



# **National Air Quality Forecasting Capability: Initial Operational Capability February 14, 2005**

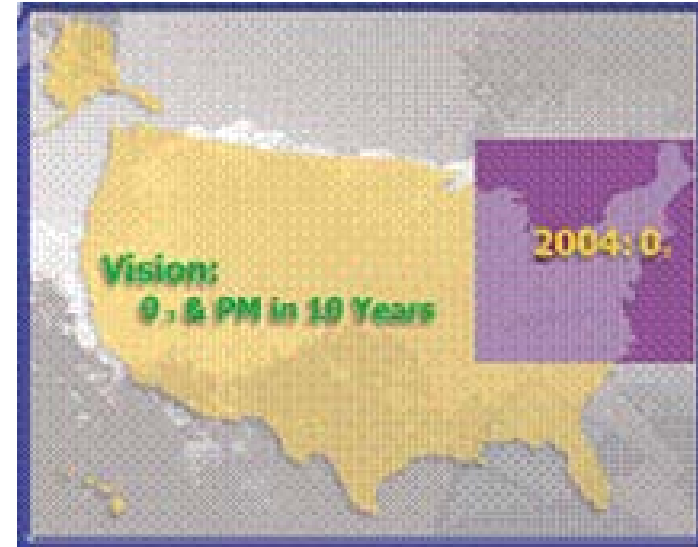
**PM Davidson<sup>1</sup>, N Seaman<sup>1</sup>, J McQueen<sup>1</sup>, R Mathur<sup>2</sup>,  
and RA Wayland<sup>3</sup>**

- 1) NOAA National Weather Service**
- 2) NOAA Research**
- 3) EPA AirNOW**

# National Air Quality Forecasting *Planned Capabilities*

## ***Current: 1-day forecast guidance for ozone***

- Developed and deployed initially for Northeastern US, September 2004
- Deploy Nationwide by 2009



## ***Intermediate (5-7 years):***

- Develop and test capability to forecast particulate matter 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

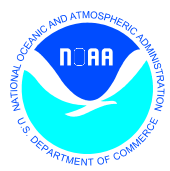


# Initial Operating Capability for NAQFC: Transitioning Research to Operations



<b>Task</b>	<b>Lead</b>	<b>Dates</b>	
<i>Plan operational production of AQ forecast guidance</i>	<b>NWS</b>	<b>10/02– 2/03</b>	
<i>Develop end-to-end integrated weather-air quality forecast capability</i>	<b>NWS</b>	<b>3/03 – 6/04</b>	
<i>Conduct real-time developmental tests</i>	<b>NWS</b>	<b>6/03-9/03</b>	
<i>Analyze 2003 system performance; identify needed upgrades</i>	<b>OAR</b>	<b>9/03 – 10/03</b>	
<i>Develop, integrate and test prioritized upgrades</i>	<b>OAR,NWS</b>	<b>10/03 – 6/04</b>	
<i>Conduct experimental (pre-deployment) real-time testing</i>	<b>NWS</b>	<b>6/04 – 9/04</b>	
<i>Operational readiness review of experimental tests: objective verif., subjective, production criteria</i>	<b>NWS</b>	<b>9/04</b>	
<b><i>Decision to implement</i></b>	<b>NWS AA</b>	<b>9/3/04</b>	

<b>Key</b>	<b>Complete</b>	<b>On schedule</b>	<b>At risk</b>	<b>Remedial Action Required</b>
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# National Air Quality Forecast Capability

## *Initial Operational Capability*



### ***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 2x daily

### ***Verification basis***

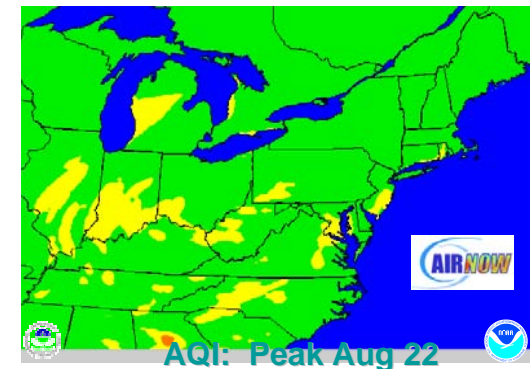
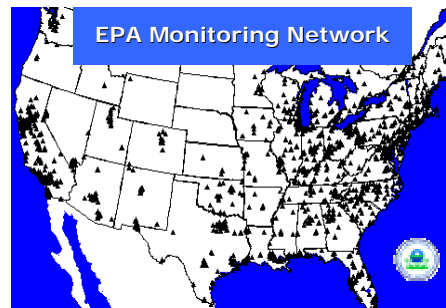
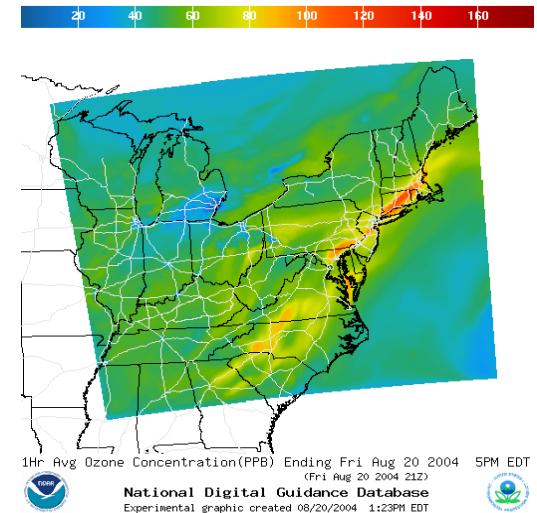
EPA ground-level ozone observations

### ***Customer outreach/feedback***

NCEP mesoscale NWP: Eta-12

State & Local AQ forecasters coordinated with EPA

Public and Private Sector AQ constituents





# Initial Operating Capability: Operational Readiness Criteria Summary



<b>Criterion</b>	<b>Lead</b>	<b>Metric</b>	<b>Dates</b>	<b>Status 9/04</b>
<b>Objective Evaluation: Accuracy</b>	<b>NCEP, OAR</b>	<b>&gt; 90 %</b>	<b>6/1/04 – 8/15/04</b>	<b>C</b>
<b>Subjective Feedback</b>	<b>OCWWS</b>	<b>Positive on balance</b>	<b>6/03 – 8/04</b>	<b>C</b>
<b>Production Readiness</b>	<b>OCIO, NCEP</b>			<b>C</b>
<b>On-time delivery</b>		<b>&gt; 95 %</b>	<b>6/1/04 – 8/15/04</b>	<b>C</b>
<b>Back-up</b>		<b>In place</b>	<b>6/1/04</b>	<b>C</b>
<b>Data retention</b>		<b>In place</b>	<b>6/1/04</b>	<b>C</b>
<b>Near-real time verification</b>	<b>NCEP</b>	<b>In place</b>	<b>6/1/04</b>	<b>C</b>
<b>Decision to implement</b>	<b>NWS Director</b>		<b>9/3/04</b>	<b>C</b>

<b>Key</b>	<b>Complete</b>	<b>On schedule</b>	<b>At risk</b>	<b>Remedial Action Required</b>
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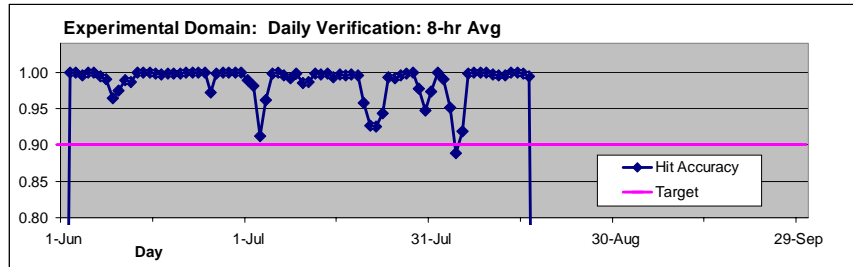
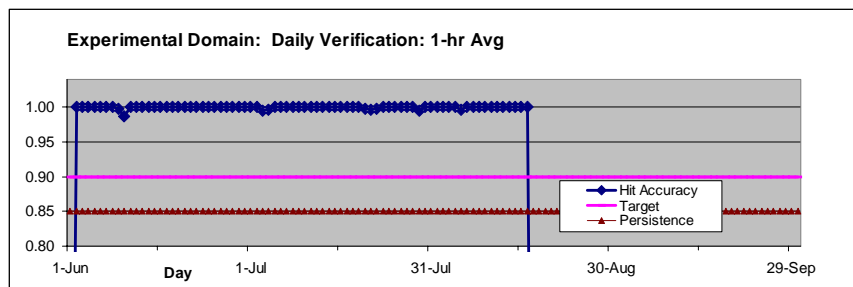
# Objective Verification (NCEP)

<b>Criterion</b>	<b>Metric</b>	<b>Dates</b>	<b>Status</b>
<b>Objective Evaluation: Accuracy</b>	<p><b>Correctly predict exceedance and non-exceedance of ozone concentration threshold metrics, during the 24-h valid forecast period, on 90% or more days</b></p> <p><b>Threshold metrics:</b></p> <p><b>1-hr avg &gt; 124 ppb</b></p> <p><b>8-hr avg &gt; 84 ppb</b></p>	<b>6/1/04 – 8/15/04</b>	C

## Summary Performance:

**June 1- Aug 15, 2004**

- Exceeds target
- Reflects clean conditions



# Objective Verification: (NCEP)

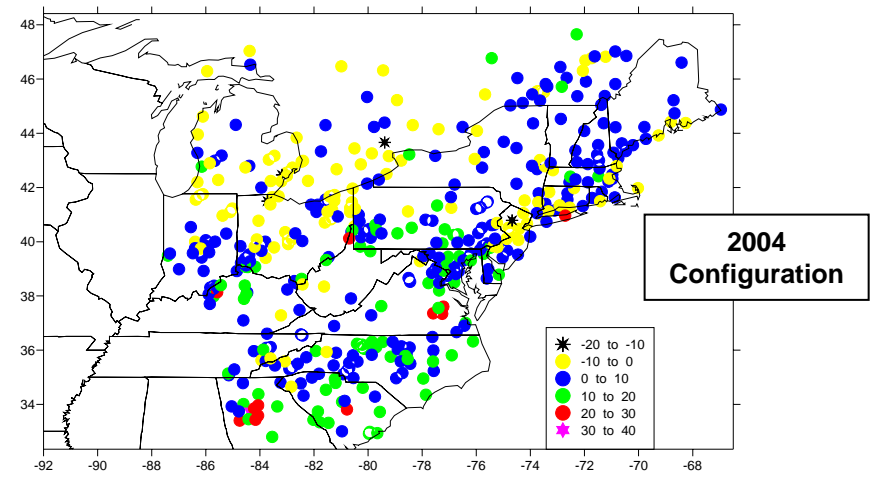
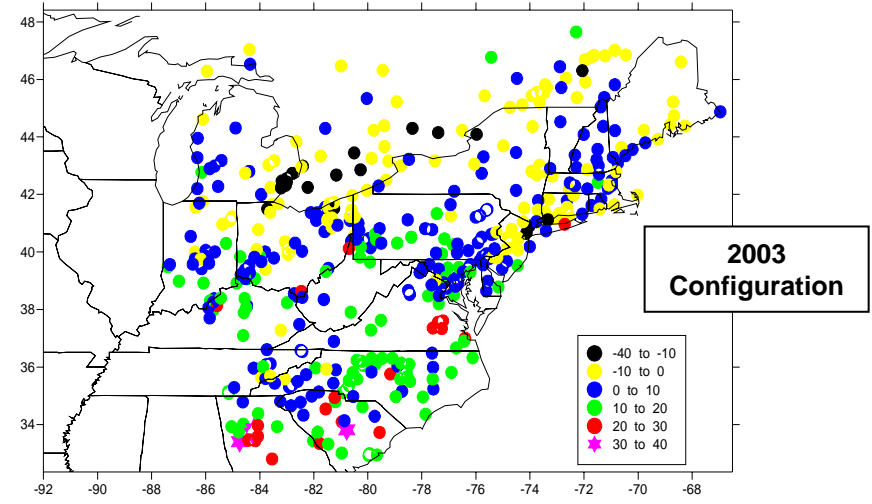
## *Improved Performance with 2004 Model Upgrades*

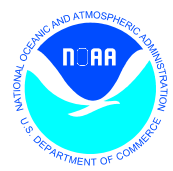
- Mean daytime bias reduced from ~17 to 5 ppb
- Mean daytime rmse reduced from 22.8 to 14.5 ppb
- Comparison shown: 2003 Aug 12-19; Bias in max 1-hr values

Mean bias:

16.0 ppb (2003 model configuration)

4.7 ppb (2004 model configuration)





# Objective Verification (NCEP) *Overall Performance - Summer 2004*

## ***Exceedance predictions***

- Exceed target

## ***Hourly predictions:***

- Over IOC domain (NE US) in 2004, daytime overprediction bias: ~ 8 ppb
  - *Nighttime overprediction bias larger than daytime; larger nighttime errors in southern areas*
    - Nighttime errors don't impact forecasts for elevated ozone; overnight ozone values are low

## ***Timing and Location of high ozone episodes***

- Generally well represented





# Subjective Feedback (OCWWS)



<b>Criterion</b>	<b>Metric</b>	<b>Dates</b>	<b>Status</b>
<b>Subjective Feedback</b>	<b>External feedback from State/Local AQ forecasters support product as helpful.</b>  <b>Other feedback: internal, constituent, general public: On Balance, positive</b>	<b>6/03 – 8/04</b>	<b>C</b>

## Feedback Sources:

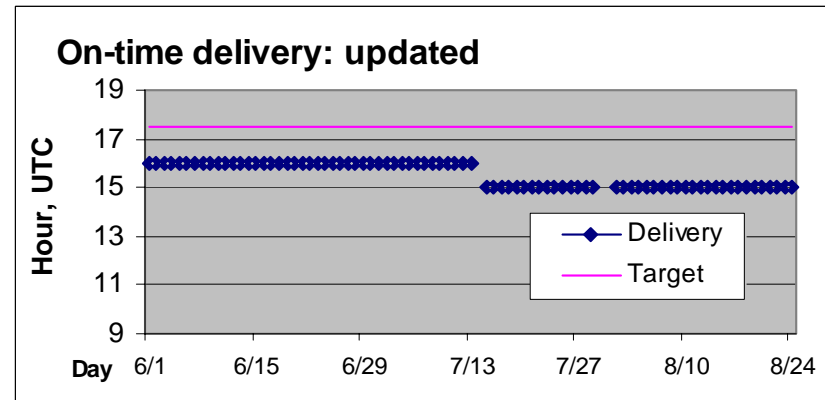
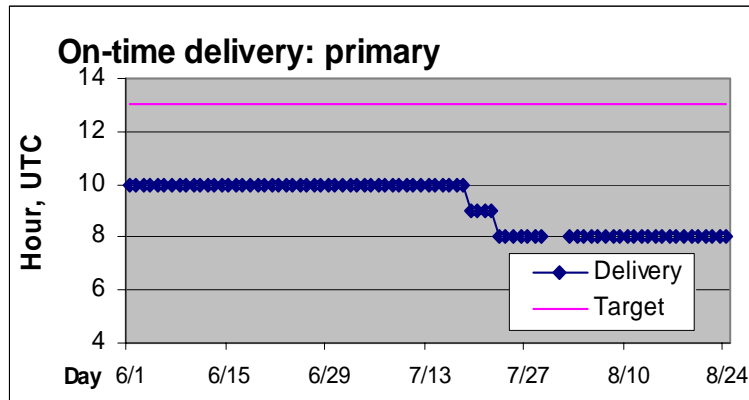
- **Constituent group**
- **State and Local AQ forecasters**
  - *comments, statement of need*
- **Other responses/comments on experimental products**

# Production Readiness (OCIO)

## *On-time delivery*

### **–On-time Delivery of Guidance and Observations:**

- *Guidance delivered to TOC FTP server on time*



- *EPA BUFR ozone observations delivered on TOC/RTP T1 directly to NWSTG; routinely switched through NWSTG to NCEP within 5 minutes of receipt*

### **–IT infrastructure Back-up:**

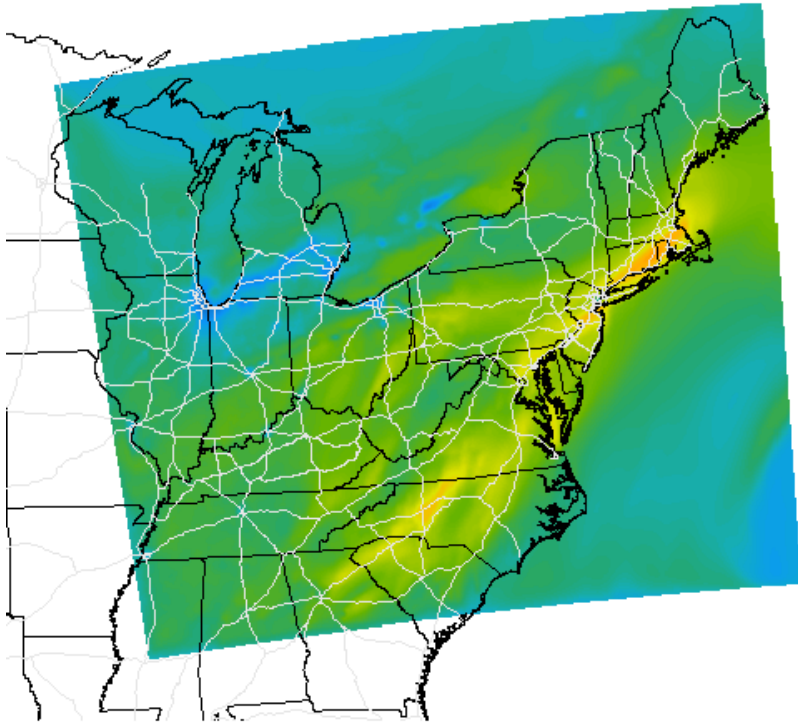
- *CCS fully redundant*
- *TOC systems fully redundant*
- *Redundant dual-path CCS-to-TOC ATM circuit, TOC-to-RTP*
- *AIRNOW T1 link contracted at 99.99% availability*



# Sample AQ forecast guidance



[www.weather.gov/aq](http://www.weather.gov/aq)

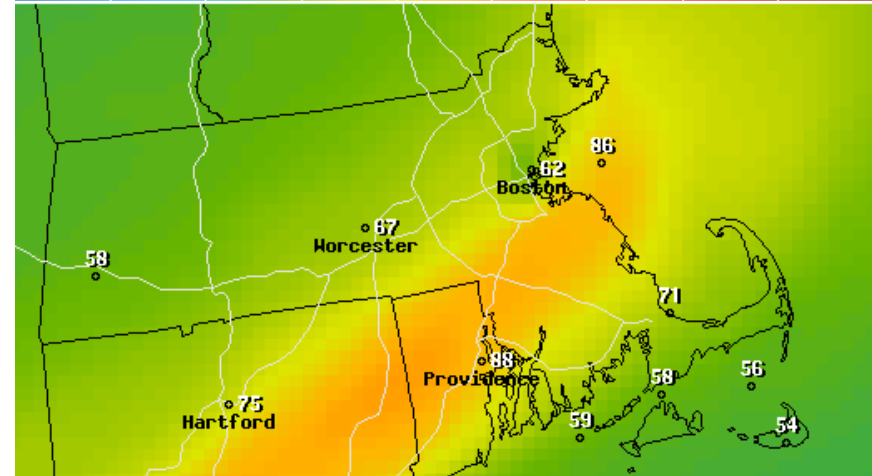


8Hr Avg Ozone Concentration(PPB) Ending Fri Aug 20 2004 7PM EDT  
(Fri Aug 20 2004 23Z)



**National Digital Guidance Database**

graphic created 08/20/2004 6:22AM EDT



8Hr Avg Ozone Concentration(PPB) Ending Fri Aug 20 2004 7PM EDT  
(Fri Aug 20 2004 23Z)



**National Digital Guidance Database**

graphic created 08/20/2004 6:24AM EDT





# Expanding the IOC

## *Development and Testing, FY05*

<b>Test</b>	<b>Start Date</b>	<b>Status</b>
<b>Ozone: Experimental</b> <i>Eastern US</i>	<b>6/1/05</b>	<b>G</b>
<b>Ozone: Developmental</b> <i>CONUS</i>	<b>6/30/05</b>	<b>G</b>
<b>Aerosols: Research Prototype</b> <i>Eastern US</i>	<b>Ongoing</b>	<b>G</b>
<b>Fire Smoke: Experimental</b> <i>CONUS + AK</i>	<b>Ongoing</b>	<b>G</b>

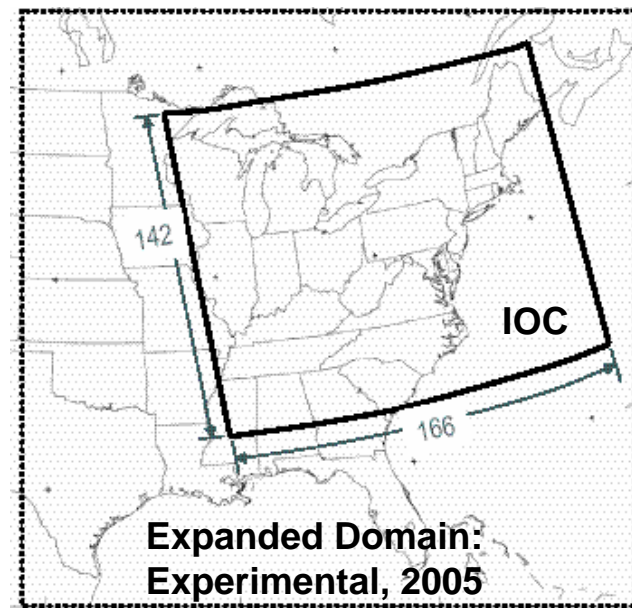
Key

<b>Complete</b>	<b>On schedule</b>	<b>At risk</b>	<b>Remedial Action Required</b>
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# Expanded Domain, Testing/Evaluation *Developmental (2004); Experimental (2005)*

- **Summer 2004: developmental testing with 2x daily production**

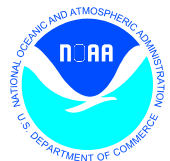
- *Domain includes SE US*
- *Results generally good; accuracy not as high*
- *Geographic differences: e.g. underprediction for Texas cities*



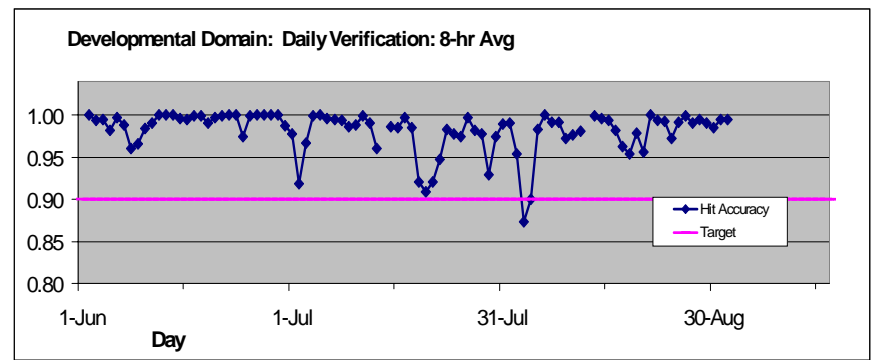
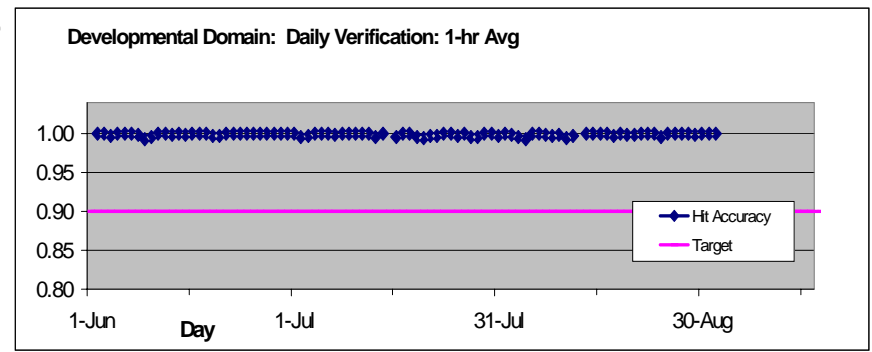
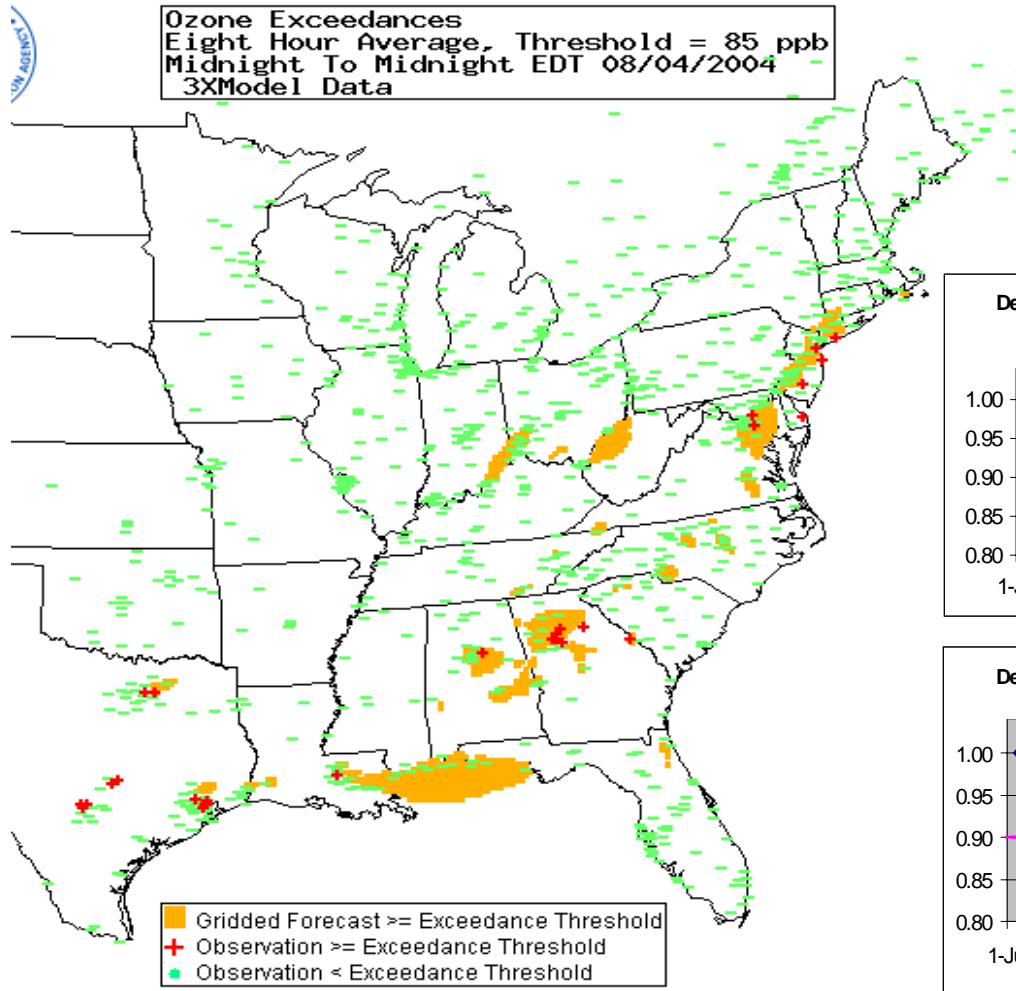
- **Evaluations/feedback from developers and Focus group of S/L AQ**

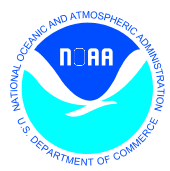
- **Developmental evaluation (2004) basis for upgrades**

- *Cloud mixing, radiation, photolysis rates*
- *Pre-deployment testing of expanded domain to begin **June, 2005***



# Expanded Domain, Development Testing: *Sample Verification, 2004*





# Expanding the IOC: 2005 Improvements



<b>Ozone testing:</b>	<b><i>Experimental (with Eta)</i></b>	<b><i>Developmental (with WRF)</i></b>
<b><i>Grid coordinates</i></b>	<b><i>interpolate to CMAQ C-grid and CMAQ <math>\sigma</math></i></b>	<b><i>common E grid; common <math>\sigma</math>-P</i></b>
<b><i>Upgrades to Eta</i></b>	<b><i>1 km NOAA landuse 2 mb top; improved precip assimilation</i></b>	
<b><i>Improved emissions</i></b>	<b><i>2005 Updates to mobile and EGU sources</i></b>	
<b><i>Photolysis</i></b>	<b><i>surface radiative flux scaling</i></b>	<b><i>surface and 3-D radiative flux</i></b>
<b><i>PBL</i></b>	<b><i>PBL height</i></b>	<b><i>Incorporate TKE/Kh</i></b>
<b><i>Clouds</i></b>		
<b><i>Phases</i></b>	<b><i>water</i></b>	<b><i>water, graupel &amp; ice</i></b>
<b><i>Mixing</i></b>	<b><i>Eta convective cloud base/top</i></b>	<b><i>WRF convective cloud base/top</i></b>
<b><i>Lateral BC (ozone)</i></b>	<b><i>GFS above 6 km; static below</i></b>	<b><i>more vertical resolution near tropopause</i></b>



# Status: February, 2005

## Current Operational Capability:

- *NE US (1x) ground-level ozone;*
- *Hour-by-hour concentrations thru midnight next-day*

## Testing Expanded Capability:

- *Developmental for Eastern US (3x); ozone.*
- *Pre-deployment testing to begin June 2005*
- *3x with Aerosols*

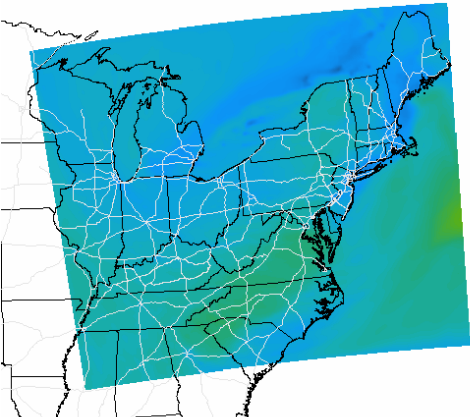
## Retrospective and real-time results improve accuracy:

- *Mean daytime bias reduced from ~17 to 5 ppb (2003 vs 2004)*
- *Mean daytime rmse reduced from 22.8 to 14.5 ppb (2003 vs 2004)*
- *Still overpredicting in daytime, poorer performance at night*

## Major improvements:

- *Eta-CMAQ linkage: T-profile; land-use. Moving to WRF*
- *Emissions updates: Mobile 6; extrapolations to current year emissions*
- *Lateral boundary conditions: GFS ozone*
- *Improvements in PBL, cloud treatment (ongoing), radiation flux*

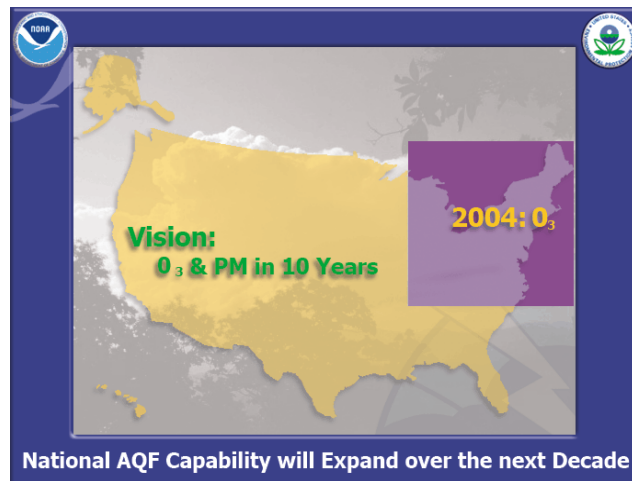




1Hr Avg Ozone Concentration(PPB) Ending Mon Dec 13 2004 1PM EST  
 (Mon Dec 13 2004 18Z)  
 National Digital Guidance Database  
 Graphic created 12/13/2004 1:22PM EST

## National Air Quality Forecast Capability:

- Improving the Basis for AQ Alerts
- AQ Information for People at Risk



National AQF Capability will Expand over the next Decade

	<b>Current AQ Alerts</b>	<b>NWS Operational Capability</b>		
		<b>Current (IOC)</b>	<b>5-Year Vision</b>	<b>10-Year Vision</b>
<b>Purpose:</b> Limit adverse effects from poor AQ, by providing:	Next-day warnings for large cities	State-of-the-science ozone forecast guidance	State-of-the-science ozone forecast guidance	State-of-the-science ozone and particulate matter forecast guidance
<b>Products for Public</b>	Daily AQ alerts; predicted interpretive AQ Index category	Hour-by-hour predictions of air pollutant concentrations in digital & graphical formats	Hour-by-hour predictions of air pollutant concentrations in digital & graphical formats	Hour-by-hour predictions of air pollutant concentrations in state-of-the-art formats
<b>Coverage</b>	Approx 300 cities	Northeast United States	Nationwide	Nationwide
<b>Pollutants Forecasted</b>	AQ Index for ozone; some cities include particulate matter	Ground-level ozone	Ground-level ozone	Ground level ozone, particulate matter, possibly others
<b>Forecast Period</b>	Next-day; also through weekends	Forecast guidance through midnight next day	Forecast guidance through midnight next day	Forecast guidance extended to 2 days or beyond
<b>Spatial Resolution</b>	Alerts are community-wide; little/no other spatial information	12 kilometer grid	5 km grid	2.5 kilometer grid
<b>Temporal Resolution</b>	Daily	1-hr and 8-hr averages each hour		