Merging space, time, chemistry and environmental media: Monitoring and Assessment Challenges

NESCAUM Meeting

Mystic, CT
October 18, 2007

Rich Scheffe, EPA-OAR

Acknowledgments

- Everyone
- Haluk Ozkanak
- Tyler Fox
- Fred Dimmick
- Jason Ching

simply, Arithmetic injustice

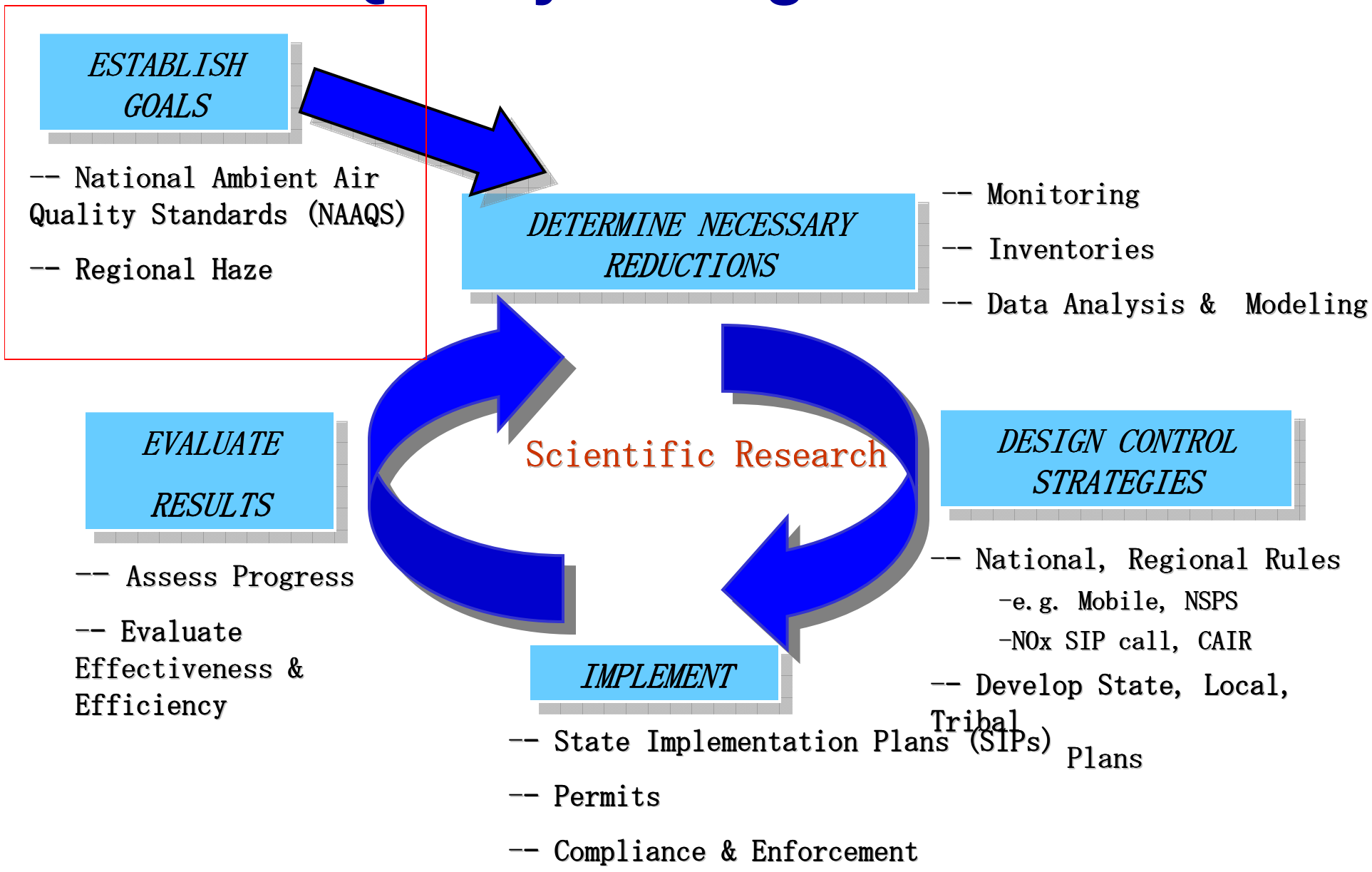
- Greater than 95% of air pollutant mass is located above 100m,
  yet we (air program community) focus 95 % of our characterization on the bottom 10 meters

  {compromises both predictive and current characterization phenomena}

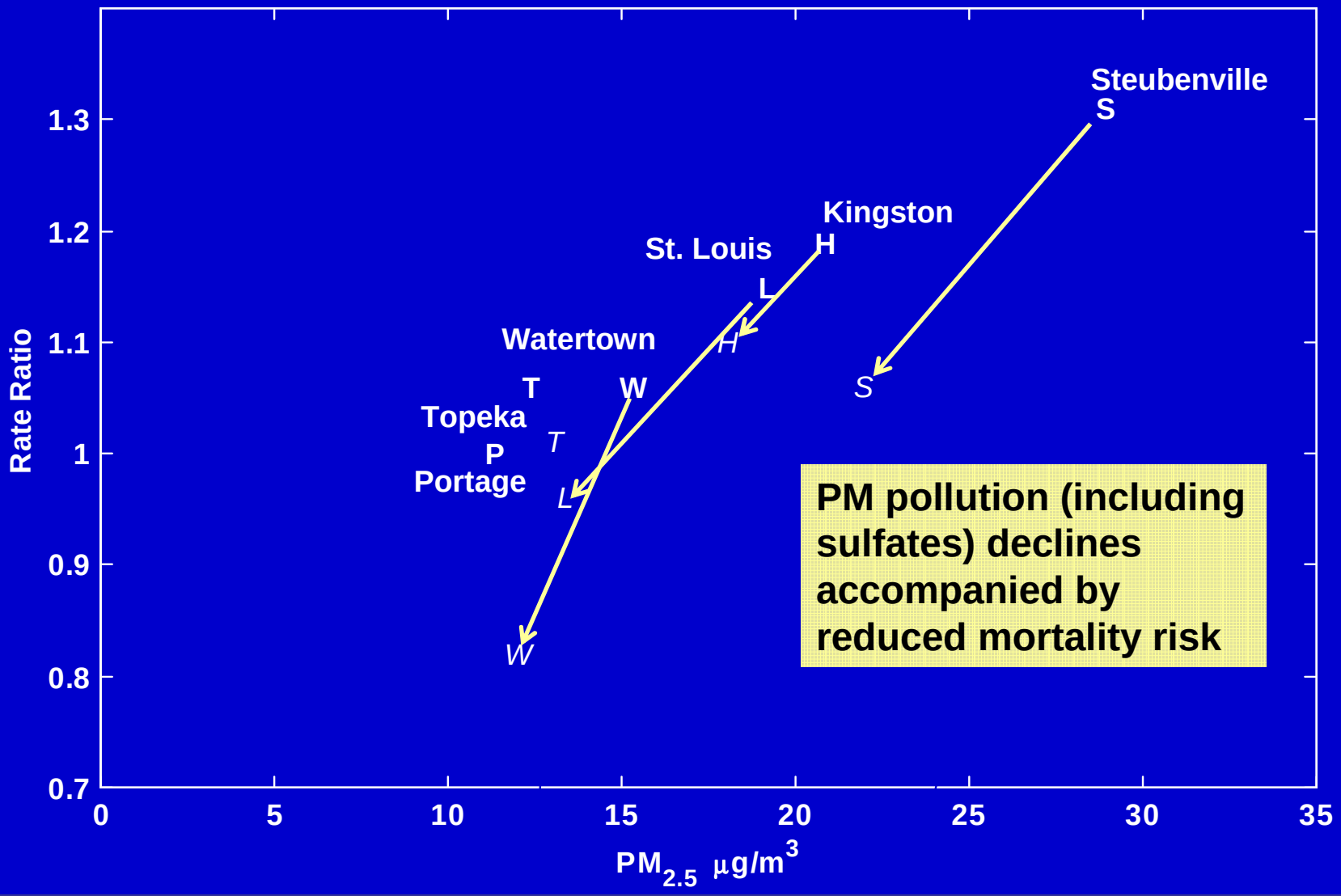
Sequence

- Background on Current/historical/future air program priorities
  - Recent rules
  - New Ozone and PM NAAQS
  - New drivers and challenges
    - Multimedia
    - Multi-pollutant
      - Climate-AQ interactions
    - Accountability
    - Multiple scales
- Linking exposure (near road) assessments with mainstream analytical tools

The Air Quality Management Process



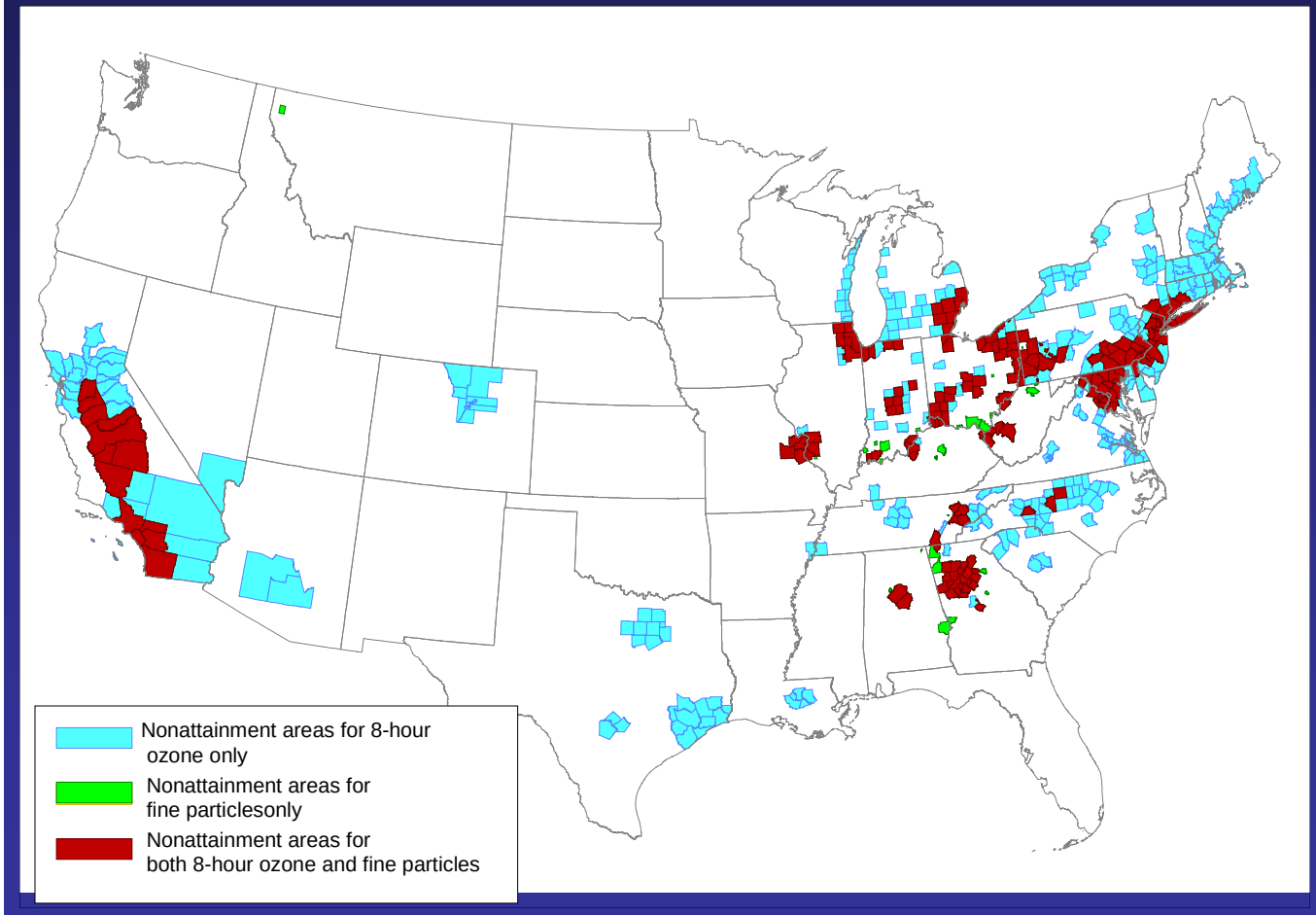
Fine Particle Reductions Work



Layden et al (2006). Effect of Reduction in Fine Particulate Air Pollution and on Mortality: A extended follow-up in of the Harvard Six Cities Adult Cohort

Which NAAQS are most important?

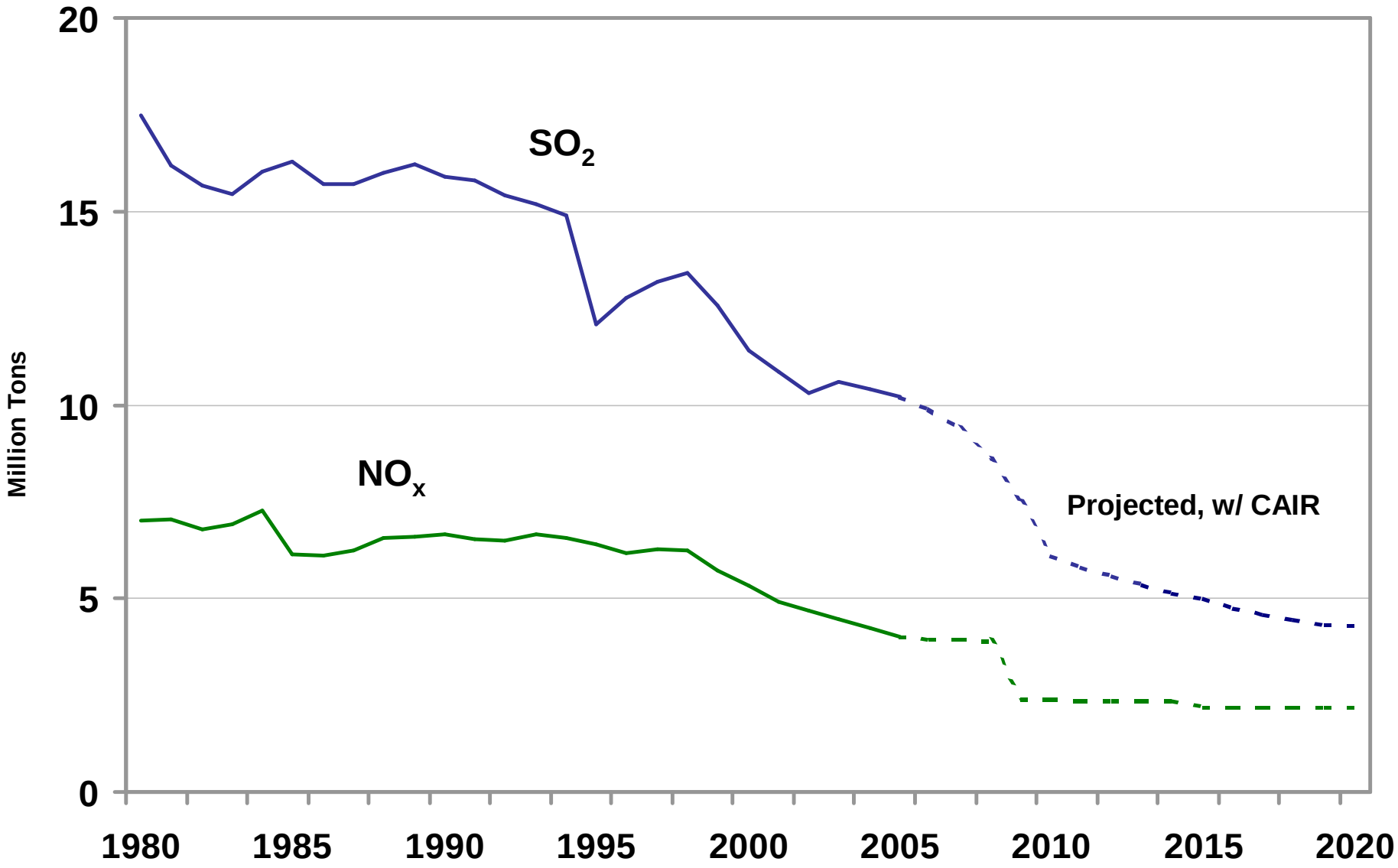
Areas Designated Nonattainment for Ozone and $PM_{2.5}$ 2004



No. Counties with Monitors>NAAQS	
CO	0
Lead	1
SO2	0
NO2	0
PM 10	4
PM 2.5	8
O_3	29

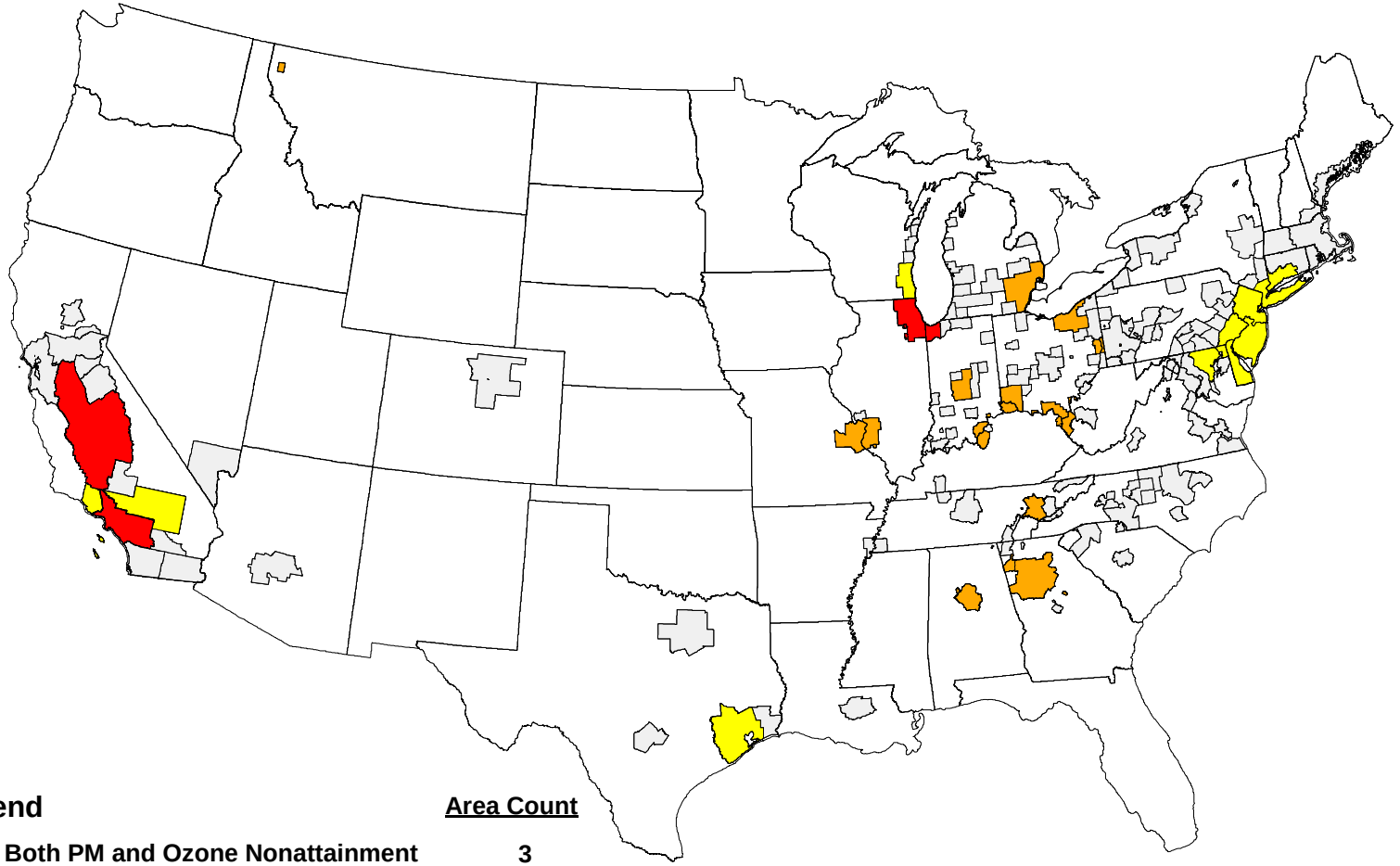
Ozone and PM are our highest priority

National NO_x and SO_2 Power Plant Emissions: Historic and Projected with CAIR



Source: EPA

Areas Projected to Exceed the $PM_{2.5}$ and 8-Hour Ozone Standards in 2015 with CAIR/CAMR/CAVR and Some Current Rules* Absent Additional Local Controls



Legend	Area Count
Both PM and Ozone Nonattainment	3
PM Only Nonattainment	14
Ozone Only Nonattainment	7
Nonattainment areas projected to attain	105

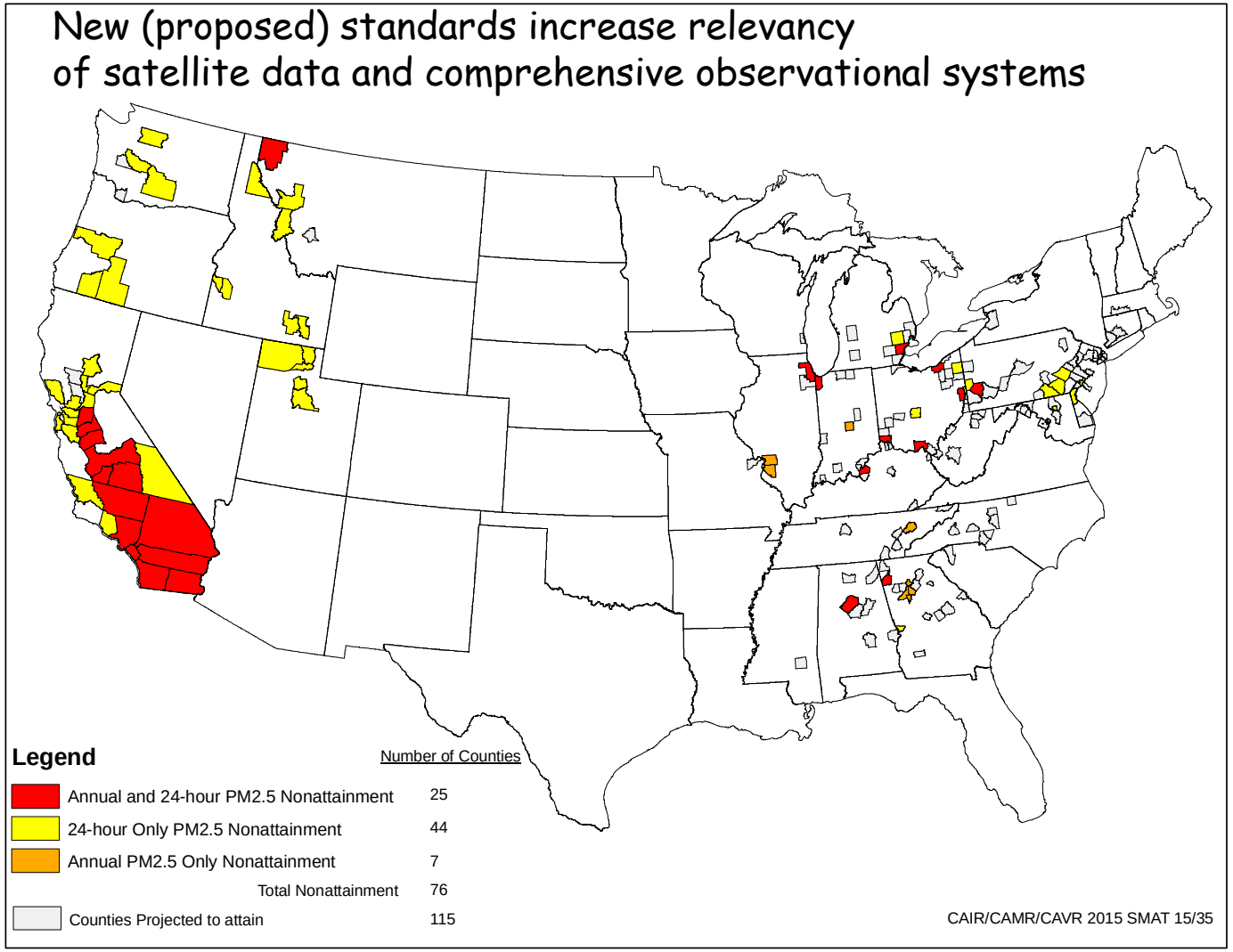
**Areas forecast to remain in nonattainment may need to adopt additional local or regional controls to attain the standards by dates set pursuant to the Clean Air Act. These additional local or regional measures are not forecast here, and therefore this figure overstates the extent of expected nonattainment.

*Current rules include Title IV of CAA, NO_x SIP Call, and some existing State rules.

New PM NAAQS 2006

- Annual NAAQS 15 ug/m3
- 24 hour 98th percentile NAAQS 35 µg/m3
  - From 65 µ g/m3
  - Implications ….new definition for anomalous events
    - Increased relevance of remote sensing information
- PM10 remains
- Requirements for $PM_{10\text{-}2.5}$ monitoring
  - focus on urban coarse PM resuspended by heavy traffic, industrial sources, and construction
    - excludes rural dust uncontaminated by urban, industrial sources (excludes agriculture, mining, wind blown dust

Counties Exceeding the Proposed PM2.5 NAAQS- 2015 Base Case Annual 15 ug/m3 and 24-Hour 35 ug/m3



**EPA models assume implementation of CAIR/CAMR/CAVR, mobile source and other federal rules and existing state programs. Air quality is expected to be better than shown. This approach does not forecast actions states will take to meet current PM standards. Also note that modeled air quality forecasts are subject to a number of uncertainties.*

Ozone Standard under review

- Current standard (not to exceed) of 0.08 ppm running 8 hour average
- Recent health effects research suggesting link between ozone exposure and mortality
- Ozone assessment considering reduced levels as low as 0.06 ppm
- Raises importance of background ozone, transport and climate-AQ interactions

Emerging Findings Suggesting Link between Ozone and Mortality

A Meta-Analysis of Time-Series Studies of Ozone and Mortality With Comparison to the National Morbidity, Mortality, and Air Pollution Study Michelle L. Bell,* Francesca Dominici,† and Jonathan M. Samet‡, Epidemiology • Volume 16, Number 4, July 2005

Ruidavets, J.-B.; Cournot, M.; Cassadou, S.; Giroux, M.; Meybeck, M.; Ferrires, J. (2005) Ozone air pollution is associated with acute myocardial infarction. Circulation 111: 563-569.

Kim, S.-Y.; Lee, J.-T.; Hong, Y.-C.; Ahn, K.-J.; Kim, H. (2004) Determining the threshold effect of ozone on daily mortality: an analysis of ozone and mortality in Seoul, Korea, 1995-1999. Environ. Res. 94: 113-119.

Huang, Y.; Dominici, F.; Bell, M. L. (2005) Bayesian hierarchical distributed lag models for summer ozone exposure and cardio-respiratory mortality. Environmetrics 16: 547-562.

Ito, K.; De Leon, S. F.; Lippmann, M. (2005) Associations between ozone and daily mortality, analysis and metaanalysis. Epidemiology 16: 446-457.

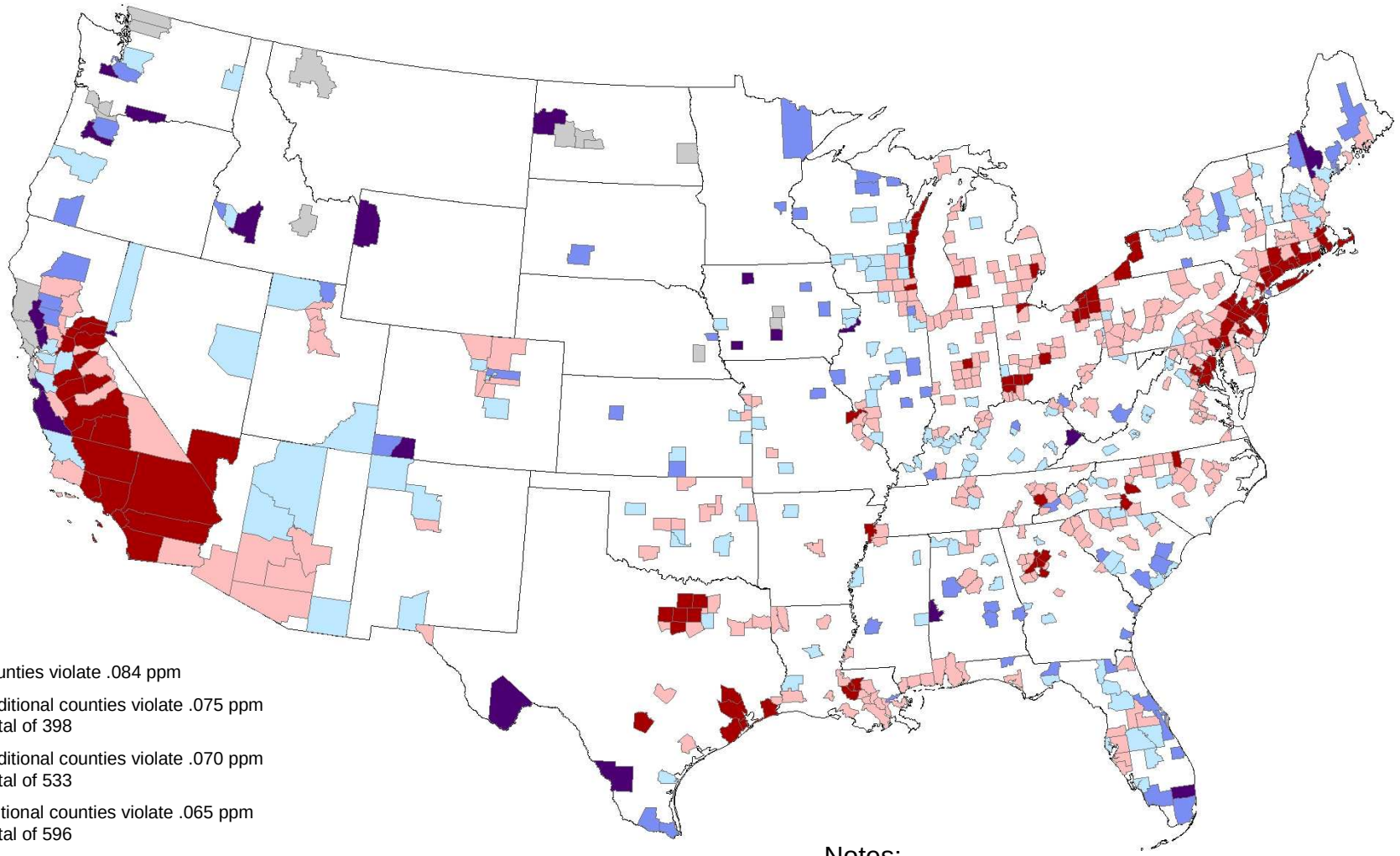
Levy, J. I.; Chemerynski, S. M.; Sarnat, J. A. (2005) Ozone exposure and mortality, an empiric Bayes metaregression analysis. Epidemiology 16: 458-468.

Liao, D.; Duan, Y.; Whitsel, E. A.; Zheng, Z.-J.; Heiss, G.; Chinchilli, V. M.; Lin, H.-M. (2004) Association of highe levels of ambient criteria pollutants with impaired cardiac autonomic control: a population-based study. Am. J. Epidemiol. 159: 768-777.

Rich, D. Q.; Schwartz, J.; Mittleman, M. A.; Link, M.; Luttmann-Gibson, H.; Catalano, P. J.; Speizer, F. E.; Dockery, D. W. (2005) Association of short-term ambient air pollution concentrations and ventricular arrhythmias. Am. J. Epidemiol. 161: 1123-1132.

Schwartz, J. (2005) How sensitive is the association between ozone and daily deaths to control for temperature? Am. J. Respir. Crit. Care Med. 171: 627-631.

Counties With Monitors Violating Alternative 8-hr Ozone Standards (Based on 2003 – 2005 Air Quality Data)



104 counties violate .084 ppm

294 additional counties violate .075 ppm for a total of 398

135 additional counties violate .070 ppm for a total of 533

63 additional counties violate .065 ppm for a total of 596

22 additional counties violate .060 ppm for a total of 618

21 counties meet .060 ppm for a total of 639

Notes:

[1] Out of 639 monitored counties

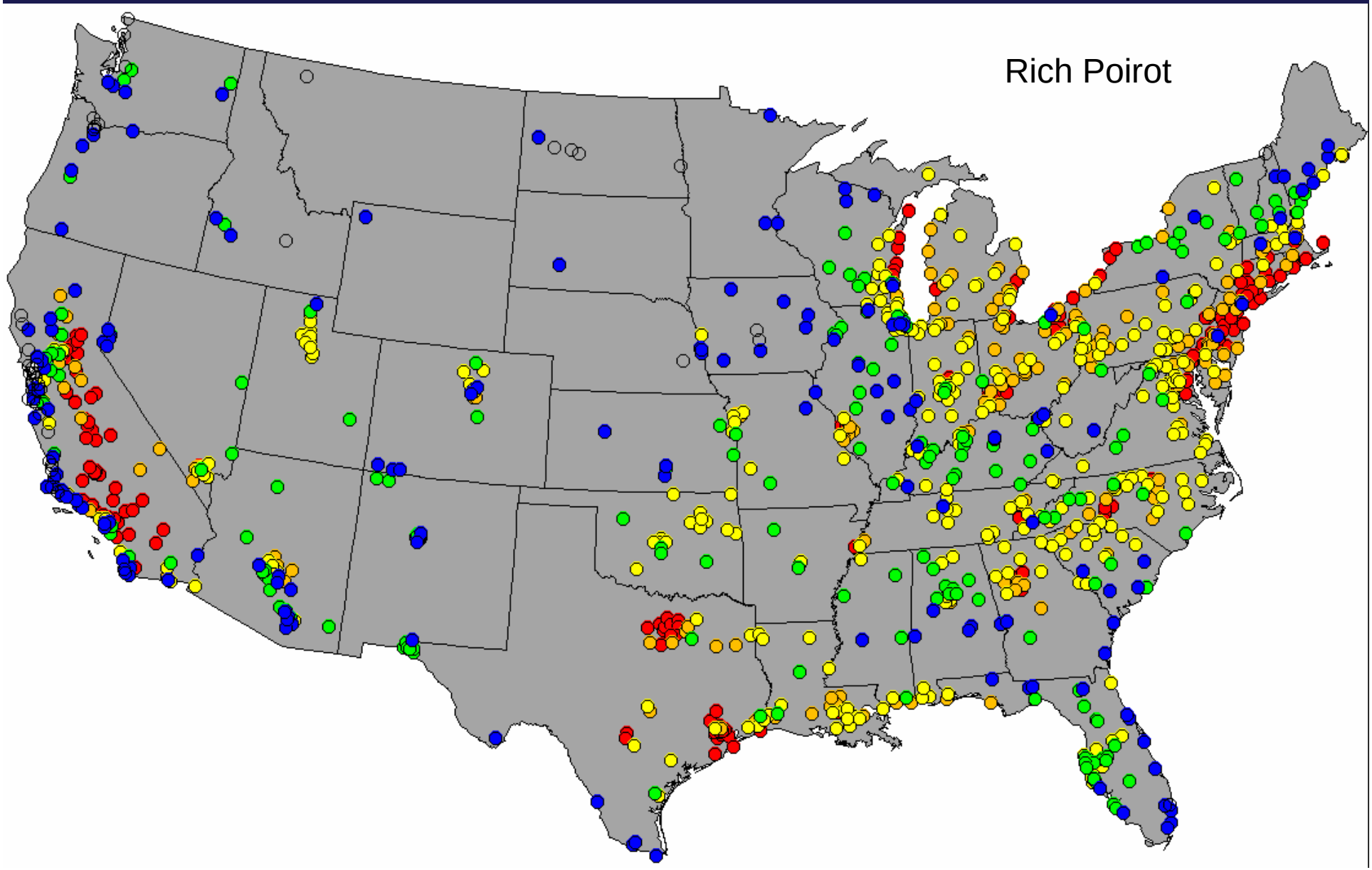
[2] No monitored counties outside the continental U.S. violate

[3] Monitored data can be obtained from the AQS system at http://www.epa.gov/ttn/airs/airsaqs/

[4] The current standard of 0.08 ppm is effectively expressed as 0.084 ppm when rounding conventions are applied.

[5] These estimates are based on the most recent data certified as complete(2003 – 2005). EPA will not designate areas as nonattainment on these data, but likely on 2006 - 2008 data which we expect to show improved air quality.

Sites with 2003-05 Ozone Design Values:
> 0.084 ppm, 0.081-0.084, 0.075-0.080, 0.071-0.074, 0.061-0.070 ppm

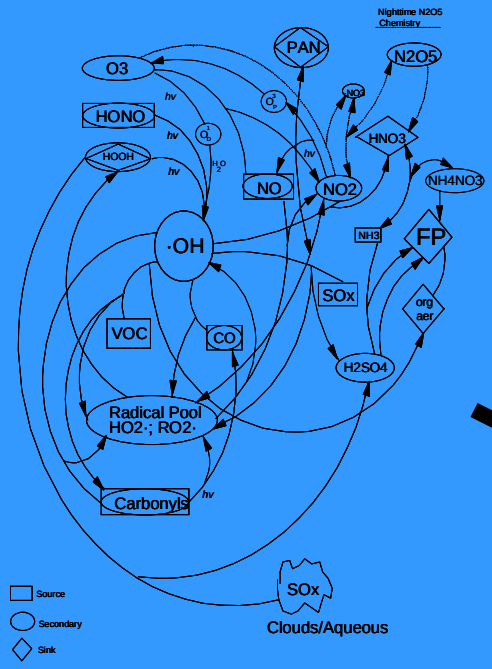


Don’t forget ozone

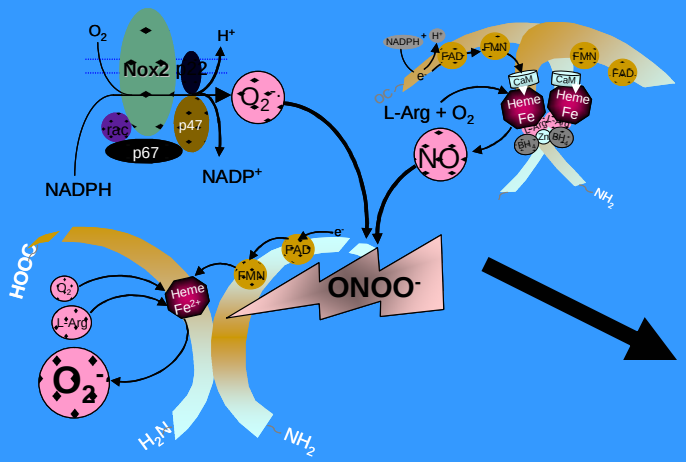
And EPA's research budget

- exploded for PM in the late 90's -2000's
- What happened to fundamental oxidant research?

Health Effects: Symmetries in atmospheric and cellular level chemistries



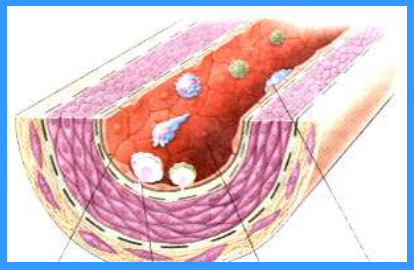
Atmospheric Pathways



Source, Harrison, 2006

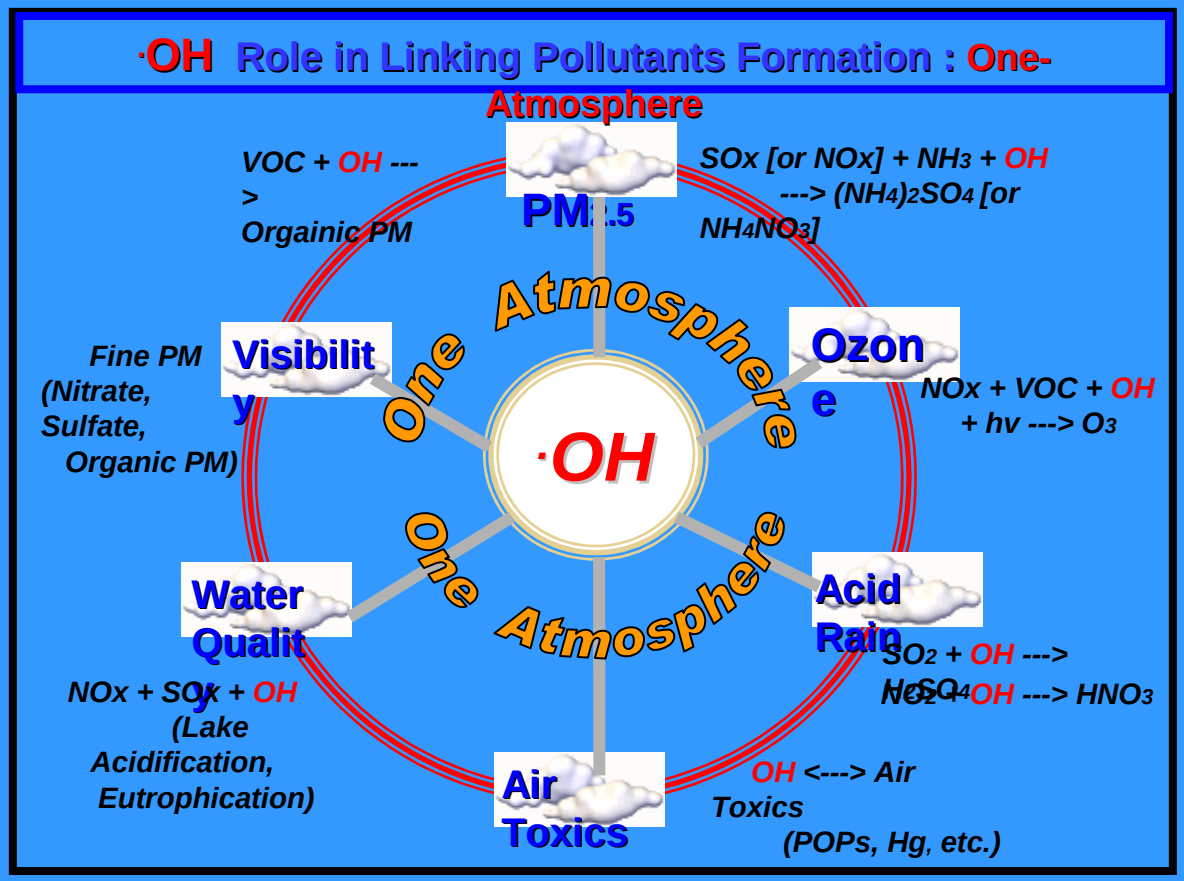
Reactive Oxidant Cell Chemistry Processes

Source, Harrison, 2006



Hypothesized effect

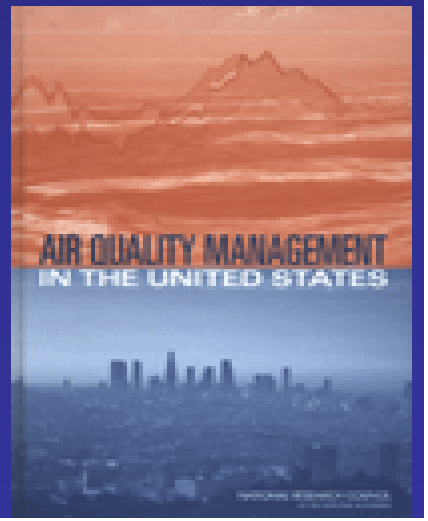
We need to re-respect the Center of the Environmental Assessment Universe…



Artist…C. Jang

Emerging Challenges for Air Policy

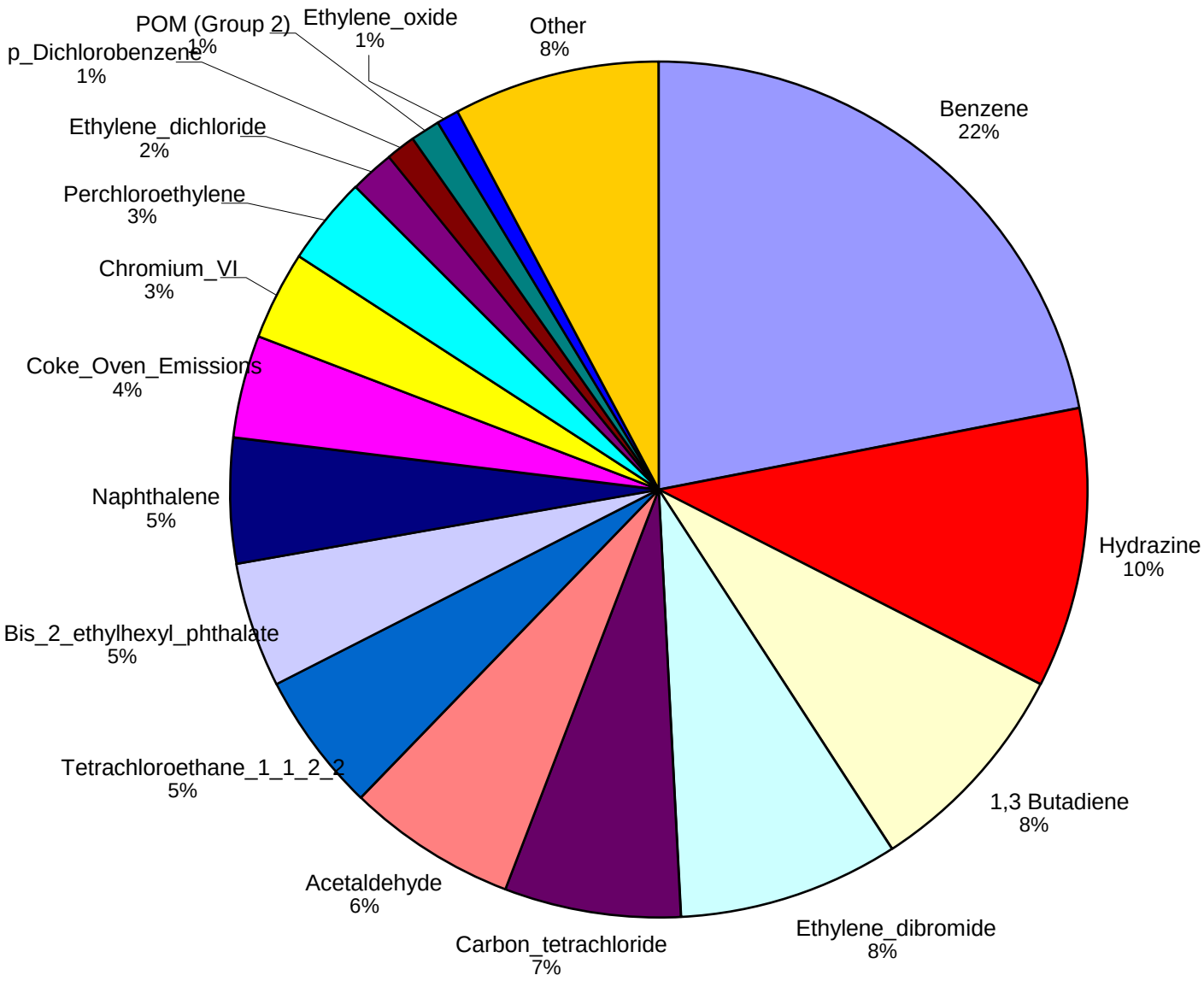
- Developing Multiple pollutant integrated management strategies
- Assessing and Protecting Ecosystem Health
- Multiple spatial scales of interest
- Intercontinental and Cross-Border Transport
- Maintaining AQM System Efficiency in the face of Changing Climate
- Ongoing Assessments and feedbacks of program progress (accountability)

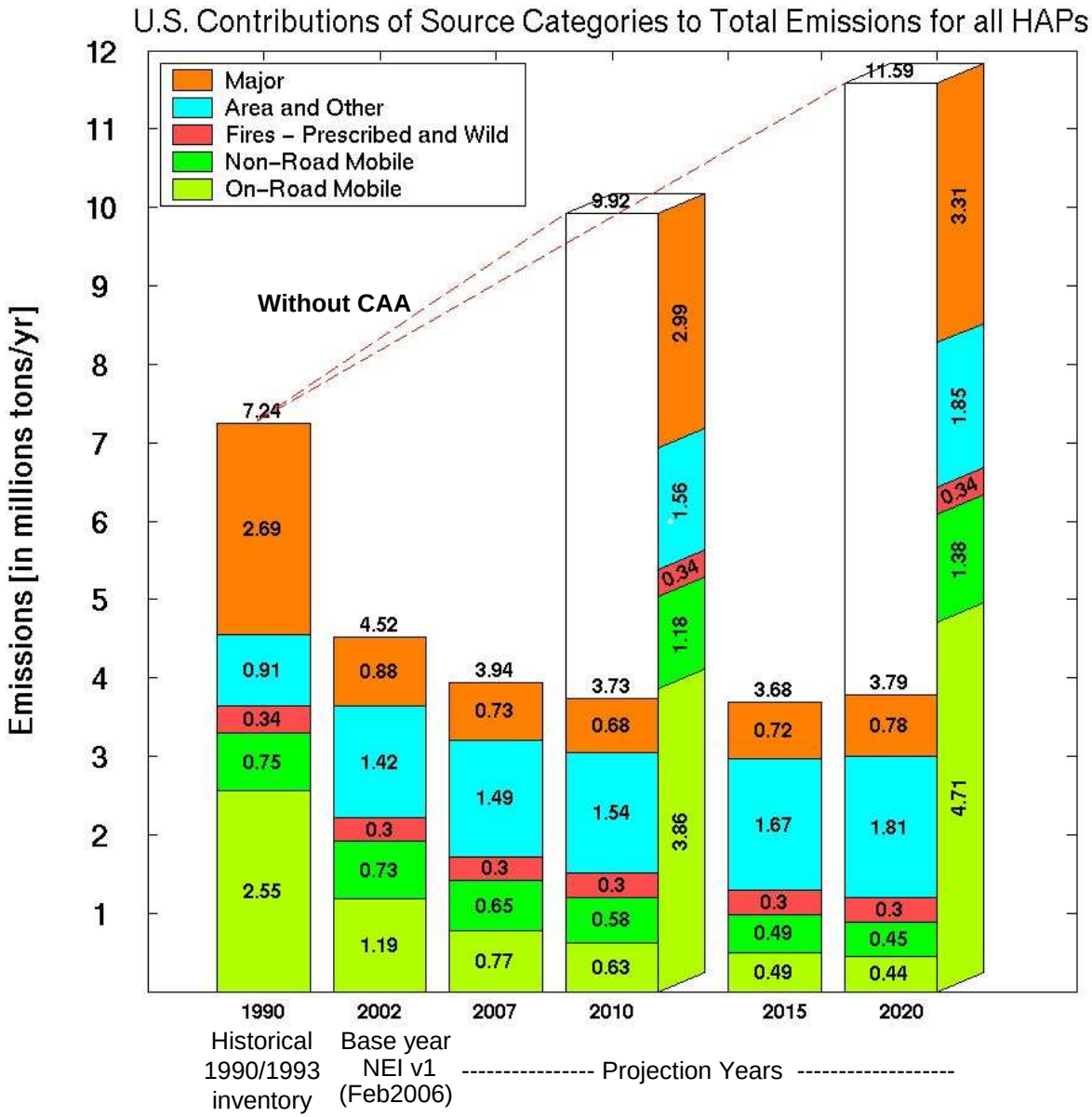


Air Toxics

- Missing step child in the PM and O3 universe

1999 NATA - Pollutant Contribution to Average Cancer Risk (48 in a million)





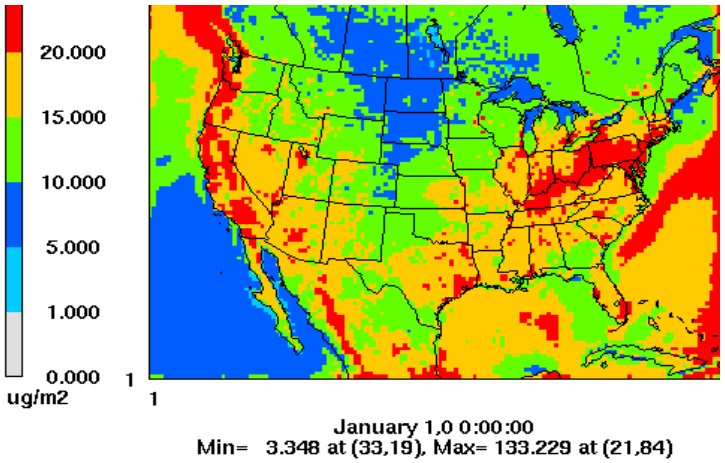
After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics. In addition, mobile source reductions are based on programs currently in place. Programs currently under development will result in even further reductions.

Projected emissions account for estimated activity growth and reductions resulting from MACT program, CAIR and Mobile source rules of the 1990's.

Key Findings:

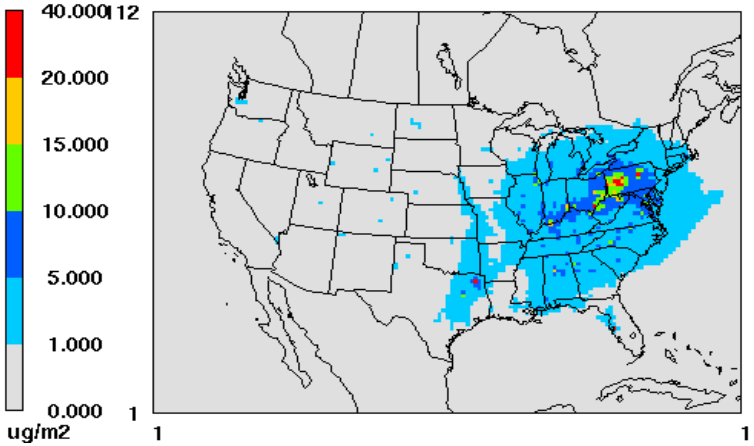
- CAA has been very effective in reducing overall tonnage of air toxics
- In absence of CAA, total emissions would be more than twice those projected in 2020

Mercury Deposition From All Sources: 2001

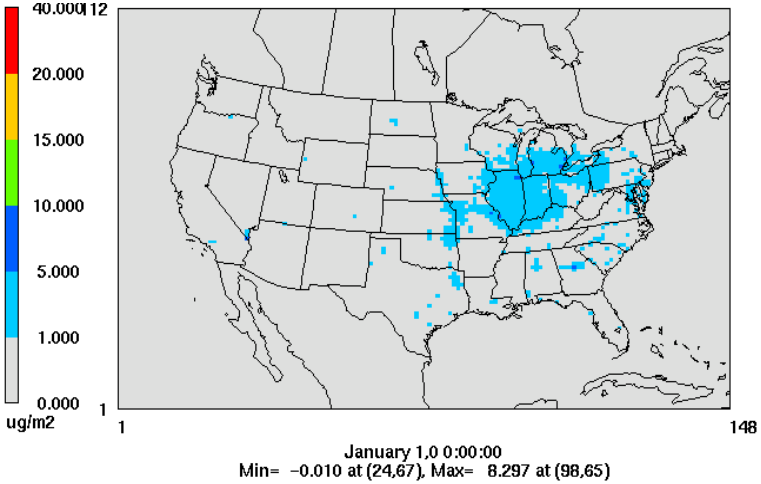


Mercury, current and future AQ challenge requiring multiple – scale approach

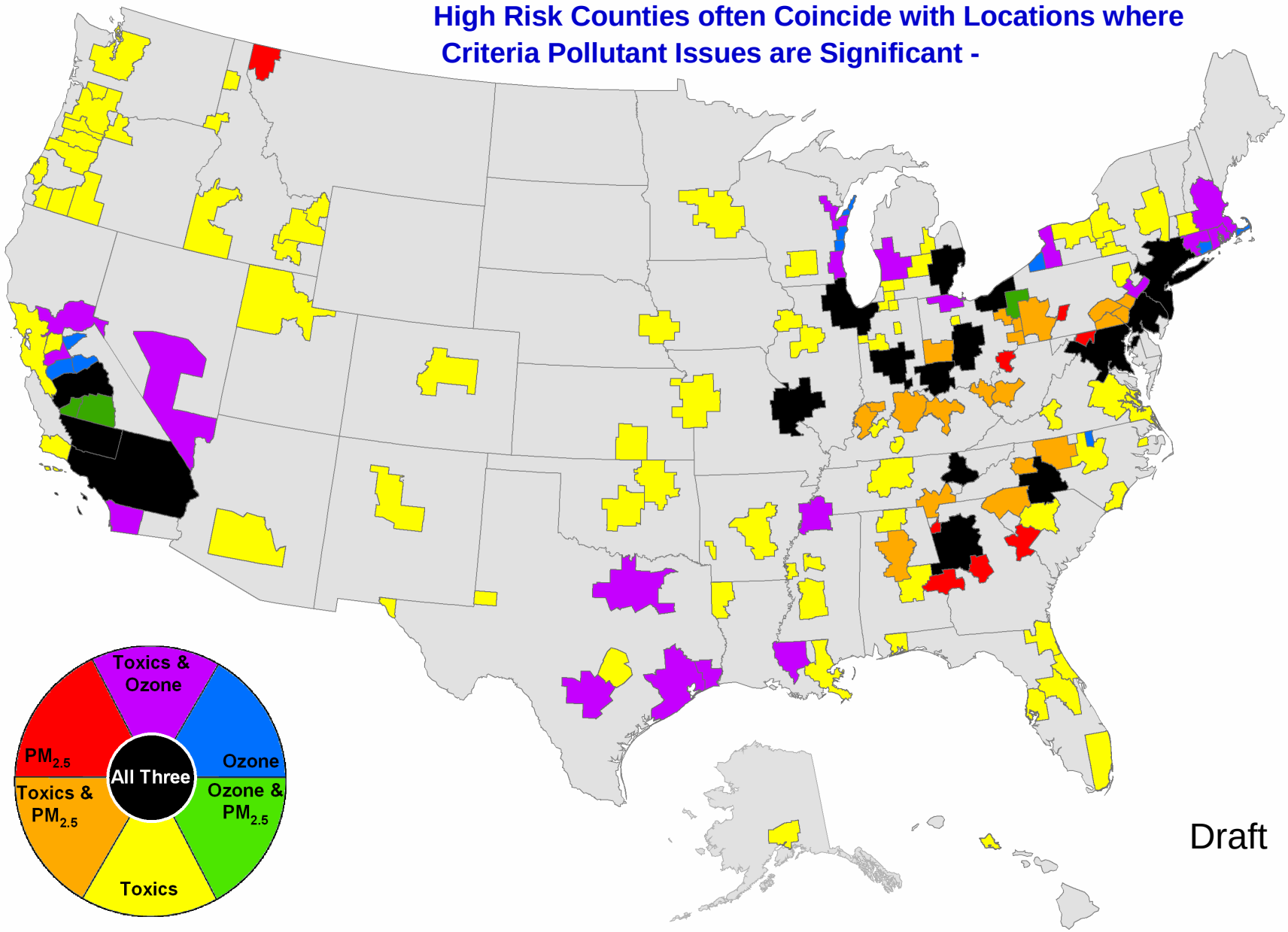
Mercury Deposition from US Power Plants: 2001



Mercury Deposition from US Power Plants: 2020 with CAIR & CAMR



Nexus of ozone, $PM_{2.5}$ (2003-5) and air toxics (NATA 1999)



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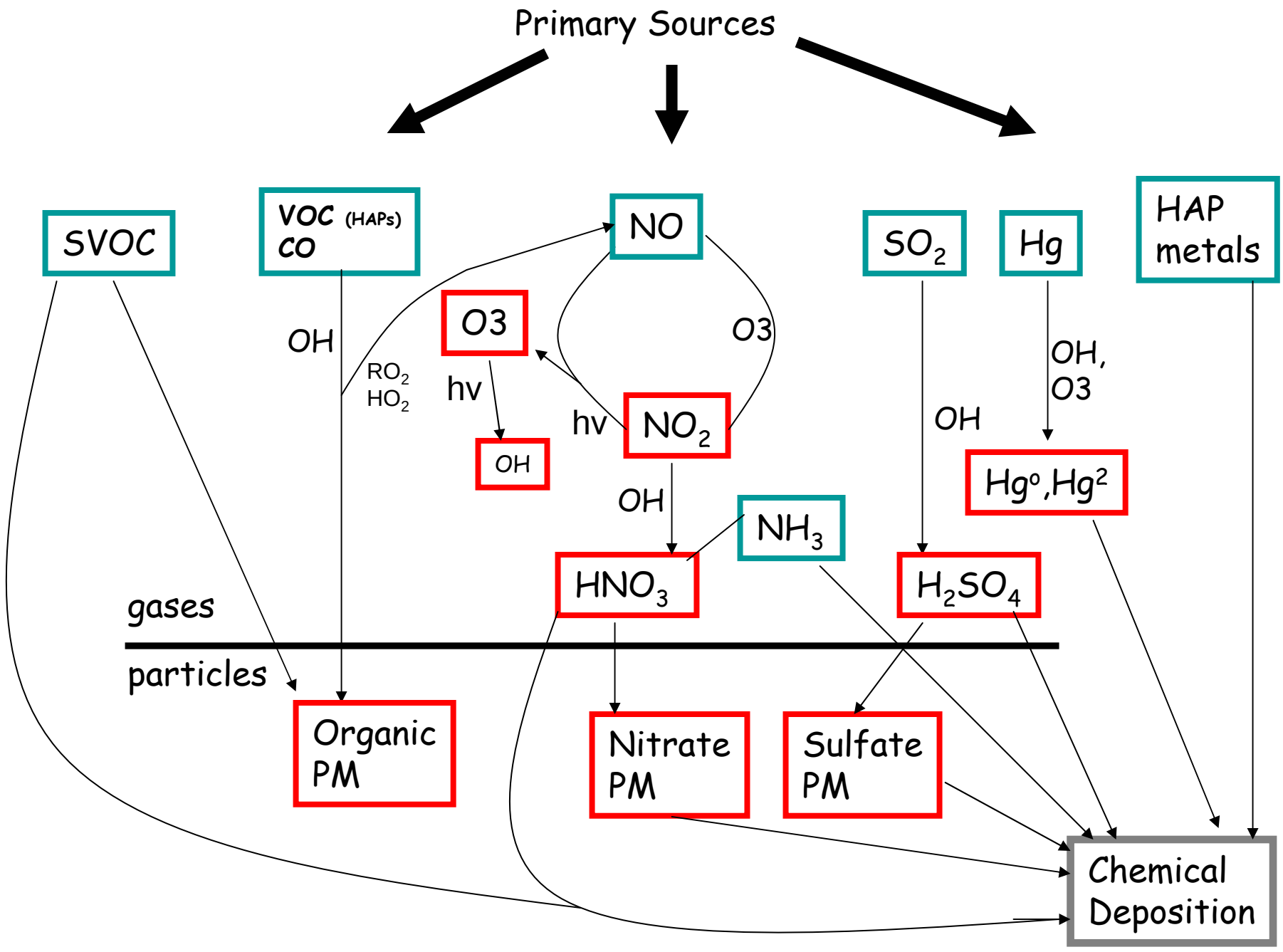
Integration across pollutants and media: tradeoffs and optimum strategies?

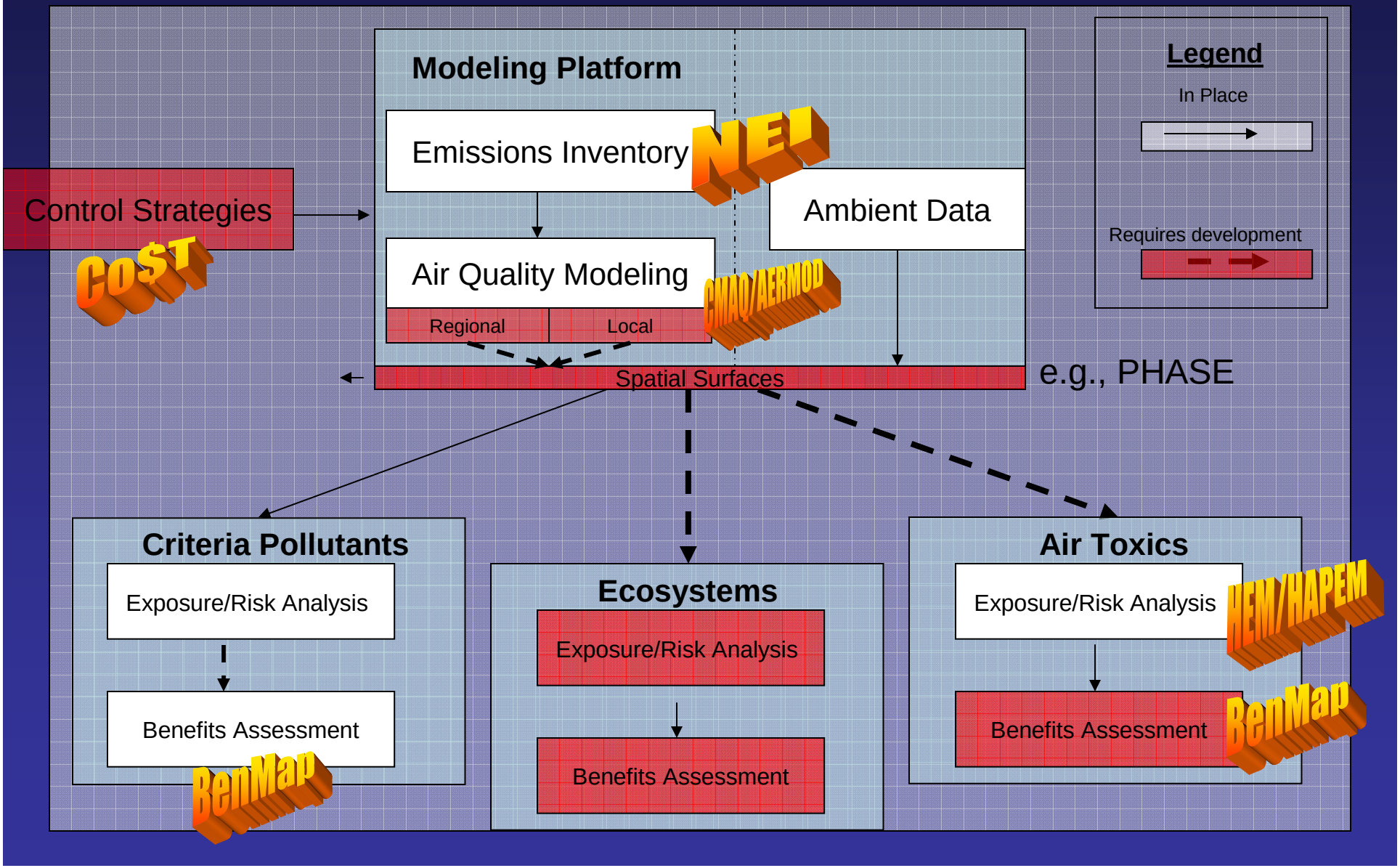


Multimedia Assessments

- Start with NAPAP (Acid rain, Title 4)
  - Interest waning as ozone, then PM2.5 emerged as dominant air quality interests starting in the late 1980's
- 2004 NAS AQ Report driving EPA, AQ community
  - Reorganization
  - Resource allocations
  - New NARSTO MP-MM-ACC assessment
    - NASA participation requested
- Focus on NOx/SOx secondary standard
  - **Draft Plan for Review of the Secondary National Ambient Air Quality Standards for Nitrogen Dioxide and Sulfur Dioxide**
  - Summer/09 ANPR

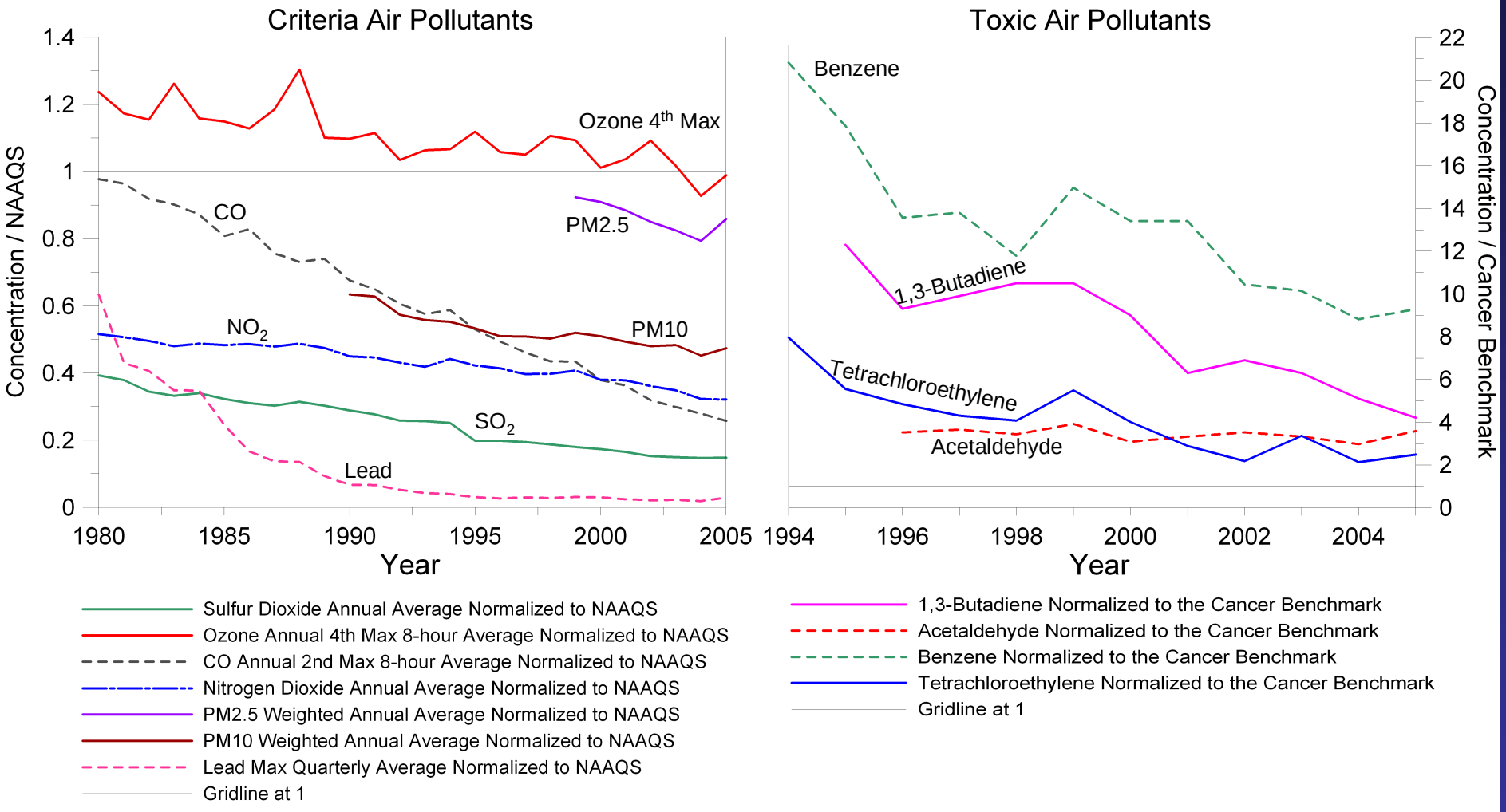
Multi-Pollutant Analytical Framework

Future = National Air Pollutant Assessment



ACCOUNTABILITY

National Average Air Quality Concentrations



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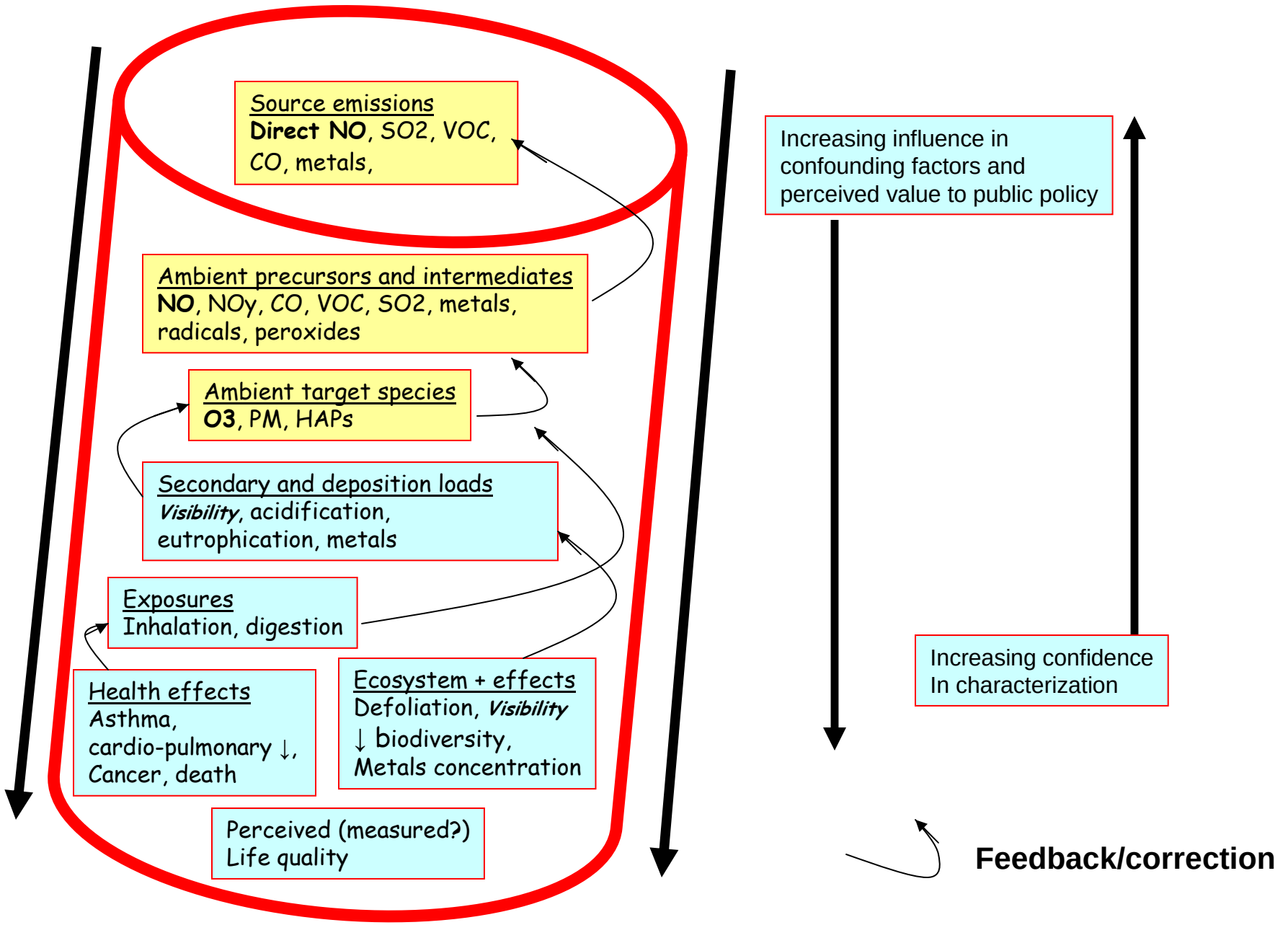
Accountability and Indicators Pipeline

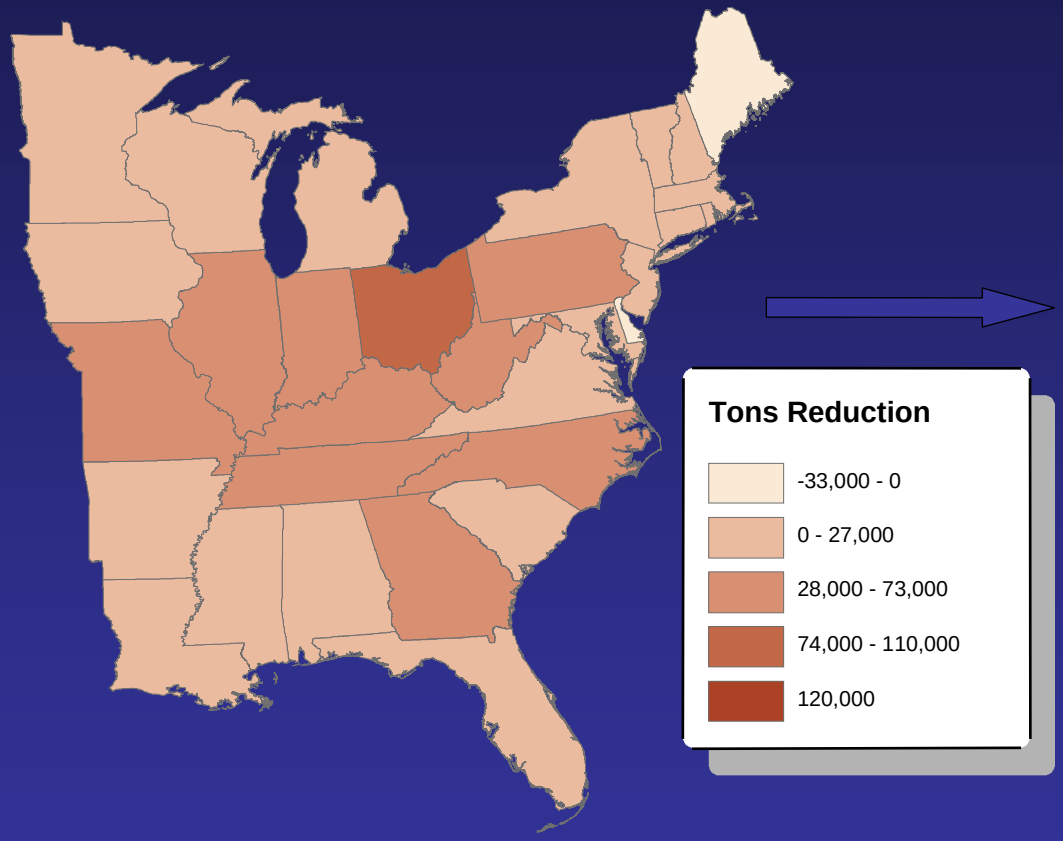


NOx SIP CALL

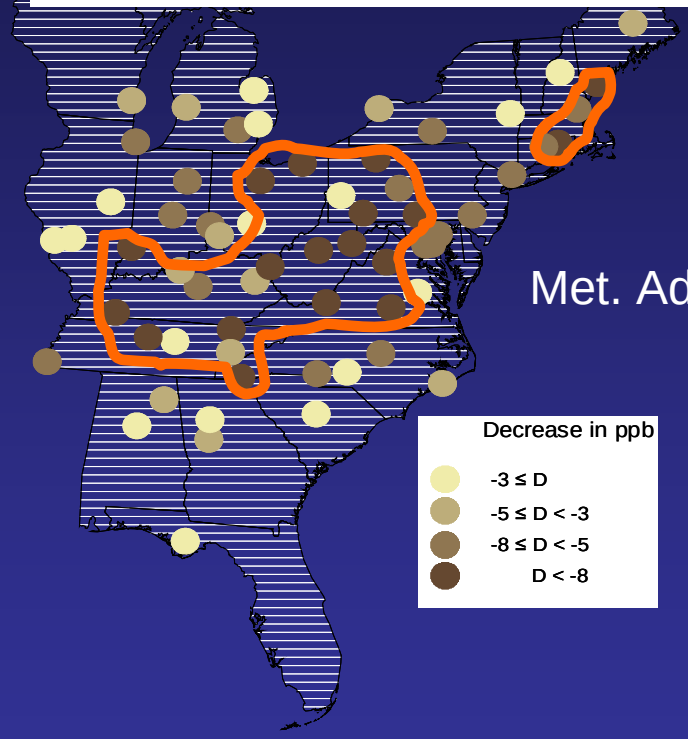
- Accountability example

Largest decline in ozone occurs in and downwind of EGU NOx emissions reductions (2002-2004) (analysis constrained by absence ambient NOx data)

EGU NOx Tons Reduced



Decline in “Seasonal Average” 8-Hour Daily Maximum Ozone



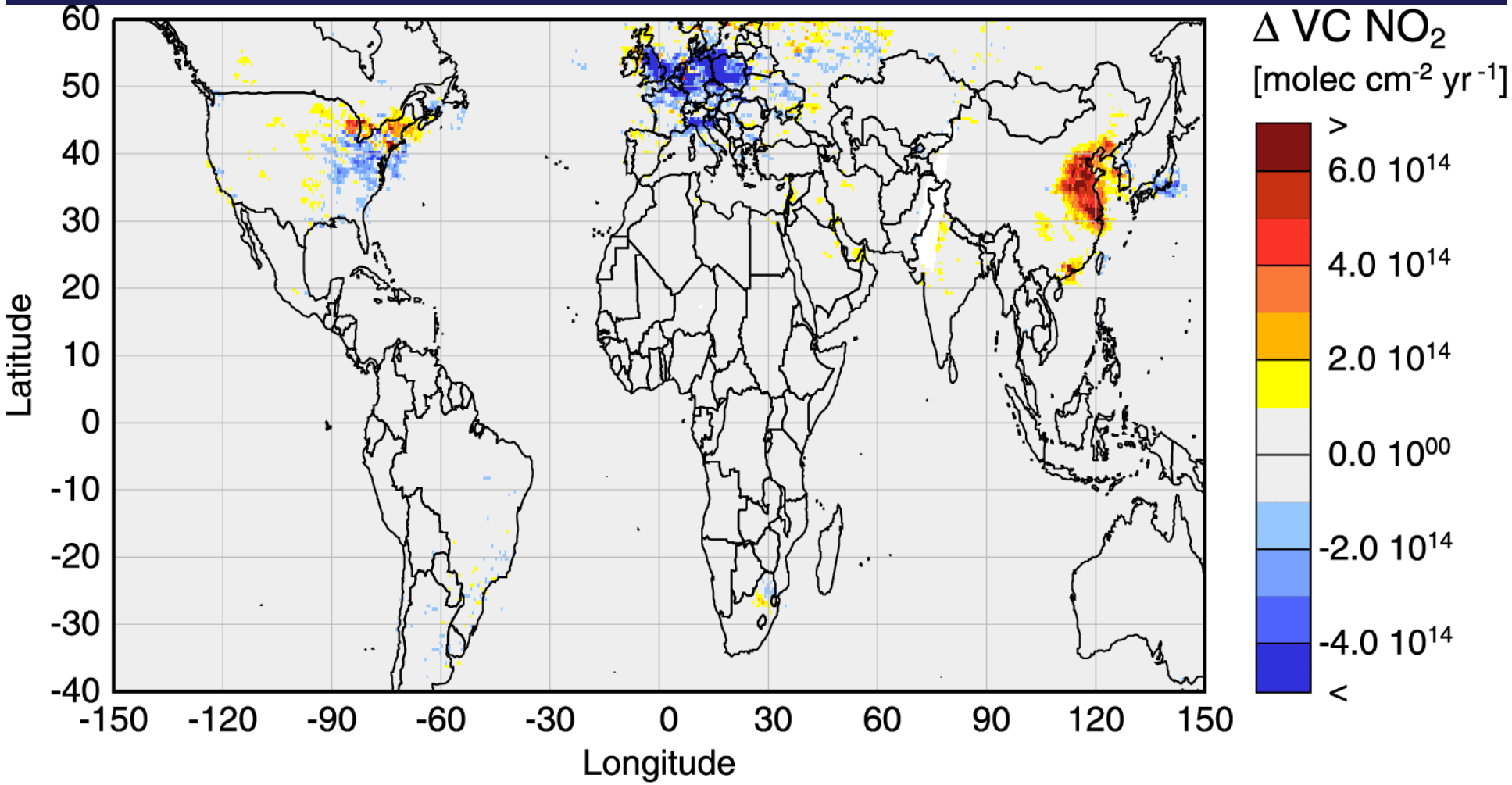
Met. Adj.

The major EGU NOx emissions reductions occurs after 2002 (mostly NOx SIP Call)

Average rate of decline in ozone between 1997 and 2002 is 1.1%/year.

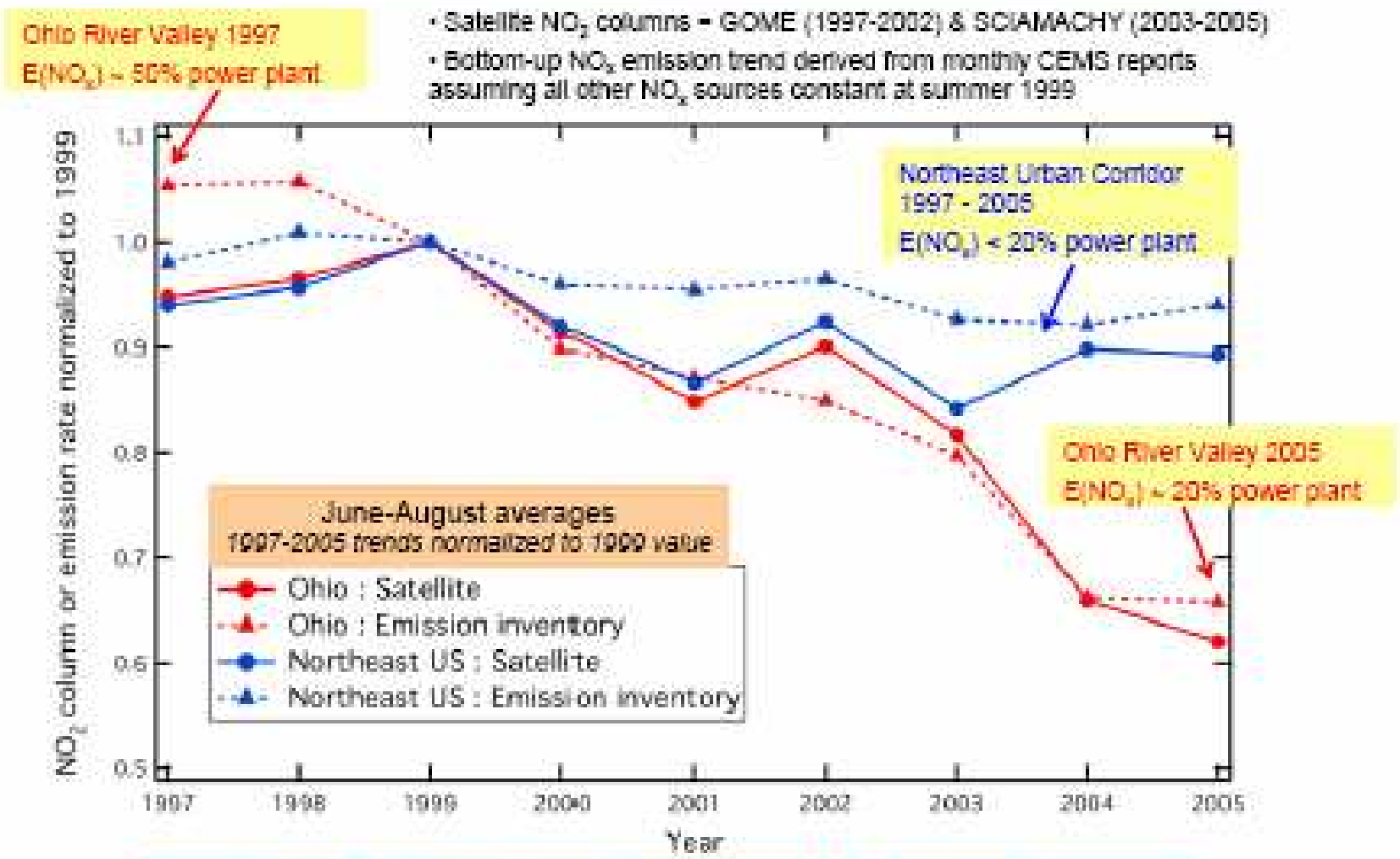
Average rate of decline in ozone between 2002 and 2004 is 3.1%/year.

GOME Satellite NO_2 Trends (1995-2002)



Richter et al., 2005

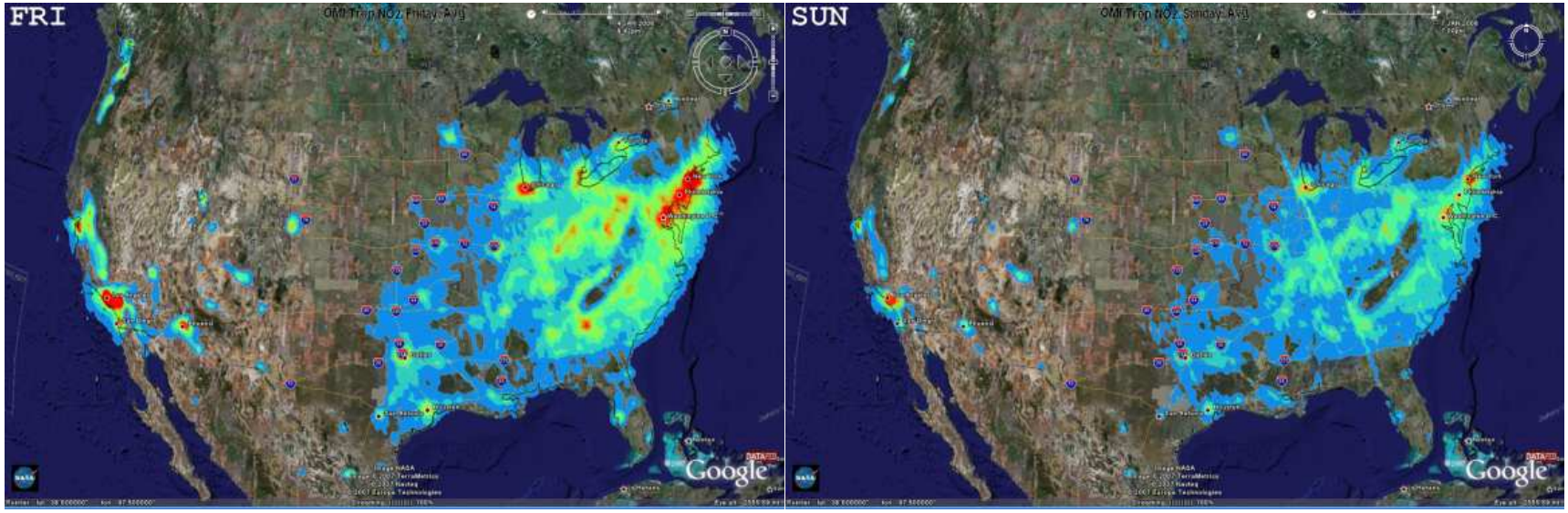
Annual Changes in Satellite NO_2 Columns and Emissions



- Similar trends in satellite NO_2 columns and NO_x emissions
  - Power plant NO_x controls have affected NO_2 columns
  - Mobile NO_x emission changes smaller than those for power plants

Courtesy NOAA, Kim et al.

Weekend/weekday effect through OMI NO2 column data: 2006
Friday and Sunday aggregated data (source, Husar..ESIP wiki).

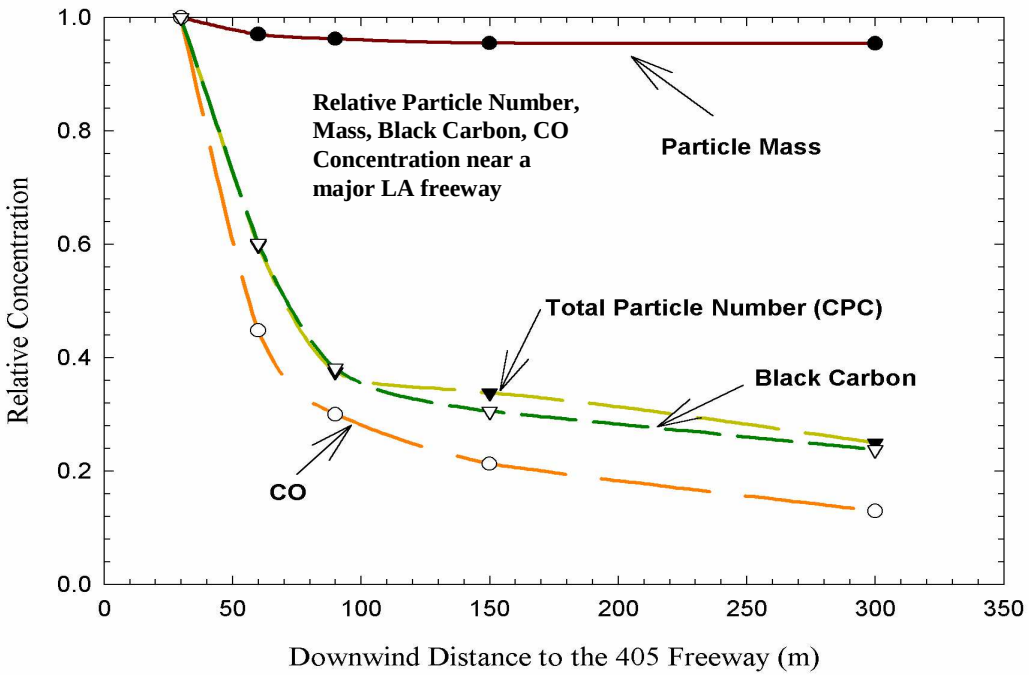


MANAGING MULTIPLE SPATIAL SCALES

New findings on roadway pollution

High exposure to ultrafine particles, CO, other pollution near roadway

Increased risk near and on roadways

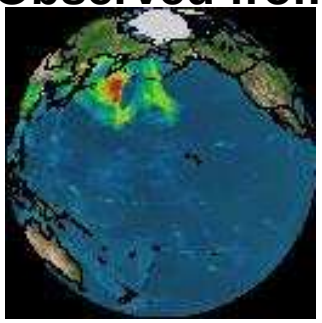


International transport/climate interactions **Scale: global/regional**

April 2001 Dust Transport Event Observed from TOMS

April 9/8

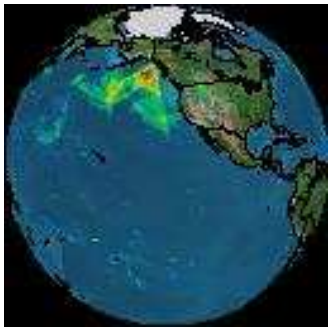
April 10/9



April 11/10

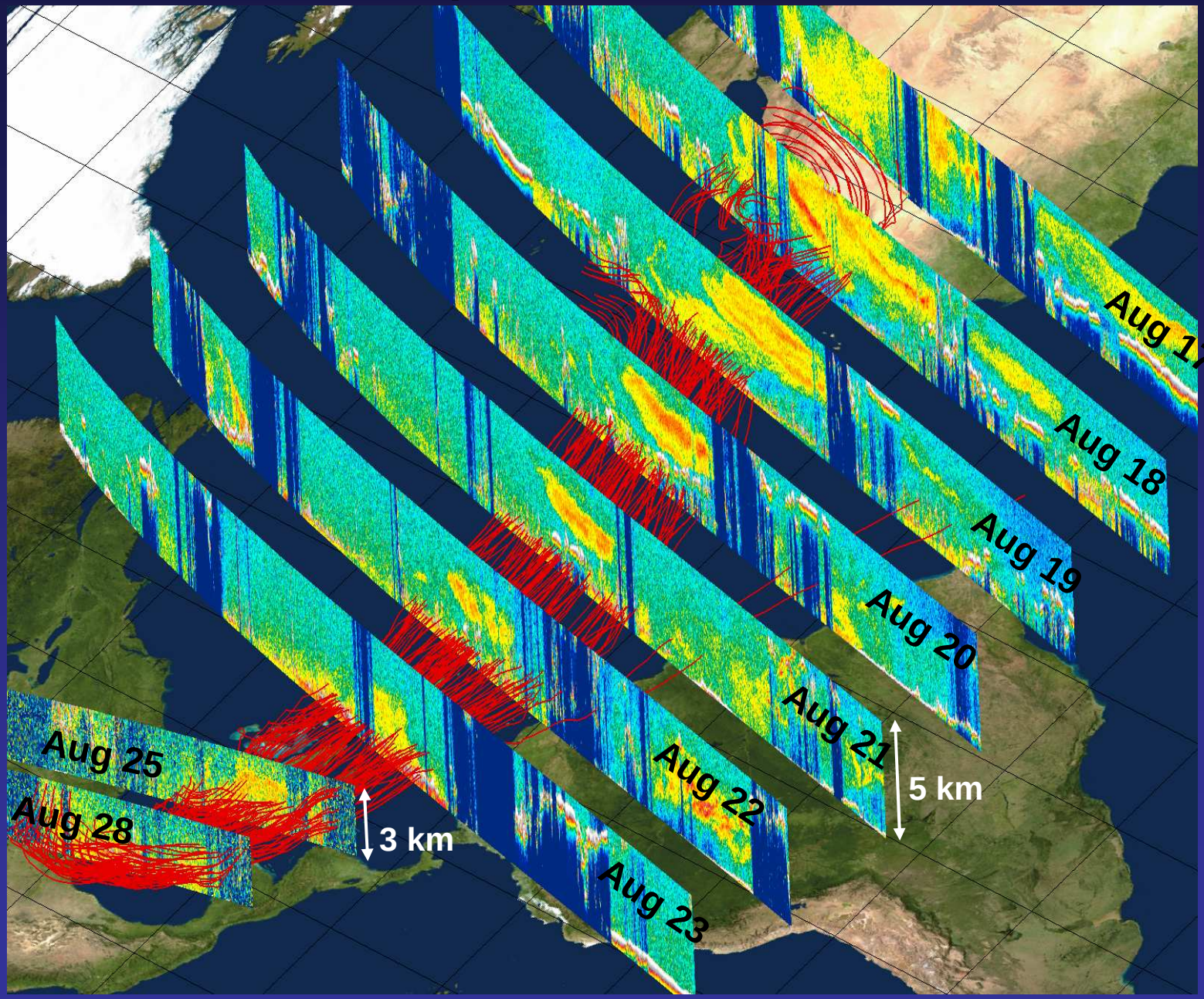
April 12/11

April 13/12



April 14/13

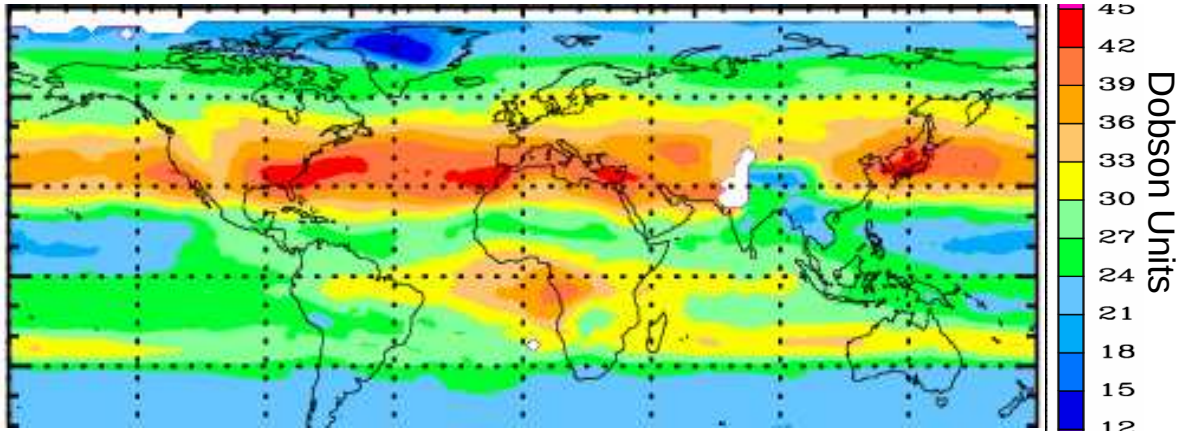
2006 Dust Transport Event Observed from CALIPSO



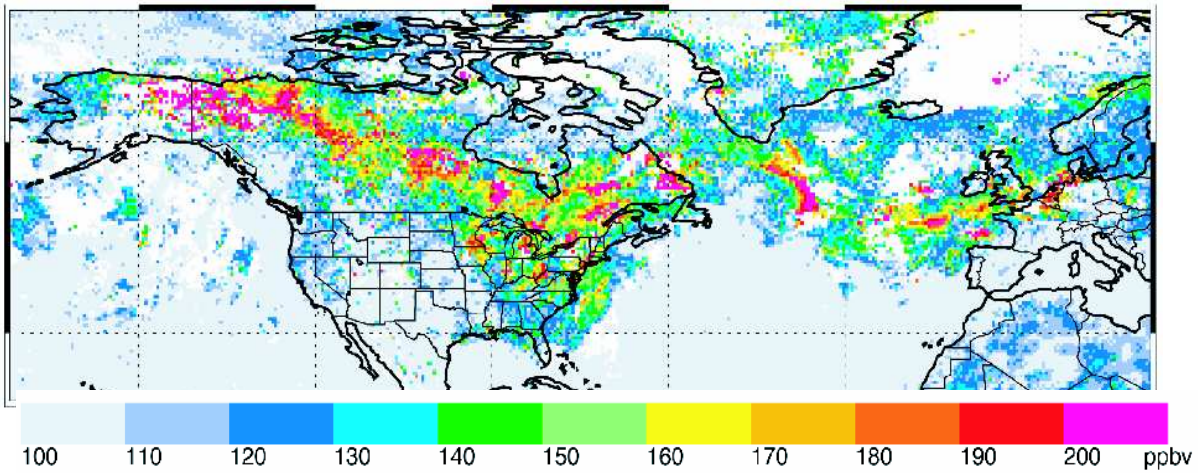
David Winker

Transport Evidence from Satellites: Ozone, CO and NO_2

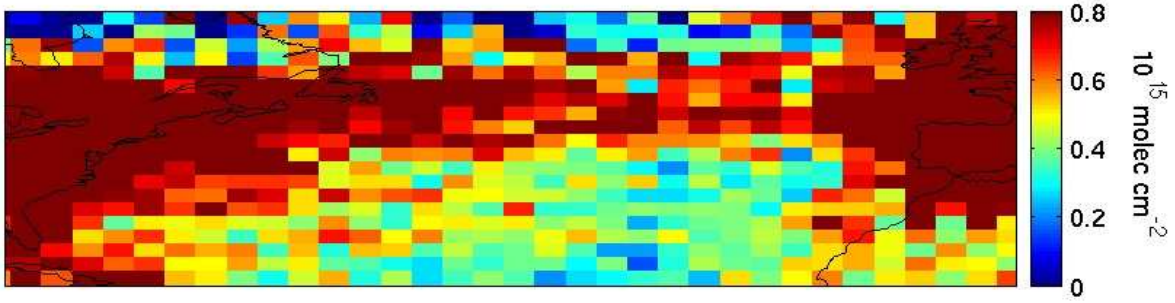
Tropospheric O_3 from GOME for summer 1997
Liu et al., 2006



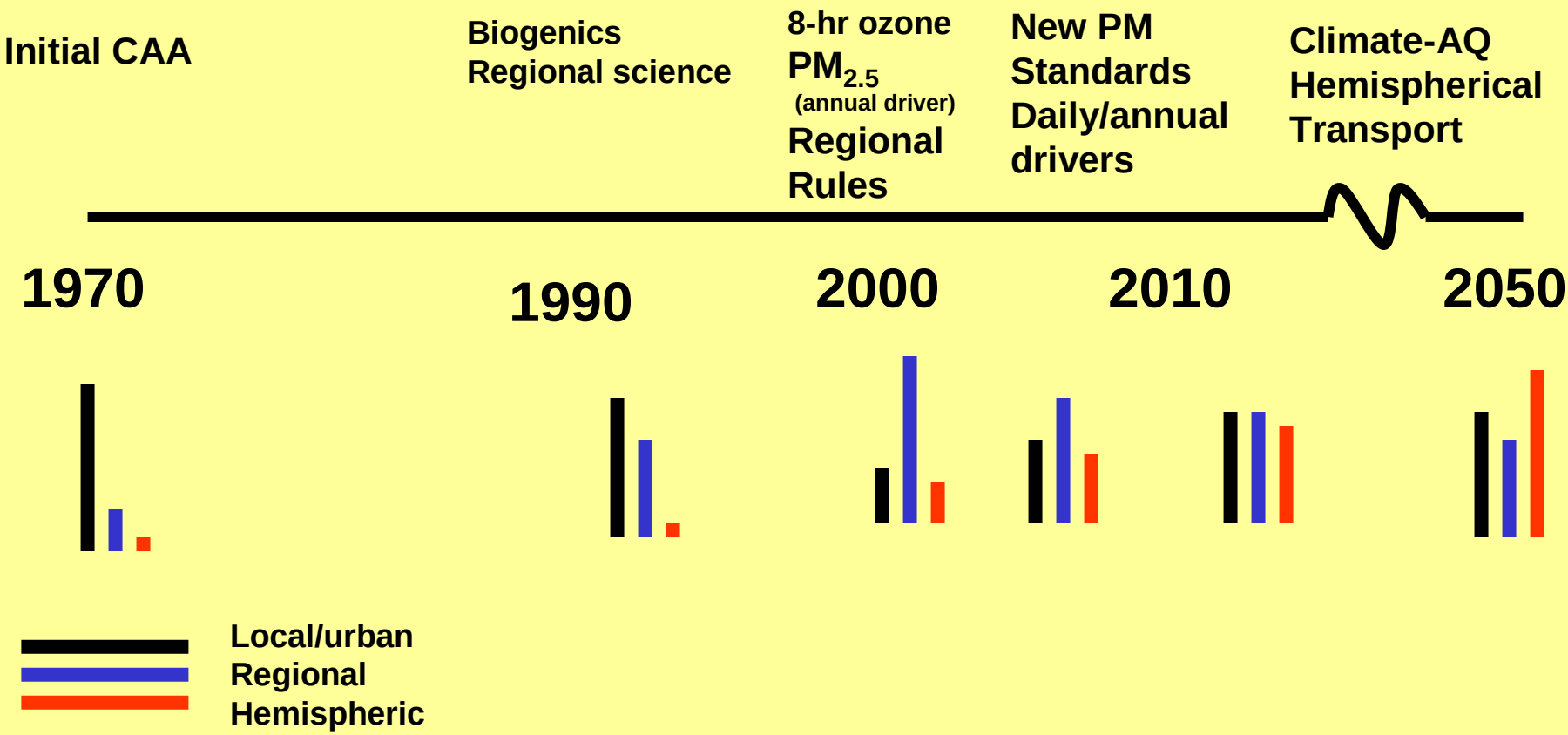
CO from MOPITT for July 2004
Pfister et al., 2006

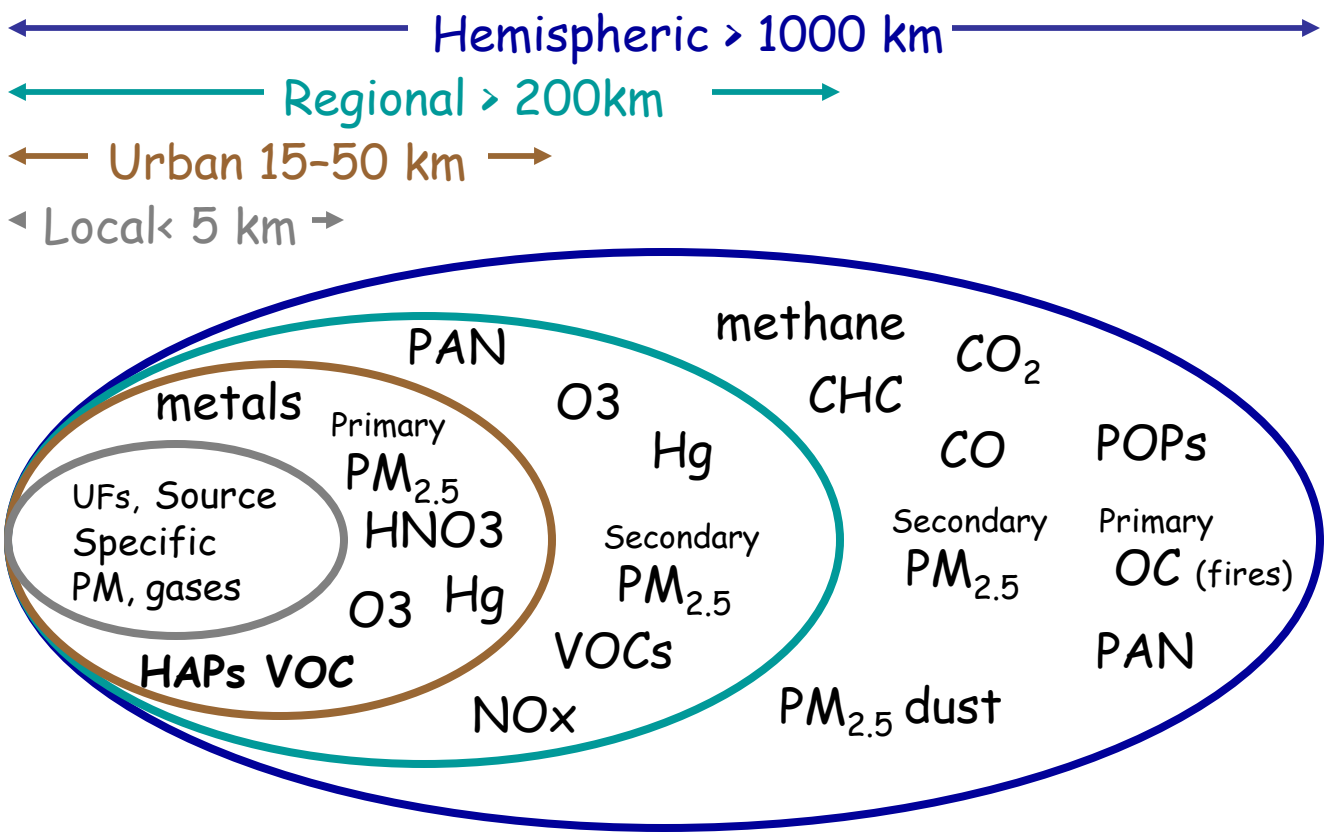


Tropospheric NO_2 from SCIAMACHY for summer 2004
Martin et al., 2006



Evolutional change in National Air Pollution Management

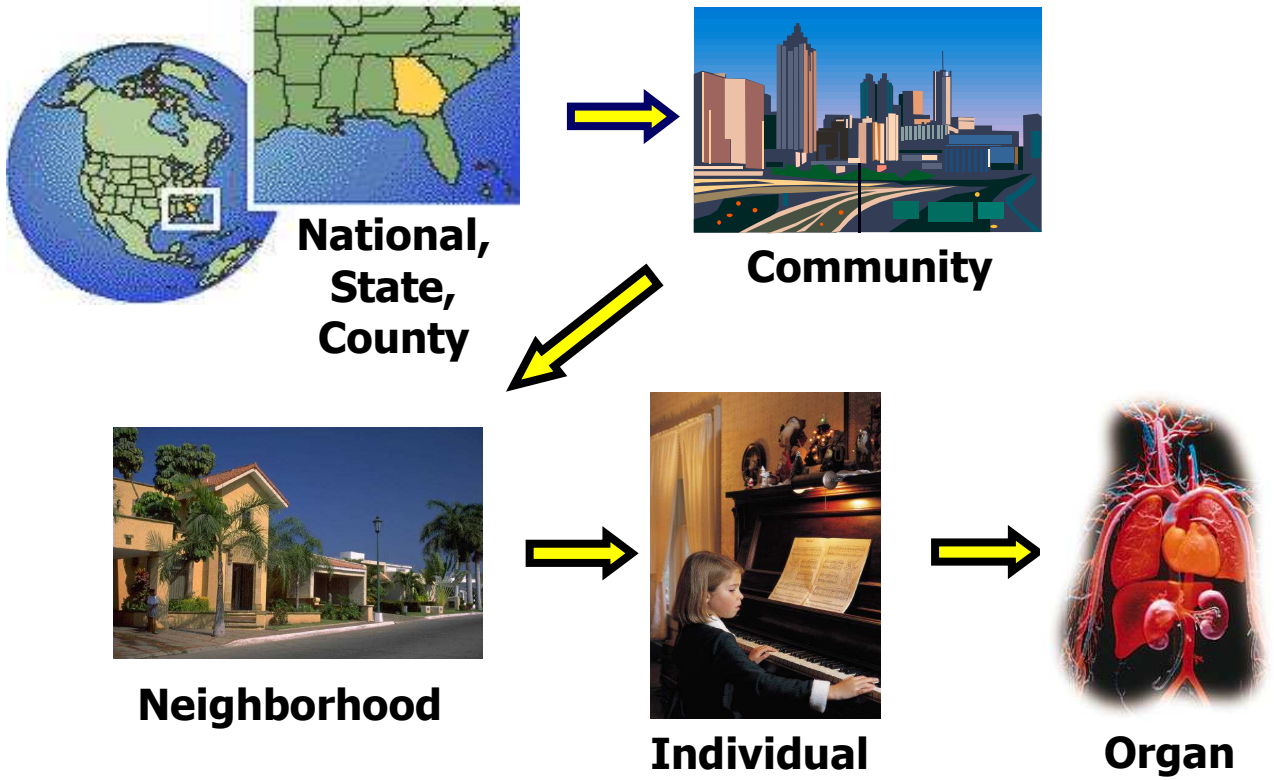



Hemispheric > 1000 km
Regional > 200km
Urban 15-50 km
Local< 5 km
PAN
methane
CO_2
metals
Primary
$PM_{2.5}$
O3
CHC
Hg
CO
POPs
UFs, Source
Specific
PM, gases
HNO3
Secondary
$PM_{2.5}$
Secondary
$PM_{2.5}$
Primary
OC (fires)
O3
Hg
VOCs
PAN
HAPs VOC
NOx
$PM_{2.5}$ dust

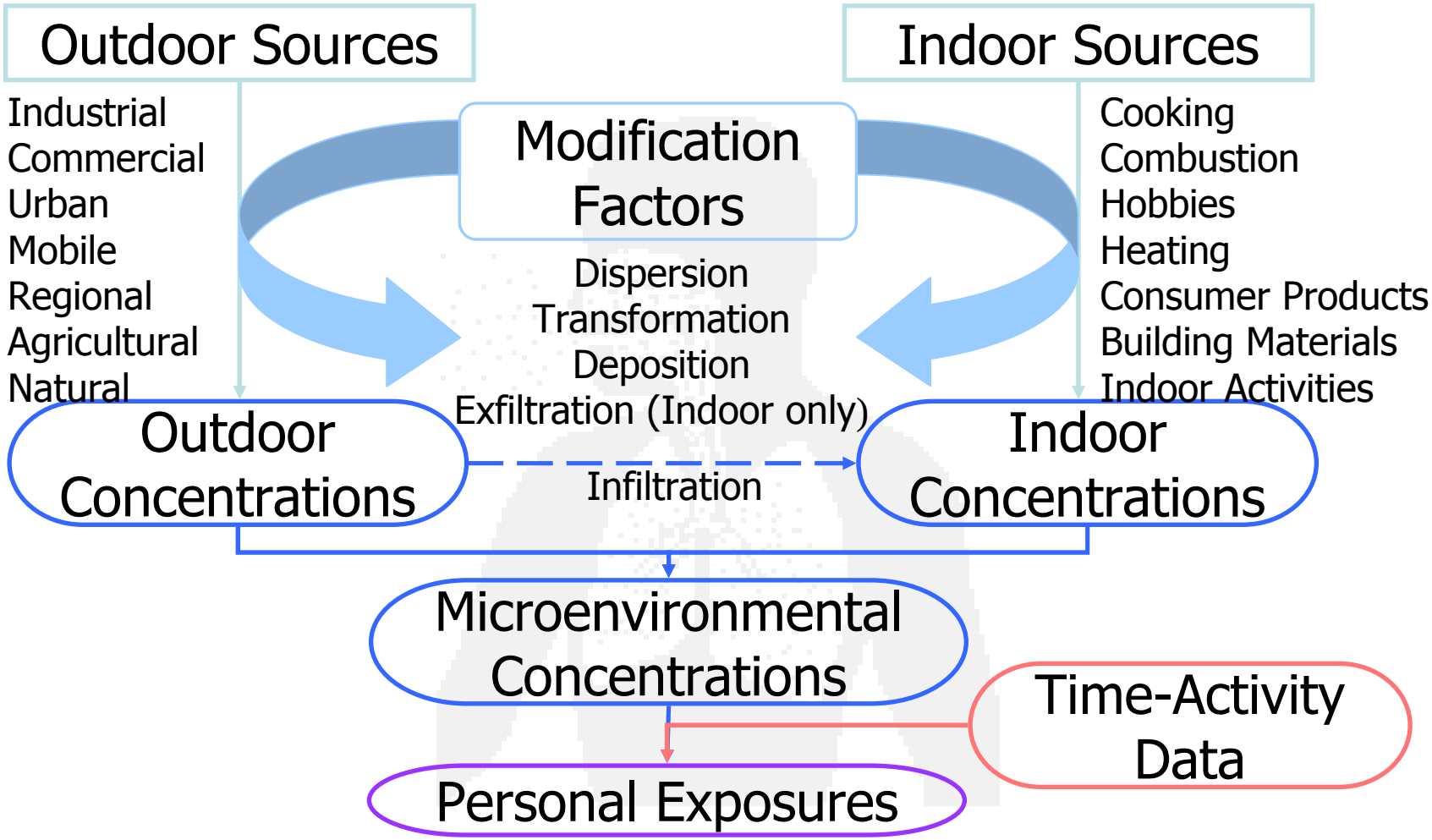
Domains for Exposure and Health Analysis

(H. Ozkanak, EPA)

- Scale of interest needs to be consistent with type of assessment

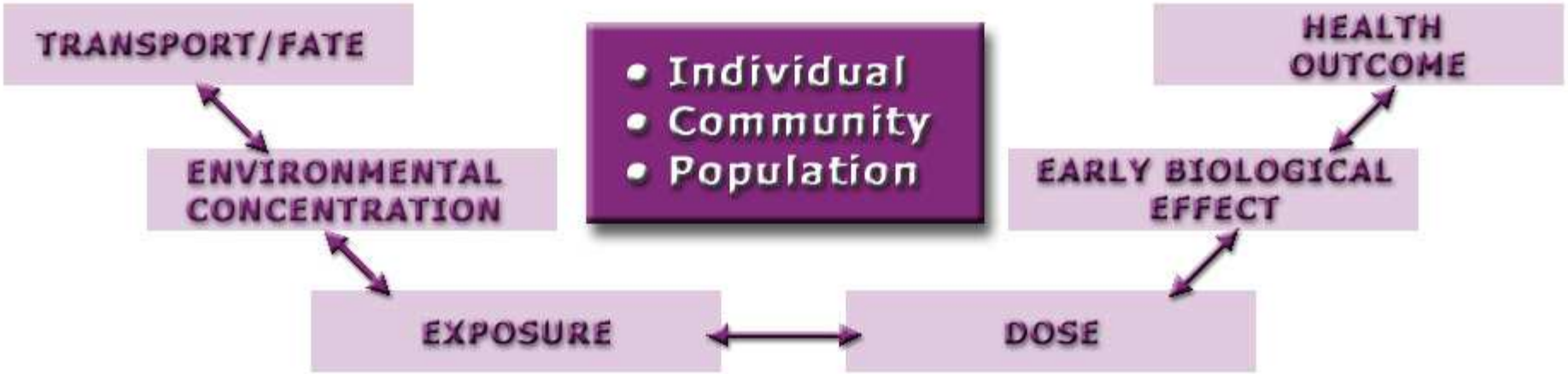


Inhalation Exposure Pathways



Factors Affecting Exposure

exposure centric view



Vulnerability Factors (exposure/activity)

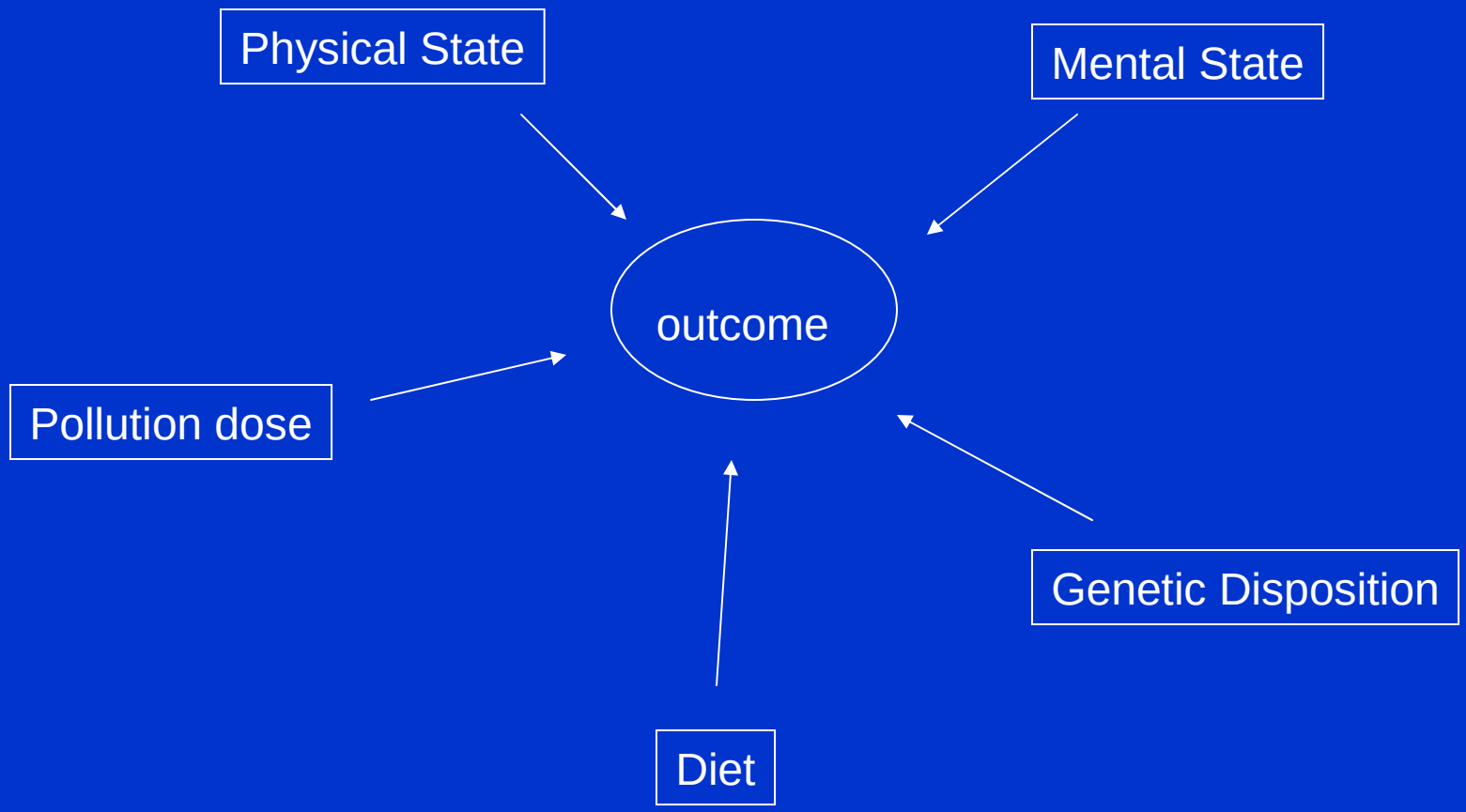
Culture and lifestyle
Diet
Activities and occupation
Geographic locations
Microenvironments
Socioeconomic status
Previous exposures

Race/Ethnicity

Susceptibility Factors (biological)

Age or life stage
Gender
Genetic differences
Reduced reserve capacity
Preexisting health status

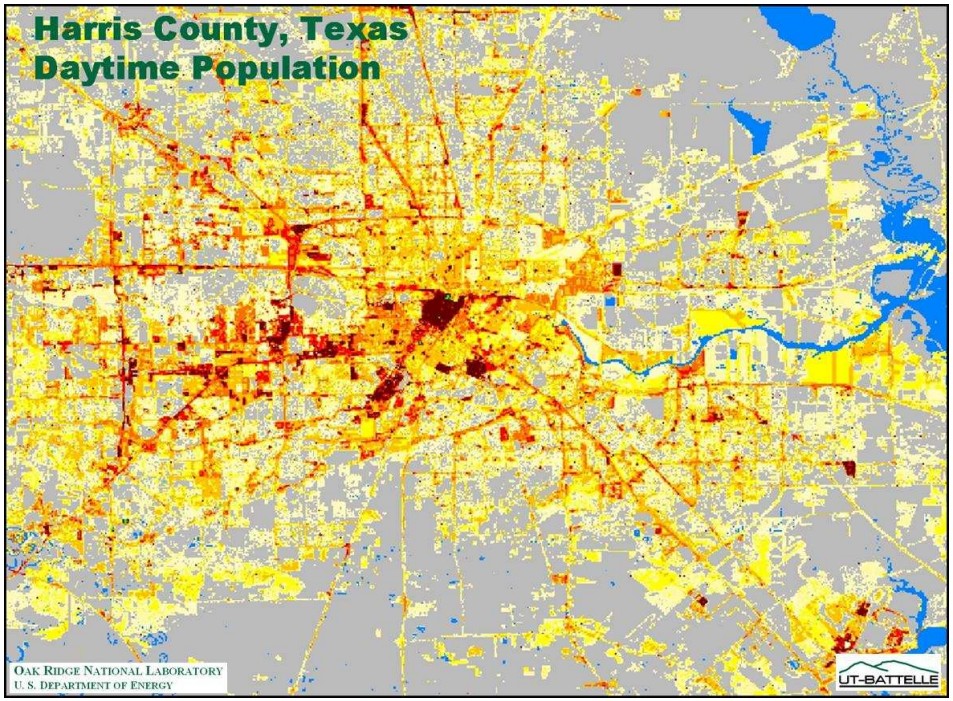
Factors affecting health outcome



Why modeling near-road impact is important? (H. Ozkanak, EPA)

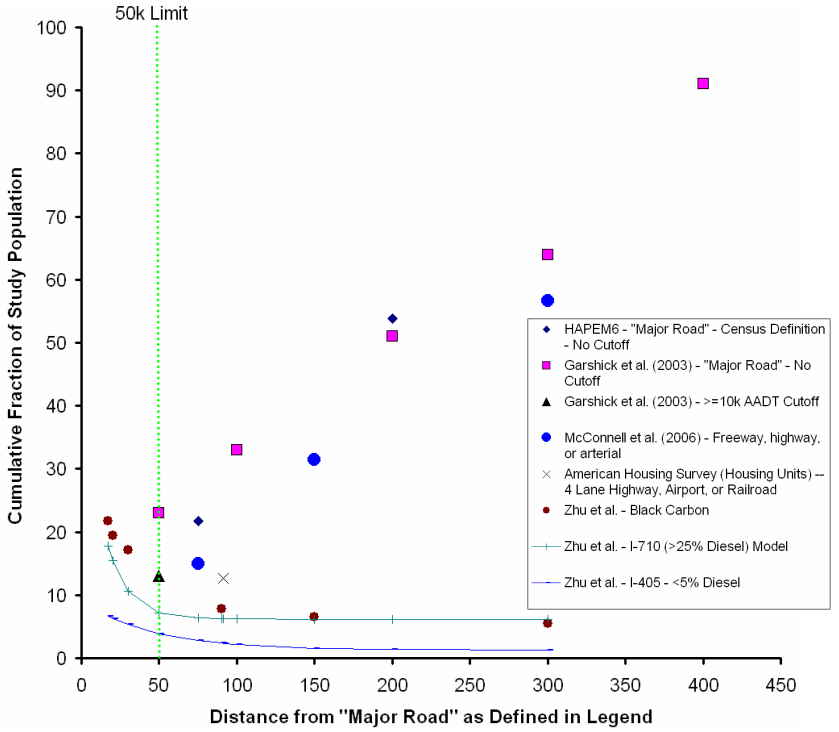
Significant fraction of population is within 300m from major roads

Example: population density map



Source: Budhendra Bhaduri et. al., LandScan project

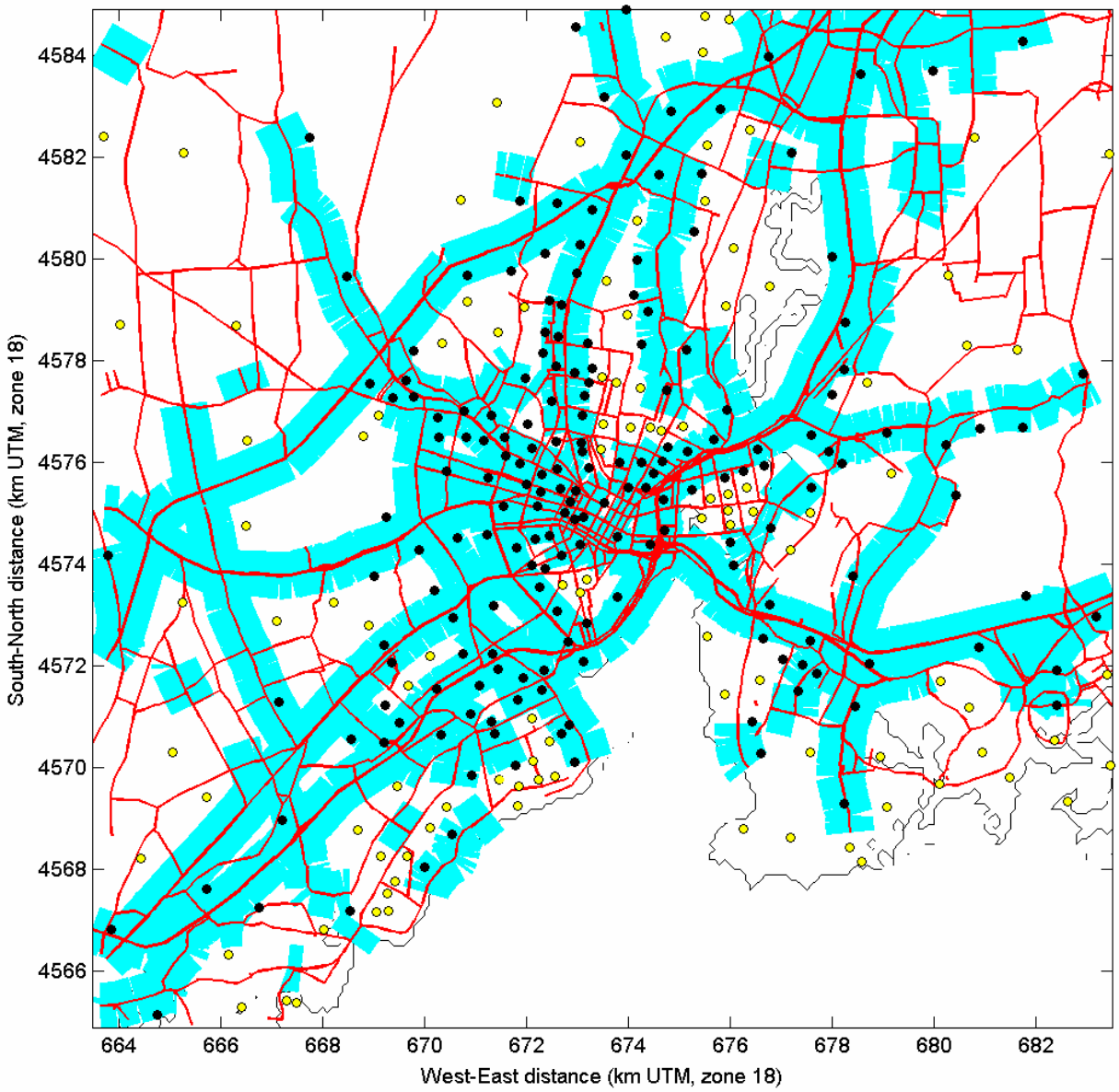
Nationwide statistics: fraction of population vs. distance



Source: Chad Bailey, OTAQ, U.S. EPA

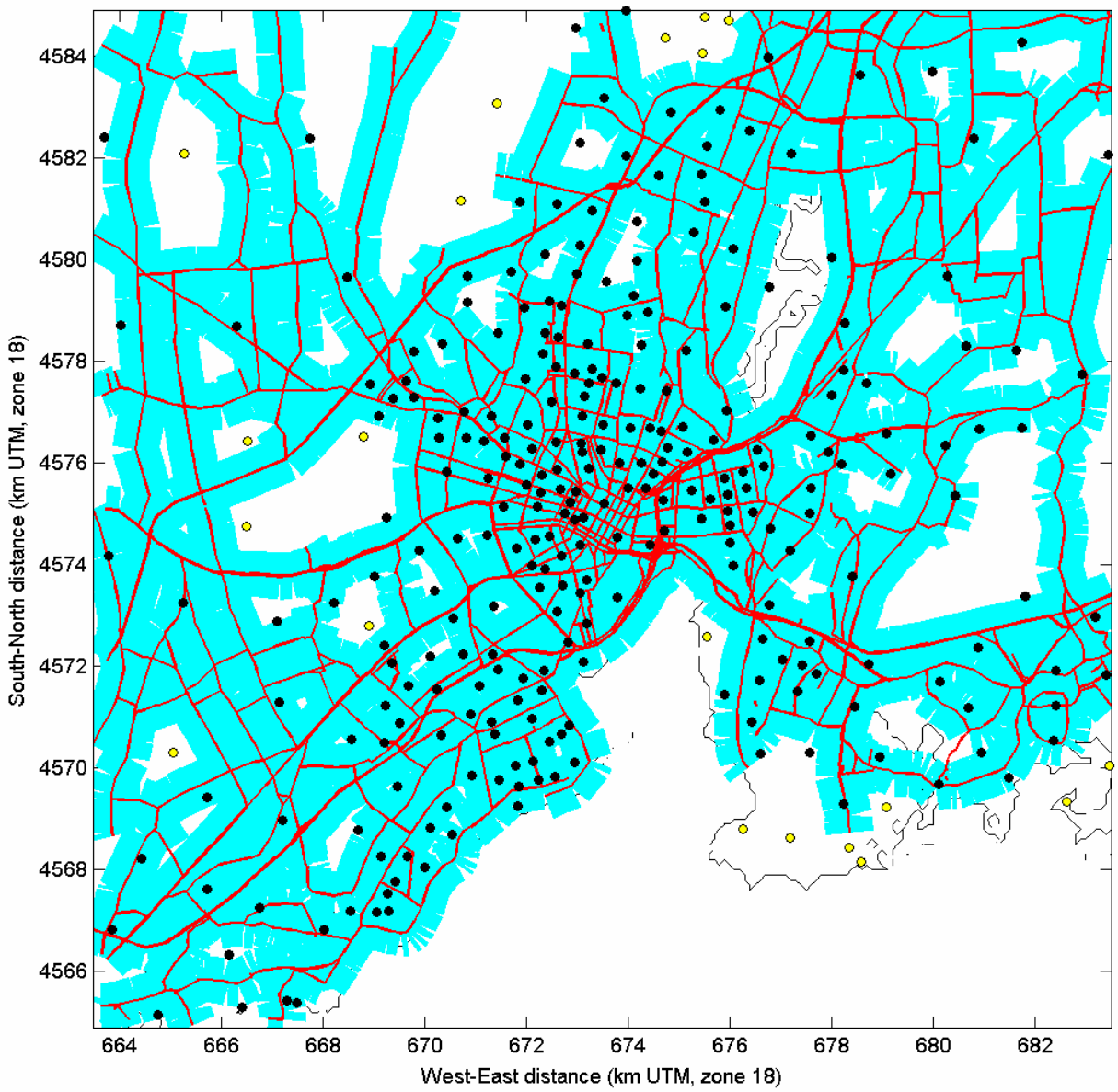
Example: New Haven, CT

70% of block group centroids are within 500m from a major road >10,000 ADT



Example: New Haven, CT

> 90% of block group centroids are within 500m from any road



How to resolve local scale when modeling mobile source impact? (H. Ozkanak< EPA)

Model inputs required:

1) Spatially resolved locations of individual road links
2) Traffic activity for each road link
3) Emission factors

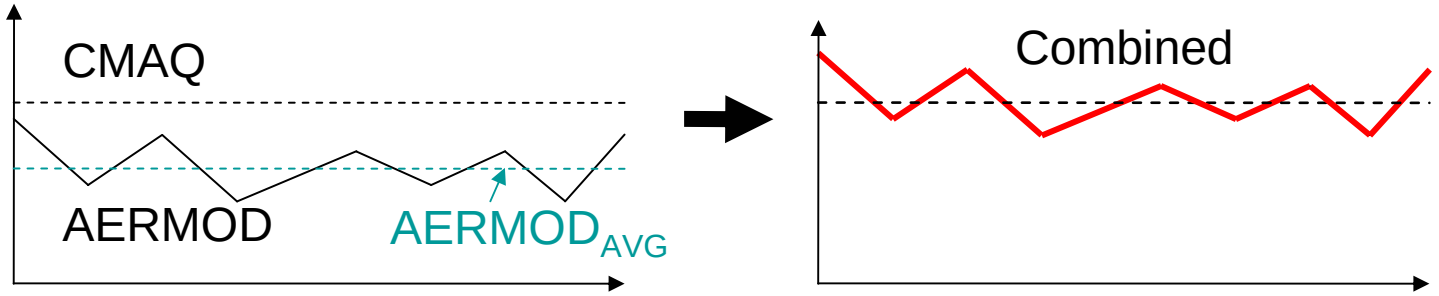
Model formulations

1) Better characterization of near-road dispersion is needed
2) Include factors such as vehicle-induced turbulence or upwind dispersion
3) Account for road configuration and sound barriers

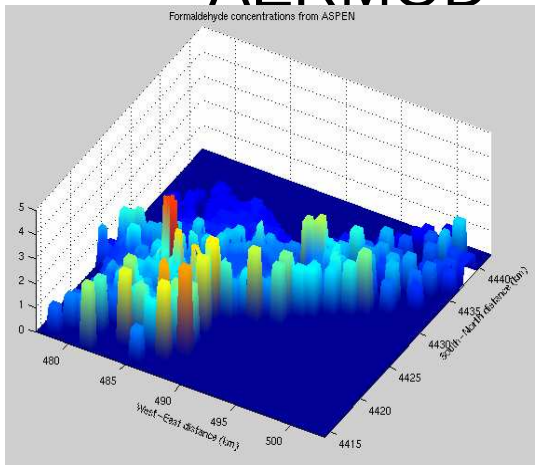
Air Quality Modeling: “Hybrid approach

- Allows preservation of the granular nature of AERMOD while properly treating chemistry/transport offered by CMAQ.

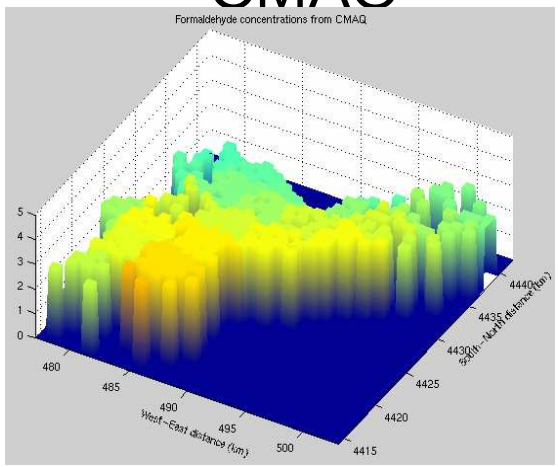
- Generates local gradients incorporating the advantages of both the dispersion and photochemical models into one combined model output (via post-processing techniques)



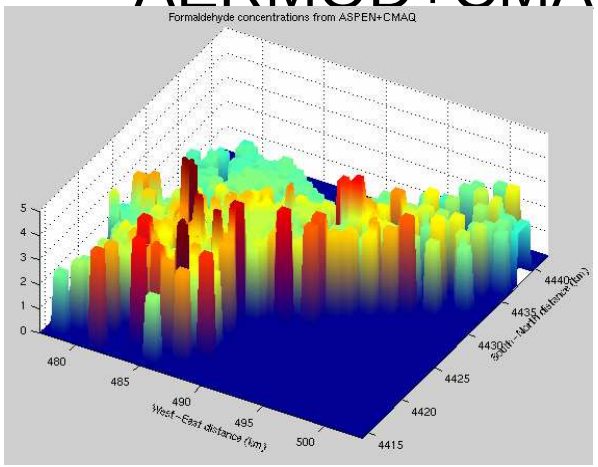
AERMOD



CMAQ

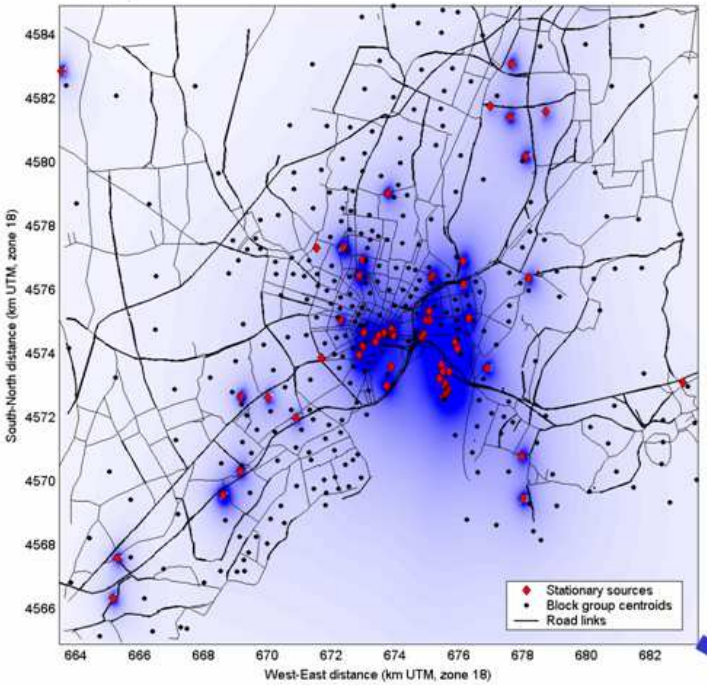


AERMOD+CMAQ

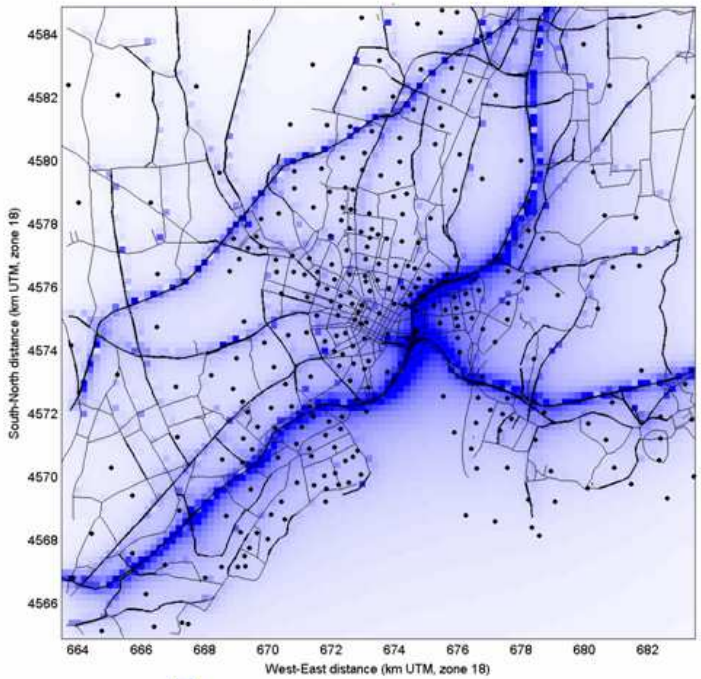


Hybrid Modeling Application in New Haven, CT

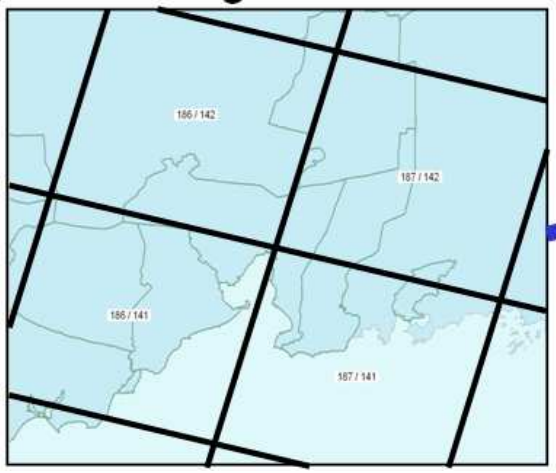
Local impact from stationary sources



Near-road impact from mobile sources

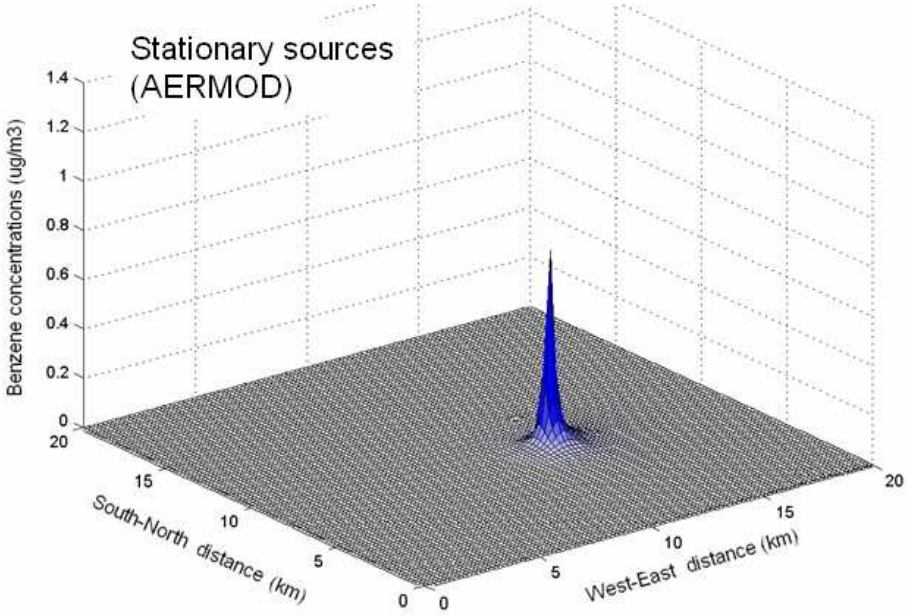


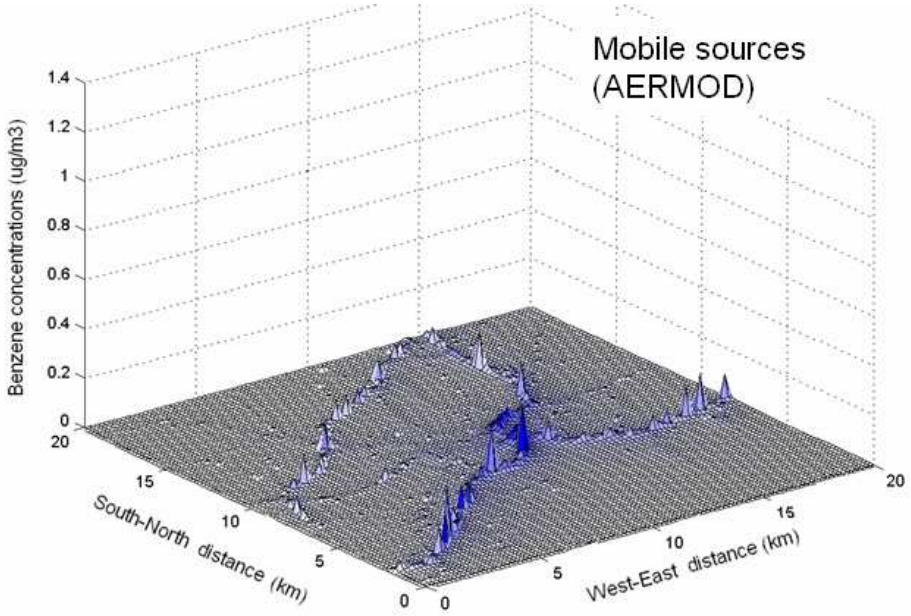
Regional background from CMAQ

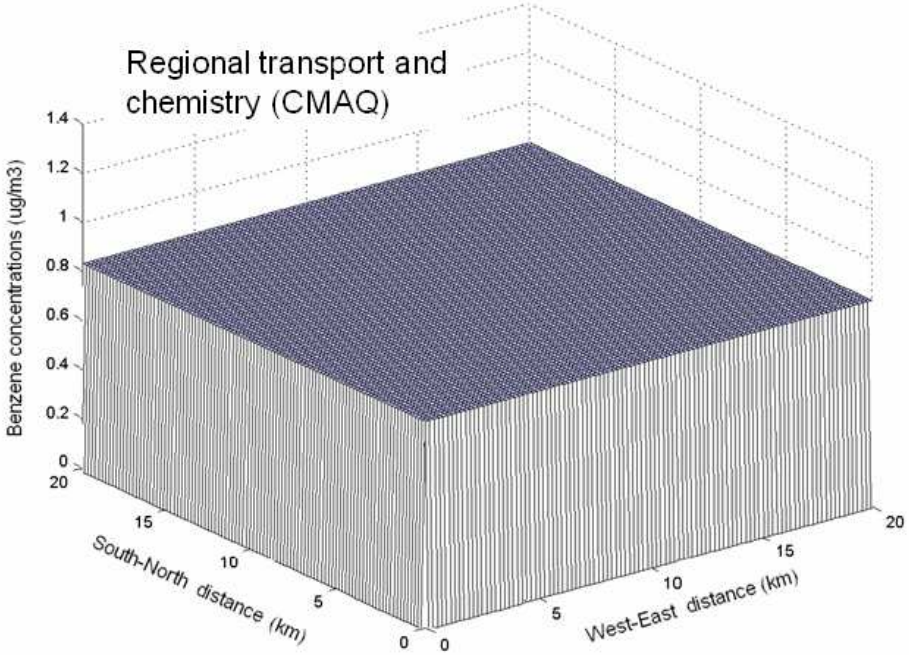


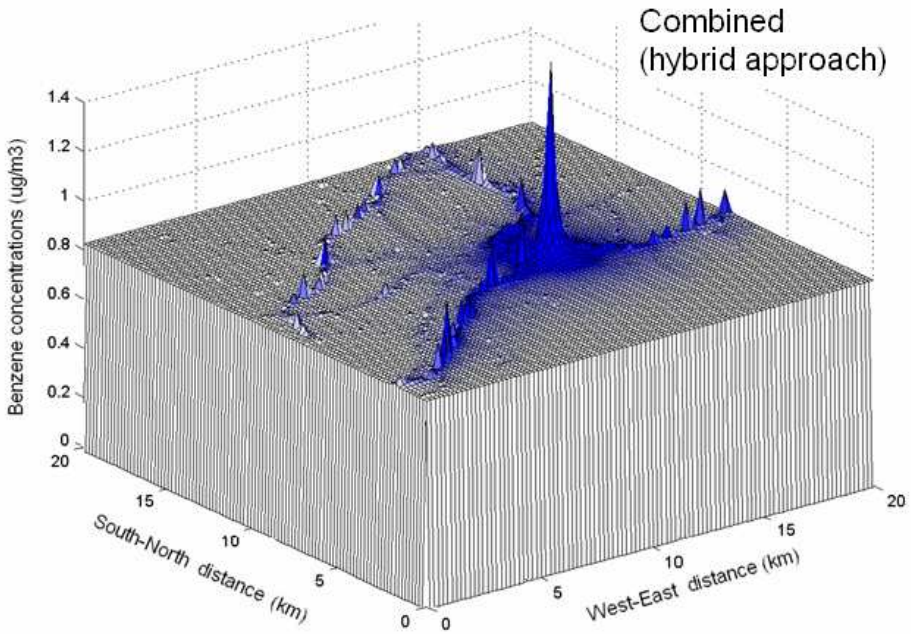
Combined model results for multiple pollutants for each of the 380 census block group centroids in New Haven area

Example: modeled annual average benzene concentrations

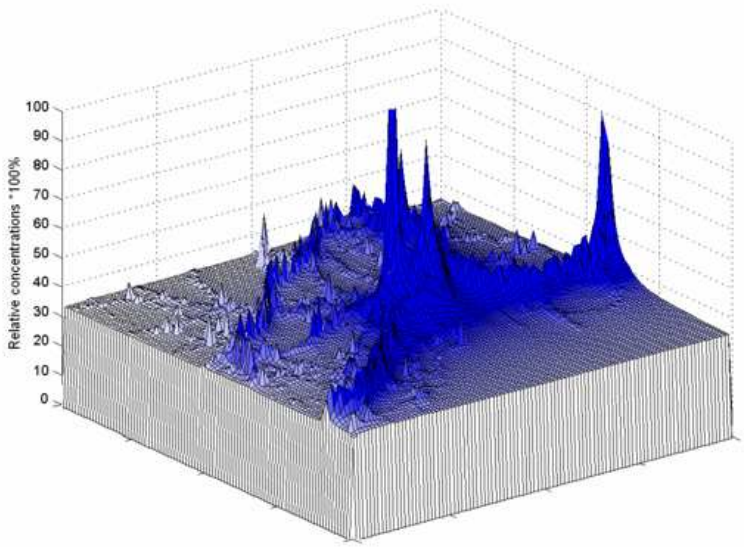




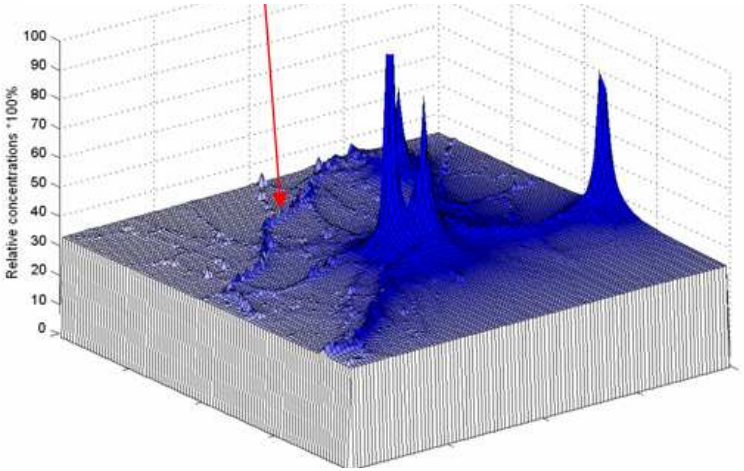




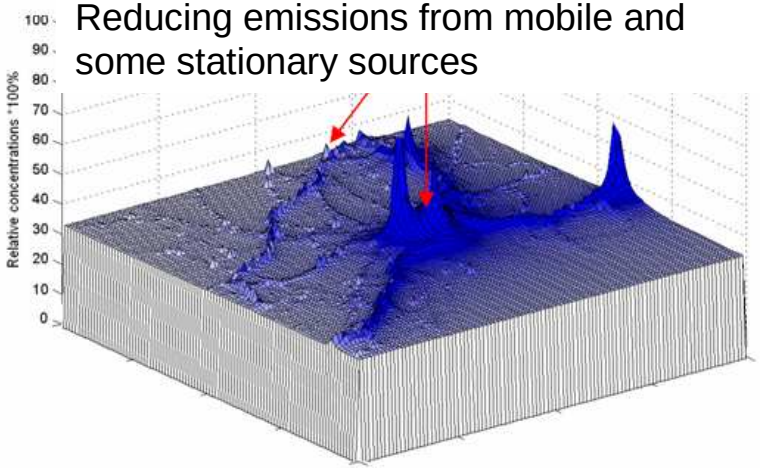
Hypothetical Example: Modeling impact of various controls for stationary sources, mobile sources, and regional background

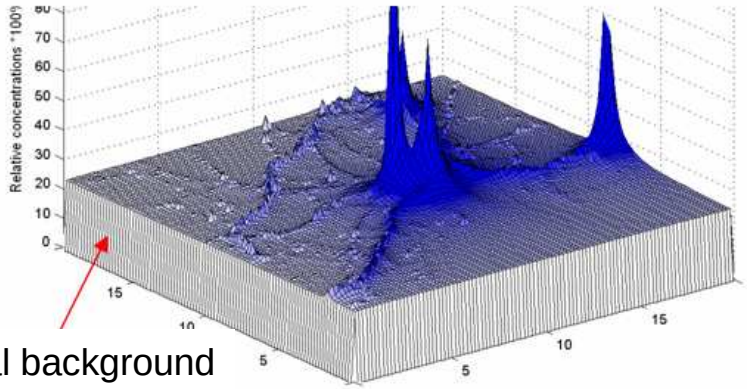


Reducing emissions from mobile sources



Reducing emissions from mobile and some stationary sources





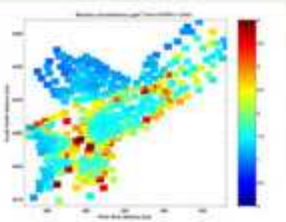
Reducing regional background

Linking Air Quality Models to Exposure Models

AQ Model Results

- Modeled ambient conc. at census tract centroids
- using
  - Emissions
  - Meteorology

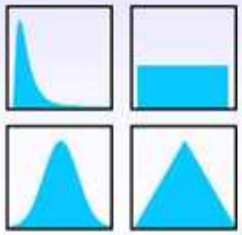
Ambient Concentrations



Input Databases

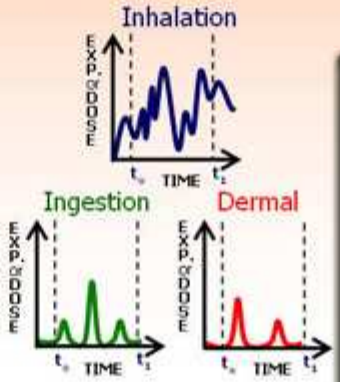
- Census
- Human Activity
- Food Residues
- Recipe/Food Diary

Exposure Factor Distributions



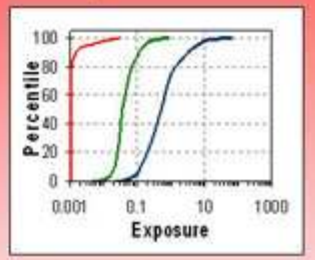
Algorithms

- Calculate Individual Exposure/Dose Profile

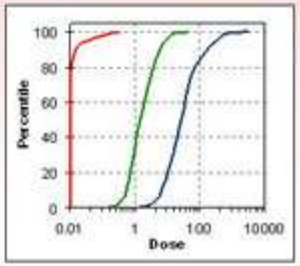


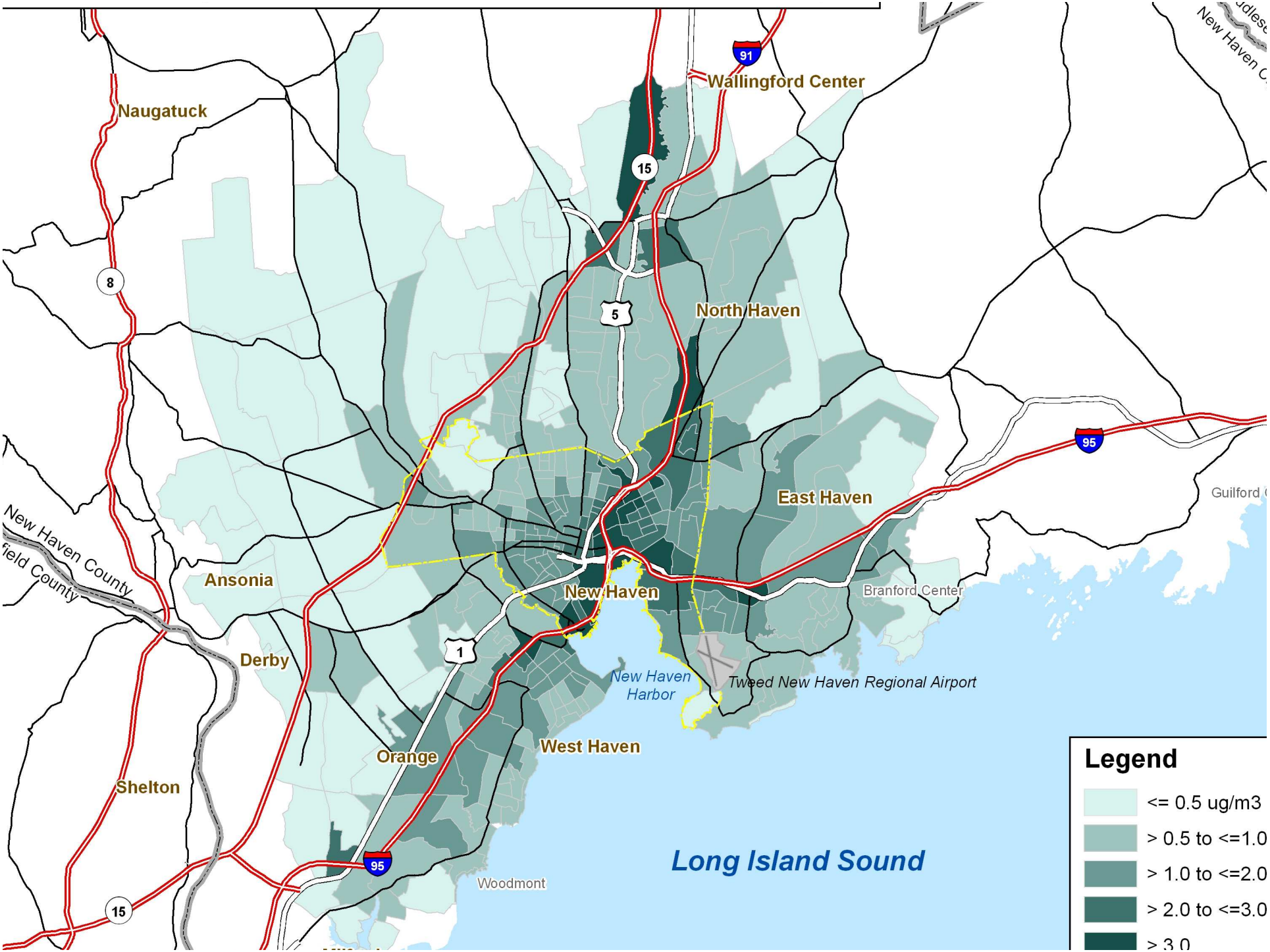
Exposure Model Output

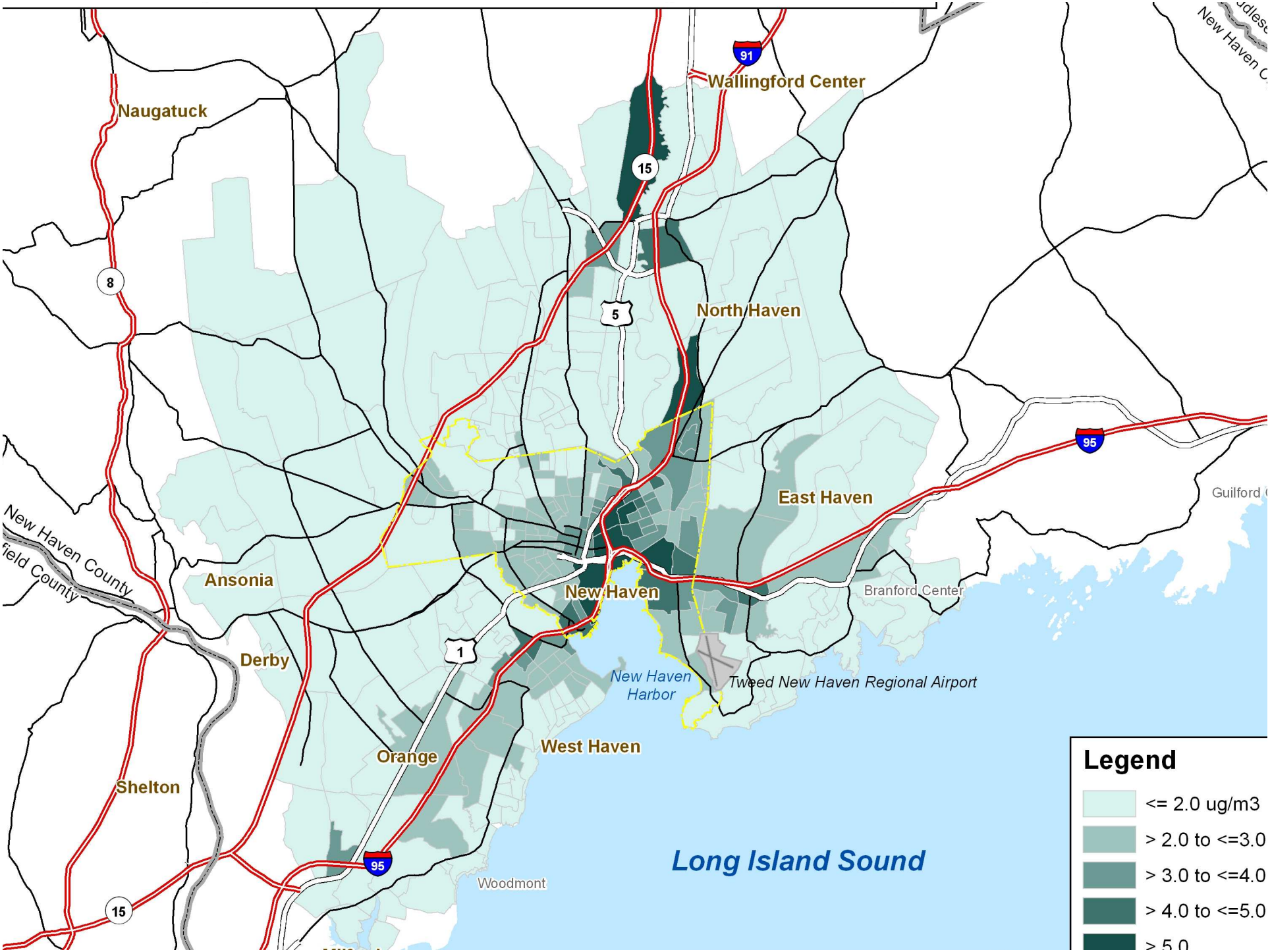
- Population Exposure



- Population Dose




Naugatuck
Wallingford Center
North Haven
East Haven
Ansonia
Derby
New Haven
Branford Center
Guilford
New Haven Harbor
Tweed New Haven Regional Airport
West Haven
Orange
Shelton
Woodmont
Long Island Sound
New Haven County
Legend
<= 0.5 ug/m3
> 0.5 to <=1.0
> 1.0 to <=2.0
> 2.0 to <=3.0
> 3.0


Naugatuck
Wallingford Center
North Haven
East Haven
Ansonia
New Haven
Derby
Orange
West Haven
Shelton
Branford Center
New Haven Harbor
Tweed New Haven Regional Airport
Woodmont
Long Island Sound
New Haven County
Legend
<= 2.0 ug/m3
> 2.0 to <=3.0
> 3.0 to <=4.0
> 4.0 to <=5.0

Collaborators

Emissions Inventories

- MaryBeth Smuts (EPA/Region 1)
- Robert McConnell (EPA/Region 1)
- Madeleine Strum (EPA/OAQPS)
- Dennis Pagano (EPA/OAQPS)
- Ct. Dept. of Transportation/Environment

Exposure Modeling

- Valerie Zartarian (EPA/ORD)
- Jianping Xue (EPA/ORD)
- Halûk Özkaynak (EPA/ORD)
- Ted Palma (EPA/OAQPS)
- Local collaborators TBD

Air Quality Modeling

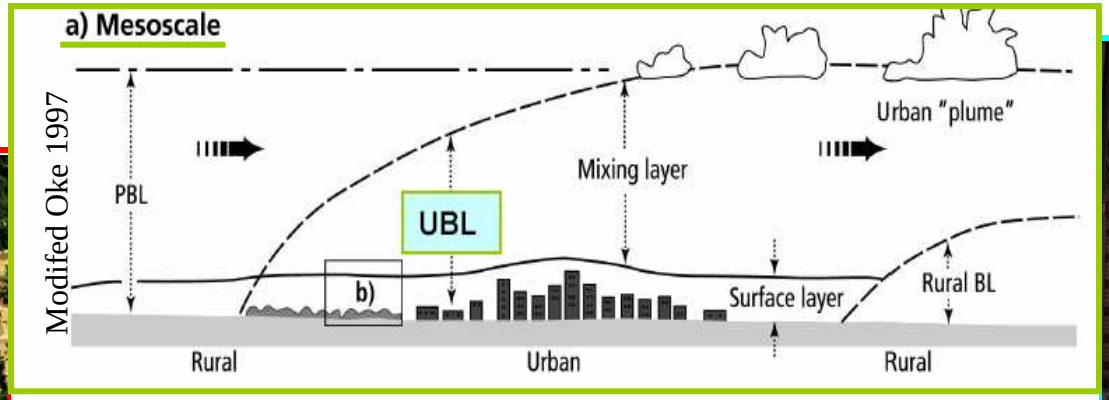
- Vlad Isakov (EPA/NOAA)
- Rich Cook (EPA/OTAQ)
- Chad Bailey (EPA/OTAQ)
- Ct. Dept. of Transportation/Environment

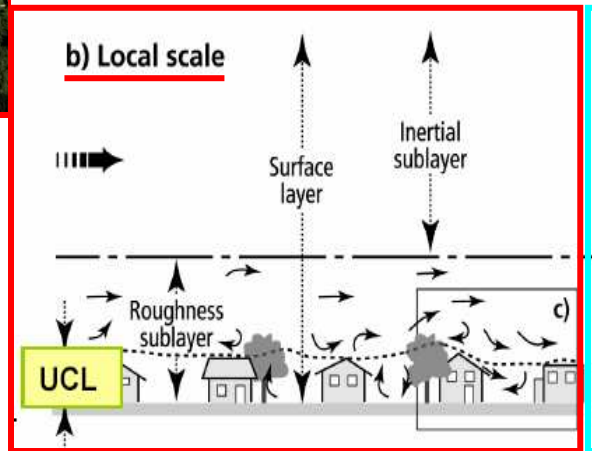
Linkage to Health Data

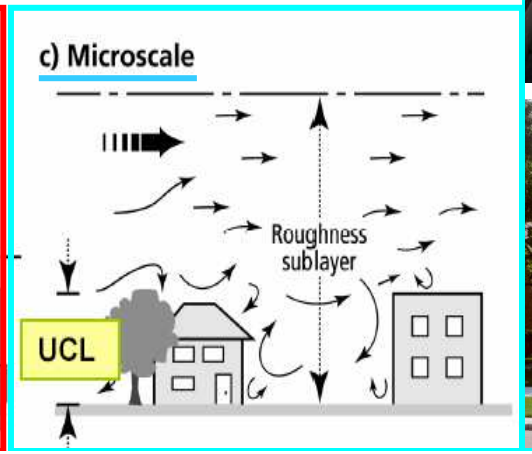
- Danelle Lobdell (EPA/ORD)
- Halûk Özkaynak (EPA/ORD)
- Marybeth Smuts (EPA/Region 1)
- Local collaborators TBD

Micro-urban scale improvements
Jason Ching, EPA

Scales, Courtesy of Grimmond



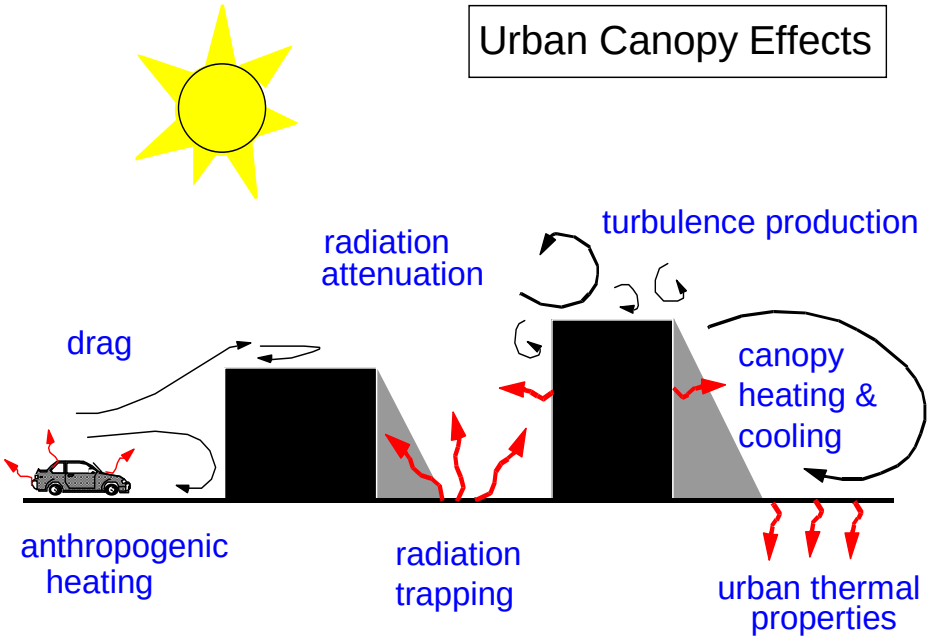


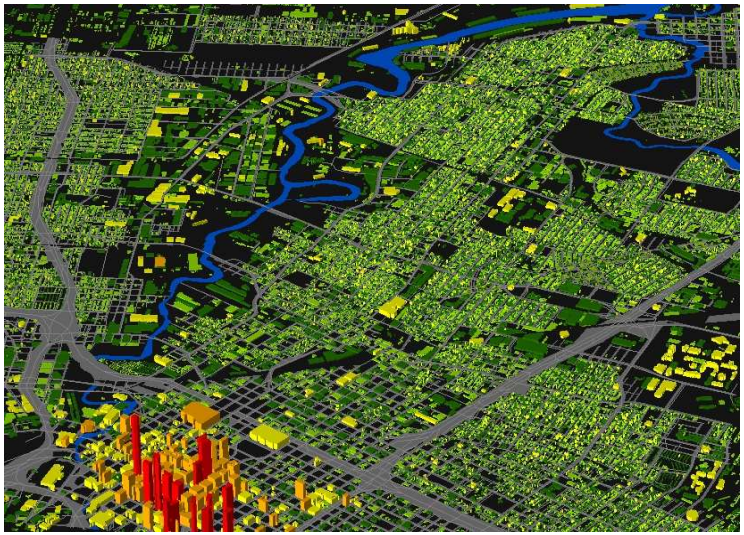


Gothenburg

Chicago

CHALLENGE for meso-to-urban scale modeling





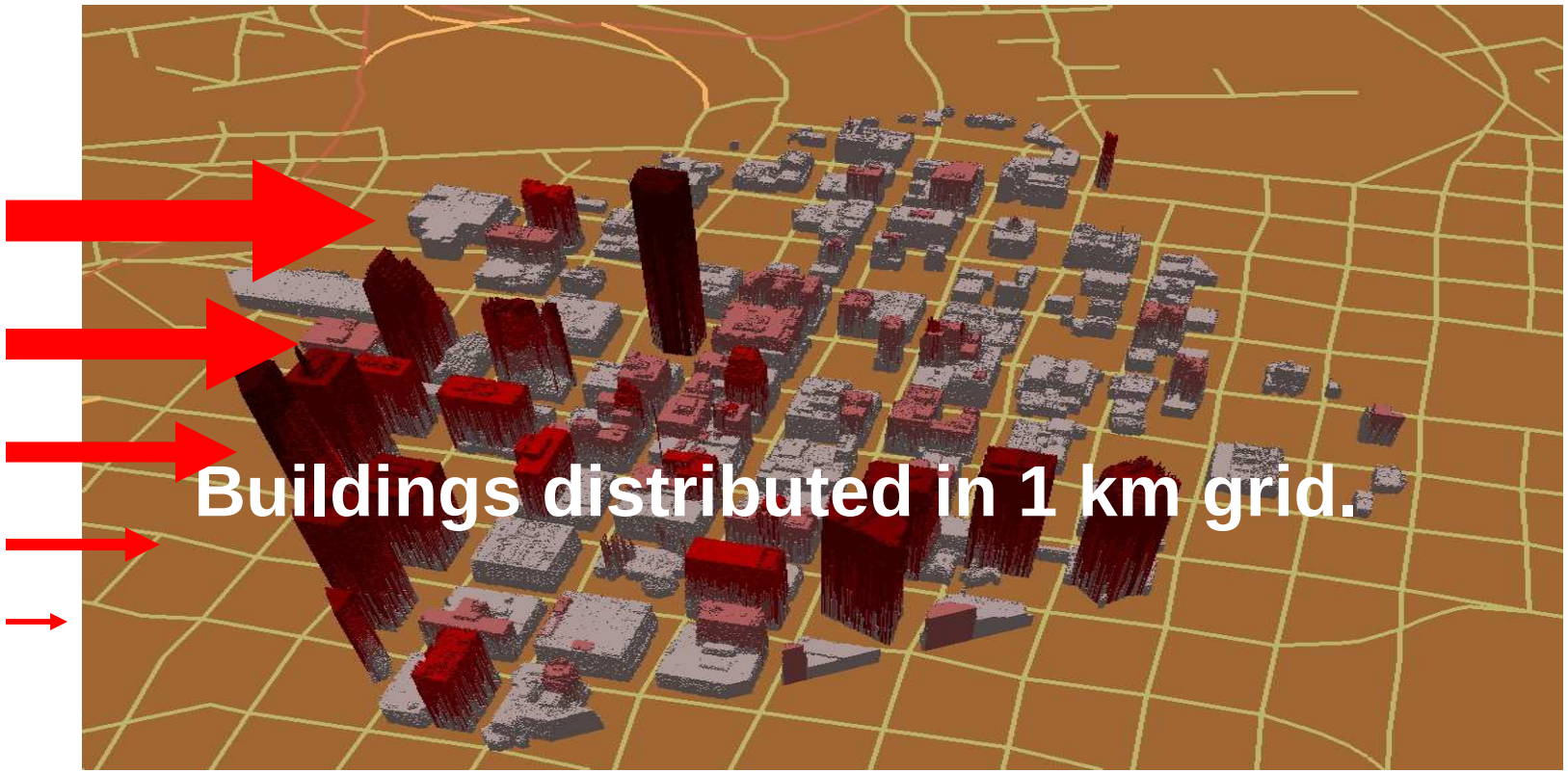
Modeler's need:

To capture the grid average effect of detailed urban features in mesoscale atmospheric models

Solution:

Modelers have defined and implemented urban canopy parameterizations into their models (e.g., MM5, WRF, HOTMAC, RAMS, COAMPS…)

ISSUE: Relating meso-urban to building scale



Mesoscale: Model produces single meteorology profile applicable to grid cell
Results influenced by the presence and aggregated effects of buildings.

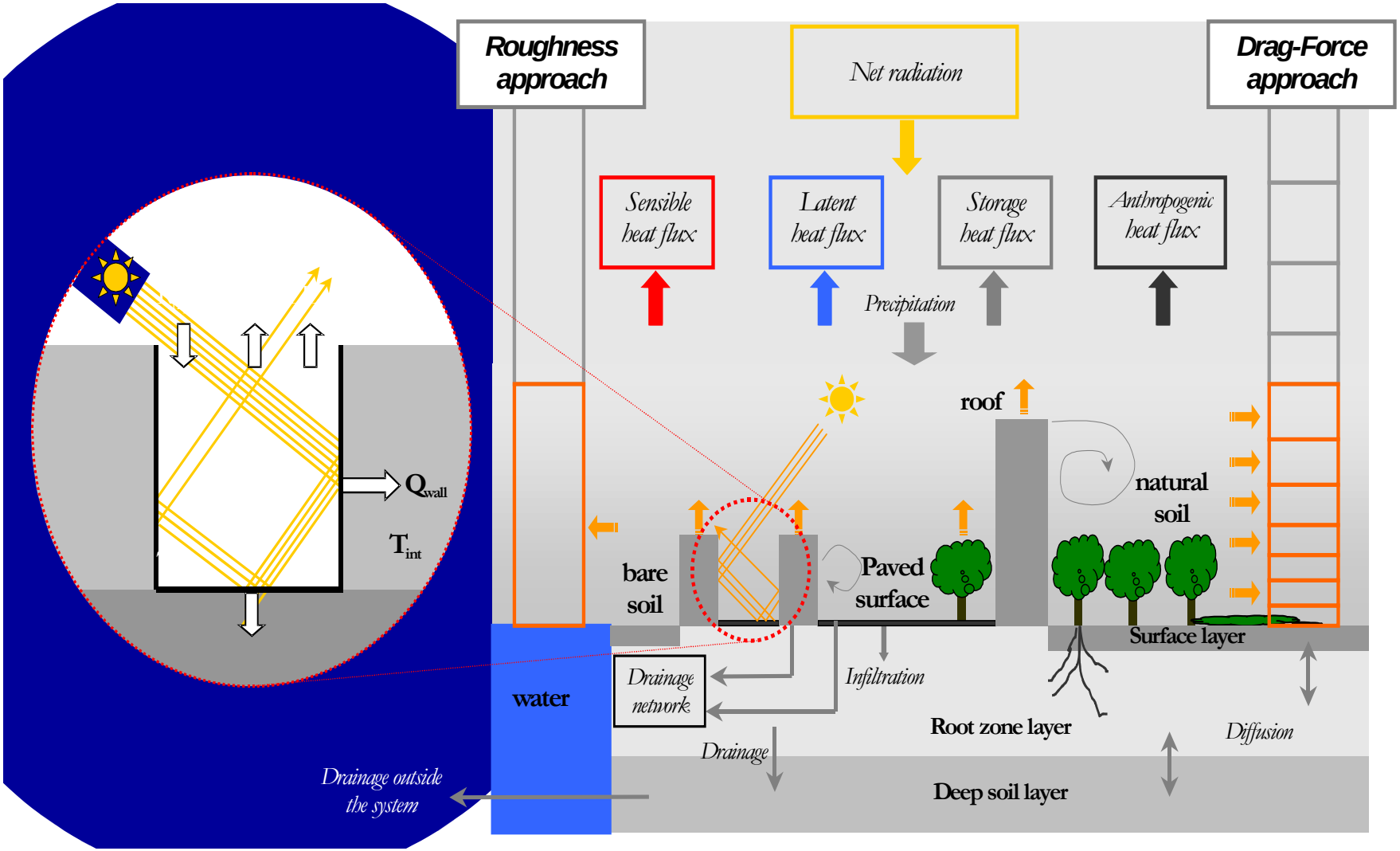
Building scale: Intra-cell flow fields will be highly variable (horizontally and vertically), influenced by the individual buildings.

An implementation: DA-SM2-U in MM5

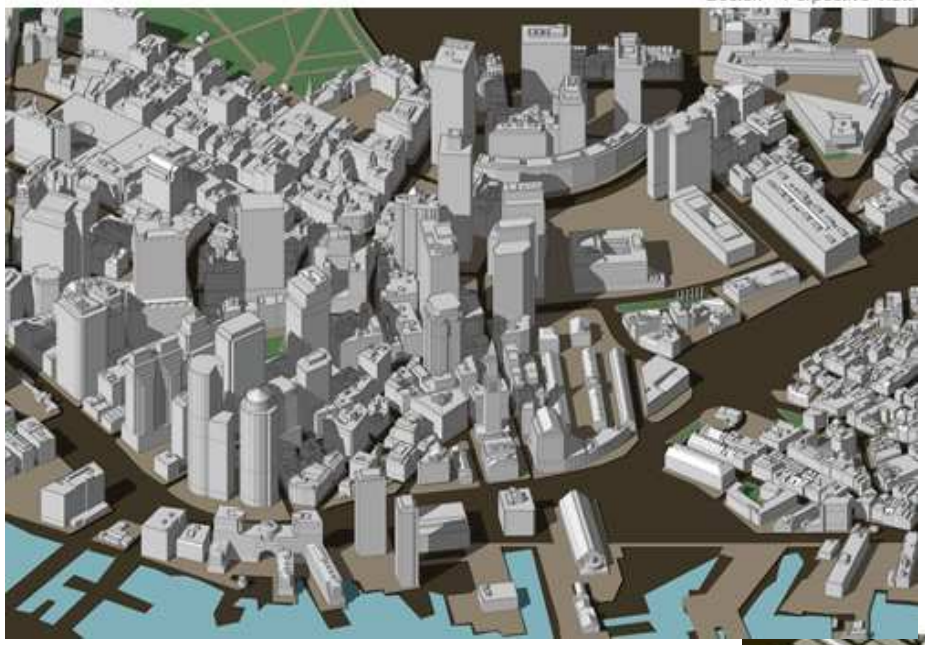
o Urbanization introduced at grid sizes of ~1km using drag approach (DA)

o Land surface model (SM2-U)

o Additional, within canopy layers



Boston - Perpective View

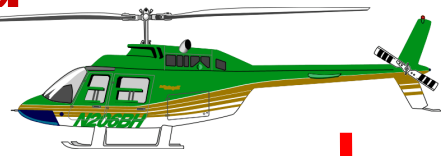


We have the technology and means for obtaining building data at high resolution; such data and ancillary data are becoming increasingly more available for our major cities

Chicago, Perspective View

High resolution urban morphological data can be derived from lidar mapping and photogrammetric techniques

LIDAR Profiling



* **Record Longest Return**
* **Normally Rotary Wing**
* **Continuous Ground Coverage**

High resolution
Data for 133 cities

What's missing in Near Road Assessments?

- Near field chemistry
- Monitoring strategy

Near Roadway Monitoring Strategy

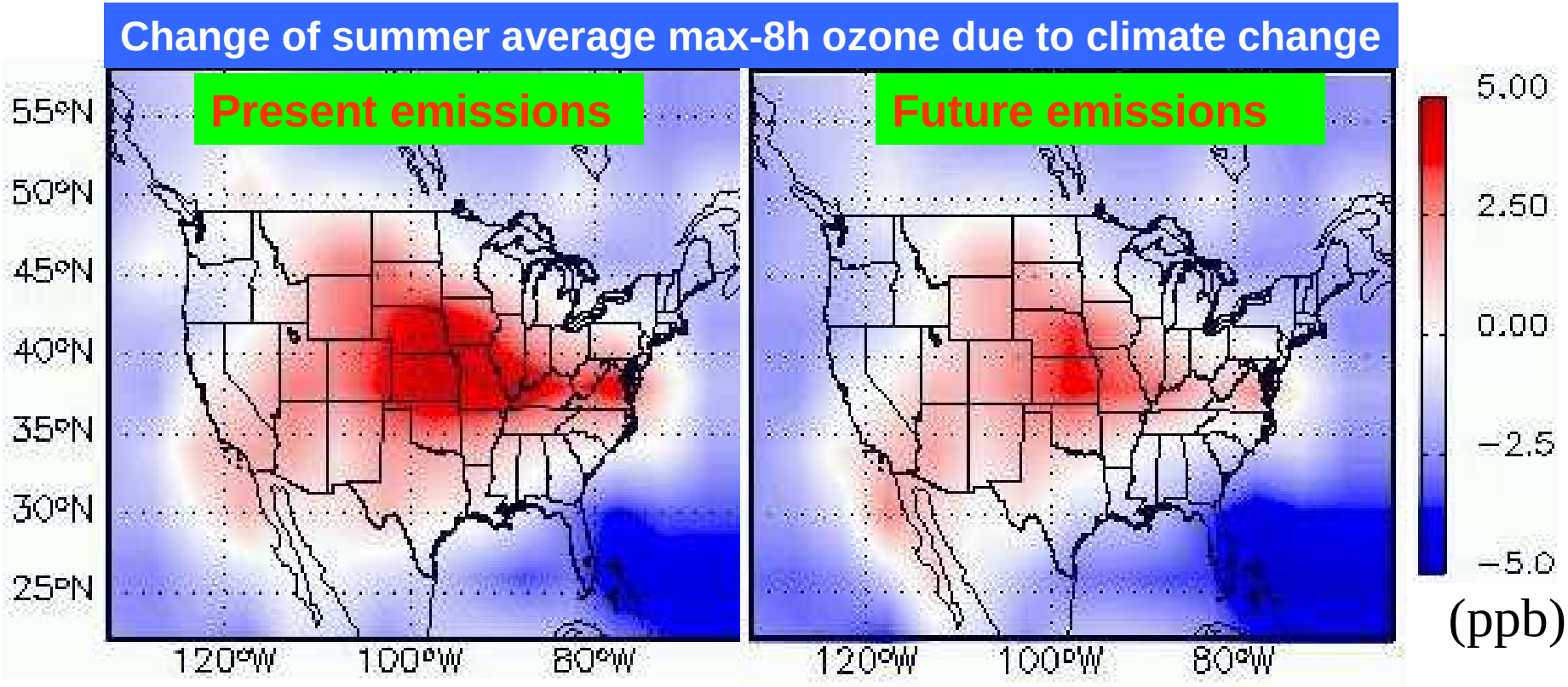
- Start
  - Select 2-4 cities for sustained monitoring
    - Exposure inputs/evaluation
    - Accountability
      - seeing signal changes associated with fuel/fleet modifications
  - Parameters
    - Particle size characteristics
      - How do size distributions change over time?
    - HCHO, PAN, acetaldehyde
      - Key chemistry indicators
    - N species
      - includingN2O
    - Aerosol chemistry…select markers
    - Routine VOCs

EPA and Climate Change (acceleration)

- Roles
  - Near term regulatory activity (OTAQ) …Supreme court ruling
    - Mobile source rulemaking under development, “20 in 10” plan to reduce GHG emissions (with USDA, DOE and DOT)
      - Alt. fuels, CAFE Standards
  - Communicating effects and mitigation strategies (OAP)
  - Emissions Inventory development (OAP/OAQPS/ORD)
    - GHG; harmonization with NEI
  - Linkages with Hemispheric transport (OAR)
    - Similar tools (emissions, obs., models)
    - Climate induced transport pathway alterations
  - Climate influences on air quality (OAQPS/ORD)
    - Linking global and regional scale modeling
    - Accounting for climate impacts in developing policies

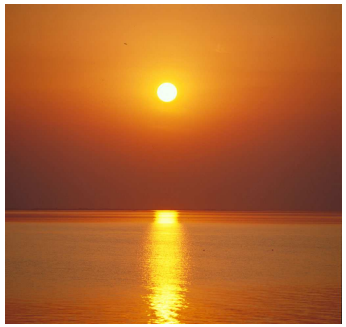
Mitigation of climate penalty by emission reductions in ozone precursors (Wu et al.)

"climate penalty" for ozone air quality = $\Delta[O_3]$ from climate change

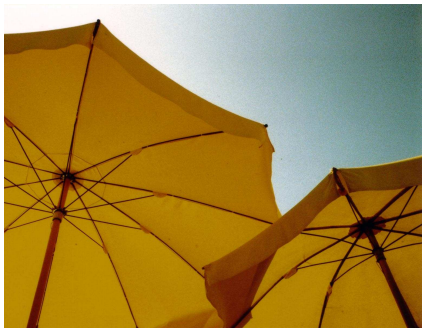


Reductions of anthropogenic emissions significantly mitigate the "climate penalty" and can even turn it into a "climate benefit" in southeast and northwest U.S.

Future Climate Modeling

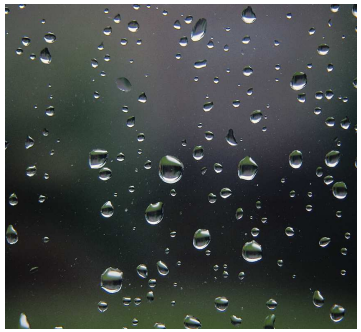


Increased Temperature



Precipitation Changes

Cloud Cover Changes

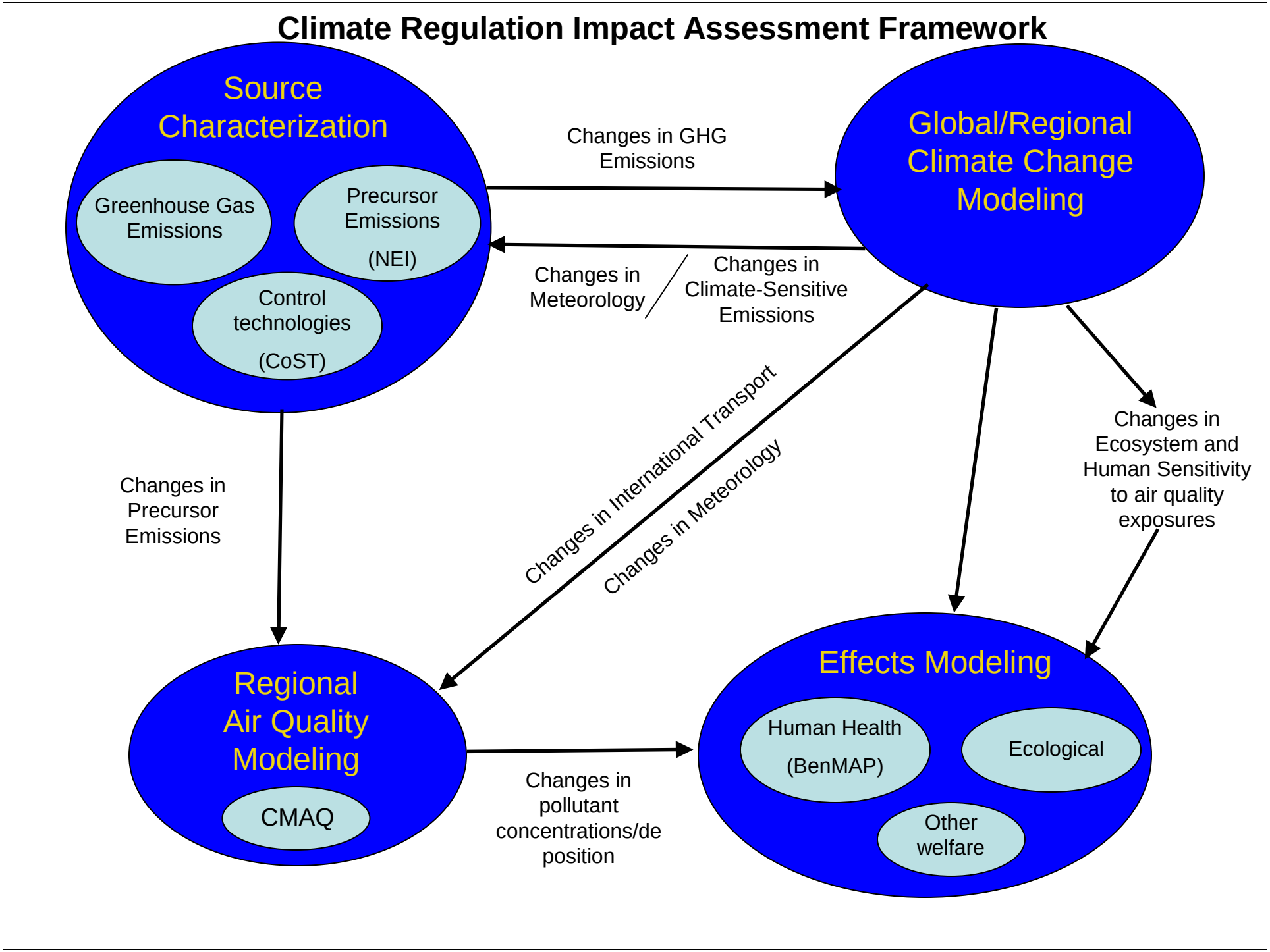


Relative Humidity

Changes to…

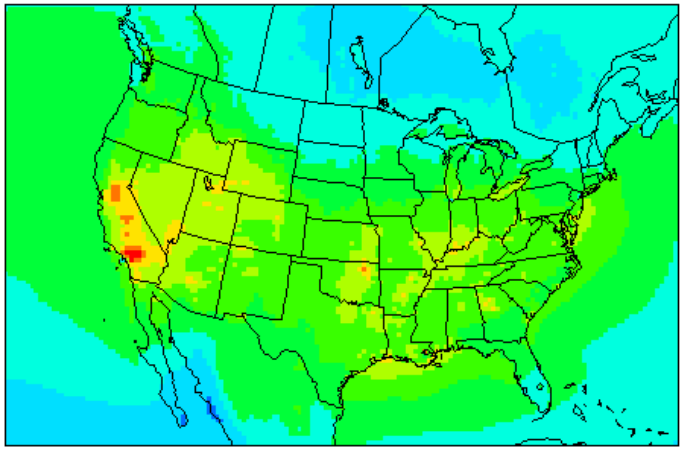
O_3 and $PM_{2.5}$

Climate Regulation Impact Assessment Framework

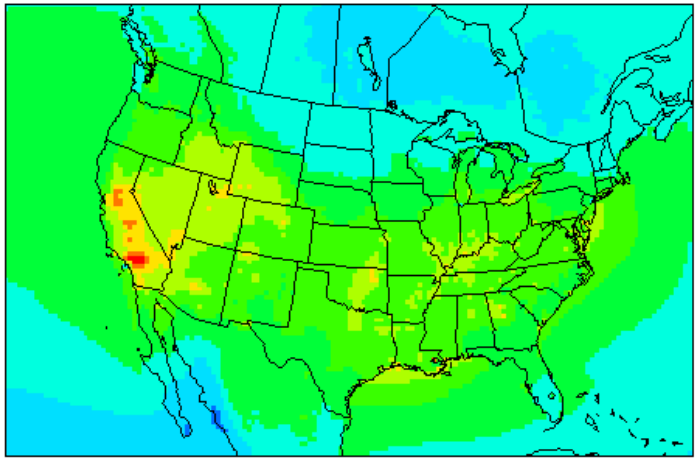


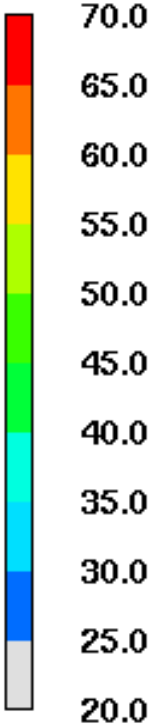
Ozone (8-hr max summer avg., 3-yr ensemble) w/ 2020 Base & CAIR Control Emissions (Jang, EPA)

2020 Base Emissions w/ Current Climate

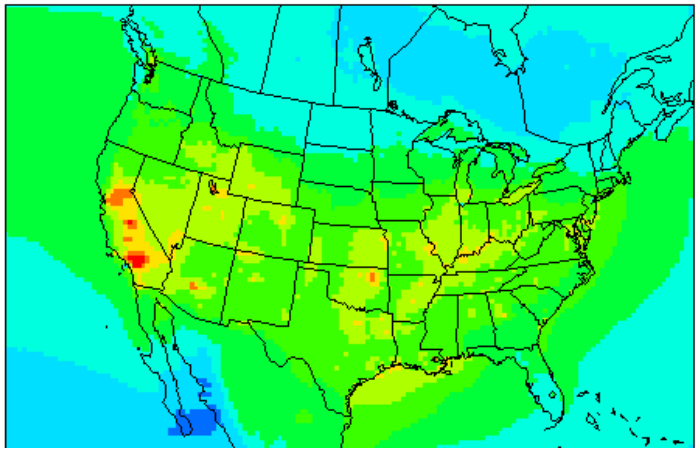


2020 CAIR Emissions w/ Current Climate

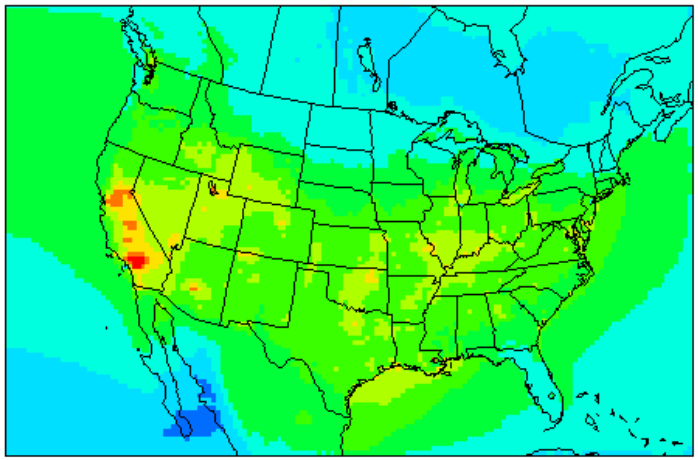




2020 Base Emissions w/ Future Climate



2020 CAIR Emissions w/ Future Climate

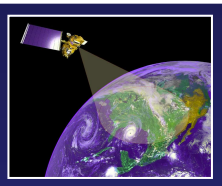


A simple overarching goal or vision

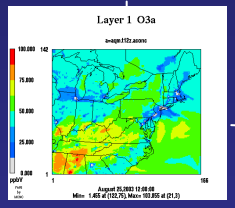
- Strive for maximum and efficient AQ characterization in time, space and compositional terms

Linking characterization systems

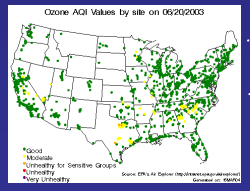
- Integration of systems to improve
  - air quality models for forecast
  - Current and
  - Retrospective assessments
- Global-Regional Air Quality Connections
- Climate-AQ connections



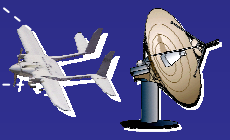
Total column depth (through Satellites)



AQ model results



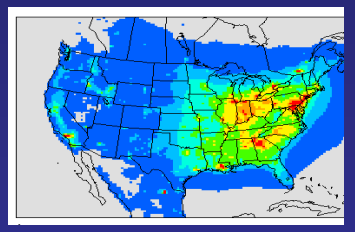
Land AQ Monitors



Vertical Profiles

Integrated Observation- Modeling

Optimized PM2.5, O3



Characterizations

Health

Air management

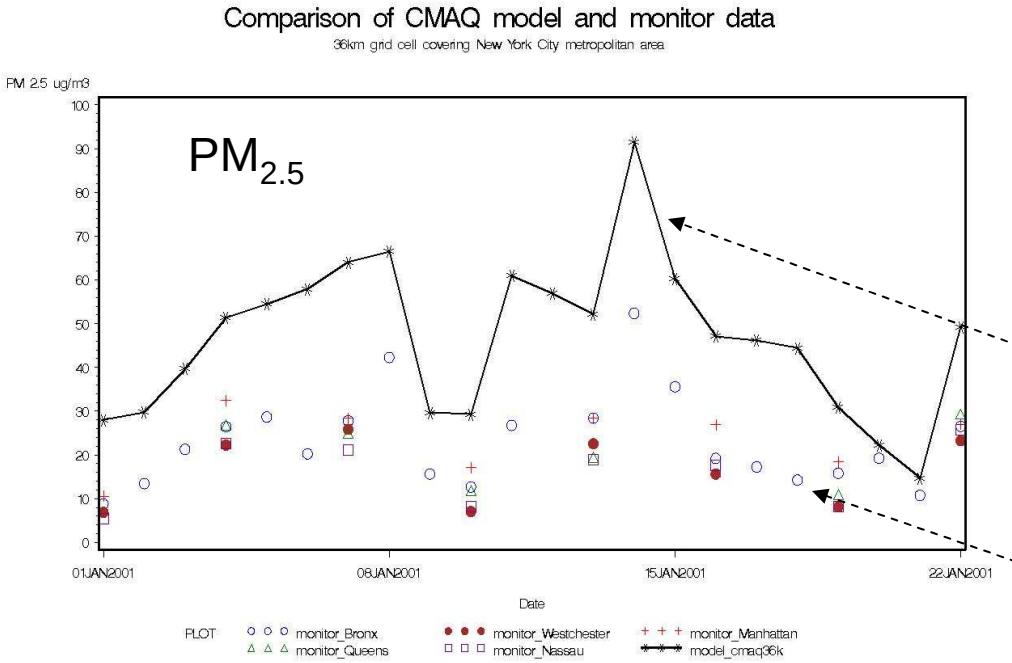
ecosystems

Early example

Public Health Air Surveillance Evaluation

PHASE Partners and Initial Outcomes

- Partner states - Maine, New York , Wisconsin
- PHASE products/outcomes:
  - EPA (& state) investigation of novel air quality estimating technique - EPA delivered monitor, CMAQ and fused AQ data
  - Study of "case-crossover" method with "how to" guide
  - Multi-state comparisons of AQ-health associations
  - Interactions with state public health agencies - Example of effective interagency collaboration
- Associations (preliminary) between AQ (8-hour O_3 and $PM_{2.5}$) and asthma, and AQ ($PM_{2.5}$) and myocardial infarction through case-crossover analyses



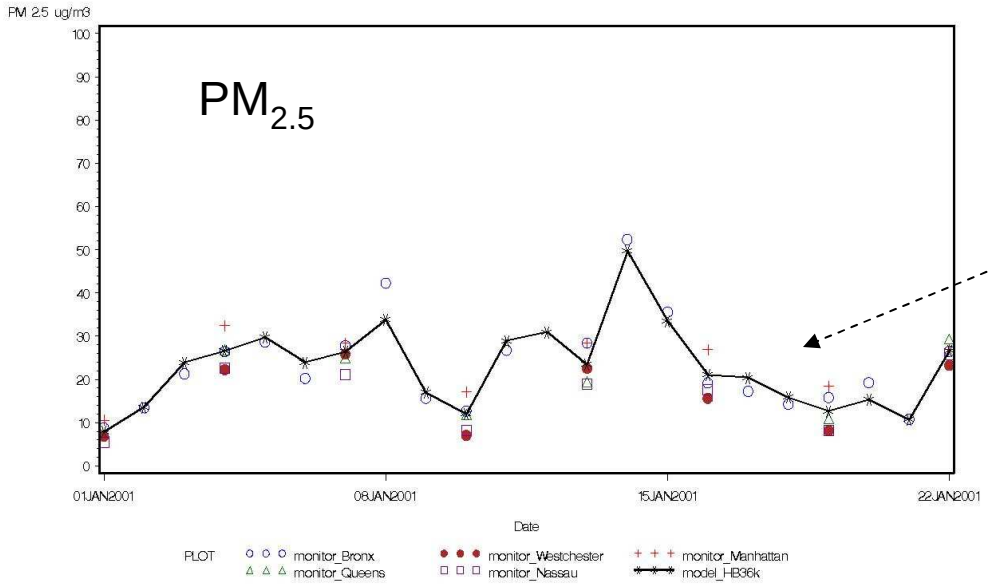
Improving the quality of observations or modeled results in isolation through "fusion" techniques.

CMAQ Prediction

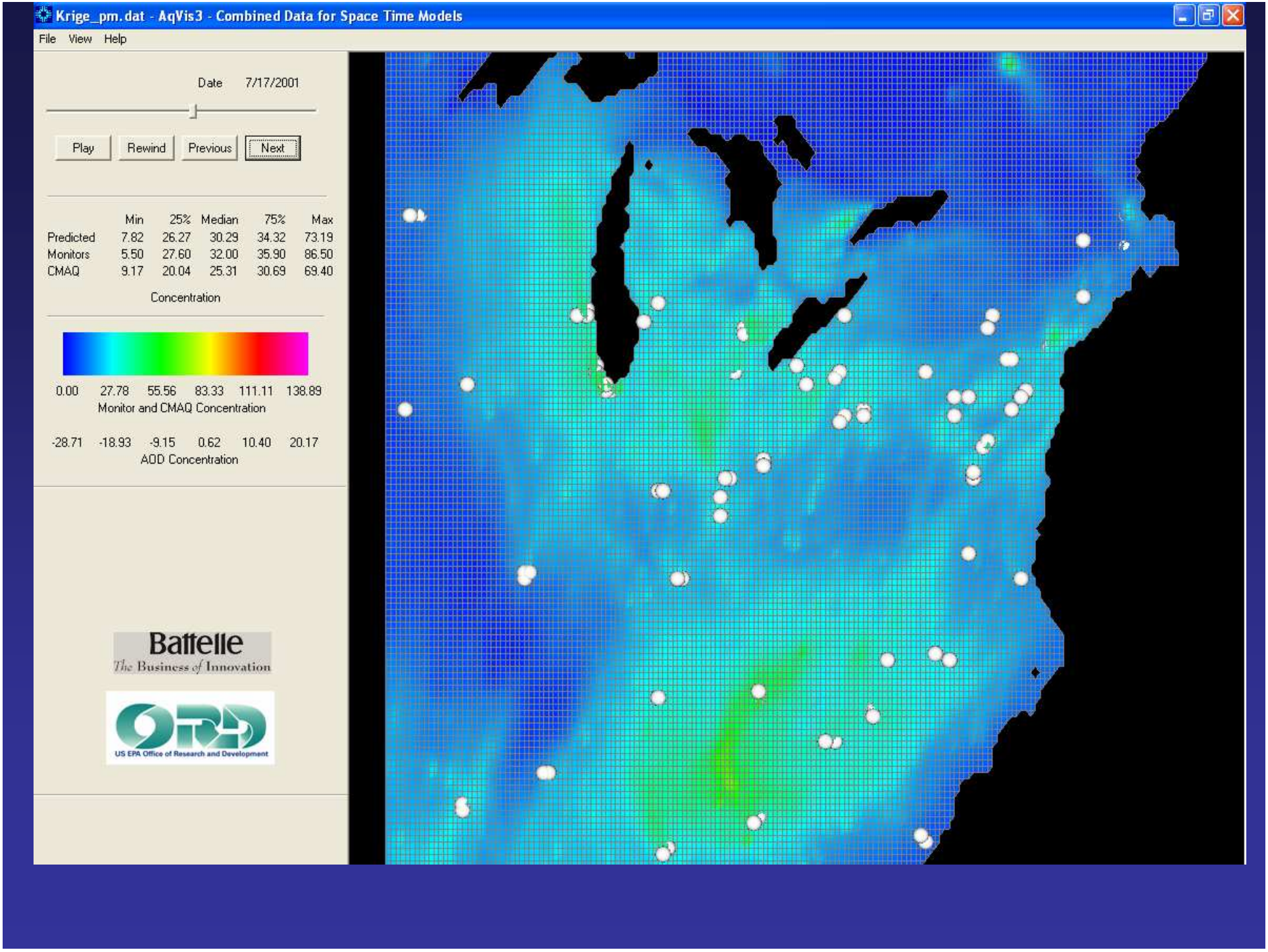
(line)

AQ Monitoring Data

(various points)



After application of statistical combination technique


Krige_pm.dat - AqVis3 - Combined Data for Space Time Models
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Next
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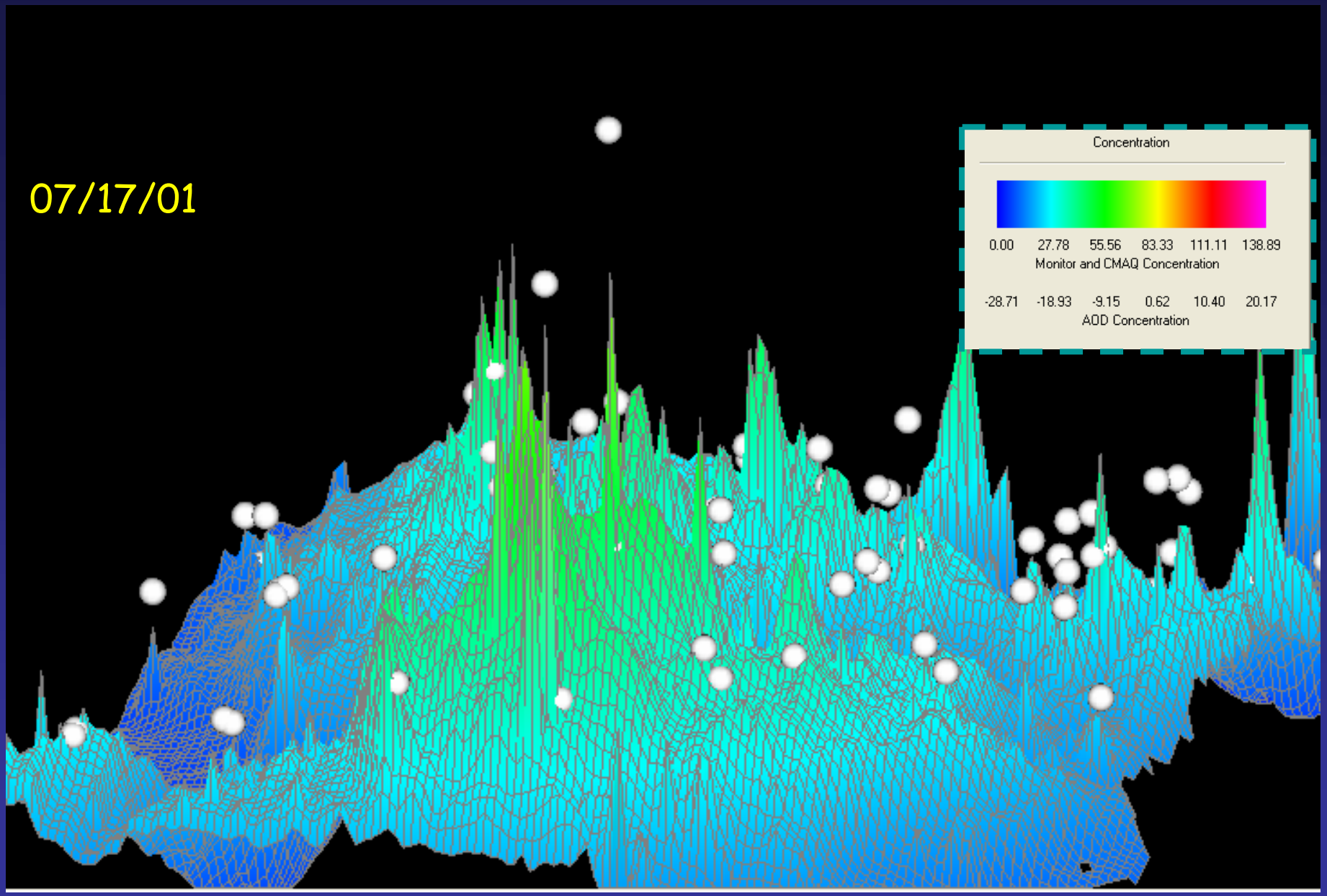
CMAQ 9.17 20.04 25.31 30.69 69.40
Concentration
0.00 27.78 55.56 83.33 111.11 138.89
Monitor and CMAQ Concentration
-28.71 -18.93 -9.15 0.62 10.40 20.17
AOD Concentration
Battelle
The Business of Innovation
US EPA Office of Research and Development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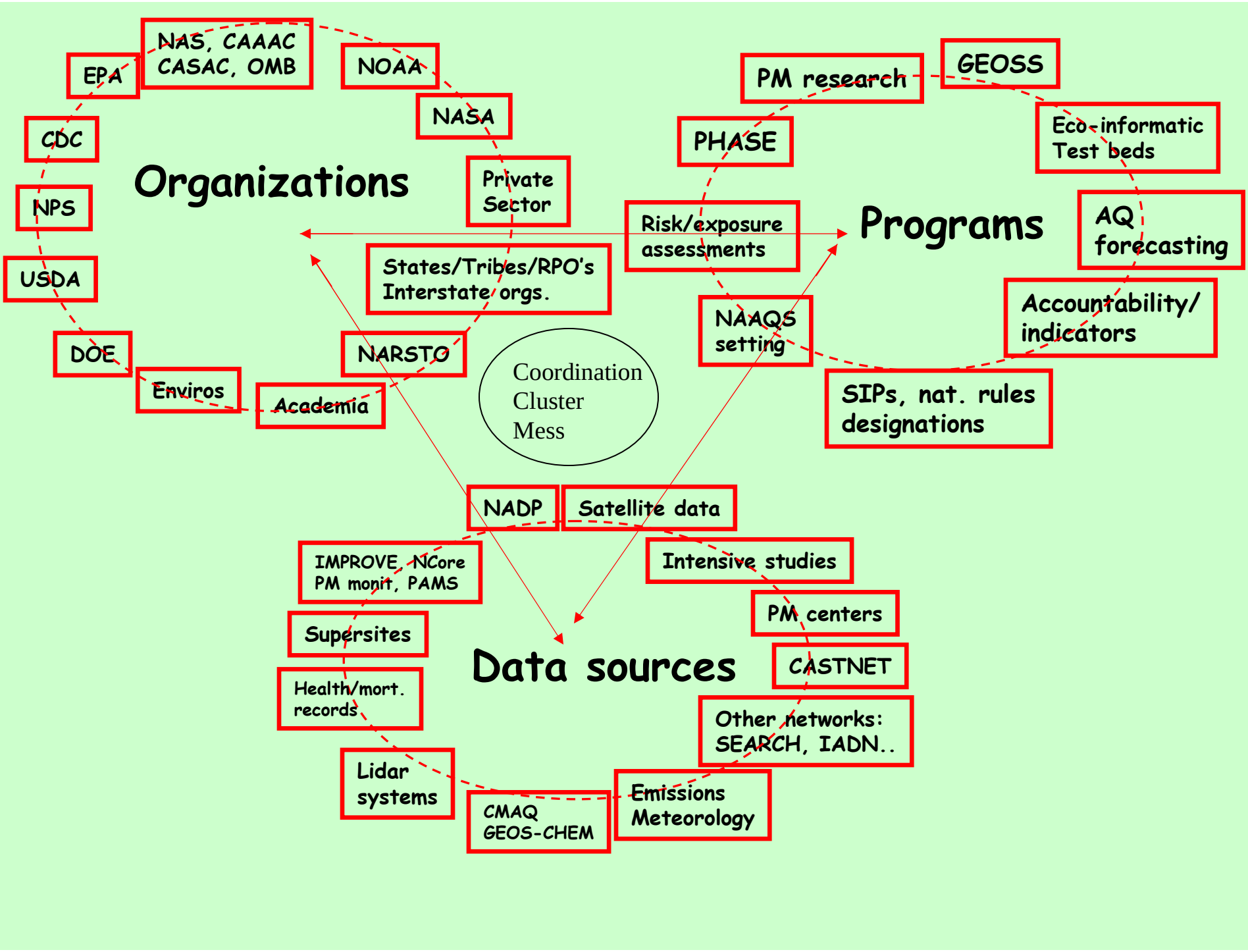
AOD Concentration

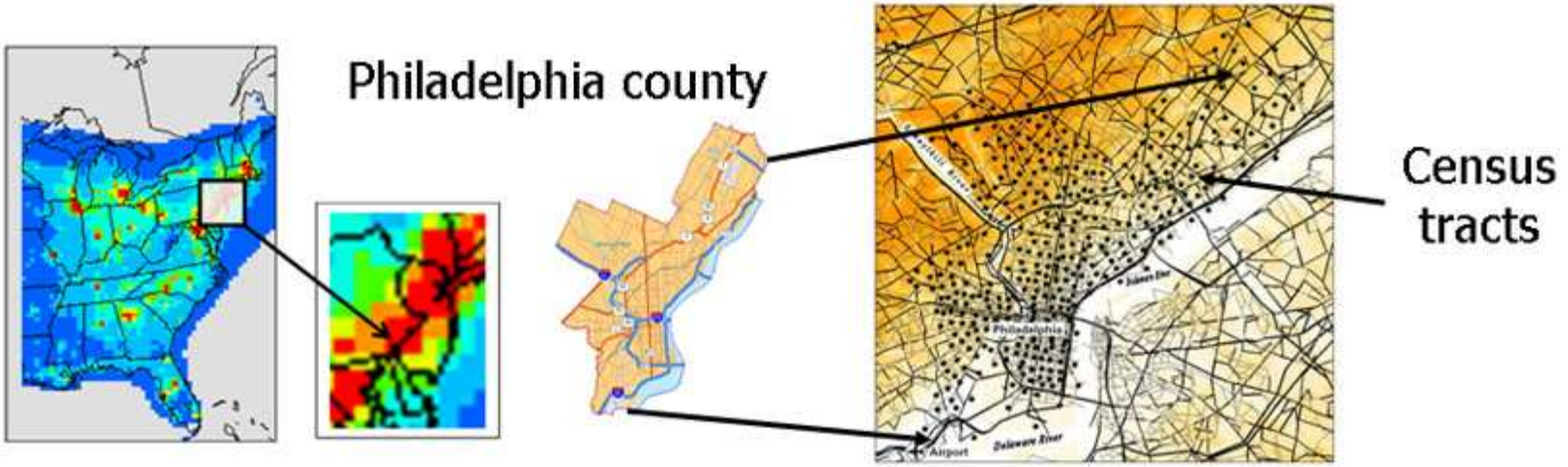

Organizations
EPA
NAS, CAAAC CASAC, OMB
NOAA
NASA
Private Sector
CDC
NPS
USDA
DOE
Enviros
Academia
NARSTO
States/Tribes/RPO's Interstate orgs.
Programs
PM research
GEOSS
PHASE
Eco-informatic Test beds
AQ forecasting
Risk/exposure assessments
Accountability/ indicators
NAAQS setting
SIPs, nat. rules designations
Coordination Cluster Mess
Data sources
NADP
Satellite data
IMPROVE, NCore PM monit, PAMS
Intensive studies
PM centers
Supersites
CASTNET
Health/mort. records
Other networks: SEARCH, IADN..
Lidar systems
Emissions Meteorology
CMAQ GEOS-CHEM

Bridging atmospheric science-IT worlds

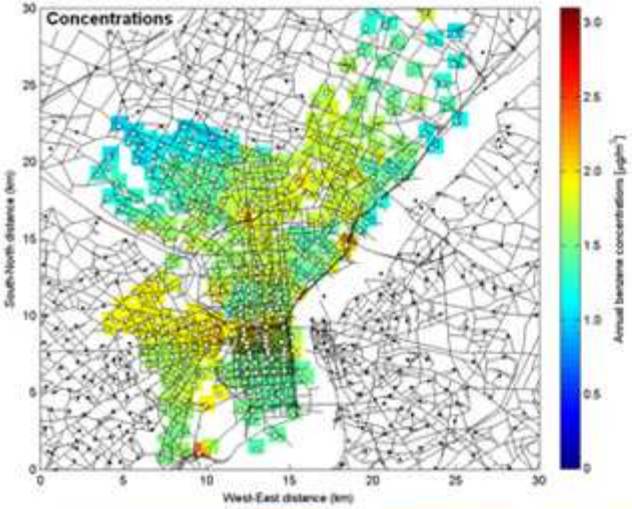
- EPA/NASA/NOAA IT systems
- US GEO role?
- Building the ESIP, DataFED concepts into a working system accessible and usable by the non expert community
  - Lessons from WMO/GAW, GEMS, GIOVANNI, VIEWS

Thank You!

Linking Emissions, Air Quality, and Human Exposures



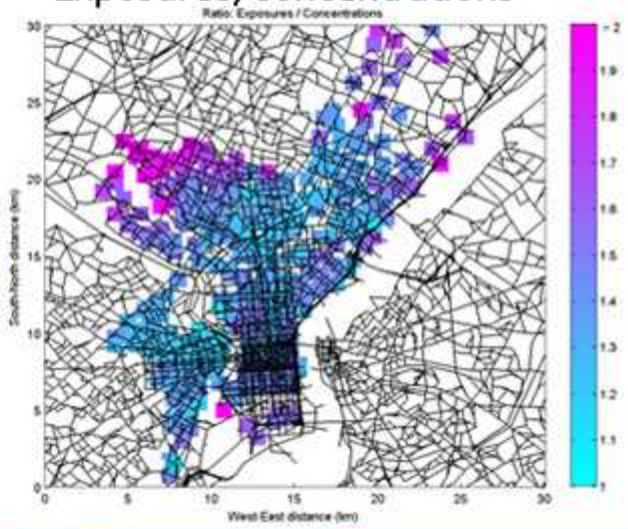
Ambient Concentrations

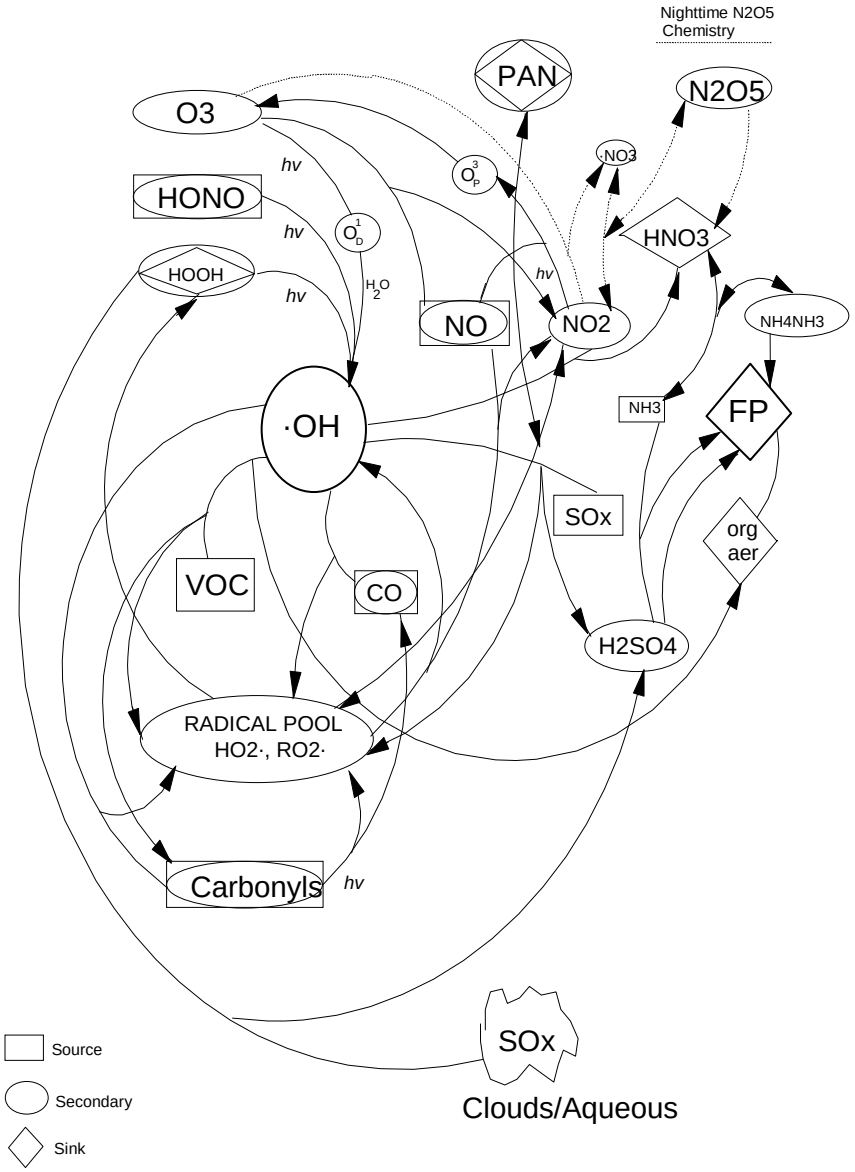


Exposure Modeling

- Indoor Penetration
- Personal Sources
- Human Activity

Ratio: Exposures/Concentrations




Nighttime N2O5
Chemistry
PAN
N2O5
O3
NO3
HONO
HNO3
HOOH
NO
NO2
NH4NH3
·OH
NH3
FP
SOx
org
aer
VOC
CO
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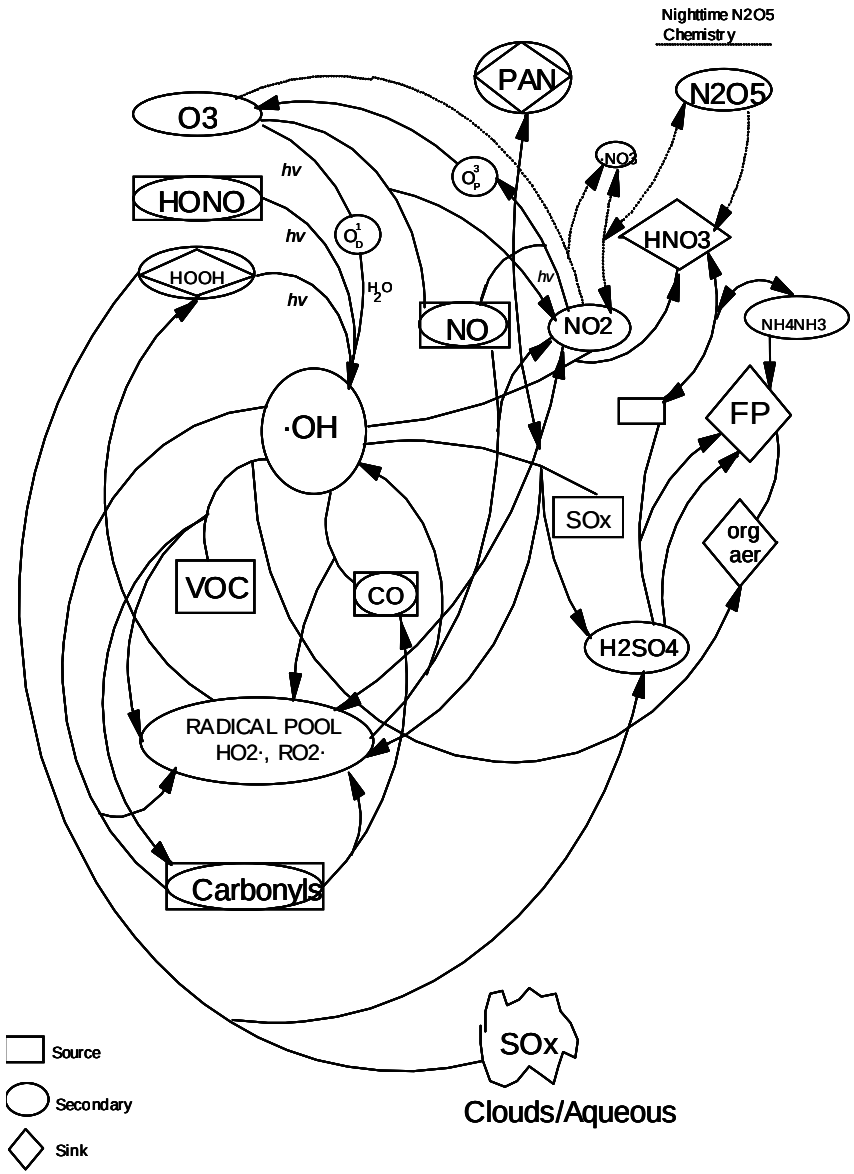
RADICAL POOL
HO2·, RO2·
Carbonyls
hv
SOx
Clouds/Aqueous
Source
Secondary
Sink


Nighttime N2O5
Chemistry
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H2O
hv
NO
NO2
NH4NH3
·OH
FP
SOx
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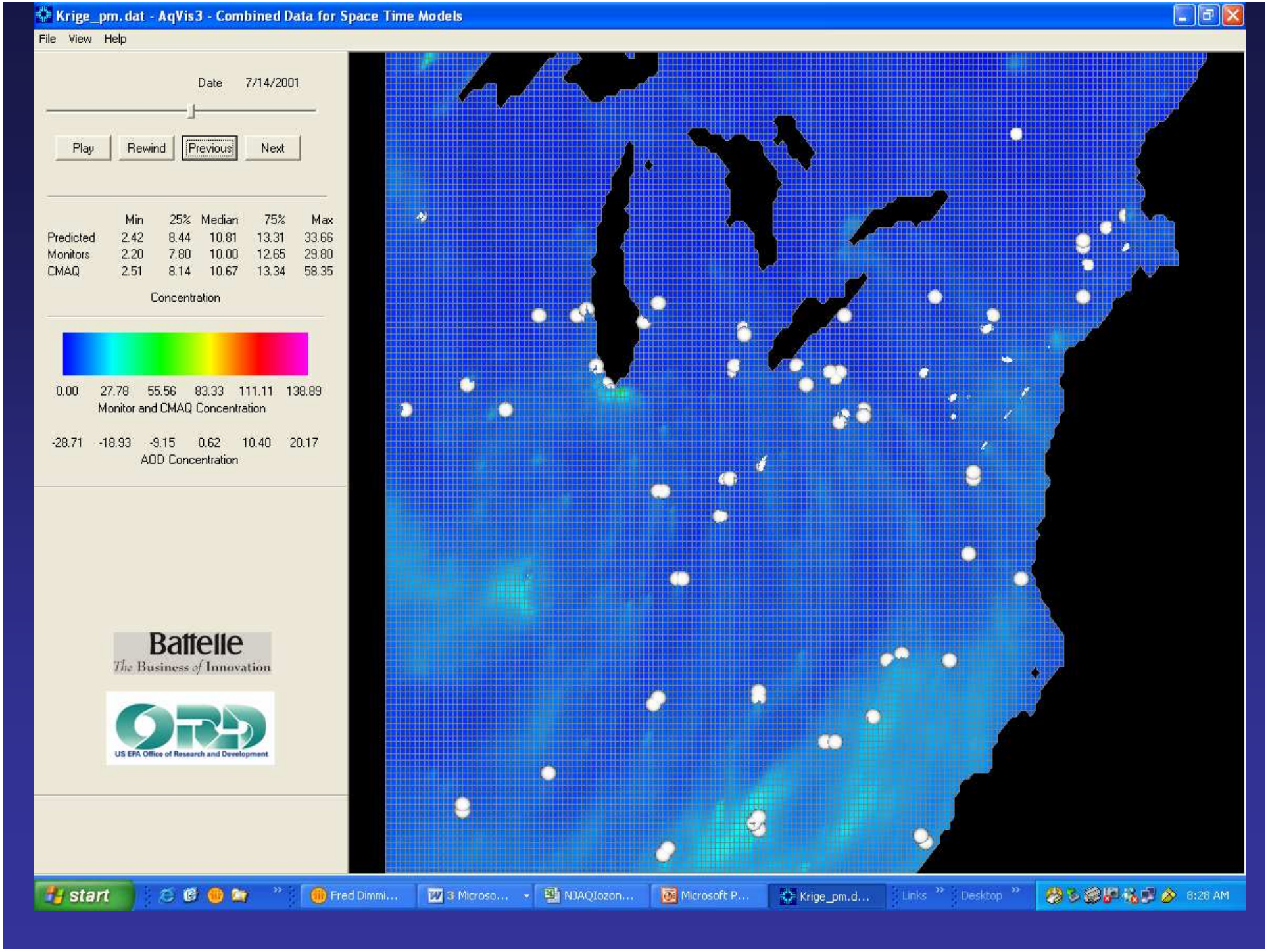
HO2·, RO2·
Carbonyls
SOx
Clouds/Aqueous
Source
Secondary
Sink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Monitors 2.20 7.80 10.00 12.65 29.80
CMAQ 2.51 8.14 10.67 13.34 58.35
Concentration
0.00 27.78 55.56 83.33 111.11 138.89
Monitor and CMAQ Concentration
-28.71 -18.93 -9.15 0.62 10.40 20.17
AOD Concentration
Battelle
The Business of Innovation
US EPA Office of Research and Development
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Krige_pm.d...
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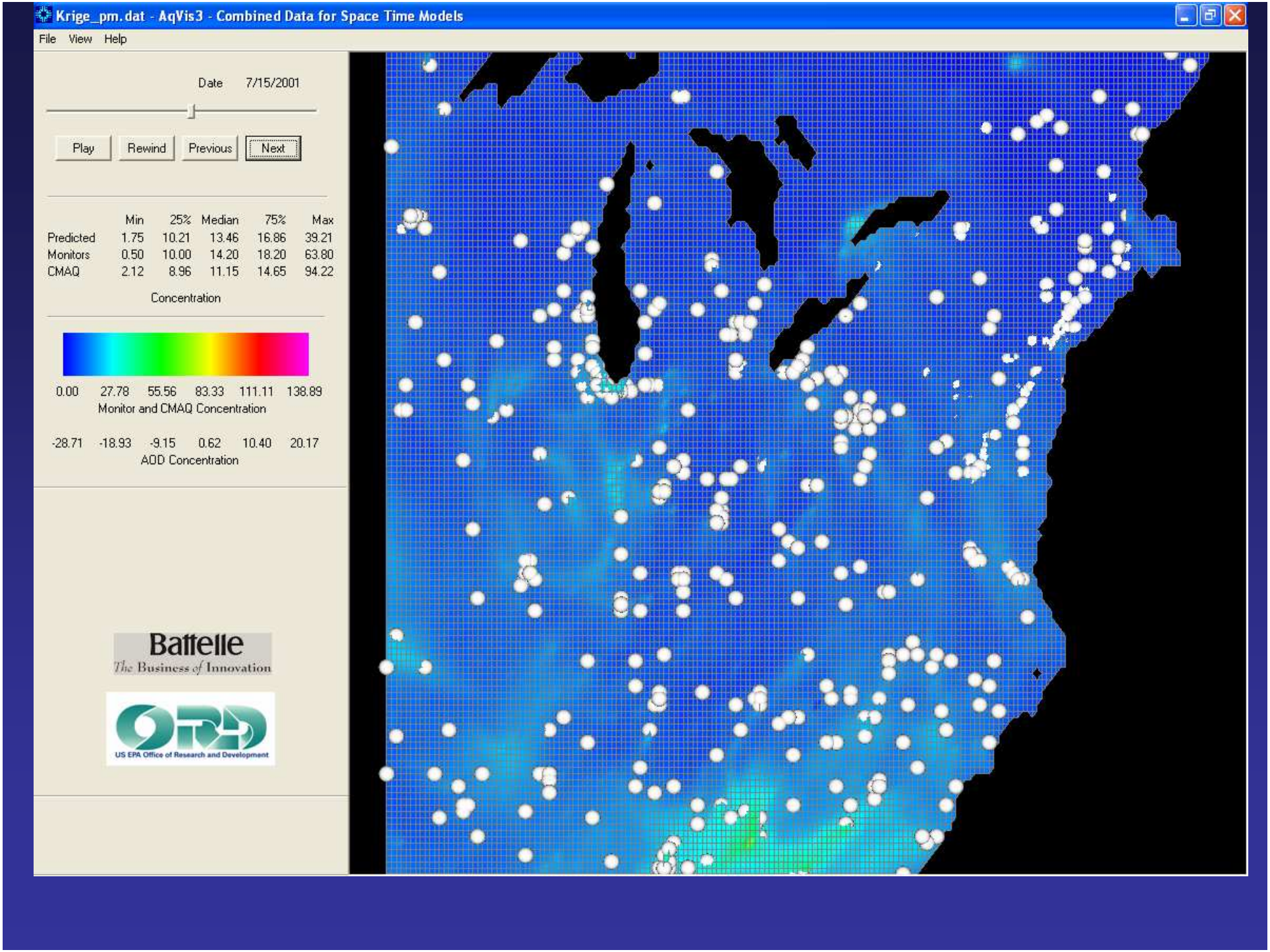
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CMAQ 2.12 8.96 11.15 14.65 94.22
Concentration
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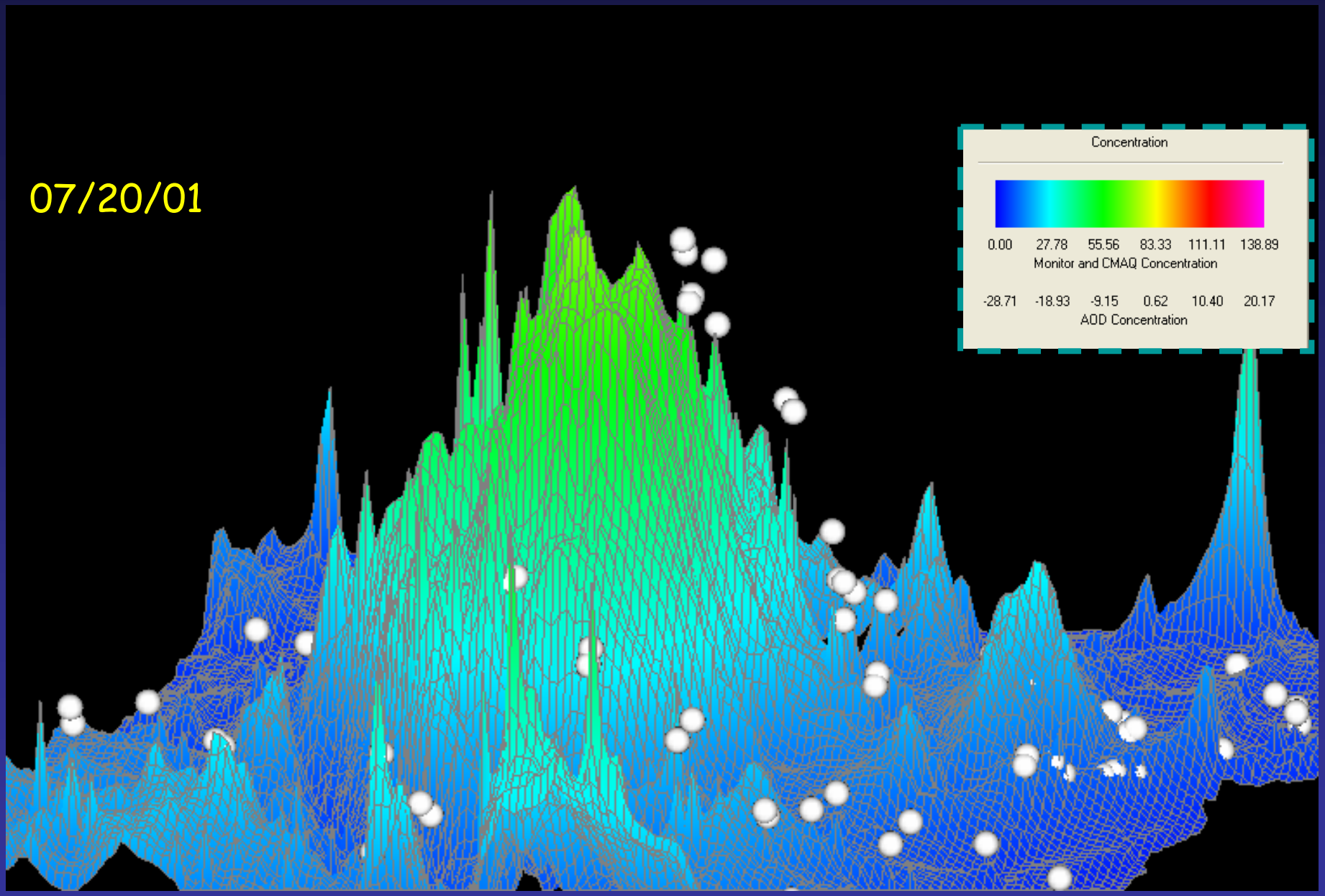
07/20/01
Concentration
0.00 27.78 55.56 83.33 111.11 138.89
Monitor and CMAQ Concentration
-28.71 -18.93 -9.15 0.62 10.40 20.17
AOD Concentration

Closer look: 2-D view of modeled benzene concentrations