National Air Quality Forecast Capability: Expansions to Current Capabilities

2009 AIRNow Conference, Addison Texas
March 4, 2009

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Outline: National Air Quality Forecast Capability (NAQFC)

Background & Current Capabilities
Progress, 2003-2008
- – *Operational products*
- - *Experimental products*
- - *Developmental testing*

Examples of feedback from forecasters
Next Steps

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***Background
and
Current Capabilities***

National Air Quality Forecast Capability

Poor air quality responsible for losses each year in the US:

- 50,000 lives

- >$100B

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
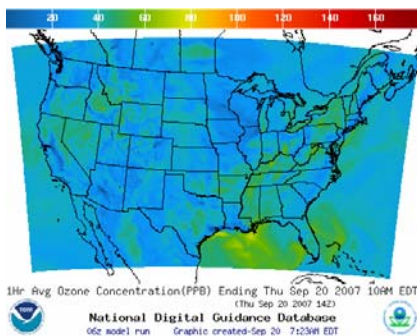
Strategy:

Work with EPA, State and Local Air Quality agencies and private sector to develop end-to-end air quality forecast capability for the Nation
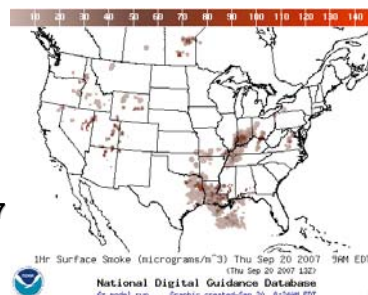
Where we are Today:
Ozone and Smoke Predictions for CONUS

www.weather.gov/aq

CONUS Ozone
Expansion Implemented September, 2007

CONUS Smoke
Implemented March, 2007

Further information: www.nws.noaa.gov/ost/air_quality

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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*
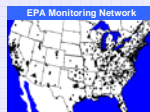- *NOAA/EPA community model for AQ: CMAQ*

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*
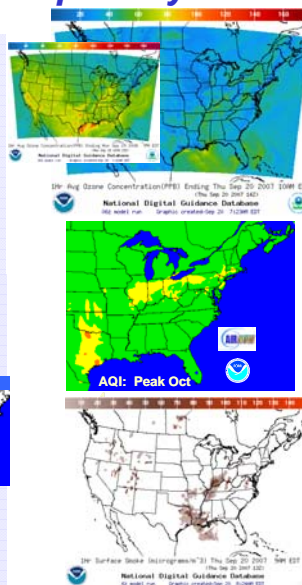- *On EPA servers*
- *Updated 2x daily*

Verification basis, near-real time:
- *Ground-level AIRNow observations*
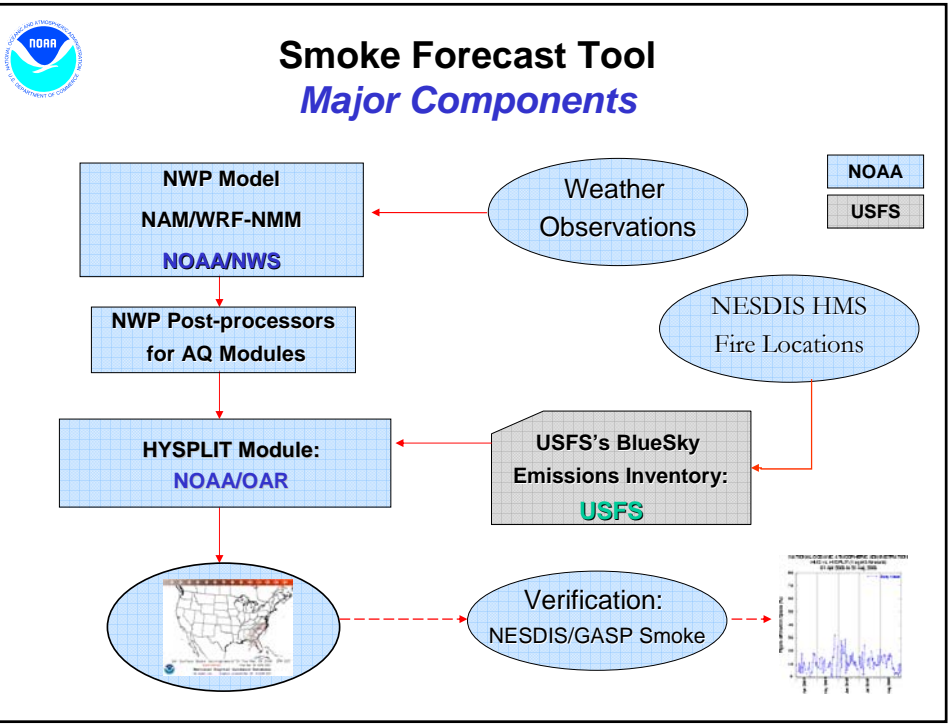- *Satellite smoke observations*

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

EPA Monitoring Network

AQI: Peak Oct

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Smoke Forecast Tool
Major Components

NOAA
USFS

NWP Model
NAM/WRF-NMM
NOAA/NWS

Weather Observations

NWP Post-processors for AQ Modules

NESDIS HMS Fire Locations

HYSPLIT Module:
NOAA/OAR

USFS's BlueSky Emissions Inventory:
USFS

Verification:
NESDIS/GASP Smoke

Smoke Prediction: Potential Life-saver

Florida, 1/09/08

- **Dense morning smoke predicted near Orlando**
- **Accident on I-4 caused 50-vehicle crash with 3 fatalities**
- **Evacuation concerns for PM exposure: senior citizen facilities**

1Hr Surface Smoke (micrograms/m^3) Wed Jan 09 2008 11AM EST
(Wed Jan 09 2008 16Z)
National Digital Guidance Database
6z model run   Graphic created Jan 09 7:16AM EST

www.cnn.com/2008/US/01/09/florida.pileup.ap

NESDIS GOES-12

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Forecast Verification Statistics: Example

Max 8-hr O₃ 081507

CMAQ (5x) 081507 Target Day (4Z-3Z)
Max 8-hr O3
Fraction Correct: 0.92
AIRNOW O3 (ppb)

MB (ppb)
Max 8-hr O₃ 081507
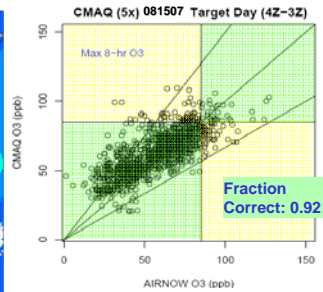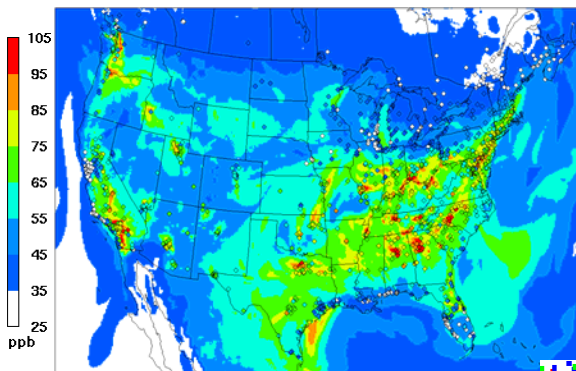
	N	Obs Mean	Model Mean	RMSE (ppb)	NME (%)	MB (ppb)	NMB (%)	r
CONUS	1094	56.62	62.29	14.54	19.73	5.66	10.00	0.75
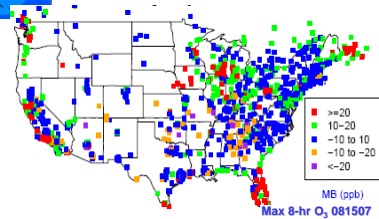
National Air Quality Forecast Capability
Current and Planned Capabilities, 3/09

- Improving the basis for AQ alerts
- Providing AQ information for people at risk

FY09 Prediction Capabilities and Targets

- Operations:
  Ozone, expanded from EUS to CONUS, 9/07
  Smoke implemented over CONUS, 3/07
  Smoke implemented over AK   9/09
- Experimental testing:
  Ozone upgrades
  Smoke predictions over AK
  Smoke predictions over HI   6/09
- Developmental testing:
  components for particulate matter (PM) forecasts
  ozone prototypes for AK, HI   9/09

Vision:
O₃ & PM in 6 Years
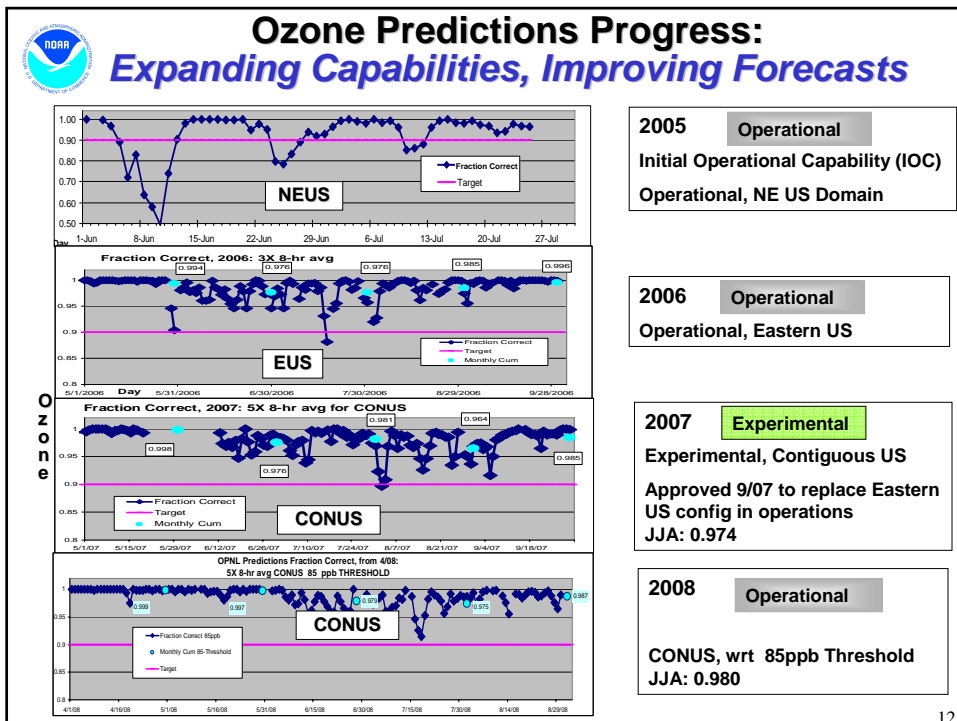2004: O₃
2005: O₃
2007: O₃ & smoke
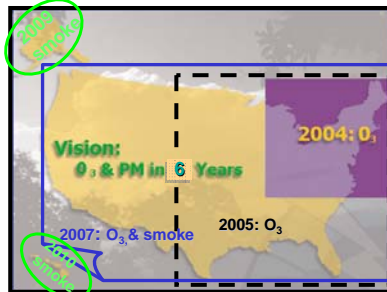
Near-term Operational Targets:
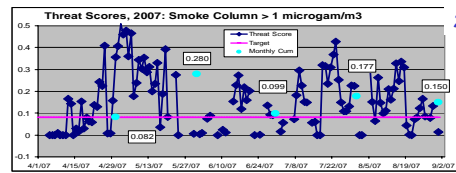- Ozone, smoke coverage extended Nationwide

Longer range:
- Quantitative PM$_{2.5}$ prediction 2015
- Extend air quality forecast range to 3-5 days…
- Include broader range of significant pollutants…

Progress

Ozone Predictions Progress:
Expanding Capabilities, Improving Forecasts

2005   Operational
Initial Operational Capability (IOC)
Operational, NE US Domain

2006   Operational
Operational, Eastern US

2007   Experimental
Experimental, Contiguous US
Approved 9/07 to replace Eastern US config in operations
JJA: 0.974

2008   Operational
CONUS, wrt 85ppb Threshold
JJA: 0.980

Smoke Predictions Summary:
Warm Season, 2007 and 2008

Threat Scores, 2007: Smoke Column > 1 microgram/m3

2007 Fraction Correct, 2007: Smoke Column > 1 microgram/m3

• TS cum = 0.159; Target = 0.08 (Column verification)

• FC generally > 0.7

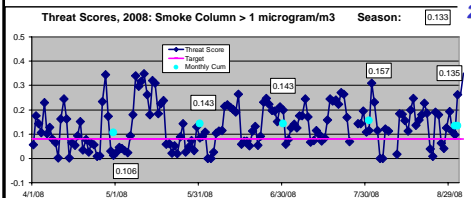• FC Target not established for qualitative smoke tool

Achieving Accuracy Target: TS > 0.08 (Column verification)

• Based on satellite AOD; column verification only

2008 Threat Scores, 2008: Smoke Column > 1 microgram/m3   Season: 0.133

Fraction Correct, 2008: Smoke Column > 1 microgram/m3

• TS cum = 0.133

• FC generally > 0.6

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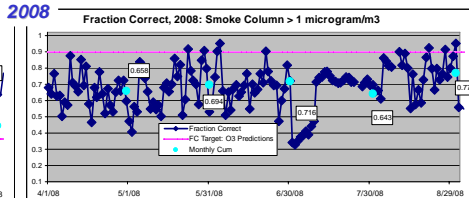
FY 09 Experimental Testing:
Ozone and Smoke

Experimental Predictions

Publicly available, real-time

Ozone:

- *CMAQ with advanced gas-phase chemical mechanism CB05*
  - more comprehensive organic reactions, also important for formation of secondary organic aerosols– setting the stage for PM!
  - challenge: more O_3 with CB05
  - regional implications: CA, NE US

Smoke:

- *Testing over AK domain*
  - new GOES-W smoke verification in development
  - challenge: little fire activity in 2008

Experimental   *Operational*
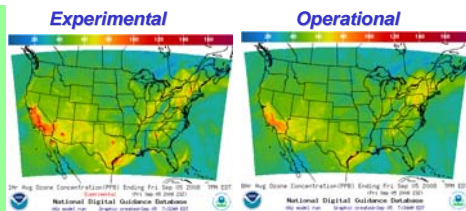
weather.gov/aq-expr/sectors/conus.php   **weather.gov/aq**

weather.gov/aq-expr/sectors/alaska.php

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Comparative Performance, O3

Exp Tests, CB05
West Coast: ●

Courtesy
J.Gorline

Fraction Correct: By Region
8-hr Average Ozone Predictions
Two Week Average: plotted at end of two-week period
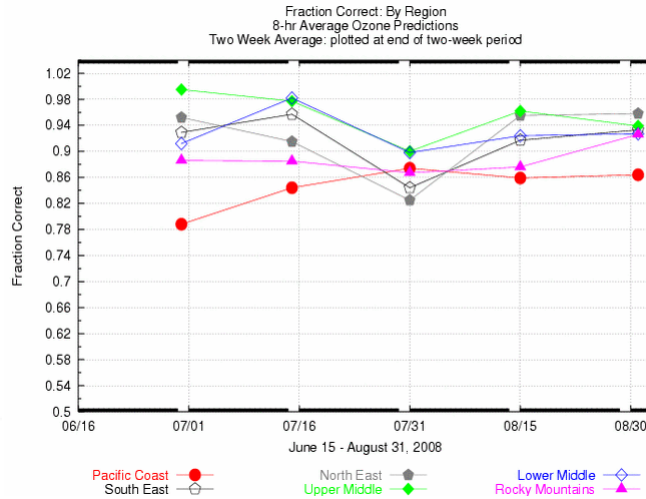
FY 09 Developmental Testing

Developmental Predictions:

Focus group access; real-time as resources permit

PM Components:

- *Aerosols from EPA's National Emissions Inventory (NEI) sources:*
  - CMAQ adaptation: Gas-phase (CB05), aerosol chemical reactions (AERO4), seasalt, heterogeneous pathways off
- *Dust (passive transport)*

Completing Nationwide Coverage:

- *HI smoke*
- *HI, AK ozone*

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Developmental Predictions, Aerosol
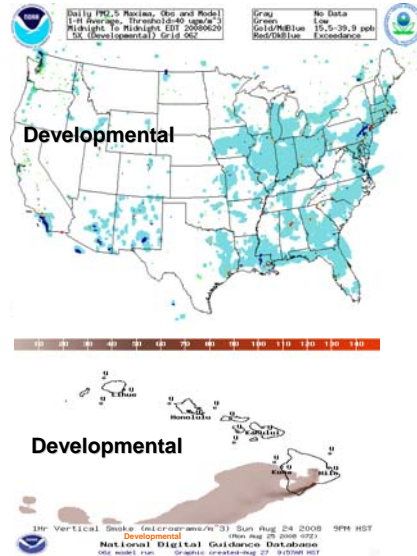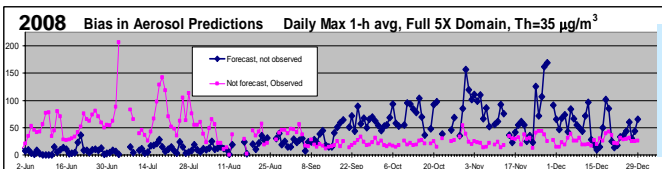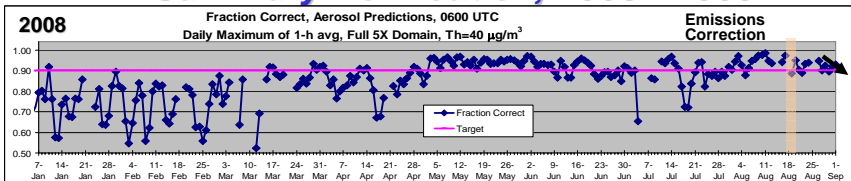### *Summary Verification, 2008 - 2009*

2008 — Fraction Correct, Aerosol Predictions, 0600 UTC
Daily Maximum of 1-h avg, Full 5X Domain, Th=40 $\mu g/m^3$ — **Emissions Correction**

2008 Bias in Aerosol Predictions   Daily Max 1-h avg, Full 5X Domain, Th=35 $\mu g/m^3$

Summertime: Low bias
Wintertime: High bias
Larger episodes qualitatively captured (next slide)

10/08 - 2/09   Fraction Correct, Aerosol Predictions   0600 UTC Daily Maximum of 1-h avg, Full 5X Domain, Th=35 $\mu g/m^3$

episode

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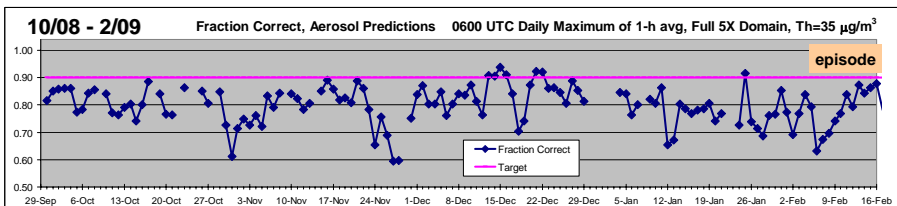
Daily PM2.5 maximum

Daily PM2.5 Maxima, Obs and Model
1-H Average, Threshold=35 ug/m^3
Midnight To Midnight EST 20090209
5X (Developmental) Grid 06Z

Gray	No Data
Green	Low
Gold/MdBlue	15.5-34.9 ppb
Red/DkBlue	Exceedance

Developmental

NWS/OST/MDL 2008

1 hour average of model and observations

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Recent Smoke Testing, Hawaii

November 18, 2008

Smoke from a short-duration fire near a resort on Lanai Island

The fire did not persist into the forecast period.

Skill in FMS (TS), 0.37 for 1 ug/m^3: above target
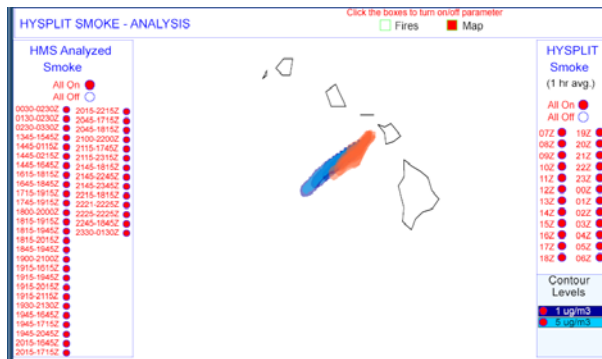
No reported activity in Dec-Jan

Courtesy G. Rolph

***Examples of
feedback from forecasters***

Example 1: Philadelphia, Courtesy Bill Ryan

NAQFC Operational O_3 Forecast:
PHL Metro Area – Domain Maximum 8-Hour

$[O_3]_{obs} = 8.3 + 0.84*[O_3]_{fc}$

May - Aug season avg FC = .86
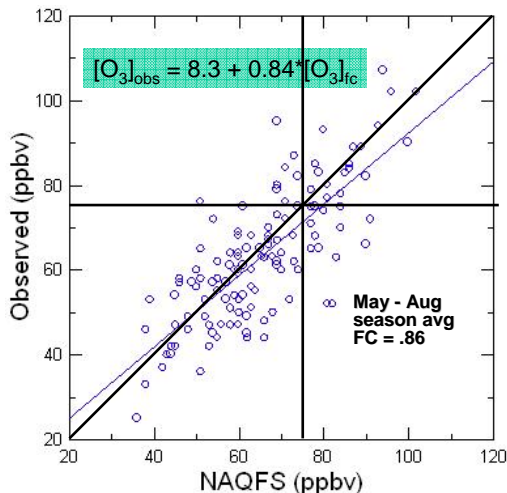
Correlation (r) = 0.78; r^2 = 0.60
Note: "Domain maximum" from predictions at O_3 monitor locations only

For period May 1-September 10:

Bias: +2.1 ppbv
Mean Absolute Error: 7.8 ppbv
Median Absolute Error: 6.0 ppbv

Mean AE is 27% improvement on older statistical model.

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O_3 in Cities vs Surrounding Areas, Courtesy B. Ryan
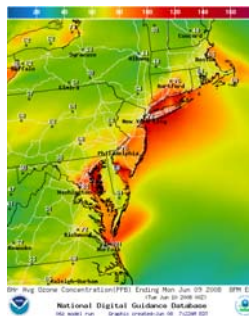
2008 May-Sept	Mean	Bias	Mean AE	Median AE
BALTO	65.8	+2.3	9.0	8.0
DC	69.5	**+7.7**	10.4	9.0
E.Shore	58.9	-0.4	7.8	7.0
W. MD	58.1	+3.0	7.0	6.5

DC: Observations (avg over metro area) show greater over-predictions than surrounding areas

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Example 2: Southern CA, after S.-M. Lee
Ozone Displaced inland from Southern CA Cities

5x (Operational) 8-hr max 14JUN2008

High O$_3$ predicted in Central Valley

Low O$_3$ predicted within LA Basin
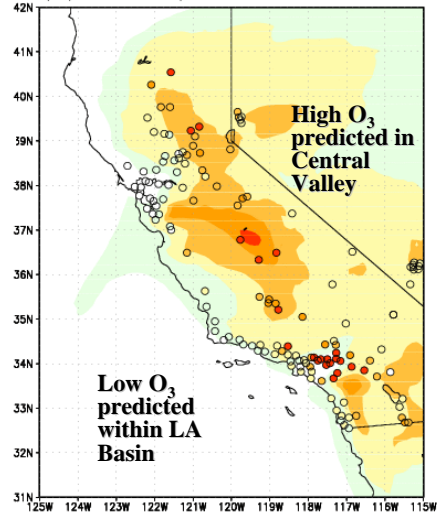
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Example 2: Southern CA, after S.-M. Lee
Large ozone gradients in Southern CA

5x(Operational) 8-hr max 09JUL2008

High O$_3$ predicted in Central Valley

Elevated O$_3$ predicted in the Salton Sea & Simi Valley

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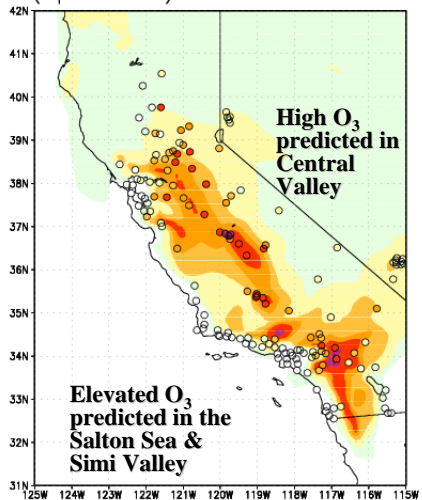
Example 3: Aerosols low in Roanoke, Courtesy D. Salkowitz
Developmental Aerosol prediction

ROANOKE NOAA DEVELOPMENTAL AEROSOL MODEL VS. 24-hr AVG, TEOM
MAY-SEPTEMBER 2008

General underprediction typical of entire domain; much more complexity unexplained
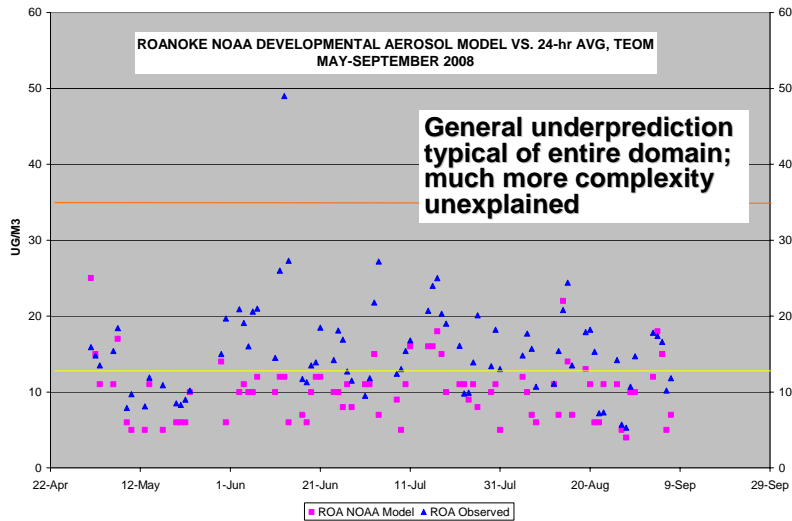
Example 4: Aerosols low in Atlanta, Courtesy W. Murphey

Developmental Aerosol prediction
vs Obs. Metro Atlanta, June 16th - Aug.15th, 2008
(Available data for time period)

Example 5.
Texas activity

Jul15-23, 2008

Courtesy
Bryan Lambeth

8Hr Avg Ozone Concentration(PPB) Ending Wed Jul 23 2008 8PM EDT
(Thu Jul 24 2008 00Z)

National Digital Guidance Database
06z model run   Graphic created-Jul 23 7:40AM EDT

July 23, 2008
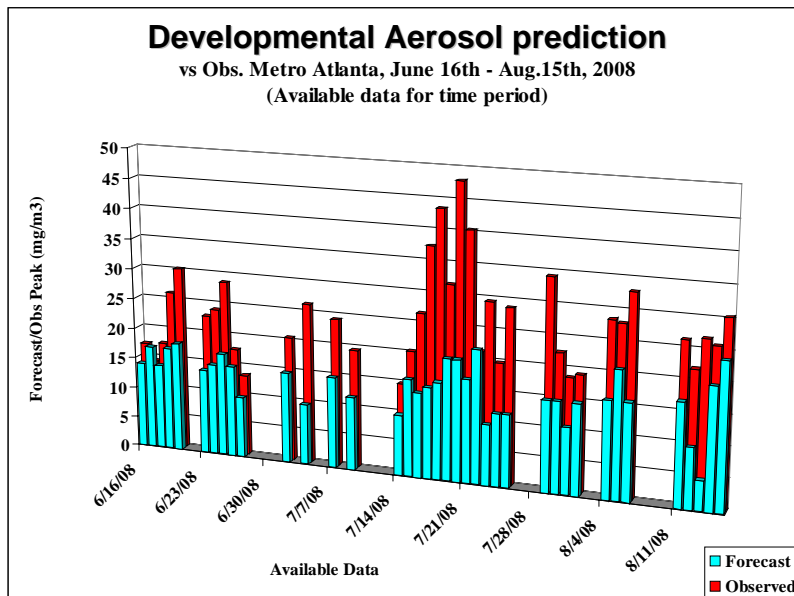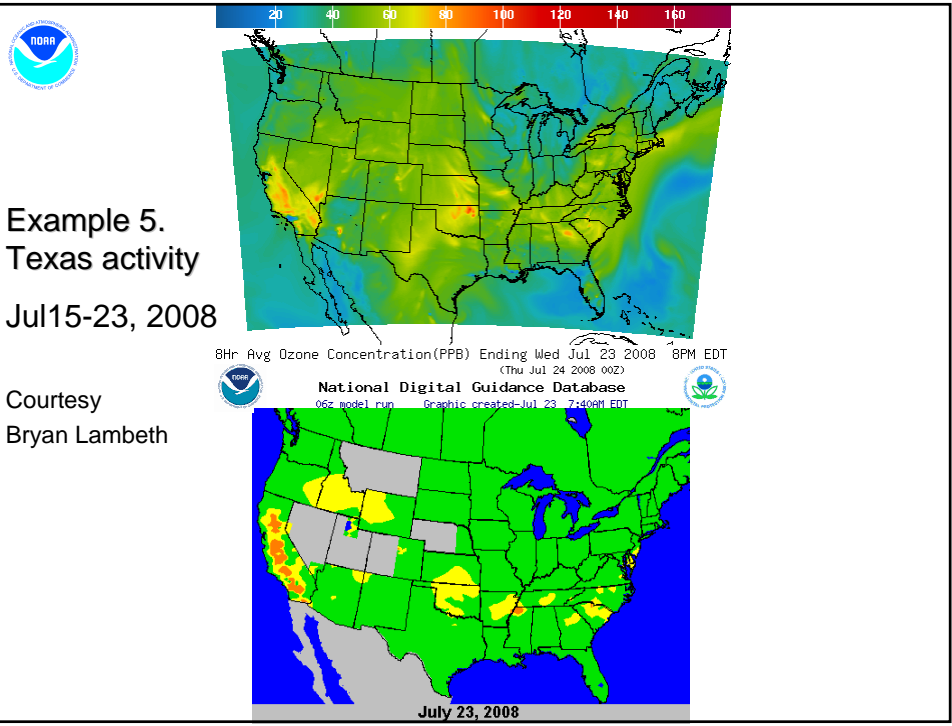
Next Steps

National AQF Capability:
Next Steps

Expanding Ozone and Smoke Nationwide

- **Development of AK, HI capabilities; target operational implementation in FY10**
- **Smoke from large fires: experimental testing in AK, HI**
- **Setting the groundwork for PM: closer coupling of AQ with NAM; treatments/resolution, horizontal boundary conditions…**

Increasing Emphasis on Particulate matter components:

- **Additional components for quantitative PM forecast capability:**
  - *Objective satellite products for verification (ongoing)*
  - *Aerosols from anthropogenic source emissions in inventories: continued development/testing/analysis– testing advanced chemical mechanisms*
  - *Dust prediction*
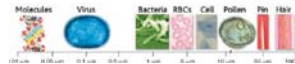 - *Chemical data assimilation, speciated fire emissions, closer coupling of weather and AQ simulation*
- **Integrated quantitative PM capability:**
  - *Developmental and experimental testing, to begin FY12*
  - *Target operational implementation for initial PM forecasts, NE US: FY14*
  - *Full Operational Capability, per FY09 Pres. Bud: FY15*

Further ahead:

- **Extend forecast range to Day 2 and beyond**
- **Include other pollutants of interest**

fine particles
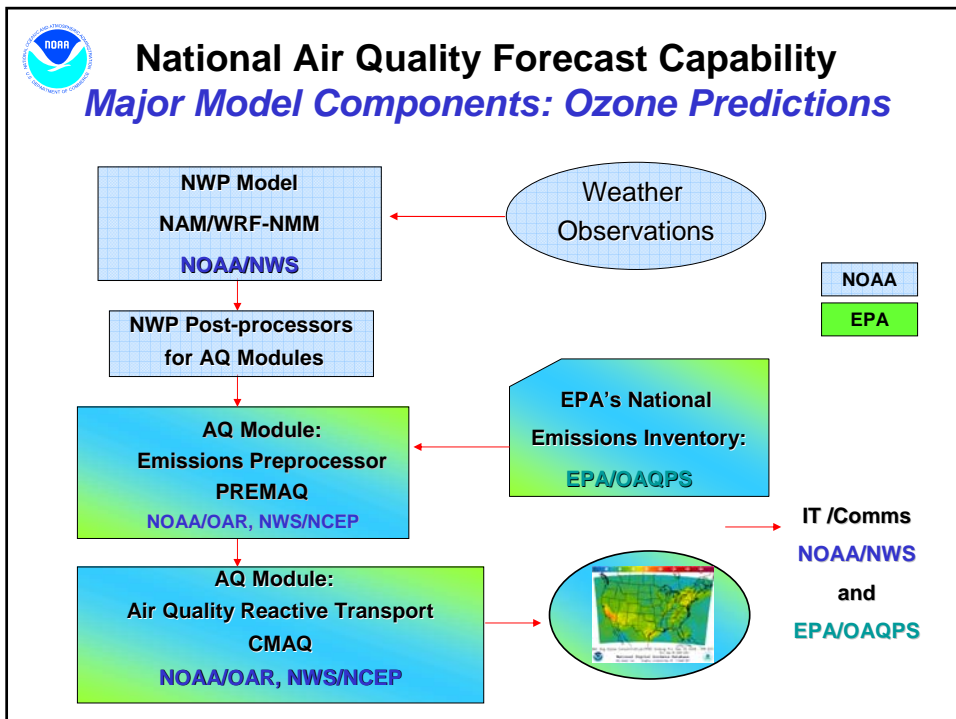
$PM_{2.5}$

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NAQFC Coordination:
Implementation Team Members

OCWWS	*Jannie Ferrell*	*Outreach, Feedback*
OCIO	*Cindy Cromwell, Dan Starosta, Bob Bunge*	*Data Communications*
OST/MDL	*Jerry Gorline*	*Dev. Verification*
OST/MDL	*Marc Saccucci, Tim Boyer, Dave Ruth*	*NDGD Product Development*
OST	*Ken Carey, Ivanka Stajner*	*Program Support*
NESDIS/NCDC	*Alan Hall*	*Product Archiving*
NOAA/OAR	*Jim Meagher*	*NOAA AQ Matrix Manager*

NCEP

Jeff McQueen, Youhua Tang, Marina Tsidulko, Ho-Chun Huang, Dongchul Kim	*EMC AQF model interface development, testing and integration*
*Sarah Lu	*Global data assimilation and feedback testing (NASA, NESDIS)*
*Brad Ferrier, *Dan Johnson, *Eric Rogers, *Hui-Ya Chuang	*WRF/NAM coordination*
Geoff Manikin	*Smoke Product testing and integration*
John Ward, Brent Gordon, Chris Magee	*NCO transition and systems testing*
Robert Kelly, Bob Bodner, Andrew Orrison	*HPC coordination and AQF webdrawer*

   * Guest Contributors

NOAA/OAR

Daewon Byun, Pius Lee, Shaocai Yu, Daiwen Kang, Hsin-Mu Lin, Daniel Tong, Tianfeng Chai	*CMAQ development, adaptation of AQ simulations for AQF*
Roland Draxler, Glenn Rolph, Ariel Stein	*HYSPLIT adaptations*

NOAA/NESDIS

Shobha Kondragunta, Jian Zeng	*moke Verification product development*
Matt Seybold, Mark Ruminski	*HMS product integration with smoke forecast tool*

EPA/OAQPS

Chet Wayland, Phil Dickerson, Scott Jackson, Brad Johns	*AIRNow development, coordination with NAQFC*

EPA/ORD

Rohit Mathur, Ken Schere, Jon Pleim, Tanya Otte, Jeff Young, George Pouliot, Brian Eder, David Wong	*CMAQ development, adaptation of AQ simulations for AQF*

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Backup

National Air Quality Forecast Capability
Major Model Components: Ozone Predictions

NWP Model
NAM/WRF-NMM
NOAA/NWS

Weather
Observations

NOAA
EPA

NWP Post-processors
for AQ Modules

AQ Module:
Emissions Preprocessor
PREMAQ
NOAA/OAR, NWS/NCEP

EPA's National
Emissions Inventory:
EPA/OAQPS

IT /Comms
NOAA/NWS
and
EPA/OAQPS

AQ Module:
Air Quality Reactive Transport
CMAQ
NOAA/OAR, NWS/NCEP

Comparative Performance, Aerosols

West Coast: ●

Courtesy J.Gorline

Fraction Correct: By Region
1-hr Average Aerosol Predictions
Monthly Average: plotted at end of month

Pacific Coast
South East
North East
Upper Middle
Lower Middle
Rocky Mountains

Th=35 ug/m³

June, 2007 - November, 2008
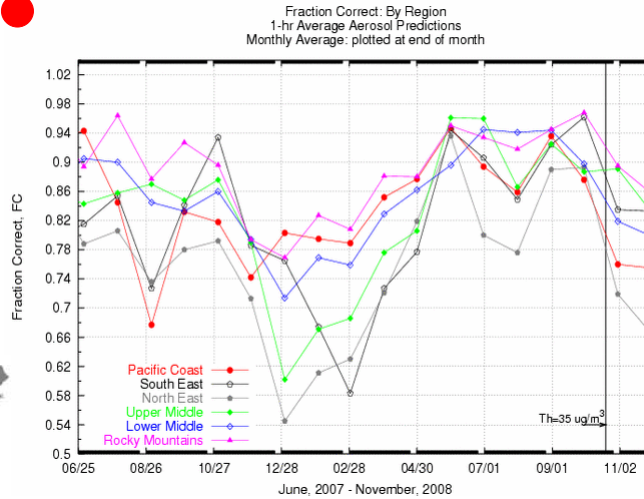
Developmental Aerosol Predictions:
Summary Verification, 2008

Fraction Correct, Aerosol Predictions, 0600 UTC
Daily Maximum of 1-h avg, Full 5X Domain, Th=40 µg/m³

Emissions Correction

Fraction Correct
Target

Developmental

Developmental

August 16, 2008

Gray	No Data
Green	Low
Gold/MdBlue	15.5-39.9 ppb
Red/DkBlue	Exceedance

August 17, 2007

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