National Air Quality Forecasting Capability: performance, recent updates and plans

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Outline

Background on NAQFC

Progress in 2009/2010
- Operational products
- Experimental testing/products
- Developmental testing

Coordination with Partners

Looking Ahead
National Air Quality Forecast Capability

Current and Planned Capabilities (2/10)

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

**Prediction Capabilities:**

- **Operations:**
  - Ozone implemented over CONUS (9/07)
  - Smoke implemented over CONUS (3/07), AK (9/09) and HI (2/10)

- **Experimental testing/products:**
  - Ozone upgrades

- **Developmental testing:**
  - Ozone over AK and HI
  - Components for particulate matter (PM) forecasts
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 2009/2010

**Ozone Upgrades: Operations (9/18/07) over Coast-to-Coast (CONUS) domain**
- **Operations**: CONUS (updated emissions); new 1, 8-hour daily maximum products
- **Experimental Testing**: CB-05 chemical mechanism
- **Developmental testing**: developing prototypes for AK, HI

**Smoke: Operations (3/1/07) over CONUS**
- **Operations**: CONUS Dec 2008 upgrades. AK (9/29/09), HI (2/23/10) smoke implemented into operations
- **Developmental testing**: Improvements to verification

**Aerosols: Developmental testing providing comprehensive dataset for diagnostic evaluations. (CONUS)**
- **CMAQ (aerosol option), testing CB05 chemical mechanism**
  - Qualitative; summertime underprediction consistent with missing source inputs
- **Dust and smoke inputs: testing dust contributions to PM2.5 from global sources**
  - Preliminary tests combining dust with CMAQ-aerosol
  - Case studies combining smoke inputs with CMAQ-aerosol
- **Testing prediction of dust from CONUS sources**
- **R&D efforts continuing in chemical data assimilation, real-time emissions sources, advanced chemical mechanisms**
Updates in 2009

Operational Products

NAM update (December, 2008)

- **Model Parameterizations**: PBL/turbulence schemes and vertical diffusion applied to separate water species, absorption coefficients for water and ice doubled in radiation scheme, changes to land-surface physics under snow coverage
- **Data assimilation**: Upgraded GSI with a new version of radiative transfer, more satellite and aircraft obs
- **Initialization**: Background for the first analysis comes from the global system (GDAS)

Ozone Predictions: Emissions Updates (May, 2009)

- Point, area and mobile source emissions: updated based on NEI (2005) and projected for the current year.
  - EPA Office of Transportation and Air Quality on-road emissions estimates
- **Biogenic sources**: updated with BEIS 3.13

Smoke:

- **Alaska**: operational implementation on Sept 29, 2009
- **Hawaii**: operational implementation on Feb 23, 2010
Operational AQ forecast guidance

www.weather.gov/aq

Ozone:
CONUS

Smoke:
CONUS, AK and HI
Progress from 2007 to 2009:

**CONUS O₃ Prediction Summary Verification**

### 2007

**Experimental**

Contiguous US (CONUS)

Implemented 9/07 to replace Eastern US config in operations

### 2008

**Operational**

CONUS, wrt 85ppb Threshold

### 2009

**Operational**

CONUS, wrt 85ppb Threshold
Experimental Predictions

Publicly available, real-time

Ozone:
- CMAQ with advanced gas-phase chemical mechanism CB05
  - more Volatile Organic Compound (VOC) reactions
  - challenge: more O₃ with CB05
  - regional implications: CA, NE US

Smoke:
- Testing over AK and HI domains
  - new GOES-W smoke verification
  - AK: active summer 2009 fire season; over 2.9 M acres burned

Both now operational
Smoke from wildfires in Alaska

86 active wildfires on **August 4, 2009**
4 temporary flight restrictions
Over 2.9 million acres burned in 2009

- Large Alaskan fires began in early July 2009
- Driest July ever recorded in Fairbanks (only 0.06” since July 1, normally the second wettest month of the year) and second warmest July ever (avg 66.5 deg).
Verification of Alaska smoke predictions

Example
7/13/09, 17-18Z

FMS = 35%,
for column-averaged
smoke > 1 ug/m³

First routine, real-time objective verification for wildfire smoke in Alaska

- Uses new GOES Aerosol Smoke Product (GASP)
  - Smoke from identified fires only
  - Filtered for interference from clouds, surface reflectance, solar angle, other aerosol

- “Footprint” comparison with Figure-of-merit statistics for concentration of (1 µg/m³):

\[
\text{Precision} = \frac{\text{Area Pred} \cap \text{Area Obs}}{\text{Area Pred. U Area Obs}}
\]

Summary for July 2009
- Daily objective verification
- Exceeds target 25/31 days
- Average FMS >16%
Testing of HI smoke predictions

1Hr Vertical Smoke (micrograms/m^3) Wed Jan 06 2010 9PM HST
Experimental (Thu Jan 07 2010 07Z)

National Digital Guidance Database
06z model run Graphic created-Jan 11 4:49AM HST
Developmental predictions, Summer 2009

HI and AK ozone (from Aug 2009) using CMAQ with CB05 (gases)

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
Forecast challenges

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

Focus group, State/local AQ forecasters:

- Participate in real-time developmental testing of new capabilities, e.g. aerosol predictions
- Provide feedback on reliability, utility of test products
- Local episodes/case studies emphasis
- Regular meetings; working together with EPA’s AIRNow and NOAA

Feedback is essential for refining/improving coordination
From Brian Lambeth, Texas CEQ:

Daily comparison of late-day predictions with AIRNow summary.

“…tendency for the model to over-predict the highest ozone levels more often than not…” [e.g.] Atlanta.”

From Bill Murphey, Georgia EPD:

Mean overprediction of daily 8-h maximum ozone over Atlanta is 6.9 ppb and correlation is 0.7 for summer 2009.
Real-time Testing, Summer 2009: Experimental vs Operational \(O_3\) at 76 ppb

**Experimental vs. Operational, 76 ppb: FC decreases in experimental predictions**
Updated CB05 mechanism shows larger biases than CBIV

- Summertime,
- Eastern US.

Sensitivity studies in progress:

- Chemical speciation
- Indicator reactions

**Graph Details:**
- **Y-axis:** Ozone Mean Bias (ppbv)
- **X-axis:** Julian Day
- **Legend:**
  - CBIV
  - CB05
- **Seasonal input differences**
  - Emissions
  - Meteorological parameters
- **Mechanism differences**
  - Ozone production
  - Precursor budget
National Air Quality Forecast Capability

Looking Ahead

Nationwide ozone and particulate matter predictions

- **Expanding ozone & smoke to 50-state coverage, Target: FY10**
- **Dust implemented as separate module**
- **Begin quantitative particulate matter predictions, Target: FY15**

- Providing information Nationwide on when/where poor AQ is expected
- Reducing losses to life (50,000) each year from poor AQ
- Reducing economic losses ($150B each year) from poor AQ
Testing of CONUS dust predictions
# Program Overview, NAQFC: Team Members

<table>
<thead>
<tr>
<th>Team</th>
<th>Members</th>
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<tr>
<td><strong>NOAA/NWS/OST</strong></td>
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<td>Matt Seybold, Mark Ruminski</td>
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**EPA/OAQPS partners:**

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

*Guest Contributors*
Backup
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
- McKeen et al., J. Geophys. Res. 110, D21307 (2005)
- Lee et al., J Applied Meteorology and Climatology (2007)

Smoke Tool
- Rolph et al., Weather and Forecasting, Volume 24, pp 361-378 (2009)
- Stein et al., Weather and Forecasting, Volume 24, pp. 379-394 (2009)