Regional Air Quality Modeling Progress at NOAA/NWS/NCEP

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NAM V3.1 Model Changes

- Replace legacy GFDL radiation with RRTM
- Modified Gravity Wave Drag/Mountain Blocking
  - More responsive to subgrid-scale terrain variability
  - Target: Improve synoptic performance without adversely impacting 10-m wind forecasts
- New version of Betts-Miller-Janjic convection
  - Moister convective profiles, convection triggers less
  - Target: Improve QPF bias from 12-km parent, esp. in warm season
- Ferrier-Aligo microphysics
- Modified treatment of snow cover/depth
  - Use forecast rime factor in land-surface physics
  - Target: Reduce snow depth in marginal winter conditions w/complex precipitation type
- Reduce roughness length for 5 vegetation types
  - Target: Improved 10-m wind in eastern CONUS

NAM 12 km parent, nests and 1.3 km fire weather domains
Changes to Downscaled Grids

- 5 km CONUS / 6 km Alaska DNG grids extended to 192-h via DGEX
- Addition of Haines Index for Fire weather
- Improved 10-m wind treatment
  - Use mass-consistent wind field model
  - Based on velocity potential, incorporating local terrain gradients

Improved representation of the effects of local terrain on winds
Surface fields: 2-m T RMS (solid) / bias (dashed) error over CONUS: 00z cycles; Green=ops, Magenta=pll

Spring 2014
3/1 – 5/30/14

East CONUS

West CONUS

Summer 2014
6/1/-8/3/14
Surface fields: 10-m Wind RMS (solid) / bias (dashed) error over CONUS: 00z cycles; Green=ops, Magenta=pll

Reduced high 10-m wind bias in East CONUS with roughness length changes
Warm Season Retrospectives: NAM-12 Control (red) vs Parallel (Blue) QPF scores: ETS (top), Bias (bottom)

July 2011

June 2013

ETS

BIas
Improving large-scale synoptic performance, especially at day 2-3 (more so during cool season)

Higher warm-season QPF bias in 12 km parent

Dramatically improves convective structures in the CONUS 4 km nest

Dropping legacy GFDL radiation for RRTM allows for better collaboration on radiation scheme enhancements with global branch

- NEMS Global Aerosol Capability interactive radiation tests
HYSPLIT UPGRADE

This project is an NWS and NCEP milestone for Q4FY14

HYSPLIT description: Current Operational Dispersion Products

• 48-hour wild-fire smoke forecasts (06 UTC cycle) for CONUS, AK, HI
  Upgrade: inclusion of Canadian/Mexican fires

• 48-hour dust forecasts (06 and 12 UTC cycles) for CONUS

• 48-hour volcanic ash forecasts whenever requested by the ICAO-designated U.S VAACS (Washington, DC, Anchorage, AK).

• 72-hour radiological emergency response plume forecast when requested per the WMO-RSMC arrangements (IAEA or other country’s NMS).
• 48-hour back-tracking product when requested per the WMO/RSMC arrangement

• 16-hour dispersion forecast for HAZMAT-type (chemical spill, explosion, etc.) incident upon the request of a WFO; and for about 25 pre-determined locations 4x/day
NESDIS GASP Imagery of fire smoke on April 3, 2014.
Smoke primarily from Mexican fires not included in operational HYSPLIT Smoke forecast system.
Canada/Mexico Emission impact
July 8 – Sept. 15, 2013 East and West Regions

- Degraded forecast for low smoke concentrations (< 5 ug/m3) with Puff option
Canada/ Mexico Emission impact
July –August, 2014 CONUS CSI verification

Using NDFD 5 km G227 model output grid
• Parallel using Particle model approach
• Good improvements with Canada/Mex emissions
Use of Canadian and Mexican emissions yields improved forecasts for real-time and retrospective HYSPLIT simulations.

- **Recommend implementation** given the relative importance of higher smoke concentrations on human health.

August 26, 2014 Smoke forecast
CMAQ V4.6.3 CB05/AERO-4

• **V4.6.2**: April 28, 2014
  • Inclusion of latest EPA Carbon Bond 5 (CB05) chemical mechanism.
  • Inclusion of AERO-4 aerosol chemistry.
  • Updated anthropogenic emissions with 2014 Dept. Energy projections.

• **V4.6.3**: June 13, 2014
  • Modulate fugitive dust emission: suppress over ice/snow.
  • Incorporate NESIDS HMS wild fire smoke. **CONUS**
  • Incorporate real-time surface dust emissions (wind dependent). **CONUS**
  • NTR, organic nitrate photolyzed and removed quicker.
  • Layer specific time step was added to speed up code.

• **V4.6.3v2**: June 27, 2014
  • Correction to overestimates of dust emissions
    • repartition percent going to PM2.5, mix beyond first level

• **V4.6.31**: July 16, 2014 With NAM Parallel
  • Turned off gas emissions from fires.
  • Ozone predictions will not be impacted by inclusion of smoke emissions.
1 hour Avg Ozone Performance
Observed, Prod, V4.6.2, V4.6.31

Improvement in Western U.S esp during the day
Improvement in Eastern U.S. at night.
Inclusions of real-time smoke emissions

- NESDIS Hazard Mapping System (HMS) provides fire points
- USFS BlueSky system run within HYSPLIT provides fire emissions (organic carbon, black carbon...)

![Map showing smoke emissions](image-url)
8 hour Avg Daily Max Ozone Performance
Skill Score: Prod, V4.6.3

Significant improvement in Western U.S for most thresholds
Significant improvement over:

SW US >65 – 85 PPB
SE US >65 PPB
Experimental run better captures Code Orange Event in Southern California

Ozone Predictions
July 25, 2014 Case
August 27, 2014 NE US exceedence
Marine Layer moves further inland with NAM Nest
But winds are weaker than observed
Frontal clouds better delineated with Nest
Can contribute to weaker ozone plume
PM Performance
Obs, V4.6.2, V4.6.31
July 16-August 9, 2014

Western U.S.

Eastern U.S.

Inclusion of smoke/dust with V4.6.3 small
- Larger impact out west and at night
PM2.5 Predictions
Smoke influence on total PM
July 21, 2014 case

EMC EXPERIMENTAL v4.6.3 nearest source PM2501 forecast

Wild fires included
PM2.5 Predictions
Valid July 26, 2014 06 UTC Utah fires/dust

CMAQ V4.6.3
UTah PM exceedence driven by smoke/dust not captured by V4.6.3

HYSPLIT V7.2
North America covered with smoke
January 2014 PM error over MidWest

NAM vs NAMx

NAM upgrade has improved winds and temperatures for Jan. 2014 over MidWest
NAM vs ACARS PBL Height
January 2014

NAM upgrade has larger PBL Height underprediction in evening over Midwest And cloud overpredictions Nationally.

Too little mixing in stable air with upgraded NAM?
PRODUCTS

CMAQ currently generates:
- 12 km hourly surface ozone grib files hourly,
- 8 hourly ozone averages
- Day 1 and Day 2 one and eight hour average ozone daily maximum

http://www.emc.ncep.noaa.gov/mmb/aq/cmaq/web/html
http://www.emc.ncep.noaa.gov/mmb/aq/hysplit/web/html

• Changes:
- Add 12 km hourly and 24 h avged surface Particulate Matter 2.5 um (PM2.5) grib files (developmental product only)
CMAQ Summary

- Ozone predictions improved with latest changes to V4.6.3
- Some improvement in PM performance with smoke emissions
- Increased smoke preprocessing time delays product availability by up to 1 hr
- Impact of smoke/dust on PM likely too small (still strong underpredictions)
- Decreased Mixing with NAM upgrade in Stable conditions may contribute to winter time PM biases
- 4 km Nest could provide useful Information to identify processes
  Not resolved with 12 km runs
  (eg: sea breezes, convective clouds)

CALIPSO overpass of July 24, 2014 major Canadian fires. Complicated multi-layer plume pattern observed.
Future plans

• Short term (1-2 years)
  – Include NGAC real-time aerosol boundary conditions
  – Improve smoke emissions
    • Update Bluesky emissions
      – (forest load, consumption, spread emissions)
    • Evaluate NGAC Fire Radiative Power smoke emissions approach
    • Evaluate plume rise (additional met constraints)
  – Improve dust emissions
    • NAM gust vs speed
    • DNG winds
    • Soil moisture impact
  – Include ESRL bias correction
    • At stations
    • spreading technique to grid
  – High Resolution smoke/dust modeling