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EXPANSION OF NOAA'S NATIONAL AIR QUALITY FORECAST GUIDANCE CAPABILITY TO 50 STATES*

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1. INTRODUCTION

Following Congressional direction, NOAA is building the US National Air Quality Forecast Capability (NAQFC) to provide operational air quality predictions with enough accuracy and lead time so that people can take actions to limit harmful effects of poor air quality. NOAA is developing the NAQFC in partnership with the US Environmental Protection Agency (EPA), and with state and local air quality agencies. NOAA has produced forecast guidance for surface ozone concentrations and smoke concentrations throughout the contiguous 48 states (CONUS) since year 2007, and added smoke forecast guidance for Alaska in August 2009 and Hawaii in February 2010. In addition, surface ozone predictions were implemented operationally for Alaska and Hawaii in September 2010. Operational forecast guidance for 50 US states is available on the web at www.weather.gov/aq, and experimental prediction guidance at www.weather.gov/aq-expr.

Ozone predictions are produced with the Community Multiscale Air Quality (CMAQ) model driven by NOAA's operational North American Mesoscale weather forecast Model (NAM); routine verification is conducted with surface monitoring data compiled by the EPA. Smoke production relies on satellite detections of smoke sources, US Forest Service emissions estimates, with transport and dispersion simulated by the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model driven by NAM. Verification is conducted with satellite data on smoke.

2. RECENT PERFORMANCE

NOAA's hour by hour forecast guidance at 12 km grid resolution out to 48 hours shows when and where predicted values of ozone and smoke are expected to reach harmful levels in cities, suburbs, and rural areas. Ozone forecasts are produced with a linked numerical prediction system run operationally at the National Centers for Environmental Prediction (NCEP) supercomputing facility: NAM weather predictions drive the CMAQ model (Lee et al. 2009). Monitoring data compiled by the EPA in real-time are used for routine verification of ozone predictions. Operational predictions are monitored to assure that they meet required accuracy targets for conditions used most commonly to issue AQ alerts (Lee et al. 2008). With respect to the current ozone warning threshold of 76 ppb, the fraction correct (Fig. 1a) has exceeded the target of 0.9 during summertime ozone season in 2010, varying from 0.99 in May to 0.95 in August (Fig. 1b). Smoke prediction relies on satellite detection of fires that emit smoke, US Forest Service emission estimates, and transport and dispersion simulations from the HYSPLIT model driven by NAM (Rolph et al. 2009). Satellite observations of smoke are used for routine verification of smoke predictions. Verification is reported as a threat score, also called a figure-of-merit in space (FMS), characterizing the overlap of predicted (P) with observed (O) smoke plumes (Fig. 1c). An example of smoke prediction performance over CONUS in August 2010 is shown in Fig. 1d, with average FMS of 0.11 exceeding the target FMS of 0.08.

3. PLANNED UPGRADES

The next upgrade of operational NAM, to the Non-hydrostatic Mesoscale Model on Arakawa B grid (NMM-B), is expected in 2011. Therefore, NOAA is modifying the coupling of NAM to CMAQ: first with a minor adaptation of CMAQ's vertical coordinate structure to that of NMM-B, and in follow-on testing, with a new version of CMAQ on the rotated longitude-latitude NMM-B grid. Use of the B-grid in CMAQ will facilitate tighter horizontal coupling between the meteorological and air quality models and it is expected to improve fidelity of air quality predictions at higher horizontal resolution. Several of the most significant changes in NMM-B for air quality predictions are: modifications to land use and

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* Dedicated to the memory of Deawon Byun

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‡ Deceased

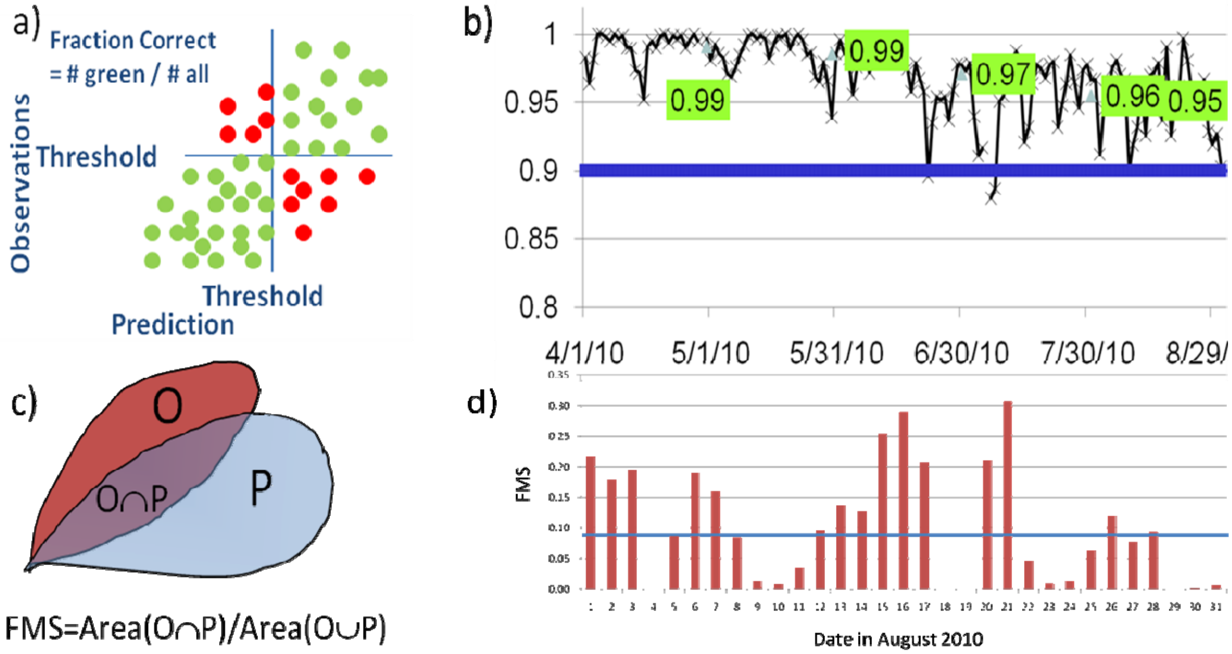

Figure 1. a) Schematic representation of the fraction correct. b) Fraction correct for operational ozone predictions for summer 2010 over CONUS. c) Schematic representation of the FMS score for predicted (P) and observed (O) smoke plumes. d) FMS score for smoke predictions over CONUS in August 2010. Blue lines in b) and d) denote target skills.

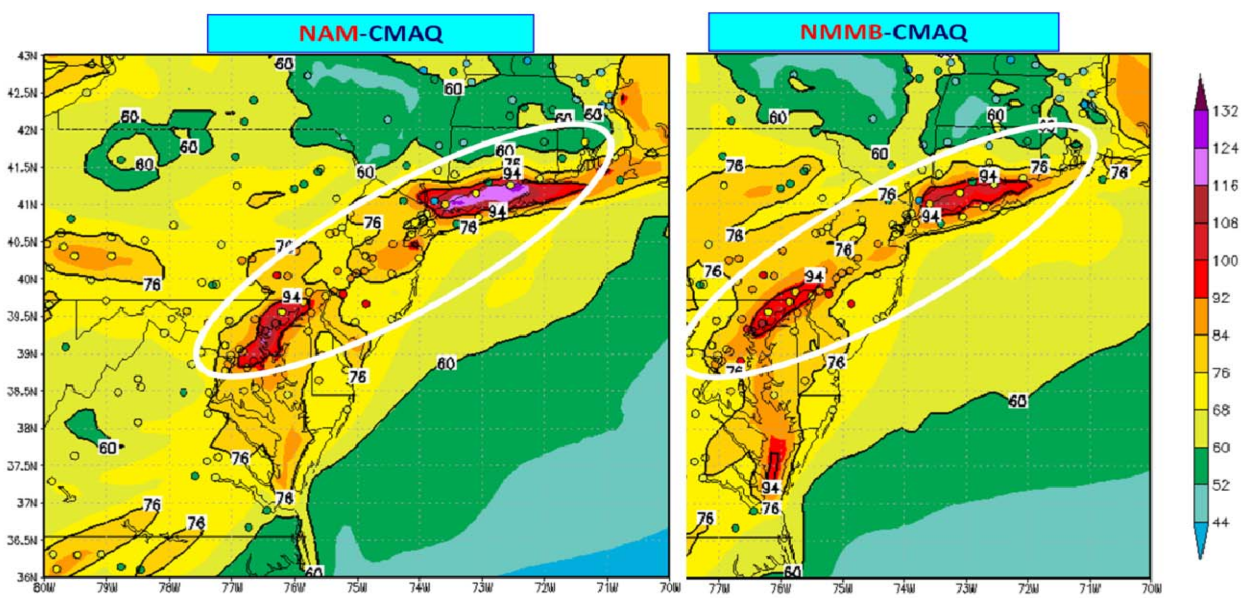

Figure 2. NMM-B coupled with CMAQ (right panel) reduces overprediction of 8-hr maximum ozone (in ppbv) on August 10, 2010 compared to NAM coupled with CMAQ (left panel) in the coastal region of the northeastern United States. Values observed at monitor locations are shown in circles using the same color scale.

land cover categories that impact biogenic emissions, and differences in planetary boundary layer depth estimates. Preliminary testing shows that NMM-B coupled with CMAQ reduces overprediction of ozone in coastal regions (Fig. 2).

In order to address a high bias in experimental ozone predictions in the more comprehensive Carbon Bond 5 (CB05) gas-phase mechanism employed in newer versions of CMAQ, recent studies examined the sensitivity of ozone predictions to several sources of model uncertainty: (1) specification of lateral boundary conditions, (2) formulation of dry deposition and (3) ways of limiting minimum depth of the planetary boundary layer. Evaluations with hindcasts for August 2009 indicate that the combination of changes in these three components reduces overprediction biases in most regions. Planned improvements in these components, along with significant updates to pollutant emission inventories are currently being tested.

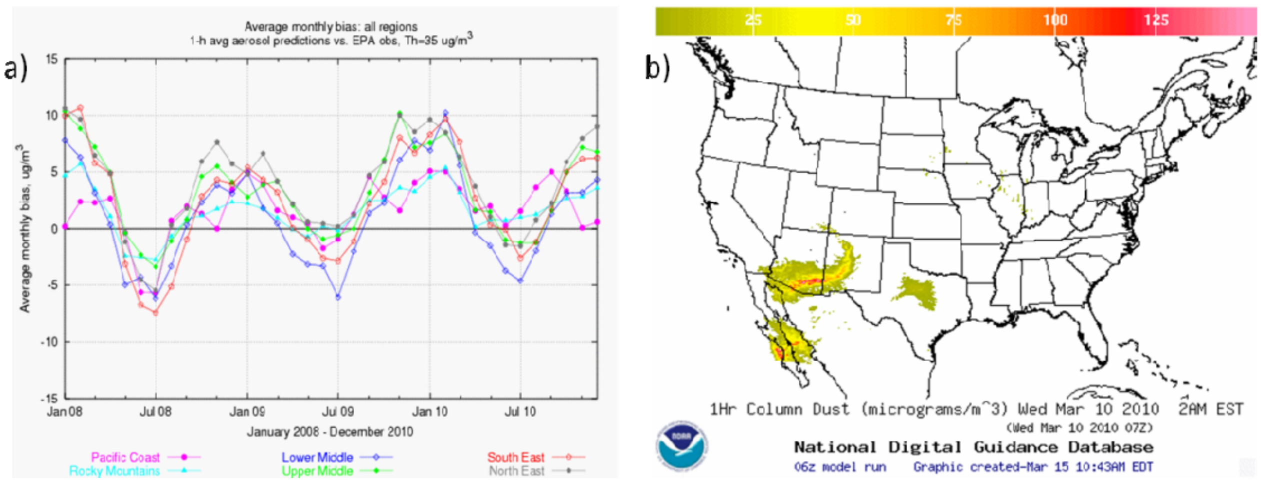

Figure 3. a) Monthly bias of CMAQ aerosol predictions in comparison with AIRNow surface observations of PM2.5 for six US regions from January 2008 through December 2010. b) Example of dust prediction showing average dust concentration in the column between surface and 5000 m for March 10, 2010.

4. DEVELOPMENT OF FINE PARTICULATE MATTER (PM2.5) PREDICTIONS

NOAA's National Weather Service (NWS) is focusing on testing advanced capabilities that will lead to quantitative predictions of airborne fine particles (PM2.5). Several challenges are being addressed:

(1) Chemical mechanisms for inventory-based predictions. More comprehensive chemical mechanisms are needed to account for reactive chemical transport and secondary formation of aerosols from pollutants, but testing has shown these more comprehensive mechanisms over-predict ozone. Compensatory improvements are in testing (see e.g. section 3).

(2) Inclusion of intermittent sources. Predictions of PM2.5 from inventoried emissions show substantial seasonal biases that are consistent with missing intermittent sources in the summertime (Fig. 3a). Smoke from wildfires, and airborne dust are being tested and implemented as components. Standalone experimental testing of dust predictions over CONUS relies on source regions with dust-emissions potential that are estimated from monthly climatology of satellite-observed dust events during 2003-2006 (Ginoux et al. 2010). When surface winds exceed entrainment thresholds, dust is emitted and transported by the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model driven by NAM meteorology to predict surface and column dust concentrations (Draxler et al. 2010). An example from testing of dust predictions is shown in Fig. 3b. Long-range transport of dust impacting CONUS domain is being incorporated through boundary-conditions to help capture events like springtime Asian dust transport and summertime trans-Atlantic transport of Saharan dust.

(3) Real-time ingestion of observations. Smoke predictions are based on satellite observations of wildfires location and extent; however surface measurements of the fine particles have not been used in real-time prediction. NOAA is testing a data assimilation capability to reduce biases in predicted surface concentrations of PM2.5 (Pagowski et al. 2010). Successful development and testing would lead to advanced developmental guidance for PM2.5 for summer 2011.

NOAA's air quality forecast guidance, experimental and developmental products are being evaluated and tested with a focus group of state and local AQ forecasters. NWS forecasters at the Weather Forecast Offices and NCEP are also encouraged to share their weather expertise and coordinate with their corresponding state and local air quality forecasters.

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