National Air Quality Forecast Capability: Updates to Operational CMAQ Ozone Predictions and Testing of PM2.5 predictions

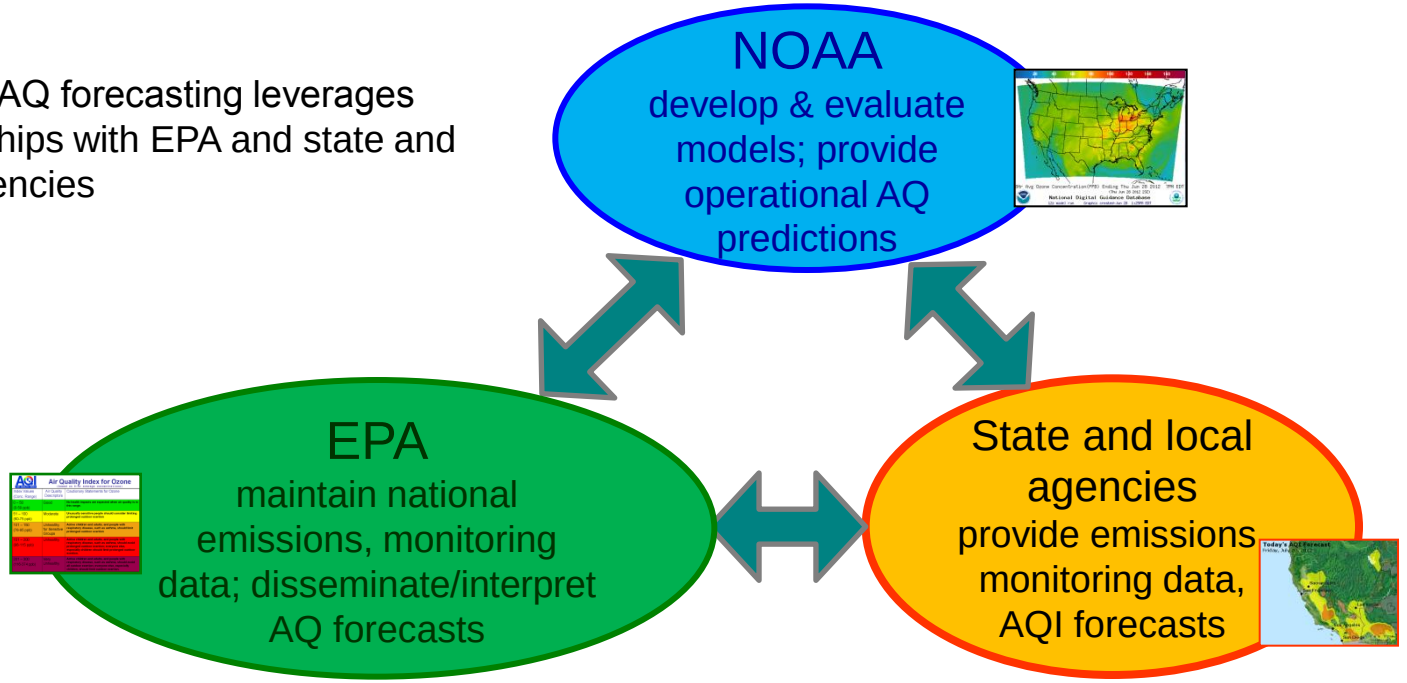
Operational Readiness Review

January 21, 2015

Background

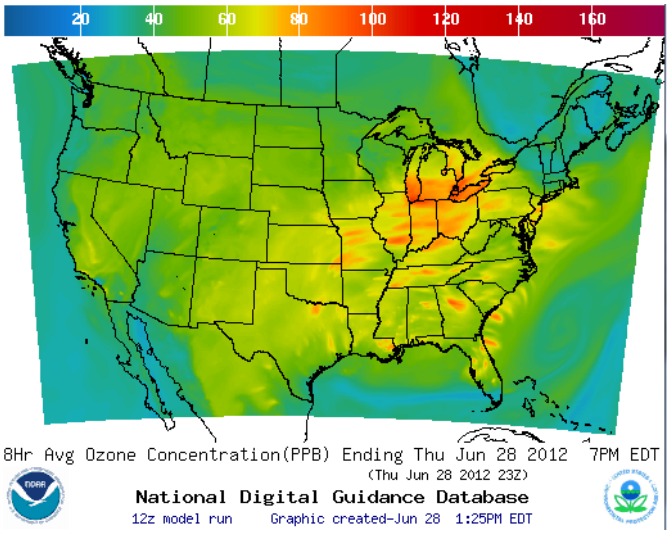
- **Ongoing implementation of NOAA/NWS National Air Quality (AQ) Forecast Capability operationally to provide graphical and numerical guidance, as hourly gridded pollutant concentrations, to help prevent loss of life and adverse health impacts from exposure to poor AQ**
  - *Exposure to fine particulate matter and ozone pollution leads to premature deaths: 50,000+ annually in the US (Science, 2005; recently updated to 100,000 deaths; Fann, 2011, Risk Analysis)*
- **Direct impact on reducing loss of life: AQ forecasts have been shown to reduce hospital admissions due to poor air quality (Neidell, 2009, J. of Human Resources)**

- NOAA's AQ forecasting leverages partnerships with EPA and state and local agencies

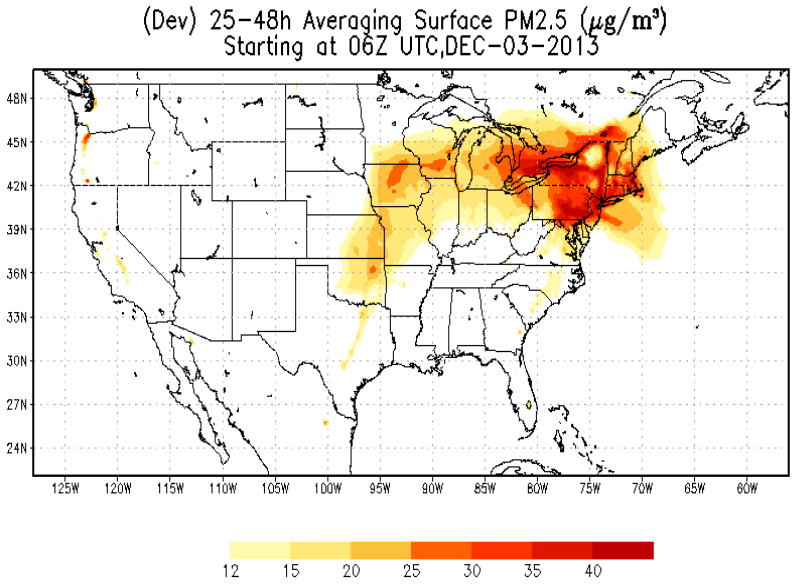


CMAQ products and testing

http://airquality.weather.gov/



Ozone predictions



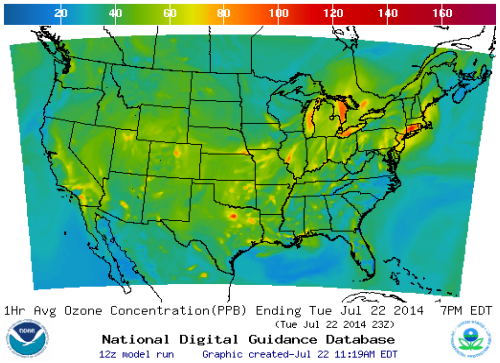
Testing of PM2.5 predictions

- Operational ozone predictions implemented for NE US in 2004, EUS in 2005, CONUS in 2007 and Nationwide in 2010
- Accuracy maintained over past 10 years: accounting for significant pollutant emission changes, weather model upgrades, and tighter warning thresholds used by state and local AQ forecasters in response to EPA's more stringent pollutant standards
- Developmental testing of semi-quantitative aerosol predictions based on pollutant emissions, begun in 2005

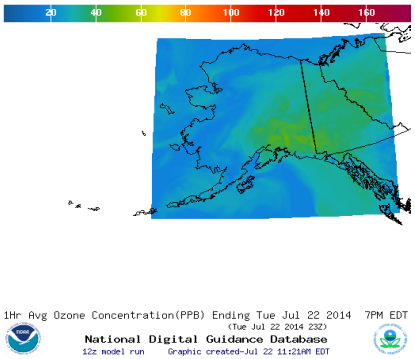
Ozone predictions

Operational predictions at http://airquality.weather.gov

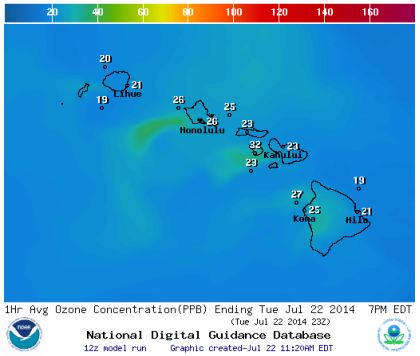
over expanding domains since 2004



1-Hr Average Ozone

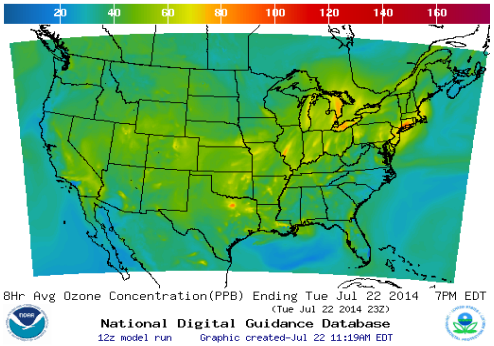


1-Hr Average Ozone

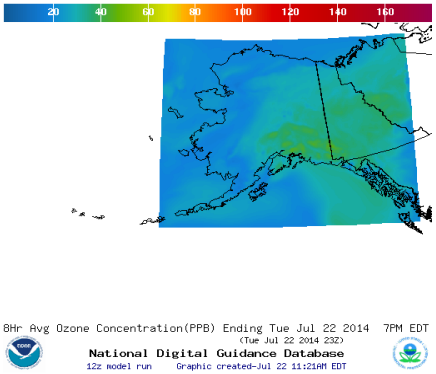


1-Hr Average Ozone

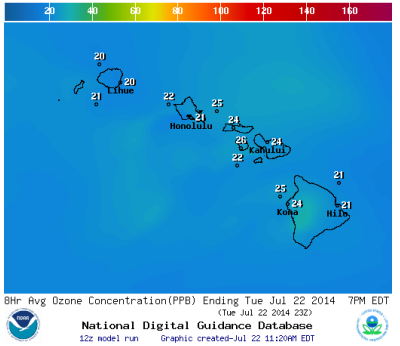
8-Hr Average Ozone

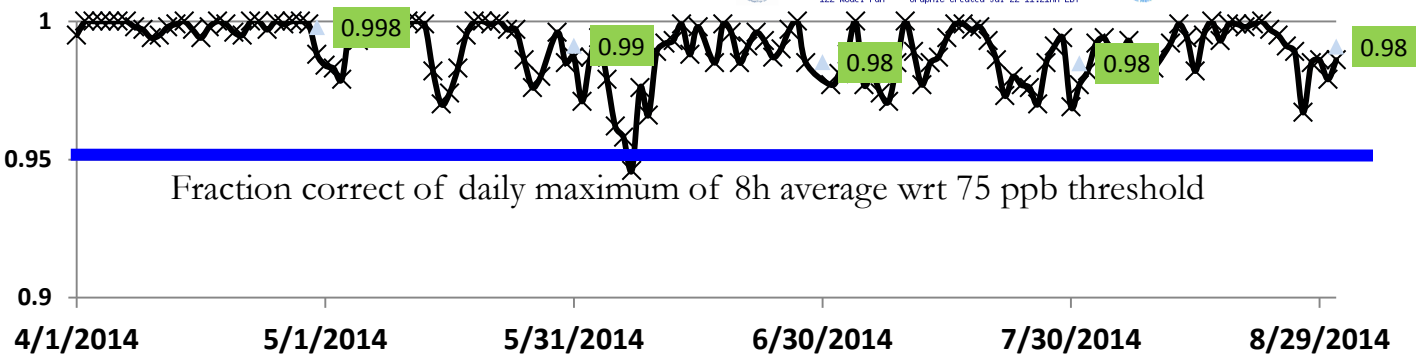


8-Hr Average Ozone



8-Hr Average Ozone





Operational

CONUS, wrt 75 ppb Threshold

Maintaining prediction accuracy as the warning threshold was lowered and emissions of pollutants are changing

Testing of PM2.5 Predictions

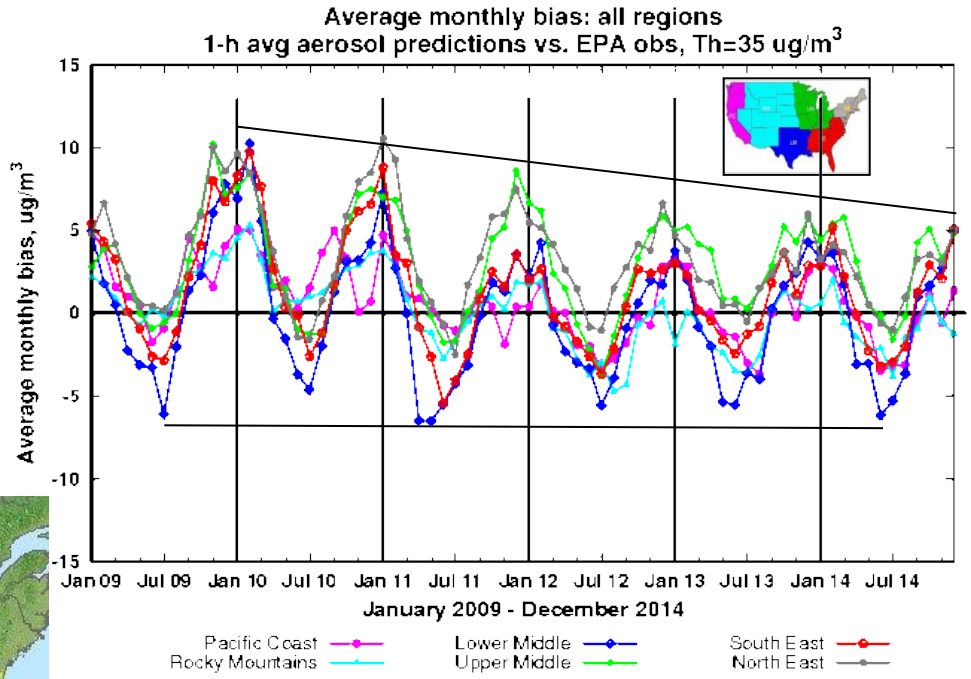
AQ Forecaster Focus group access only, real-time as resources permit

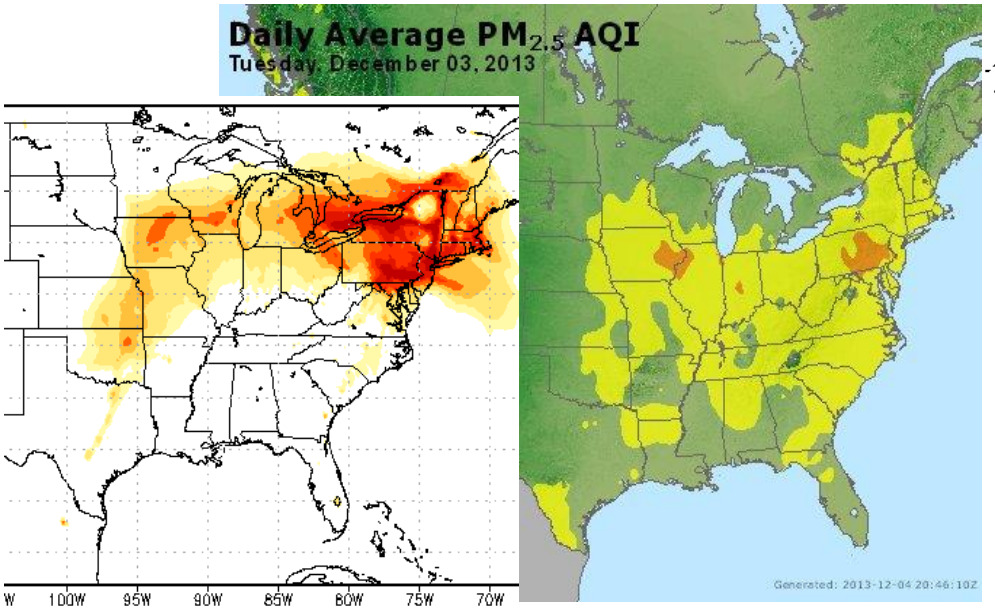
Aerosols over CONUS

From NEI sources only before summer 2014

- CMAQ:
  CB05 gases, AERO-4 aerosols
- Sea salt emissions

- Show seasonal bias-- winter, overprediction; summer, underprediction





NAQFC PM2.5 test predictions

Forecast challenges

- *Improving sources for **wildfire smoke and dust** – in testing since summer 2014*
- *Chemical mechanisms eg. SOA*
- *Meteorology eg. PBL height*
- *Chemical boundary conditions/trans-boundary inputs*

Updates to CMAQ system for CONUS Domain

The scientific enhancements include the following:

- Carbon Bond gas-phase Mechanisms (CB05) with updated rate constants and linkage with the particulate phase through heterogeneous reactions,
- Monthly varying lateral boundary conditions for 36 gaseous and aerosol species below 7 km altitude,
- Modified dry deposition velocity calculation,
- Planetary boundary layer height in the model constrained to be at least 50 m,
- Faster removal of organic nitrate from the atmosphere,
- Inclusion of particulate emissions from wild fires based on wildfire locations observed over the previous day,
- Suppression of soil emissions when terrain is covered by ice or snow,
- Windblown dust emissions are included using threshold friction velocity and soil wetness fraction with climatological source composition and locations.

- Simplify maintenance of AQ predictions by unifying prediction code for CONUS, AK and HI.

Testing of ozone prediction updates

Evaluation of daily maximum of 8h average ozone

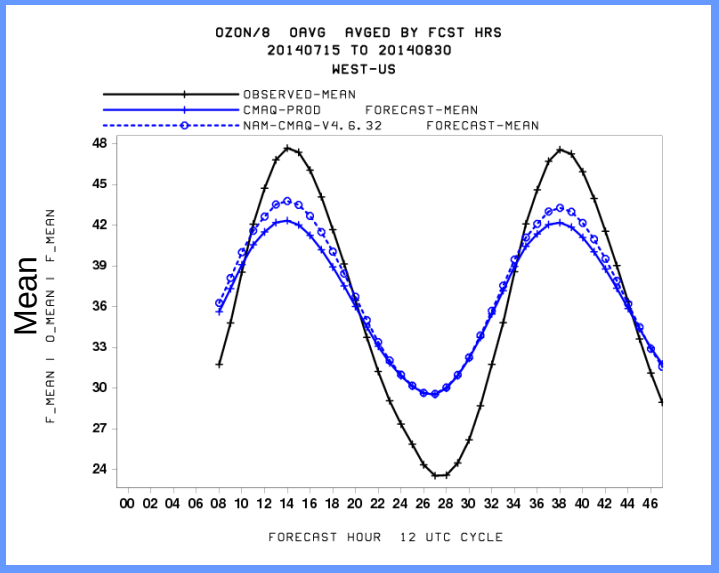
Model updates:

- CB05 chemical mechanism
- Lateral boundary conditions
- Dry deposition
- Minimum PBL height
- Faster removal of organic nitrate

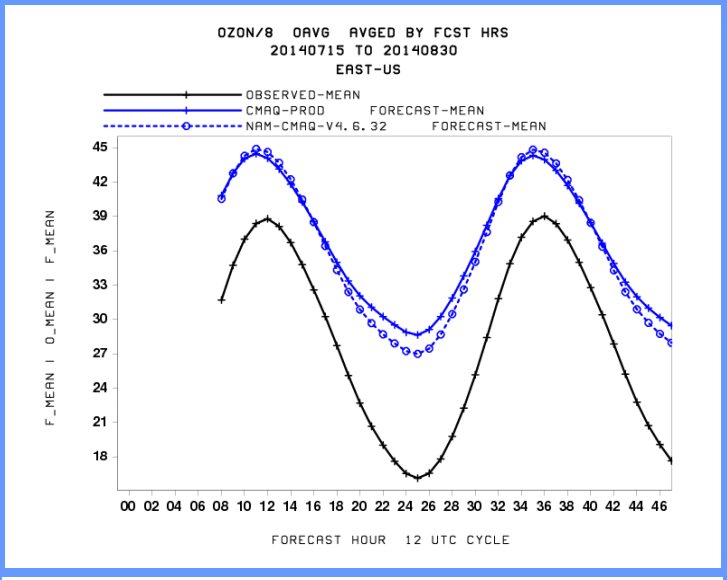
Performance:

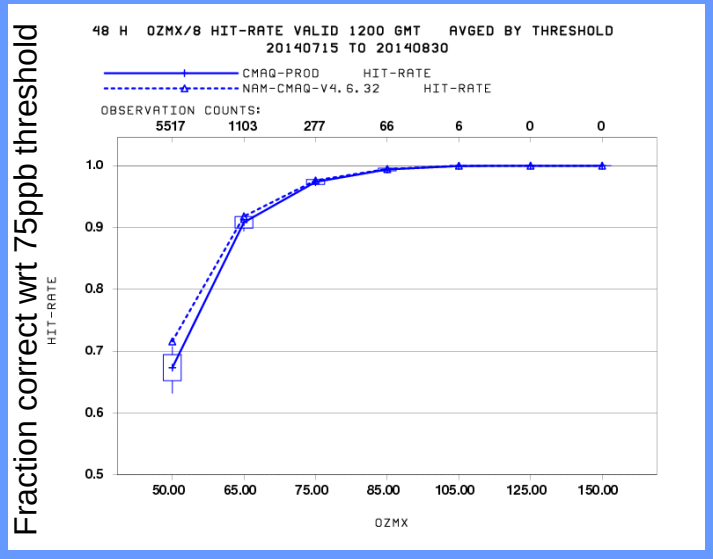
- Increased (better) diurnal variability
- Increased (better) peak ozone in the Western US
- Decreased (better) night-time minimum in the Eastern US
- Slightly increased (worse) peak ozone in the Eastern US
- Small changes in fraction correct for 75ppb threshold

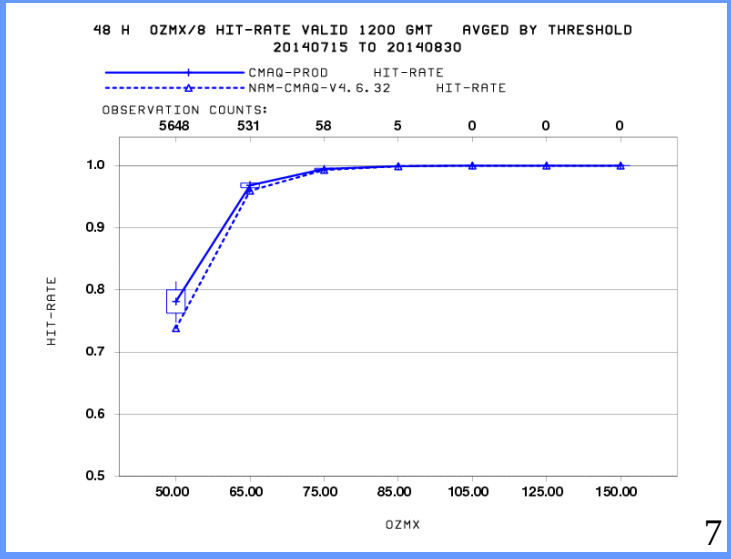
Western US



Eastern US

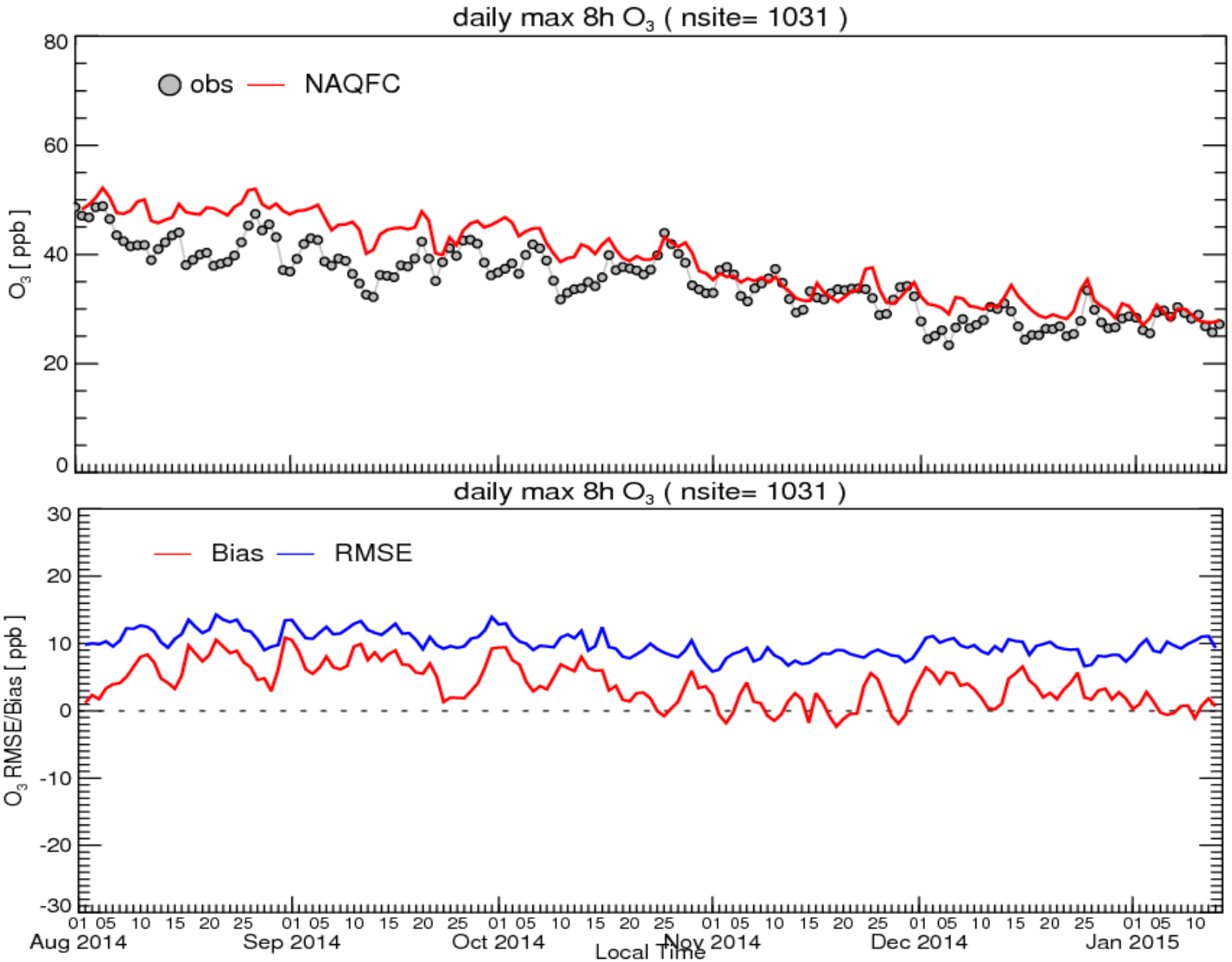






Experimental Ozone Predictions

CMAQ 4.6.3 (CONUS domain)



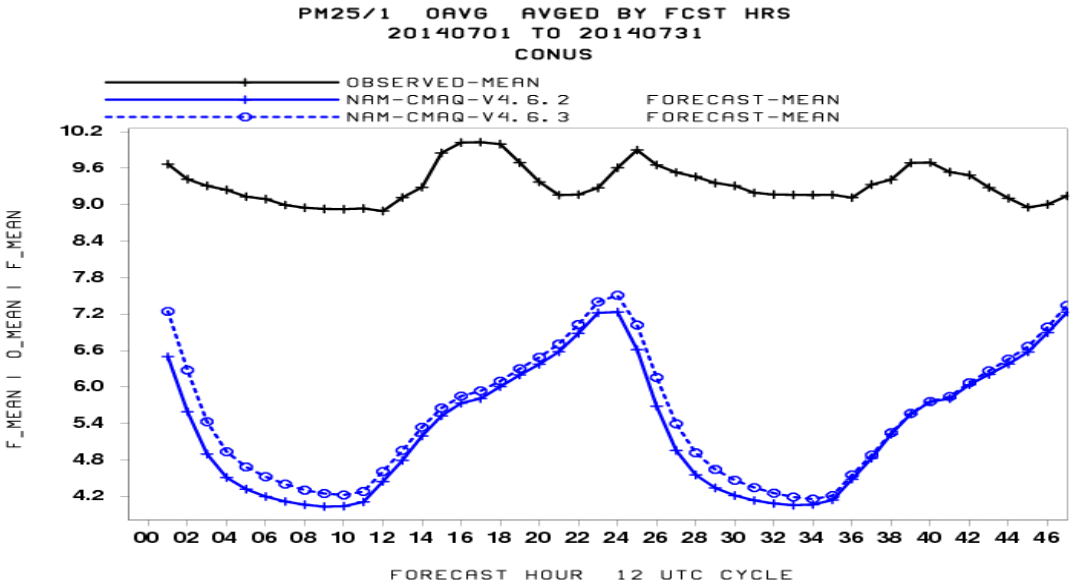
Testing of PM2.5 prediction updates

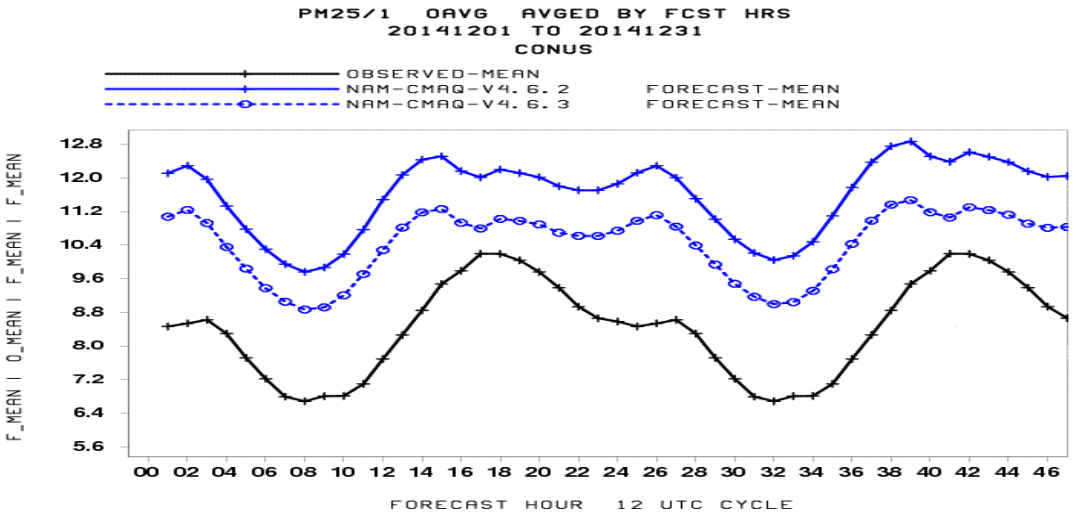
Evaluation of one hour average PM2.5 over CONUS

Performance:

- Slightly increased underprediction (better) in PM2.5 in the summertime
- Decreased (better) overprediction PM2.5 for wintertime

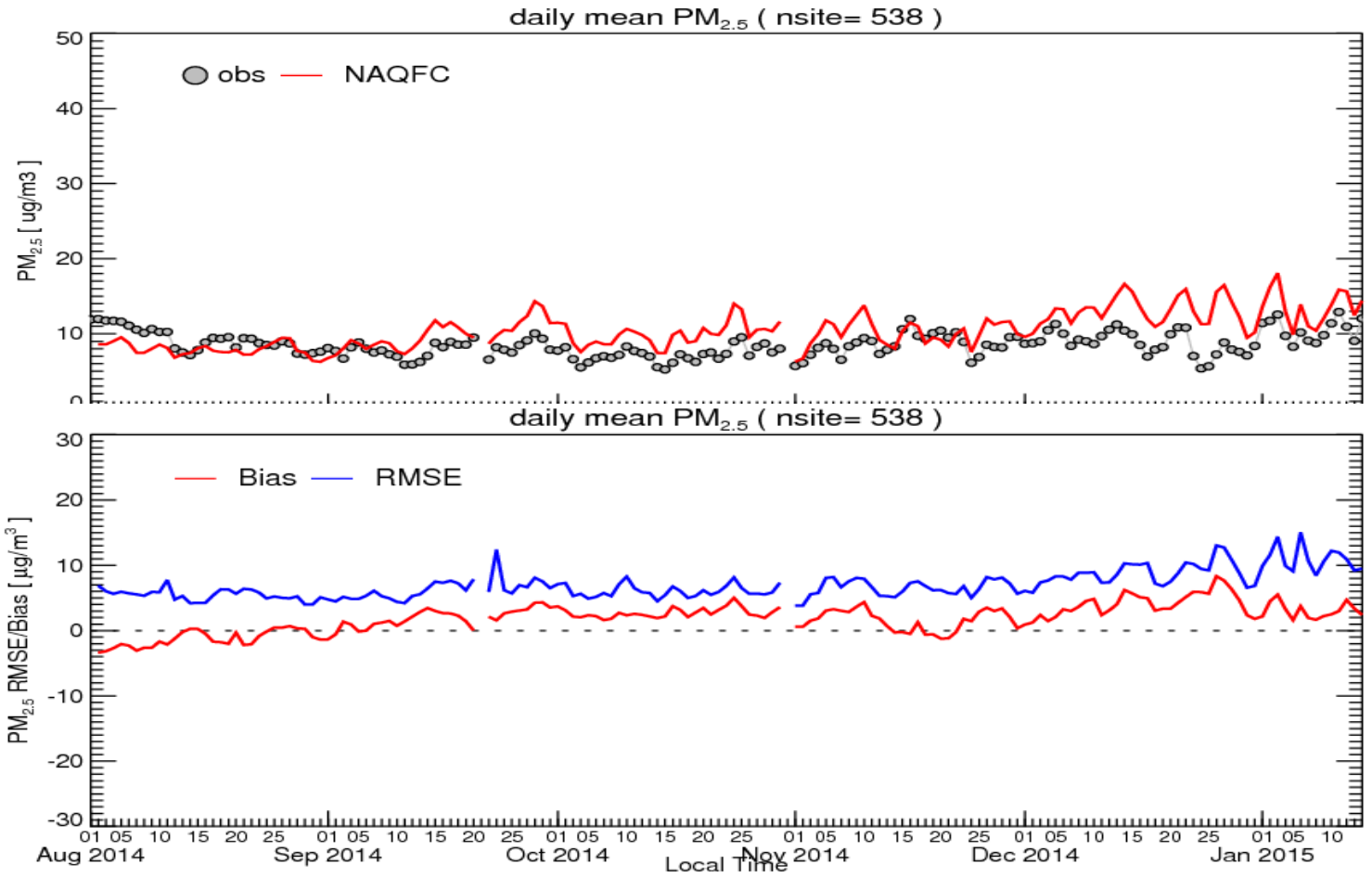
Mean





Developmental testing of PM2.5 Predictions

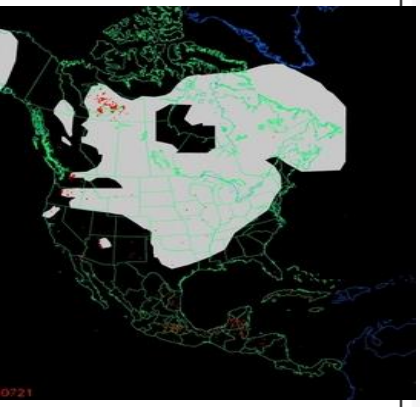
CMAQ 4.6.3 (CONUS domain)



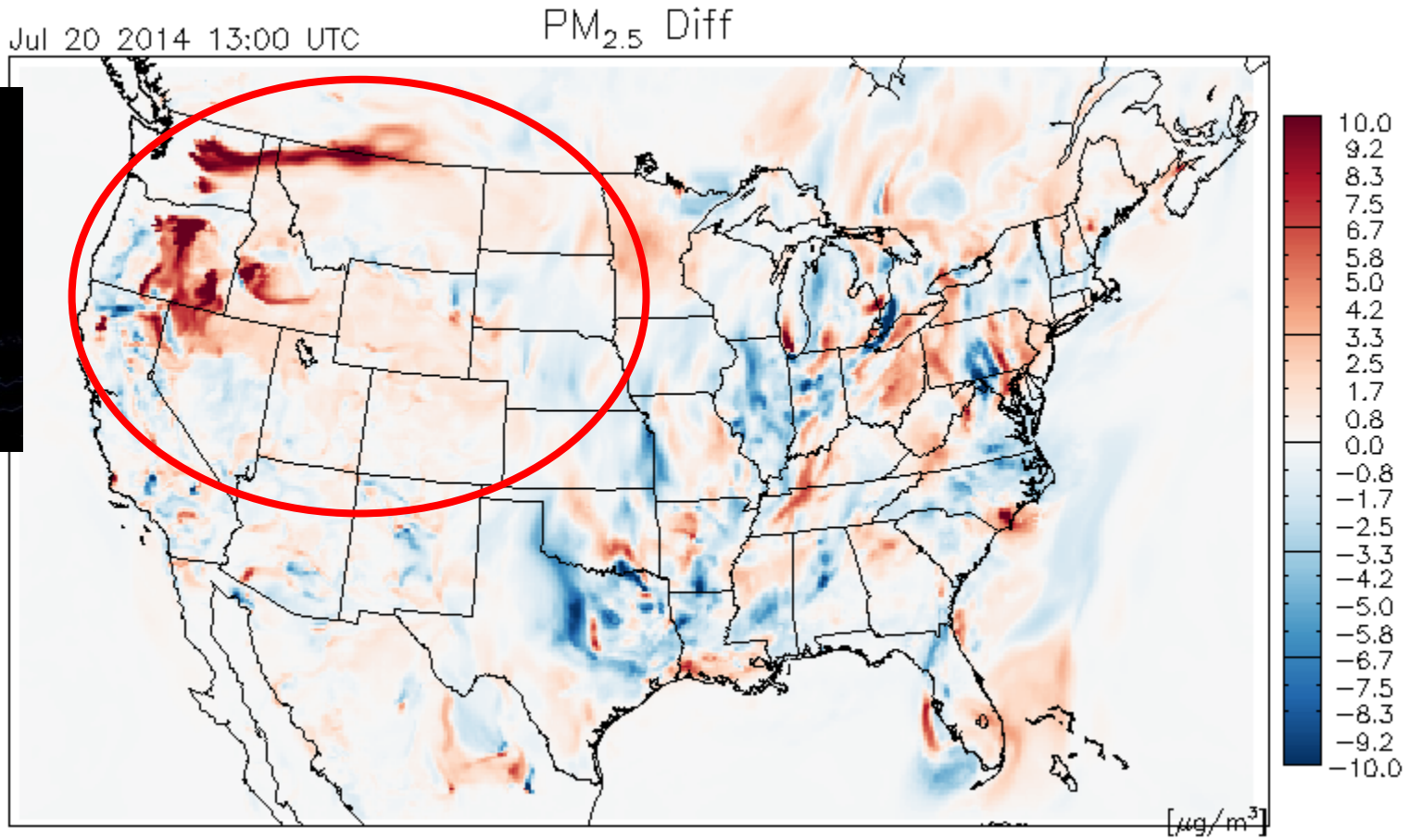
An error in computation of the daily average and daily maximum of PM2.5 developmental predictions was identified and corrected. 30-day parallel test was restarted on December 1.

Impact of forest fires in testing of PM2.5 predictions

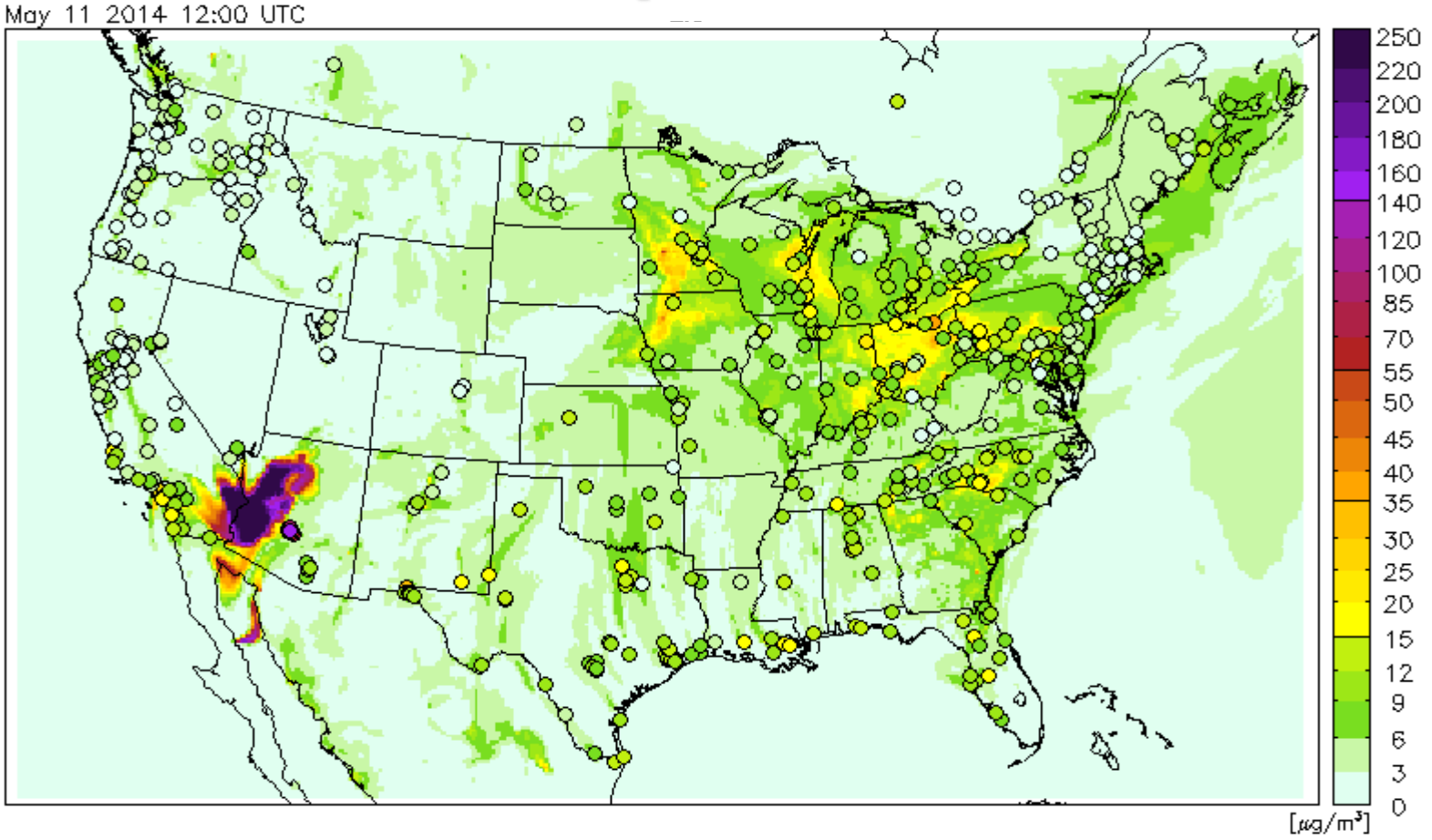
Difference between two PM2.5 predictions: with-minus-without fire emissions



NOAA NESDIS Hazard Mapping System Fire and Smoke Analysis



Blowing Dust Event in testing of PM2.5 predictions



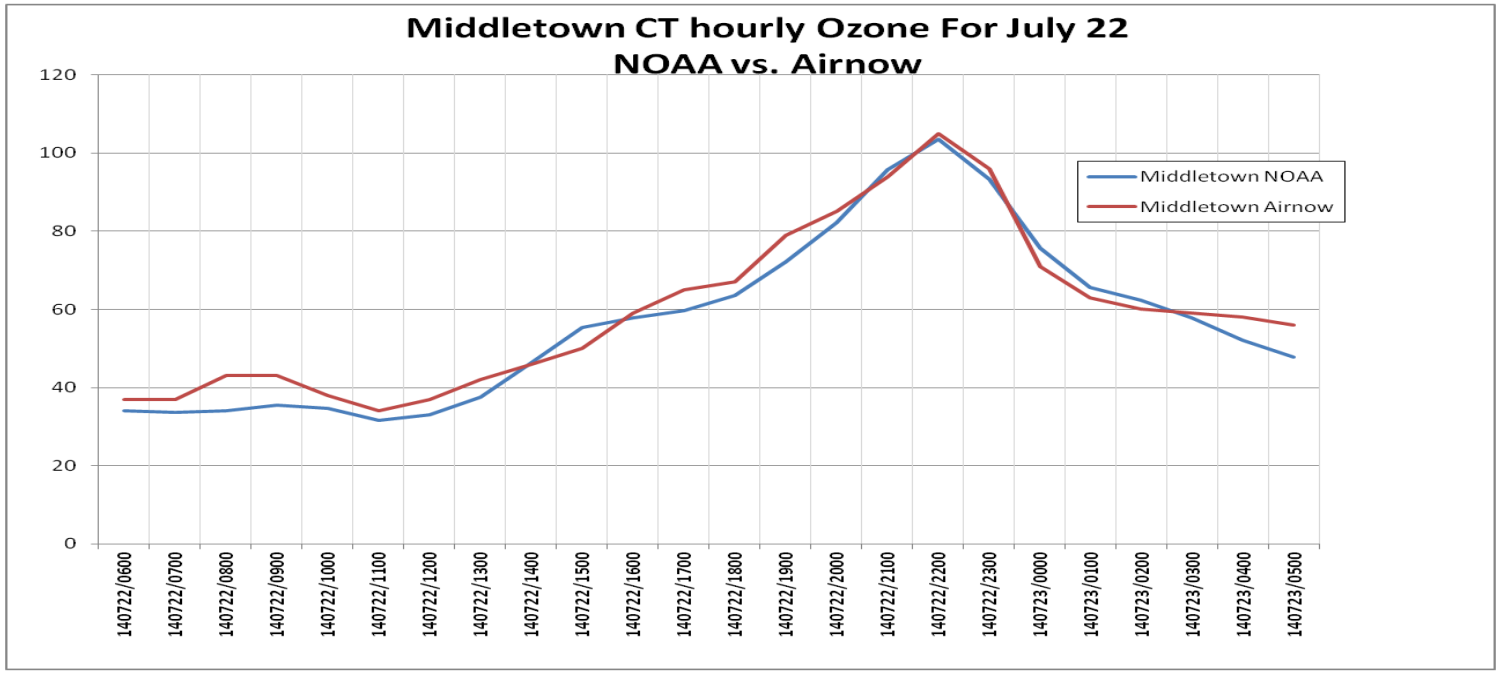
Independent NOAA/NESDIS analysis narrative based on satellite imagery:

BLOWING DUST

California/Arizona: An area of moderately dense blowing dust was visible sweeping across northern Baja California/Arizona into western New Mexico behind a strong cold frontal boundary. This remnant dust originated from multiple areas in southern California last evening.

Subjective Feedback

Comparison of 12z experimental ozone predictions with AirNow observations for Middletown, CT



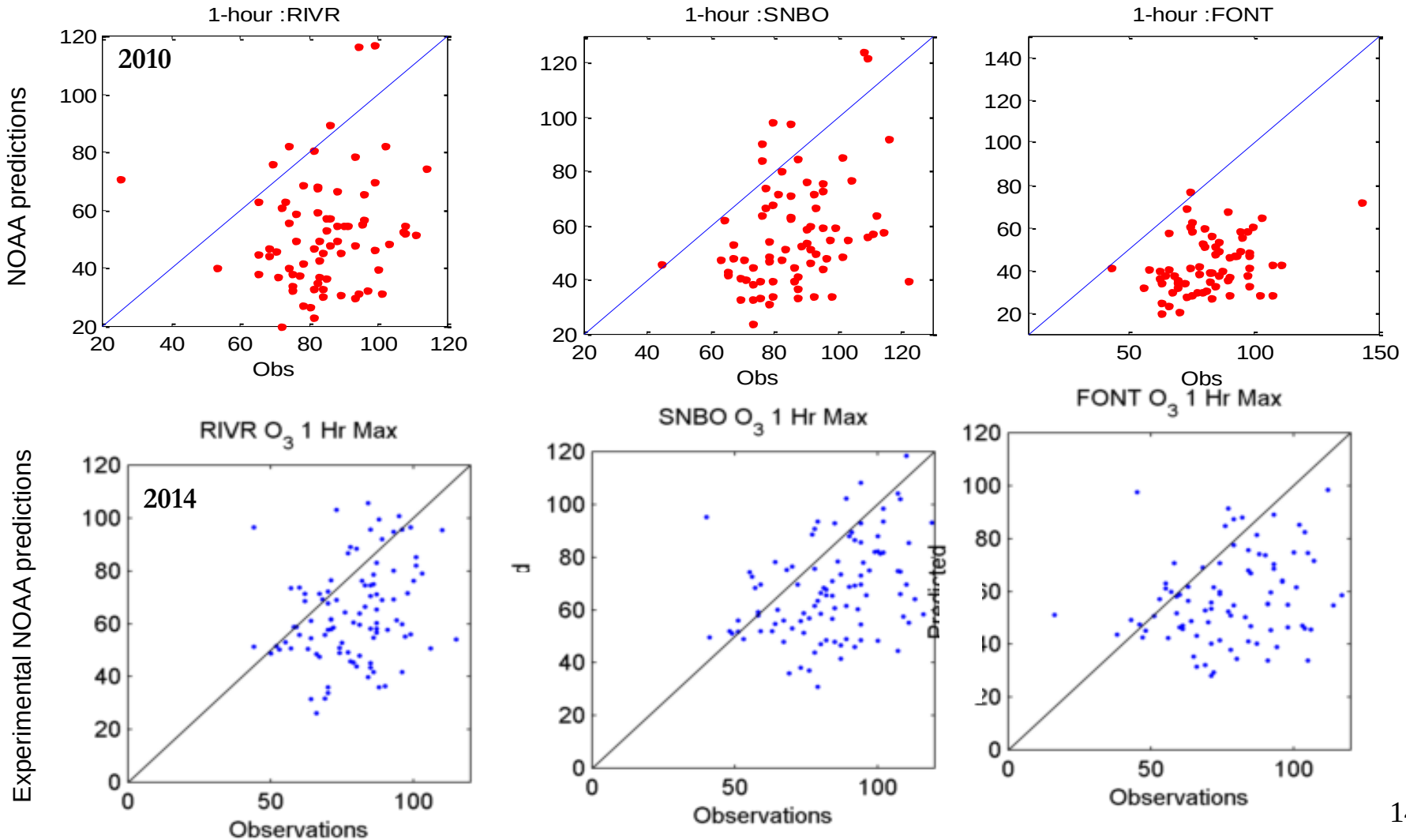
In Connecticut:

- Changes to the CB05 (EXP) model this year have markedly improved the ozone predictions in Connecticut.
- The CB05/AERO-4 model looks good for production.
- Model very useful for when it matters most: > 75ppb

(Michael Geigert, Connecticut Department of Energy and Environmental Protection)

Subjective Feedback (contd.)

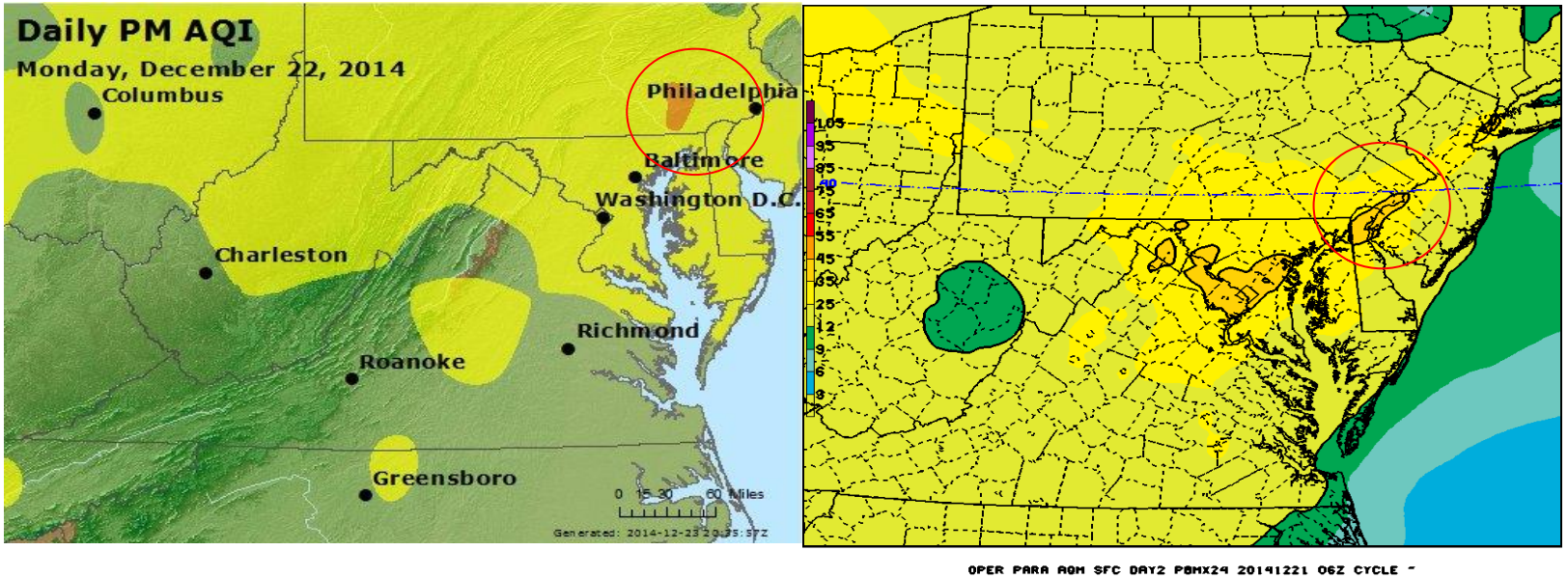
In California, 2014 experimental prediction has improved compared to 2010 model (Sang-Mi Lee, South Coast Air Quality Management District)



Subjective Feedback (contd.)

- The performance of the ozone predictions shows improvements for historically high ozone areas in Maine. The ozone predictions are very beneficial for our ozone forecasts (Tom Downs, ME CEP).
- During the evaluation period from July 15- to September 30, 2014 (for ozone), the NAQC-expr over-predicted peak ozone on the first day of the poor air episodes, but not excessively (i.e., near misses). The model accurately captured the upward trend in concentrations during the episodes. The NAQC-expr accurately captured the worst air quality day of the episodes. The NAQC-expr accurately captured the clean-out on the final day of the episodes. (Amy Huff, PSU).
- We support NOAA's continued efforts improve these models since some stakeholders in Missouri regional planning organizations are known to consult the NOAA air pollution forecast models (Stephen Hall, MI DNR).
- The experimental CMAQ runs were certainly no worse than the operational runs. (Dan Salkovitz, VA DEQ).
- All evaluations recommend to implement model update as proposed.

Subjective Feedback (contd.)



- The NAQC-expr accurately captured the worst air quality day of the episode (December 22) in Philadelphia. The availability of prototype predictions of fine particulate matter (PM2.5) from this system is beneficial as there are very few PM2.5 forecasting tools, so any improvements in PM2.5 predictions from NAQCF are very helpful. (Dr. Amy Huff, PSU).

Subjective Feedback (contd.)

- We use the PM2.5 model daily as one of our air quality forecast tools. It provides highly valuable information which we incorporate in our forecast analyses. Overall, we strongly support the implementation of the Community Multi-scale Air Quality (CMAQ) v3.6.8 model. (Dan Salkovitz, VA DEQ).
- The State of CT air quality forecasters depend on the PM2.5 model for our forecasts. It needs to be continued and developed further. (Michael Geigert, CT DEP).
- The availability of those (PM2.5) predictions is beneficial showing us the timing of regional transport into Maine (Tom Downs, ME CEP).
- Having hourly ozone and PM2.5 concentrations available is helpful (Michael Ku, NY DEC).
- All evaluations recommend to implement model update as proposed (PM2.5 remains in developmental testing).

Recommendation for Implementation

Recommendation:

NWS deploy updated CMAQ for operational ozone predictions as an update of operational air quality product suite and provide real-time testing of PM2.5 predictions from the same system.