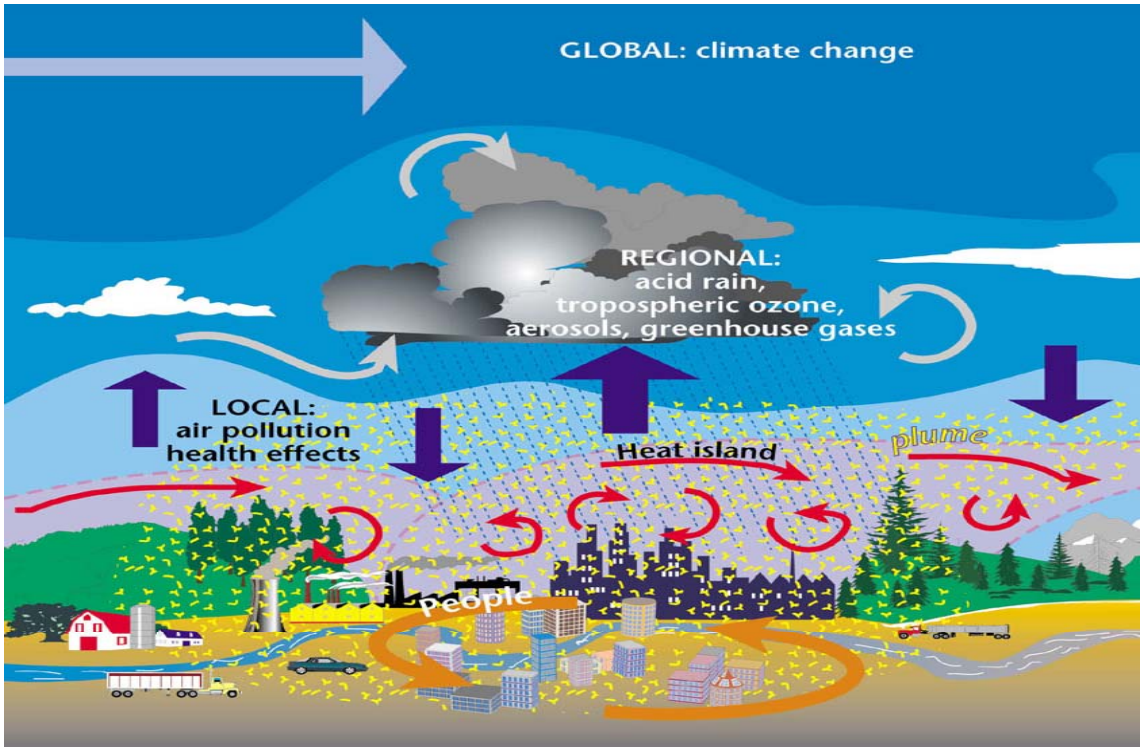
Growing Importance of Air Quality Modeling in Environmental Science & Management

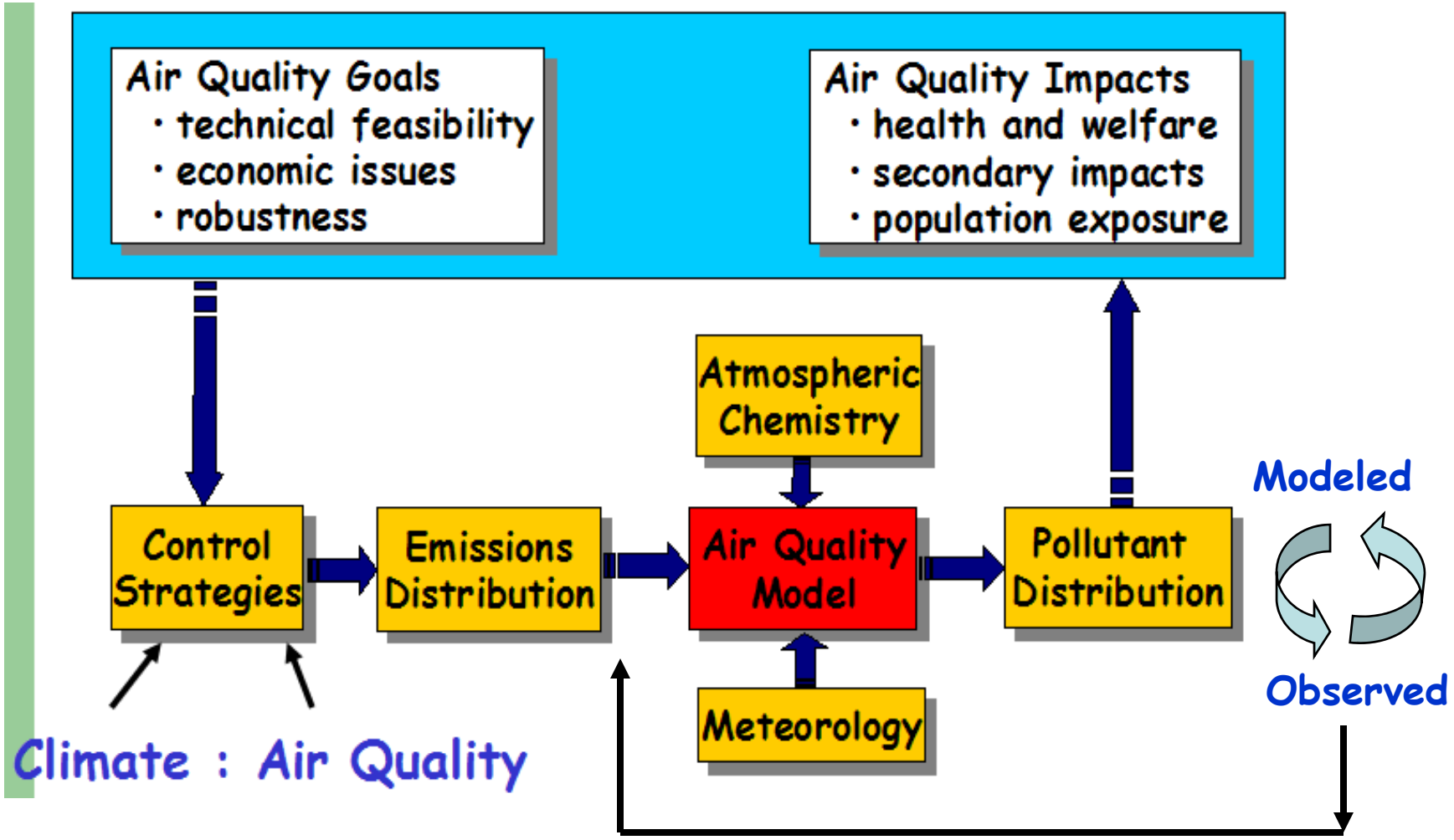


WMO: GAW Urban Research Meteorology and Environment Project -- GURME

Topics Covered:

- ✓Role of Models
- ✓Key Applications
  - ✓Forecasting
  - ✓Source Receptor Analysis
- ✓Key Needs
  - ✓Observations
  - ✓Improved Emissions
- ✓Integration

Models Play a Critical Role in Linking Emissions to Aerosol and Trace Gas Distributions and Subsequent Effects

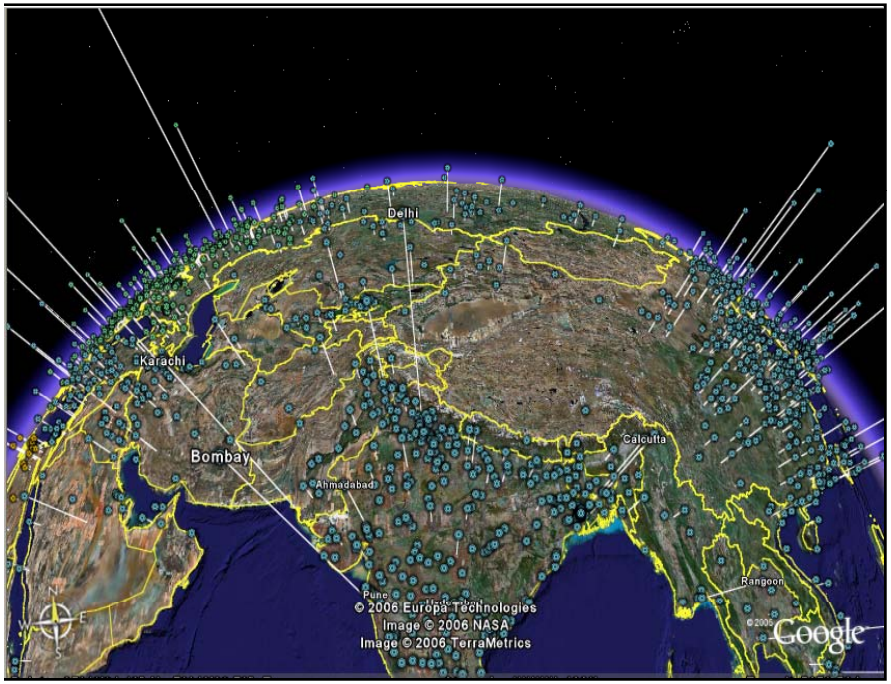


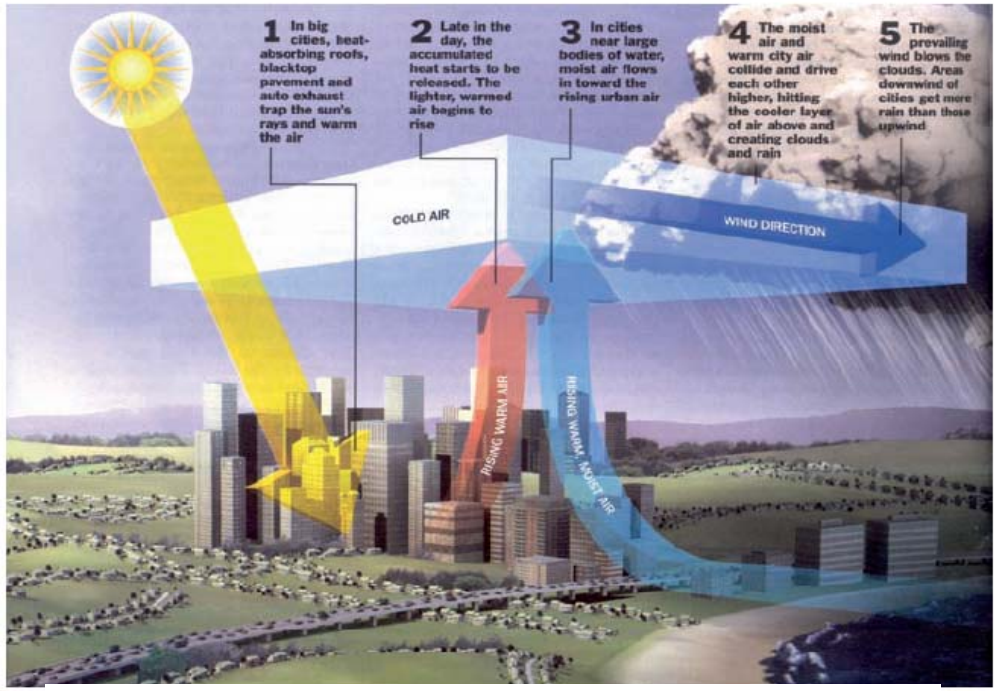
Models are an Integral Part of Air Quality Studies

- Field experiment planning
- Provide 4-Dimensional context of the observations
- Facilitate the integration of the different measurement platforms
- Evaluate processes (e.g., role of biomass burning, wet removal, heterogeneous chemistry….)
- Evaluate emission estimates (bottom-up as well as top-down)
- Scenario analysis/attribution studies
- Air quality forecasts and management

Regional and Global Perspectives of Megacity Air Pollution

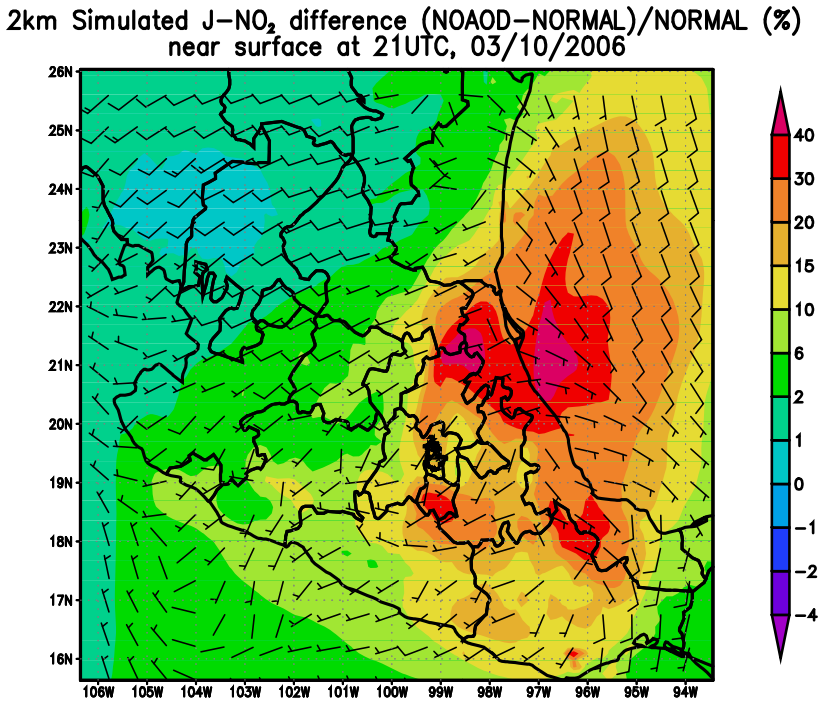
Urban Environments Involve Complex Interactions from Local to Global Scales





Where problems and solutions occur first!

Impact of Aerosols on Mexico City Photochemistry – MILAGRO Period

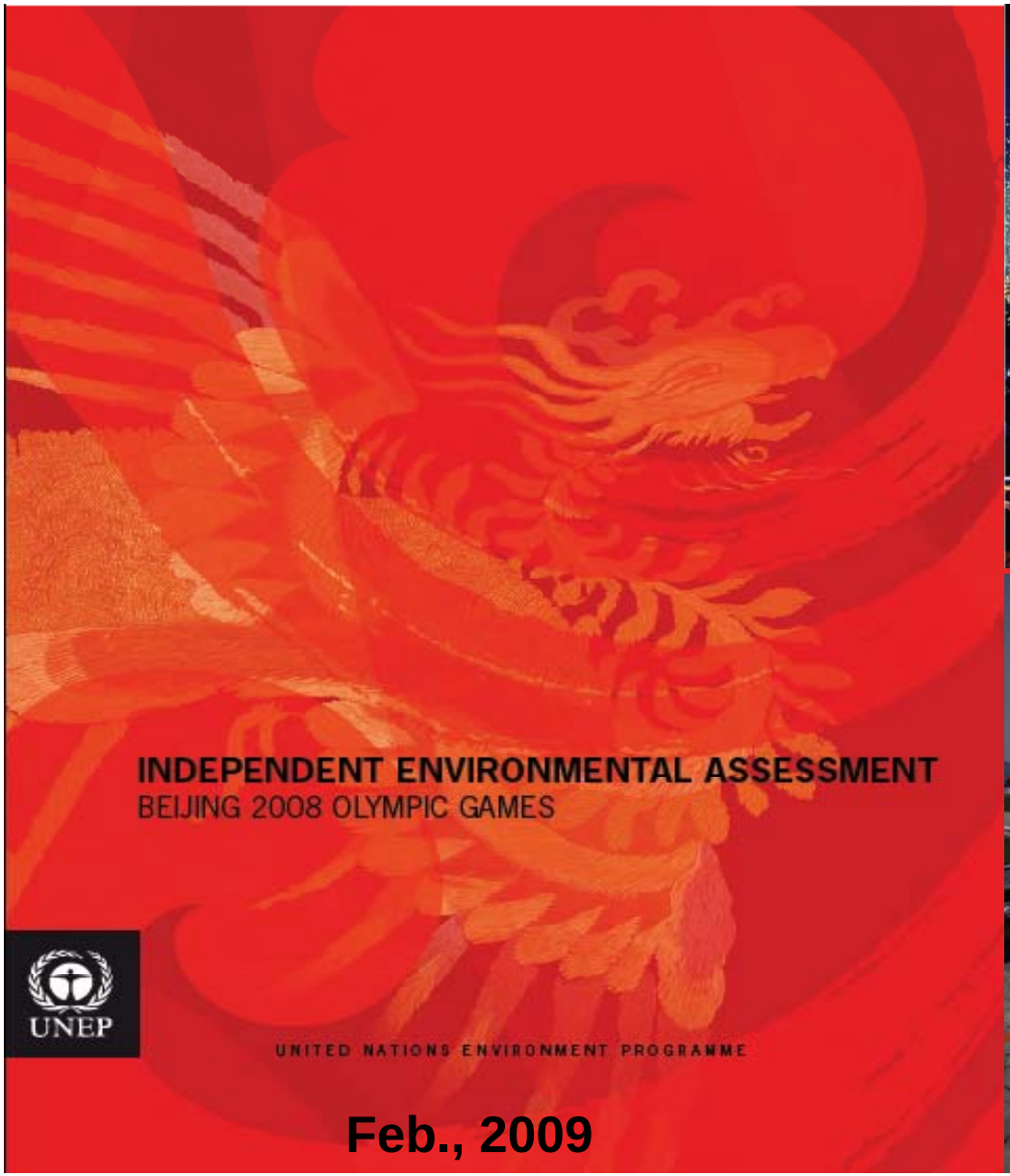


J-NO2

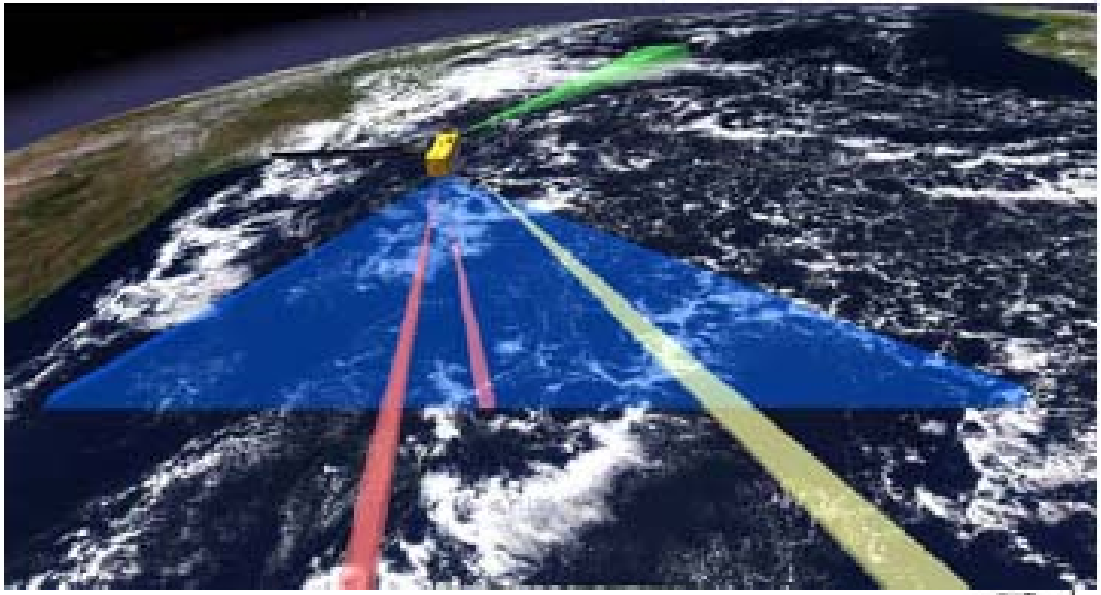
% Difference (without aerosol – with)/with

Mena et al., ACP, 2009

Mega City Detection – The Beijing Olympics Case Study



Satellite Detection of Emissions (OMI)



OMI Satellite Analysis of NO2 And SO2 Columns Were Able To Detect The Emission Changes

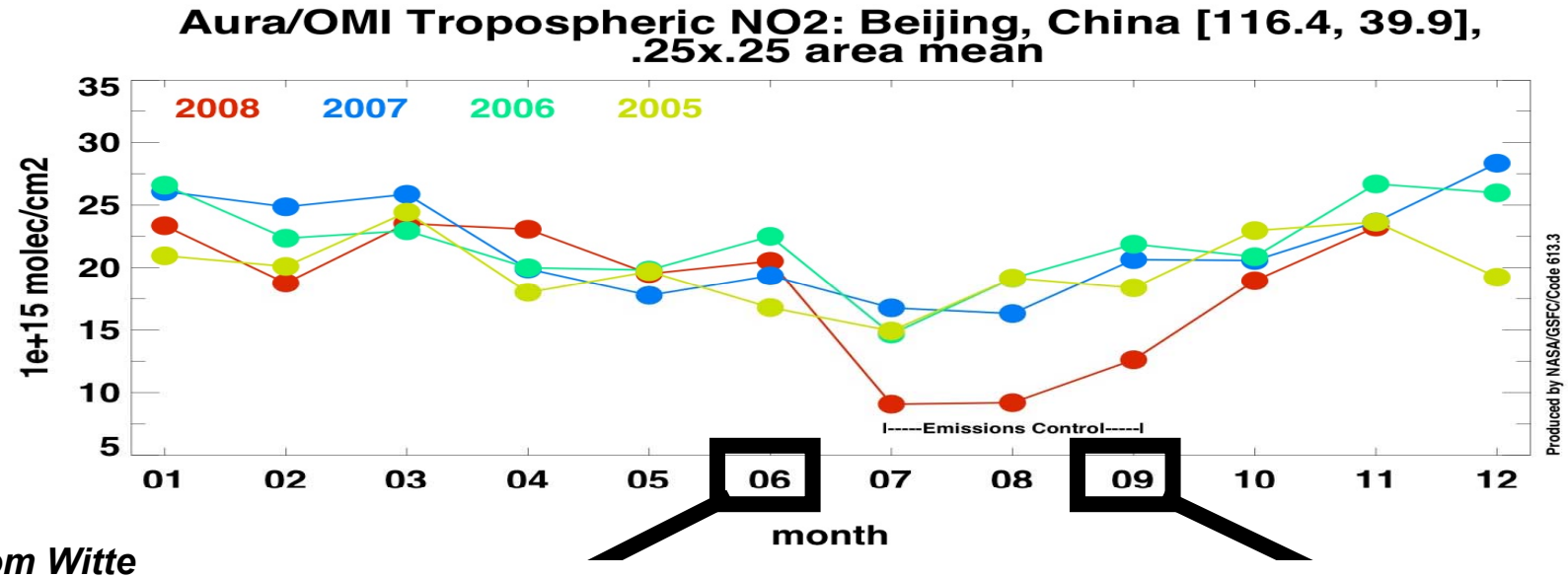
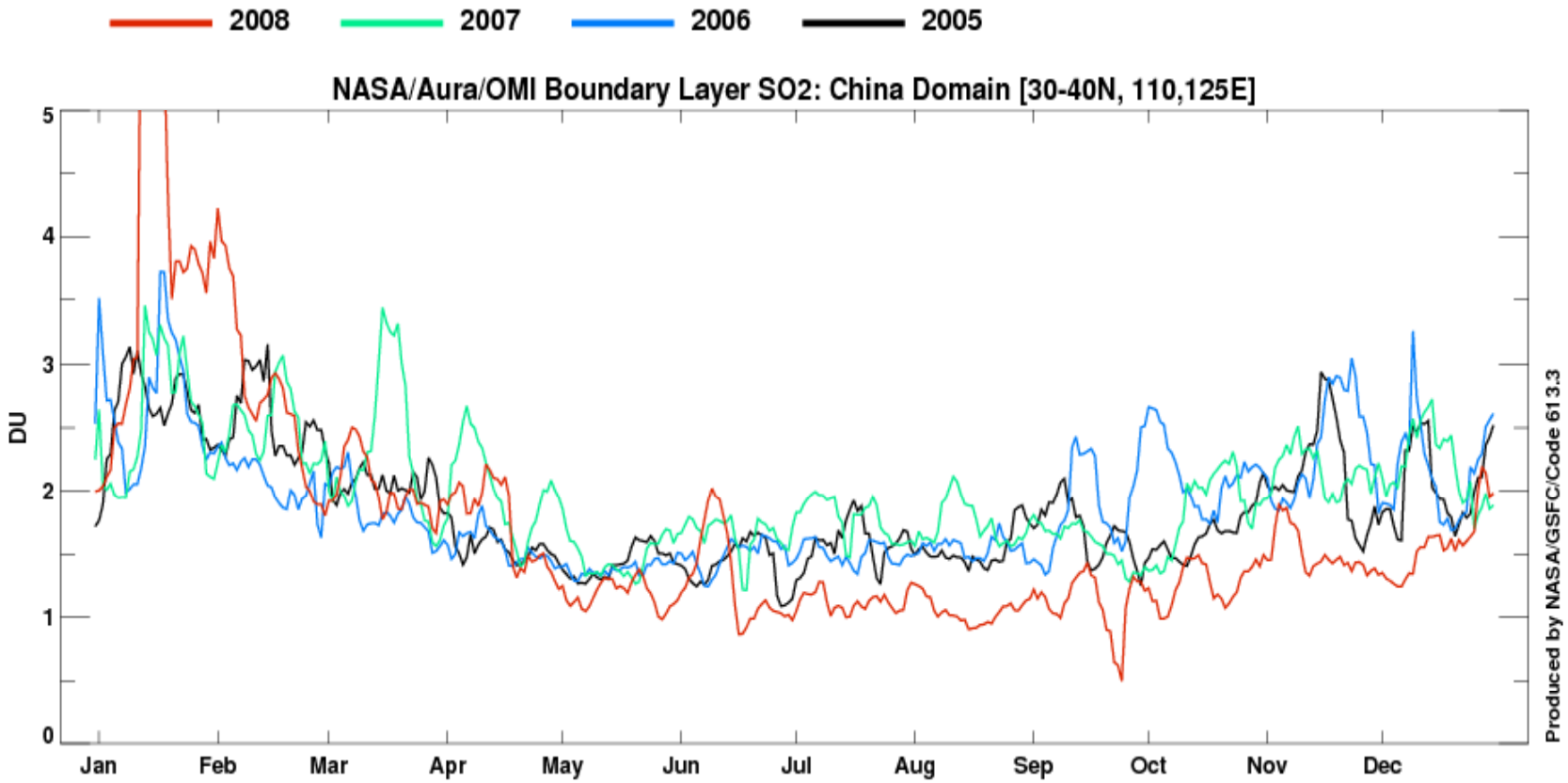


Figure from Witte et al., 2008.

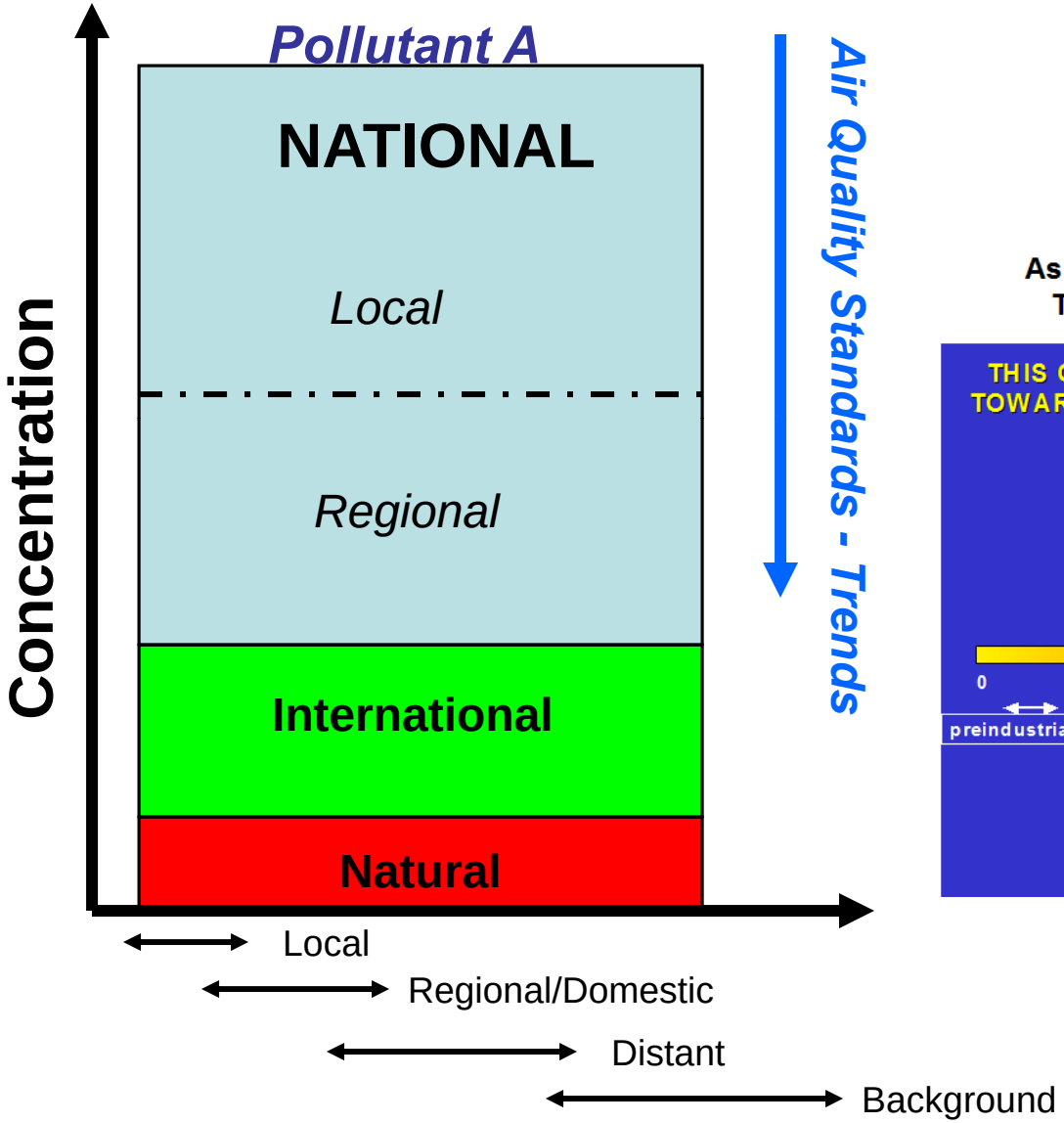
Over what scales can we detect the signal? To what extent can we attribute the signal to emissions vs meteorology?

A Few Surprises SO2 Columns

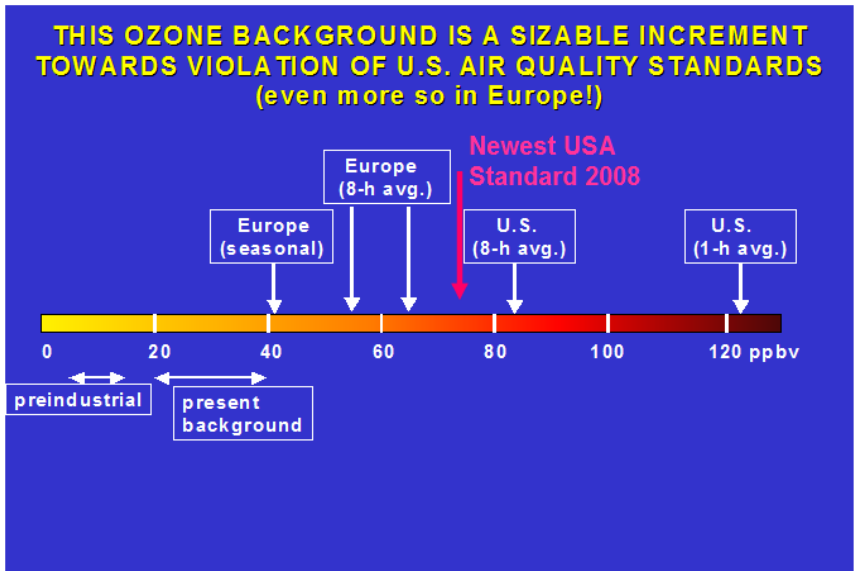


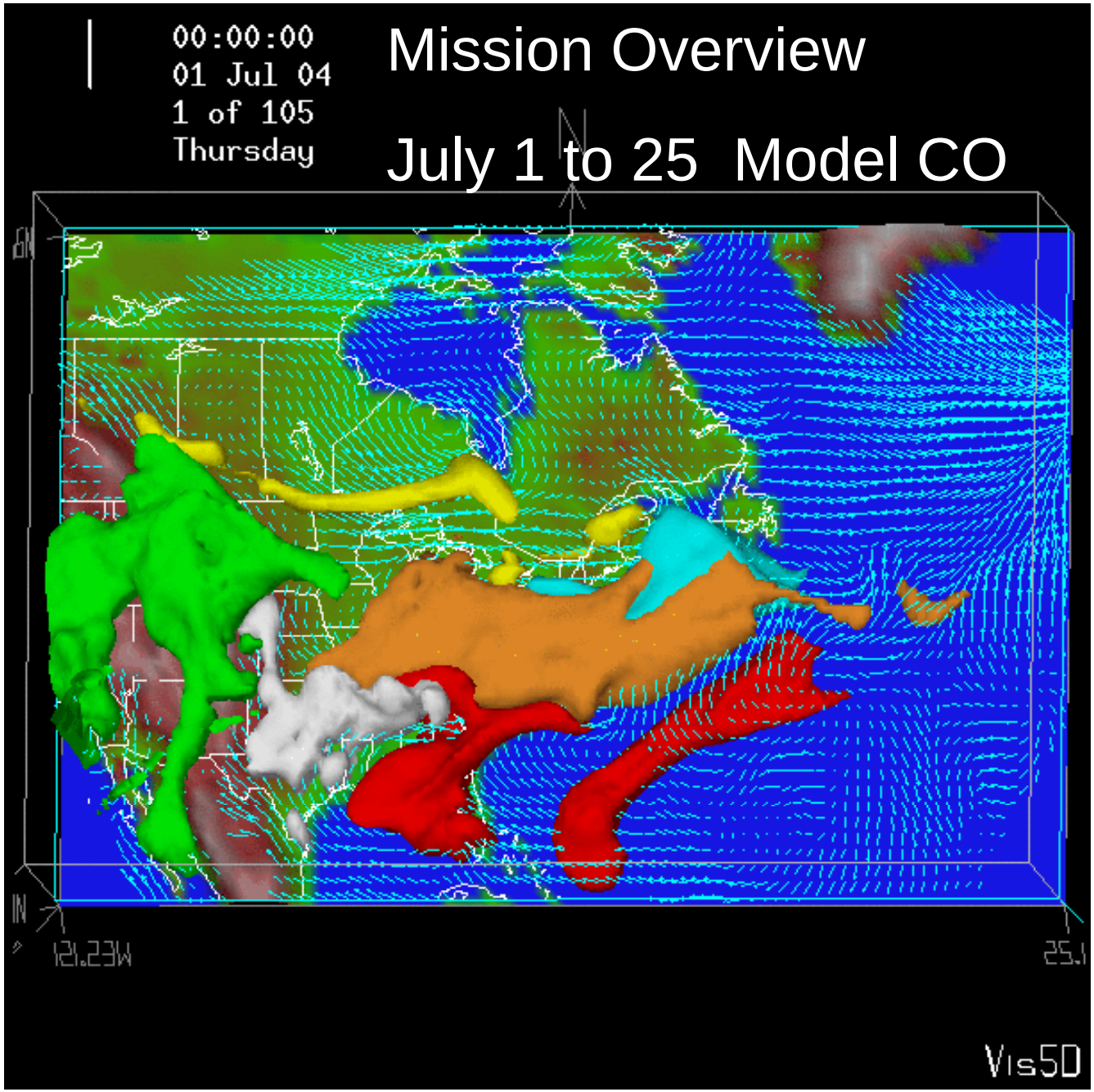
Krotkov et al., NASA GODDARD

Source Attribution at Global (and All) Scales is Becoming More Important (*We need better tools*)



As Air Quality Standards Become More Stringent
The Importance Of Distant Sources Increases





Midwest

Ohio etc

NY-MA-MD

TX-NM

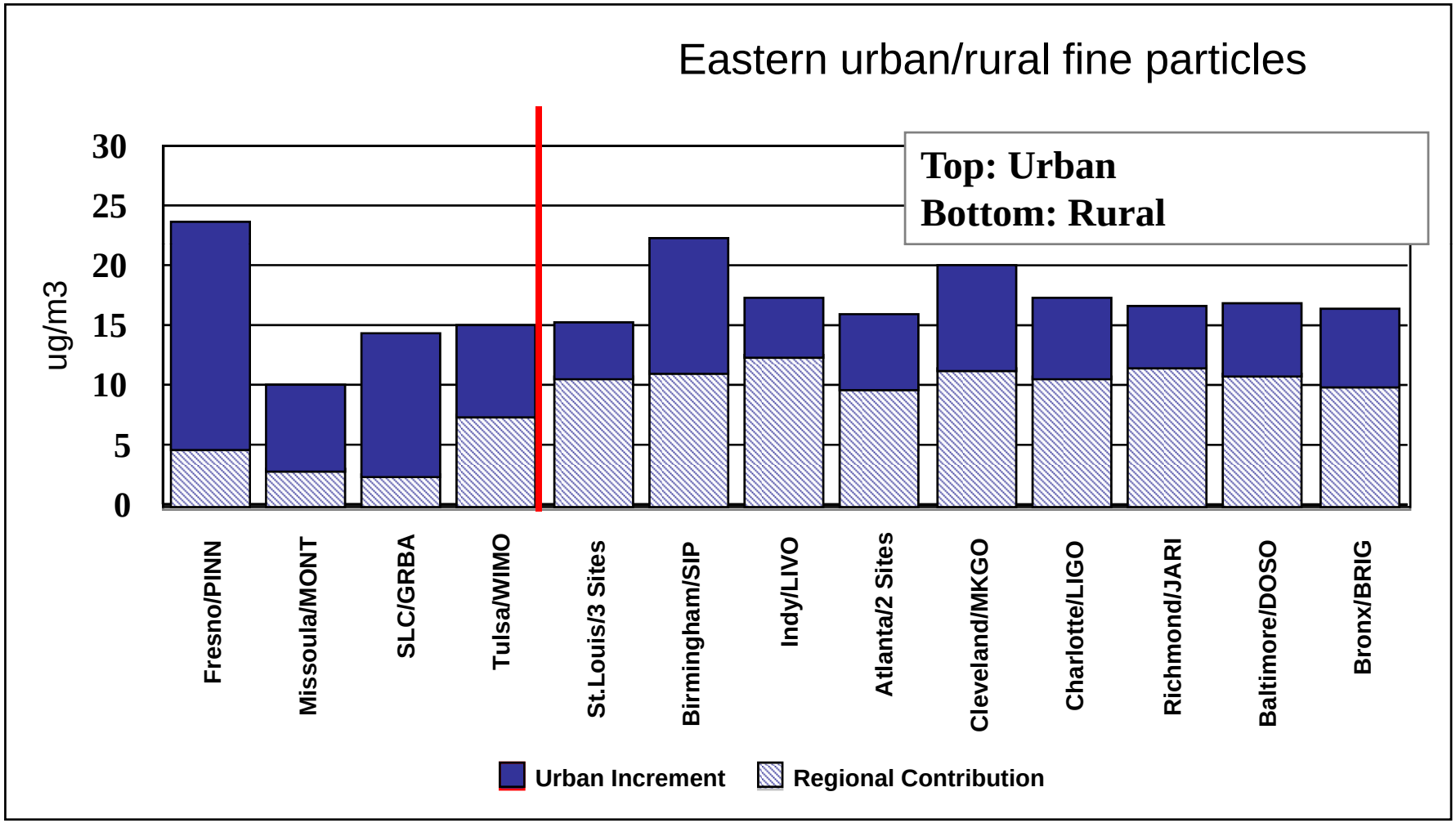
Southeast

California

Canada

2km wind field

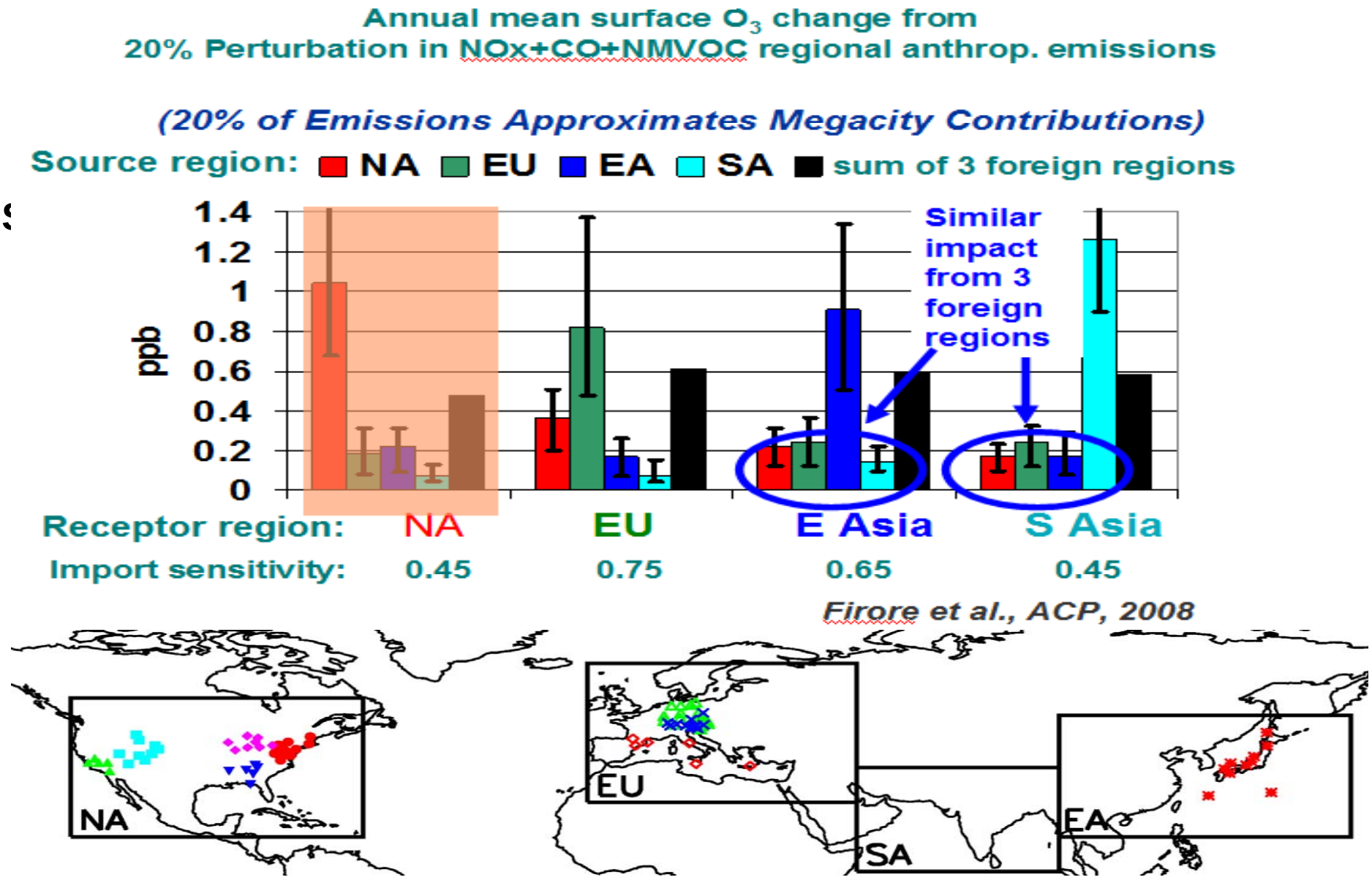
Regional Transport Is a Major Fraction of $PM_{2.5}$ and Ozone



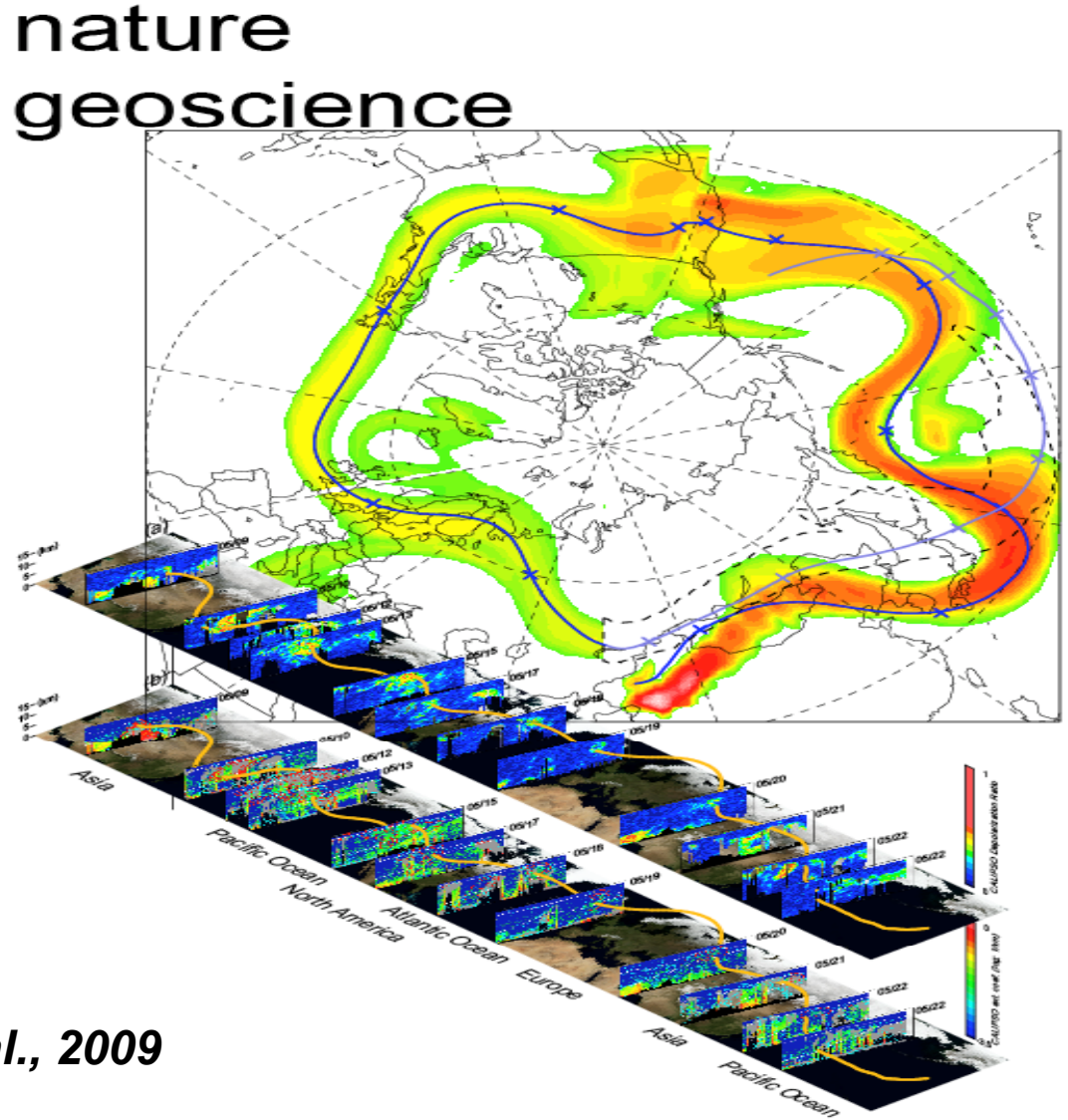
12-month average PM2.5 mass from speciation samplers

Reference: 2002 EPA Trends Report http://www.epa.gov/air/airtrends/chem_spec_of_pm2.5_b.pdf

Estimates of S-R relationships for surface O_3 pollution



Through Better Models and Observations We Can Better Quantify The Long Reach Of Pollutant Transport



Ono et al., 2009

Air Quality Forecast Capability
End-to-End Operational Capability

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- *NCEP mesoscale NWP: WRF-NMM*
- *NOAA/EPA community model for AQ: CMAQ*

Observational Input:

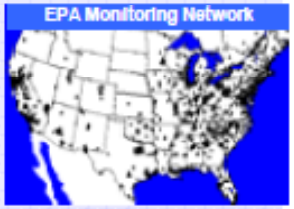
- *NWS weather observations; NESDIS fire locations*
- *EPA emissions inventory*

Gridded forecast guidance products

- *On NWS servers: www.weather.gov/aq and ftp-servers*
- *On EPA servers*
- *Updated 2x daily*

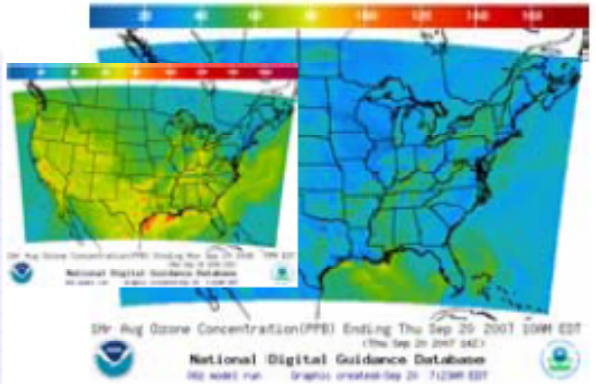
Verification basis, near-real time:

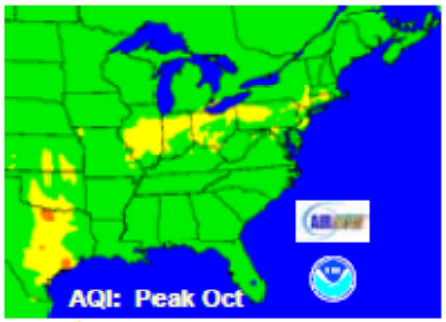
- *Ground-level AIRNow observations*
- *Satellite smoke observations*



Customer outreach/feedback

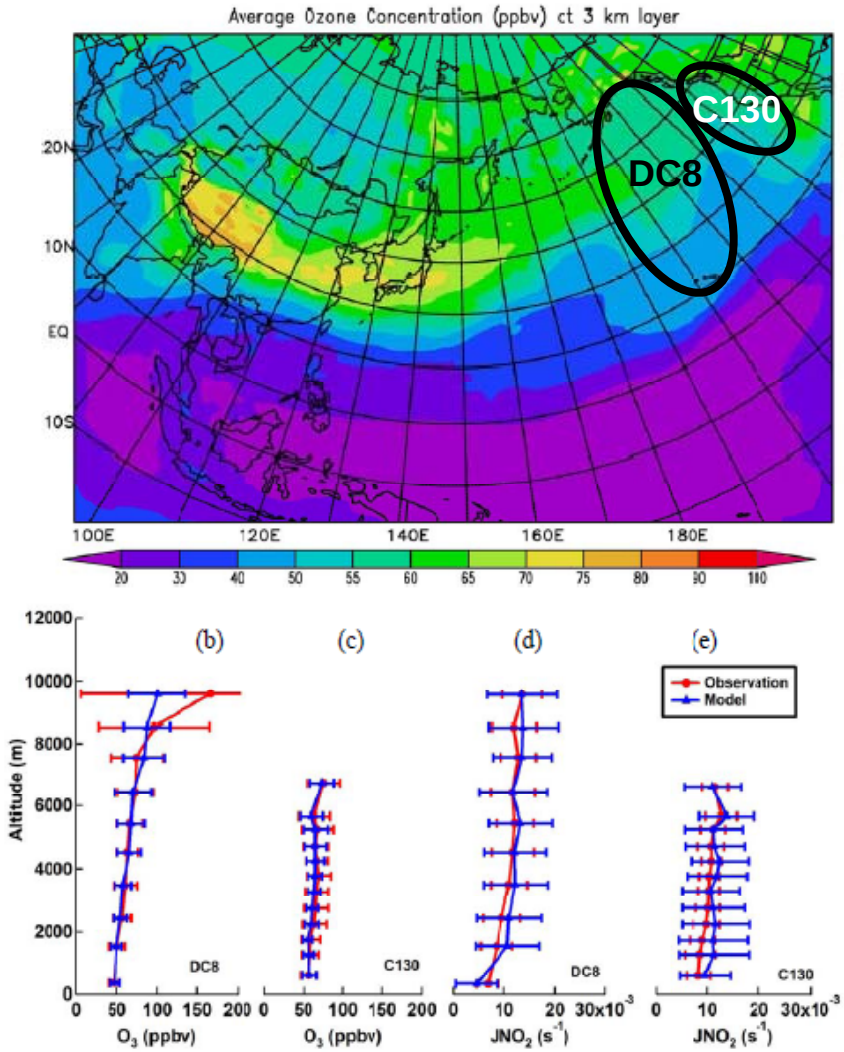
- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*
- *Website monitoring*





Slide provided by Paula Davidson

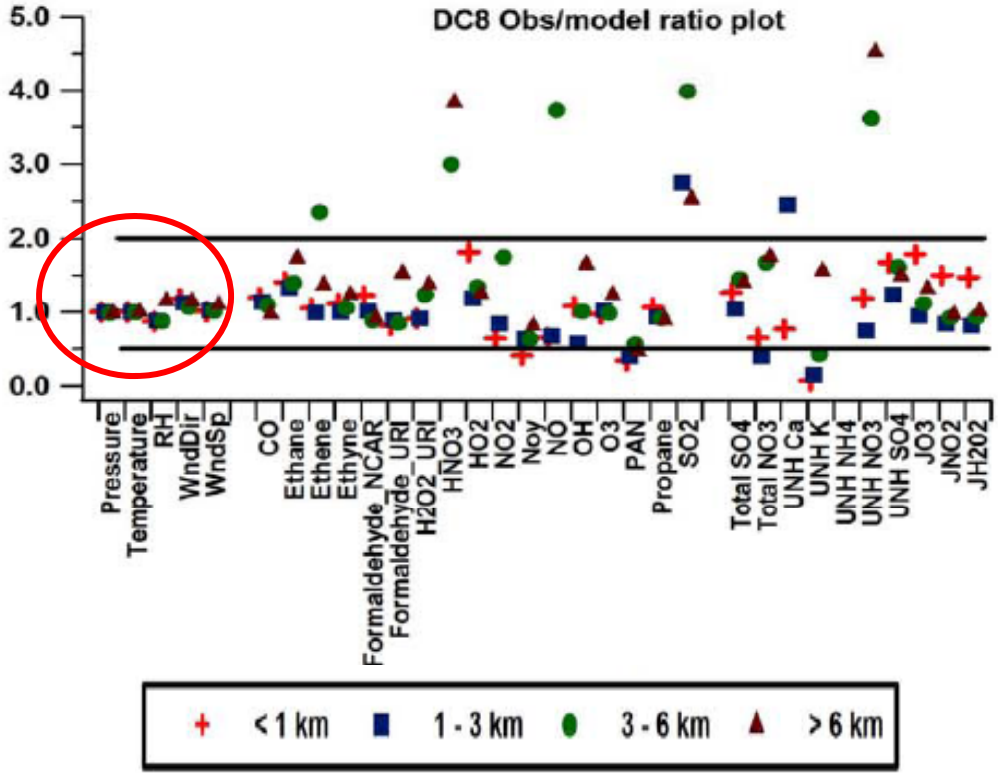
Intensive field experiments provide opportunities for comprehensive evaluations

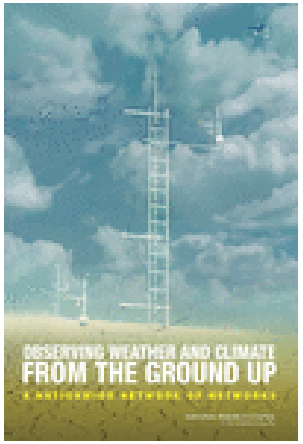


DC8 **C130**

Current CTMs Do Have Appreciable Skills In Predicting A Wide Variety Of Parameters

INTEX B – STEM Forecasts



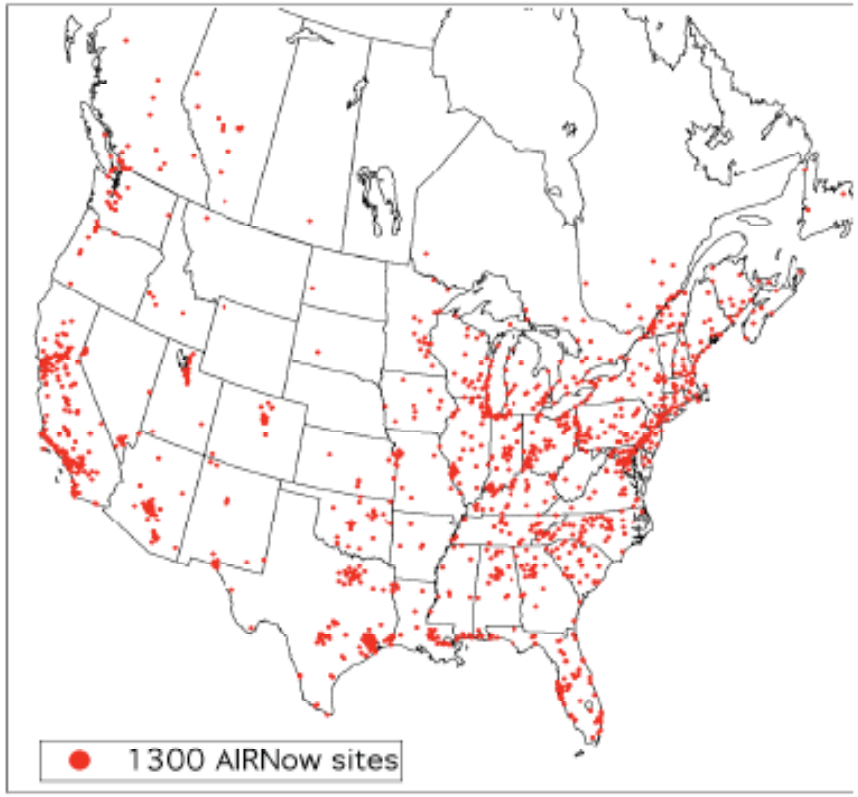


NAS - 2008

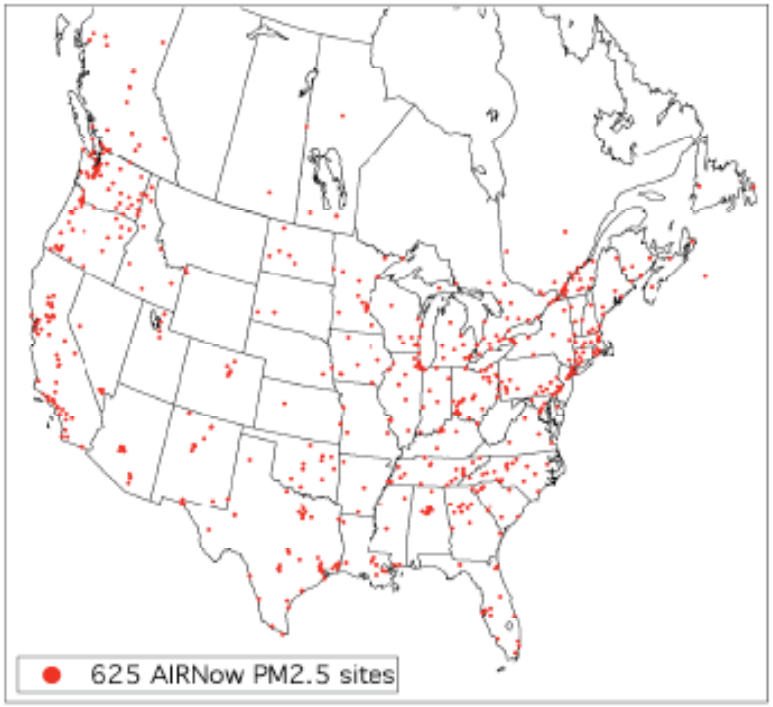
Observing Weather and Climate FROM THE GROUND UP A Nationwide Network of Networks

www.nap.edu/catalog.php?record_id=12540

What's wrong with these pictures?



O3



PM2.5

Common Measurement Needs Threads

Sector/ Variable	Weather and Climate	Energy	Public Health and Safety	Transportation	Food and Water
Surface wind speed and direction	x	x	x	x	x
Surface temperature	x	x	x	x	x
Surface relative humidity	x	x	x	x	x
Surface pressure	x		x	x	
Visibility	x		x	x	
Precipitation rate	x		x	x	x
Snow cover and depth	x			x	x
Precipitation amount	x	x	x	x	x
Precipitation type	x	x		x	x
sea-surface temperature	x				
Lightning	x		x	x	
planetary boundary layer height	x	x	x	x	
Soil-moisture and soil-temperature profiles	x	x	x	x	x
Direct and diffuse radiation	x	x	x	x	
Vertical wind profiles	x	x	x	x	
Vertical temperature profiles	x	x	x	x	
Vertical humidity profiles	x	x	x	x	
Hydrometeor mixing ratios	x				
Reservoir temperature/water temperature		x			x
Stream flow		x		x	x
Ag climate variables		x			x
Icing near surface		x		x	
Air quality—surface	x	x	x		
Air quality—aloft	x		x		
Cloud cover/ sky view		x	x	x	
Surface turbulence parameters		x	x	x	
Roadway temperature				x	
Subsurface temperatures				x	x
Low-level shear	x	x		x	
Marine swell heights/water depth/ currents/air gaps				x	
Evapotranspiration					x
Water quality					x

X important gaps may exist;  so inadequate that no network can be said to exist.

Observations Priorities Stemming from Common Threads

MOST NEEDED:

- Height of the planetary boundary layer
- Soil moisture and temperature profiles
- High resolution vertical profiles of humidity
- Measurements of air quality and atmospheric composition above the surface layer

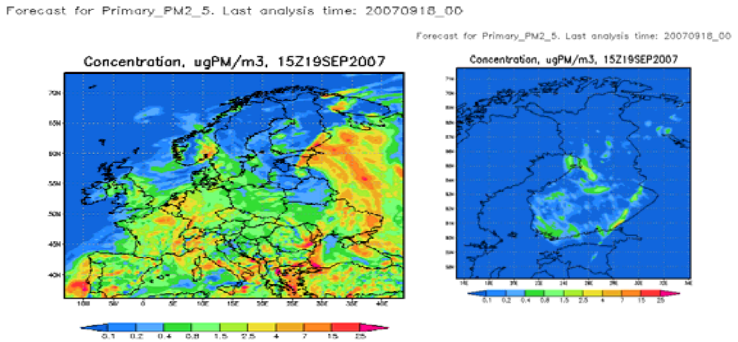
NEEDED:

- Direct and diffuse radiation
- Vertical profiles of wind
- Sub-surface temperature profiles (e.g., under pavement)
- Icing near the surface
- Vertical profiles of temperature
- Surface turbulence parameters

Many Meteorological Services Already Supply Operational Chemical Weather Products (e.g., FMI)

Satellite observations

Fire Assimilation System



Final AQ products

Phenological observations

Aerobiological observations

Physiography, forest mapping

Phenological models

SILAM AQ model

EVALUATION: NRT model-measurement comparison

Assimilation

HIRLAM NWP model

UN-ECE CLRTAP/EMEP emission database

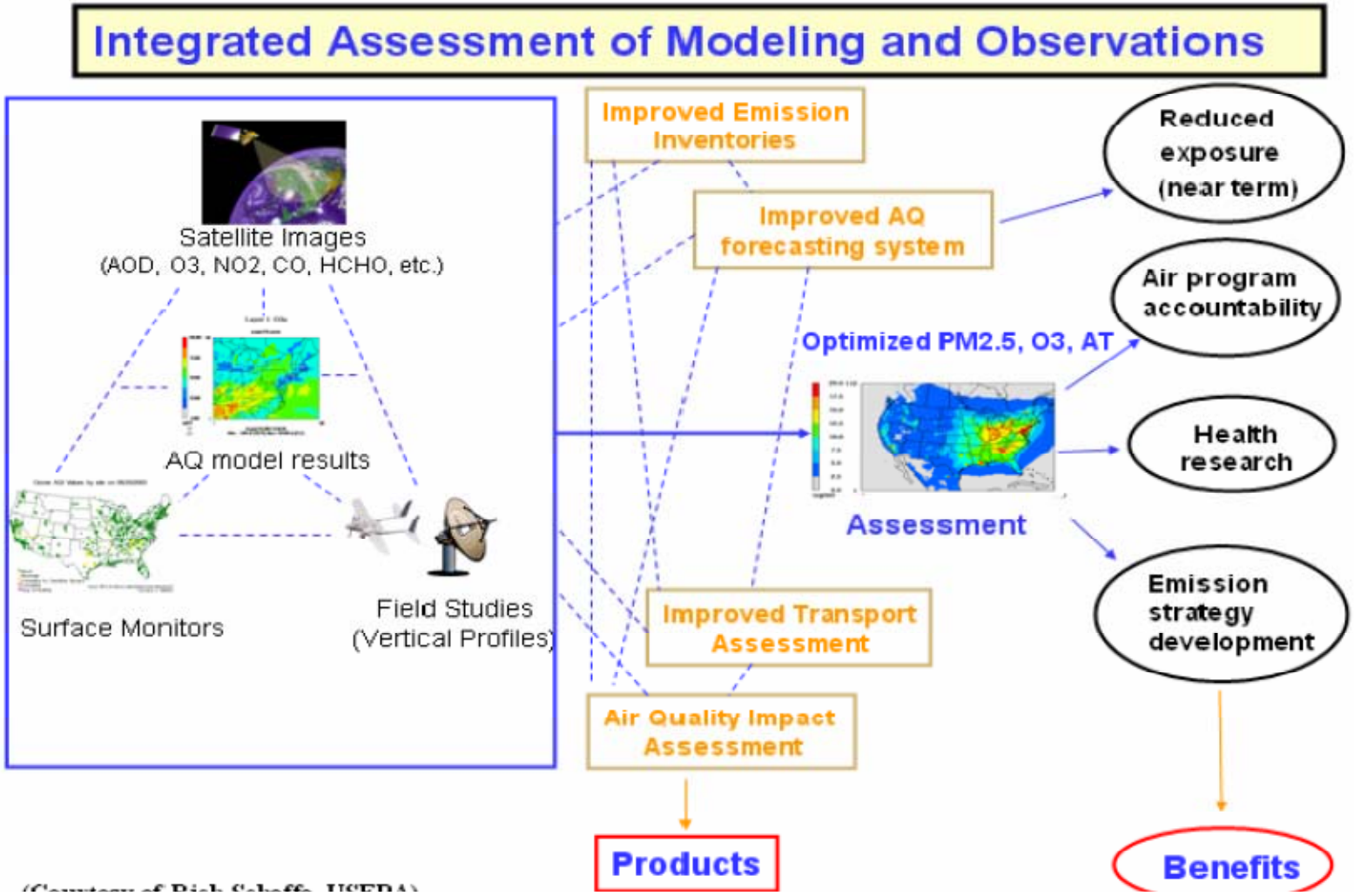
Meteorological data: ECMWF

Aerobiological observations

Online AQ monitoring

Real-time data needs!

Growing Importance of Air Quality Modeling in Environmental Science & Management



and derived benefits.

EXPO 2010 Shanghai China

WMO (GURME) Pilot Project MHWS

- **Theme:** Better City, Better Life
- **Period:** May 1 to Oct. 31, 2010

China Pavilion

Meteorology Pavilion
“Cloud drop”