Chemistry-Climate WG: Current and planned activities

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ChemClim WG Charter

- The goal of the Chemistry-Climate WG is to continue the development of the representation of chemistry in the CESM and to further our understanding of the interactions between chemistry and climate.
- Scientific motivations include advancing knowledge on past, present and future atmospheric composition, interactions between atmospheric composition and the Earth System, stratosphere-troposphere coupling, and impacts of global composition and climate on air quality.

Participation

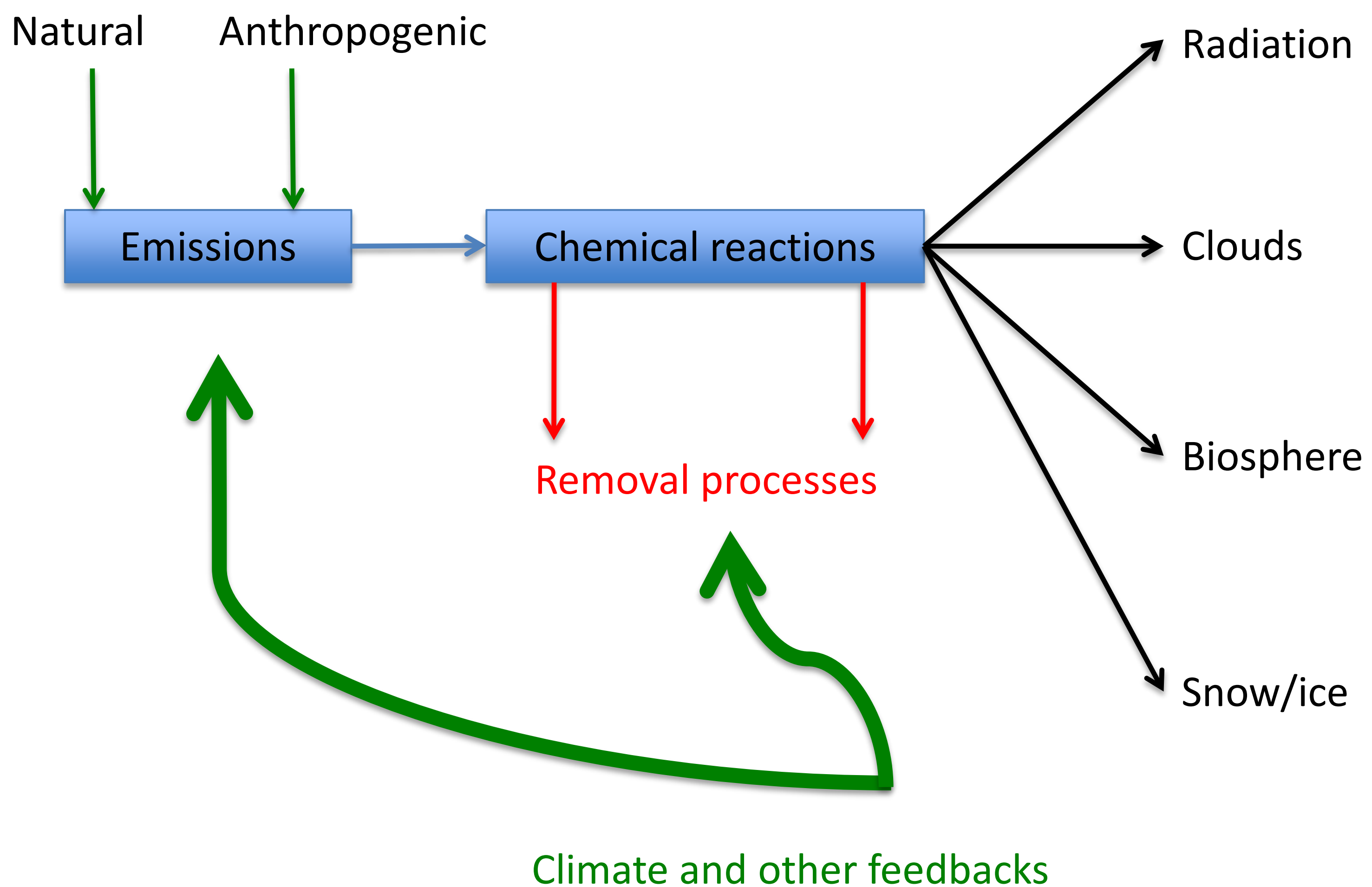
United States

- Colorado State University, Fort Collins, CO
- Cornell University, Ithaca, NY
- Jet Propulsion Laboratory, Pasadena, CA
- Lawrence Livermore National Laboratory, Livermore, CA
- Massachusetts Institute of Technology, MA
- NOAA, Boulder, CO
- Pacific Northwest National Laboratory, Richland, WA
- University of Colorado, Boulder, CO
- University of Illinois, Urbana-Champaign, IL

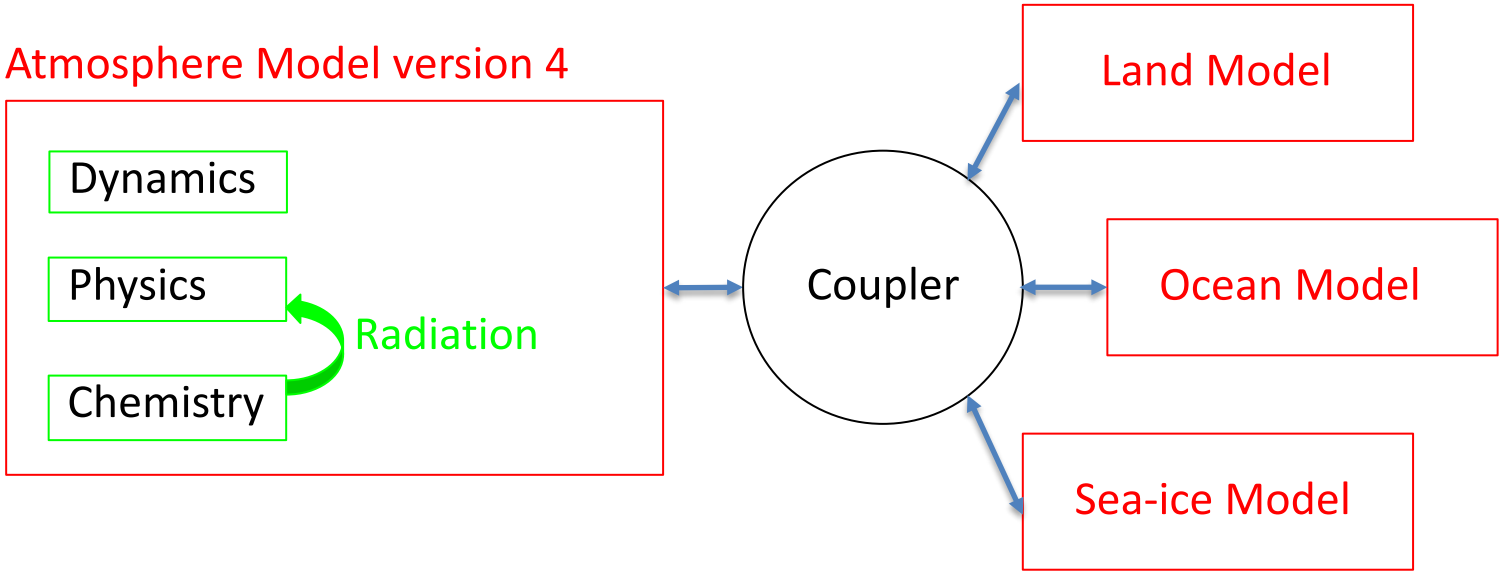
International

- Laboratory for Atmospheric and Climate Science (CIAC), CSIC, Toledo, Spain
- University of Leeds, UK
- University of Oslo, Norway
- University of Toronto, Canada

Chemistry in an Earth System Model

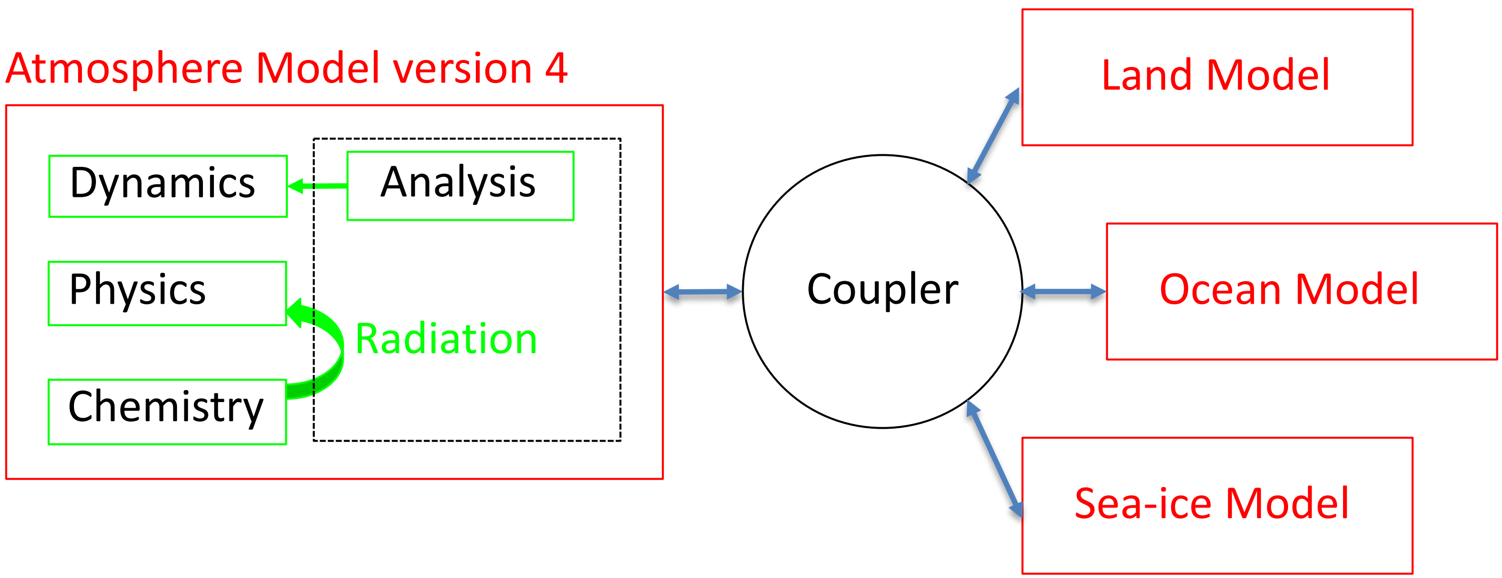


CAM-chem: chemistry in CESM



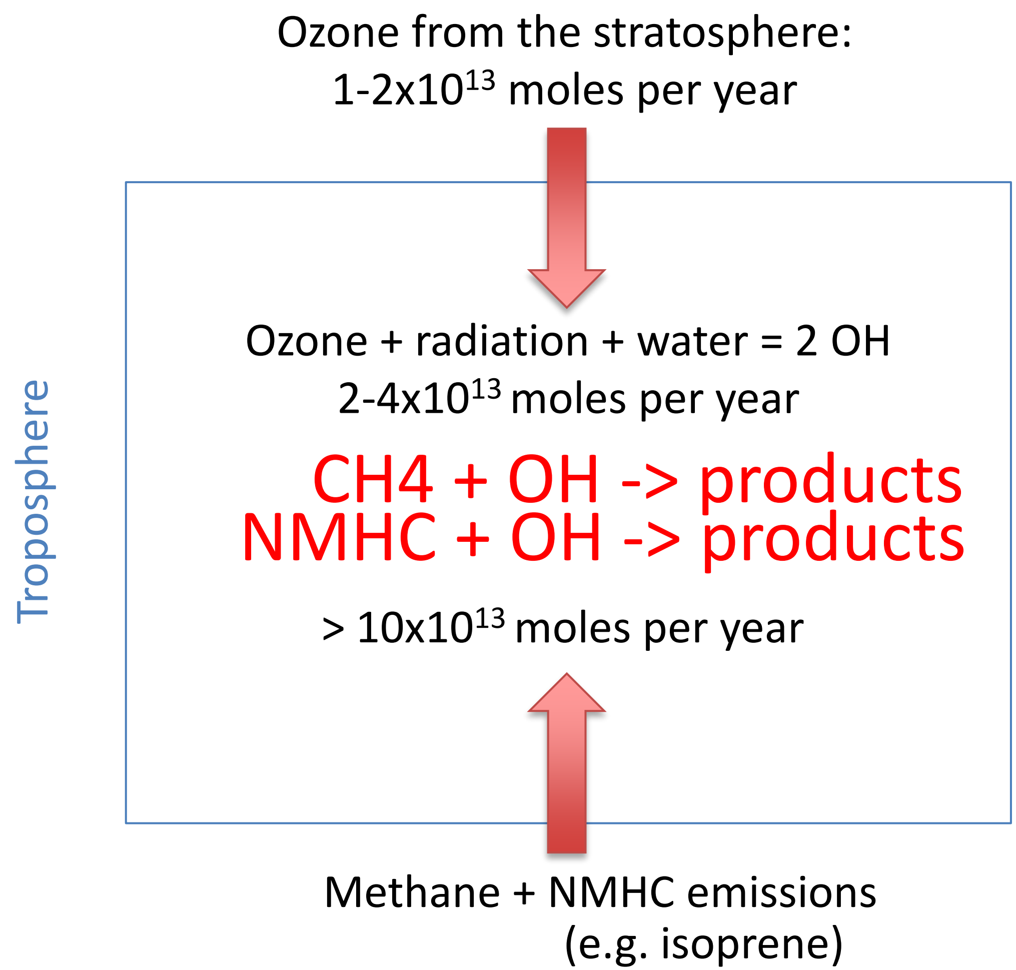
Lamarque et al., GMDD, 2011

CAM-chem: chemistry in CESM



Lamarque et al., GMDD, 2011

Why do we need extensive chemistry?



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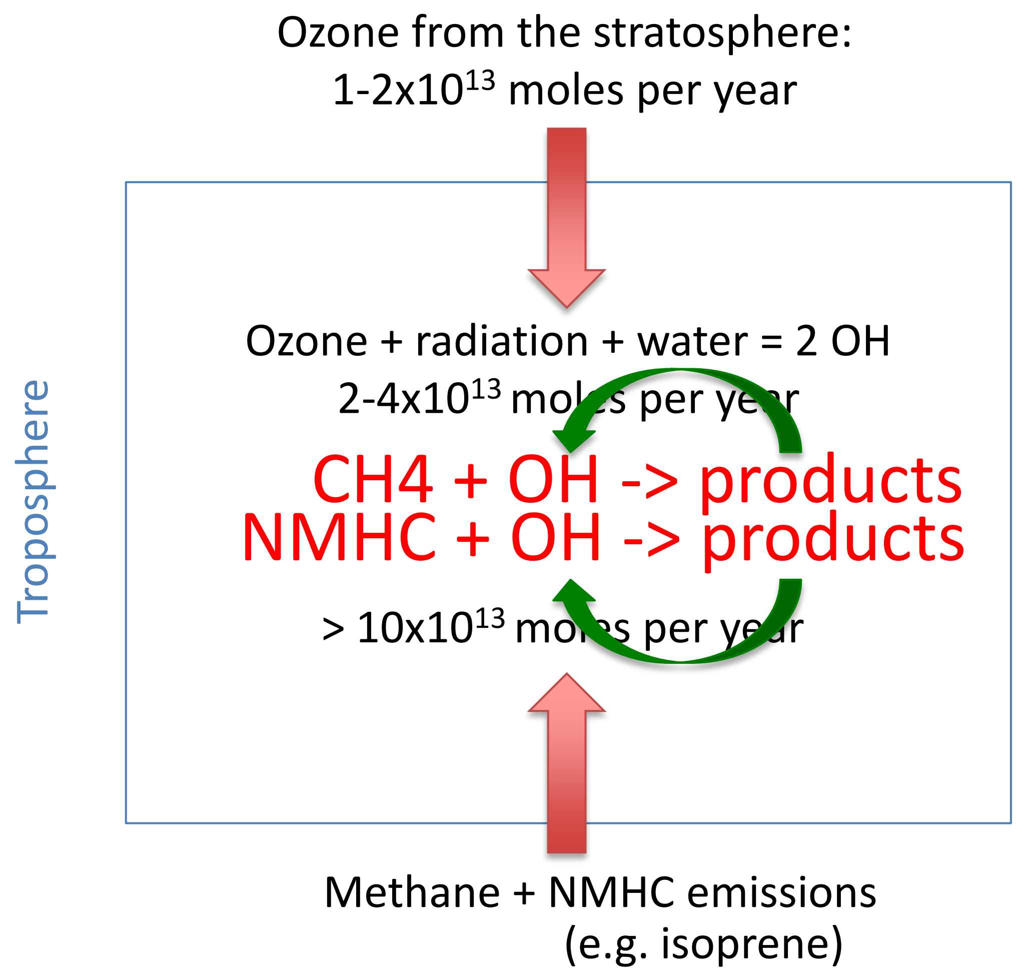
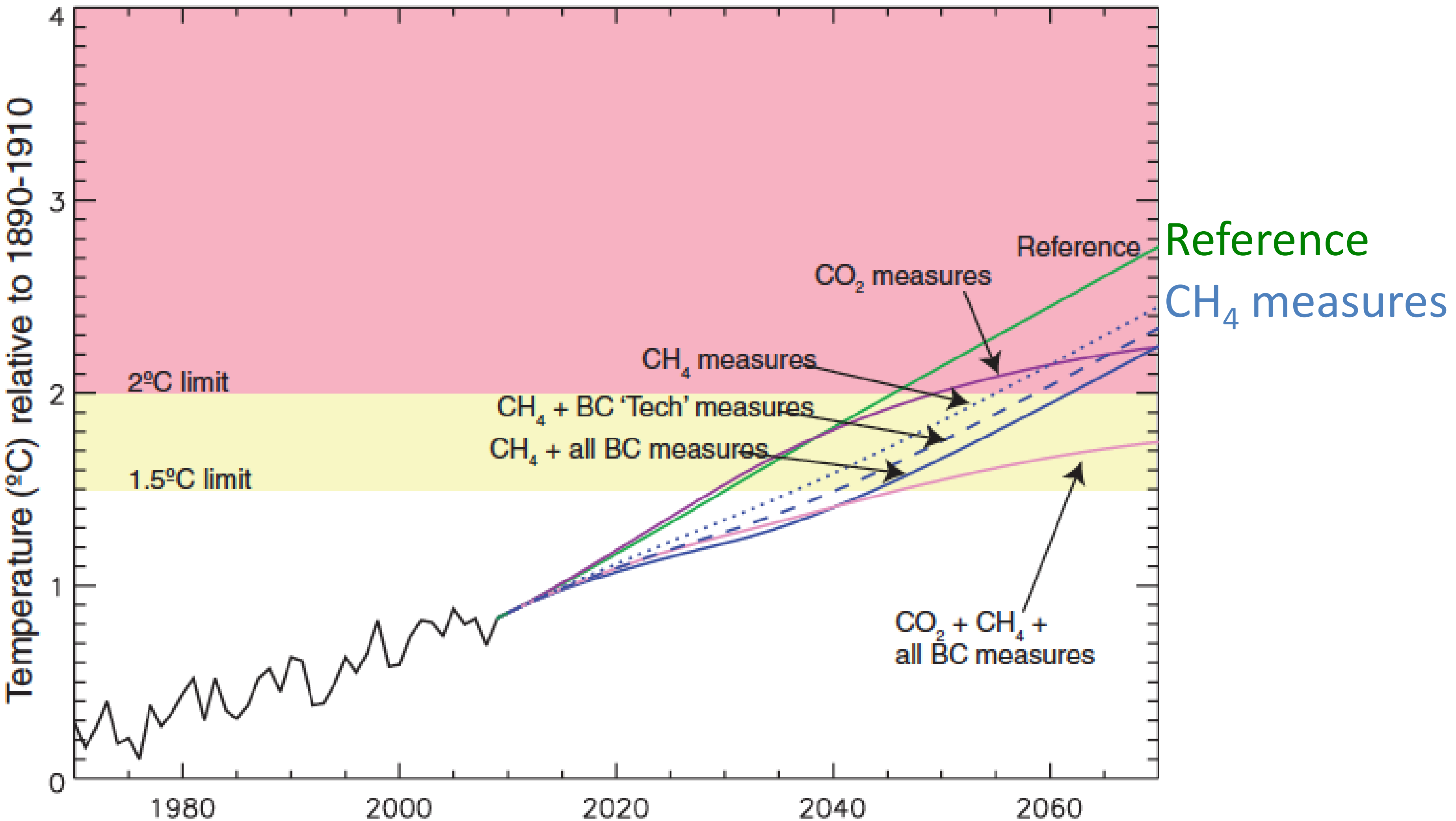


Climate benefits from methane reductions



Shindell et al., Science, 2012

Global modeling of CH4 lifetime in IPCC AR5

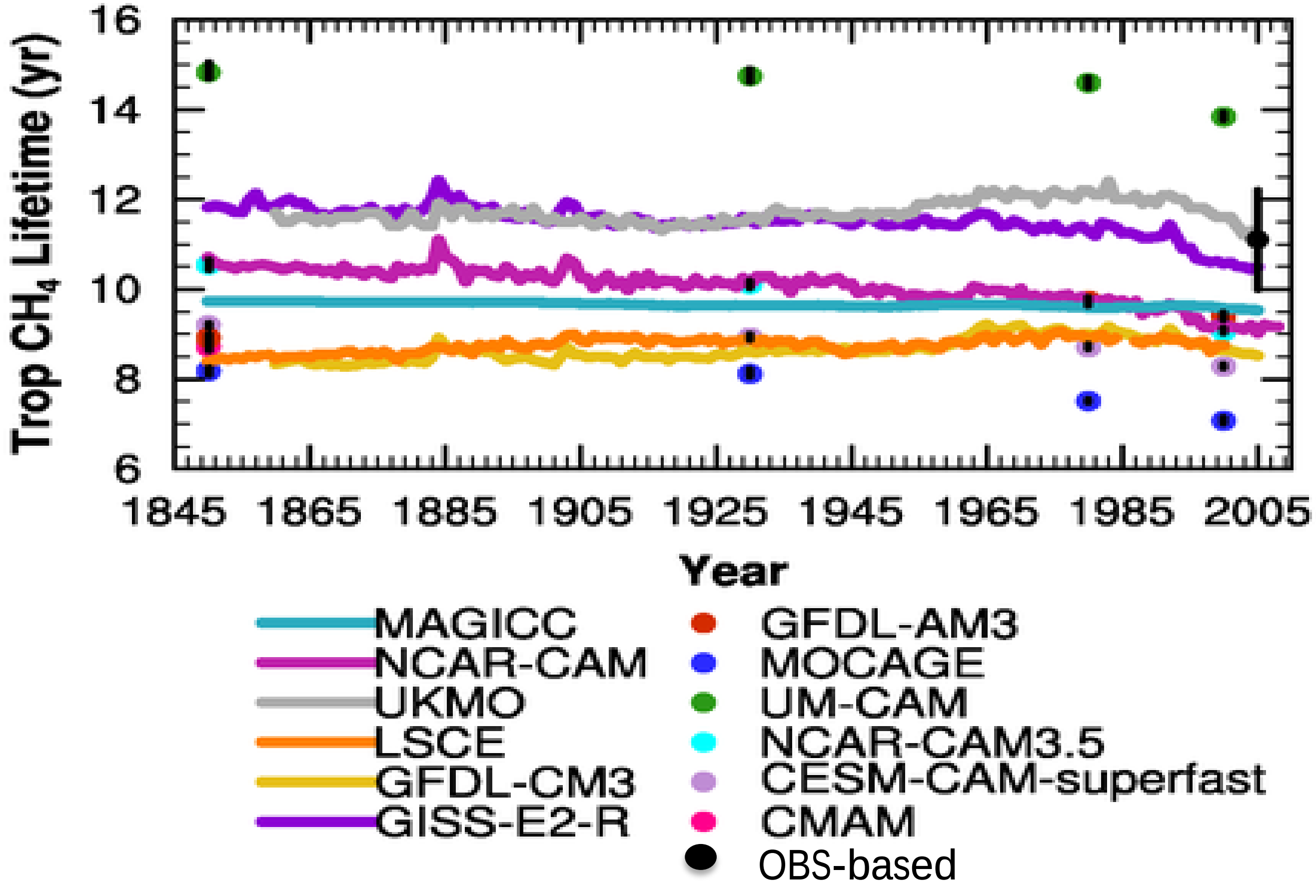
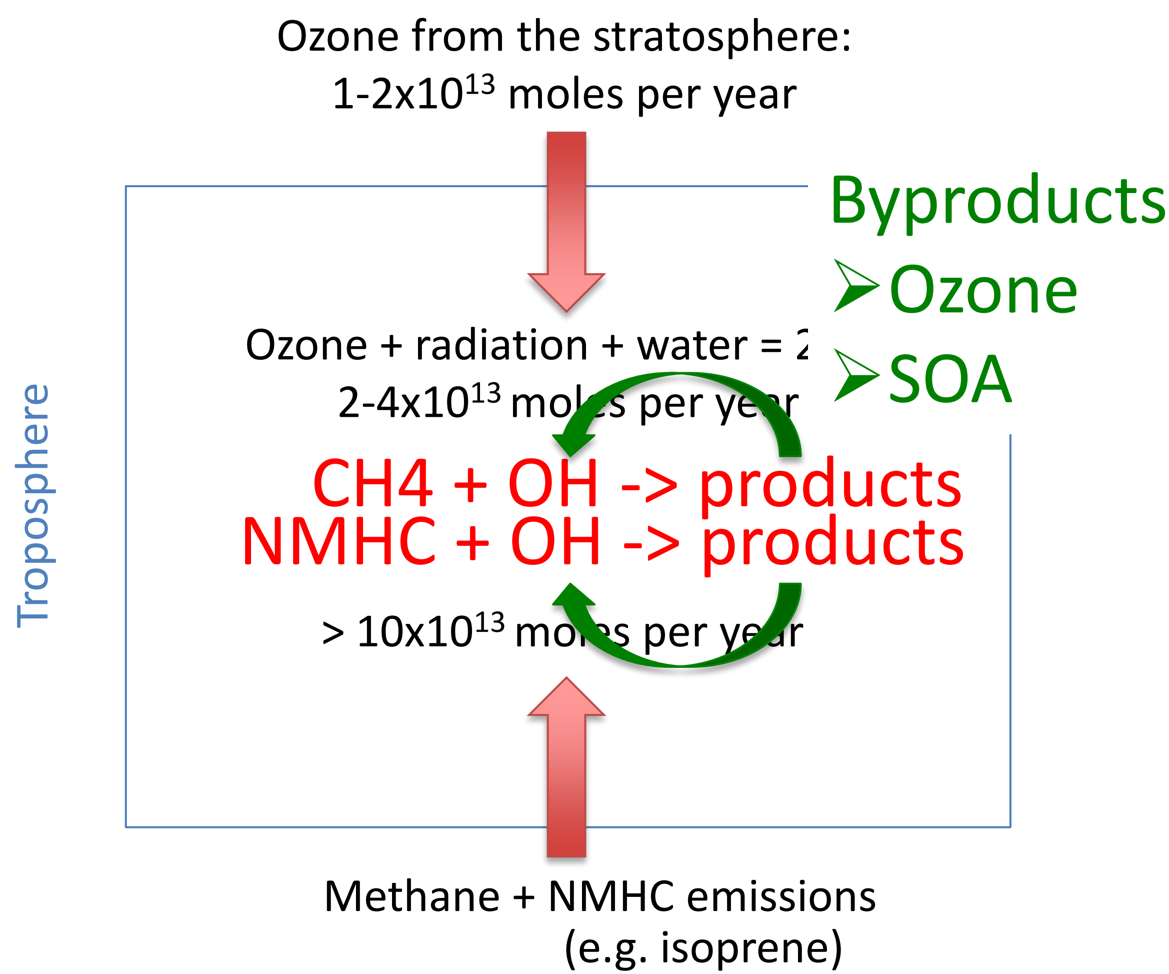


Figure courtesy of V. Naik, GFDL, 2012

Why do we need extensive chemistry?



Aerosols

Primary:
- dust
- soot
- some organics
- pollen
- metals

Secondary:
- sulfate
- nitrate
- ammonium
- most organics

Mixed:
- most !!

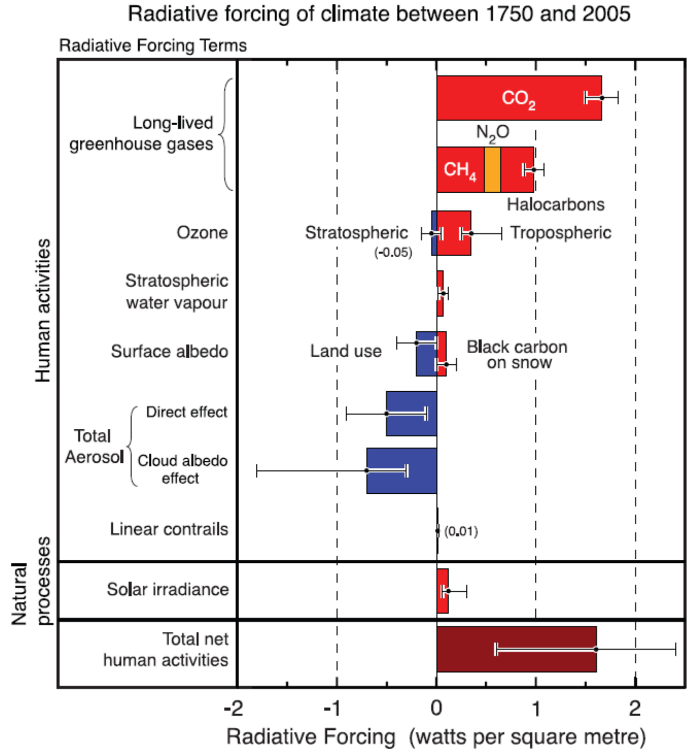
Radiative Forcing of Climate

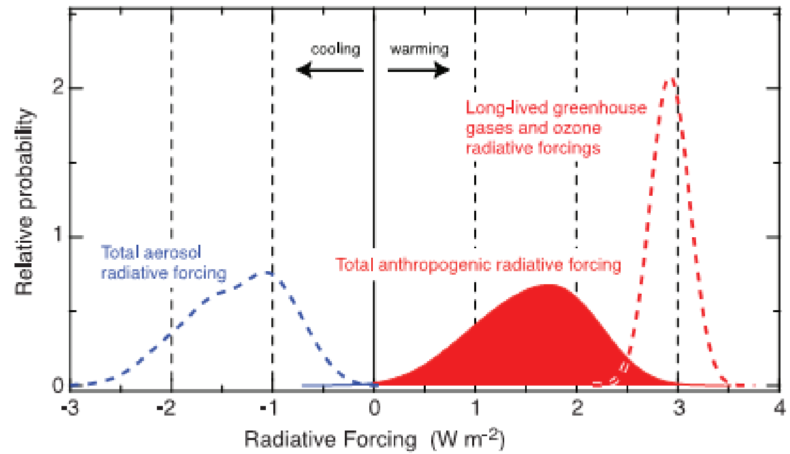
Incoming solar ~340 W m^{-2}

Changes since 1750:

long-lived gases ~ 3 W m^{-2}
ozone ~ 0.4 W m^{-2}
aerosols and clouds ~ -1 W m^{-2}

Forcing by aerosols is largest uncertainty

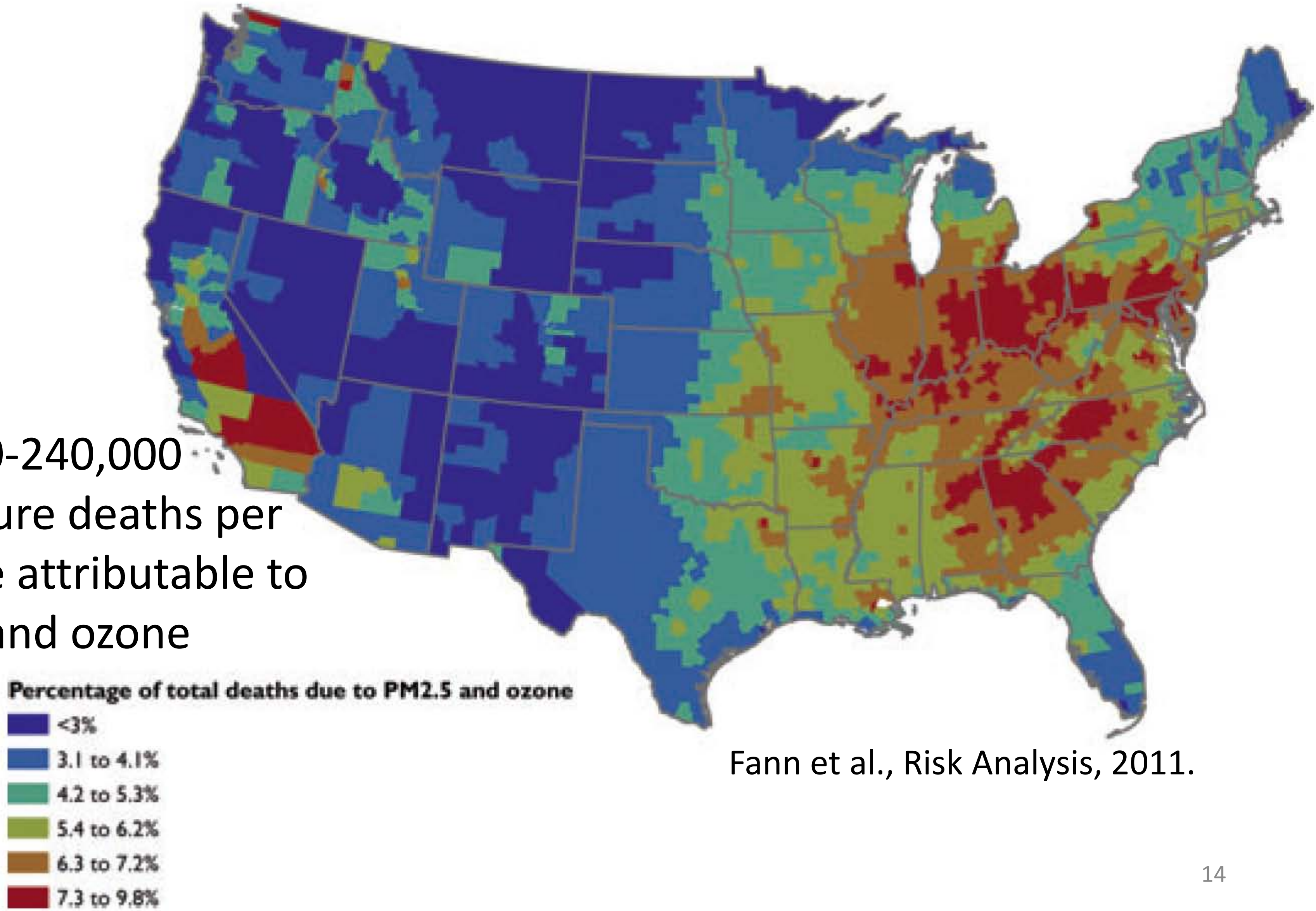




IPCC, 2007

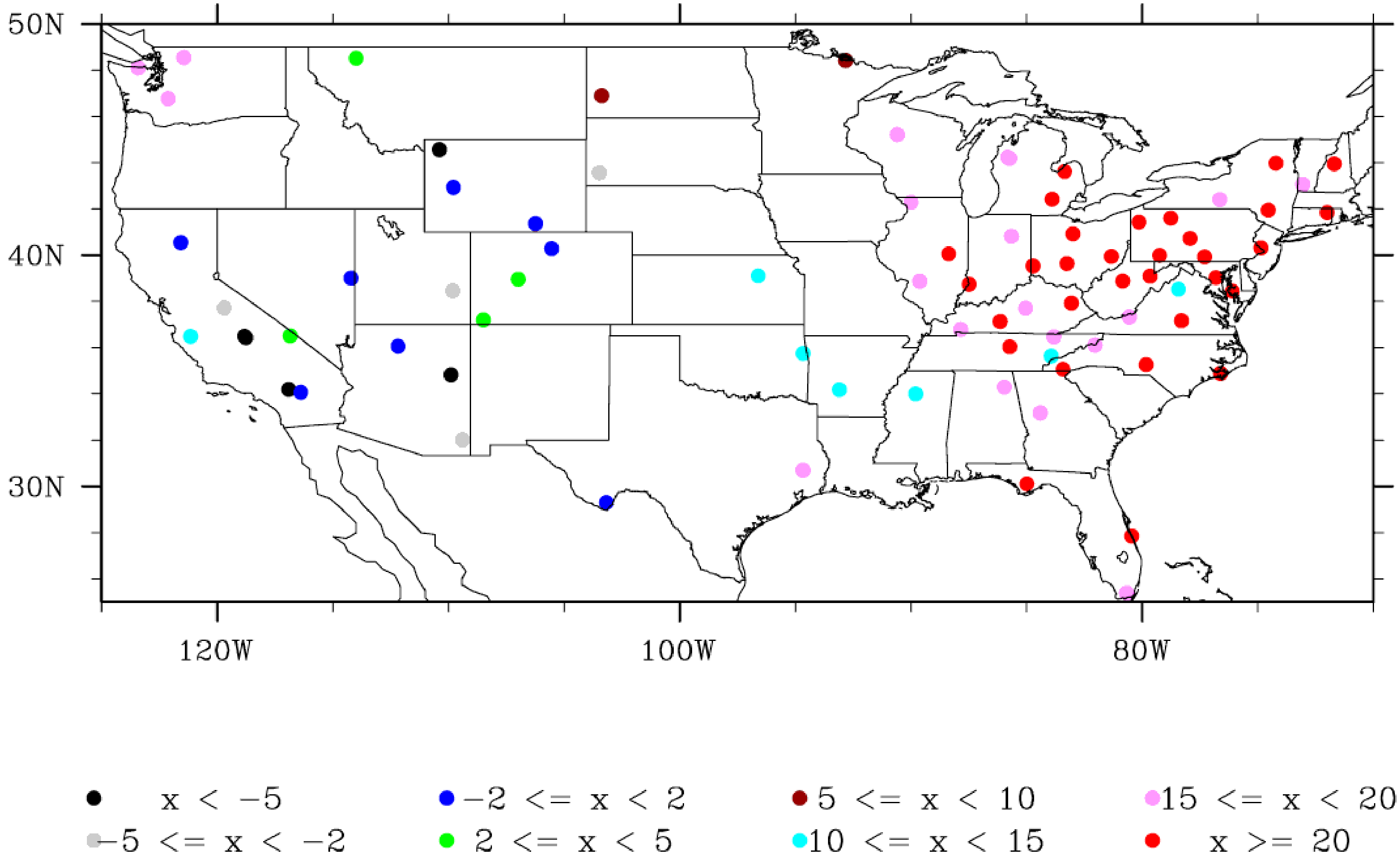
Not just climate: air quality and mortality

130,000-240,000 premature deaths per year are attributable to PM2.5 and ozone

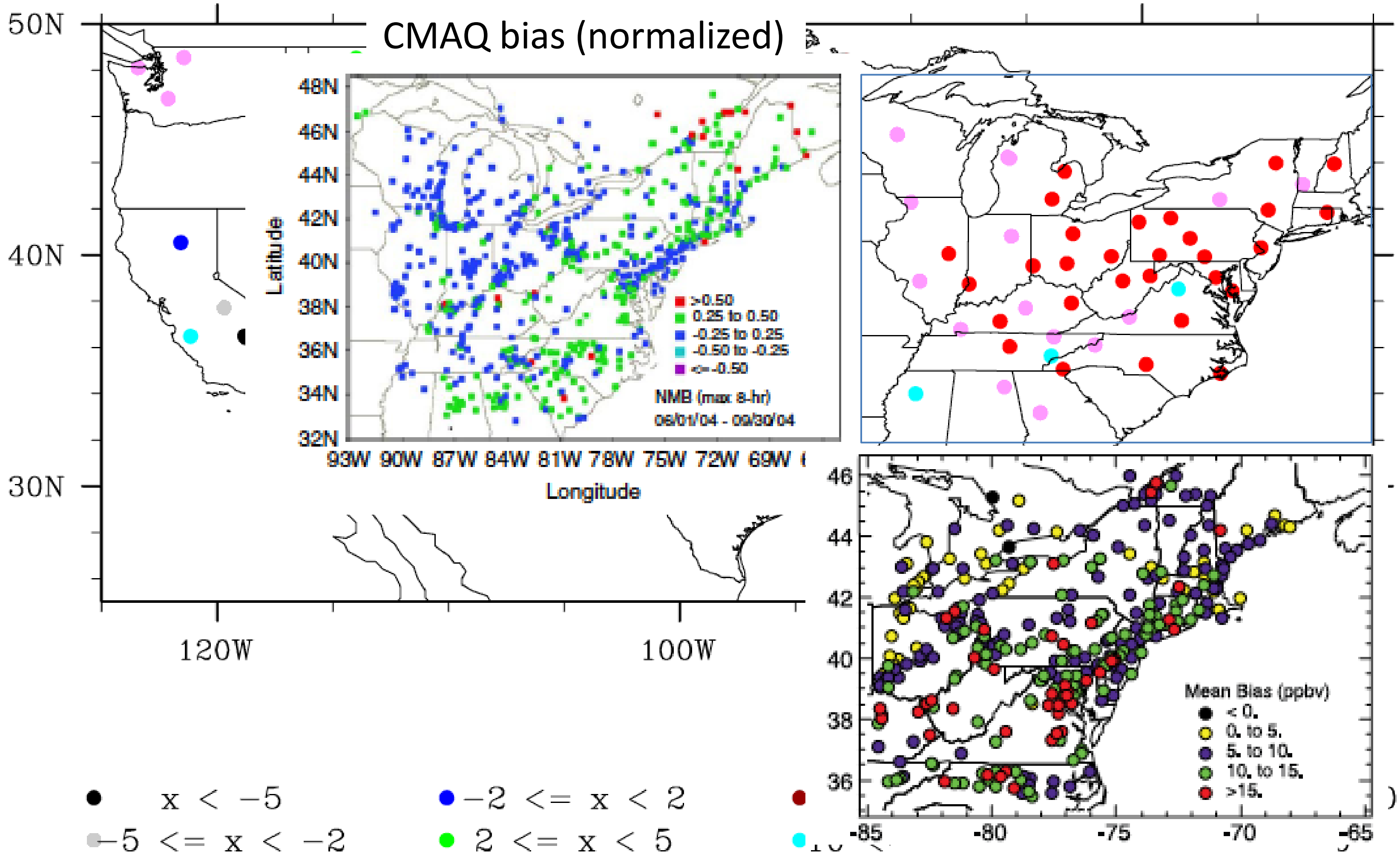


Fann et al., Risk Analysis, 2011.

Multi-model mean bias



Multi-model mean bias

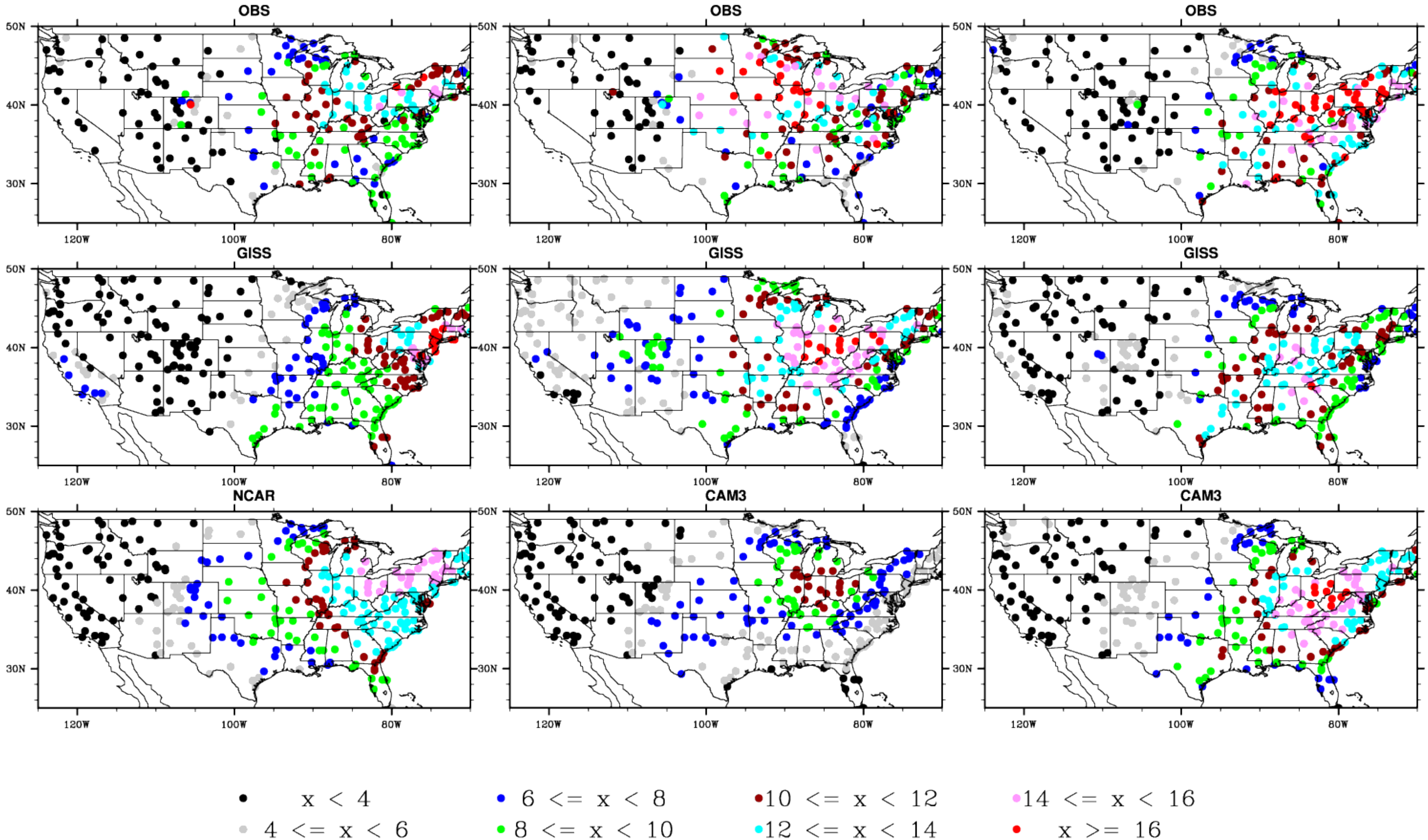


McKeen et al.,JGR, 2005

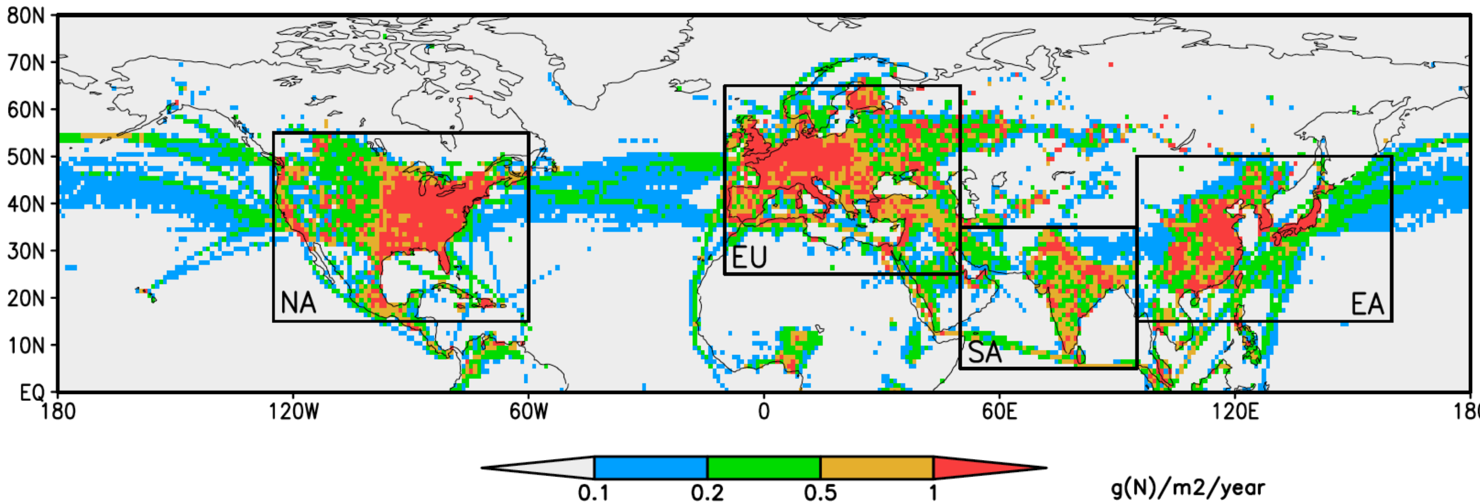
NO_3 deposition kg/ha/year

NH_4 deposition kg/ha/year

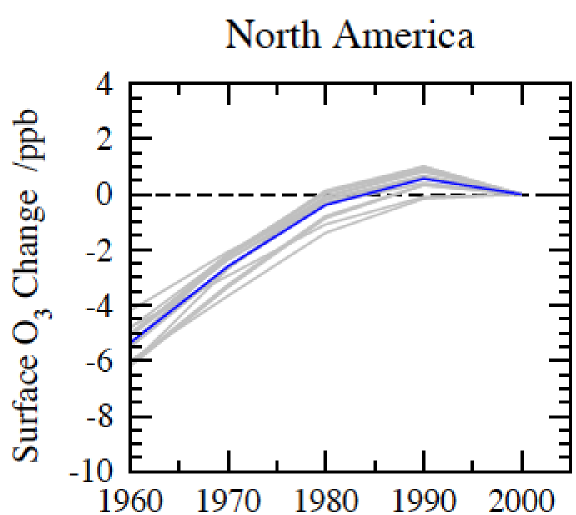
SO_4 deposition kg/ha/year

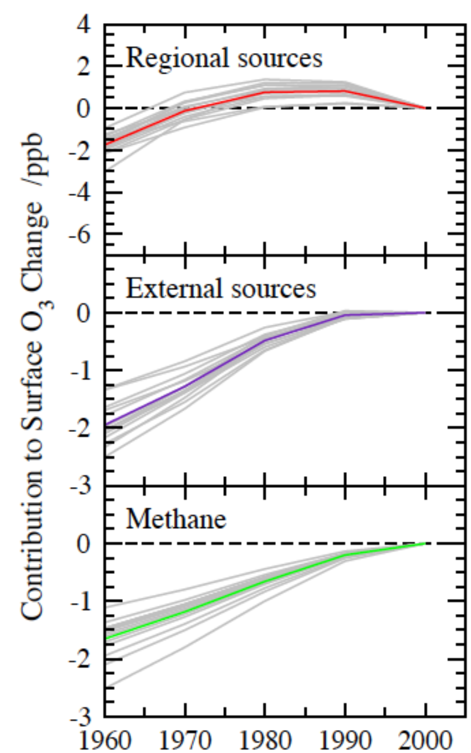


Source-receptor relationships



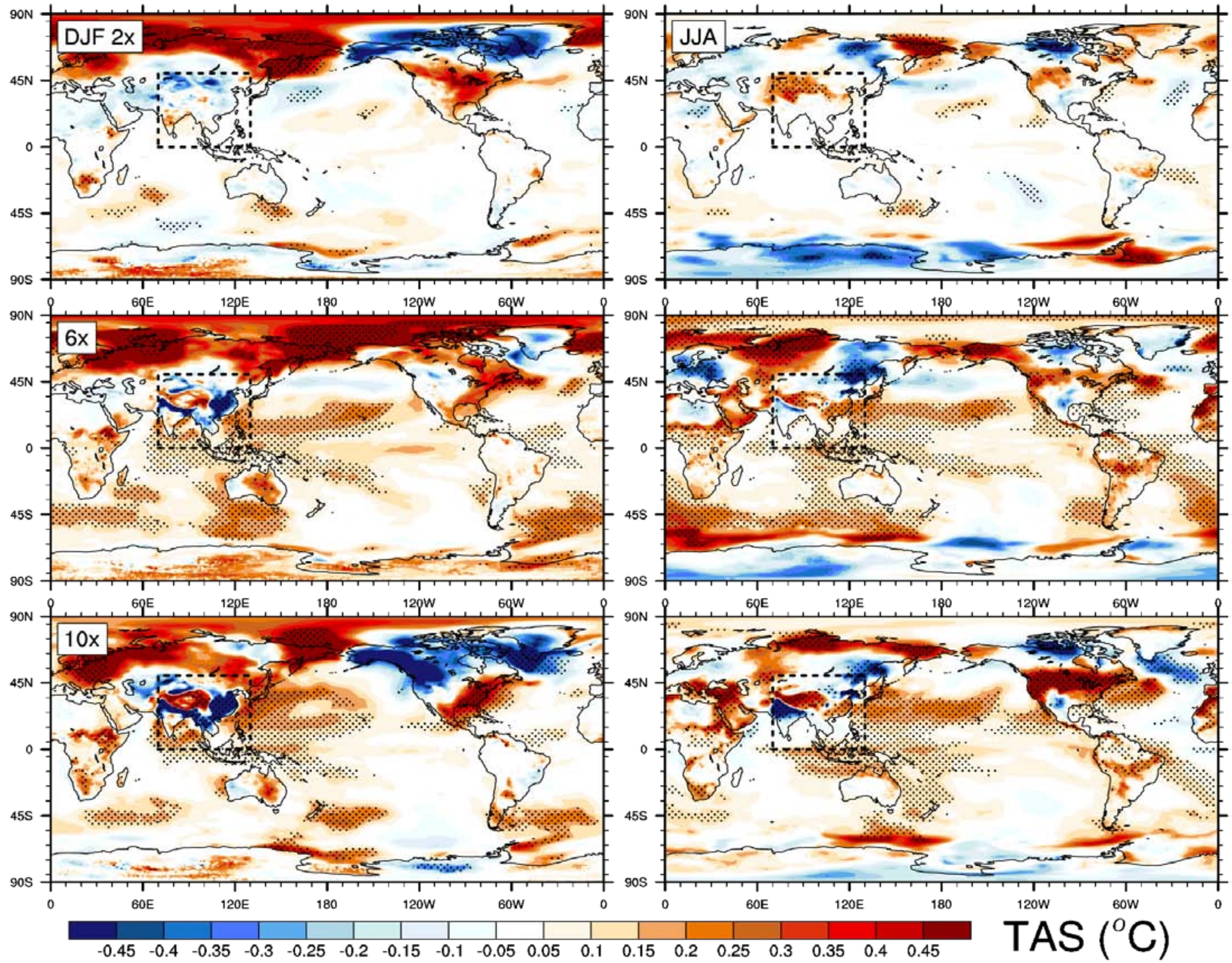
14 models, including CAM-chem





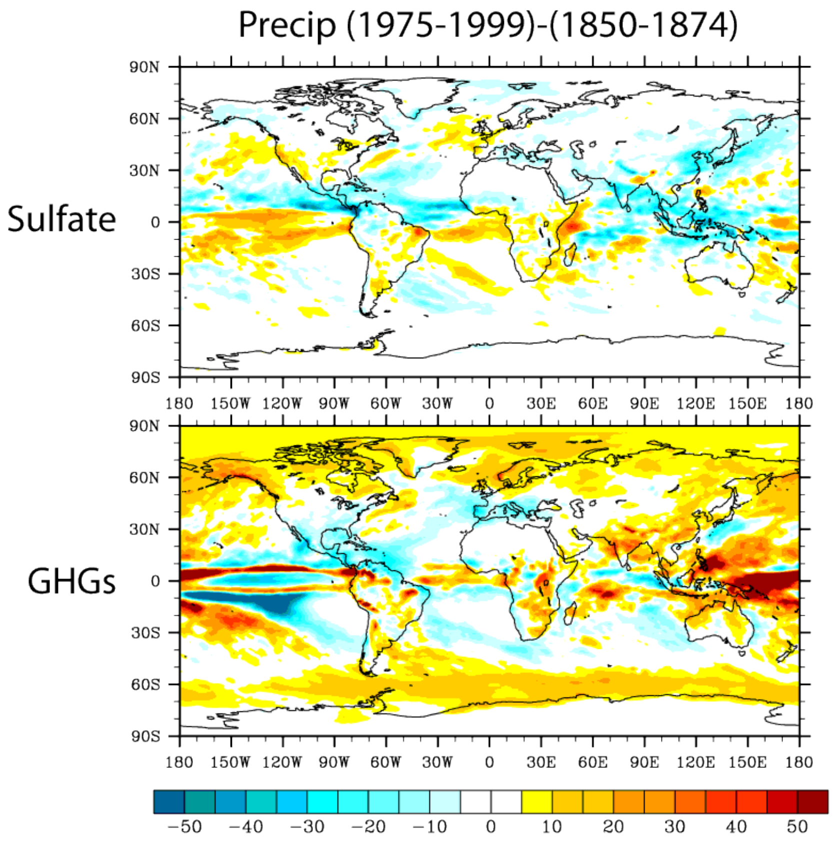
Wild et al., ACP, 2012

Chemistry-climate coupling: BC



Teng et al., in preparation

Chemistry-Climate coupling: single forcing



Annual average

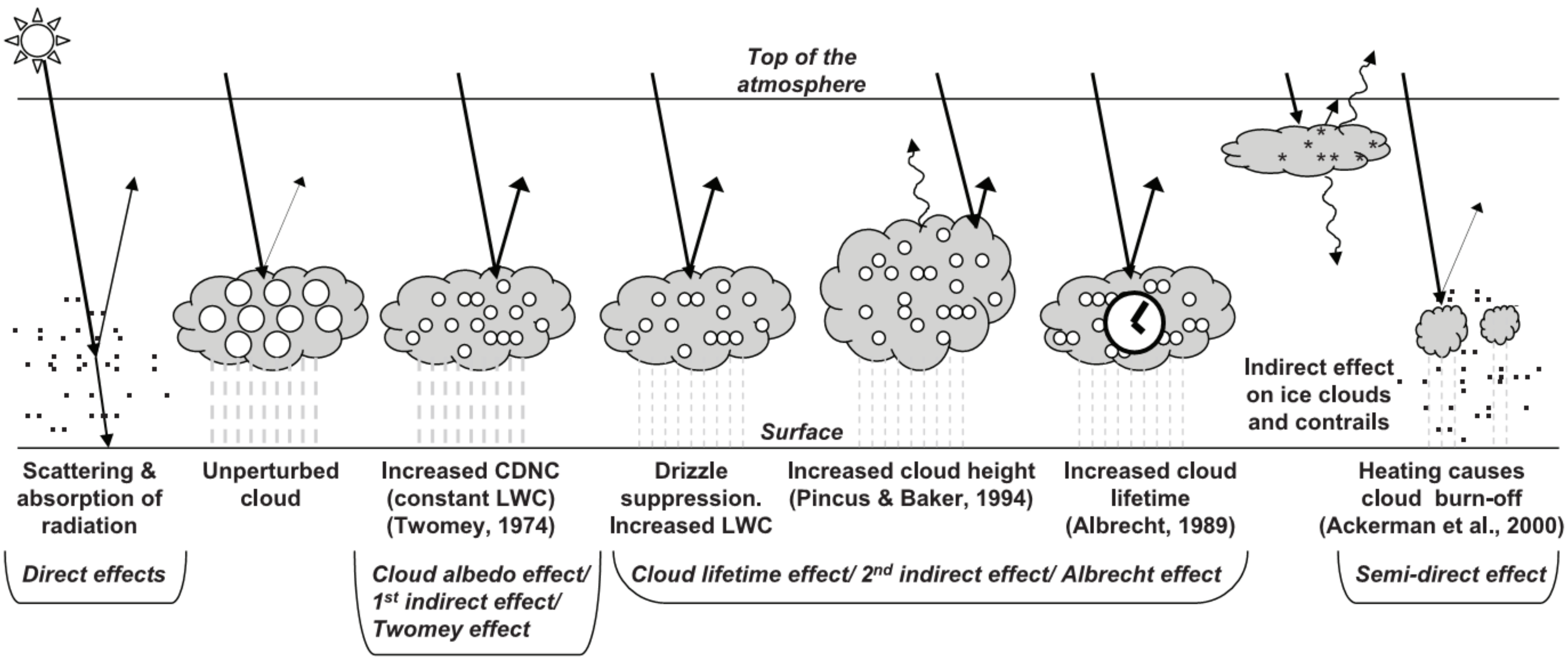
Units: mm/season

Summary

- Chemistry capability in CESM
- Surface air quality (health & ozone impact on agricultural yields) research possible but beware of biases
- Source-receptor relationship: surface ozone
- Near-field and far-field climate response to regional emissions

Thank you.
Questions?

How Aerosols Affect Radiative Forcing and Climate



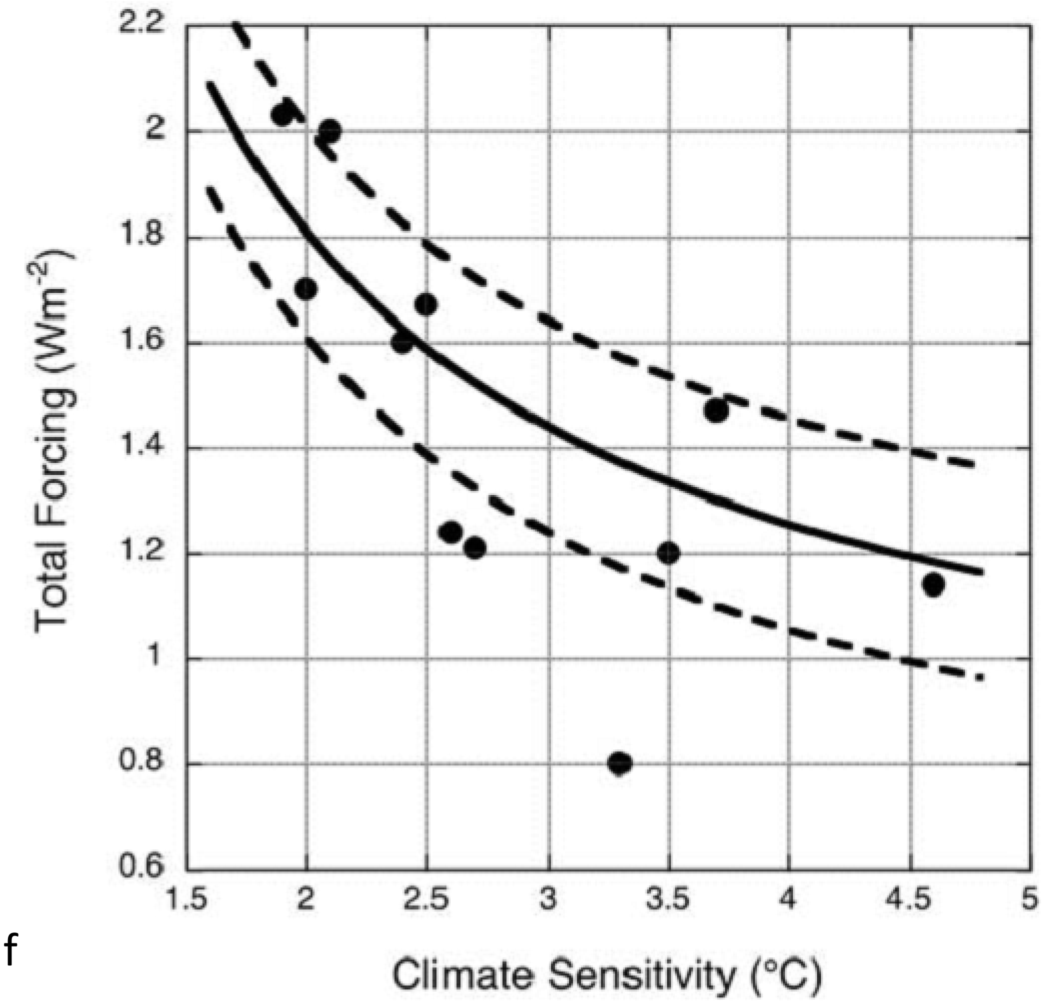
IPCC, 2007

Climate Models Are Sensitive to Aerosol Forcing

11 models compared, each with different aerosol forcing

Trade off between

- aerosol forcing
- climate sensitivity



Climate sensitivity = ΔT f

Kiehl, 2007