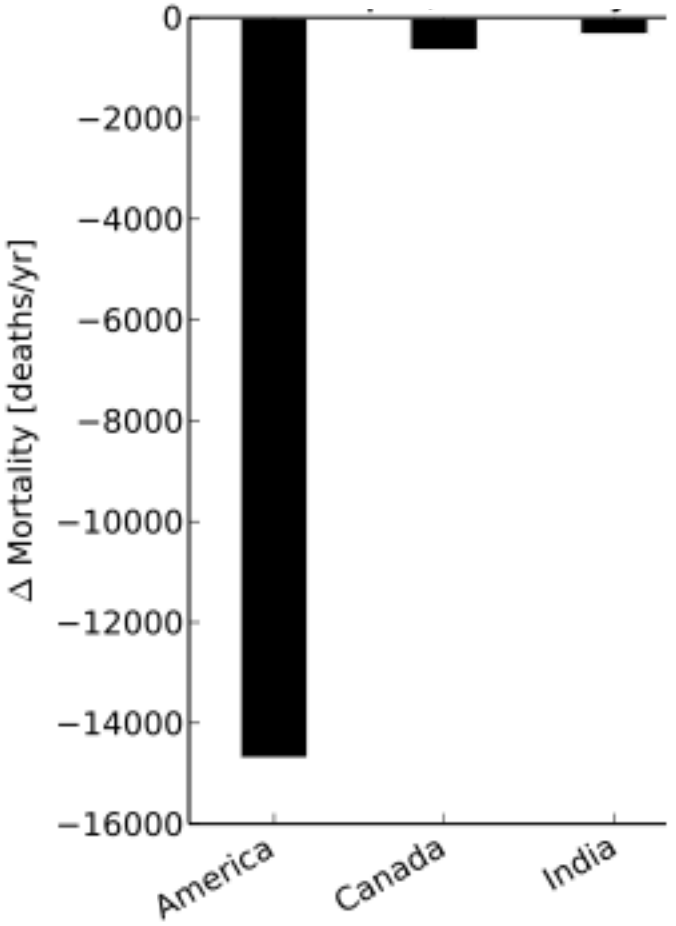


Health Effect of $PM_{2.5}$ Reductions

Transportation Policy

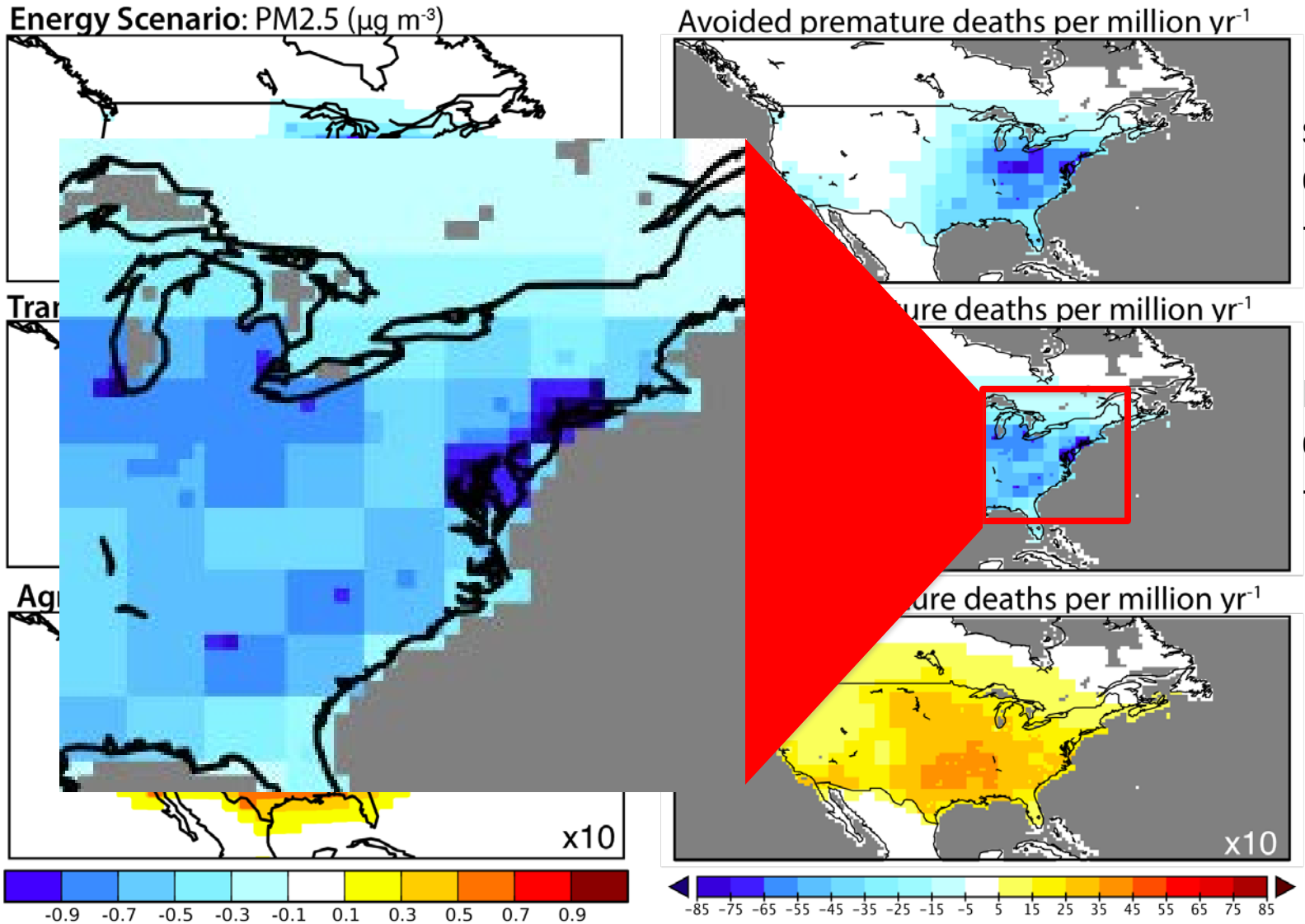


Energy Policy



Health impacts use PM2.5 downscaled to higher resolution
Using log(PM2.5), impacts 26,000 and 77,000.

$PM_{2.5}$ Changes & their Health Effects



Key projected emissions change

sulfate decrease -16 to -101k/yr

$BC/OC/NO_x$ decreases -19 to -119k/yr

NH_3 increase 1 to 8k/yr

Conclusions

Initial results presented to US Dept of Transportation; very positive response

Cooperation underway with US EPA including detailed scenario modeling for US emissions

Flexible tool can be used to analyze multiple scenarios and generate realistic global & regional climate forcing and surface pollutants

Combine with increasing knowledge on forcing/response relationships for climate impacts + detailed studies of key cases