Recent Performance of the NOAA Air Quality Forecasting Capability and the Impact of Driving Meteorology

http://www.emc.ncep.noaa.gov/mmb/aq

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Meteorological processes influencing air quality

• Coastal sea/bay breeze flows
• Complex topographical processes
  → mountain/valley flows; trapping, cold pools
• Urban meteorology
  → urban boundary layer, in canyon, skim flows
• Land surface/air-surface exchange
  → Deposition, biogenic emissions
• Aerosol interactive radiative/cloud microphysical processes
• Clouds and aqueous phase chemistry, wet deposition
• Vertical mixing esp in stable boundary layers
NAM Forecast System - Version 4 (March 2017)

- **Resolution Changes**
  - CONUS (4 km) and Alaska (6 km) nests → 3 km
  - Sync AK and CONUS On-Demand Fire Weather nests → 1.5 km

- **Select Model Changes**
  - Updated microphysics → Improved stratiform precip
  - Reduce incoming SW Rad under clouds: reduce warm season 2-m T warm bias
  - More frequent calls to physics → Physics/dynamics more in sync
  - Improve effect of frozen soil on transpiration and soil evaporation → Improve cold season 2-m T/Td biases
  - Adjustment to convection in 12 km NAM
  - Modify latent heat flux treatment → Improve visibility along CA coast

- **Data Assimilation**
  - DA cycles for 3 km nests → Much less ‘spin-up’ time
  - Use of Lightning/Radar Refectivity-derived temperature tendencies
    - Improved short-term forecasts of storms at 3 km
  - New satellite radiances, satellite winds

Courtesy Eric Rogers, EMC
NAM March 21, 2017 Upgrade

Mean 2-M Temp vs. sfc obs (12h cycle) over the Western US for NCEP NAM and CMAQ V4.7 forecasts from 201607190000 to 201608011200

WEST

Mean 2-M Temp vs. sfc obs (12h cycle) over the Eastern US for NCEP NAM and CMAQ V4.7 forecasts from 201607190000 to 201608011200

EAST

2 m Temperature

NAM - CMAQ V4.7

NAM-V4 - CMAQ V4.7
July 2016 NRT CMAQ Prod vs V5.0.2

1 h avg Diurnal Ozone

- **CMAQ V5.0.2 NAM-V4**: improvement in ozone over-prediction over the East

- **CMAQ V5.0.2 NAM-V4**: Strongest underestimate over West

- Meteorological impact nearly as large as CMAQ/Emissions upgrade
Ozone Errors: July 2017
Obs vs Raw vs Bias Corrected

East: Overprediction overall but underprediction for July 10-12 exceedences.
West: Continued underprediction.

O3 BIAS CORRECTION:
→ Diurnal performance good, overcorrects some events (July 10-12, 18-21)

Jianping Huang, NCEP
Cool, moist biases on 11th and 12th coincides with ozone underprediction.
July 12, 2017 NAM-CMAQ V5 Performance

- Continued less ozone predicted for day 2
- O3 Bias correction improved over LI
July 12, 2017 NAM-CMAQ V5 Performance

NE U.S. NAM, Nest, CMAQ 7/11/12Z 33h Cloud Cover

- NAM-12 cloud cover too high and extent too broad, CMAQ less
- NAM nest captures clearing along LIS and CT better
July 12, 2017 NAM-CMAQ V5 Performance
NE U.S. NAM vs Nest 7/11/12Z 33 h forecast
2m temperature, PBLH

NAM: Temps too cool over CT coast, Nest better
Winds coming from the bay brought the marine air inland.

The NAM NEST 3km tended to bring the MBL further inland in the northern Chesapeake bay area, especially north of Baltimore.

Courtesy: Amanda Sleinkofer
NAM-12 vs NAM-3 km nest vs Howard U – Beltsville, Maryland
Lufft Ceilometer PBLH (June 13, 2017)
Day 1 (solid) & Day 2 (dashed) forecasts
August 2017 PM Predictions
1 h avg PM BIAS

- WEST: Underpredict PM transitions to overprediction.
- **Bias Correction** w/ V5. analogs better than oper BC
- More consistent smoke event analogs?
Northern California Fires
October 13, 2017 PM 2.5 predictions

Day 1

Day 2
Summary

– V5.0.2 Ozone w/ NAM V4
  • Improvement correcting over-prediction esp along coasts
    – Long Island Sound (CT DEP analysis), Lake Erie/Michigan and Ohio Coastline
  • Improved for marginal or non-events
  • Still Missed exceedences in NE with overprediction of cloudiness
  • Remarkable overall improvement with KFAN ozone bias correction but overcorrects for episodes in East

– PM
  • Large positive impact near forest fires:
    – Updated BlueSky and 24 h pre analysis run
    – Underprediction when external sources (Canadian fires) are impacting CONUS
    – Emission timing and ejection height uncertainties
  • Continued overprediction in Winter from raw predictions
  • Exp PM bias correction w/ V5 analogs improves performance (Summer)

– Normally Updated NAM alone improves ozone overprediction forecast
  • Amount of incoming radiation under clouds critical
Future Emphasis

– Extend to 72 hours, update emissions to 2014 base
– Near real-time fire locations, strength, emissions
  • Canadian & external source impacts (testing)
  • Improved temporal profiles (testing) and plume rise algorithms
– NGAC full aerosol boundaries
– Unification of AQ systems
  • HYSPLIT smoke/dust → NGAC Aerosol
  • CMAQ ozone & total PM
  • HRRR-smoke
– Bias Correction:
  • Implement Ozone Kalman Filter bias correction (testing)
  • PM: Use CMAQ V5 predictions as analogs (testing)
– Improved Evaluations
  • Use of VIIRS/GOES-16/AERONET AOD, CALIPSO aerosols
  • Evaluate Operational models for field experiments (ESRL FireX 2019, FASMEE)
Thunderstorm-resolving resolution in a unified meso-global prediction system (FV3-GFS)

1) Grid stretching (smooth variation of grid spacing)

1) 2-way nesting (Harris and Lin 2014)
   FV3 is uniquely suitable for 2-way nesting, due to the application of two-time-level Finite-Volume transport scheme

2) Optimal combination of the “stretching” and “nesting”

- FY19 Global: 9 km L64
- Regional: 3km nest or stand alone
- aerosol aware microphysics/radiation option

S.J. Lin, NOAA/GFDL
GFS-FV3 Comparisons (13 km)
June- July 2017 Day1

GFS-FV3 too warm and under-predicts clouds over North America
Web pages
CMAQ V5.0.2

• Real-time parallel runs (July 2016-Present)

• No NOx adj/NAM-X/4x-day cycling (Aug. 7-Sept 10)

• Gridpoint NOx adj/NAM-X/1x-day cycling (Aug. 1-Sept 10)

• Verification statistics (prod,para, cmaqnox11, cmaqnox)