ELECTRIC POWER RESEARCH INSTITUTE

Program on Technology Innovation

Interactions of Climate Change and Air Quality: Research Priorities and New Directions

Project Manager: Naresh Kumar

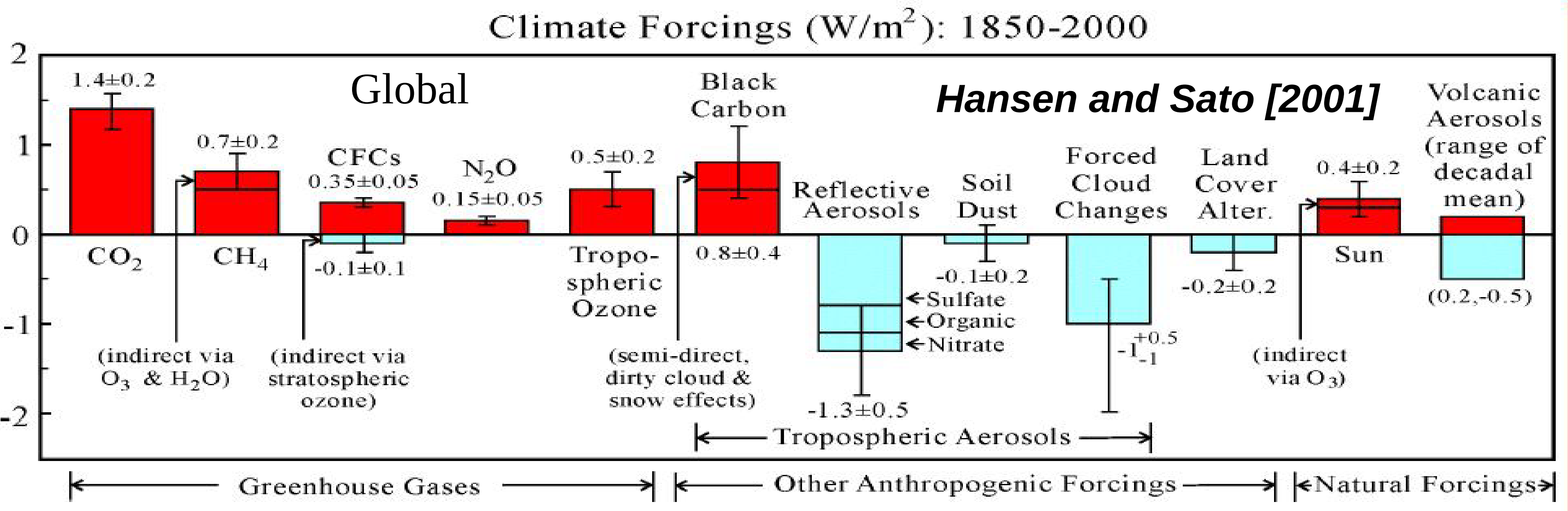
1012169

Workshop held in Washington, DC, April 27-29, 2005

Daniel J. Jacob (chair), William F. Fitzgerald, James Hansen, Jeffrey T. Kiehl, Jennifer A. Logan, Loretta J. Mickley, Joyce E. Penner, Ronald G. Prinn, V. Ramanathan, S.T. Rao, S.E. Schwartz, J.H. Seinfeld

Report available from http://www-as.harvard.edu/chemistry/trop/publications

EFFECTS OF AIR POLLUTANTS ON CLIMATE CHANGE



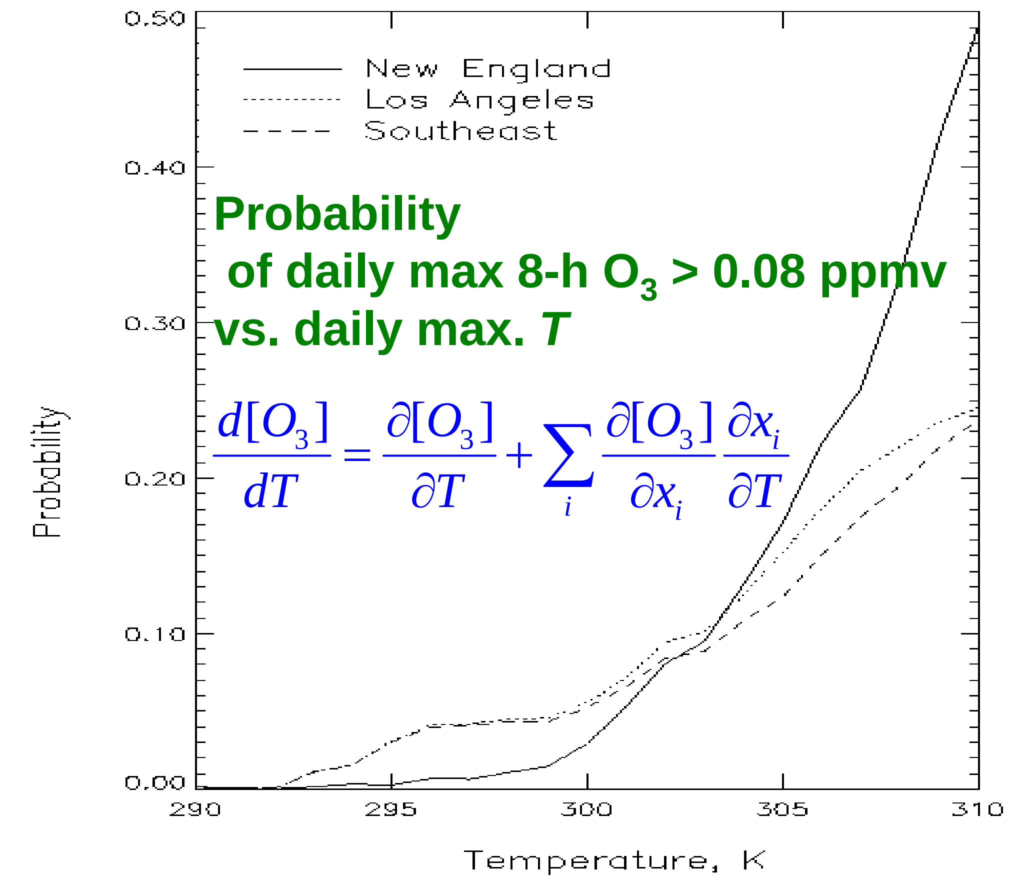
Air pollution - related greenhouse forcing: 0.5 (O_3) + 0.8 (BC) + 0.7 (CH_4)
= 2.0 W m^{-2}…larger than CO_2

Cooling from scattering anthropogenic aerosols: -1.3 (direct) – 1.0 (clouds)
= -2.3 W m^{-2} …would cancel half the warming

Global radiative forcing is not the whole story, pollutants also affect

- regional and surface forcing ⇨ regional climate change
- climate variables not quantified by radiative forcing (effect of aerosols on precipitation, of ozone on stratospheric temperatures…)

EFFECTS OF CLIMATE CHANGE ON AIR QUALITY



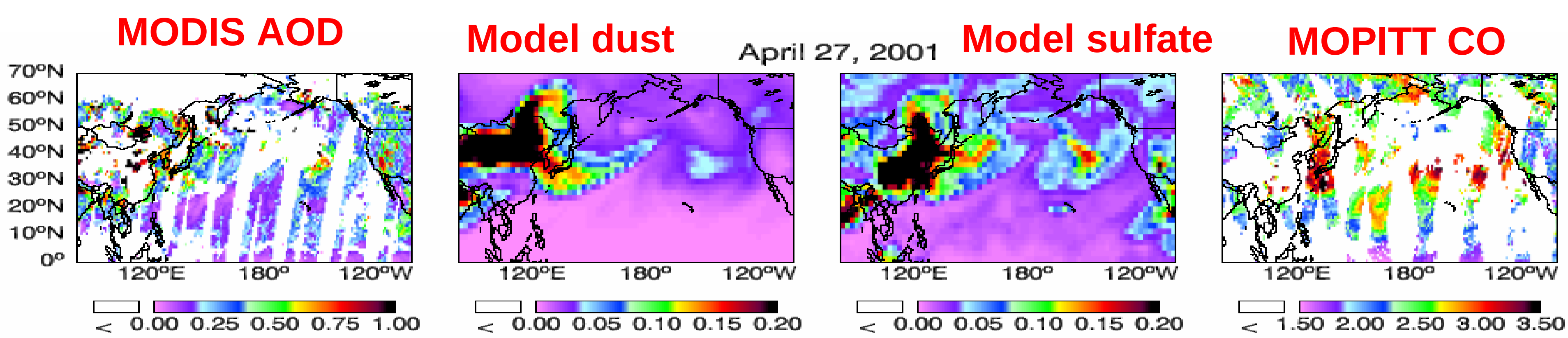
$$\frac{d[O_3]}{dT} = \frac{\partial[O_3]}{\partial T} + \sum_i \frac{\partial[O_3]}{\partial x_i}\frac{\partial x_i}{\partial T}$$

-through perturbations to air pollution meteorology, chemistry, scavenging

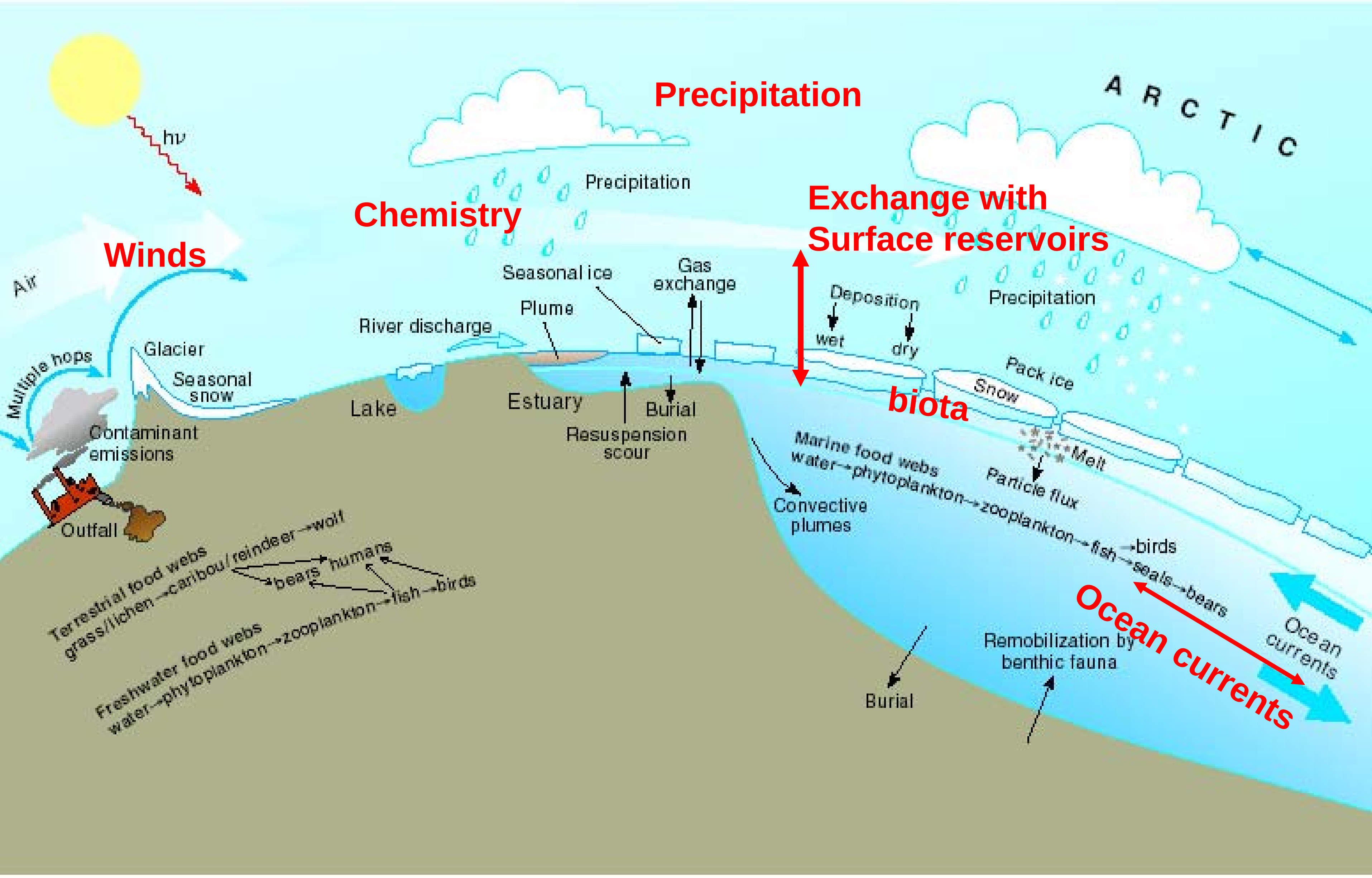
- through perturbations to regional and intercontinental transport

- through perturbations to fires, dust generation, biogenic emissions

Transpacific transport of Asian aerosol pollution



EFFECTS OF CLIMATE CHANGE ON MERCURY AND PERSISTENT ORGANIC POLLUTANTS (POPs)



WORKSHOP CONCLUSIONS & RECOMMENDATIONS

RESEARCH GOAL: "***The construction of global models that can describe the effects of air pollutants on climate, the effects of climate change on air quality, and the interactions of these effects in a manner that can guide the development of scientifically sound policy.***"

RECOMMENDATIONS were arranged around seven themes:

1. **Aerosol model simulation capabilities**
2. **Aerosol forcing estimates**
3. **Specific issues relating to black carbon aerosol**
4. **Tropospheric ozone and related chemistry**
5. **Effects of climate change on air quality**
6. **Effects of climate change on mercury**
7. **System models**

For each theme, two NEW RESEARCH DIRECTIONS were identified

1. AEROSOL MODEL SIMULATION CAPABILITIES

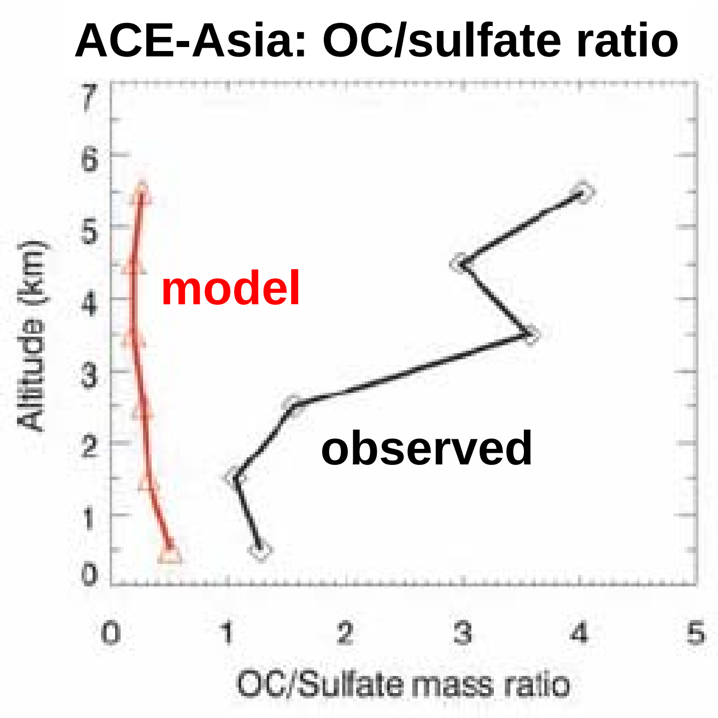
- Improve simulations of aerosol mixing states, size distributions, and CCN activities.

- Better characterize aerosol sources through a combination of process and inverse models.

- Better understand the processing of aerosols from large concentrated sources such as fires and megacities

- **NEW DIRECTION:** Test global models against observed vertical profiles of aerosols.

- **NEW DIRECTION:** Mine air quality data from monitoring networks in North America and Europe to determine long-term aerosol trends and assess the ability of models to reproduce them.



2. AEROSOL FORCING ESTIMATES

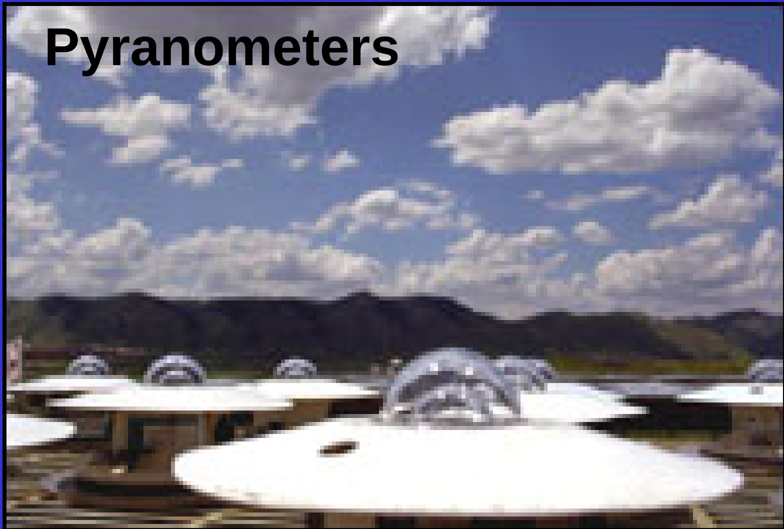
- Better understand the coupling of aerosols to the hydrological cycle

- Improve characterization of aerosol optical properties in relation to composition

- Assimilate aerosol observations into climate models to seek evidence of regional climate forcing

- NEW DIRECTION: Explain the observed long-term trends of solar radiation at the surface in North America.

- NEW DIRECTION: Understand aerosol effects on climate variability and extremes



3. ISSUES RELATING TO BLACK CARBON AEROSOL

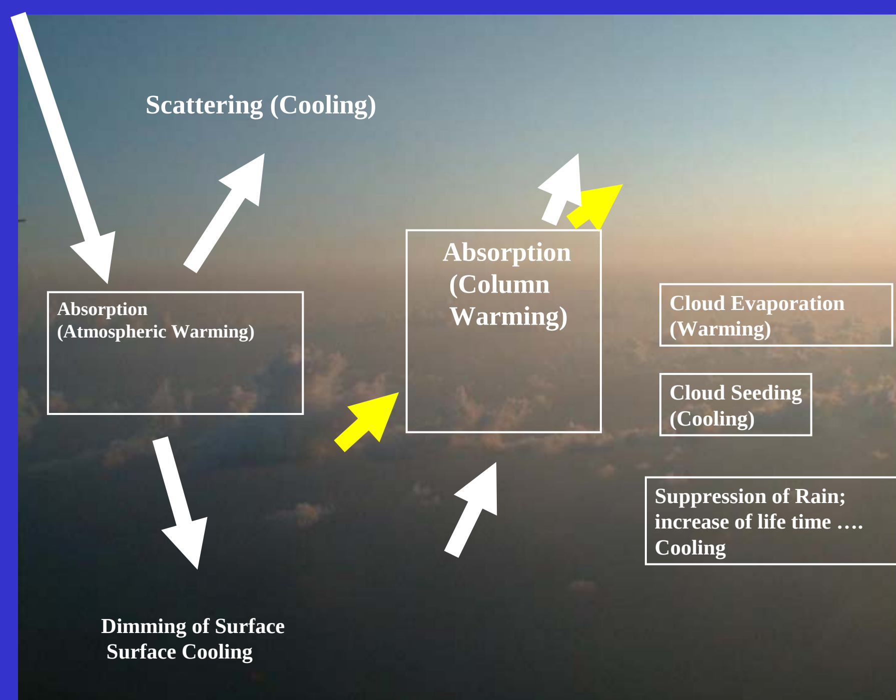
- Improve emission inventories and scavenging parameterizations in global models

- Improve understanding of BC-cloud interactions

- **NEW DIRECTION:** better understand the effects of the vertical distribution of BC on atmospheric heating rates and the implications for climate

- **NEW DIRECTION:** measure the effects of BC on the albedo of important snow and ice fields including sea ice, mountain glaciers, and Greenland

BC atmospheric absorption



4. TROPOSPHERIC OZONE AND RELATED CHEMISTRY

- Improve understanding of methane source processes and their geographical distribution

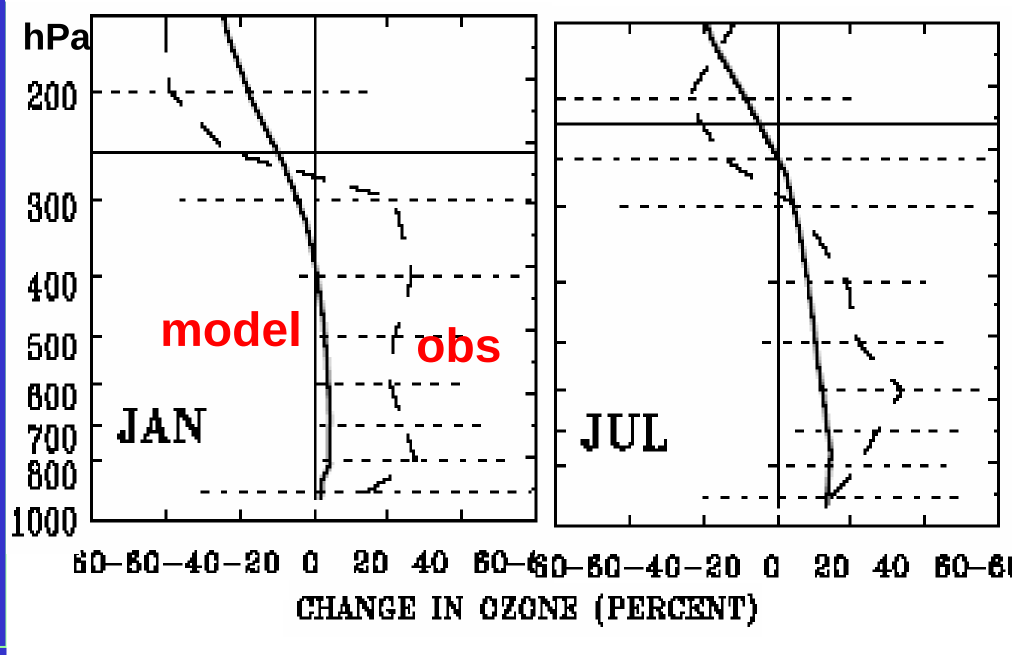
- Better understand the role of heterogeneous oxidant chemistry on ozone and aerosol budgets

- Better understand the sensitivity of stratosphere-troposphere exchange to climate change

- **NEW DIRECTION:** Improve the ability of global models to reproduce long-term trends in background tropospheric ozone

- **NEW DIRECTION:** Better understand the factors controlling the concentrations and trends of tropospheric hydroxyl (OH) radicals, and the implications for the methane lifetime

Hohenpeissenberg ozone trends, 1970-1995



5. EFFECTS OF CLIMATE CHANGE ON AIR QUALITY

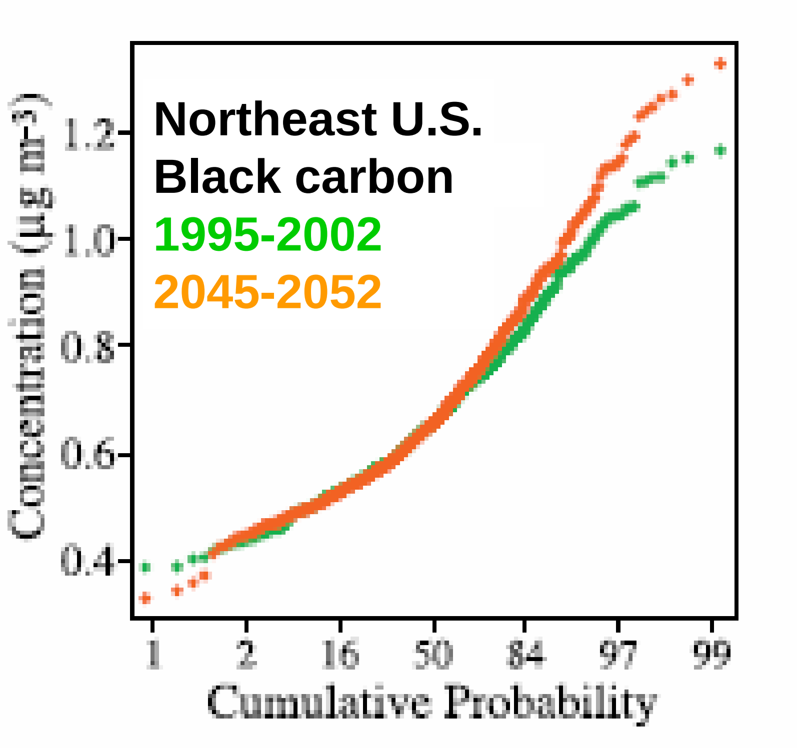
- Better quantify biogenic emissions of volatile organic compounds (VOC) and their dependences on meteorological and atmospheric composition variables

- Better understand the relationship of wildfires to climate variables

- Better understand how climate-driven changes in land cover may affect air quality

- **NEW DIRECTION:** Produce ensemble general circulation model (GCM)/regional climate model (RCM) simulations to analyze the effects of climate change on air pollution meteorology and regional air quality

- **NEW DIRECTION:** Construct two-way linkages between regional air quality models and RCMs.

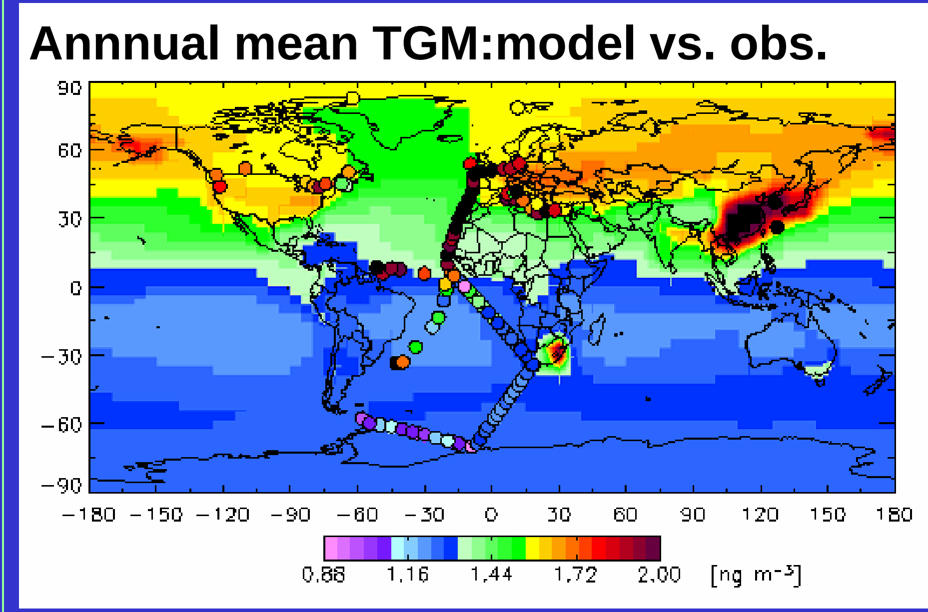


6. EFFECTS OF CLIMATE CHANGE ON MERCURY

- Better understand the role of biomass fires as sources of mercury

- **NEW DIRECTION:** Better understand the atmospheric chemistry of mercury and the effect of a changing climate on the patterns of mercury deposition.

- **NEW DIRECTION:** Examine the effects of climate change on mercury cycling in aquatic ecosystems, especially marine, and including re-emission to the atmosphere



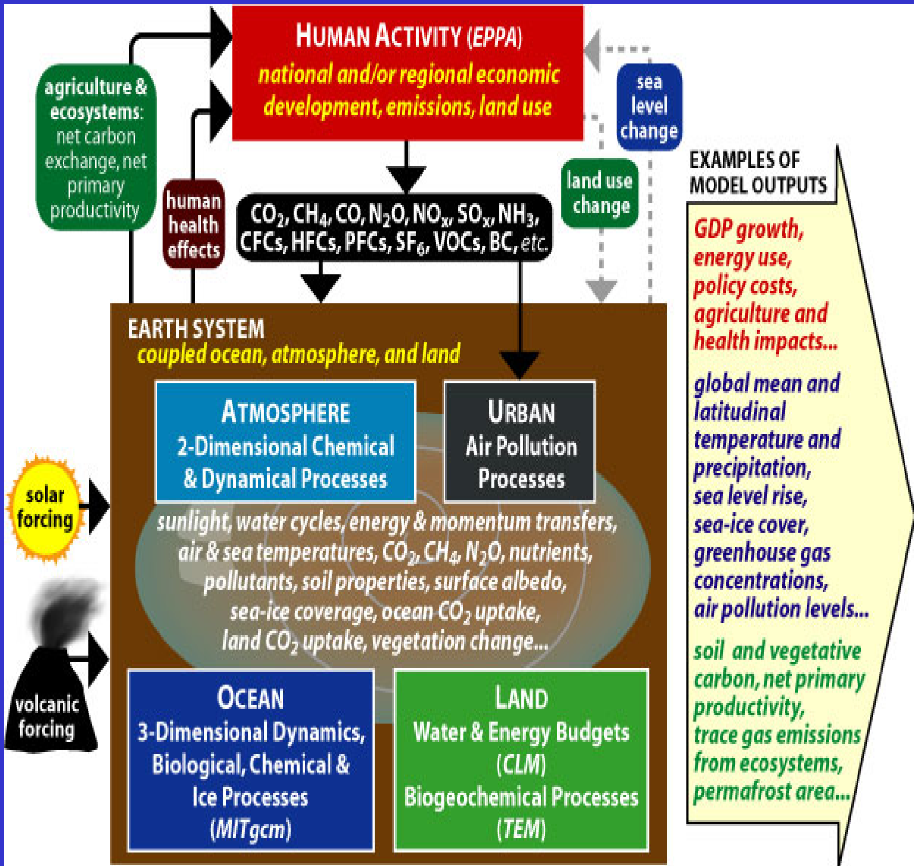
7. SYSTEM MODELS INTEGRATING CLIMATE CHANGE, AIR QUALITY, ECONOMICS, AND POLICY

- Achieve better coupling between system model components (submodels) including development of knowledge at the interfaces

- Assess the joint impacts of different energy policies on air quality and climate change

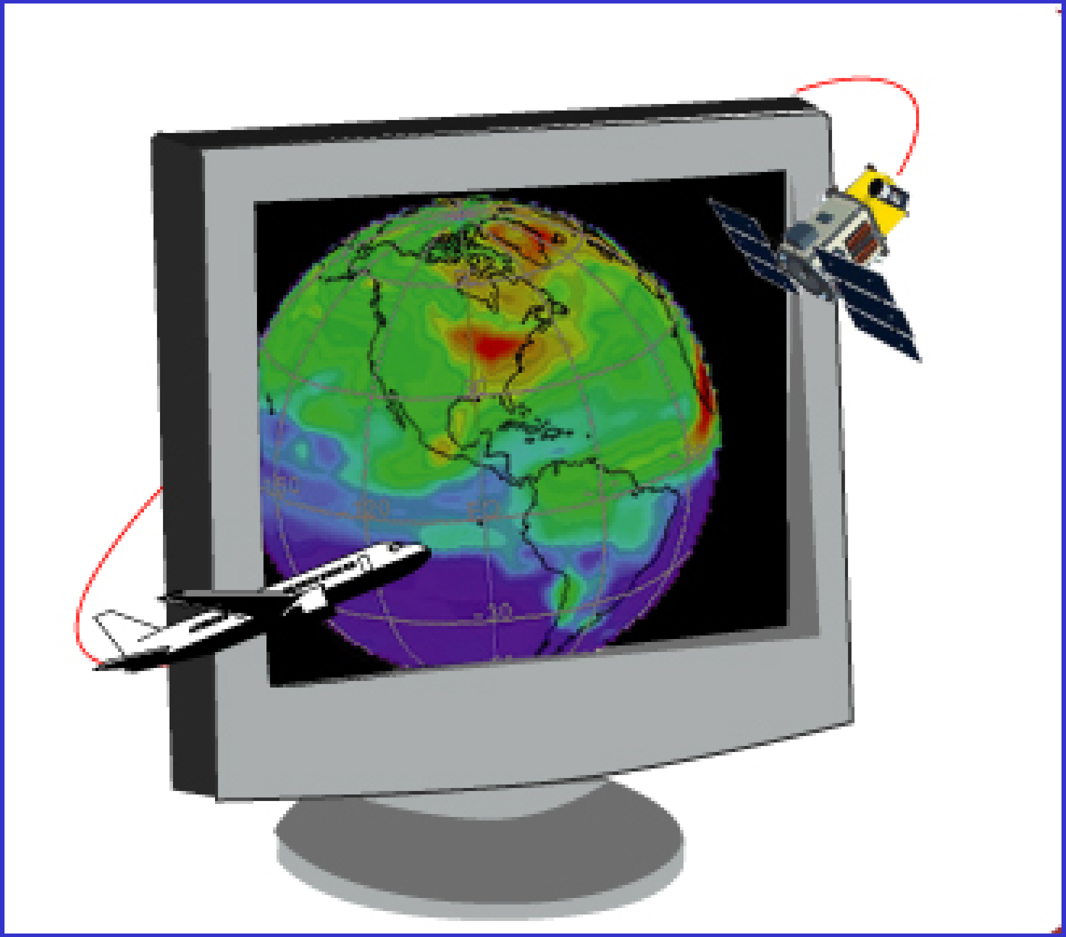
- **NEW DIRECTION:** Explore scenarios for improving air quality without incurring a major climate penalty

- **NEW DIRECTION:** Improve computational efficiency of physical, chemical, and biological submodels

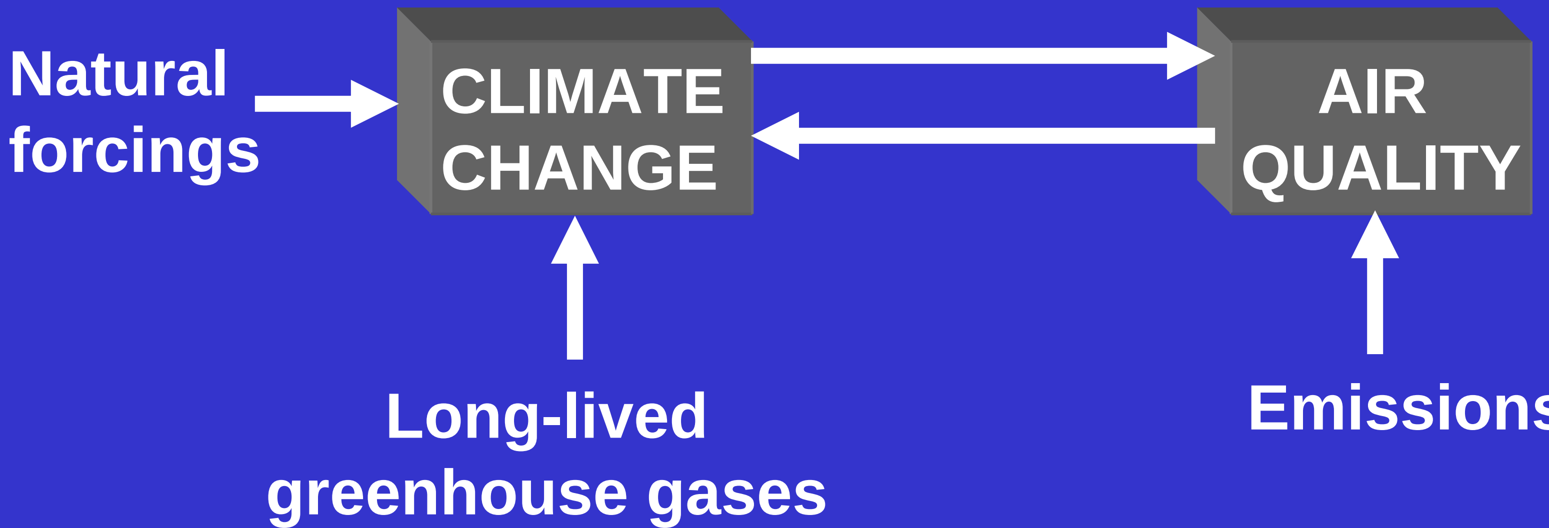


RESEARCH INFRASTRUCTURE FOR CLIMATE CHANGE – AIR QUALITY INTERACTIONS

Integration of in situ observations, satellite observations, And aerosol-chemistry-climate models



CLIMATE CHANGE AND AIR QUALITY FEEDBACK LOOPS



REPORT AUTHORS

DANIEL J. JACOB (chair), Harvard University
WILLIAM F. FITZGERALD, University of Connecticut
JAMES HANSEN, National Aeronautics and Space Administration
JEFFREY T. KIEHL, National Center for Atmospheric Research
JENNIFER A. LOGAN, Harvard University
LORETTA J. MICKLEY, Harvard University
JOYCE E. PENNER, University of Michigan
RONALD G. PRINN, Massachusetts Institute of Technology
VEERABHADRAN RAMANATHAN, Scripps Institution of Oceanography
S. TRIVIKRAMA RAO, National Oceanic and Atmospheric Administration
STEPHEN E. SCHWARTZ, U.S. Department of Energy
JOHN H. SEINFELD, California Institute of Technology

with contributions from Francisco C. de la Chesnaye (EPA), Philip DeCola (NASA), Jay Fein (NSF), Thomas Grahame (DOE), Anne Grambsch (EPA), John Jansen (Southern Company), Eladio Knipping (EPRI), Naresh Kumar (EPRI), Leonard Levin (EPRI), Peter Lunn (DOE), David Michaud (We Energies), Michael Miller (EPRI), Nehzat Motallebi (CARB) Stephen Mueller (TVA), William Pennell (DOE), A. Ravishankara (NOAA), Anne-Marie Schmoltner (NSF), Darrell Winner (EPA).