Evaluation of Air Quality Prediction and NAM models

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More Emphasis on NAM Nests

NCEP/EMC will move to high resolution (3 km) Ensembles
In the next 3-5 years.
NAM Parent may be replaced by Global Model in this time frame.

HYSLPLIT, other dispersion models like HPAC
• Smoke/dust/radiological/chemical releases
• Support Jianping Huang’s study for the AMS annual meeting where he will compare HYSLPLIT using the NAM parent vs the nest

RTMA and downscaling (DNG)
• Most of downscaling is done from the NAM nests for hours 01-60 (and parent for other hours).
Global Forecast System (April 2014)
Probable components

• Model
  – T1534 Semi-Lagrangian (~13km globally)
  – Use of high resolution daily SST and sea ice analysis
  – Physics
    • Cloud estimate modifications
    • Radiation modifications
    • High wind surface drag modification
    • Convective gravity wave drag
    • Dissipative heating
    • Snow accumulation consistent between model and post-processor
  – Land Surface
    • Removal of soil moisture nudging to climatology
    • Modification of vegetation tables
    • 20 category high resolution vegetation and high resolution soil type
    • Spin up of land state
Mesoscale Modeling 3-5 yr goals

High Resolution Rapid Refresh ENSEMBLE (HRRRE)

Each member of NARRE contains 3 km nests

- CONUS, Alaska, Hawaii & Puerto Rico/Hispaniola nests
- The two control runs initialized with radar data & other hi-res obs

- Provide PROBABILITY guidance with full Probability Density Function specified, hence uncertainty information too
- Provide a vehicle to improve assimilation capabilities using hybrid (EnKF+4DVar) technique with current & future radar & satellite
- Address Warn-on-Forecast as resolutions evolve towards ~1 km
CMAQ Operational Ozone Forecasts

Ozone Updates:

- Continued to use 2012 emission updates:
  - Mobile6 used for mobile emissions, but with emissions scaled by growth/reduction rate from 2005 to 2012
  - Non-road area sources use Cross State Rule Inventory
  - Canadian emissions use 2006 inventory
- FY14: CMAQ V4.6 ozone transferred to NCEP Production run and continue PM testing
- Suspended: Testing of V4.7.1, inclusion of smoke, PM data assimilation at EMC

**Dust updates:**
- *Dust predictions implemented operationally in March 2012*
- *Dust emissions are modulated by real-time soil moisture*

**Smoke updates:** **CONUS, Alaska, Hawaii in July 2013**
- updates to plume rise and deposition parameters

**Emergency Response, On-Demand:** Upgraded July 2013
- Volcanic ash, WMO Center for emergency response for radiological release
- Comprehensive Test Ban Treaty Rad. Source Location support
HYSPLIT Smoke Upgrades Impact
Column Avg (op-exp, ug/m3)
HYSPLIT Smoke and Dust Verification
Column Avg (op-exp, ug/m3)

http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html
Emergency Response: Fukushima Simulations

- Cs-137 air concentrations
- 5000 particles per hour
- 0.5 degree NOAA GDAS meteorological data
- Most important Met parameter:
  - Precip near the source

NOAA HYSPLIT MODEL
Concentration (mBq/m³) averaged between 0 m and 500 m
Integrated from 1800 11 Mar to 0000 12 Mar 11 (UTC)
Cpar Release started at 1800 11 Mar 11 (UTC)

Source: 37.421 N 141.033 E

GHDA METEOROLOGICAL DATA

- >1.0E+03 mBq/m³
- >5.0E+02 mBq/m³
- >2.0E+02 mBq/m³
- >1.0E+02 mBq/m³
- >5.0E+01 mBq/m³
- >2.0E+01 mBq/m³
- >1.0E+01 mBq/m³
- >5.0E+00 mBq/m³
- >1.0E+00 mBq/m³
- >5.0E-01 mBq/m³
- >2.0E-01 mBq/m³
- >1.0E-01 mBq/m³

Maximum: 1.2E+03 (identified as a square)
Minimum: 5.1E-04
Overview of NOAA GFS Aerosol Component (NGAC)

Model Configuration:
- Forecast model: Global Forecast System (GFS) based on NOAA Environmental Modeling System (NEMS), NEMS-GFS
- Aerosol model: NASA Goddard Chemistry Aerosol Radiation and Transport Model, GOCART

Phased Implementation:
- Dust-only guidance is established in Q4FY12
- Full-package aerosol forecast after real-time global smoke emissions are developed (JSCDA project)

Near-Real-Time Dust Forecasts
- 5-day dust forecast once per day (at 00Z), output every 3 hour, at T126 L64 resolution
- ICs: Aerosols from previous day forecast and meteorology from operational GDAS

Acknowledge: Development and operational implementation of NGAC represents a successful “research to operations” project sponsored by NASA Applied Science Program and JCSDA
Dynamic LBCs for regional models

- Baseline NAM-CMAQ with static LBCs versus experimental NAM-CMAQ with dynamic LBCs from NGAC, verified against AIRNOW observations
- The inclusion of LBCs from NGAC prediction is found to improve PM forecasts (e.g., reduced mean biases, improved correlations)

<table>
<thead>
<tr>
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<th>CMAQ Baseline</th>
<th>CMAQ Experimental</th>
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<tbody>
<tr>
<td>Whole domain July 1 – Aug 3</td>
<td>MB= -2.82 R=0.42</td>
<td>MB= -0.88 R=0.44</td>
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<tr>
<td>South of 38°N, East of -105°W July 1 – Aug 3</td>
<td>MB= -4.54 R=0.37</td>
<td>MB= -1.76 R=0.41</td>
</tr>
<tr>
<td>Whole domain July 18– July 30</td>
<td>MB= -2.79 R=0.31</td>
<td>MB= -0.33 R=0.37</td>
</tr>
<tr>
<td>South of 38°N, East of -105°W July 18– July 30</td>
<td>MB= -4.79 R=0.27</td>
<td>MB= -0.46 R=0.41</td>
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</tbody>
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NAM Parent and Nest Domains

- 84 hour (Nests : 60 h) forecasts 4x/day
- North American Parent : 12 km
- CONUS, AK, HI, PR Nests : 4 km
- Fire Weather Nest : 1.3 km

http://www.emc.ncep.noaa.gov/mmb/mmbpll/nam_conusnest
Real Time Mesoscale Analysis
2.5 km

- Useful for Evaluations
- Downscaled predictions to 84 forecast hours (DNG)

http://www.emc.ncep.noaa.gov/mmb/mmbpll/nampllverif_2mods
CMAQ 8h max O3
Threat Score by threshold

West

East

CMAQ Ozone BIAS by day (33 hr, 8 H avg)

West

Strongest overprediction in East
Highest Observations on 6/20-22, 7/18-20

www.emc.ncep.noaa.gov/mmb/aq/fvs/web/html/
CMAQ Operational 1h Max
Day 2 Ozone forecast

(prd) 12Z 17H-40H 2 day 1h max sf O₃ (ppbv) Valid 22 JUN 2013

(prd) 12Z 17H-40H 2 day 1h max sf O₃ (ppbv) Valid 19 JUL 2013
Largest daytime Cold Bias: NMN, SMN + moist bias
Largest nighttime Cold Bias: SWC

Largest daytime warm bias: SWC (large diurnal amplitude) + strong dry bias
warm bias: NMN, SMN + dry bias

Largest T/TD errors largest over mountainous areas (small diurnal amplitude)
Physics Changes in NAM-X Parallel
To be implemented in June 2014

- **Gravity wave drag / mountain-blocking changes**: more responsive to subgrid-scale terrain variability (impacts the synoptic scale)

- **Moister convective profiles so convection triggers less** (fres = 0.75 in parent vs fres = 0.25 in nests)

- **RRTM (SW/LW) with enhancements**:
  - Bug fix for sub-hourly zenith angle calculations
  - Updated O3, CO2 and other trace gases
  - Changes to albedo (removed diurnal variation)
  - Include effects of shallow (non-precipitating) convection
  - Remove 4x diffusion of moisture variables
  - **Microphysics bug fix, reduced max. number concentration of ice**
2 M Temperature
Summer 2013
NAM, NAMX vs Nest Runs

CONUS Nest warm bias
2 M Dewpoint Temperature
Summer 2013
NAM, NAMX vs Nest

NAM-X very moist
CONUS Nest best
10 M Wind Speed
Summer 2013
NAM, NAMX vs Nest

NAM-X and Nest strongest winds
PBL Height (RI # based)
NAM, NAMx vs Nest BIAS
36 hour forecast valid 00 UTC
Summer 2013

PBL Hgt underpredicted
NAM-X lowest in West
Parallel Nest Performance (NAM-X)
24h Precip: Summer 2013
NAM Nests Large over prediction in evening
Timing error, too much convection?
Summary

**CMAQ**
- WCOSS transition completed
- CMAQ experimental ozone performance improved

**NAM Nest Behavior**
- Larger wet precip bias over domain compared to Parent at higher thresholds (> 1”) for both prod and para runs
- Wet bias also in 3 hr precip as well as +6 hr phase shift compared to parent
- Warm, dry daytime bias over Rockies
- General moist dew point bias except over Rockies

**NAM-X behavior**
- Convective Precip over prediction
  - Increased mixing near surface needed?
  - vertical resolution tests underway
  - Improved convective mixing tests