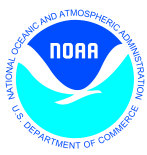


Evaluation of Air Quality Prediction and NAM models

*Jeff McQueen, Jianping Huang, Perry Shafran
and Sarah Lu*

26 September 2013



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.

HYSPLIT, other dispersion models like HPAC

- Smoke/dust/radiological/chemical releases
- Support Jianping Huang's study for the AMS annual meeting where he will compare HYSPLIT 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).

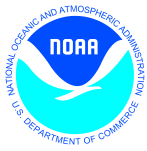


Global Forecast System (April 2014)

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*

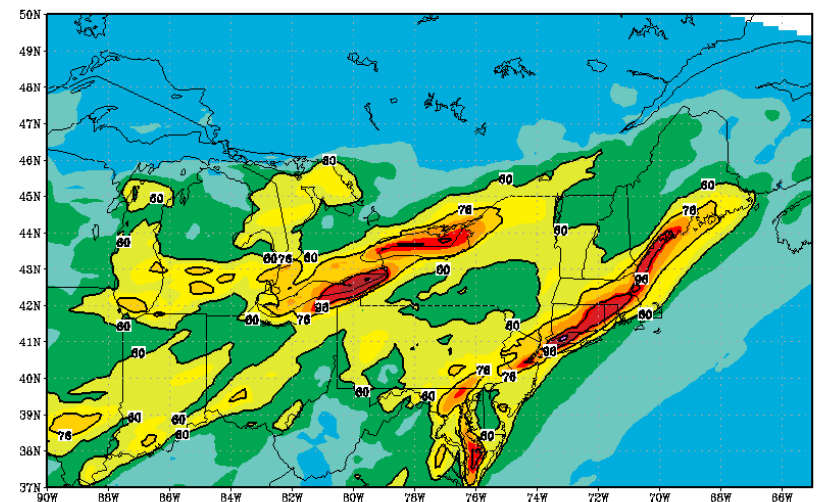
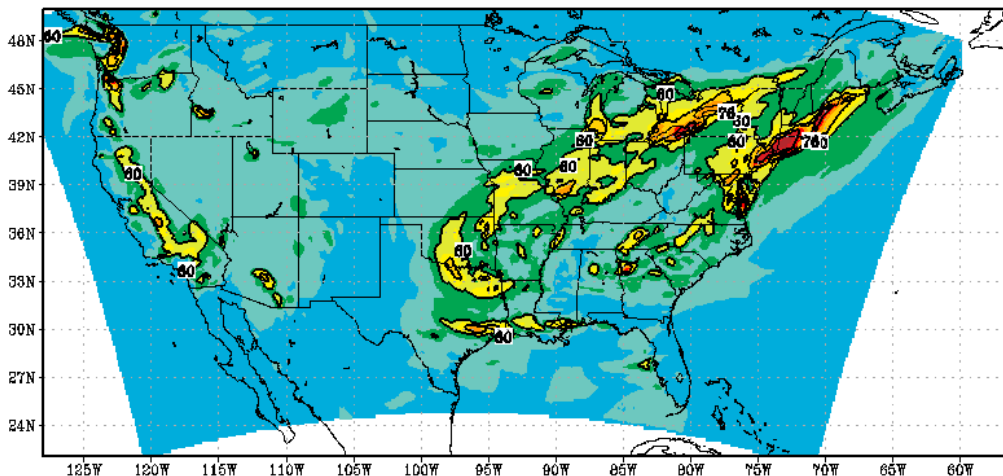
- CONUS, Alaska, Hawaii & Puerto Rico/Hispaniola nests
- The two control runs initialized with radar data & other hi-res obs
- Provide PROBABILITY guidance with full Probability Density Function specified, hence uncertainty information too
- Provide a vehicle to improve assimilation capabilities using hybrid (EnKF+4DVar) technique with current & future radar & satellite
- Address Warn-on-Forecast as resolutions evolve towards ~1 km

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

(prd) 12Z 1H-16H 1st d 1h max sf O₃ (ppbv) Valid 11 SEP 2013

(prd) 12Z 17H-40H 2 day 1h max sf O₃ (ppbv) Valid 11 SEP 2013



HYSPLIT Dispersion

Dust updates:

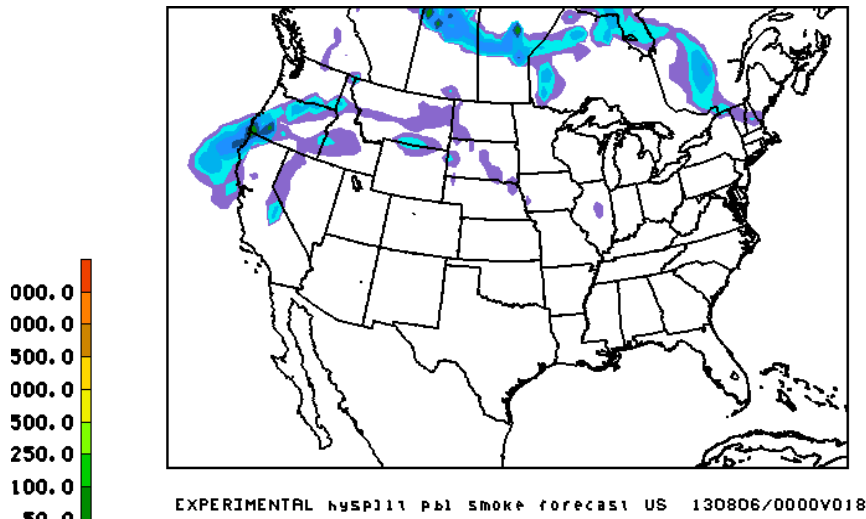
- **Dust predictions implemented operationally in March 2012**
- *Dust emissions are modulated by real-time soil moisture*

Smoke updates: CONUS, Alaska, Hawaii in July 2013

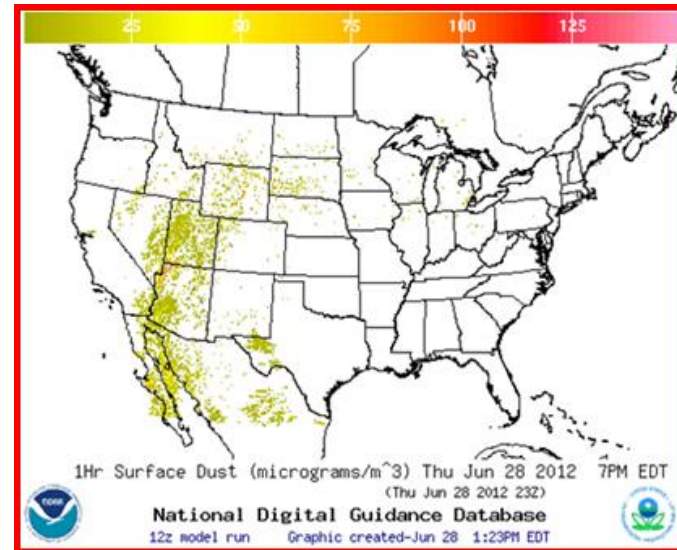
- *updates to plume rise and deposition parameters*

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*



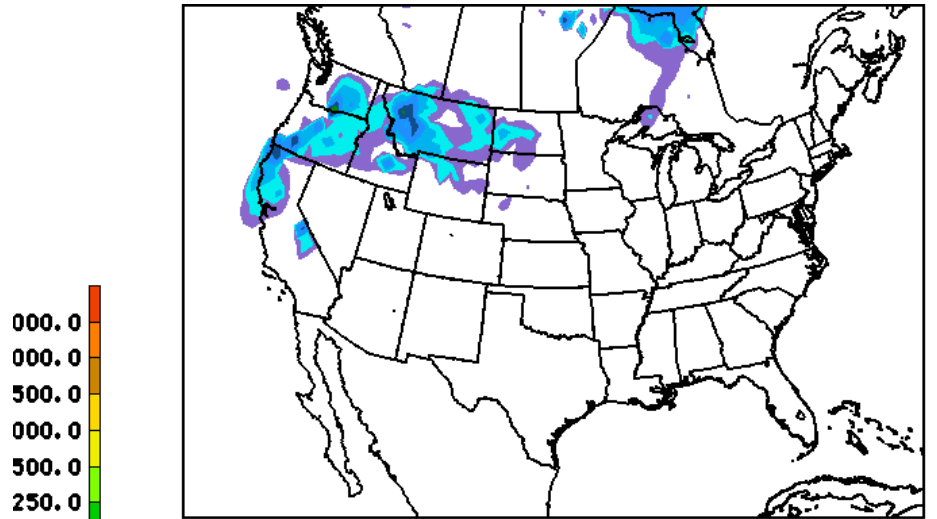
Column Smoke



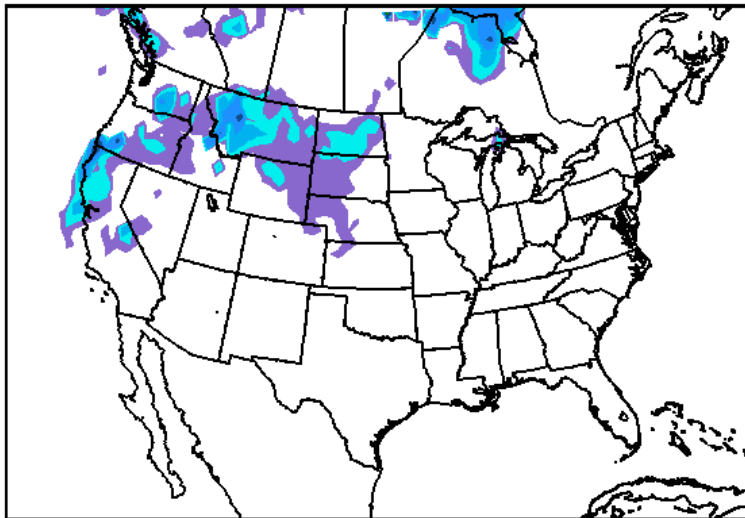
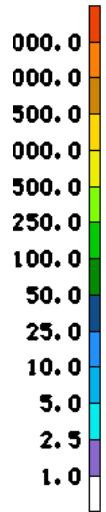
Surface Dust

HYSPLIT Smoke Upgrades Impact

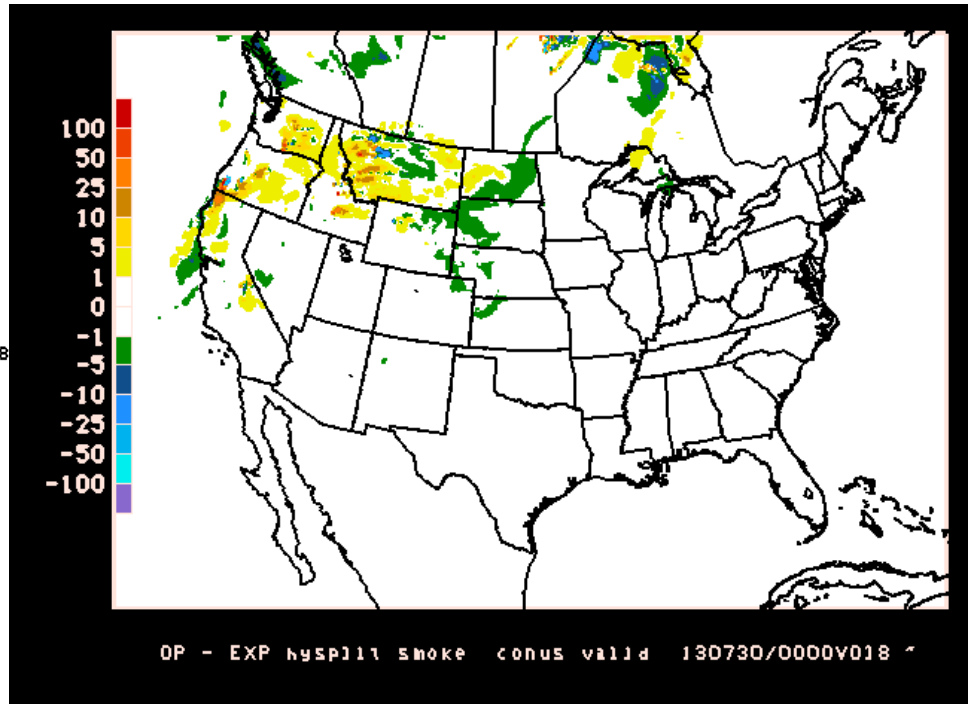
Column Avg (op-exp, ug/m³)



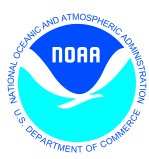
OPERATIONAL hysplit pbl smoke forecast US 130730/0000V018



EXPERIMENTAL hysplit pbl smoke forecast US 130730/0000V018



OP - EXP hysplit smoke conus valid 130730/0000V018



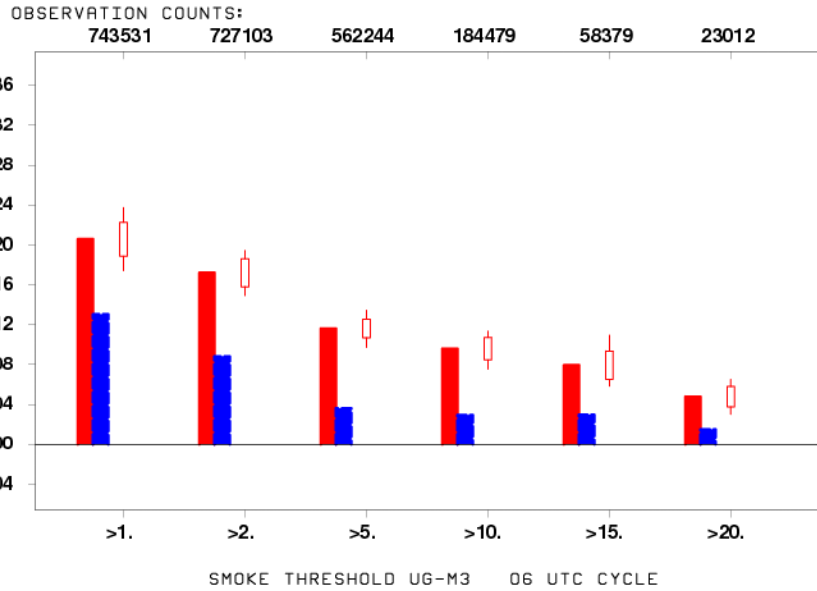
HYSPLIT Smoke and Dust Verification

Column Avg (op-exp, ug/m3)



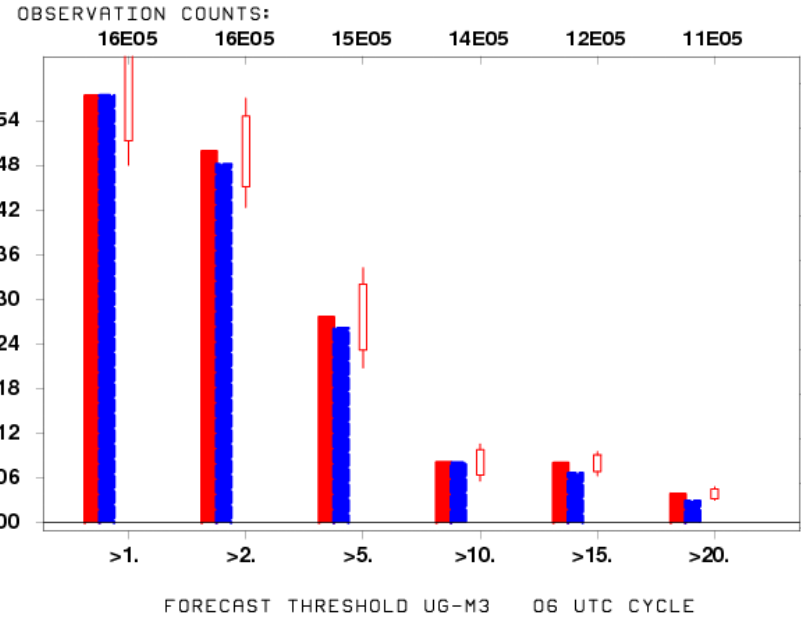
01 H SMOKE CRIT_SUC_INDX AVGED BY THRESHOLD
20130708 TO 20130729
HYSPLIT-EXPR

■ HYSPLIT CONUS 01 -> 48 HRS CRIT_SUC_INDX
■ HYSPLIT-EXPR CONUS 01 -> 48 HRS CRIT_SUC_INDX



01 H FORECAST DUST CSI AVGED BY THRESHOLD
20130601 TO 20130708
HYSPLIT-EXPR

■ HYSPLIT DUST 01 -> 48 HRS CRIT_SUC_INDX
■ HYSPLIT-EXPR DUST CONUS 01 -> 48 HRS CRIT_SUC_INDX

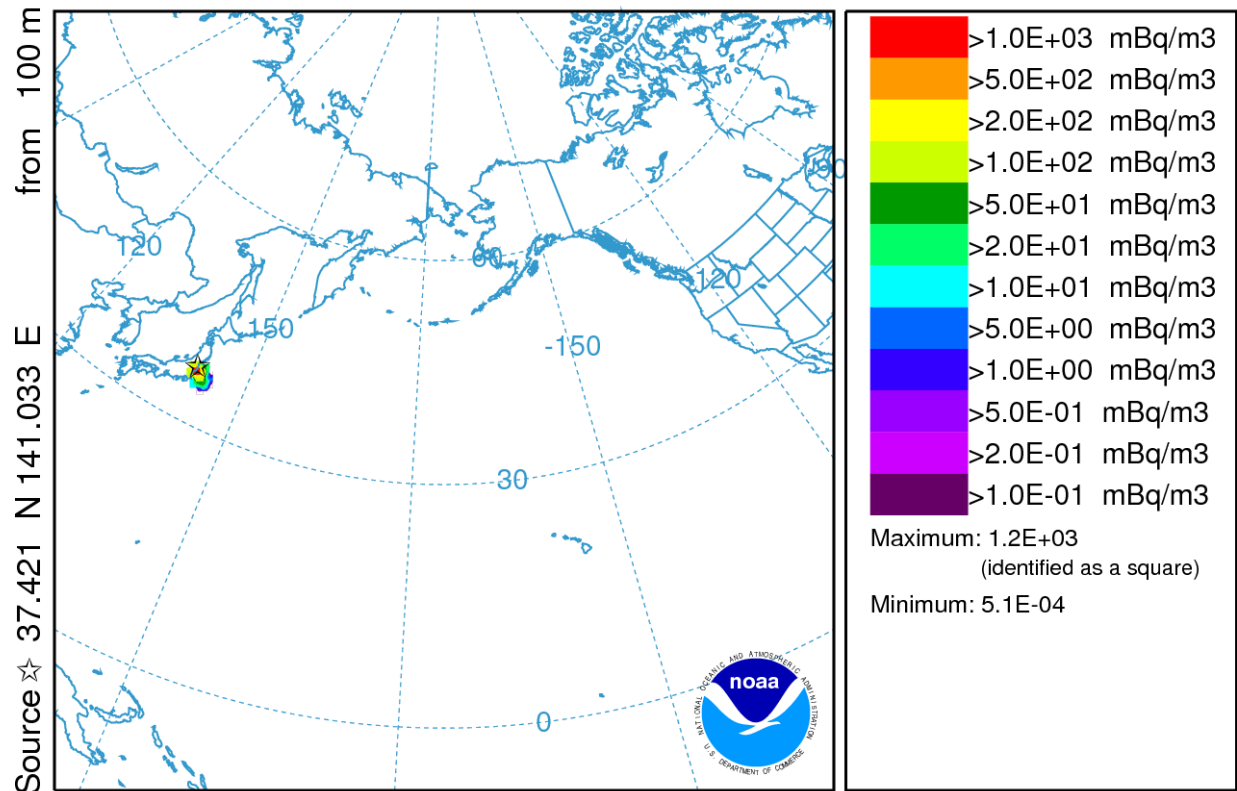


<http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html>

Emergency Response: Fukushima Simulations

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)



GHDA METEOROLOGICAL DATA

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

Overview of NOAA GFS Aerosol Component (NGAC)

Model Configuration:

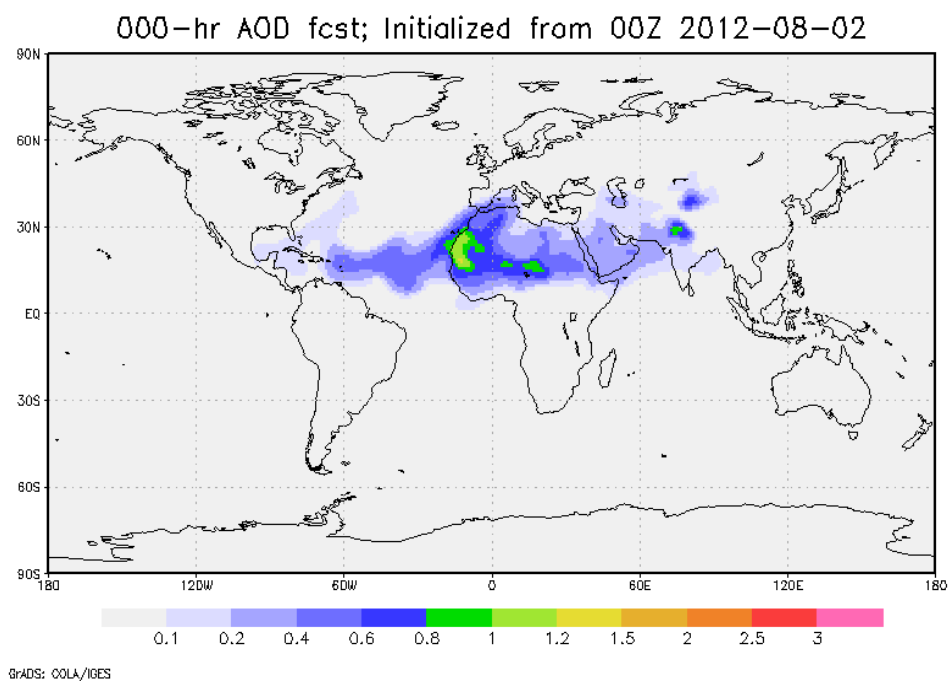
- Forecast model: Global Forecast System (GFS) based on NOAA Environmental Modeling System (NEMS), **NEMS-GFS**
- Aerosol model: NASA Goddard Chemistry Aerosol Radiation and Transport Model, **GOCART**

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



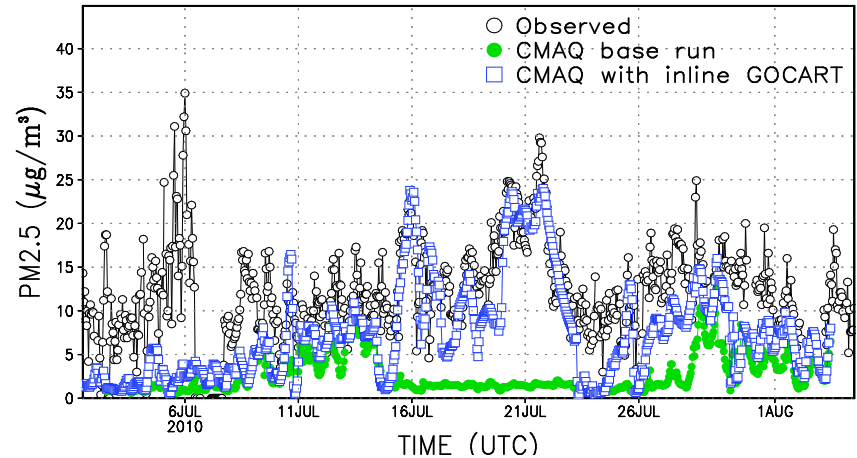
Acknowledge: Development and operational implementation of NGAC represents a successful “research to operations” project sponsored by NASA Applied Science Program and JCSDA

Dynamic LBCs for regional models

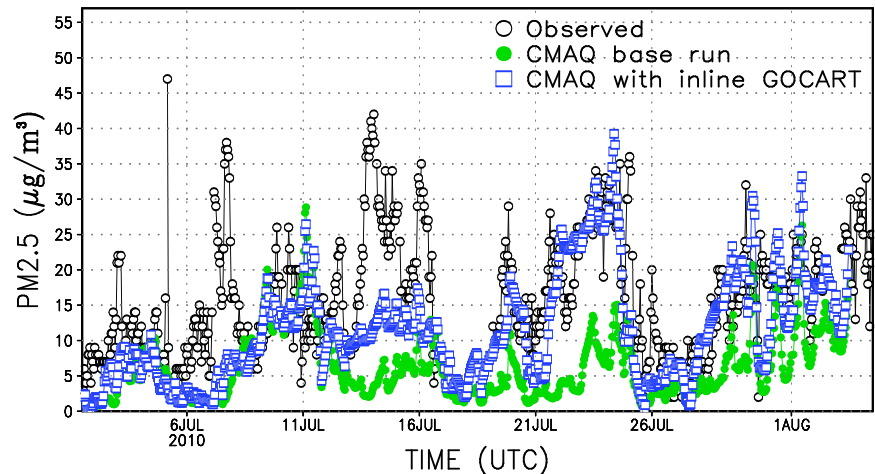
- Baseline NAM-CMAQ with static LBCs versus experimental NAM-CMAQ with dynamic LBCs from NGAC, verified against AIRNOW observations
- The inclusion of LBCs from NGAC prediction is found to improve PM forecasts (e.g., reduced mean biases, improved correlations)

	CMAQ Baseline	CMAQ Experimental
Whole domain July 1 – Aug 3	MB= -2.82 R=0.42	MB= -0.88 R=0.44
South of 38°N, East of -105°W July 1 – Aug 3	MB= -4.54 R=0.37	MB= -1.76 R=0.41
Whole domain July 18– July 30	MB= -2.79 R=0.31	MB= -0.33 R=0.37
South of 38°N, East of -105°W July 18– July 30	MB= -4.79 R=0.27	MB= -0.46 R=0.41

Model Predictions Compared to AIRNOW PM2.5 over 'Miami Fire Station #5', FL Lat=25.795 Lon= -80.216

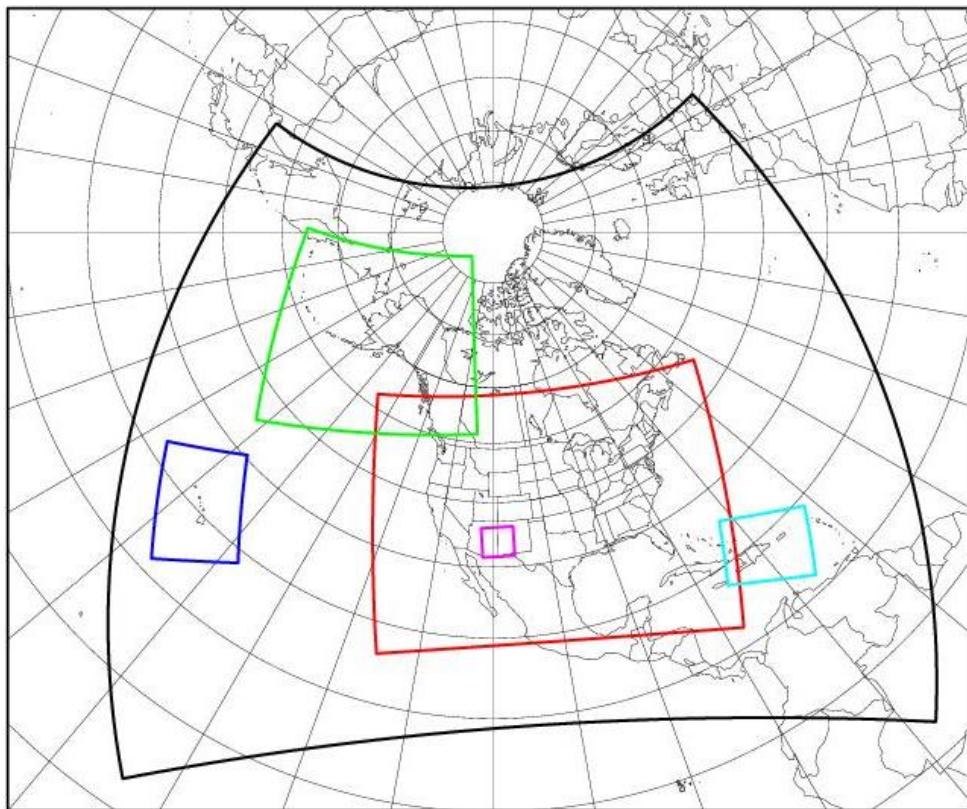


Model Predictions Compared to AIRNOW PM2.5 over 'Kenner', LA Lat=30.041 Lon= -90.273



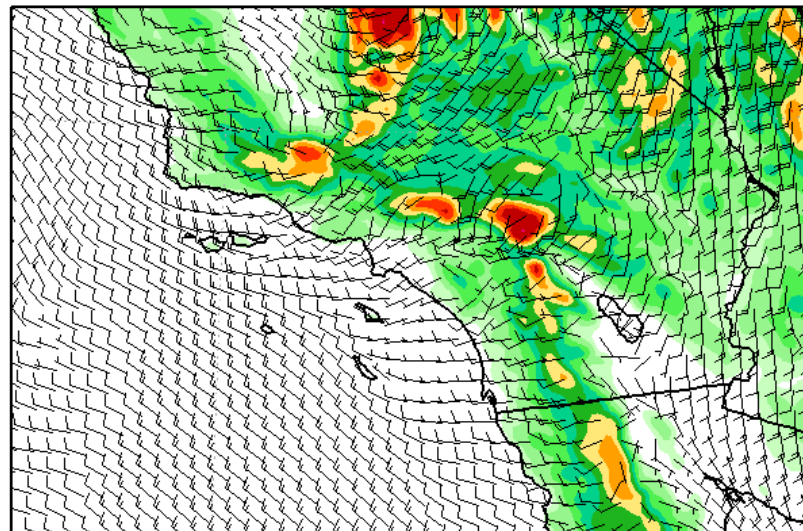
NAM Parent and Nest Domains

NAM INTEGRATION 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

10-M WND, SFC HGT CONUS4KM 33H FCST VALID 21Z 21 SEP 2013

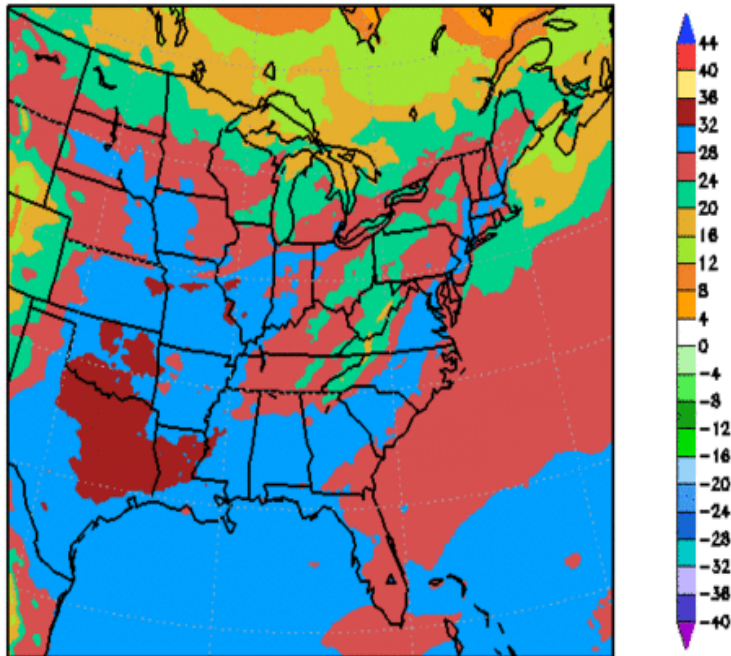


http://www.emc.ncep.noaa.gov/mmb/mmbpll/nam_conusnest

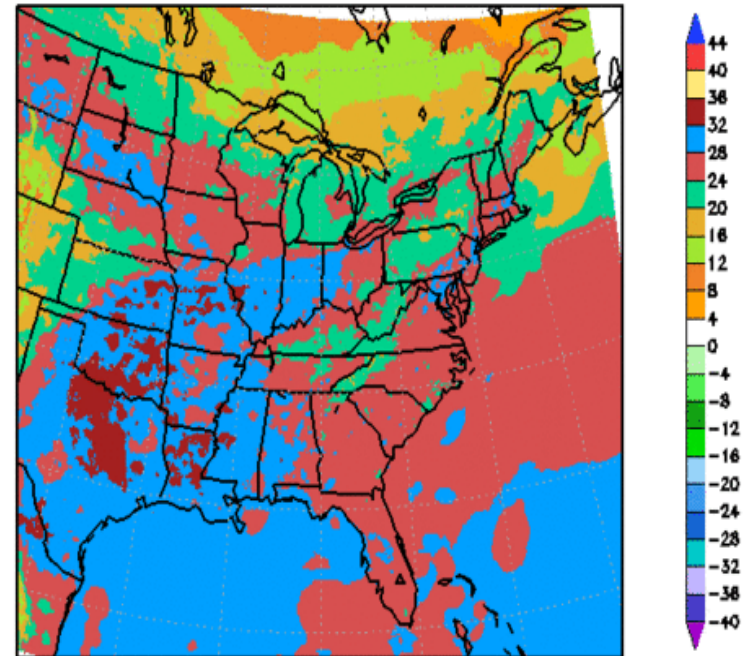
Real Time Mesoscale Analysis 2.5 km

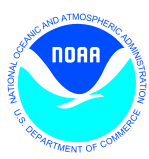
- Useful for Evaluations
- Downscaled predictions to 84 forecast hours (DNG)

2-M TEMP NAM 12H FCST VALID 00Z 12 SEP 2013



2-M TEMP RTMA VALID 00Z 12 SEP 2013





CMAQ 8h max O3 Threat Score by threshold



West

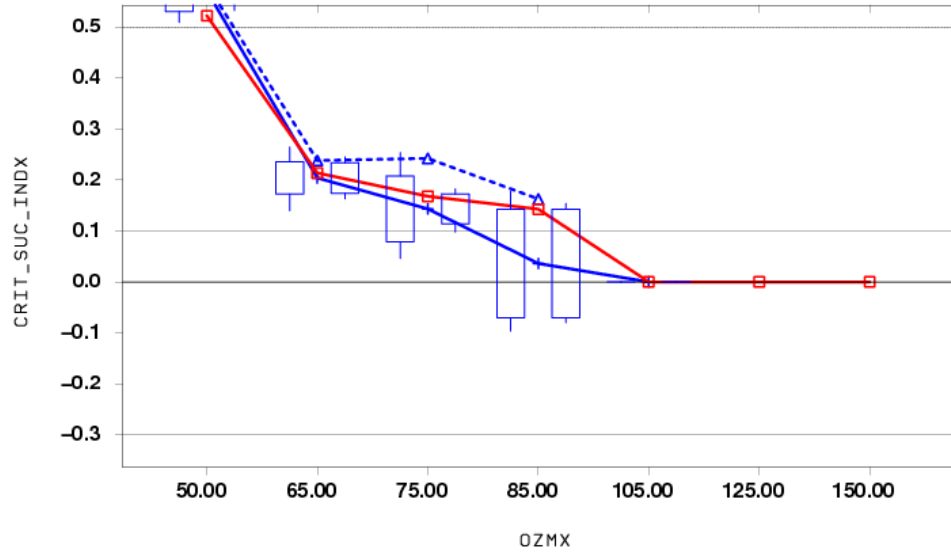
East

48 H OZMX/8 CRIT_SUC_INDX VALID 1200 GMT AVGED BY THRESHOLD
 20130601 TO 20130831
 CMAQWCOSS

— CMAQ5X CRIT_SUC_INDX
 - - - CMAQPARA CRIT_SUC_INDX
 — CMAQWCOSS WEST-US CRIT_SUC_INDX

OBSERVATION COUNTS:

3812 981 309 81 5 0 0

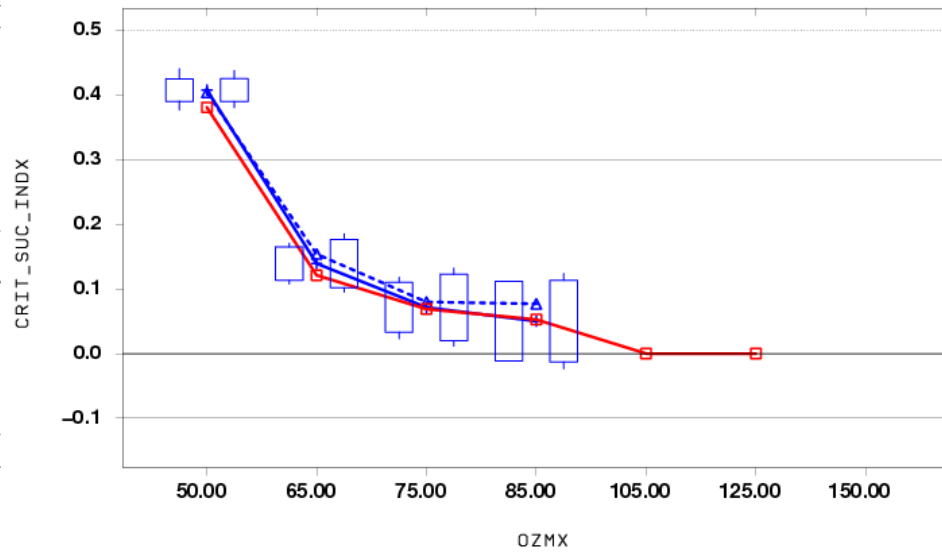


48 H OZMX/8 CRIT_SUC_INDX VALID 1200 GMT AVGED BY THRESHOLD
 20130601 TO 20130831
 CMAQWCOSS

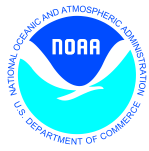
— CMAQ5X CRIT_SUC_INDX
 - - - CMAQPARA CRIT_SUC_INDX
 — CMAQWCOSS EAST-US CRIT_SUC_INDX

OBSERVATION COUNTS:

5792 692 88 15 0 0 0



<http://www.emc.ncep.noaa.gov/mmb/aq/fvs/web/html/fho.html>



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



West

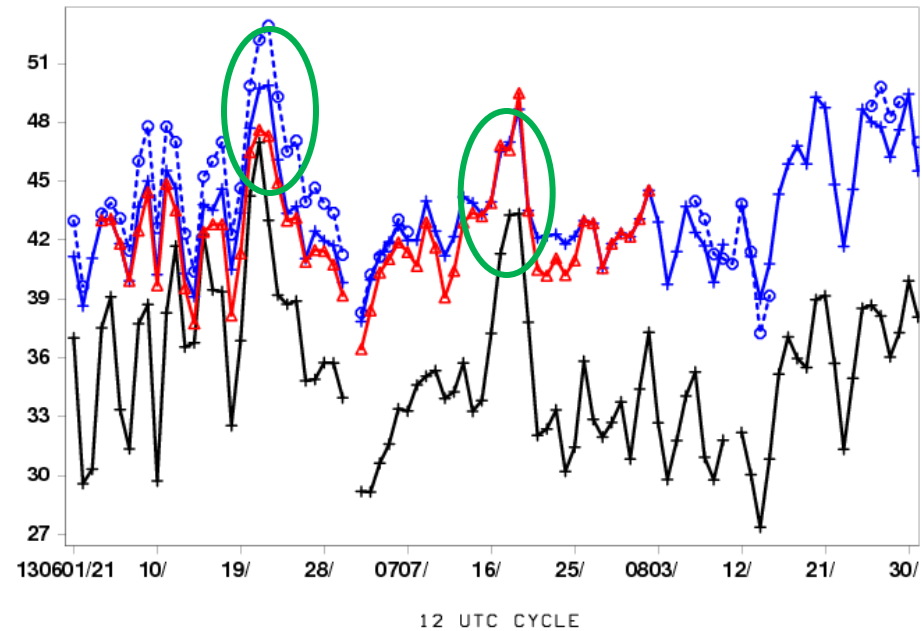
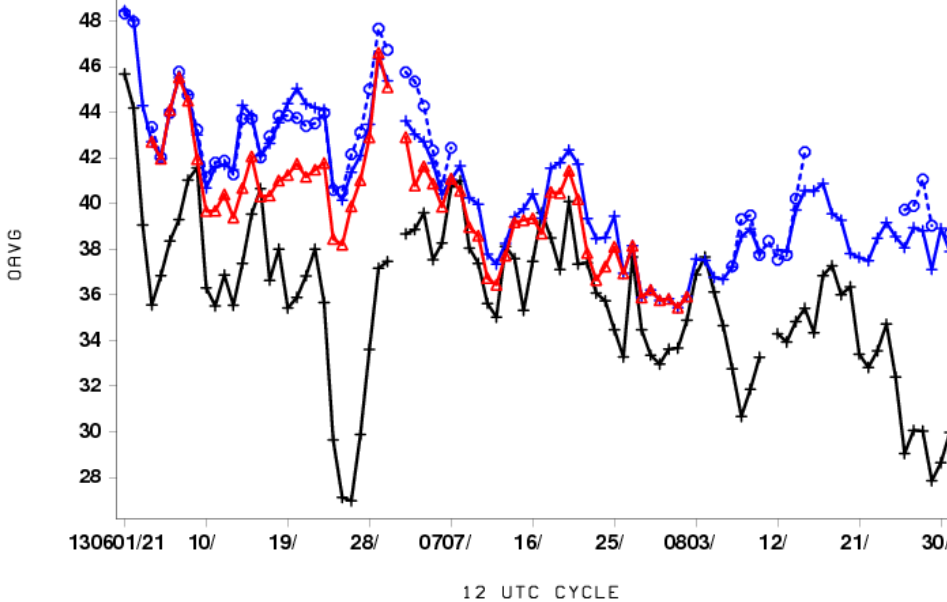
East

33 H OZON/8 VALID 2100 GMT
CMAQWCOSS

33 H OZON/8 VALID 2100 GMT
CMAQWCOSS

—+—	OBSERVED-MEAN	
—+—	CMAQ5X FORECAST-MEAN	
-o-	CMAQPARA WEST-US FORECAST-MEAN	
-△-	CMAQWCOSS WEST-US FORECAST-MEAN	

—+—	OBSERVED-MEAN	
—+—	CMAQ5X FORECAST-MEAN	
-o-	CMAQPARA EAST-US FORECAST-MEAN	
-△-	CMAQWCOSS EAST-US FORECAST-MEAN	



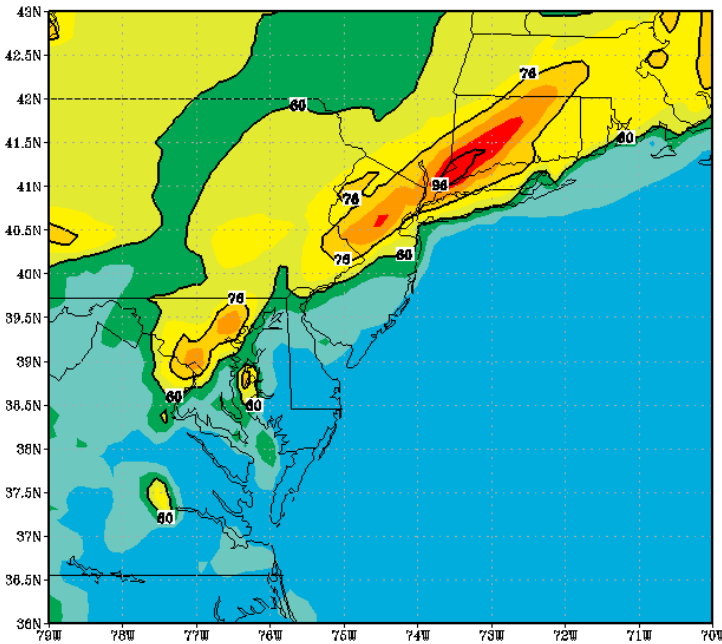
Strongest overprediction in East

Highest Observations on 6/20-22, 7/18-20

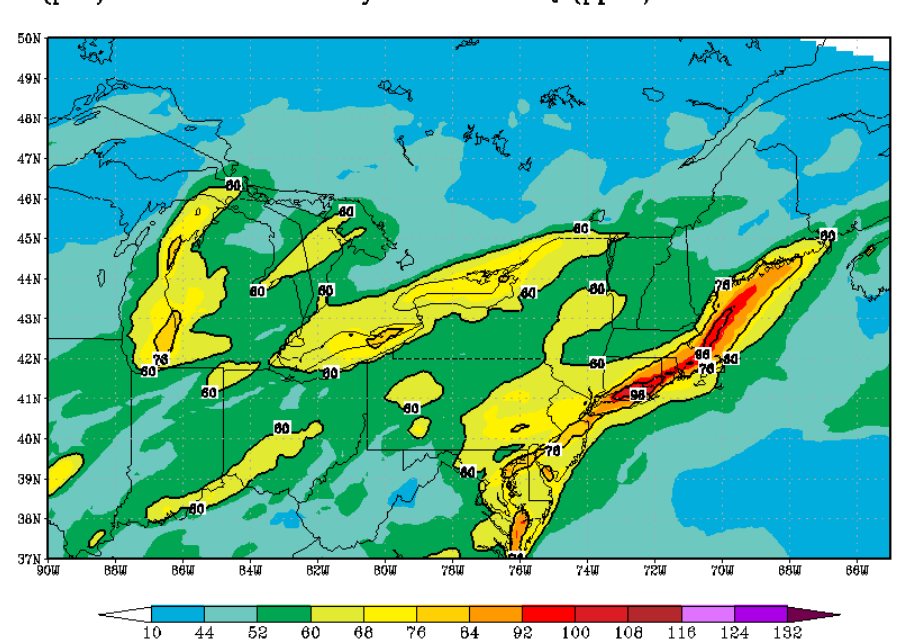
www.emc.ncep.noaa.gov/mmb/qaq/fvs/web/html/

CMAQ Operational 1h Max Day 2 Ozone forecast

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



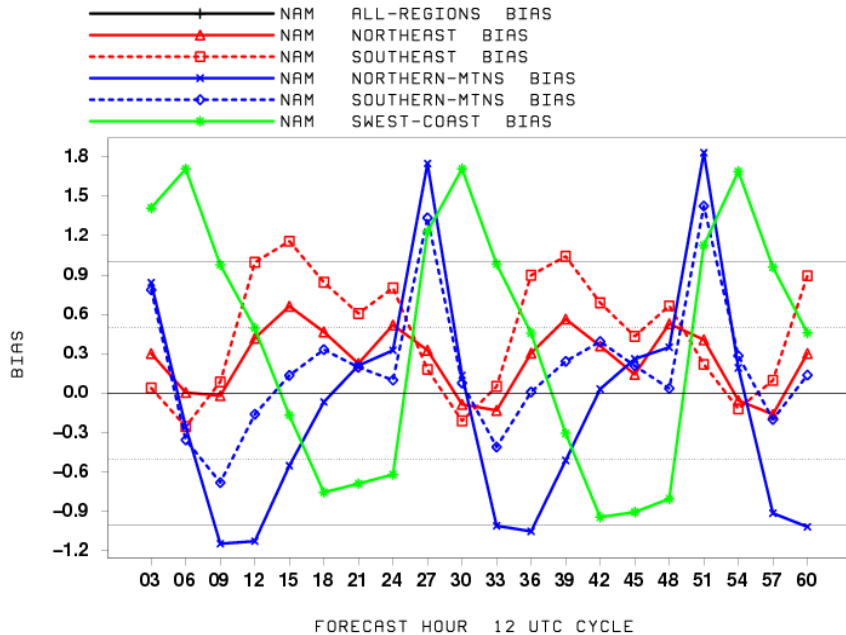
(prd) 12Z 17H-40H 2 day 1h max sf O₃ (ppbv) Valid 19 JUL 2013



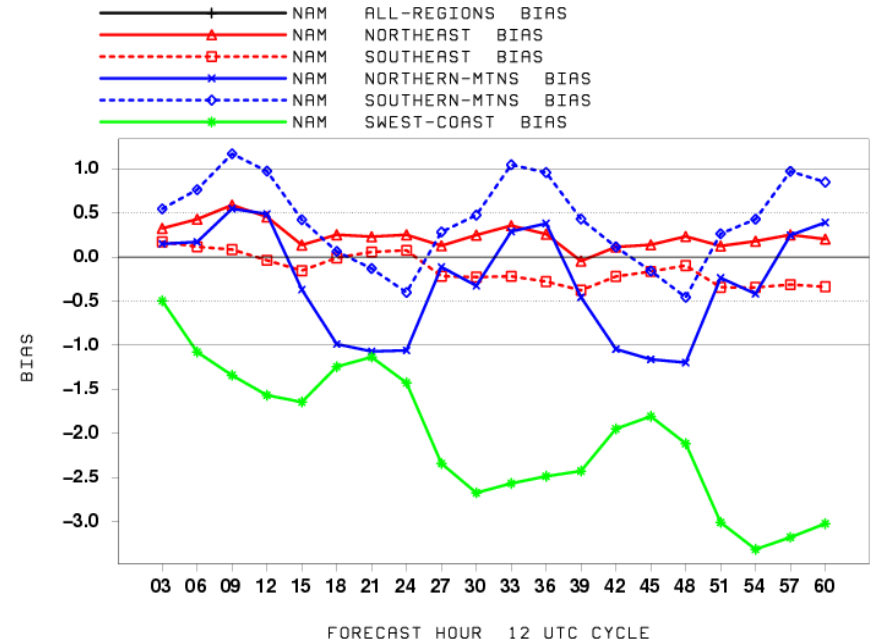
2 M T & TD BIAS by region

NAM Parent

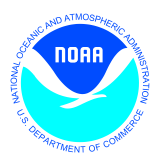
T BIAS AVGED BY FCST HRS
20130601 TO 20130831
NAM



DPT BIAS AVGED BY FCST HRS
20130601 TO 20130831
NAM



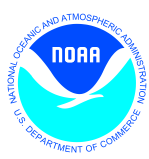
- Largest daytime Cold Bias : NMN, SMN + moist bias
- Largest nighttime Cold Bias : SWC
- Largest daytime warm bias: SWC (large diurnal amplitude) + strong dry bias
- warm bias : NMN, SMN + dry bias
- Largest T/TD errors largest over mountainous areas (small diurnal amplitude)



Physics Changes in NAM-X Parallel To be implemented in June 2014

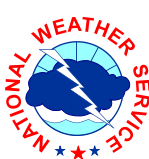


- **Gravity wave drag / mountain-blocking changes: *more responsive to subgrid-scale terrain variability* (impacts the synoptic scale)**
- **Moister convective profiles so *convection triggers less* (fres=.75 in parent vs fres=.25 in nests)**
- ***RRTM (SW/LW) with enhancements:***
 - Bug fix for sub-hourly 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***

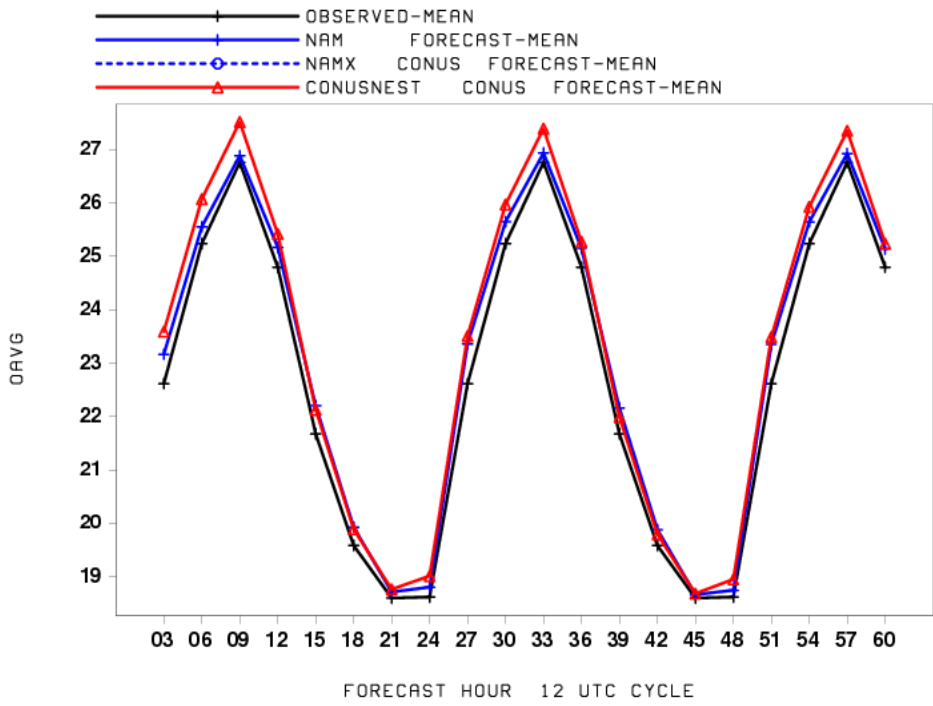


2 M Temperature Summer 2013

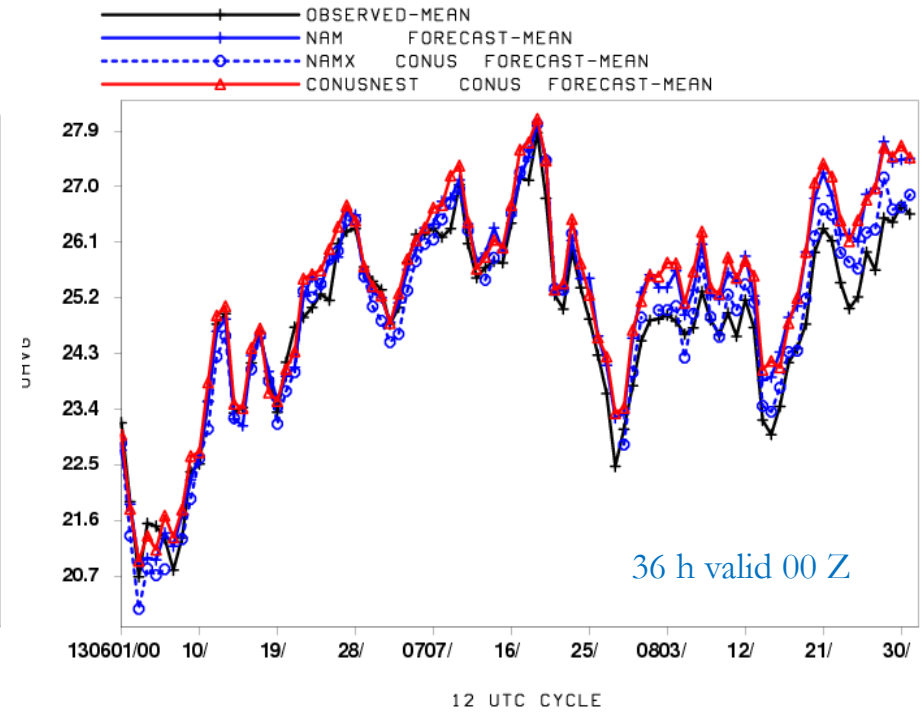
NAM, NAMX vs Nest Runs



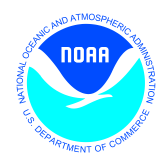
T OAVG AVGED BY FCST HRS
20130601 TO 20130831
CONUSNEST



36 H T VALID 0000 GMT
CONUSNEST



CONUS Nest warm bias



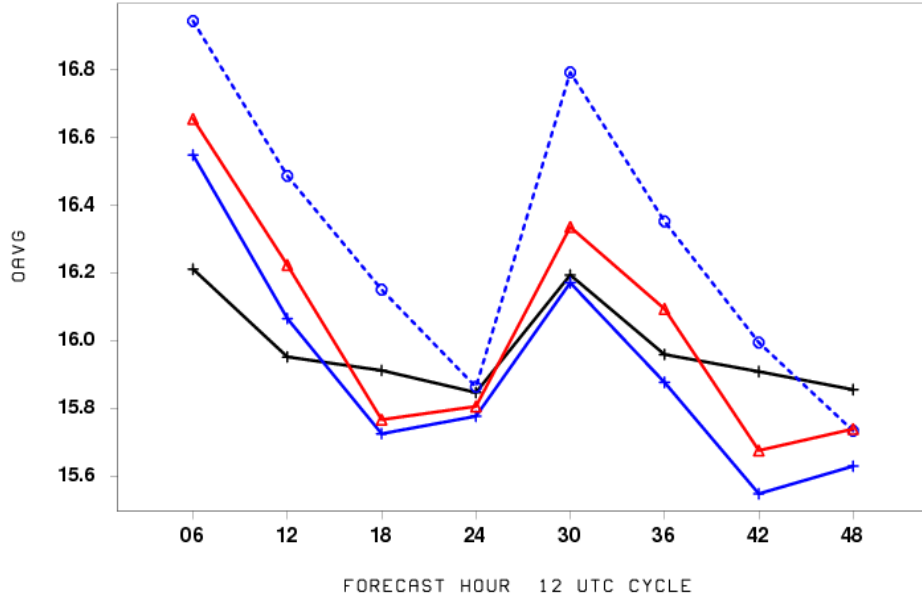
2 M Dewpoint Temperature Summer 2013

NAM, NAMX vs Nest



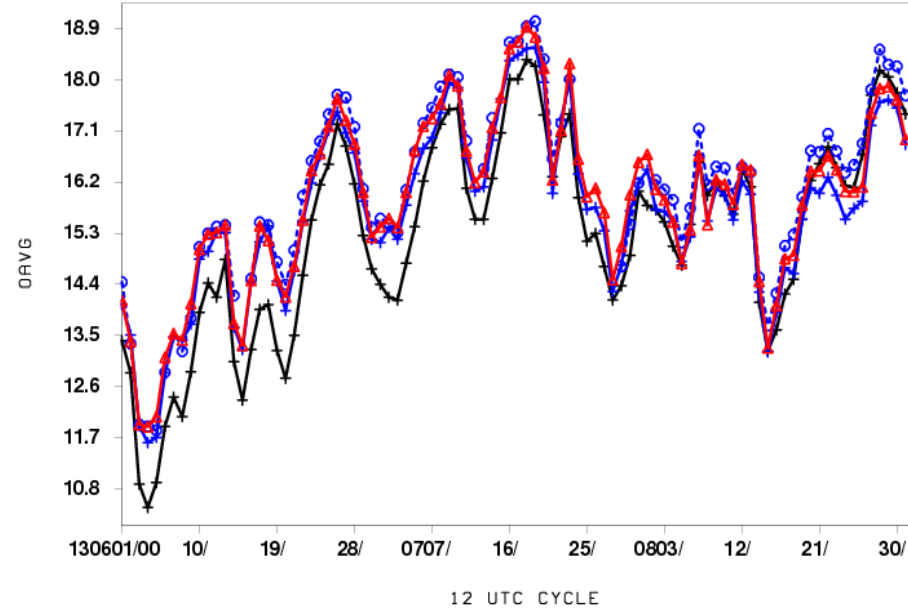
DPT OAVG AVGED BY FCST HRS
20130601 TO 20130831
CONUSNEST

—+— OBSERVED-MEAN
—+— NAM FORECAST-MEAN
- - -○- - - NAMX CONUS FORECAST-MEAN
—△— CONUSNEST CONUS FORECAST-MEAN

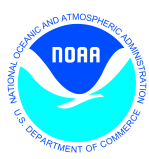


36 H DPT VALID 0000 GMT
CONUSNEST

—+— OBSERVED-MEAN
—+— NAM FORECAST-MEAN
- - -○- - - NAMX CONUS FORECAST-MEAN
—△— CONUSNEST CONUS FORECAST-MEAN



NAM-X very moist
CONUS Nest best



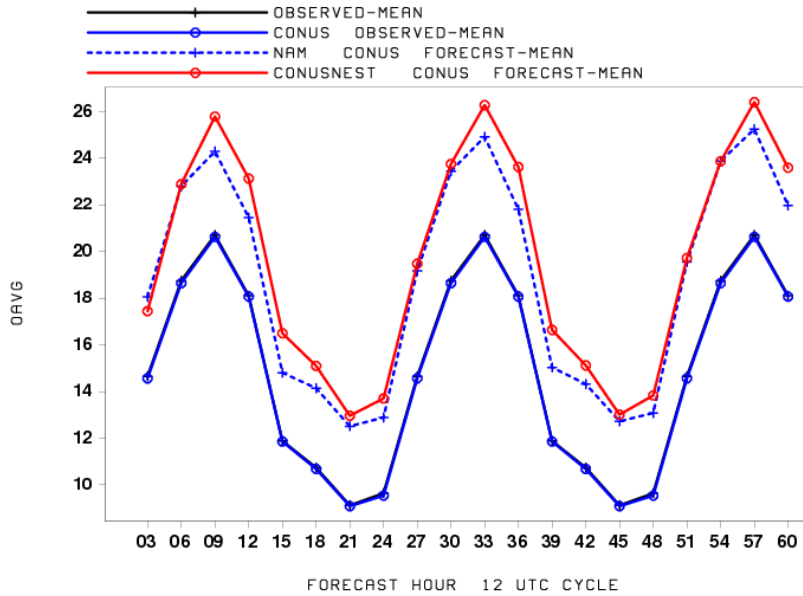
10 M Wind Speed

Summer 2013

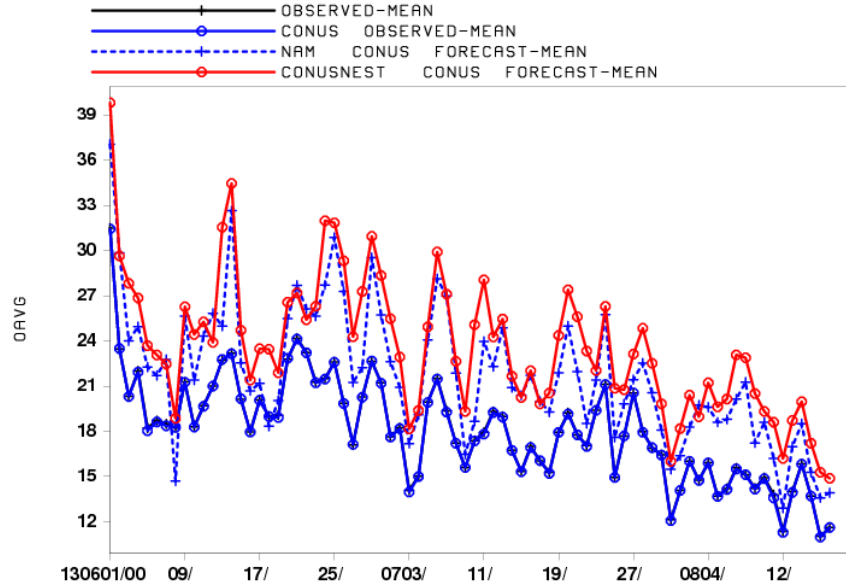
NAM, NAMX vs Nest



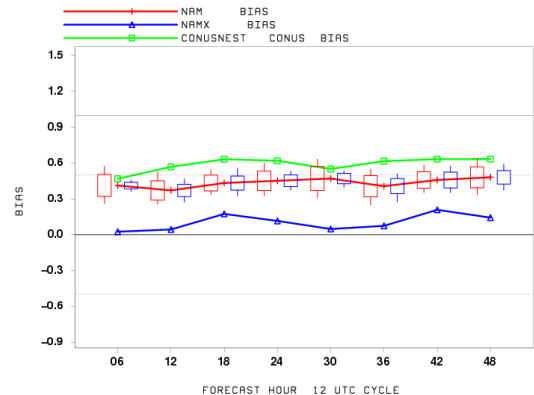
VWIND OAVG AVGED BY FCST HRS
20130601 TO 20130818
CONUSNEST



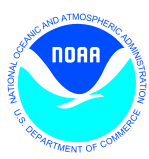
36 H VWIND VALID 0000 GMT
CONUSNEST



VWIND BIAS AVGED BY FCST HRS
20130601 TO 20130831
CONUSNEST



NAM-X and Nest strongest winds

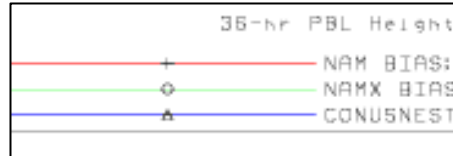


PBL Height (RI # based)

NAM, NAMx vs Nest BIAS

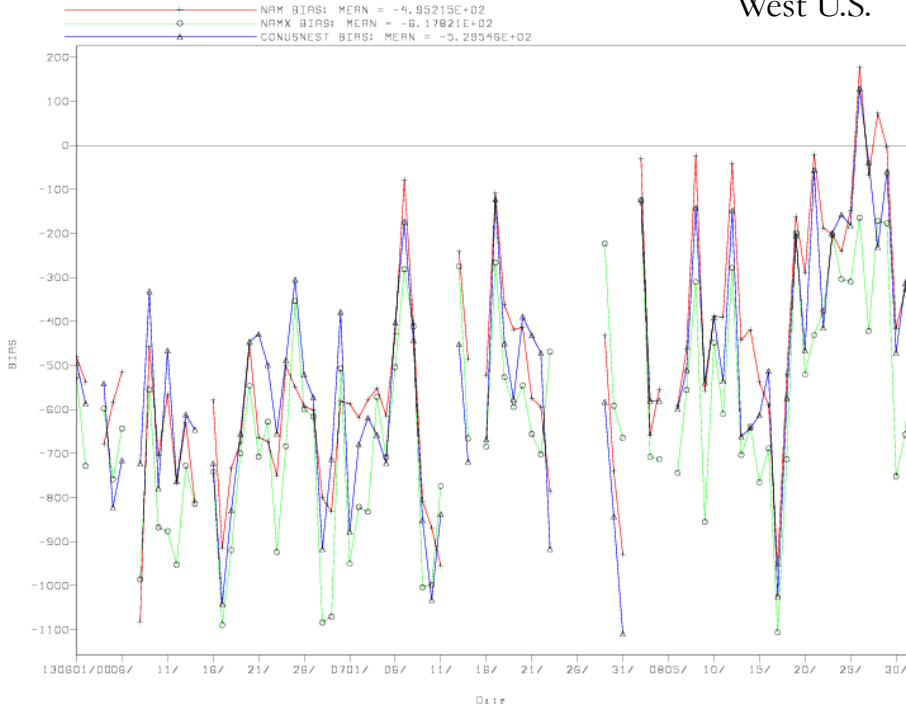
36 hour forecast valid 00 UTC

Summer 2013



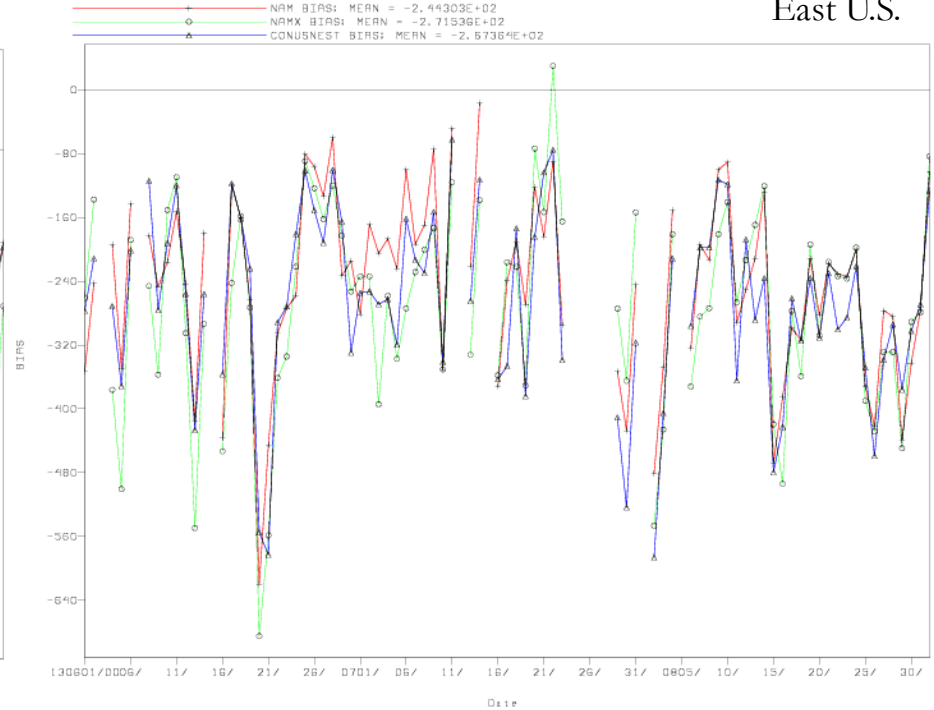
36-hr PBL Height 1 Jun 2013 to 1 Sep 2013 - Valid 00Z - Western US

West U.S.



36-hr PBL Height 1 Jun 2013 to 1 Sep 2013 - Valid 00Z - Eastern US

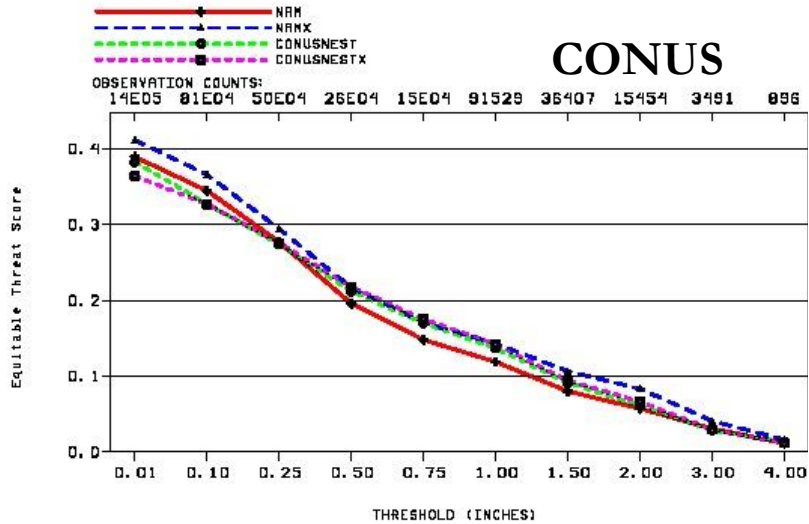
East U.S.



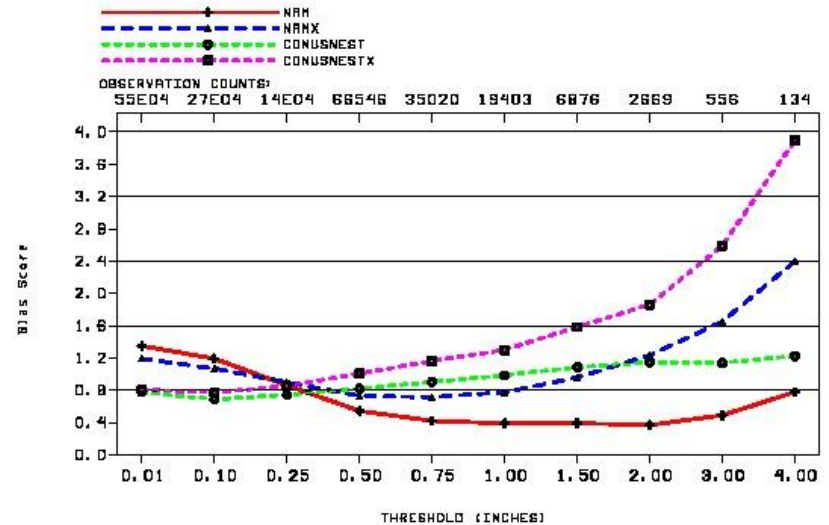
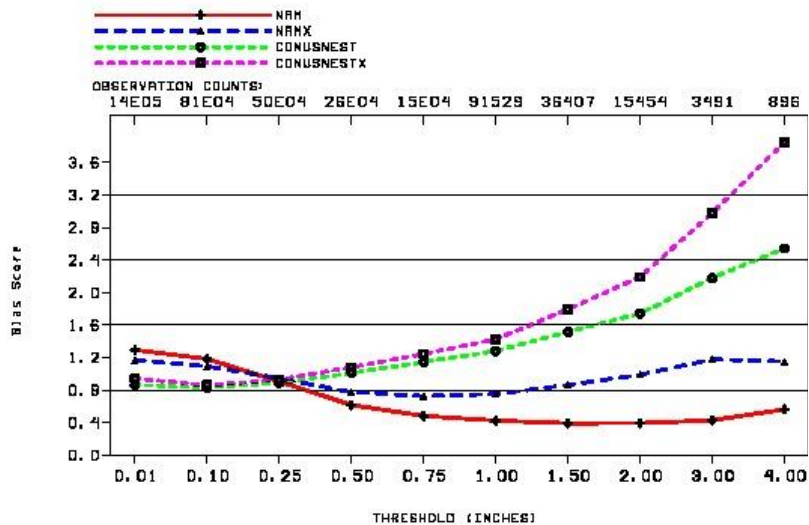
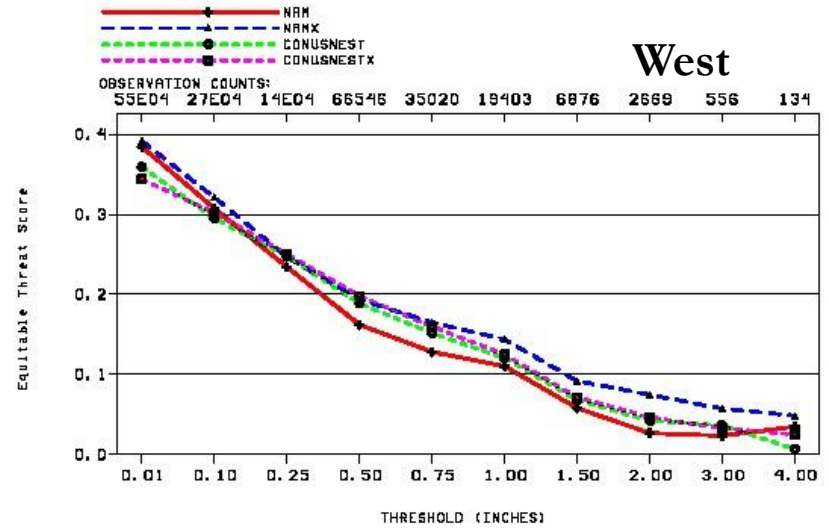
**PBL Hgt underpredicted
NAM-X lowest in West**

Parallel Nest Performance (NAM-X) 24h Precip: Summer 2013

24 h CONUS precip verification for 201306020000 to 201308122300



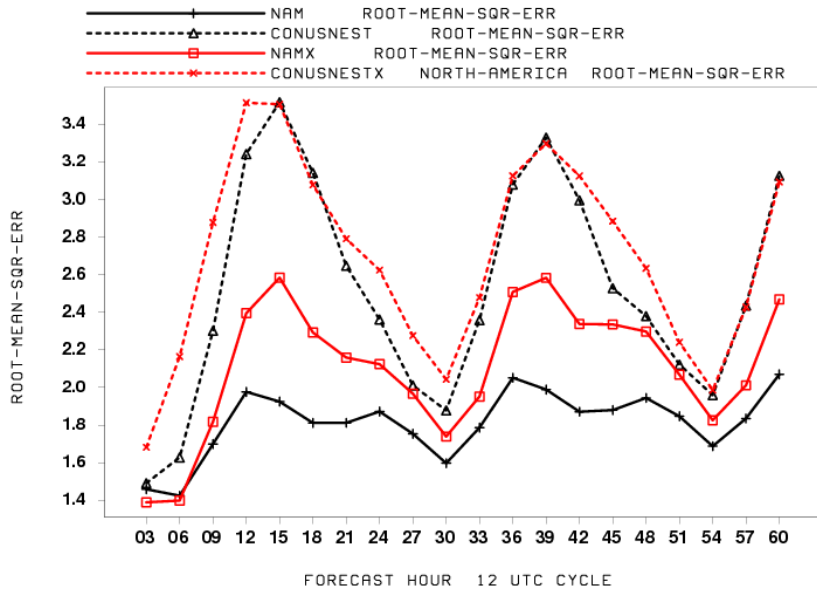
24 h West US precip verification for 201306020000 to 201308122300



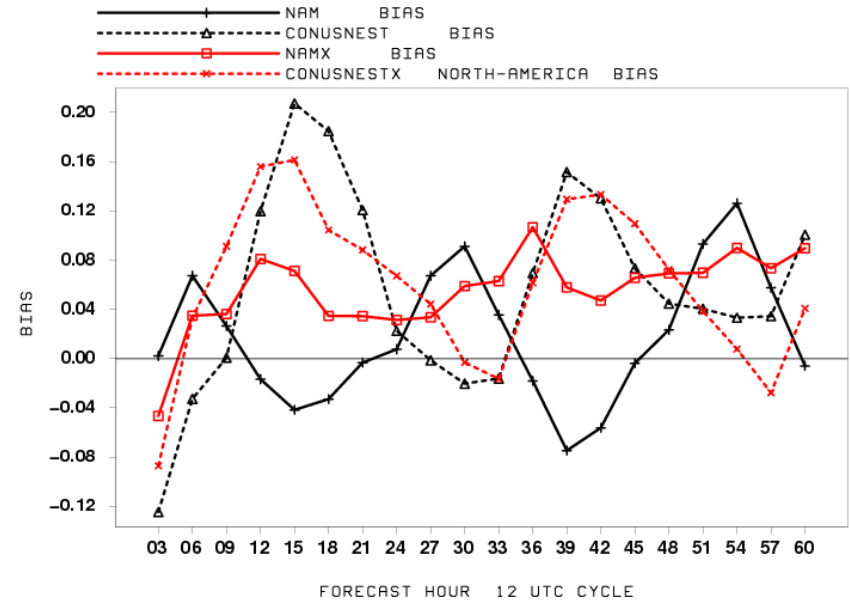
NAM vs NAM-X & Nests RMSE/Bias

03 h Diurnal Precip: Summer 2013

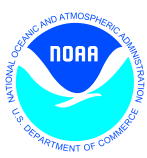
APCP/03 ROOT-MEAN-SQR-ERR AVGED BY FCST HRS
20130601 TO 20130818
CONUSNESTX



APCP/03 BIAS AVGED BY FCST HRS
20130601 TO 20130615
CONUSNESTX



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