Accomplishments Towards Improving the NOAA National Air Quality Forecast Modeling Capability

August 23, 2016

NOAA/OAR/ARL and NWS/NCEP/EMC

Air Quality Team

NCEP AQ Project Team

- *Marina Tsidulko* — *- PBL & Chemistry Verification*
- *- High Res. Met modeling*

- *Youhua Tang* — *- Regional In-line NEMS AQ development*
- *- Lateral Boundary Condition studies*

- *Jianping Huang* — *- Improved Met-chem coupling*
- *- National AQF System Design & Implementation*
- *- U.S. Hysplit Smoke/Dust testing & CMAQ AOD verification*

- *Sarah Lu* — *- Global radiative feedback testing*
- *- NEMS inline aerosols development*

- *Ho-Chun Huang* — *- Global aerosol system Sources*
- *- Global aerosol data assimilation*

- *Mariusz Pagowski* — *- Regional chemical data assimilation*

- *Jeff McQueen* — *- AQF System Evaluation*
- *- DOD Dispersion & PBL analysis support*

- *Geoff Manikin* — *- Hysplit Smoke testing & implementation*

- Binbin Zhou &
- Perry Shafran — – Dispersion/ensemble modeling for H.S.

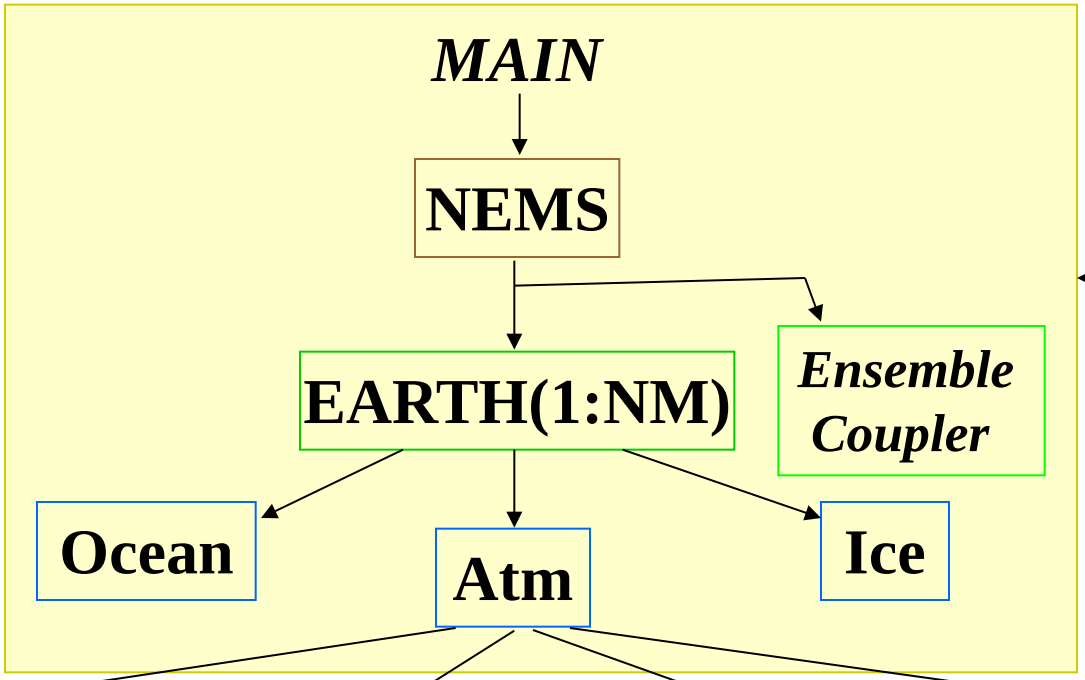
Outline

- NAQFC Model Evaluation
  - Implementing EPA Community Air Quality Forecast System
    - Driving Met processes
      - air-sfc interactions → Dry Deposition, biogenic emissions
      - boundary layer mixing
      - Radiation → Chemistry photolysis
      - Clouds → aqueous chemistry
- Emphasis
  - High resolution NMMB Prediction
  - Evaluation of met errors important for AQ
    - Surface fluxes, Low level winds, temperature, moisture
    - Boundary layer turbulence, evolution
    - Orographic flow features & timing
    - Cloud, convection, precip evolution, timing
    - weak & strong frontal features
- Suspended:
  - Upgrades to CMAQ (eg: V4.7.1, coupling)
  - High resolution AQ (eg : 4 km)
  - Inclusion of smoke/dust in CMAQ

NEMS Component Structure

All boxes represent ESMF components (now supported by NOAA/ESRL).

Below the dashed line, the source codes are organized by the model developers.



NEMS LAYER

NMM

GFS

FIM

ARW

Domains(1:ND)

Dyn Phy Wrt

CMAQ

Dyn Phy Wrt

NGAC

Dyn Phy Wrt

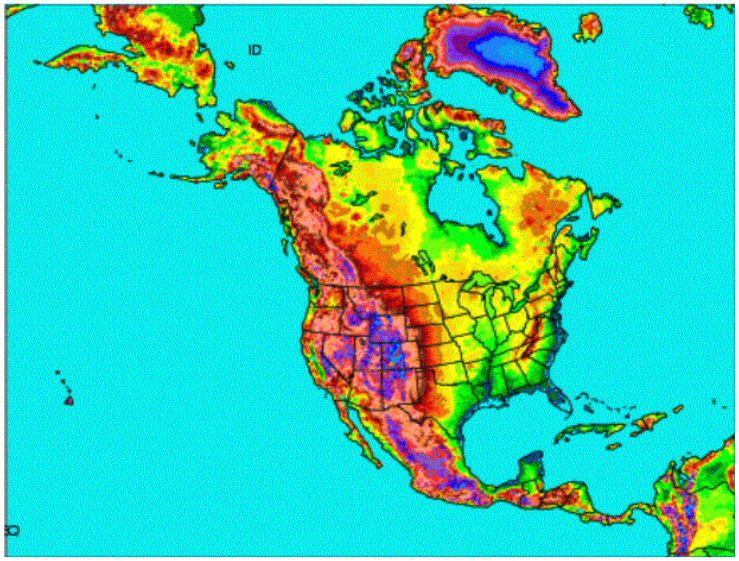
Dyn Phy Wrt

WRF-Chem

October 2011 NAM Upgrade

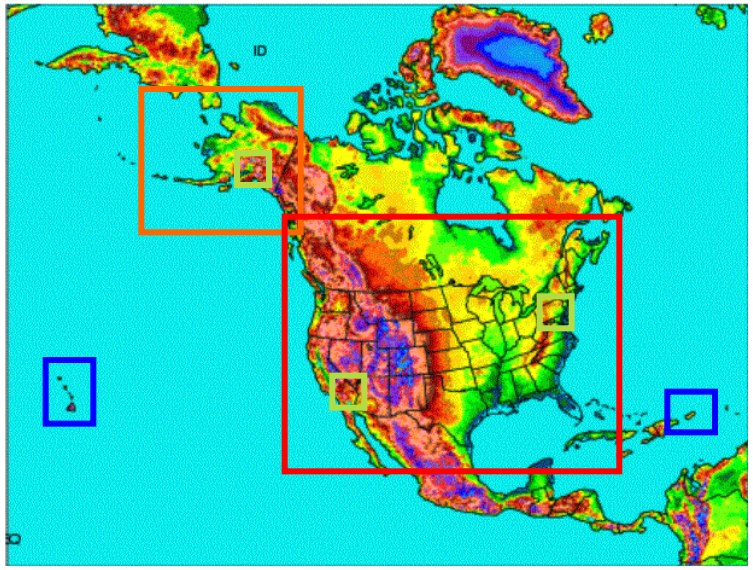
Old NAM

- WRF-NMM (E-grid)
- GSI analysis
- 4/Day = 6 hr update
- Forecasts to 84 hours
- 12 km horizontal
- 12 hr pre-forecast assimilation period with 3hr updates (catch-up)



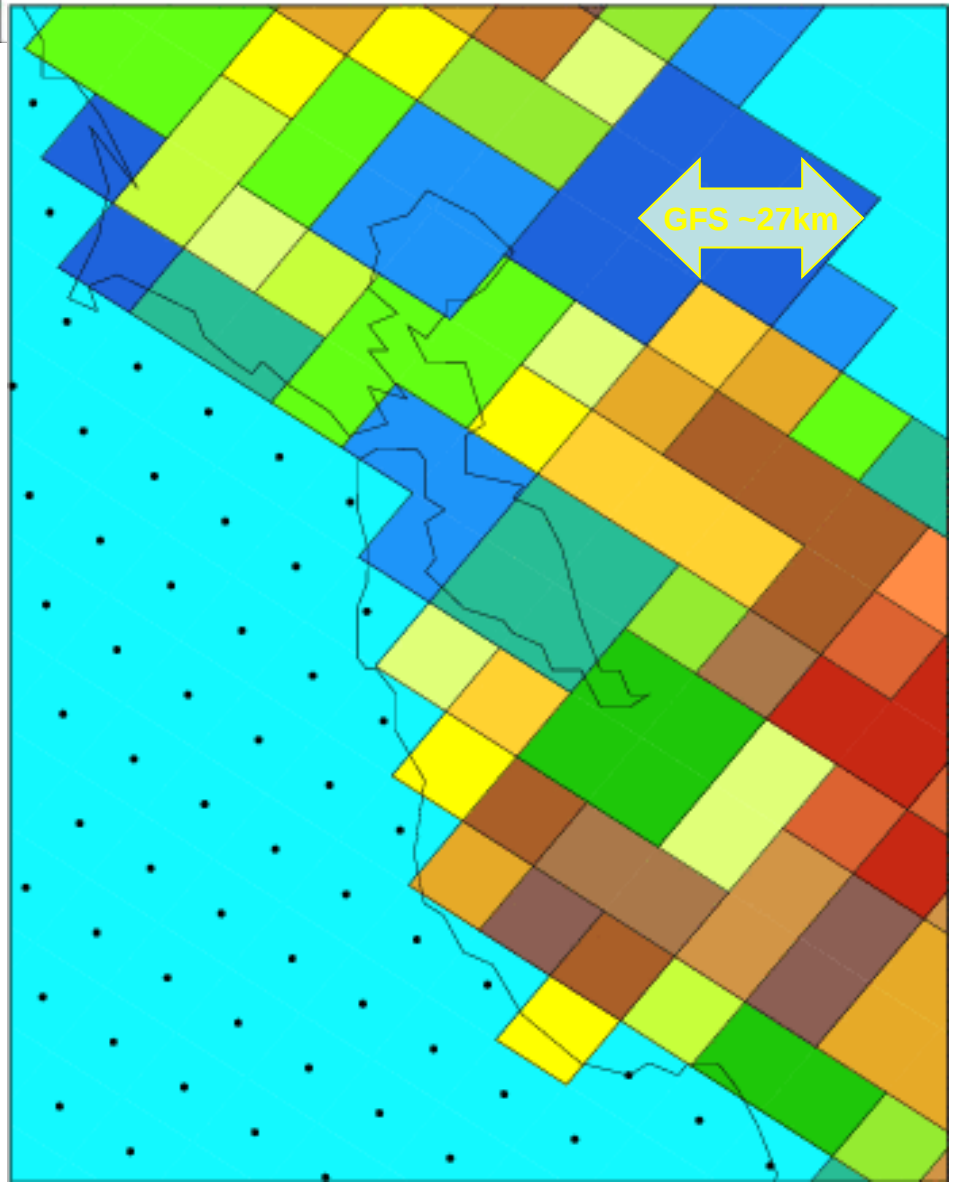
New NAM

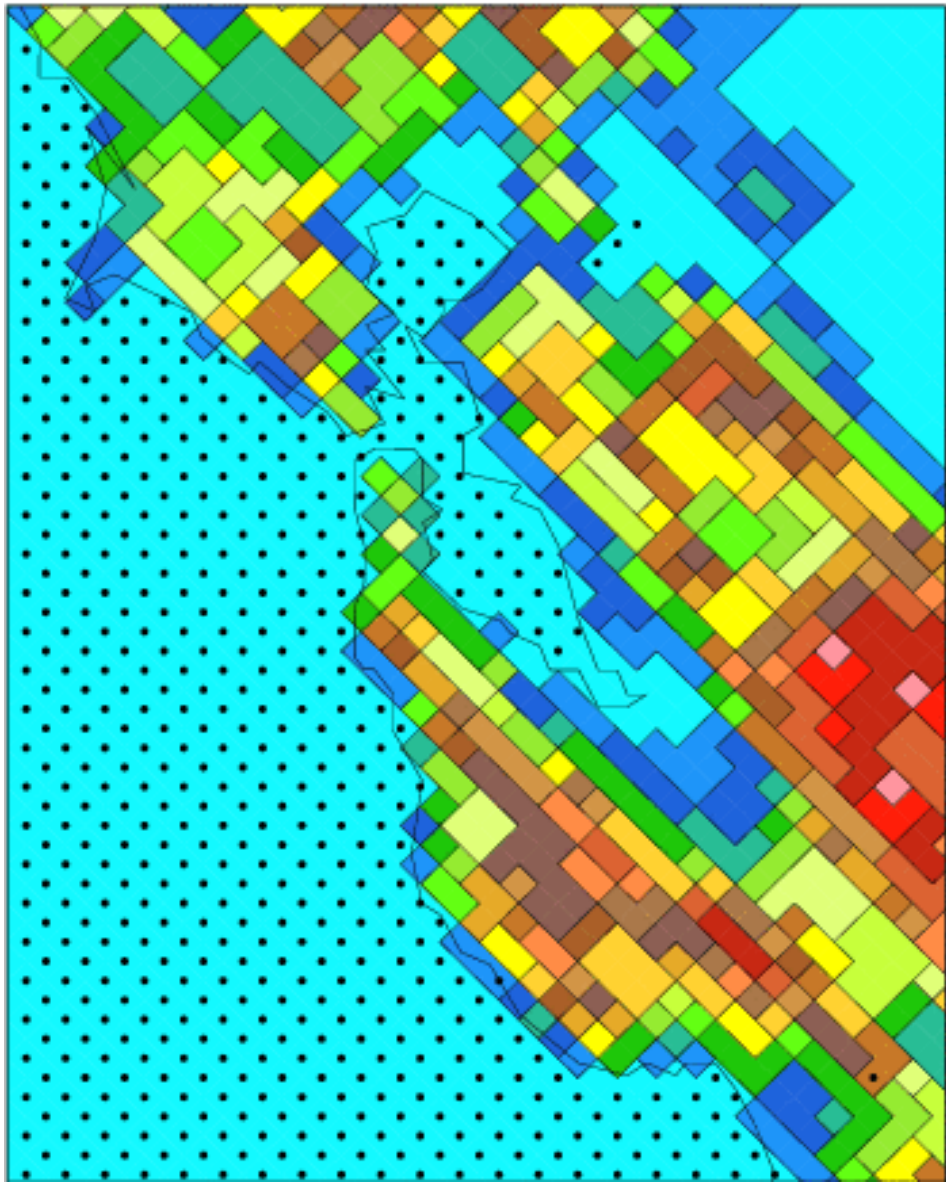
- NEMS based NMMB
- B-grid replaces E-grid
- Parent remains 12 km to 84 hr
- Multiple Nests Run to 60 hr
  - **4 km CONUS nest**
  - **6 km Alaska nest**
  - 3 km HI & PR nests
- **Single locatable ~1.33-1.5 km FireWeather/IMET/DHS run to 36hr**



12 km Terrain

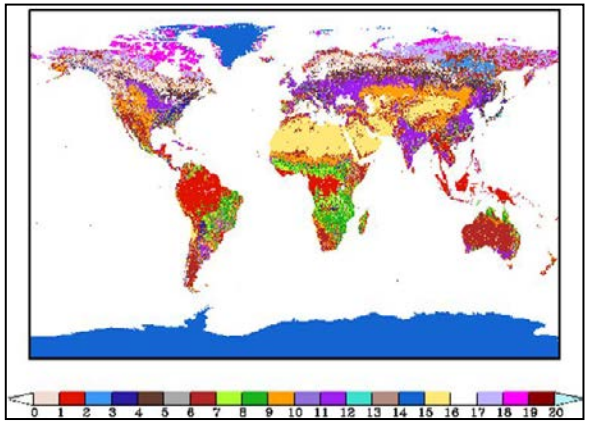
4 km





Dots represent water points Domain is San Francisco Bay

Land Data Set: Land-Use and Improved Model Performance



Land-use type (1-km, MODIS)

- New land-use (vegetation type) data set based on MODIS used by Noah land model in NAM.

- Better surface representation yields better surface fluxes and temperature forecasts in NAM.

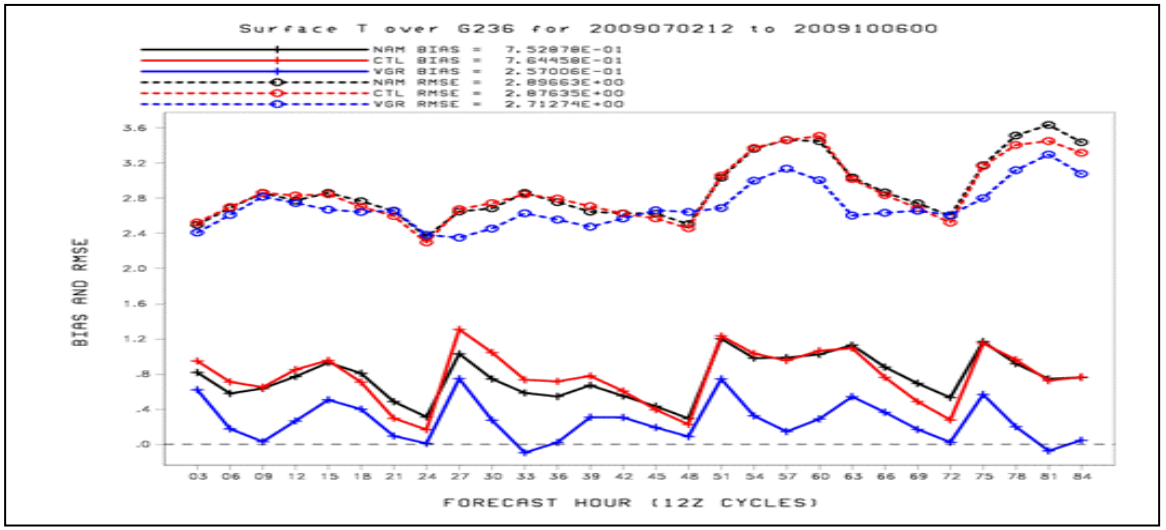
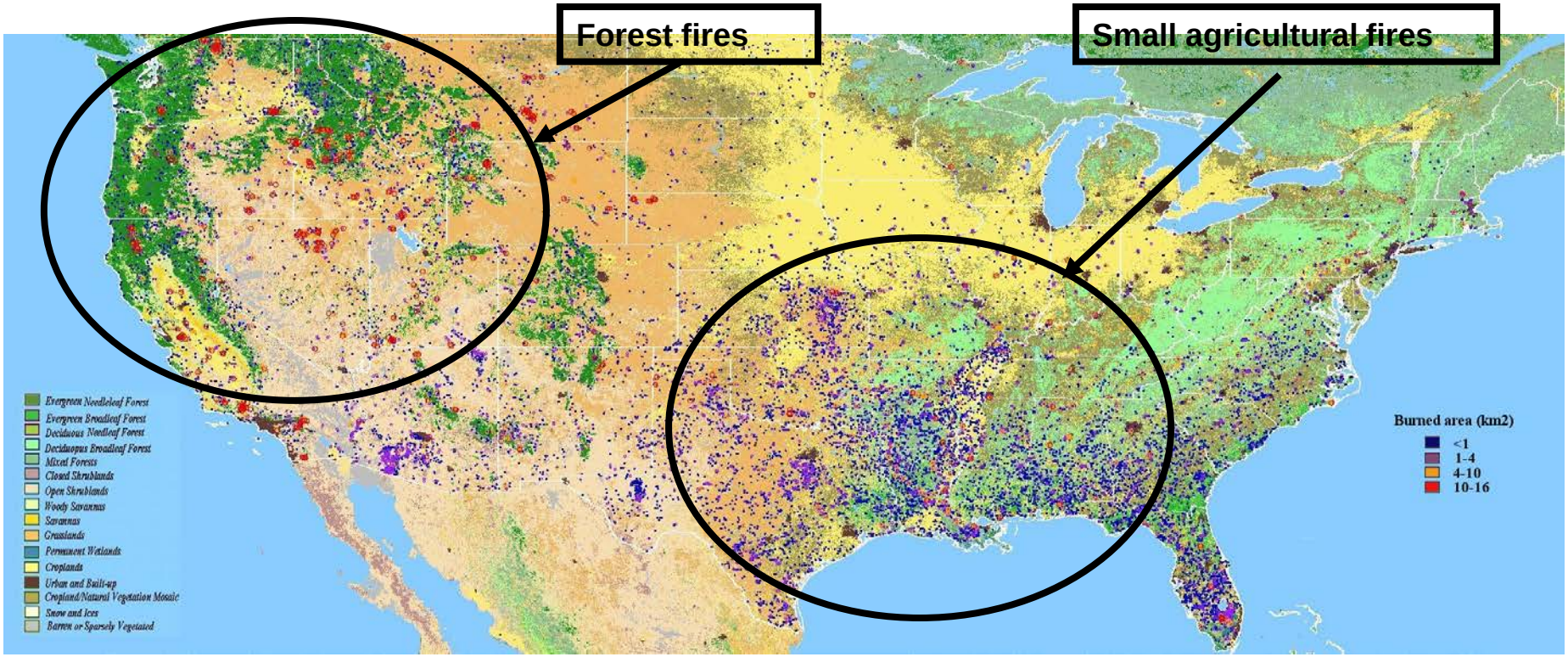


Figure 1. Composite diagrams of the CONUS averaged 2-m temperature bias (solid lines) and RMSE (dash lines) (left), and 48-72 hr Precipitation ETS (right) for operational (NAM in black) run, control (NMMB in red) run and new (NMMB+GVF+IGBP in blue) run of 11 case studies from July 2 to October 5, 2009.

Near Real Time Burned Area Product

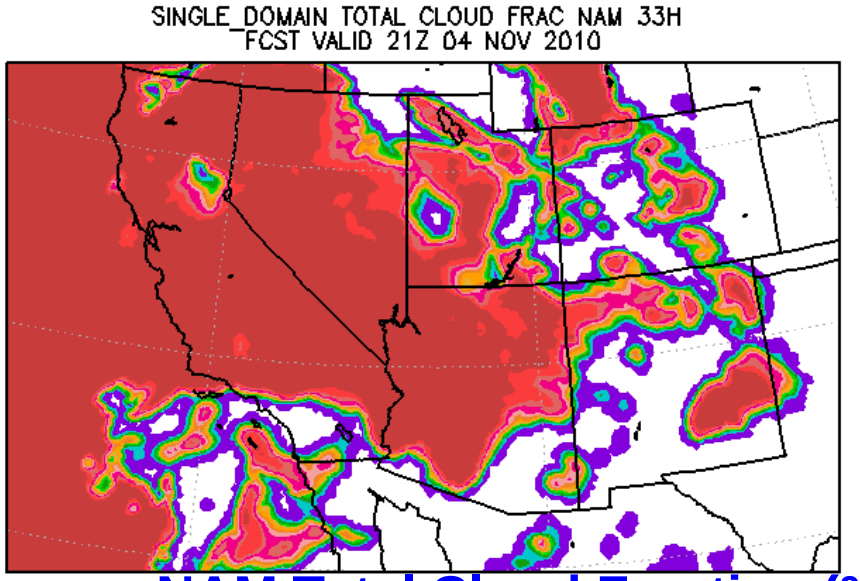


- **Derived from GOES at 30-minute interval for every fire pixel**
- **Data from 2002 – present available (*for product access contact Shobha.Kondragunta@noaa.gov*)**
- **Product to become operational in Spring 2008 which will allow users to obtain this data in near real time. Product will be archived and can be accessed from NOAA/ NCDC**

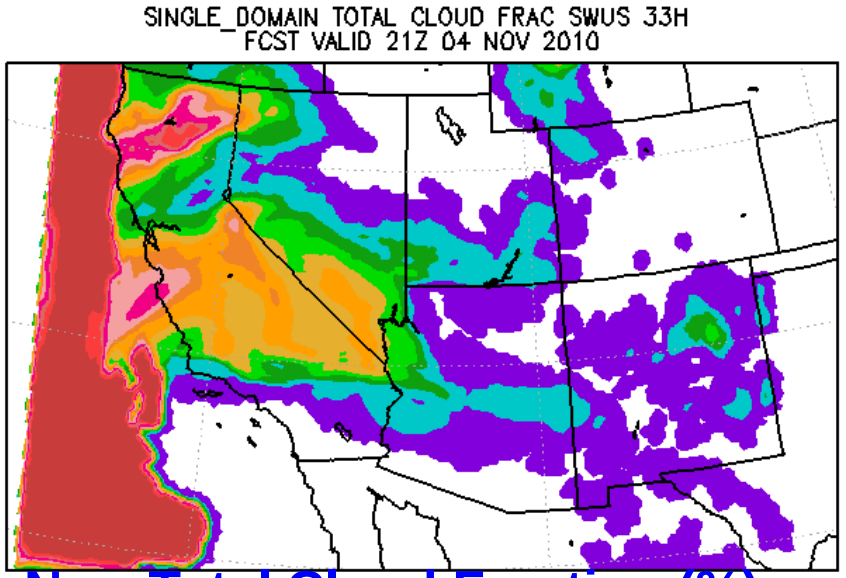
Zhang and Kondragunta, RSE, in press

New Cloud Fraction

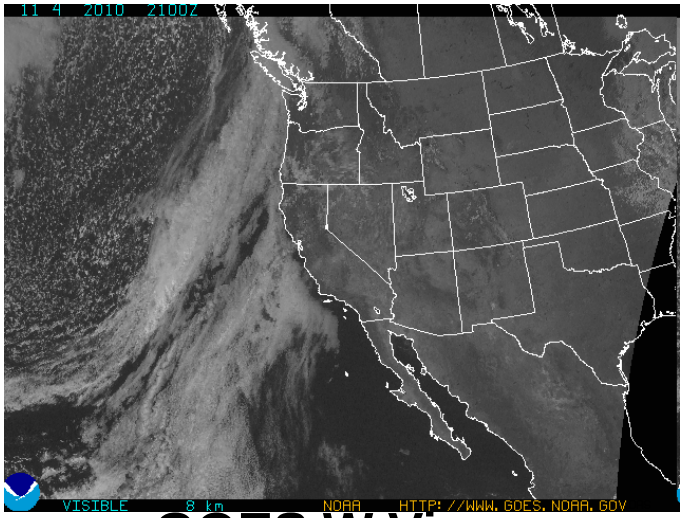
reduced for cold, high clouds



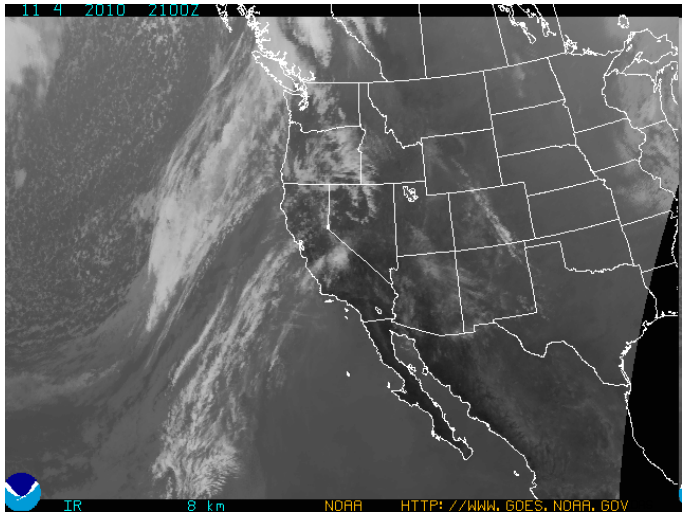
NAM Total Cloud Fraction (%)



New Total Cloud Fraction (%)



GOES W Vis



GOES W IR

NAM-CMAQ NAQFC Current Configuration

Ozone and PM2.5 Predictions

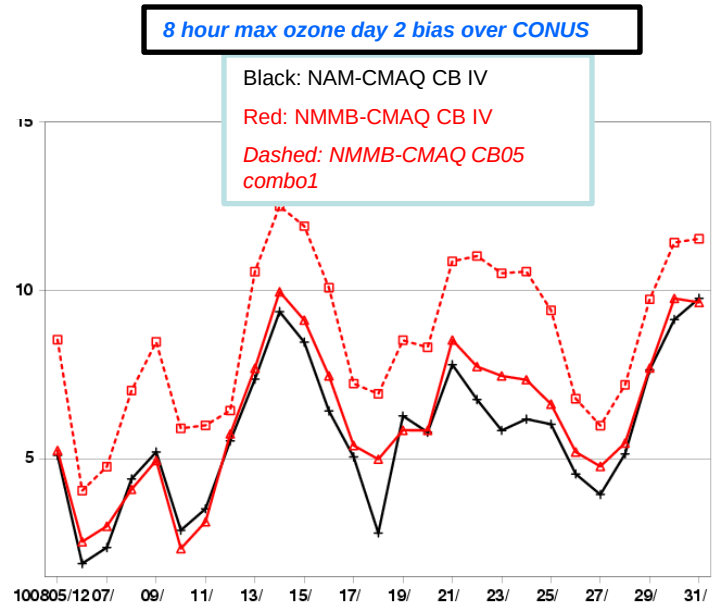
http://www.weather.gov/aq

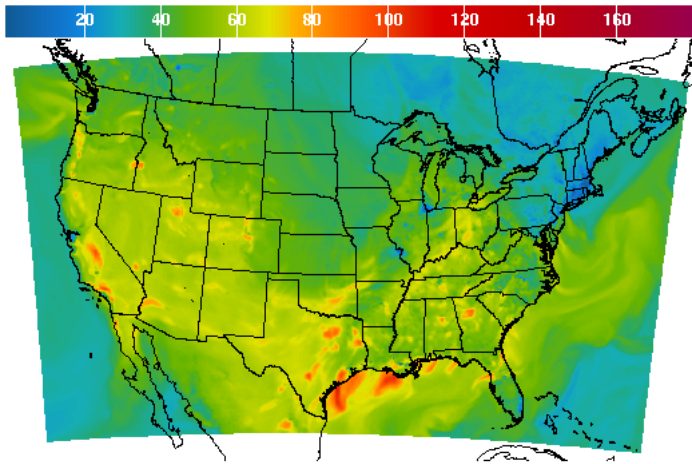
Emissions:
- EPA CEM anthropogenic inventories
- 2005 base year projected to current year w/ EGU
- BEIS V3 Biogenic Emissions

Met Model:
- North American Model (NAM)
- Non-hydrostatic Multi-scale Model (NEMS/NMMB)
- 12 km 60 Levels

AQ Model:
- EPA Community Model For Air Quality
  - CMAQ V4.6: 12 km/L22 CONUS Domain
  - Operational: CB04 gas-phase
  - *Exper: CB05 gas-phase/ Aero-4 aerosols*

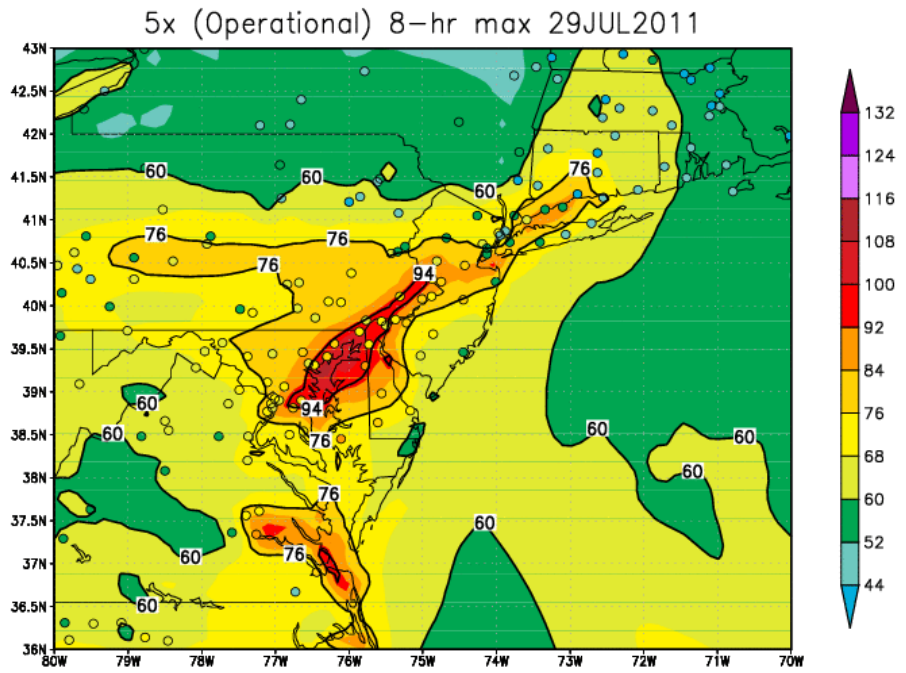
Access
- Output available on National Digital Guidance Database
  - 48 hour forecasts from 06/12 UTC Cycles
- PM graphics, GRIB files from EMC



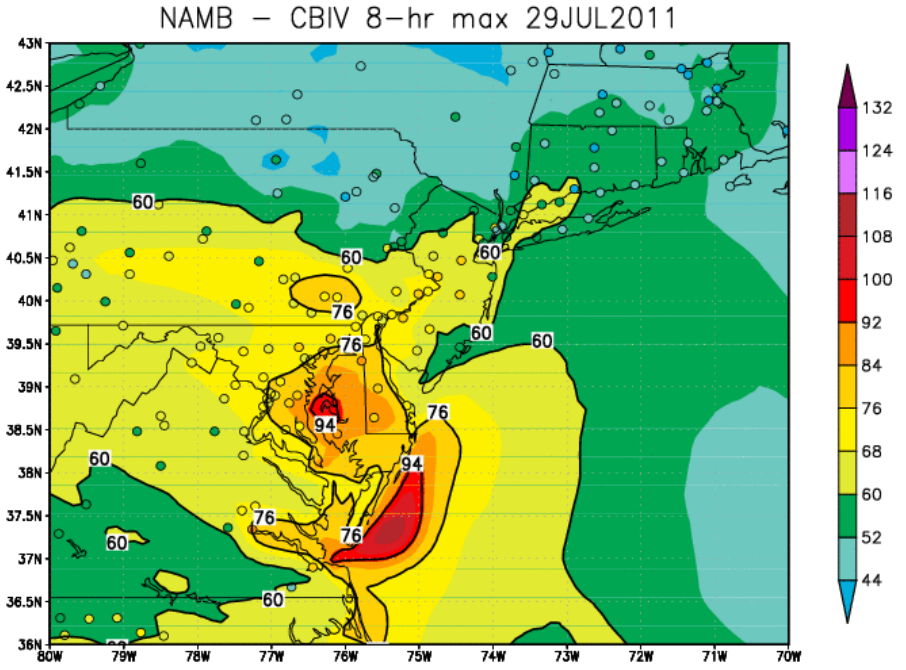


Air Quality Forecast 2011 Verification

July 29, 2011 case



NAM-CMAQ CB-IV chemistry



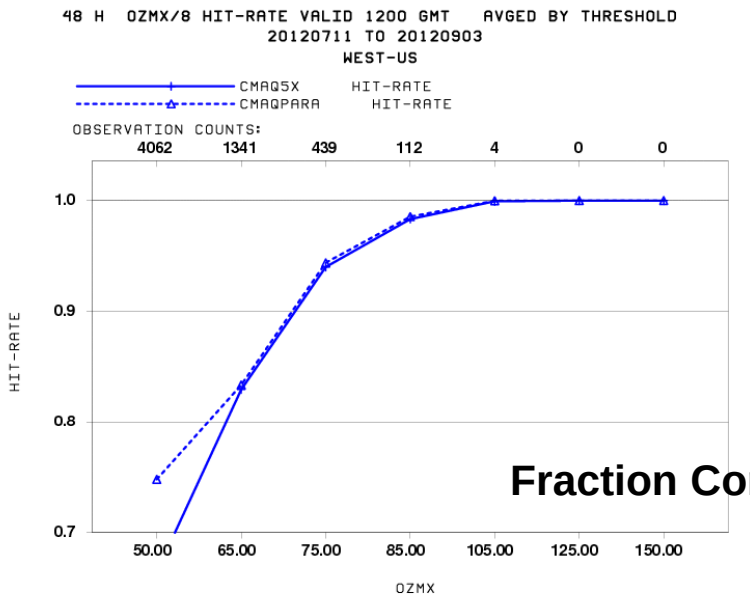
NAMB-CMAQ CB-IV chemistry

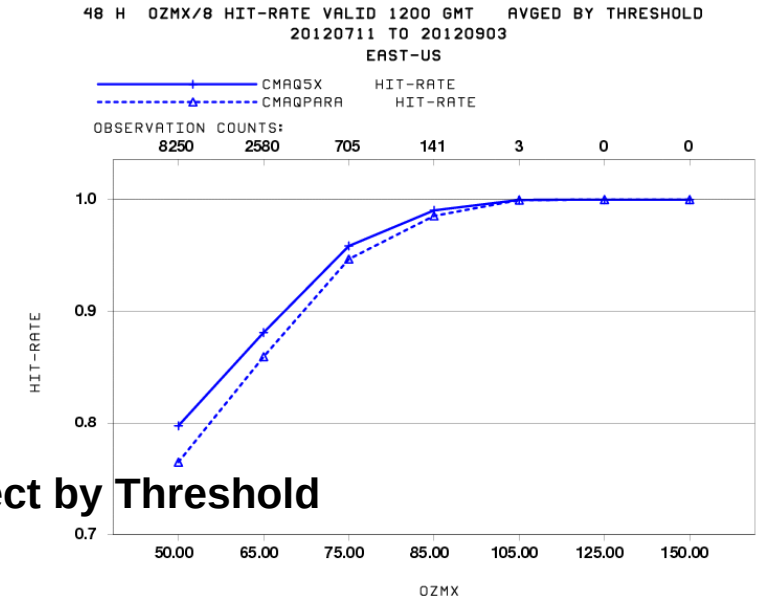
- NAM-B CMAQ: Significant improvement over Mid-Atlantic

Air Quality Forecast 2012 Verification

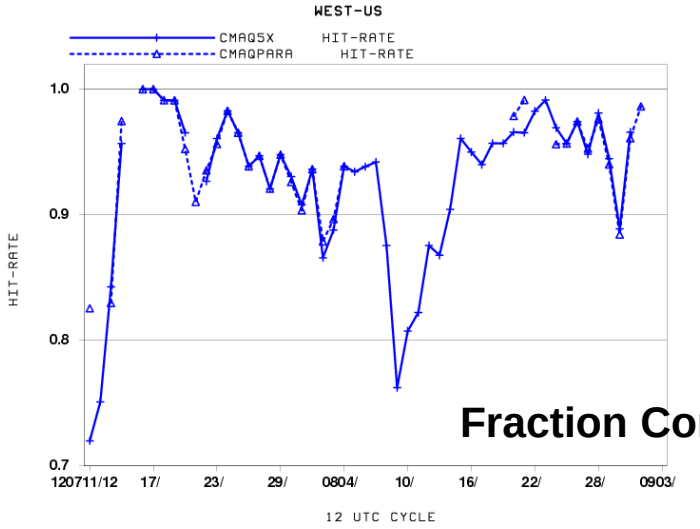
Daily 8 hr Max ozone. Errors for Day 2

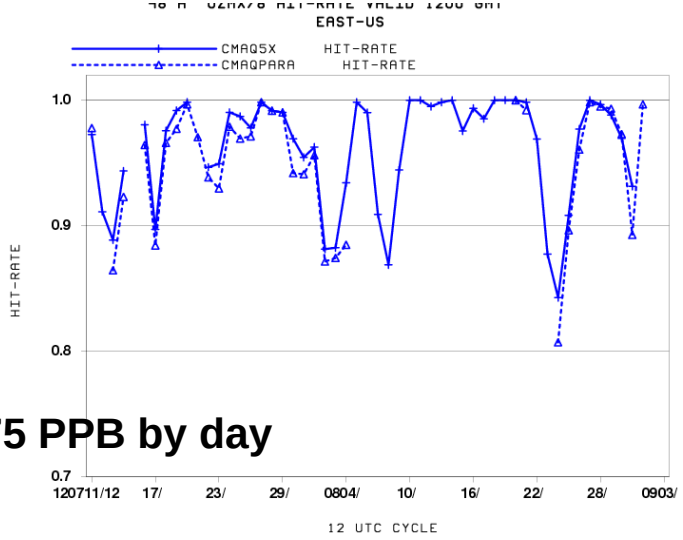
NAM - CMAQ 12 km





Fraction Correct by Threshold



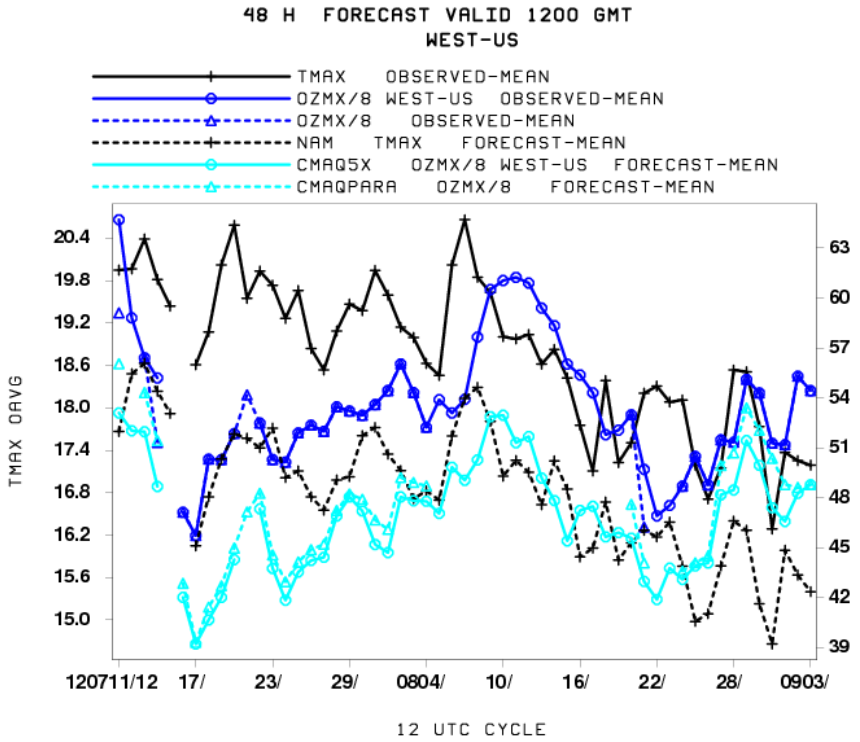


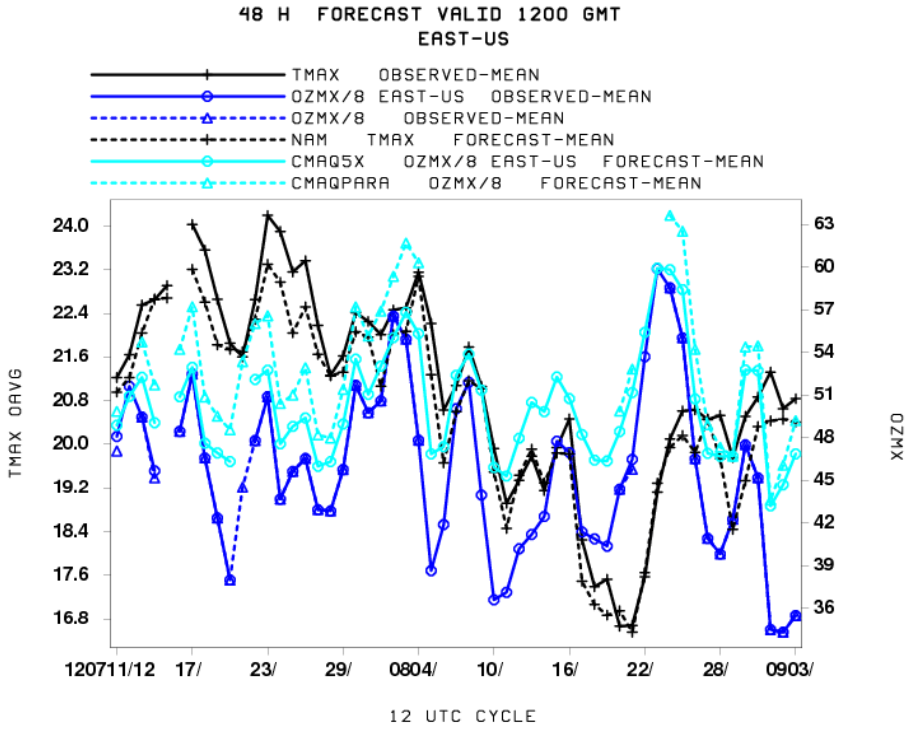
Fraction Correct > 75 PPB by day

NMMB West vs East

2 m Max Temperature vs 8 h Max ozone

Day 2





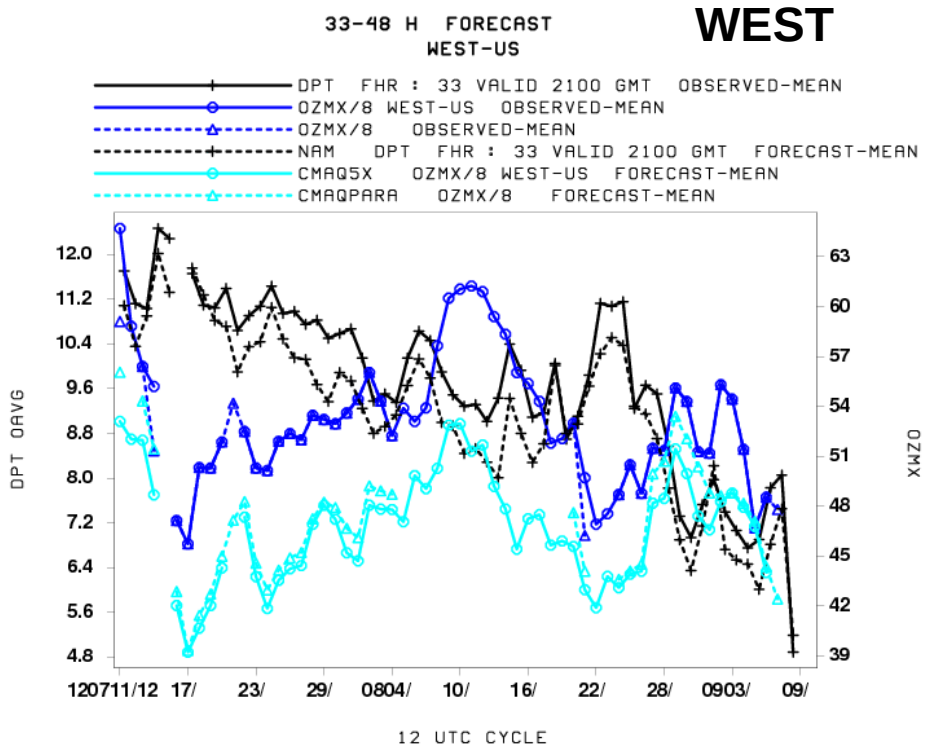
- West : Temperatures & Ozone underpredicted
- East : Slightly cooler, Ozone overpredicted

NMMB West vs East

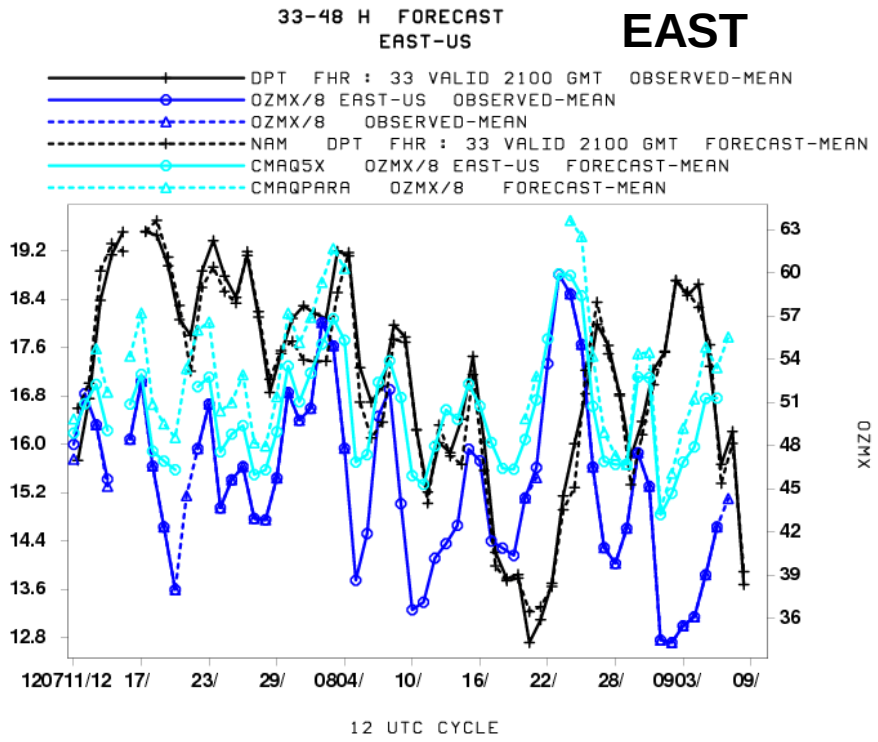
2 m Dew Point T vs 8hr Max ozone

33 hour forecasts valid 21:00 UTC

WEST



EAST



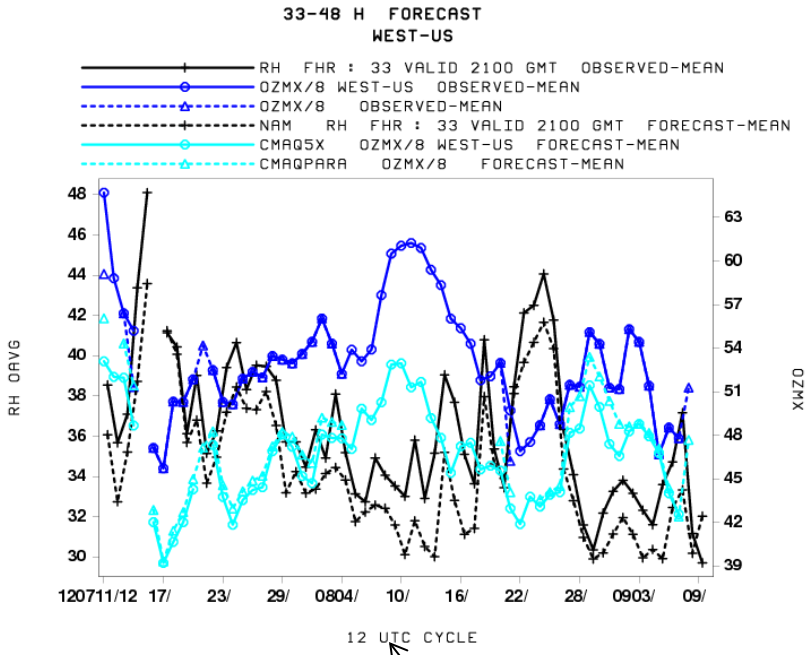
- West : Dewpoint dryer than observed
- East : Dew points good

NMMB West vs East

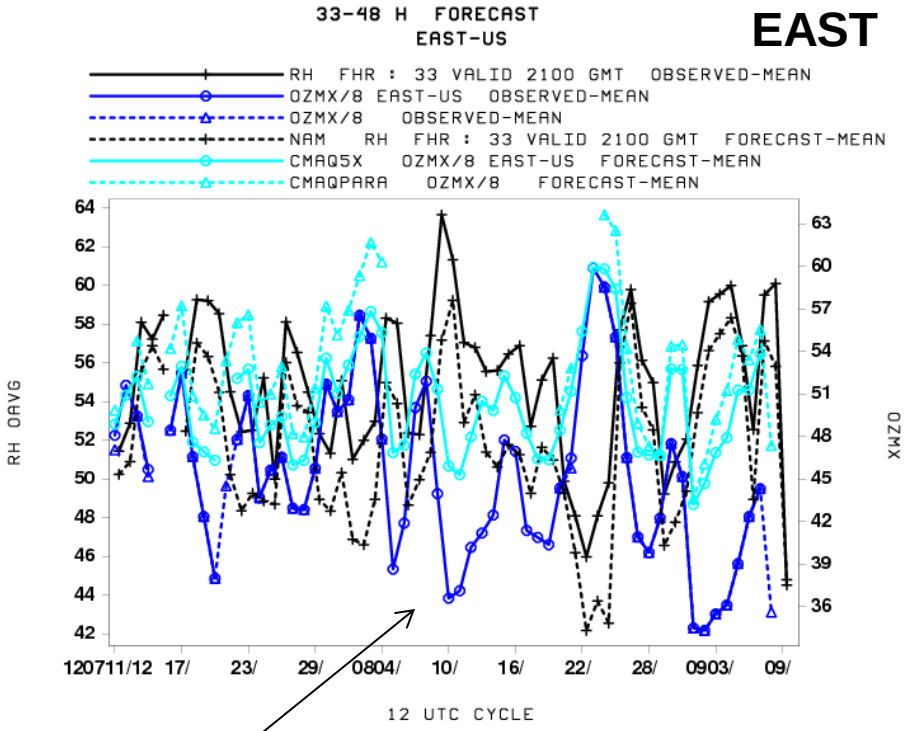
2m RH vs 8h Max ozone

33 hour forecasts valid 21:00 UTC

WEST



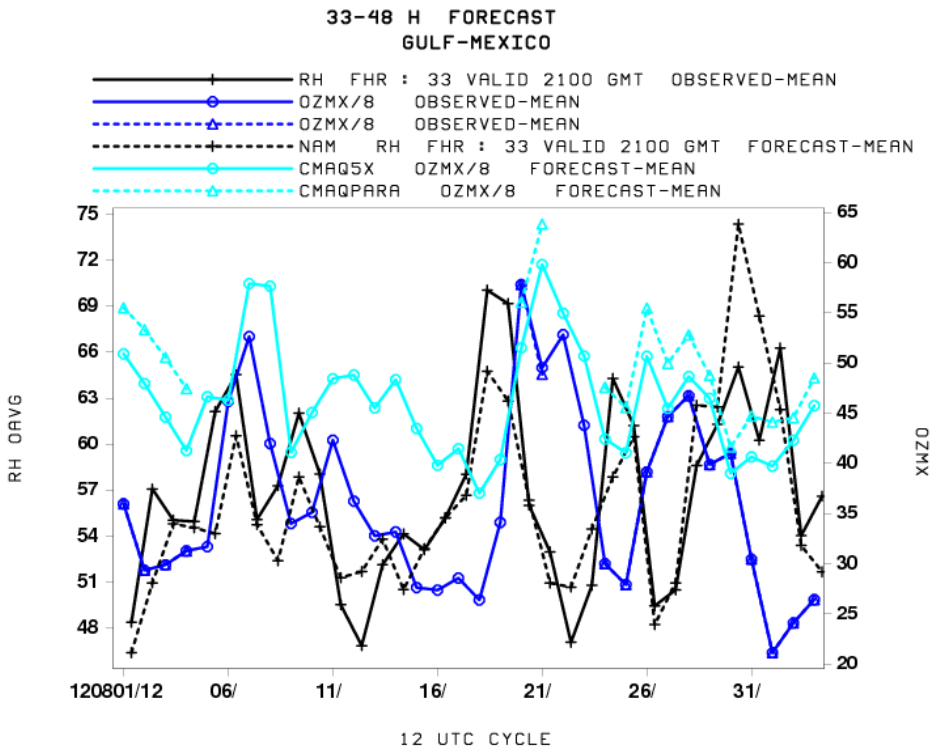
EAST

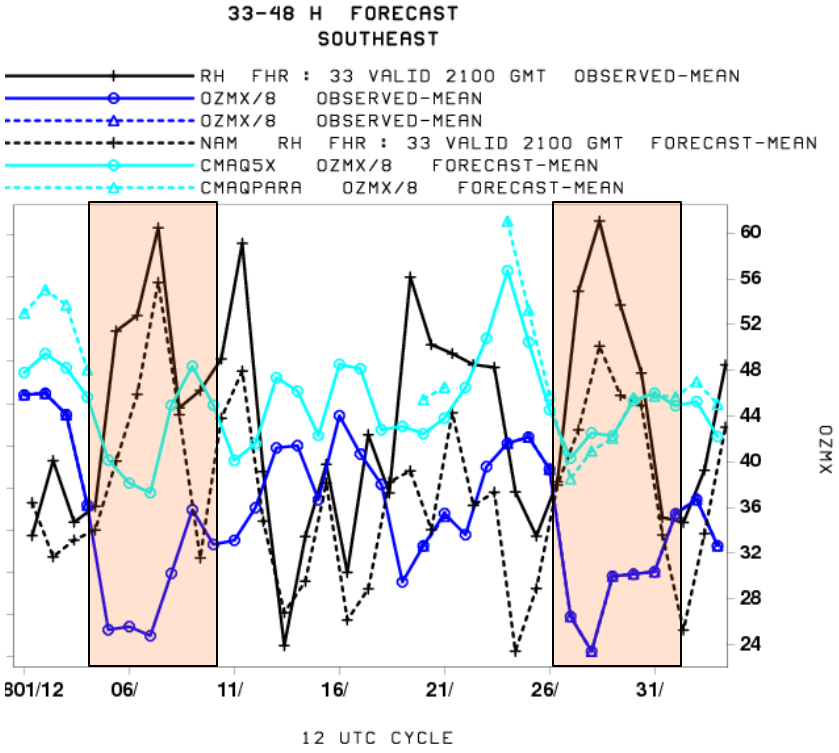


- NMMB RH forecasts good
- High RH correlated with lower ozone
  - Clouds ?

NMMB Gulf and SE States

2m RH vs 8h Max ozone

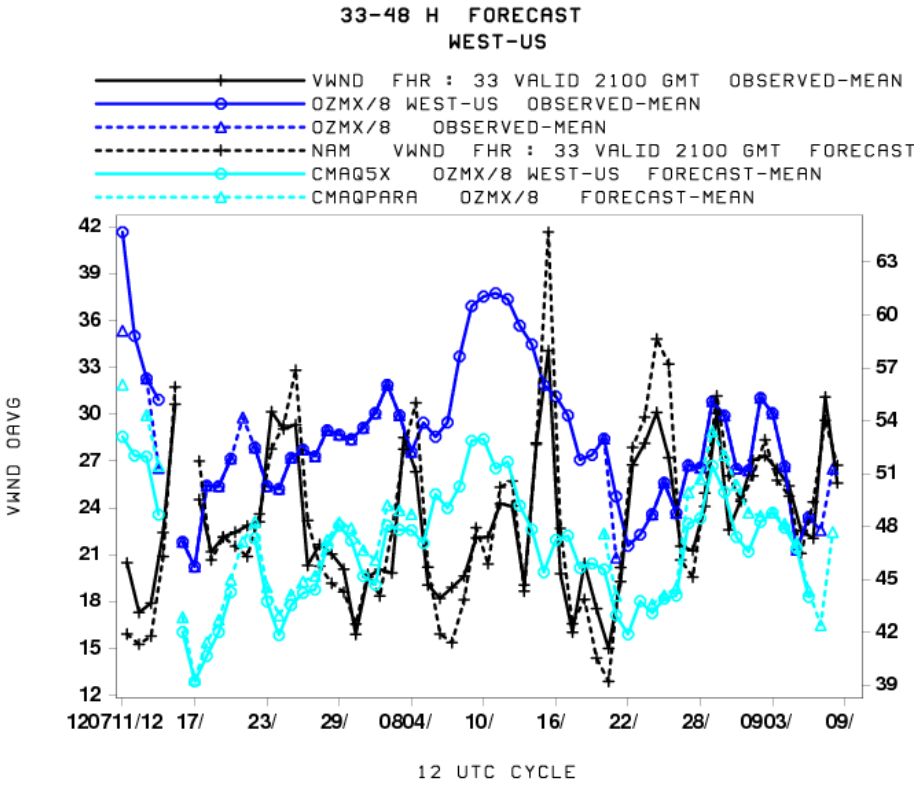


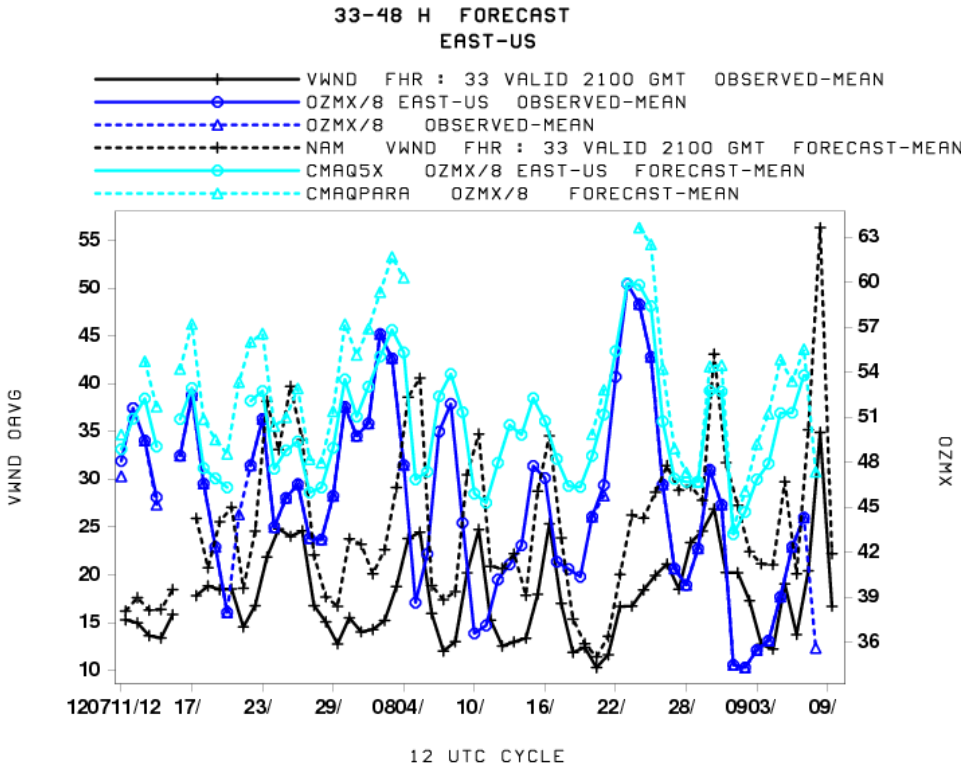


- High RH can be correlated with lower observed ozone and largest model overprediction
  - Esp. over SE

NMMB West vs East

10 m Wind Speed vs Daily max ozone



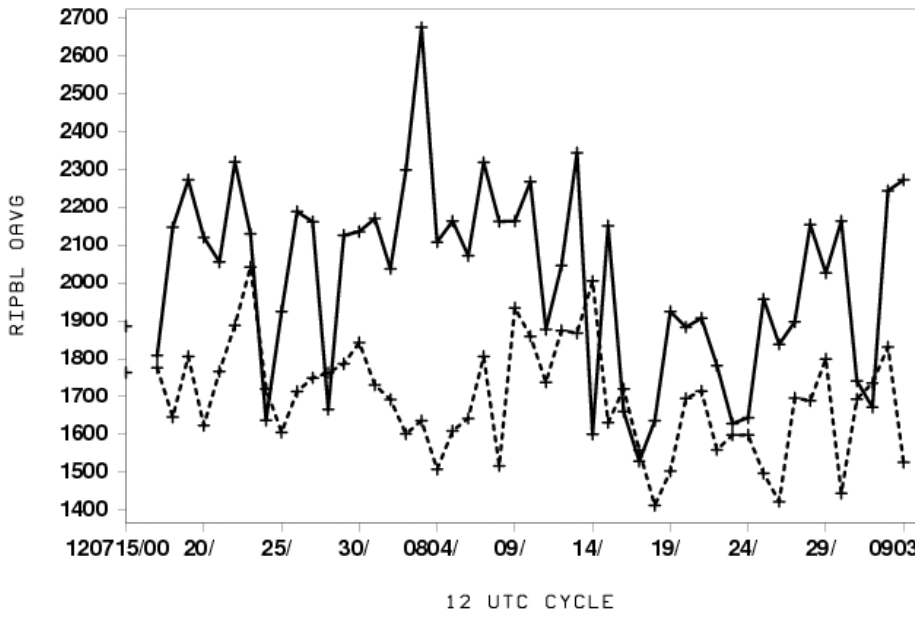


West : Wind Speed good, ozone underpredicted
East : Wind Speed & ozone overpredicted

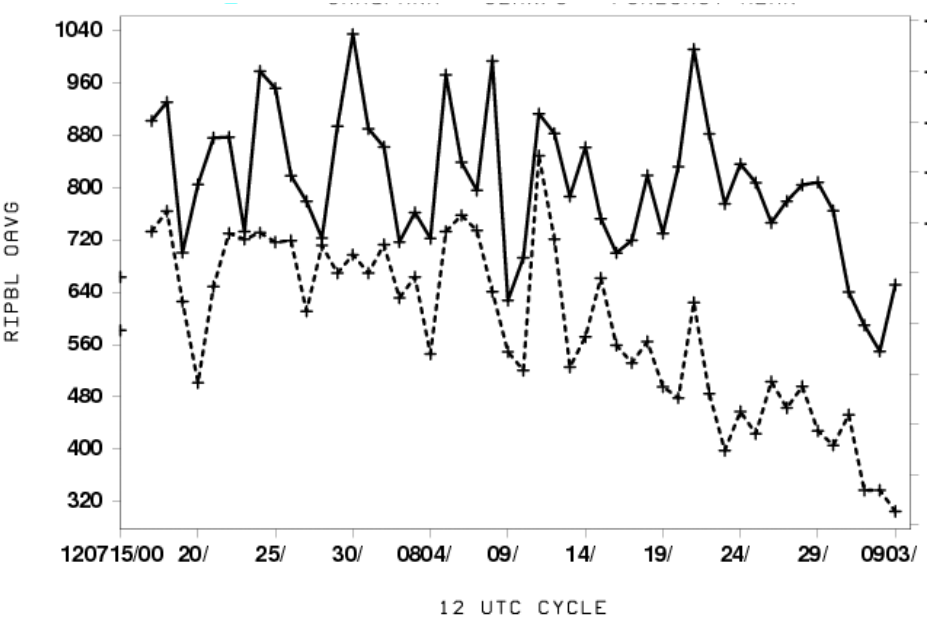
NAM PBL Hgt verification
averaged over West, East domains

Perry Shafran

WEST



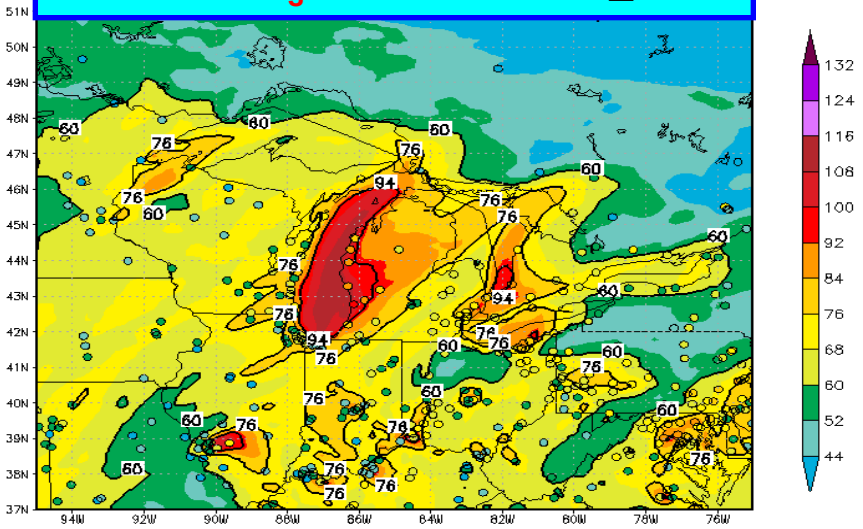
EAST



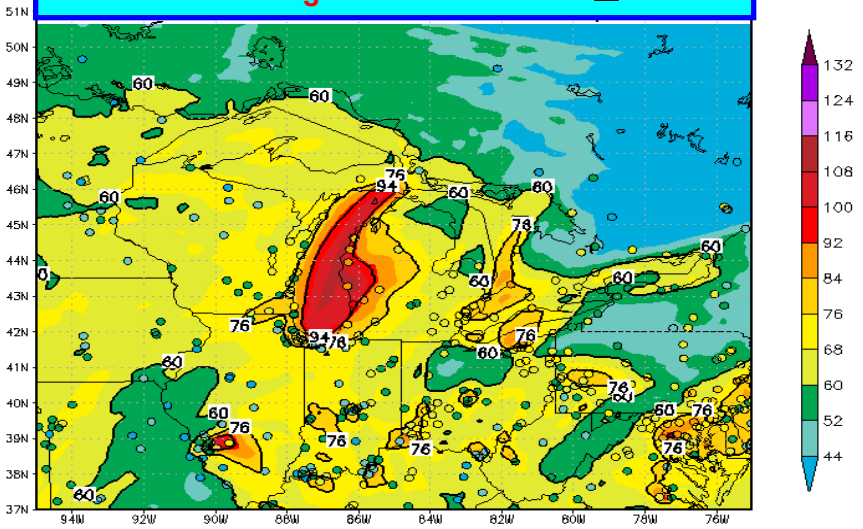
O3 Overprediction over lakes ?

Max 8-hr O_3 on July 20, 2011 (Jianping Huang)

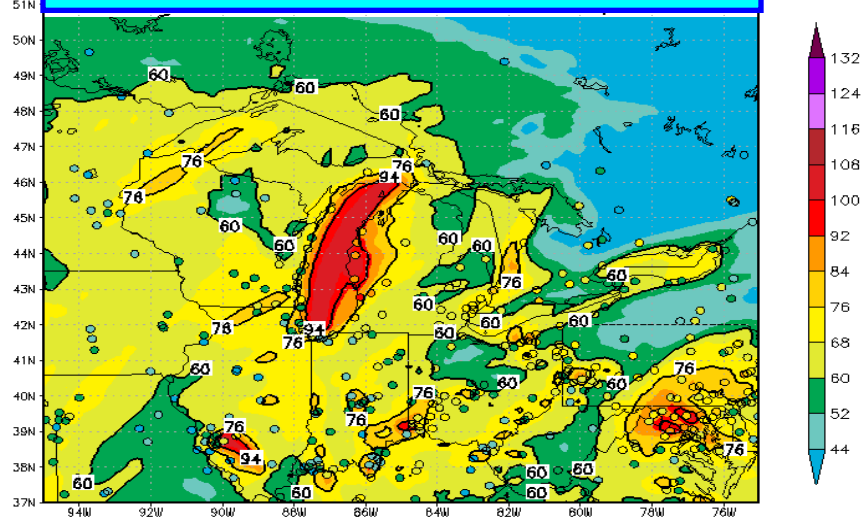
8-hr max O_3 for case ACM2_BMJ



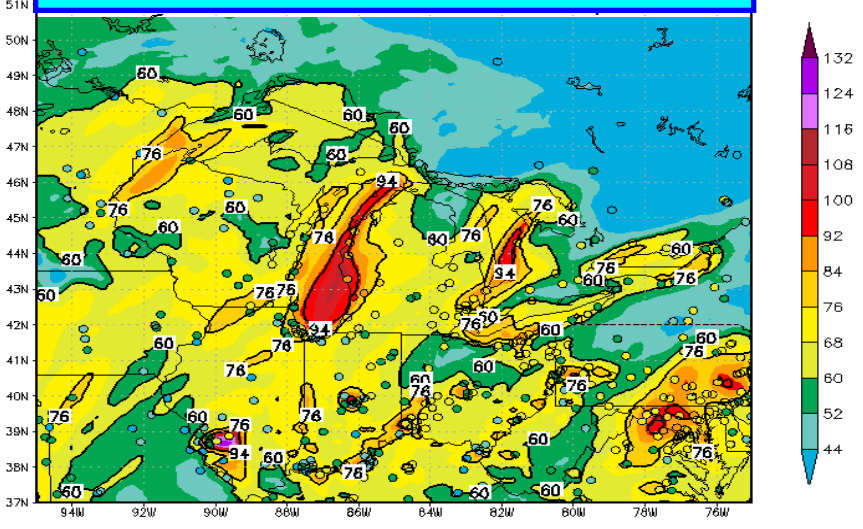
8-hr max O_3 for case MYJ_BMJ



8-hr max O_3 for case MYJ_SAS

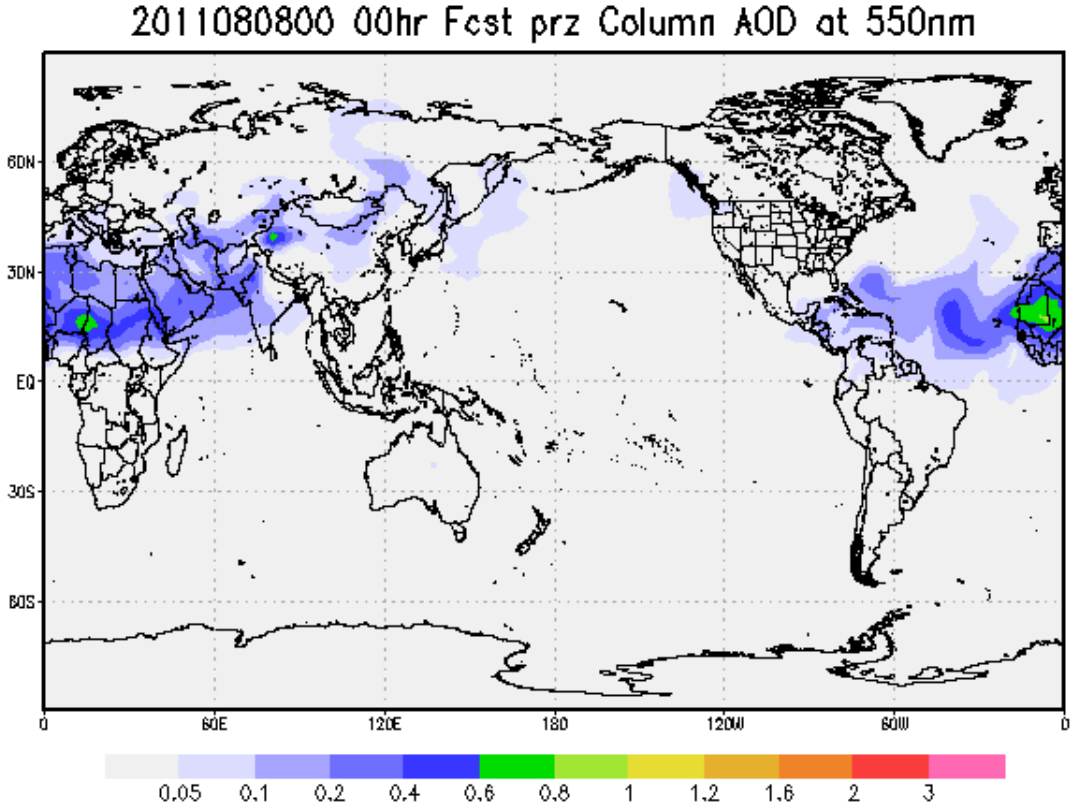


8-hr max O_3 for case GFS_SAS



Operational NGAC

Operational on Sept. 11, 2012
Sarah Lu, NCEP/EMC



- 120-hr dust-only forecast once per day (00Z)
- ICs: Aerosols from previous day forecast and meteorology from operational GDAS
- 3-hourly products: 3d distribution of dust aerosols (5 bins from 0.1 – 10 μm)
- Automatic output archive, post-processing and web update since June 11, 2011
- Same physics and dynamics as operational GFS with the following exceptions:
  - Lower resolution (T126 L64)
  - Use Relaxed Arakawa-Schubert scheme [Moorthi and Suarez, 1999] with convective transport and tracer scavenging
  - Turn off aerosol-radiation feedback

Summary

Met Model Characteristics Continue to have a Large Impact on AQ

NEMS NMMB Behaviors

- *West*: Strong underpredicton of Max Temperatures in West
- *East* : Good T, Td forecasts, winds overpredicted
- PBLH underpredicted everywhere at 00 UTC

Met Impacts on AQ

- In East, O3 overprediction sometimes correlated to high RH conditions
- In West, O3 underprediction may be related to cooler temperature predictions

Inclusion of intermittent sources Suspended

- Plume rise calibrations
- Inclusion of dust
- Inclusion of external sources from boundaries

Improved metrices required – AQME II

- FC strongly forced by non-events
- Vertical profiles of PBL and AQ