National Air Quality Forecast Capability:

First Steps Toward Implementation

May 7, 2003

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Office of Science and Technology

Outline

- Background, Vision
- Some Basics on Air Quality Prediction
- Planned Capabilities
  - *Initial Operating Capability*
  - *NOAA and EPA Responsibilities*
  - *National AQ Forecasting*
- Path to Implementation
- May 2003 Status

National Air Quality Forecasting
Background

Congressional interest

- **H.R. 4 Energy Policy Act of 2002 (Senate Amendment)**
  S. 517, SA 1383, Forecasts and Warnings:

  "The Secretary of Commerce, through the Administrator of the National Oceanic and Atmospheric Administration, shall, in order of priority as listed in section (c) establish a program to provide operational air quality forecasts and warnings for specific regions of the United States…"

Constituent interest

- **AQ managers, public health officials, private weather sector partners urge NOAA to provide AQ forecasts**

Science is mature

- **Ozone forecast models demonstrated in lab -- others in development**
- **Other nations (Canada, Australia) have existing AQ forecast capability**

National Air Quality Forecasting

Vision and Strategy

Vision

National Air Quality Forecast System which provides the US with ozone, particulate matter and other pollutant forecasts with enough accuracy and advance notice to take action to prevent or reduce adverse effects

Strategy

Work with EPA, State and Local Air Quality agencies and private sector to develop end-to-end air quality forecast capability for the Nation

National Air Quality Forecasting
Planned Capabilities

Initial: 1-day forecasts of ozone (O_3)

- *Develop and validate in Northeastern US within 2 years*
- *Deploy Nationwide within 5 years*

Intermediate (5-7 years):

- *Develop and deploy capability to forecast particulate matter (PM) concentration*
  - Particulate size $\leq$ 2.5 microns

Longer range (within 10 years):

- *Extend air quality forecast range to 48-72 hours*
- *Include broader range of significant pollutants*

Air Quality Forecasting

Basic considerations for predicting air pollution

How it forms

Physical and chemical processes

When/where it forms

Climatological record, emissions inventory

How weather affects it

Key meteorological and air quality interactions for generating and transporting

Air Quality Forecasting

Basic considerations for predicting Ground-level Ozone concentration

Simplified chemistry

UV radiation (hν), acting on atmospheric NO_2 creates ozone (O_3):

$$NO_2 + h\nu \rightarrow NO + O$$

$$O + O_2 \rightarrow O_3$$

But ozone is also destroyed (titrated) if NO is still present:

$$O_3 + NO \rightarrow NO_2 + O_2$$

Why does O_3 build up? If volatile organic compounds (VOCs) are also present, NO is consumed by other reactions and is not available to titrate the O_3 :

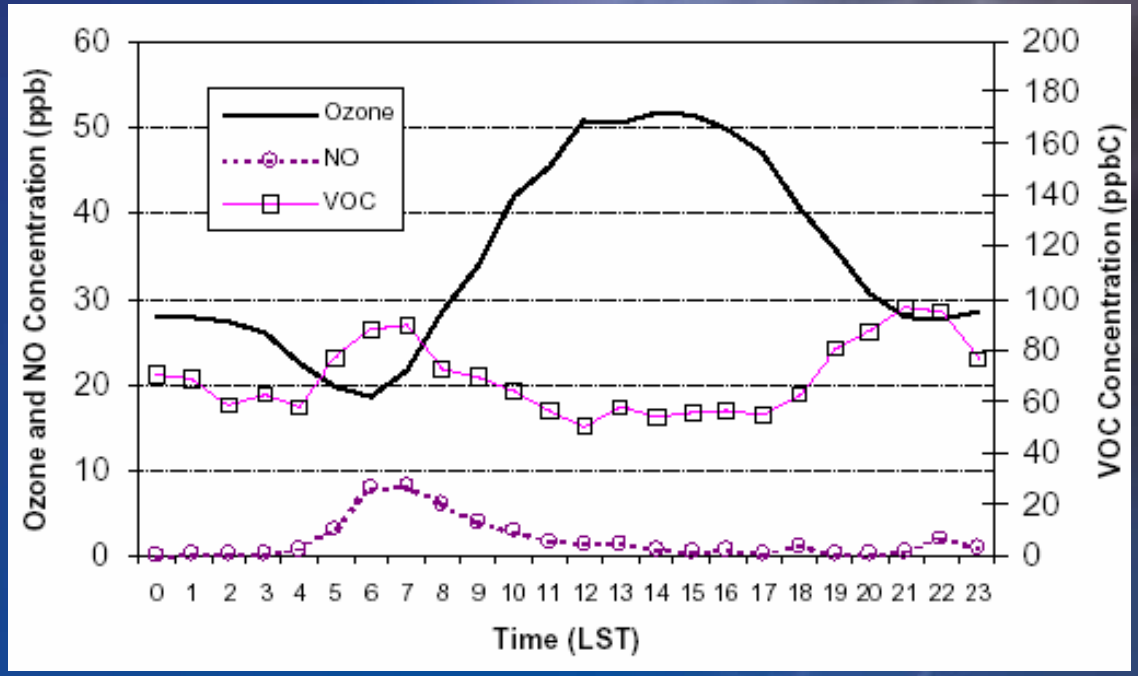
$$VOC + NO \rightarrow NO_2 + \text{other products}$$

Air Quality Forecasting
Ozone Precursor Emissions

When it forms

Average diurnal profile (Lynn, MA, August 1995.) Source: EPA

NOx and VOC sources: both static and mobile



Where it forms

Anthropogenic: Predominantly urban areas for both VOC and NO_x

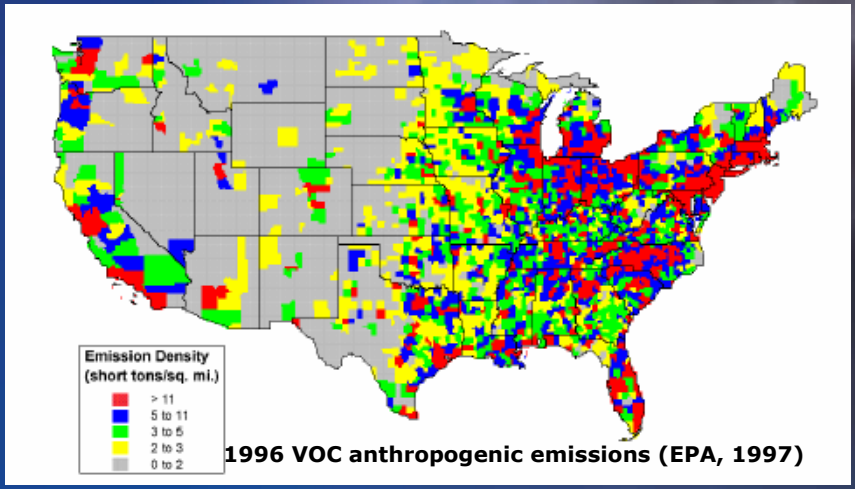
Biogenic: VOCs in forested areas; NO_x in agricultural areas

Air Quality Forecasting

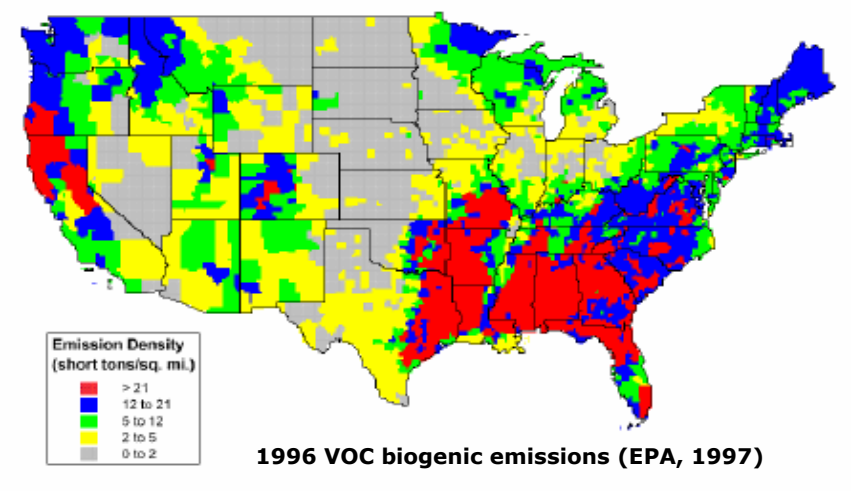
Ozone Precursor Emissions

Where it forms

EPA National Emissions Inventory



1996 VOC anthropogenic emissions (EPA, 1997)



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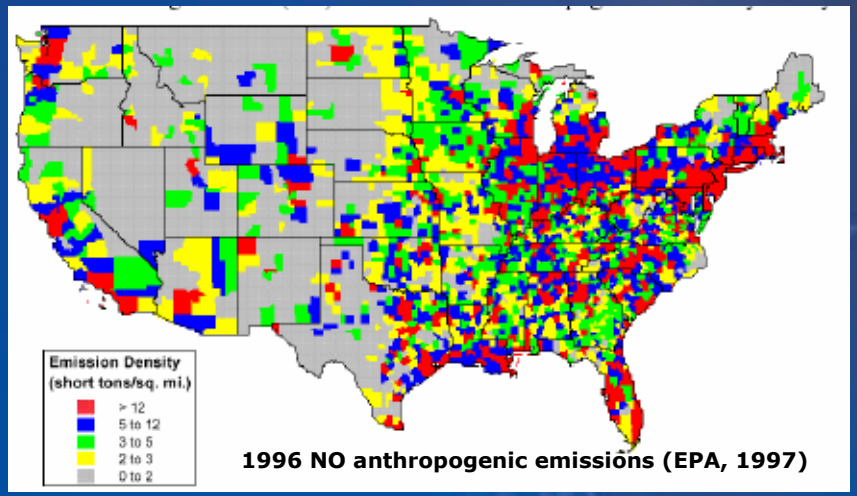


1996 NO anthropogenic emissions (EPA, 1997)

Air Quality Forecasting

Basic considerations for predicting air pollution

Atmospheric Transport/Diffusion:

Airborne pollutants/precursors (whether reactive or inert) are dispersed in the atmosphere, by both advection and diffusion.

Advection:

Wind-driven.

Comprehensive models include time-varying 3-D windfields, turbulence, dry and wet deposition, resuspension

Diffusion:

Thermally, dynamically and chemically driven.

Comprehensive models include energetics/ dynamics of several diffusion mechanisms: molecular (Brownian), eddy diffusion (turbulence-driven), chemical (concentration gradient- driven)

Air Quality Forecasting

Basic considerations for predicting air pollution

Key weather parameters:

Sunlight, Temperature, Vertical temperature structure, Surface winds, Aloft winds

Some key synoptic features:

Ridge – high pressure	*High Ozone*
Ridge – back side of high	*High Ozone*
Trough – cold front	*Lower Ozone*

Some Planetary Boundary Layer (PBL) complications:

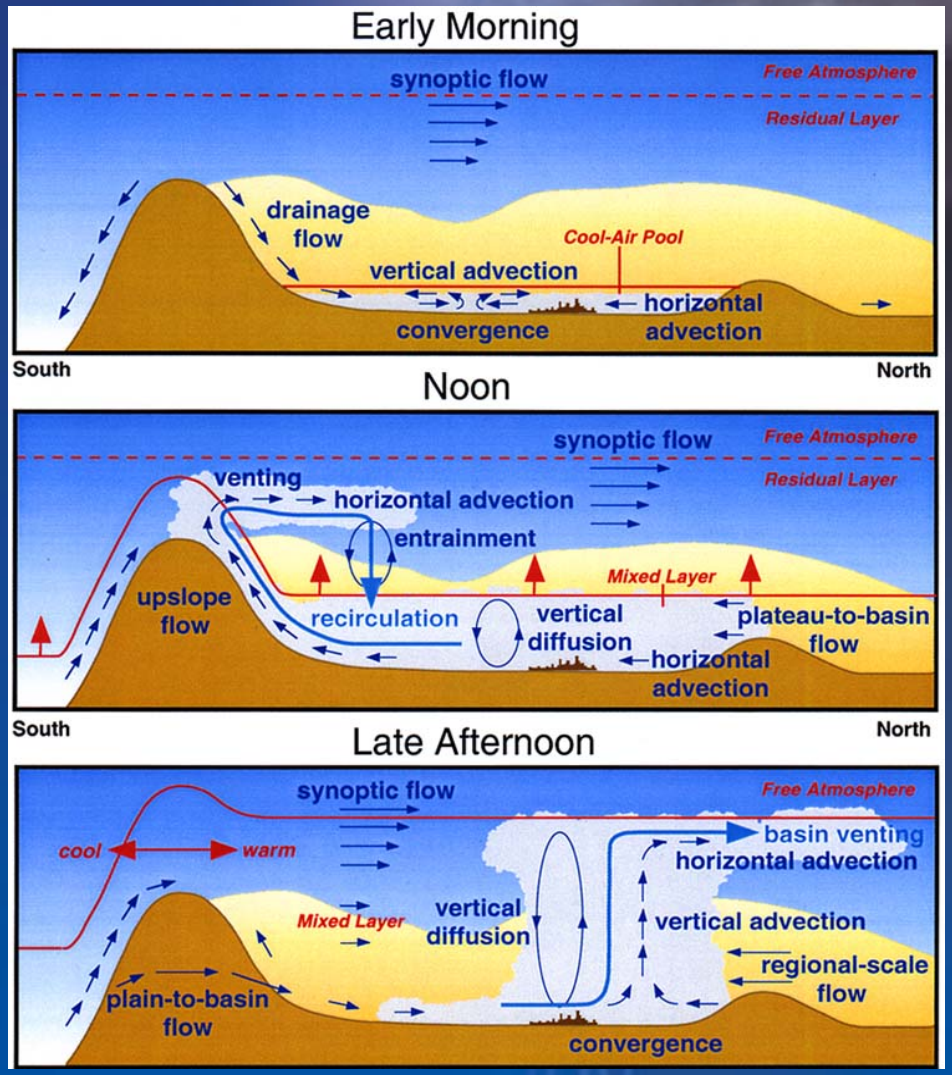
Terrain-forced flow, Land-sea breezes, Low-level jets, PBL height, Turbulent mixing, PBL Cloud structure and processes

Air Quality Forecasting

Basic considerations for predicting air pollution

Putting it all together

- Emissions Sources
- Transport/ Dispersion
- Weather



Jerome Fast, PNNL/ USDOE; http://www.pnl.gov/atmos_science/as_meso5.html

National Air Quality Forecast Capability

Major Components

NWP Model:	***NOAA/NWS***
AQF Model:	***NOAA/OAR*** ***EPA/ORD***
Emissions Inventory: **National Emissions**	***EPA/OAQPS***
Supporting Comms/IT:	***NOAA/NWS*** ***EPA/OAQPS***

National Air Quality Forecast Capability

Major Components: IOC

NWP Model

Eta-12

NOAA/NWS

Weather Observations

AQ Module:
Emissions Preprocessor

PREMAQ

NOAA/OAR and EPA/ORD

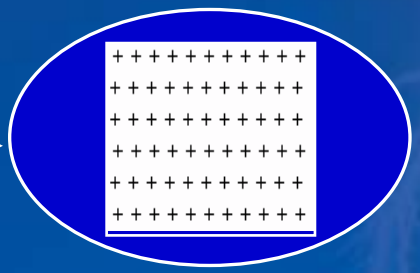
EPA's National Emissions Inventory:

EPA/OAQPS

AQ Module:
Air Quality Reactive Transport

CMAQ

NOAA/OAR and EPA/ORD



IT /Comms

NOAA/NWS

and

EPA/OAQPS

National Air Quality Forecasting
Initial Operational System

Linked numerical prediction system

Operationally integrated on NCEP's supercomputer :
- *NCEP mesoscale NWP: Eta-12*
- *NOAA/EPA community model for AQ: CMAQ*

Observational Input: NWS weather observations; EPA emissions inventory

Gridded forecast guidance products

Delivered to NWS Telecommunications Gateway and EPA for users to pull

Verification basis

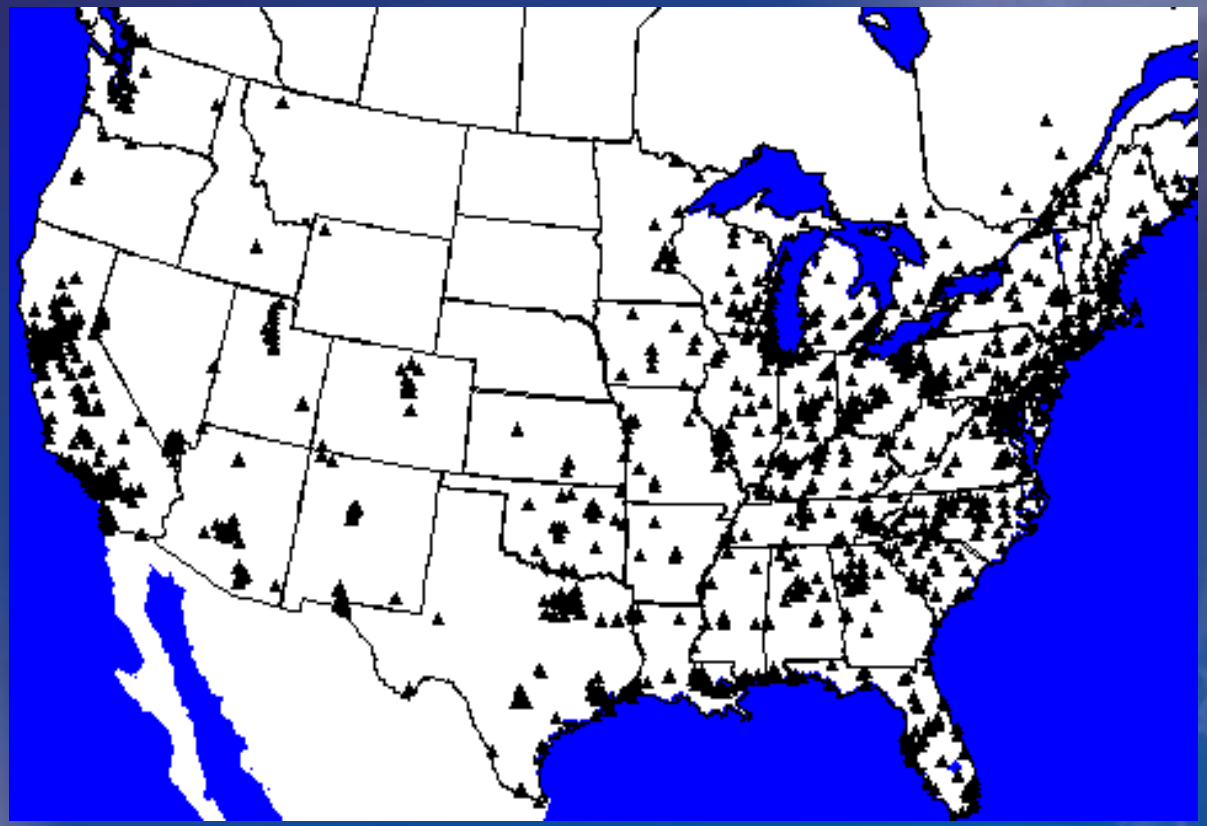
EPA ground-level ozone observations

Customer outreach/feedback

State and Local AQ forecasters coordinated with EPA

Public and Private Sector AQ constituents

EPA's Static Ozone Monitors



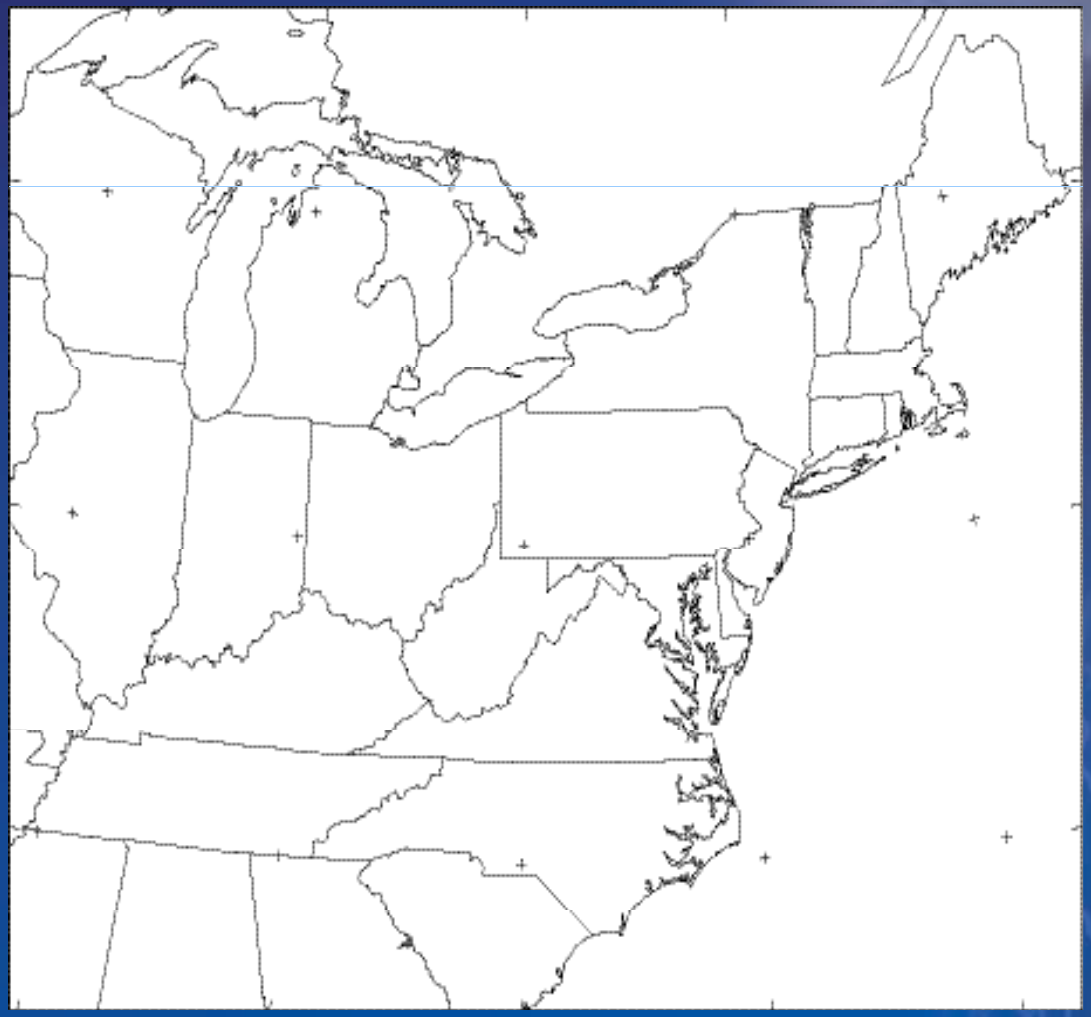
Initial Operating Capability (IOC)

1-Day ozone forecasts: Target deployment 9/15/04 for NE US

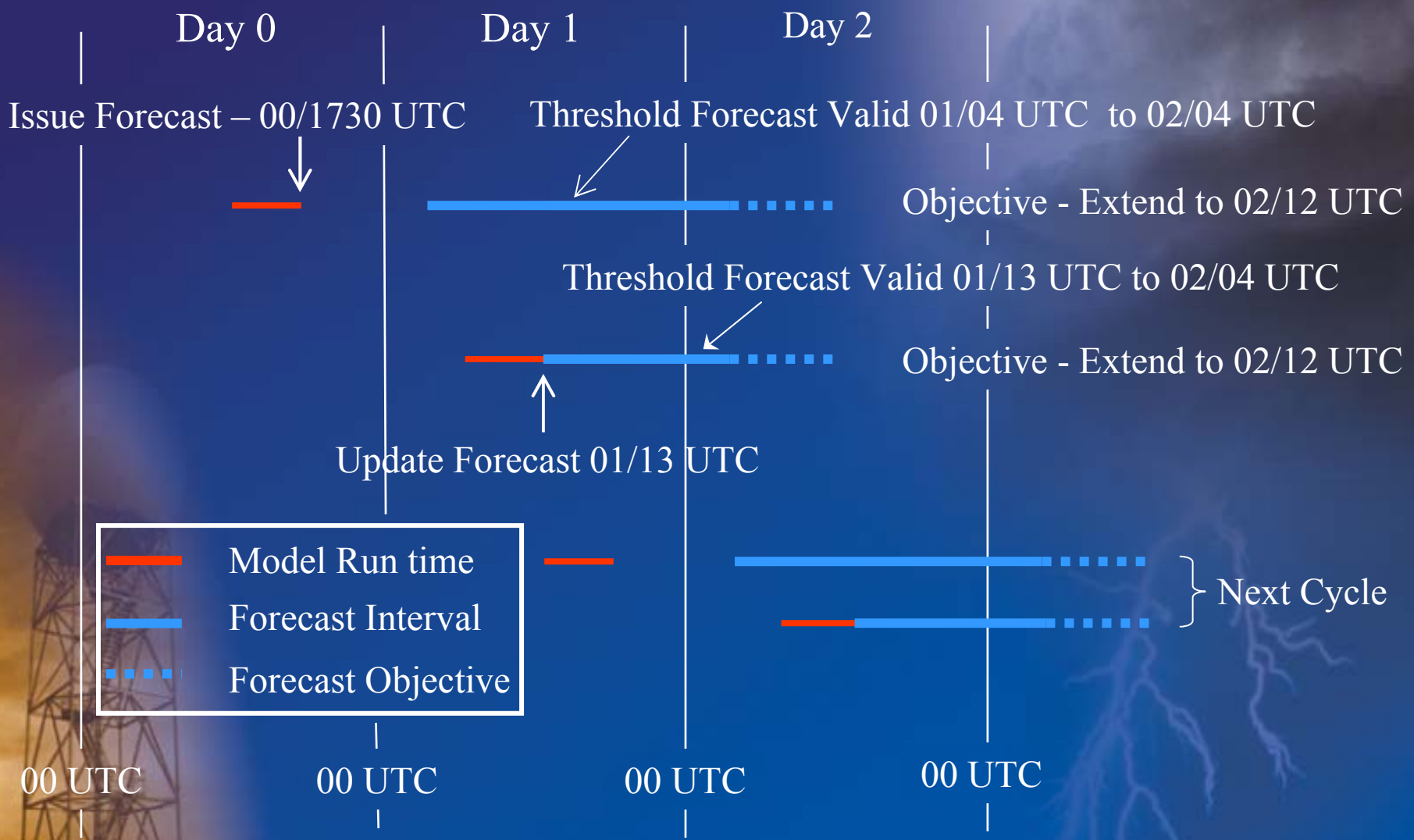
- *1-hr and 8-hr avg O_3 levels: categories for EPA and in parts per billion (ppb)*
- *Threshold: Surface level. Objective: 2 vertical levels, TBD*
- *Delivered 2X daily*
  - Primary forecasts for following day: delivered by 1730 UTC
    - *valid for 24 hours through 4 UTC, day 3*
  - Update forecasts for current day: delivered by 1300 UTC
    - *valid for 15 hours through 4 UTC, day 2*
  - Threshold: through 4 UTC. Objective: through 12UTC

Proposed Initial Operational Domain

December 2002



IOC Production Cycle



IOC: NOAA's IT Links

AQ Data from S/L Agencies

EPA Data Management Center

O_3 Movies/ Forecasts

NOAA National Center for Environmental Prediction

Weather Obs

EPA Emissions Inventory

Commercial Weather Providers

Data "pull" - - ->
Data "push" ——>

Predicted Pollutant Concentration Fields

Media

City-specific AQI forecasts

State/Local Air Agencies

Public

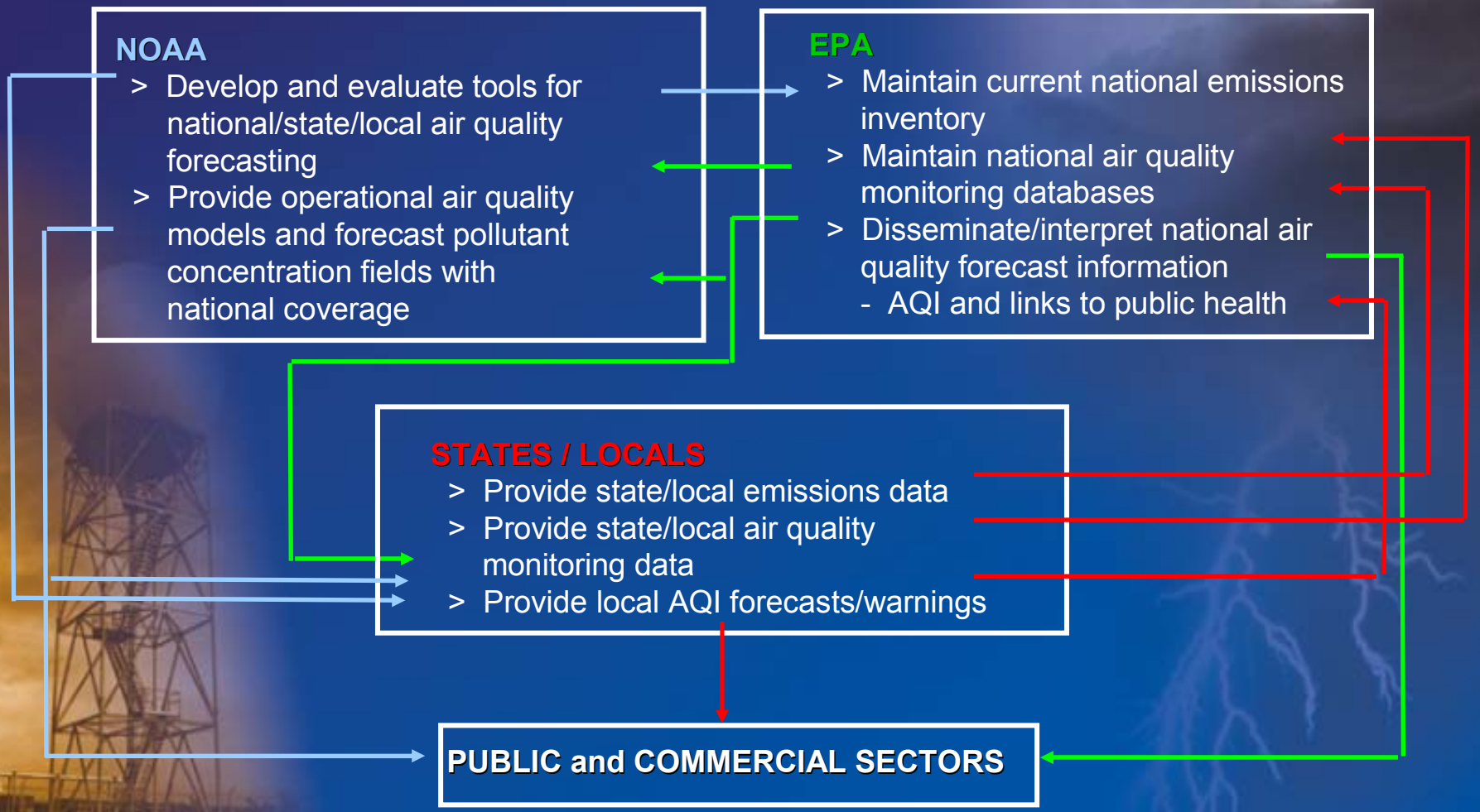
EPA's Role: IOC

- Compile, maintain, and provide current National Emissions Inventory to NOAA
  - *Updates approx every 3 years*
  - *Consists of S/L and federal inventories; including fixed point/area and mobile sources, biogenic sources*
- Compile and maintain National AQ Databases
  - *Includes ozone observations*
  - *Current data (ozone and other precursors) delivered to NOAA within (2) days*
- Compile databases for S/L AQ Forecasts
- Make AQ Forecasts available to States/Locals and private sector
  - *Produce AQI and links to public health information*
- Provide AQ forecasting support for all products
  - *Staffs required customer help desk*

NOAA's Role: IOC

- Develop and integrate tools for weather and AQ forecasting
  - *Eta/WRF*
  - *CMAQ*
  - *Verification and Archiving*
  - *Underlying IT for NOAA side of interface*
- System operations: AQ prediction models driven by NCEP weather prediction models
- Provide AQF guidance products to EPA twice daily
- Provide AQF guidance on NWS Gateway servers
  - *available for public and private sector users to "pull"*
- Verification
- Archiving
- Customer Outreach/feedback

Partnerships in Air Quality Forecasting



IOC: Success Criteria

Forecast Performance Accuracy:

Threshold target: critical level "hit accuracy" predicted on 90% of days

- Propose: Objective: critical level "hit accuracy" predicted on 93% of days
- Persistence forecast "hit accuracies" are ~85%

On-time delivery

Forecasts provided on schedule: at least XX%

- Propose: 95%

Initial Operating Capability

Responsibilities and Schedule: Development, Testing, Integration

Task	Lead	Dates	Status
Model Development	NOAA/NWS and NOAA/EPA/ORD	09/02 – 05/03	G
Acquire IT Resources	NOAA/NWS	02/03 – 09/03	Y
Model Integration	NOAA/NWS and NOAA/EPA/ORD	04/03-06/03	G
Model Testing	NOAA/NWS	06/03 – 09/04	G
Initial: Test products to focus group		06/03 – 09/03	G
Final go/no go decision		09/04	G
Develop/implement required verification	NOAA/NWS and NOAA/EPA/ORD	10/02 – 06/04	G
Develop required product archiving	NOAA/NWS	04/03 -- 09/04	G

Key: Complete | On schedule | At risk | Remedial Action Required

National Air Quality Forecast Capability

Beyond IOC: Goals/Targets to FY 12

- Near-Term: Initial Operating Capability (IOC)
- Mid-Term (YR 5): Initiate nationwide forecasting
- Longer-term (YR 10): Enhanced capabilities

Proposed Products	*2-year Target*	*5-year Target*	*10-year Target*
Ozone forecasts	IOC 1-day forecasts: Northeast US	1-day forecasts for the Nation	Extend to day 2 and beyond
PM	R&D	1-day forecasts: Northeast US	1-day forecasts for the Nation
Extend to other pollutants		R&D	1-day forecasts

National Air Quality Forecast Capability

Science Challenges for Reaching Operational Goals/Targets to FY 12

USWRP Workshop on AQF, Houston TX, 4/29/03 – 5/01/03. Session on operational AQ forecasting* identified high-impact areas for operations over next decade.

Components	Lead contributor
• Improving Emissions Inventories	Daewon Byun
• Data assimilation of realtime air chemistry observations	Joseph Vaughan
• Weather and AQ model improvements: Ryan	Nelson Seaman/ Bill
• Statistical and ensemble approaches	Jeff McQueen
• Coupled AQ and weather prediction methods	Nelson Seaman
• Forecasting particulates	Paul Makar
• Algorithm design and efficiency – specific to chem	Paul Makar
• Forecasting other pollutants: beyond ozone and PM	Paul Makar (summarizing group comments)
• Forecast products: improving effectiveness	Bill Ryan

* (Appleby and Davidson, co-chairs)

National Air Quality Forecast Capability

Science Challenges for Reaching Operational Goals/Targets to FY 12

USWRP Workshop on AQF, Houston TX, 4/29/03 – 5/01/03 prioritized research needed to address anticipated needs in operational forecasting over next decade

Most Urgent Science Questions for AQF:

- **Investigate optimal integrated observational basis for chemical data assimilation and develop chemical DA methods**
- **Develop 3-D chemistry and aerosol observing systems technologies with the accuracy, density, timeliness, and cost effectiveness to support operational needs**
- **Demonstrate value added by coupled (on-line) modeling**

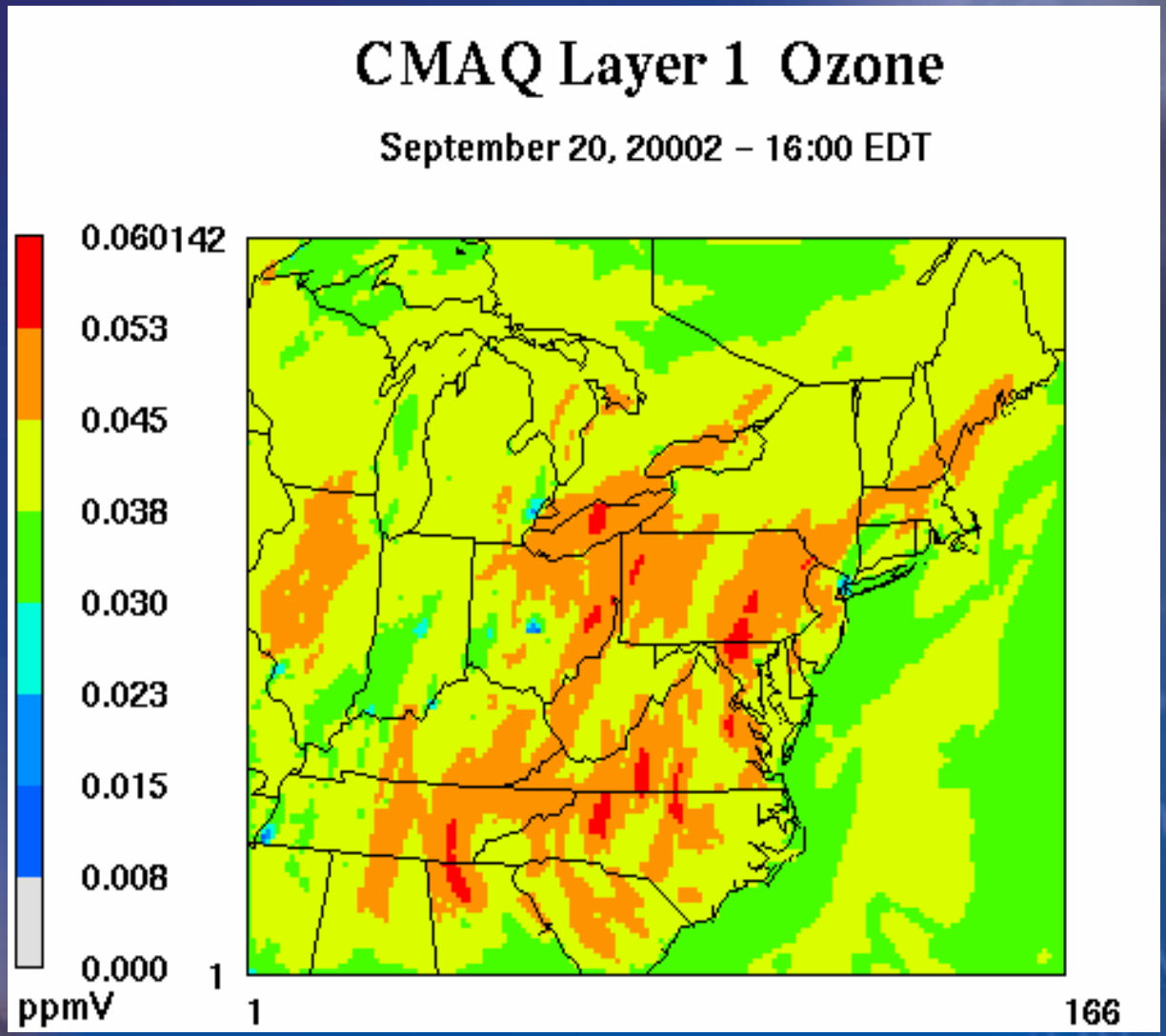
Specific to Forecasting Particulates:

- **Develop computationally efficient chemical reaction modules. Inorganic particle chemistry: esp SO4, NO3, NH4, Na, Cl, Ca. Organic: most poorly understood. Include primary C emissions rather than total PM2.5, PM10 Secondary organics parameterizations for accuracy/efficiency.**
- **Evaluate of particle size parameterizations (distribution function vs. discrete size range) needed in dynamics simulations of growth/removal of airborne particulates**
- **Improve primary PM emissions inventory : measure chemical speciation**
- **Evaluate benefit/develop methods to incorporate size-resolved particle chemistry.**
- **Evaluate accuracy improvements from including organic/Inorganic Interactions**

Status: May 2003

- Ozone forecasting: NOAA & EPA Planning for IOC in NE US
  - *Models being adapted and integrated for linked operations at NCEP*
  - *Necessary HPCC Hardware acquisition in progress*
  - *IT architecture being developed for testing/ evaluation of AQF model system in 2003*
  - *Customer focus group identified to provide feedback on Summer 2003 testing*
  - *RTT&E in Summer 2004 - - >> commissioning by September, 2004*
- Extension to Nationwide within five years
- Extension to PM initiated within five years, resources permitting
- EPA-NOAA Partnership: Essential for AQF
  - *MOU and MOA signed by Dep Sec Bodman and Adminstrator Whitman*
    - MOU renews interagency cooperation and collaboration in research
    - More specific MOA lists responsibilities/deliverables for Air Quality Forecasting

Test Display: Gridded Forecast Guidance



National Air Quality Forecast Capability

Implementation Team

Special Thanks To:

Nelson Seaman	Science Advisor
Ken Schere and RTP research group at NOAA/EPA/ORD	CMAQ Adapation
Paul Stokols	Services Lead
Jeff McQueen, Pius Lee, John Ward et al. at NWS/NCEP	Model Adaptation/ Integration at NCEP
Ken Carey	AQF Program Administration Support
Pai-Yei Whung	NOAA/OAR AQF Research Lead
Fred Branski, Allen Darling et al. at NWS/TOC	NWS IT/Comms Infrastructure
Chet Wayland, Tim Dye et al. at EPA/Airnow	EPA-NOAA Coordination
Jon Adkins	IT Architecture Support
Wil Shaffer, Paul Dallavalle et al. at OST/MDL and Brian Eder, et al. at NOAA/EPA/ORD	Verification Statistics