

NOAA's National Air Quality Forecast Guidance Capability: Reaching 50 States

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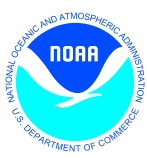
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91st AMS Annual Meeting, 13th Conference on Atmospheric Chemistry

Seattle, Washington

January 27, 2011



Outline



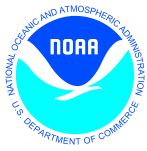
Background on NAQFC

Progress in 2010

- *Operational products*
- *Experimental products*
- *Developmental testing*

Coordination with Partners

Looking Ahead



National Air Quality Forecast Capability

Current and Planned Capabilities 1/11



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

FY10 Prediction Capabilities:

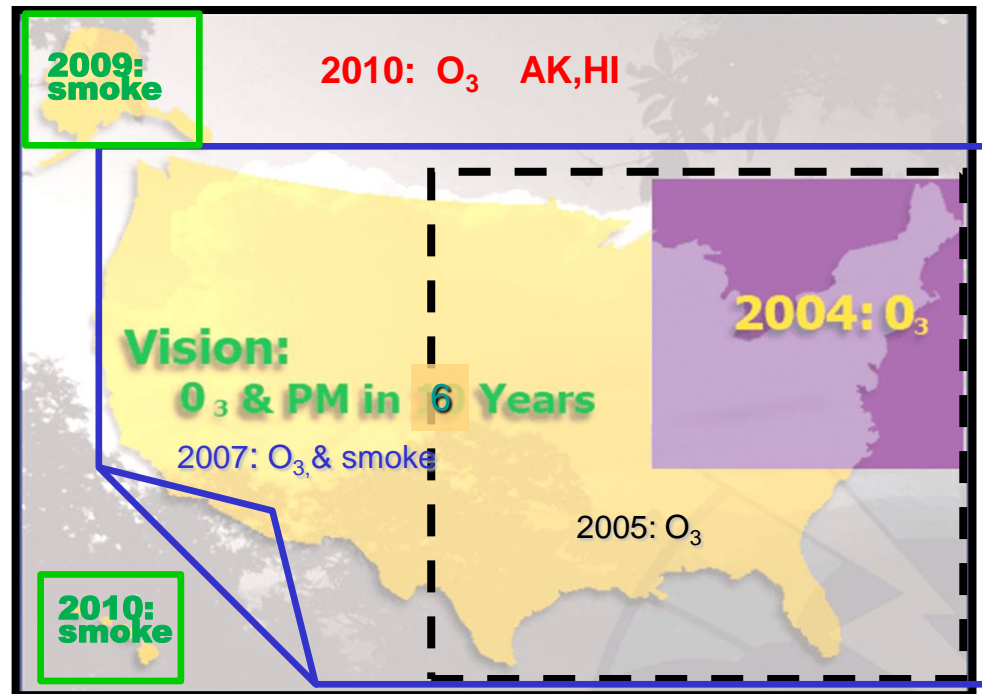
- Operations:
 - Ozone nationwide*
 - Smoke nationwide*
- Experimental testing:
 - Ozone upgrades*
 - Dust predictions*
- Developmental testing:
 - Components for particulate matter (PM) forecasts*

Near-term Operational Targets:

- Higher resolution prediction (4km)
- CONUS dust prediction

Longer range:

- Quantitative PM_{2.5} prediction
- Extend air quality forecast range to 48-72 hours
- Include broader range of significant pollutants



National 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

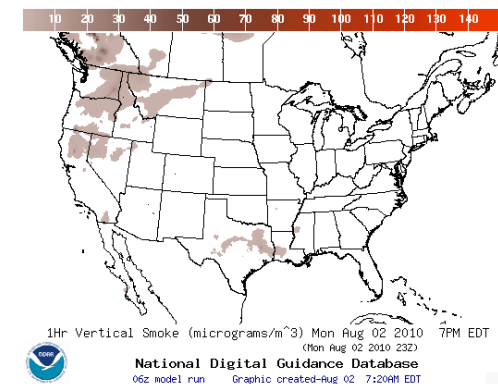
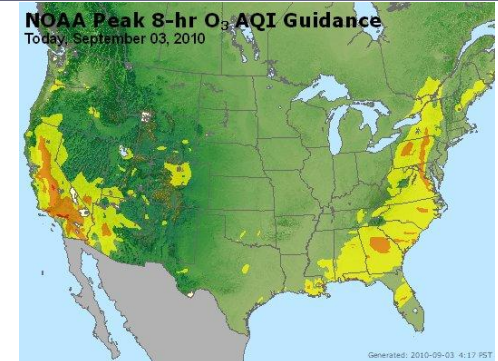
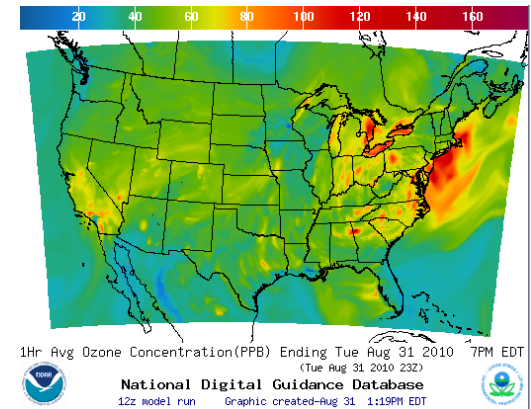
- *On NWS servers: www.weather.gov/aq and ftp-servers*
- *On EPA servers*
- *Updated 2x daily*

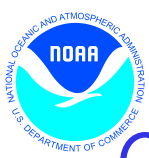
Verification basis, near-real time:

- *Ground-level AIRNow observations*
- *Satellite smoke observations*

Customer outreach/feedback

- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*





Progress in 2010

Ozone, Smoke Operational Nationwide; Dust Testing

Ozone: Expanded Forecast Guidance to Alaska and Hawaii domains in NWS operations (9/10)

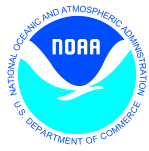
- Operations, 2010: Updates for CONUS (emissions), new 1, 8-hour daily maximum products
- Developmental testing: changing boundary conditions, dry deposition, PBL in CB-05 system

Smoke: Expanded Forecast Guidance to Hawaii domain in NWS operations (2/10)

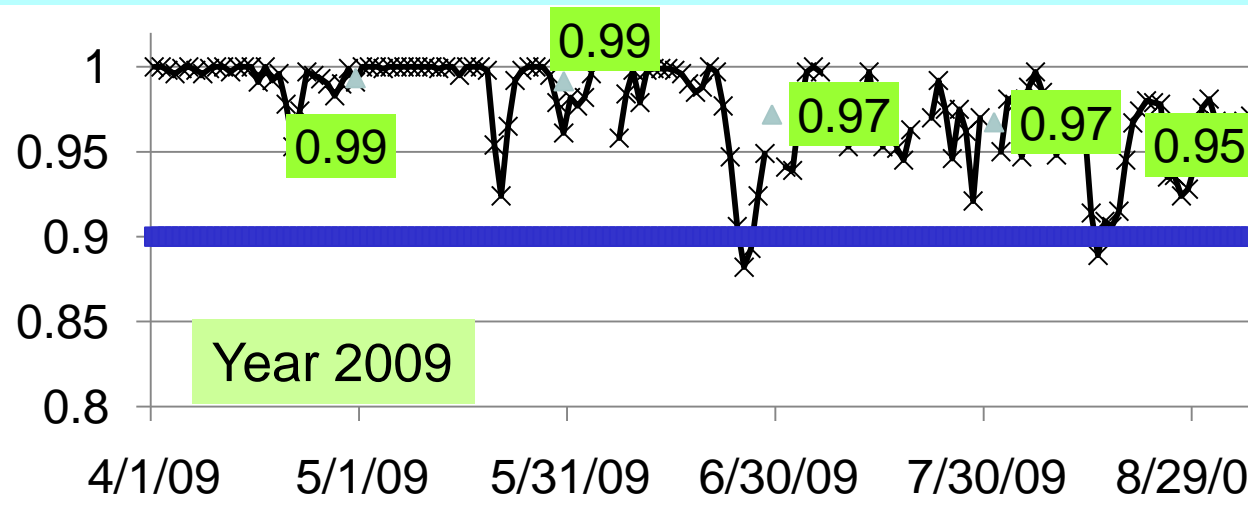
- Operations: CONUS predictions operational since 2007, AK predictions since 2009
- Developmental testing: Improvements to verification

Aerosols: Developmental testing providing comprehensive dataset for diagnostic evaluations. (CONUS)

- CMAQ (aerosol option), testing CB-05 chemical mechanism with AERO-4 aerosol modules
 - Qualitative; summertime underprediction consistent with missing source inputs
- Dust and smoke inputs: testing dust contributions to PM_{2.5} from global sources
 - Real-time testing of combining smoke inputs with CMAQ-aerosol
- **Testing experimental prediction of dust from CONUS sources**
- Developing prototype for assimilation of surface PM_{2.5} measurements
- R&D efforts continuing in chemical data assimilation, real-time emissions sources, advanced chemical mechanisms

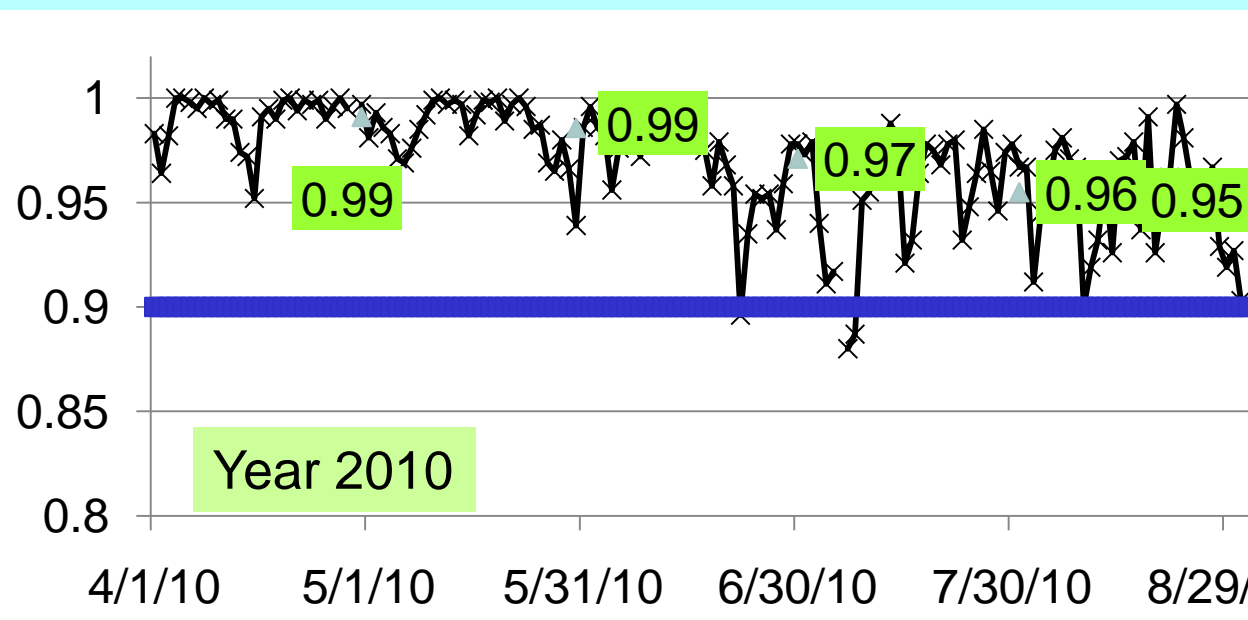


Ozone Prediction: Recent Performance



CONUS ozone prediction operational since 2007

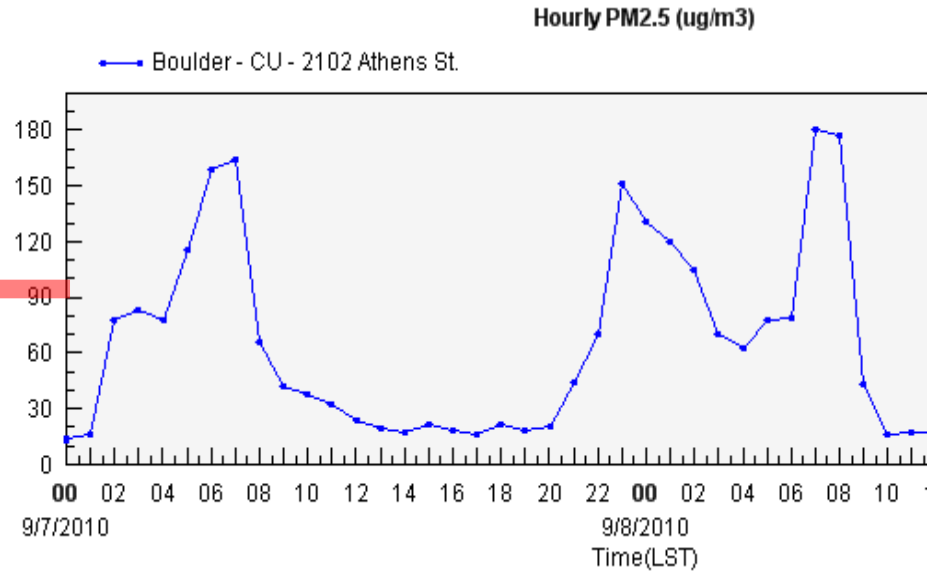
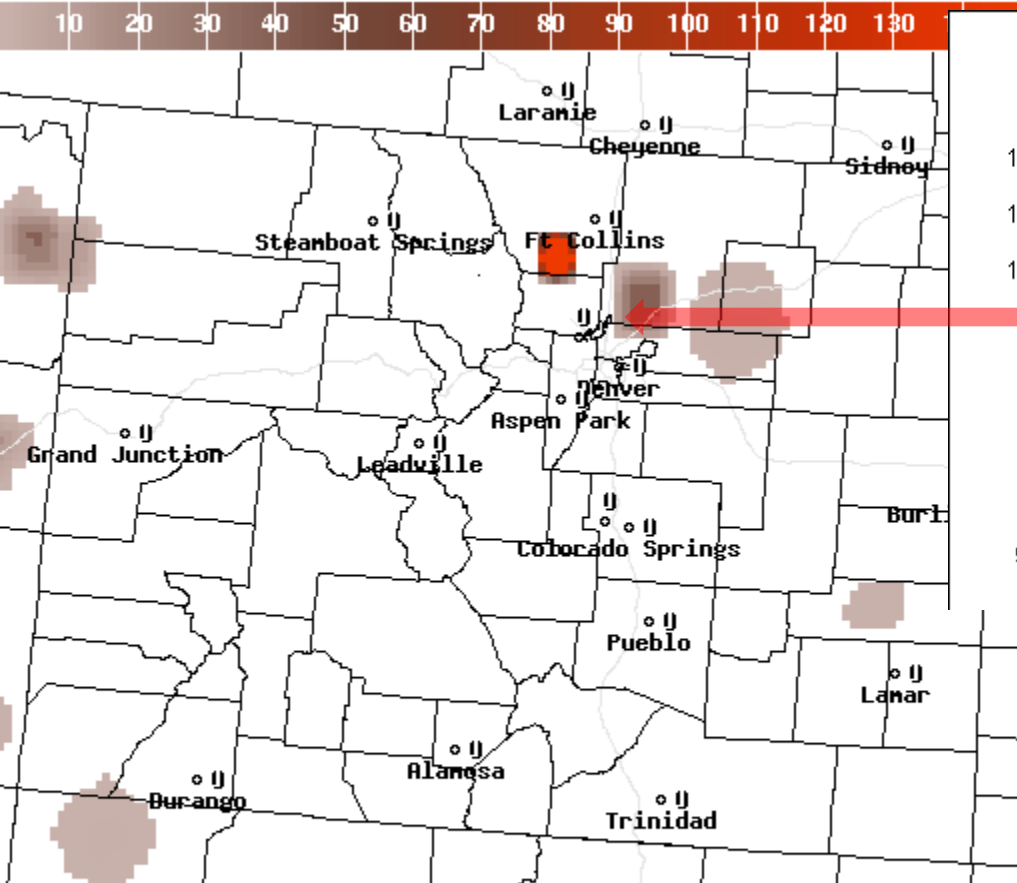
Fraction correct with respect to 75ppb threshold for operational prediction over 48 contiguous states



skill target:
fraction correct ≥ 0.9

Smoke Prediction Example: Four Mile Canyon Fire

September 7-8, 2010



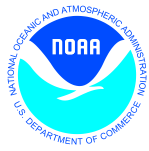
"The blaze broke out Monday morning in Four Mile Canyon northwest of Boulder and rapidly spread across roughly 1,400 hectares. Erratic wind gusts sometimes sent the fire in two directions at once."

"The 11-square-mile blaze had destroyed at least 92 structures and damaged at least eight others by Tuesday night, Boulder County sheriff's Cmdr. Rick Brough said."

1Hr Surface Smoke (micrograms/m³) Tue Sep 07 2010 7AM EDT
(Tue Sep 07 2010 11Z)

National Digital Guidance Database

06z model run Graphic created-Sep 07 7:17AM EDT



CONUS Dust Predictions: Experimental Testing since June 2010



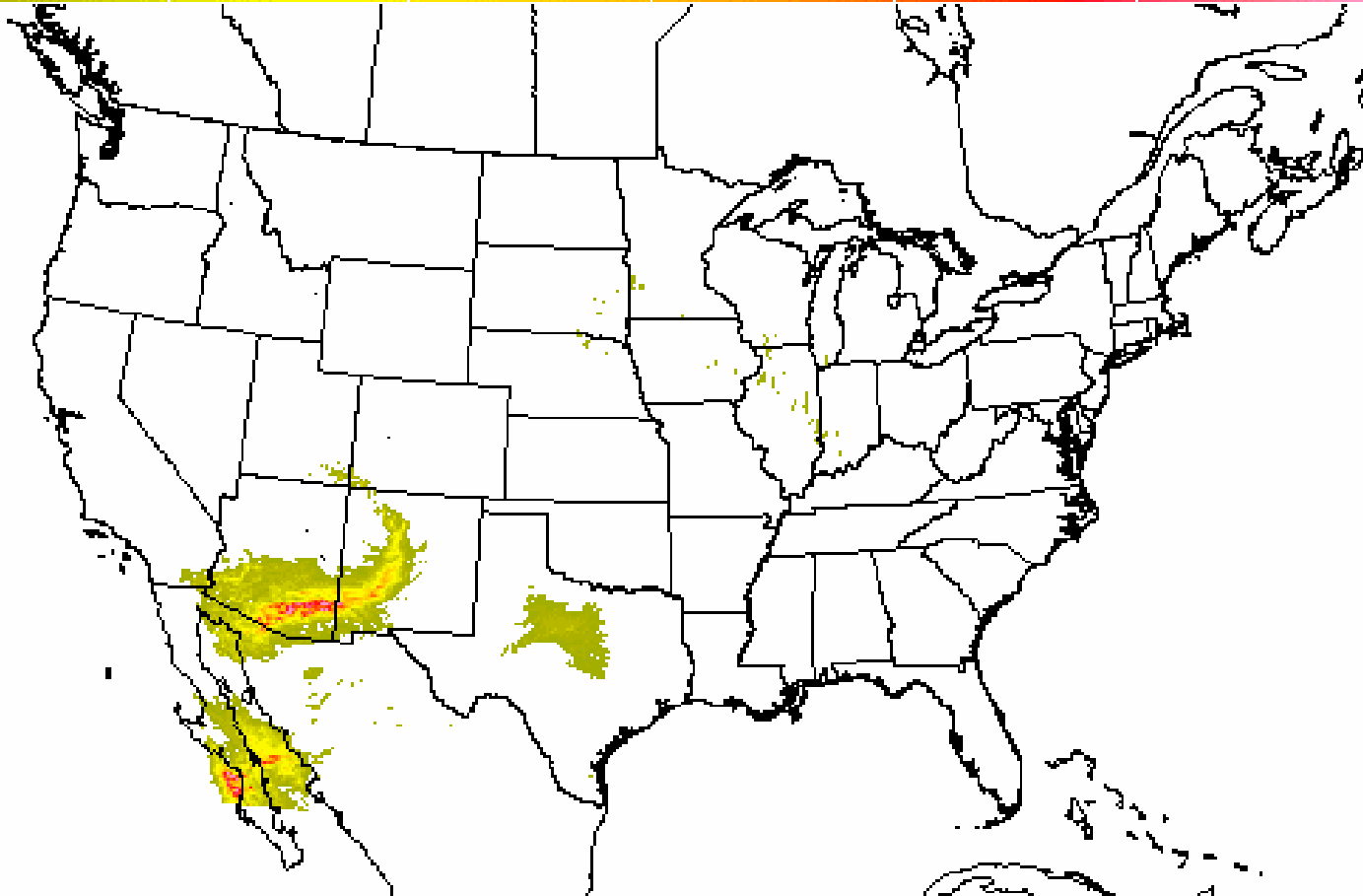
25

50

75

100

125



•Components of CONUS dust predictions include:

•Standalone prediction of airborne dust from dust storms over CONUS

•Wind-driven dust where surface winds exceed thresholds over source regions

•Source regions w/ emission potential estimated from monthly climatology (2003-2006)

•Incorporated into predictions via HYSPLIT transport

1Hr Column Dust (micrograms/m³) Wed Mar 10 2010 2AM EST

Developmental testing (Wed Mar 10 2010 07Z)

National Digital Guidance Database

06z model run Graphic created-Mar 15 10:43AM EDT

Draxler, et al, 2010, JGR



Chemical Mechanism Sensitivity Analysis

Experimental ozone predictions

CMAQ with advanced gas-phase chemical mechanism CB05

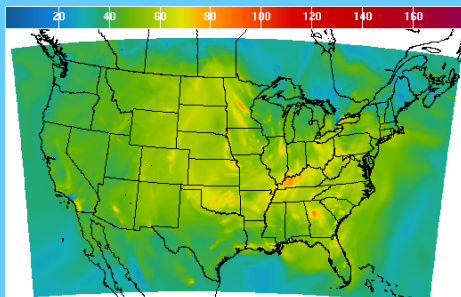
- More volatile organic compound (VOC) reactions

Shows larger biases than CBIV

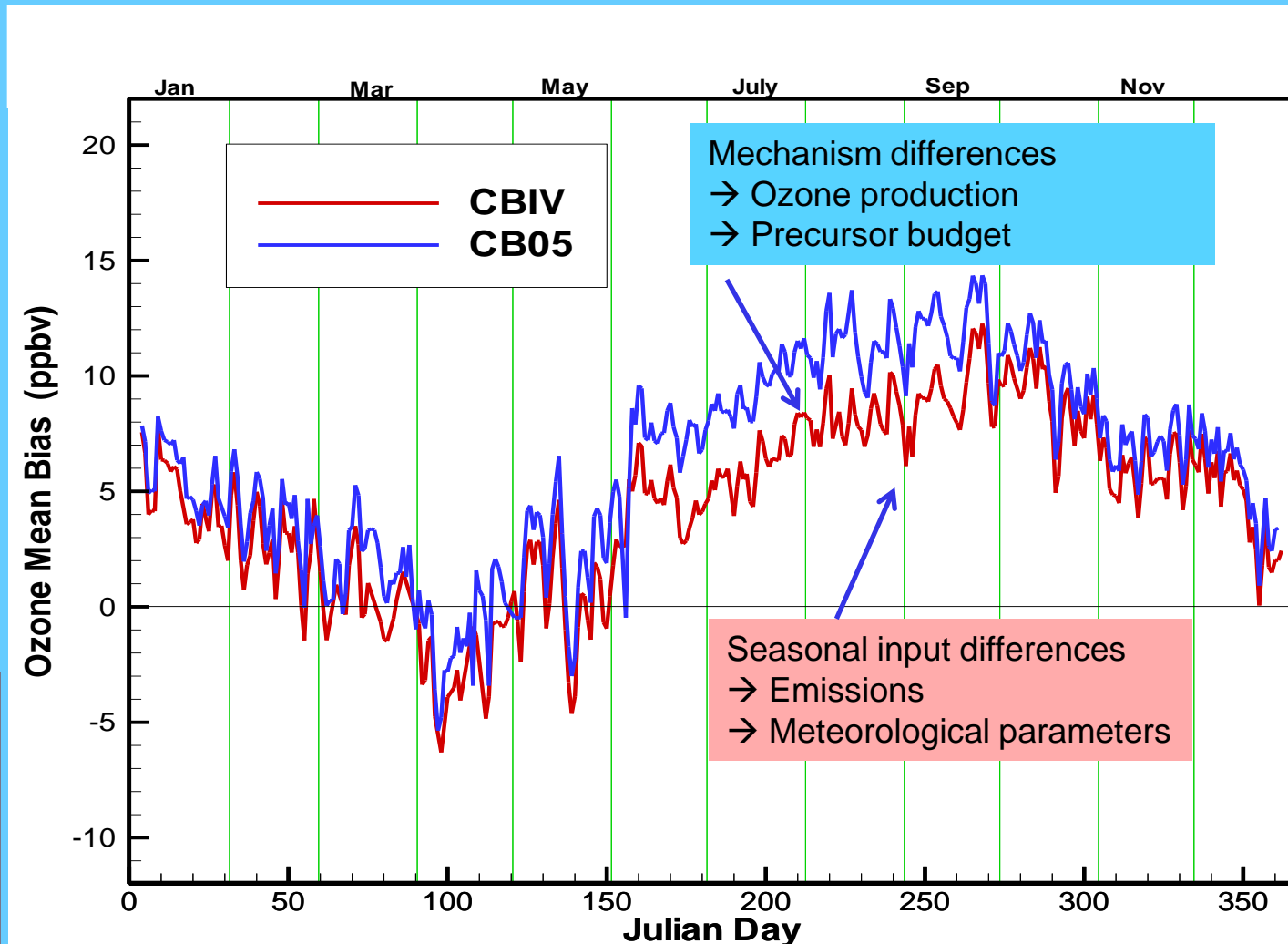
- Summertime
- Eastern US

Sensitivity studies in progress:

- Chemical speciation
- Indicator reactions

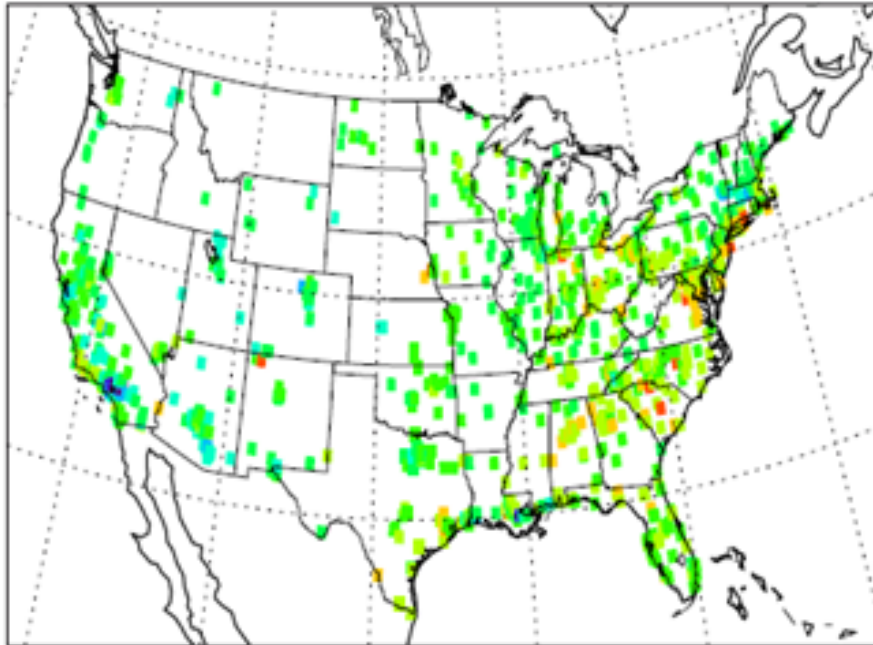


8Hr Avg Ozone Concentration(PPB) Ending Sun Aug 22 2010 7PM EDT
Experimental (Sun Aug 22 2010 23Z)
National Digital Guidance Database
12z model run Graphic created Aug 22 1:34PM EDT

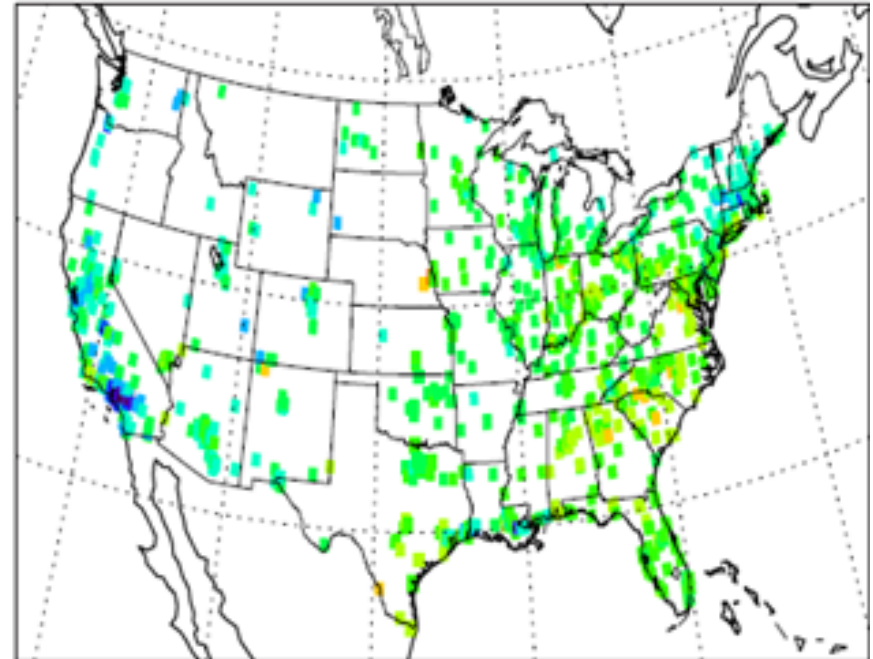


Developmental Testing of CB05 Ozone Predictions

Model-minus-AIRNow observations: mean for daytime in August 2009



Experimental

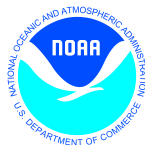


Developmental:
- LBCs,
- minimum PBL height
- dry deposition



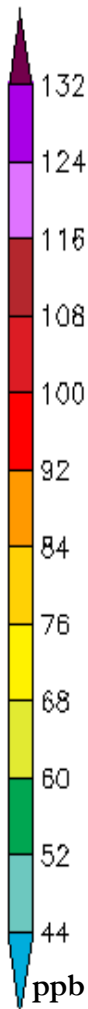
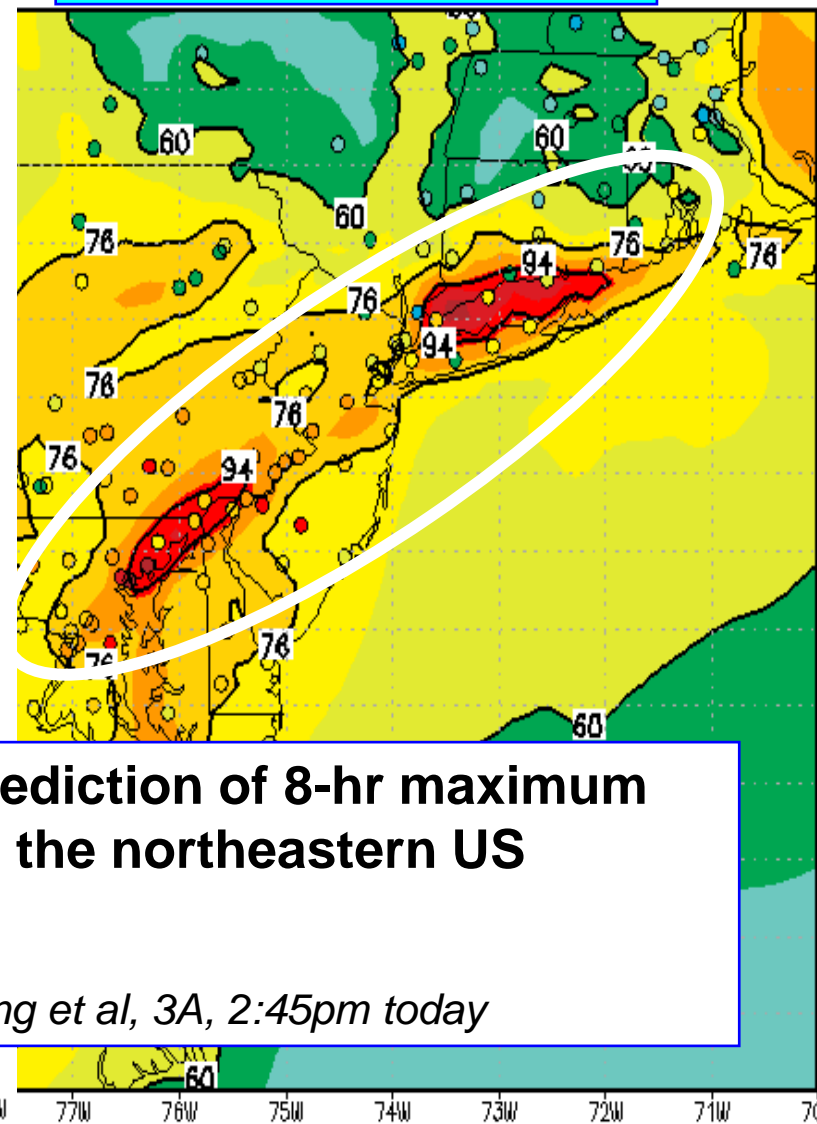
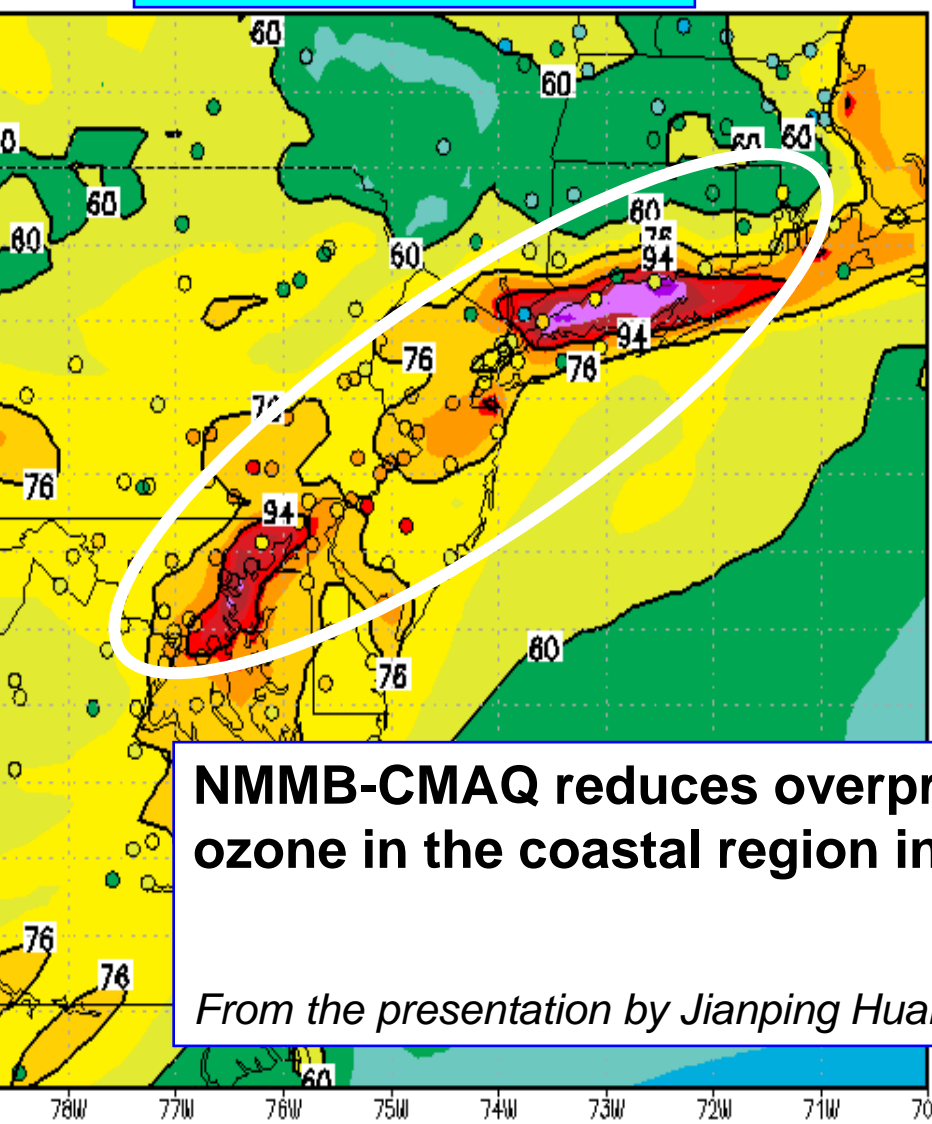
Impact of NMM-B meteorology

August 10, 2010 example



WRF/NMM-CMAQ

NMMB-CMAQ



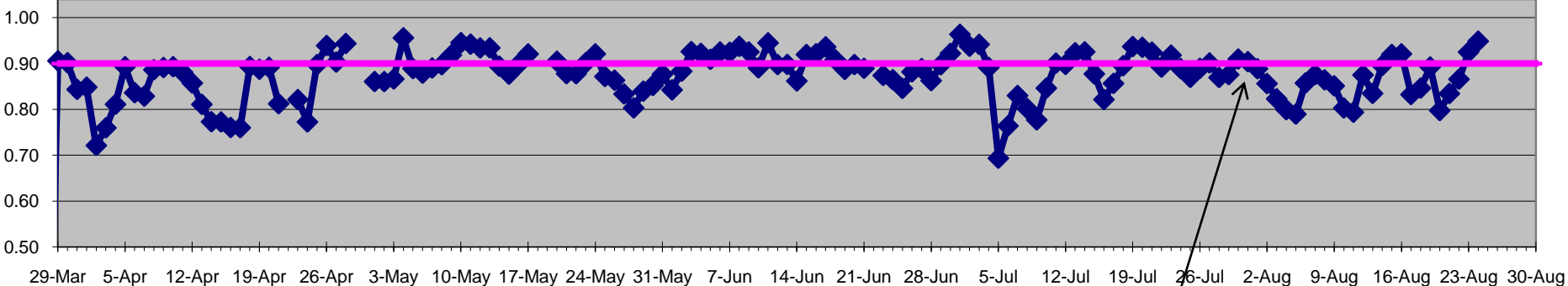
NMMB-CMAQ reduces overprediction of 8-hr maximum ozone in the coastal region in the northeastern US

From the presentation by Jianping Huang et al, 3A, 2:45pm today

Developmental Aerosol Predictions: Summary Verification, 2010

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

◆ Fraction Correct



Focus group access only, real-time as resources permit

Aerosols over CONUS

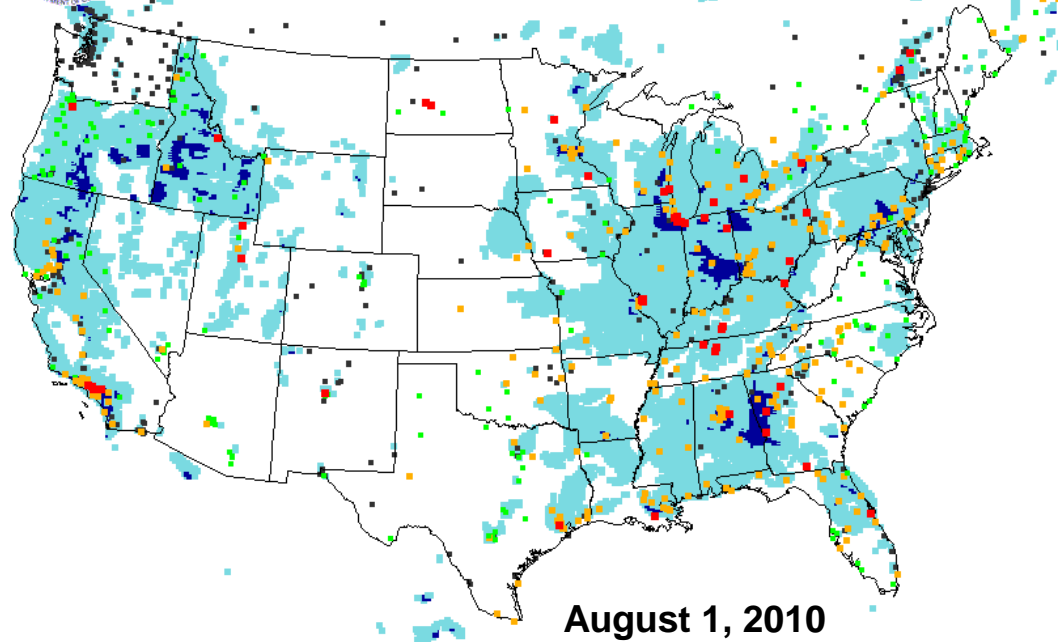
- From NEI sources only
- CMAQ: CB05 gases, AERO-4 aerosols
- sea salt emissions and reactions

Testing of real-time wildfire smoke emissions in CMAQ



Daily PM2.5 Maxima, Obs and Model
1-H Average, Threshold=35 $\mu\text{g}/\text{m}^3$
Midnight To Midnight EDT 20100801
5X (Developmental) Grid 0600 UTC

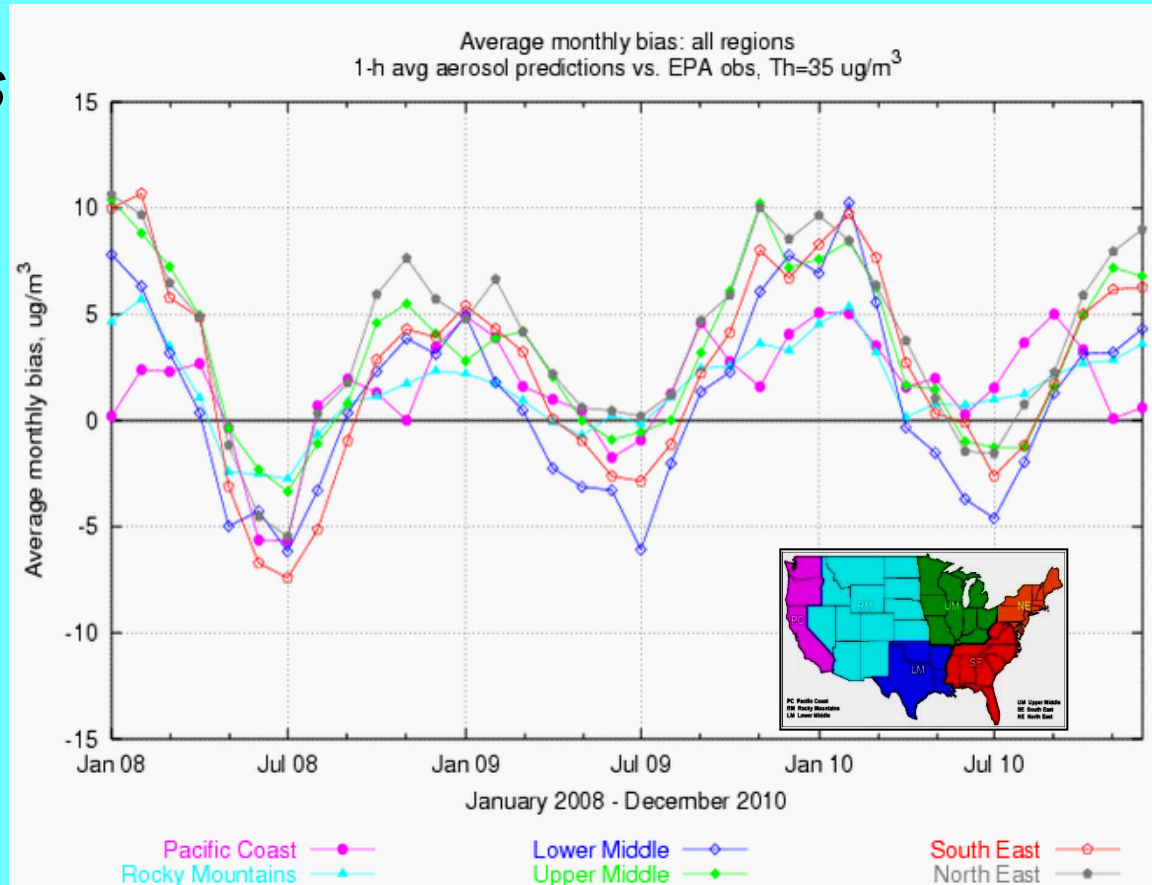
Gray	No Data
Green	Low
Gold/MdBlue	15.5–34.9 $\mu\text{g}/\text{m}^3$
Red/DkBlue	Exceedance



August 1, 2010

Forecast challenges

- *Aerosol simulation using emission inventories:*
- Show seasonal bias-- winter, overprediction; summer, underprediction
- *Intermittent sources*
- *Chemical boundary conditions/trans-boundary inputs*



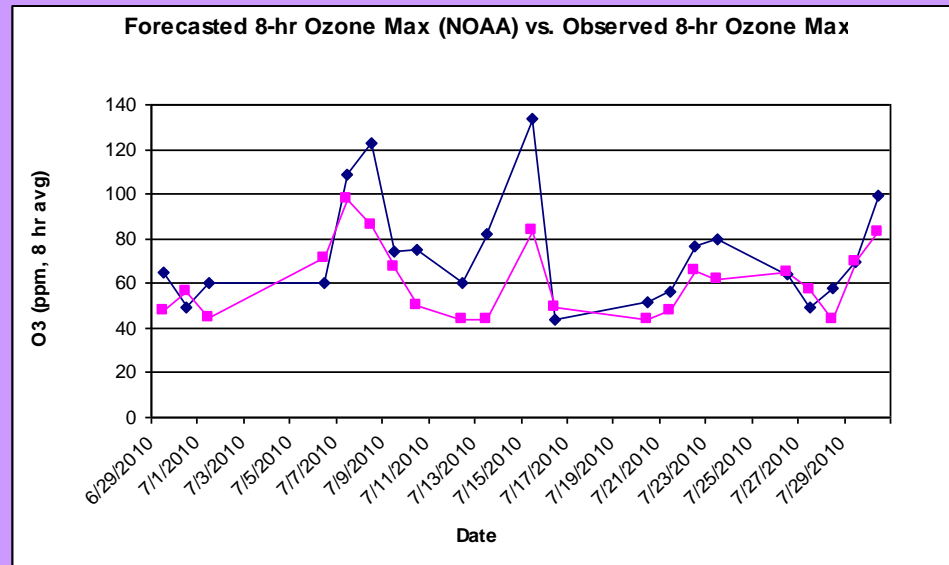
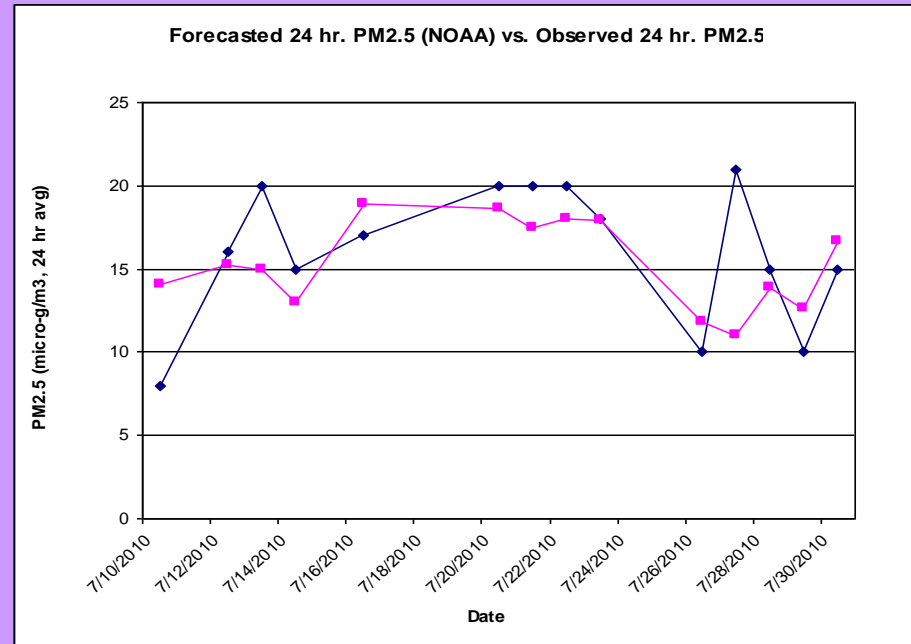
Example Feedback

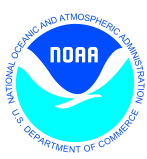
From Nyasha Dunkley, Georgia AQ Forecaster

"...looking at the values, it appears that the NOAA model has a slight tendency to overpredict the 8hr ozone values, as well as PM2.5 (though the PM overprediction is not quite as dramatic as the ozone)..."

"...noticed about the experimental model (as can be seen in the graph), is that although it's overpredicting a fair amount, it seems to be catching the trend in concentrations fairly well (especially considering how much trouble moisture has made forecasting for this season)..."

Looking at June-July data





National AQF Capability: *Summary*



US national AQ forecasting capability status:

- Ozone predictions nationwide
- Smoke predictions nationwide
- Experimental testing of dust predictions over contiguous 48 states
- Testing of CMAQ aerosol predictions with NEI sources

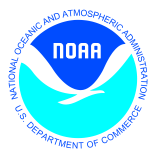
Next steps:

- Transition to predictions driven by NMM-B met. model: testing in progress
- Continued testing and implementation of predictions of dust from CONUS sources

Towards quantitative PM predictions:

- Integration of NEI, smoke and dust sources; inventory updates
- Data assimilation, bias correction; starting with surface PM monitor data
- Inclusion of lateral boundaries from global model predictions
- Testing advanced chemical mechanisms; evaluation of PM speciation
- Closer coupling of meteorological and chemical models; higher resolution

Target operational implementation of initial quantitative total PM_{2.5} forecasts for northeastern US in 2015



Acknowledgments:

AQF Implementation Team Members



NOAA/NWS/OST

NWS/OST

NOAA/OAR

NWS/OCWWS

NWS/OPS/TOC

NWSOST/MDL

Tim McClung

Ivanka Stajner

Jim Meagher

Jannie Ferrell

Cindy Cromwell, Bob Bunge

Jerry Gorline, Marc Saccucci,

Tim Boyer, Dave Ruth

Ken Carey, Kyle Wedmark

Alan Hall

NWS/OST

NESDIS/NCDC

NWS/NCEP

Jeff McQueen, Youhua Tang, Marina Tsidulko,

Jianping Huang

**Sarah Lu, Ho-Chun Huang*

**Brad Ferrier, *Dan Johnson, *Eric Rogers,*

**Hui-Ya Chuang*

Geoff Manikin

Dan Starosta, Chris Magee

Robert Kelly, Bob Bodner, Andrew Orrison

NOAA/OAR/ARL

Daewon Byun, Pius Lee, Rick Saylor,

Daniel Tong, Tianfeng Chai, Fantine Ngan

Yunsoo Choi, Hyun Kim

Roland Draxler, Glenn Rolph, Ariel Stein

NESDIS/STAR *Shobha Kondragunta, Jian Zeng*

NESDIS/OSDPD *Matt Seybold, Mark Ruminski*

EPA/OAQPS partners:

Chet Wayland, Phil Dickerson, Scott Jackson, Brad Johns

NAQFC Manager

Acting OST Program Manager for NAQFC

NOAA AQ Matrix Manager

Outreach, Feedback

Data Communications

Dev. Verification, NDGD Product Development

Program Support

Product Archiving

AQF model interface development, testing, & integration

Global data assimilation and feedback testing

WRF/NAM coordination

Smoke Product testing and integration

NCO transition and systems testing

HPC coordination and AQF webdrawer

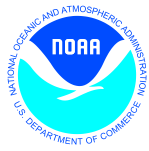
CMAQ development, adaptation of AQ simulations for AQF

HYSPLIT adaptations

Smoke Verification product development

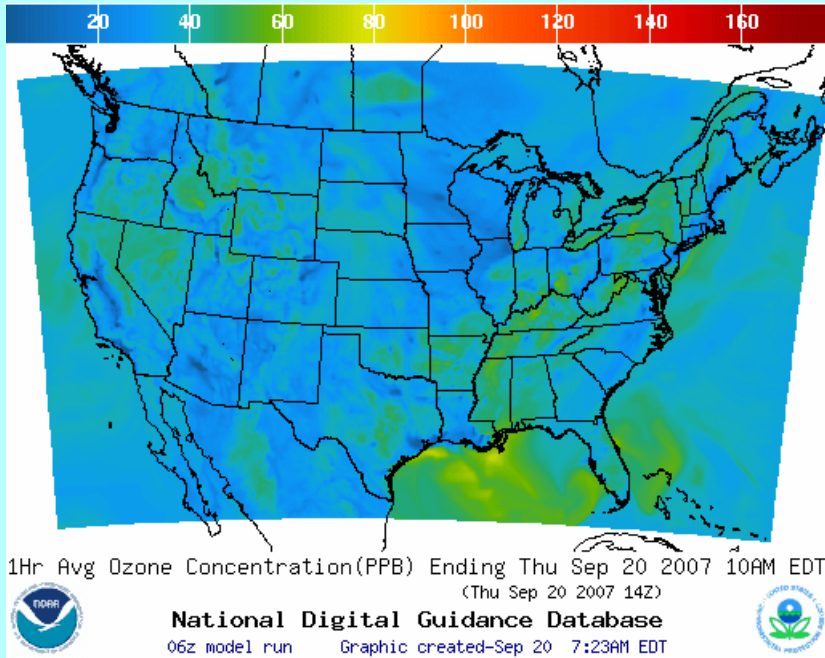
HMS product integration with smoke forecast tool

AIRNow development, coordination with NAQFC



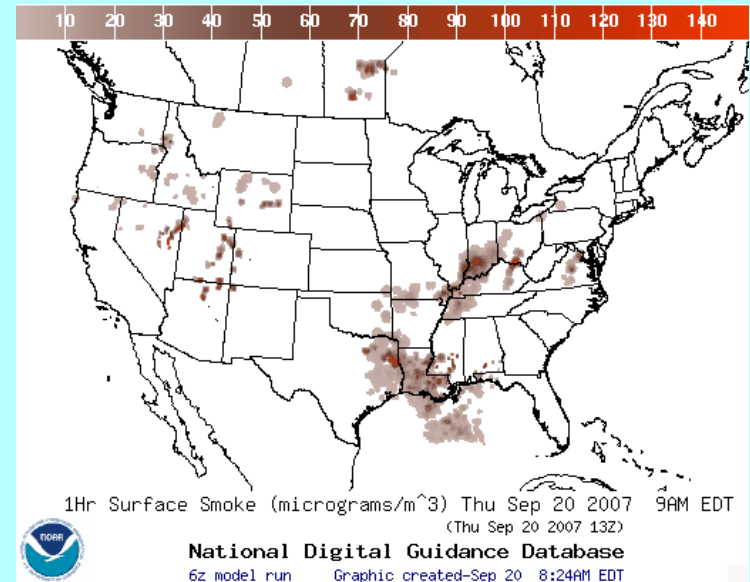
Operational AQ Forecast Guidance

www.weather.gov/aq



CONUS Ozone

Expansion Implemented in September 2007
AK and HI implemented in September 2010



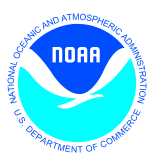
Smoke Products

CONUS implemented in March 2007

AK implemented September 2009

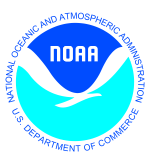
HI implemented in February 2010

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



Backup





Smoke Forecast Tool: *What is it?*

Overview

- Passive transport/dispersion computed with HYSPLIT & WRF-NAM (or GFS, OCONUS). 24-hr spin-up, 48-hour prediction made daily with 6Z cycle

Fire Locations

- NESDIS/HMS: Filtered ABBA product (only fires with observed associated smoke)

Emissions

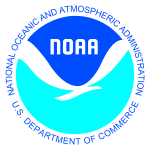
- USFS' BlueSky algorithm for emitted PM_{2.5}

Smoke Transport/dispersion

- HYSPLIT (Lagrangian); plume rise based on combustion heat and meteorology

Verification

- Based on satellite imagery for footprint of extent of observed smoke in atmospheric column exceeding threshold of detection



Continuing Science Upgrades

Improvements to the expanding NAQFC



Continuing R&D required

- OAR and EPA working actively with NWS to provide prototype capabilities for pre-operational development, testing experimental production, and implementation

Assuring quality with science peer reviews:

- Design review of major system upgrades (initial, yearly upgrades)
- Diagnostic evaluations with field campaigns and evaluations
- Publication of T&E in peer-reviewed literature

Ozone Capability

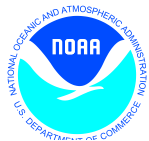
- *Otte et al. Weather and Forecasting, 20, 367-385 (2005)*
- *Mckeen et al., J. Geophys. Res. 110, D21307 (2005)*
- *Lee et al., J Applied Meteorology and Climatology (2007)*
- *Yu, et al. , J. Geophys. Res. (2007)*
- *Lee et al., Environmental Fluid Mechanics, 9 (1), 23-42, doi:10.1007/s10652-008-9089-0 (2009)*
- *Tang et al., Environmental Fluid Mechanics, 9 (1), 43-58, doi:10.1007/s10652-008-9092-5 (2009)*

Smoke Tool

- *Prados, A et al., J. of Geophys. Res., 112, D15201, doi:10.1029/2006JD007968 (2007)*
- *Kondragunta. S., et al., J. of Applied Meteorology and Climatology, doi:10.1175/2007JAMC1392.1 (2008)*
- *Rolph et al., Weather and Forecasting, Volume 24, pp 361-378 (2009)*
- *Stein et al., Weather and Forecasting, Volume 24, pp. 379-394 (2009)*

Dust prediction: Draxler et al., JGR, J. Geophys. Res., 115, D16212, doi:10.1029/2009JD013167 (2010)

PM Assimilation: Pagowski et al., QJRMS, Volume 136, pp 2013-2024 (2010)



Fraction correct of daily 8 hr Max ozone for next day predictions over CONUS for August 2010



OBSERVATION COUNTS:

8802

2112

551

137

5

0

0

