Modeling Air Quality

"Many Voices - One Vision"

Environmental Public Health Tracking Conference

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Presentation Overview

- Air Quality Models
- Statistical Models

EPA Uses of Air Quality Models

1) Evaluate the impact of air quality management practices

2) Support exposure and risk assessments

3) Better probe, understand, and simulate chemical and physical interactions in the atmosphere.

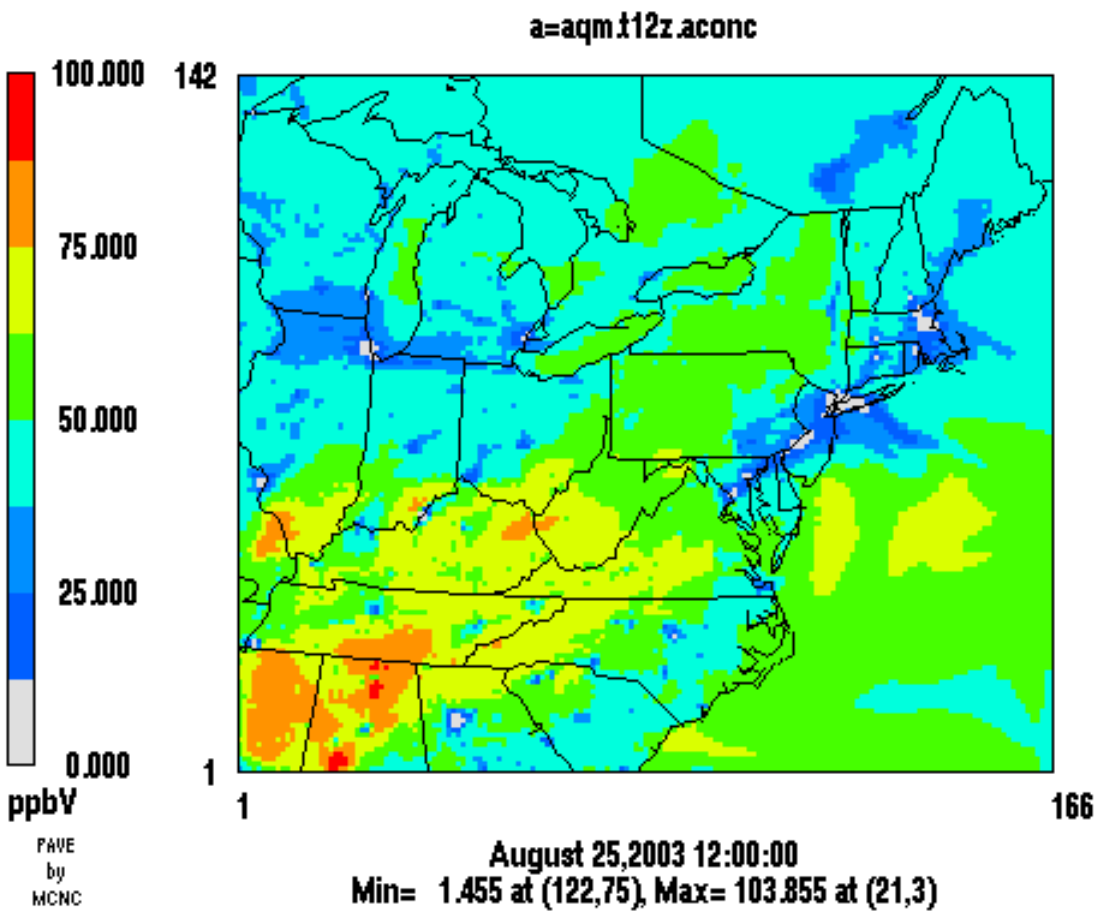
The Community Multiscale Air Quality Model (CMAQ)

- Developed in EPA's Office of Research and Development (ORD)
- Reflects State-of-the-Science
- "One atmosphere" model
  - Treats multiple pollutants simultaneously at several spatial scales
    - regional to urban to "neighborhood" scales
    - tropospheric ozone, fine particles, air toxics, acid deposition, and visibility.

CMAQ Components

- Emissions Model
  - Man-made and natural emissions into the atmosphere
- Meteorological Model
  - Description of atmospheric states and motions
- Chemical Transport Model
  - Simulation of chemical transformation and fate in the atmosphere

CMAQ Output


Layer 1 O3a
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Min= 1.455 at (122,75), Max= 103.855 at (21,3)

CMAQ Peer Review

- Individual components are peer reviewed in scientific literature
  - Example - CMAQ Model Aerosol Component, Model Description and Evaluation (Journal of Geophysical Research, Vol. 108, 2003)
- Peer-review panel
  - 5-6 member independent peer panel to review CMAQ model – December 2003
- Open architecture
  - Scientific community contributes to model development

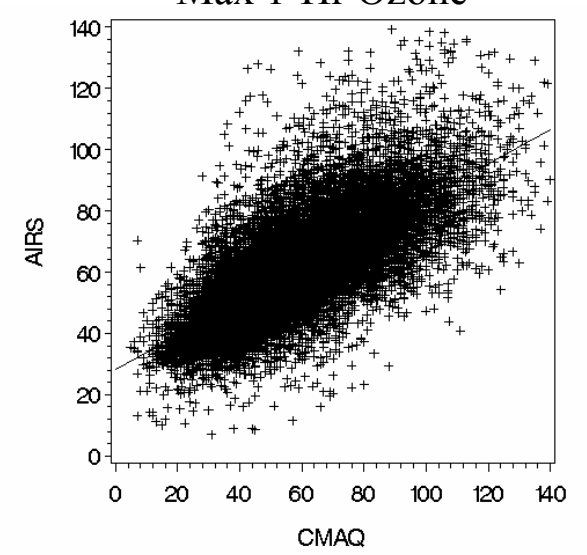
CMAQ Model Evaluation

- Rigorous Model Evaluation Process
  - Evaluation process peer reviewed
  - Evaluations published in literature
  - Diagnostic Evaluation
    - Identify influence of individual atmospheric processes – model sensitivity
    - Right Answer for the Right Reason
  - Performance Evaluation
    - Predictions versus Observations
    - Statistical metrics
  - Model inter-comparison

Model Evaluation: 2003 CMAQ Release

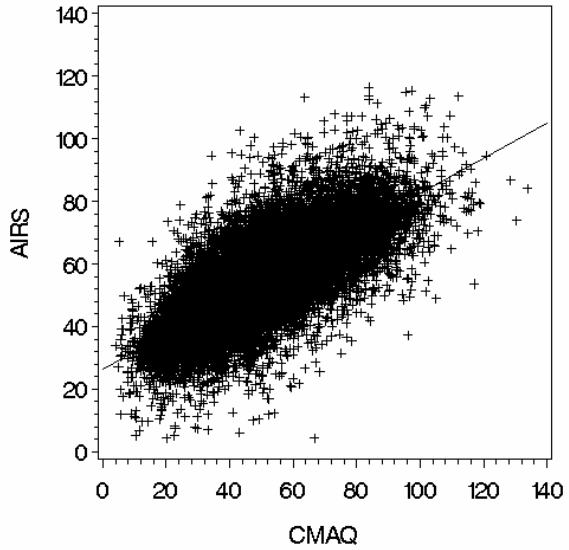
June 15 – July 16, 1999

Max 1-Hr Ozone



	CMAQ	OBS		
Mean	61.3	59.0	n	23,196
SD	16.2	20.7	R	0.72
CV	26.4%	35.0%	MB	2.3

Max 8-Hr Ozone



	CMAQ	OBS		
Mean	54.5	50.2	n	23,196
SD	13.7	18.2	R	0.75
CV	25.1%	36.3%	MB	4.3

CMAQ Applications

- Current applications
  - Air Quality Planning
  - National Air Toxics Assessments
  - Fine or “neighborhood” scale modeling
- Emerging applications
  - Air Quality Forecasting

Connection to Environmental Public Health Tracking

Air Quality Forecasting and Environmental Public Health Tracking

- Environmental Public Health Tracking requires data generated on an on-going, systematic basis.

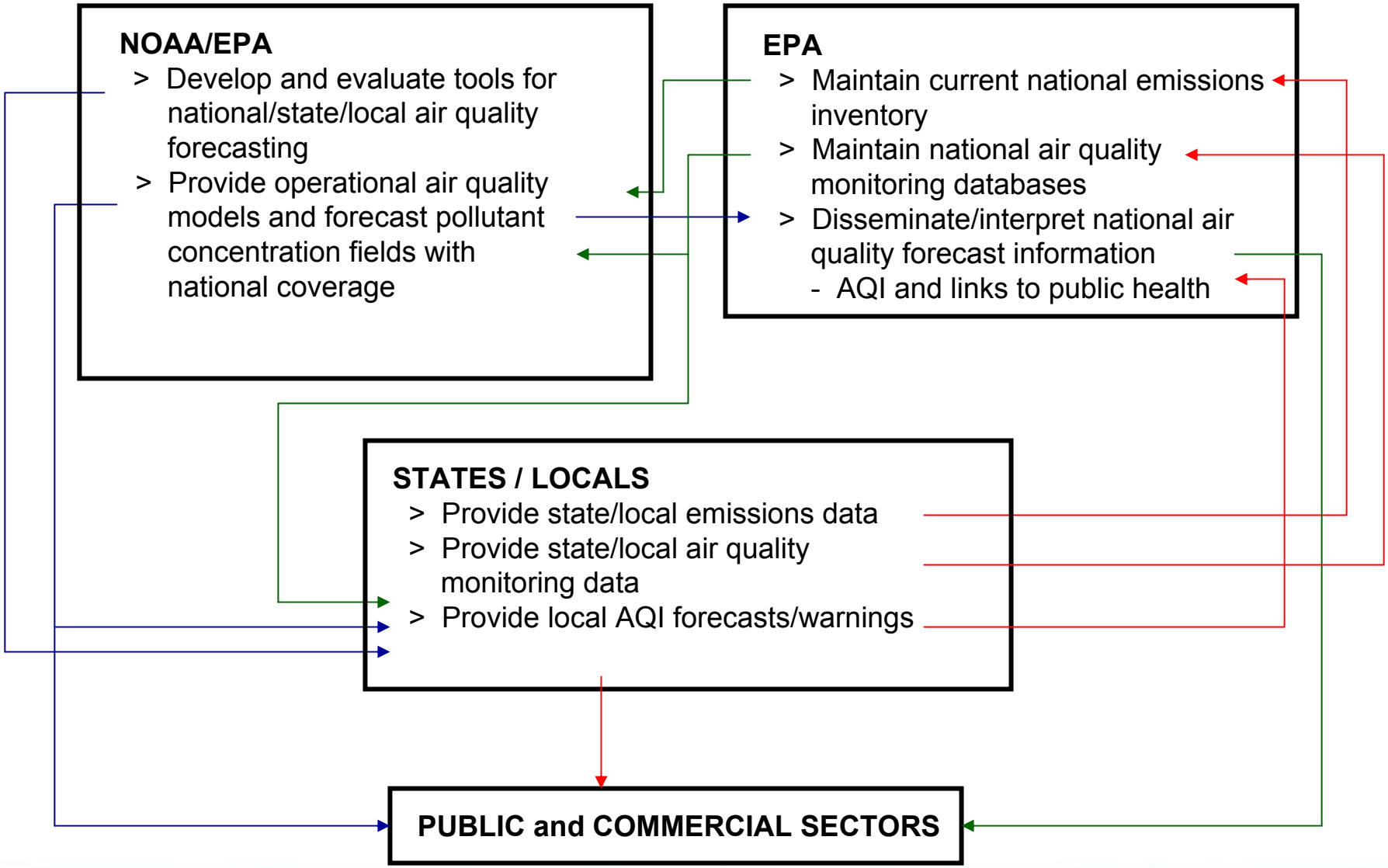
- Current applications of air quality models do not generate routinely available results.

- However, emerging Air Quality Forecasting applications will generate routinely available data.

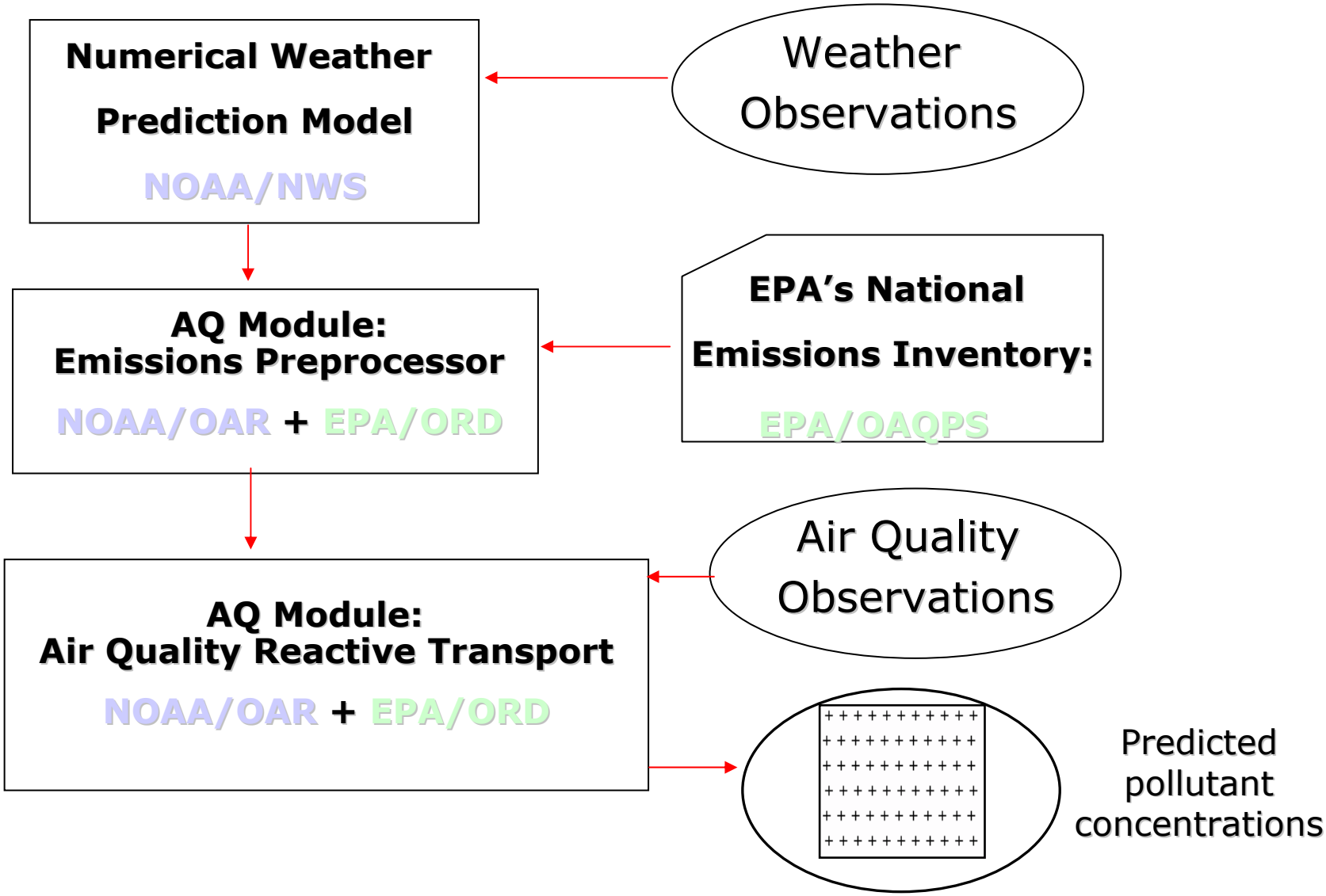
Air Quality Forecasting Drivers

- Congressional Mandate (2002)
  - Directs NOAA to “establish a program to provide operational air quality forecasts and warnings for specific regions of the United States…”
- NOAA-EPA Agreements (2003)
  - To collaboratively facilitate the preparation and dissemination of air quality forecasts for use by States, local authorities, and others for public health advisories and short-term emissions management strategies

PARTNERSHIPS IN AIR QUALITY FORECASTING



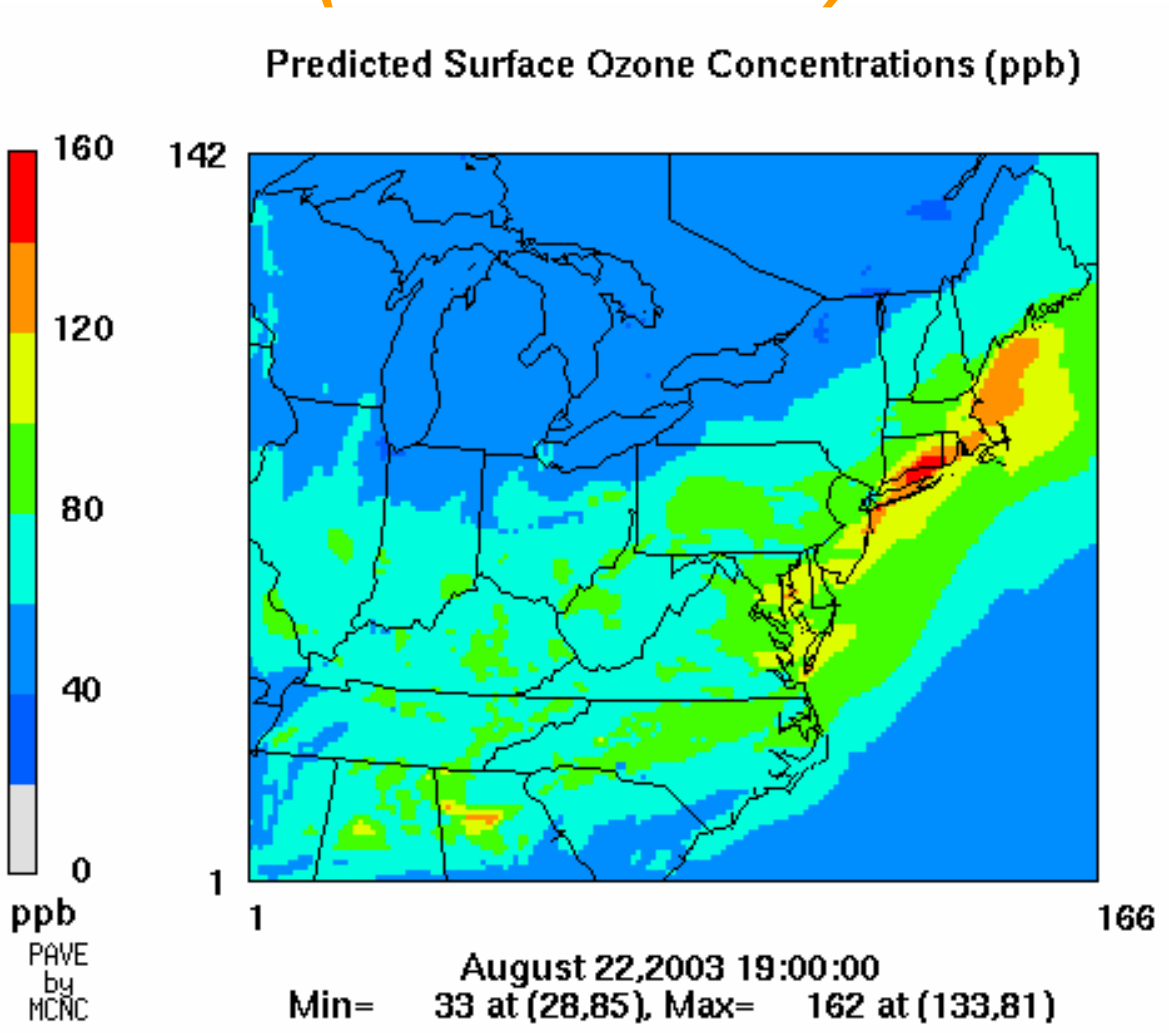
Air Quality Forecast Model System



Air Quality Forecasting Timeline

- 2003 Summer Pilot – Initial testing of forecast modeling system at NOAA/National Weather Service (NWS)
  - CMAQ run twice daily for Northeast U.S. on 12-km grid
  - 1-h and 8-h ozone concentration forecast guidance
  - Initial testing was successful
- Summer 2004 Real-time Test and Evaluation
  - Similar to 2003 Summer Pilot (NE US and 12-km grid)
  - Final check-out of air quality prediction system for ozone
  - At completion, decision by NOAA on making system fully-operational for ozone air quality forecasting
- Future Plans (2004-2009)
  - Expansion of model domain to continental U.S.
  - Addition of PM2.5 predictions

Initial NE US Domain
(12 km Grids)



Statistical Models

Potential Uses of Statistical Models

- Define air pollution non-attainment areas
- Input to human exposure models
- Design networks for “optimal” spatial prediction
- Support investigations between air quality and public and ecological health

Existing Approaches

- Inverse Distance Weighting (IDW)
  - Simplest interpolation method
    - FAST - few parameter decisions
  - Weighted average of monitoring values
    - Decreasing function of distance
  - No assessment of variability
  - Produces a “bull’s eye” around data locations
- Kriging
  - Very flexible, allows assessment of spatial correlation
  - Provides prediction errors
  - Relies on some user assumptions / decisions
  - When applied to sparse air monitoring networks, may miss important gradients

Solution: Combining Information

- Monitoring data
  - Close to “truth,” but low spatial and temporal resolution
  - Most monitoring site in urban areas
- Air Quality Model output
  - High spatial and temporal resolution, but an “estimate” of the truth - i.e., less reliable.
  - Scientifically based estimate of spatial and temporal monitoring gaps (e.g., in rural areas)
- Combining sources
  - More accurate predictions
  - Take advantage of strengths of each source
  - Better estimates of uncertainties

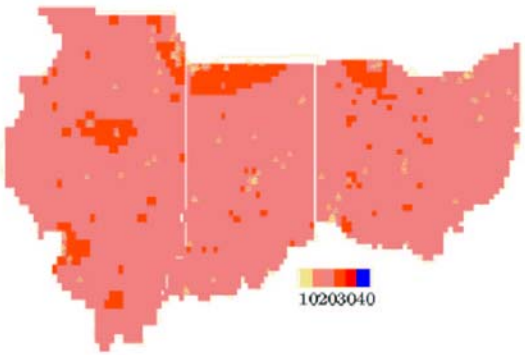
Combining Sources Visual Demonstration

Future Research

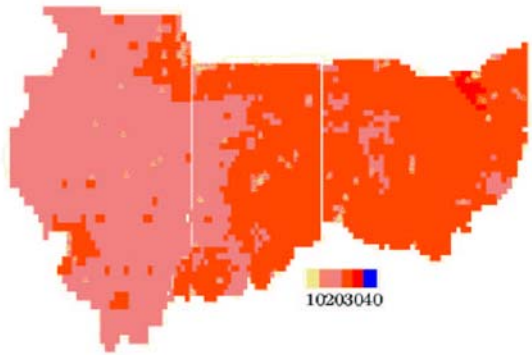
- Develop space-time models which combine data sources to provide improved predictions (and error estimates).
- Explore the use of such models for establishing relationships between air quality and public health.

Example of Temporal Variability

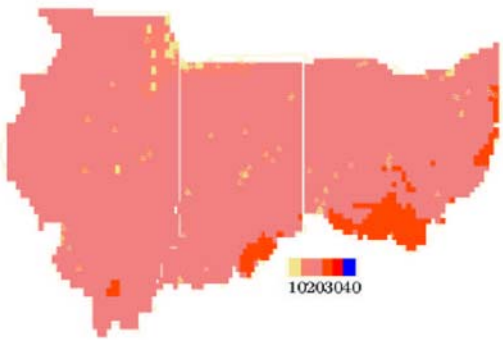
predictions for week 7: February 12–18



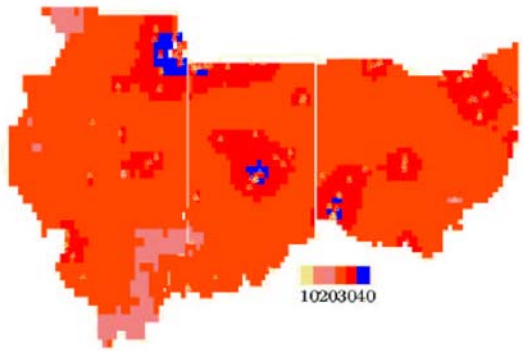
predictions for week 20: May 14–21



predictions for week 33: August 13–20



predictions for week 46: November 11–17



Summary

- EPA develops air quality models for a variety of uses
  - The CMAQ model provides state-of-science modeling capabilities
  - Air Quality Forecasting applications will provide routinely available air quality data of potential value for Environmental Public Health Tracking
- Emerging statistical approaches provide an opportunity to improve spatial and temporal coverage
  - Potential value for Environmental Public Health Tracking