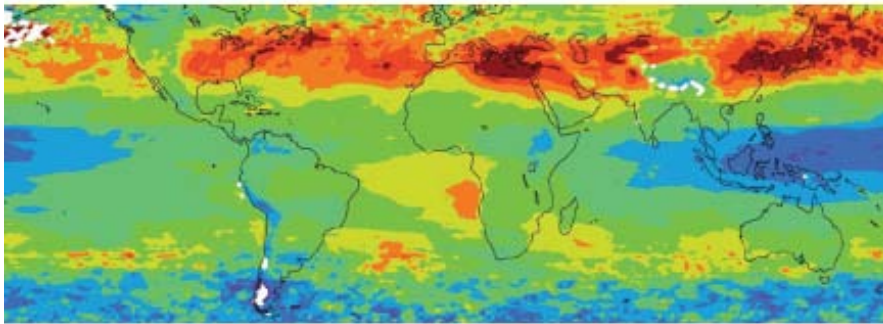


# GLOBAL SOURCES OF LOCAL POLLUTION



**An Assessment of Long-Range Transport of Key Air Pollutants  
to and from the United States**



**A U.S. National  
Academies study  
requested by:**

- EPA
- NOAA
- NASA
- NSF

# Committee Membership

NATIONAL

ACADEMIES

- Charles Kolb, Aerodyne Research [Chair]
- Tami Bond, Univ Illinois. Urbana [emission inventories, PM]
- Mae Gustin, Univ of Nevada - Reno [mercury]
- Gregory Carmichael, Univ of Iowa [atm chemistry and modeling]
- Kristie Ebi, IPCC TSU II [pollution impacts]
- David Edwards, NCAR [remote sensing]
- Henry Fuelberg, Florida State Univ [meteorology]
- Jiming Hao, Tsinghua Univ [pollution control, Asian perspective]
- Daniel Jacob, Harvard Univ [ozone, chemical-transport modeling]
- Daniel Jaffe, Univ Washington-Bothell [in situ obs, mercury]
- Sonia Kreidenweis, Colorado State Univ [PM chemistry, obs]
- Katharine Law, CNRS (France) [atm.chem, European perspective]
- Michael Prather, UC Irvine [atm chemistry, radiative forcing]
- Staci Simonich, Oregon State Univ [POPs]
- Mark Thiemens, UC San Diego [isotopic analysis methods]
- Laurie Geller, Study Director

# Committee Charge

How does international transport of air pollutants ( $O_3$ , PM, Hg, POPs) affect U.S. air quality, pollutant deposition, and radiative forcing?

How are foreign emissions sources expected to change in the future and how might these changes affect achievement of U.S. environmental policy objectives?

How does international transport of air pollutants out of the U.S. affect the achievement of environmental policy objectives in other parts of the world?

What additional research, observations, analysis, and information management efforts, are needed to better understand and quantify the impacts and implications of the international transport of air pollutants?

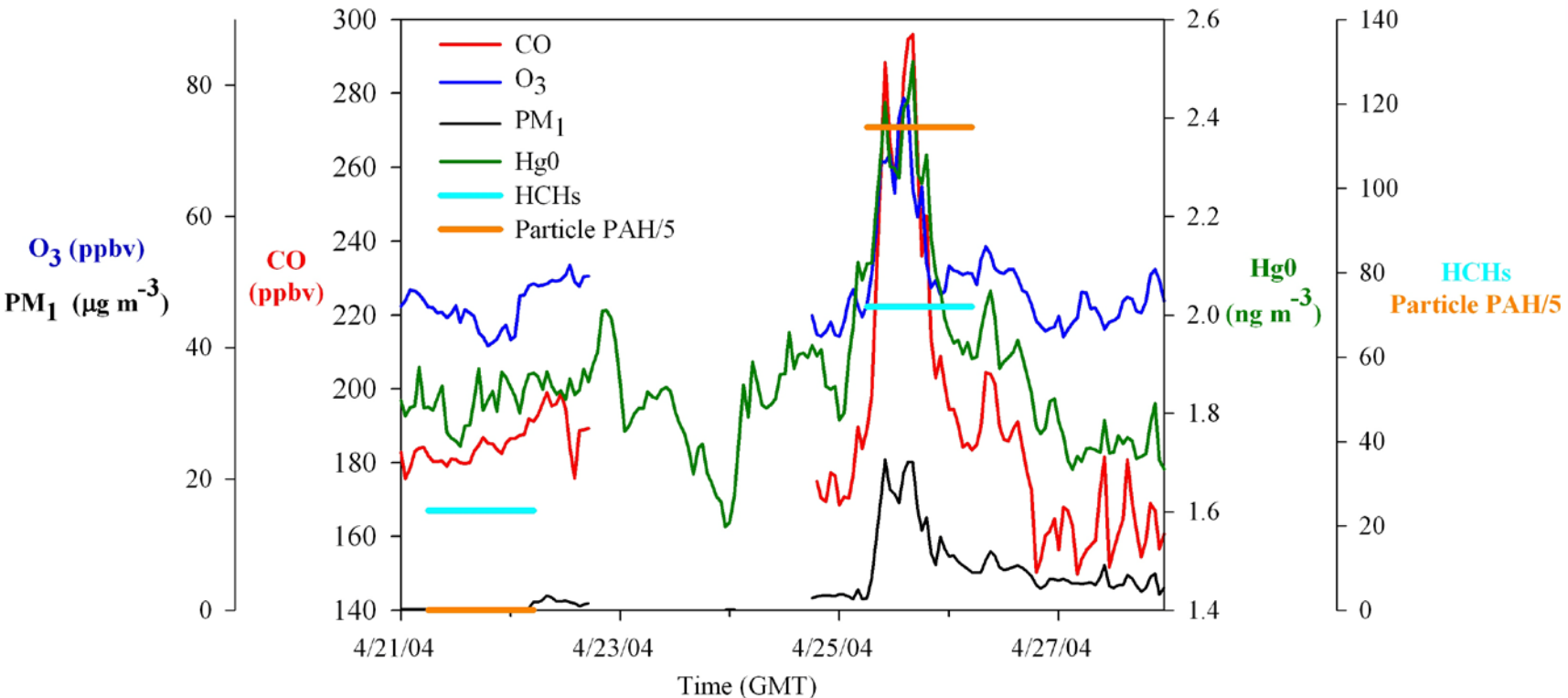
Modeling and observations provide ample evidence that atmospheric transport of key pollutants does occur on international scales, and this can affect air quality and human/ecosystem health far from the site of emission.

Transported pollution is likely to increase as emissions grow in the developing world. The relative importance of transported pollutants will increase as domestic air quality regulations become stricter.

In some cases, these impacts could be deemed 'significant' from a regulatory and public health standpoint.

**HOWEVER....**We have very limited ability to quantitatively attribute observed pollution to long-distance sources, or to characterize how transported pollution observed aloft is mixed down to the surface and ultimately affects environmental quality.

# Example of multi-pollutant observations



Multipollutant observations from the Mt. Bachelor Observatory on April 25, 2004. Measurements of particulate-phase HCH and PAHs occur on discrete filter samples (units are  $pg/m^3$  for a 24-hr integrated sample).

[Source: D.Jaffe]

## 1. Defining baseline (background) pollutant concentrations, as a benchmark to discern and quantify low-level, persistent long-range transport influences.

Models can identify baselines through sensitivity analyses that simply turn particular sources on and off (e.g. used in EPA's 'Policy Relevant Background').

But in real-world observations, background concentrations must be estimated (for example) as *'the average weakly-varying concentrations against which pollution plumes are referenced'*, or as *'the lower envelope of the frequency distribution of concentrations, reflecting conditions of minimum source influences'*. Either case is ambiguous, as the 'baseline' can still contain diluted contributions from distant sources.

At a minimum, the scientific community needs to agree on a standard way to define (observational-based) background concentrations, in a way that is consistent with the approaches used in models.

## 2. Advancing fingerprinting methods to identify contributions from particular pollutant sources or regions.

A variety of new techniques are emerging, for instance:

- tracer compounds (e.g. compounds banned in some countries but not others)
- ratios among particular compounds found in a pollution plume
- isotopic signatures
- racemic/chiral signatures
- real-time single particle analysis techniques

### 3. Better quantifying and reducing uncertainties in the different components of source/receptor modeling studies.

This includes, for instance, efforts to reduce uncertainties in:

**emissions:** need to validate bottom-up emissions inventories with top-down observations and inverse modeling techniques

**pollutant transport:** need better representation of the dynamics and meteorology that drive exchange of pollution between the boundary layer and free troposphere

**pollutant chemical transformations:** need more lab studies to quantify critical kinetics parameters (esp. for secondary aerosols), and field studies to evaluate the accuracy of proposed chemical transformation mechanisms

**pollutant deposition:** need more wet deposition data, and much more dry deposition data (esp for mercury)

**exposure/impacts:** need to continue to assess exposure patterns via ecological / public health studies, and actual impacts via epidemiological and biological studies.

Need statistically valid ways to integrate all these different layers of uncertainty.

**O<sub>3</sub>: Improving assessment of recent trends/patterns in background concentrations**

**PM: Growing capabilities to observe total column PM, and vertical distribution with the column**

**PM: Real-time single particle analysis techniques**

**O<sub>3</sub>/PM: Preliminary efforts to estimate health impacts of imported pollution**

## **Long range transport of Hg is a unique challenge because:**

- Once emitted from any source, Hg may be mixed into the global atmospheric pool, and recycled between the atmosphere and numerous reservoirs (atmosphere, oceans, freshwater systems, soils, biota, cryosphere).
- Thus Hg emitted from any source may be transported long distances and deposited to ecosystems remote from sources.
- Deposition rates in remote locations have increased three-fold since pre-industrial times. As emissions increase with energy use and economic development the global pool will increase.

## **Three sources of atmospheric Hg important to consider when assessing long-range transport:**

- Current geogenic emissions (geologically-enriched substrates, geothermal areas, volcanic emissions)
- Current anthropogenic emissions
- Legacy emissions: Re-emission of previously-released Hg that has accumulated in terrestrial and aquatic reservoirs (includes that derived originally from natural and anthropogenic sources)

## **Fundamental knowledge limitations in current assessments:**

- Atmospheric chemistry of Hg (mechanisms of reactive Hg formation ? likelihood of bioaccumulation?)
- Unknown deposition rates (especially dry deposition, which is not measured)
- Potential for re-emission (only limited study thus far using isotopic methods)
- Potential atmospheric deposition effects on biosphere accumulation

## POPs: Some key points

POPs can clearly be transported over long distances, but only a few transport pathways (e.g. trans-Pacific transport to the U.S. and transport to the Arctic) are reasonably characterized.

Need to consider the different sources, trends, and use-status of different classes of POPs (pesticide-related compounds, discontinued industrial chemicals, combustion-related POPs, current use vs. historic use).

Must account for exposure from both direct releases and re-release of legacy POPs (from melting glaciers, forest fires and vaporization from soils and oceans).

Difficult to quantify transport and deposition fluxes because of limited inventories, observations, modeling tools, and understanding of photochemical processes.

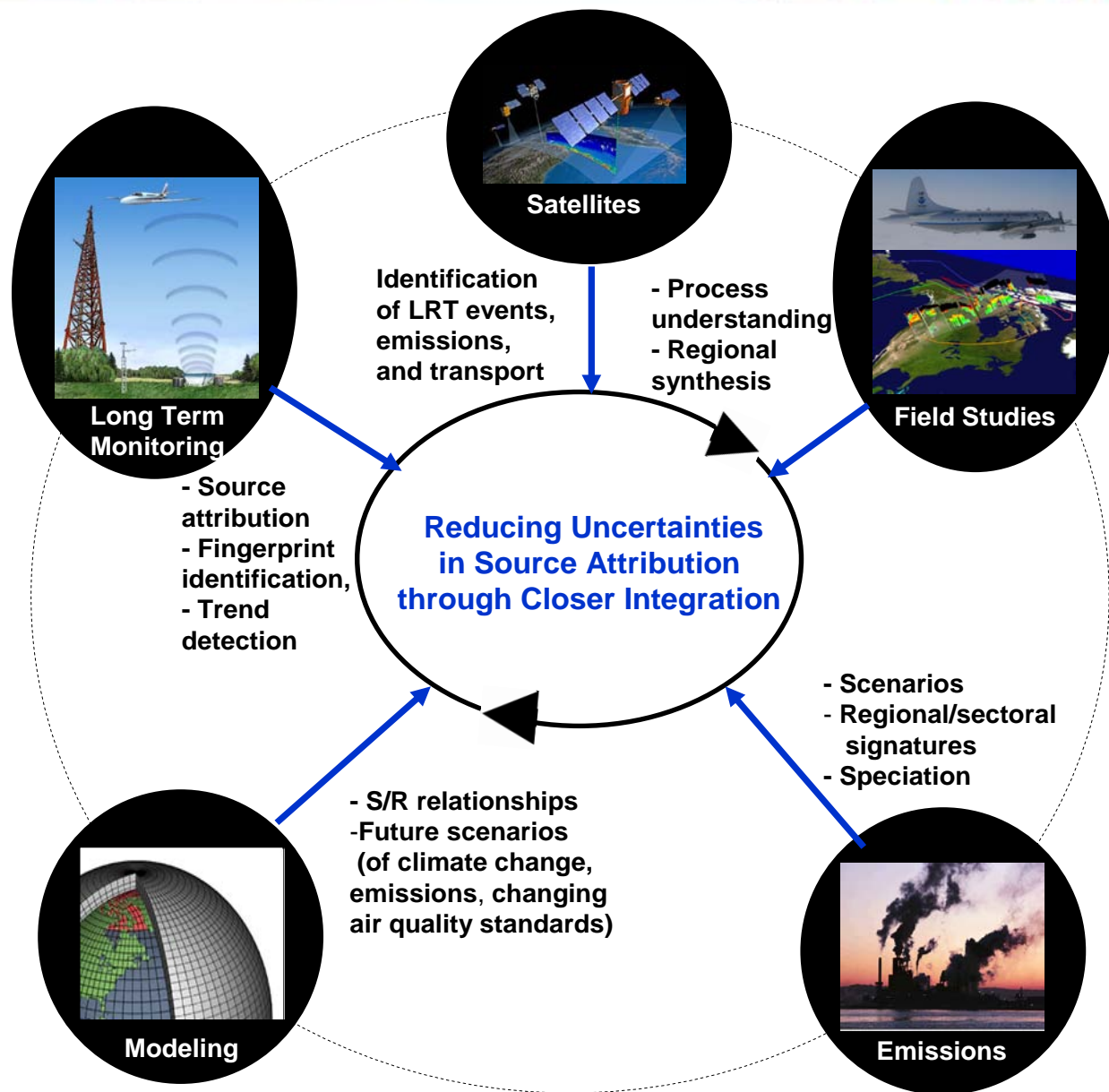
With existing global inventories for PAH emissions, one could conduct global modeling exercises that compare gas-phase and particulate-phase PAHs, based on their differing emissions, chemical properties, and atmospheric lifetimes.

## Integrated System for Tracking and Attribution of Long-Range Transport of Pollution

Establish an integrated source-attribution system focused on improving capabilities (and reducing uncertainties) in: **emission measurements and estimates, atmospheric chemical and meteorological modeling, long-term ground-based observations, satellite remote sensing, field experiments, and impact assessments.**

Integrate these components as effectively as possible, focusing on quantifying and reducing uncertainties in source/region attribution.

Establish an expert group to help design, test, and evaluate this source-attribution system, building on existing international efforts such as the WMO/GAW International Global Atmospheric Chemistry Observation program.



## **General need for more engagement:**

- across pollutant classes and across disciplines (i.e., between chemists and meteorologists; between observational and modeling specialists)
- across national programs (i.e., international cooperation in monitoring, research, emissions inventories, pollution control strategies).

**HTAP should play a leading role increasing this multi-disciplinary, multi-national, multi-pollutant engagement.**

For More Information

NATIONAL

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