



CMAQ V5.0 Upgrade for ozone and Particulate Matter Predictions

<http://www.emc.ncep.noaa.gov/mmb/qa>

Pius Lee, Li Pan, Daniel Tong –NOAA/ARL
Jeff McQueen, Jianping Huang, Ho-Chun Huang,
Perry Shafran, Geoff DiMego – NCEP/EMC
Jim Wilczak, Irina Djalalova, Dave Allerud – NOAA/ESRL/PSD
Ivanka Stajner, Sikchya Upadhaya – NWS/STI
Amanda Sleinkofer – Millersville University

February 17, 2017



CMAQ weaknesses Identified

- Overprediction of ozone in Eastern U.S. in Summer
 - Especially along coastal cities (NYC, DC, Cleveland)
 - Update National Emission Inventory point sources to 2011 (project to 2016)
 - *Evaluate NOx emissions based on OMI satellite trends (Deferred)*
 - *Evaluate Impact of NAM-X and reduced SW radiation under clouds*
 - *Update CMAQ gas and aerosol chemistry/biogenic emissions to EPA V5.0.2*
- Underprediction of particulate matter (PM) in Summer and near wild-fires
 - *Update 9 year old USFS BlueSky smoke emission system*
 - *Introduce 24 h pre-analysis cycle to correct fire time mismatch with CMAQ initial time*
- Underprediction of Ozone and PM when strong fires are present outside CMAQ domain
 - *Test NGAC full aerosol predictions for CMAQ lateral boundaries*
- Overprediction of PM during winter-time stagnation episodes (cold, stable)
 - *update emissions/chemistry as in bullet 1*

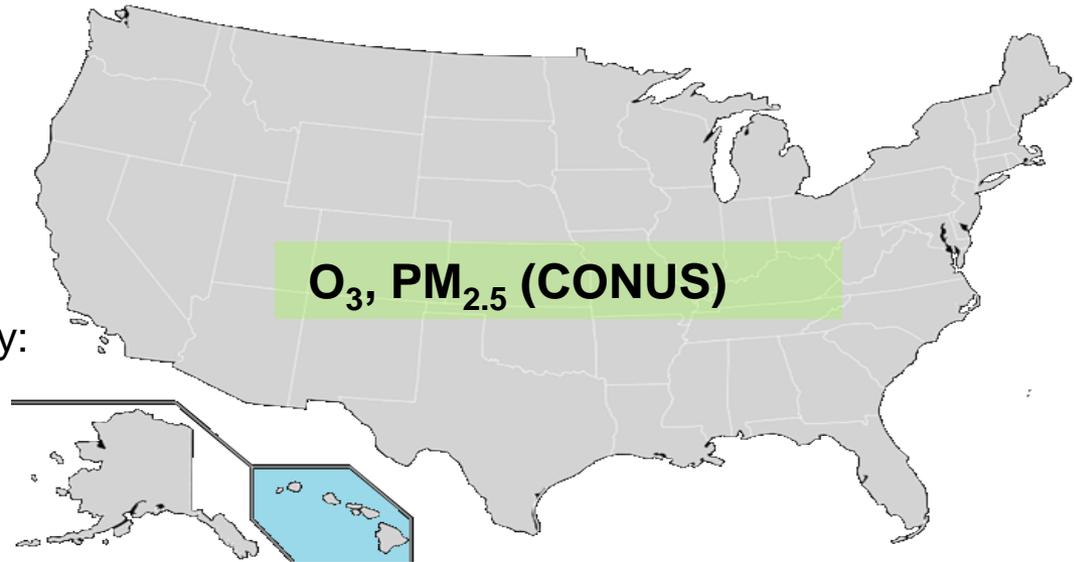


Proposed CMAQ FY2017

Chemical Transport Model:

▪ **CMAQ5.0.2** for **CONUS**

- CB05 gas chemistry: increased from current 105 to 155 species: Improved heterogeneous, aqueous, and winter-time reactions
- From current aero4 to aero6 chemistry: Improved SOA and coarse mode PM
- LBC: Static from GEOS-CHEM + Dynamic LBC for dust derived from NGAC
- Added a 24 h analysis PM field for initialization adjustment



For Wildfire Emission:

- Adopt Bluesky HYSPLIT/SMOKE emission strength and duration for the aforementioned 24h analysis and 48h forecast;
- New Bluesky version 3.5.1 from US Forest Service
- Upgrade Bias correction to include temporal trends (Kalman Filter Analog technique, ESRL)
- NEW OUTPUT to MDL NDGD web site: *bias corrected hourly & daily 24 h avg M2.5*



Emissions accompany CMAQ5.0.2

- Point source: Baselined from NEI2011v1 & updated by 2014 CEM & 2016 DoE Energy Outlook
Canada: Environment Canada 2006 Inventory made available as part of US EPA NEI2011;
Mexico: Inventory (MI) 2012 v2.2 for six Northern bordering states & 2.1 other states
- Area Sources
 - US EPA 2011 NEIs;
 - Canada 2006 Emission Inventories (in NEI2011 package);
 - Mexico 2012 EI for six Northern bordering states (in NEI2011 package);
 - US residential wood combustion and oil and gas sectors;
 - Snow/Ice effect on fugitive dust emissions;
- Mobile Sources (on-road)
 - NEI 2005 projected to 2011 using Cross-State Air Pollution Rule (CSAPR) projection for US sources and;* Canada 2006 Emission Inventories; MI 2012;
- Natural Sources
 - Terrestrial biogenic emission: BEIS model v3.14;
 - Sea-salt emission: CMAQ online Sea-salt emission model based on 10m wind;
 - Fire emissions based on HMS fire detection and BlueSky V3.5.1 emission model
- Windblown dust emission: FENGSHA model

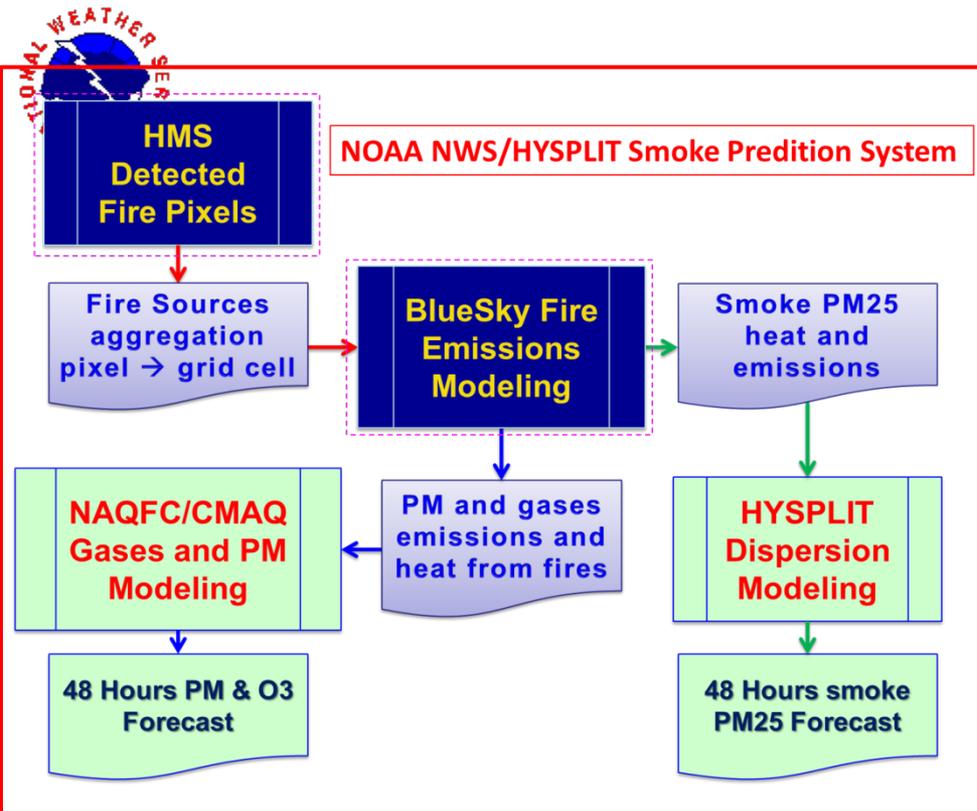


Emissions Testing (ARL)



ARL ensures a robust and thorough quality check of emission files:

- **Monthly emission quality assurance (QA) check and test results will be posted in ARL website so that the scope of check is shared with EMC and focus group.**
- **Annual emission delivery will happen in December and April. Testing should be conducted before both deliveries. Typically ARL mimics January 1st and June 1st 12 UTC cycle for the respective test. For leap years the December test should also include December 31st 12UTC cycle.**
- **Extend emergency contact list: Add Li Pan to the current ARL list: Pius Lee and Daniel Tong**

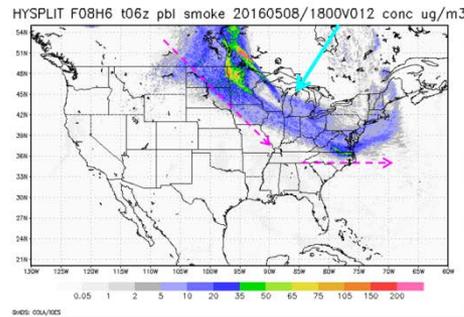


New Updated BlueSky:

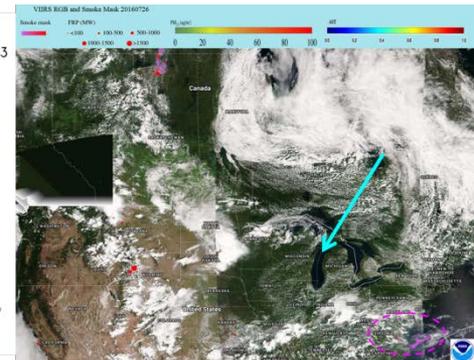
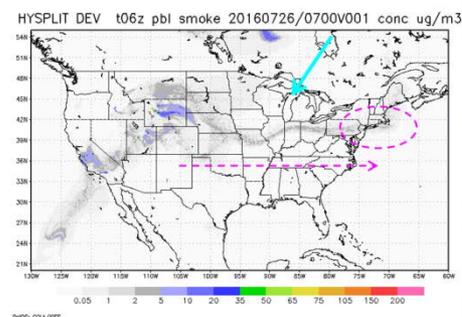
- The Fuel Characteristic Classification System version 2 (FCCS2) which includes a *more detailed description of the fuel loadings with additional plant type categories.*
- Explicit fuel load map for Alaska
- improved fuel consumption model and fire emission production system (FEPS).

Courtesy Ho-Chun Huang, EMC

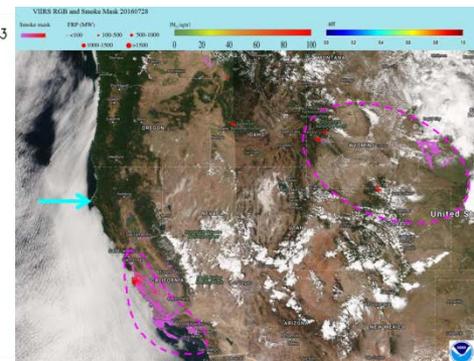
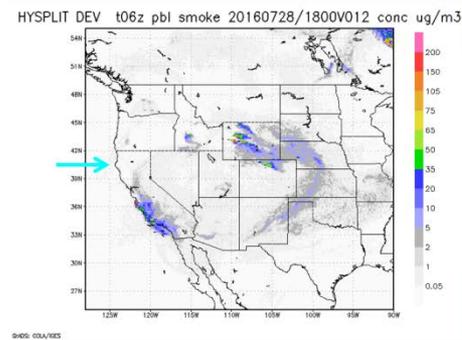
May 2016 Ft McMurry (Canada) Fires



July 2016 Northern Wyoming Fires



July 2016 California Big Surf Fires



HYSPLIT/Smoke prediction

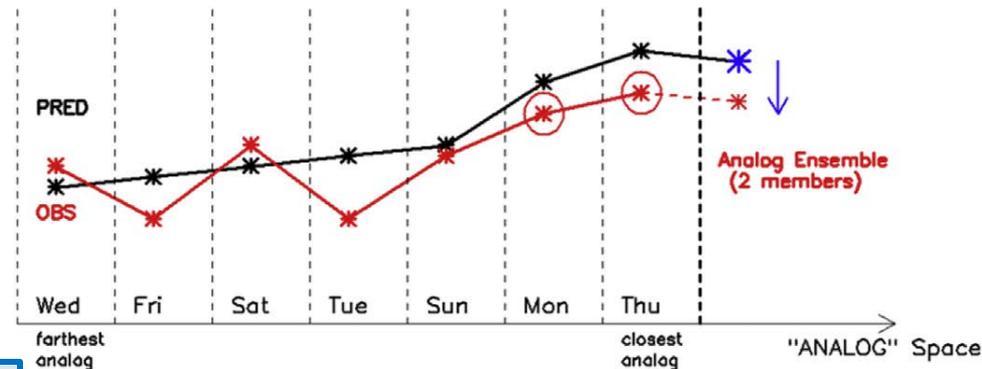
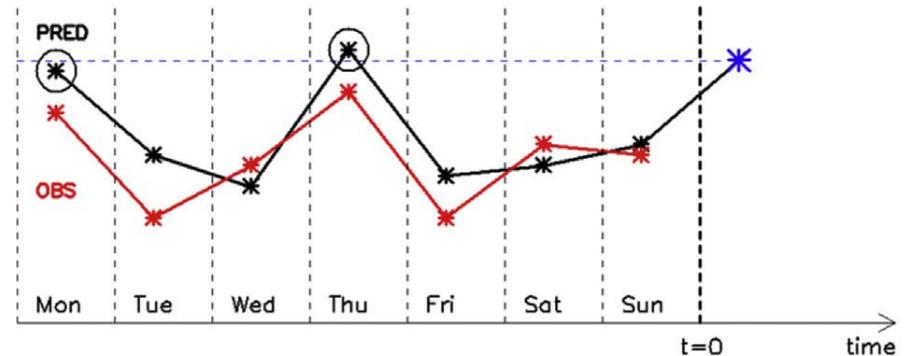
eIDEA Smoke Mask

Analog Ensemble for PM_{2.5} Bias Correction

- **Analog metric is determined by (Monache et al. 2011)**

$$\|F_{t'}, A_{t'}\| = \sum_{i=1}^{N_v} \frac{w_i}{\sigma_{f_i}} \sqrt{\sum_{j=-\tilde{t}}^{\tilde{t}} (F_{i,t'+j} - A_{i,t'+j})^2},$$

where F_t is current NWP forecast valid at future time t , $A_{t'}$ is analog at past time t' , N_v is the number of variables, \tilde{t} is half the number of additional computation time, w_i weight, σ_{f_i} standard deviation



Implementation in NAQFC

- Variables for Analog search: PM_{2.5}, T₂, WS/WD
- Ensemble members: 5
- Training period: one year

(Source: Djalalova et al., 2015)

● Resolution Changes

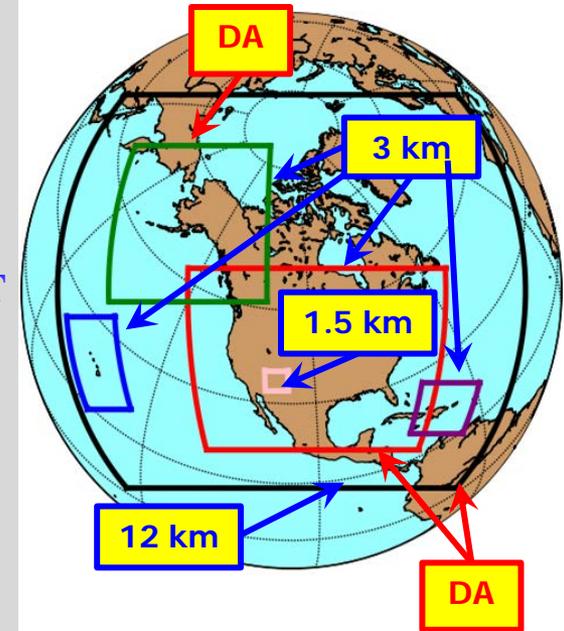
- CONUS (4 km) and Alaska (6 km) nests → **3 km**
- Sync AK and CONUS On-Demand Fire Weather nests → **1.5 km**

● Select Model Changes

- Updated microphysics → **Improved stratiform precip., better anvil reflectivity, lower peak dBZs, smaller areas of light/noisy reflectivity (rain treated as drizzle), improved nest QPF bias in warm season, Reduce incoming SW Rad under clouds; reduce warm season 2-m T warm bias**
- More frequent calls to physics → **Physics/dynamics more in sync (e.g. improved upper air, improved nest QPF)**
- 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 → **Improve QPF**
- Modify latent heat flux treatment → **Improve visibility along CA coast**

● Data Assimilation:

- DA cycles for 3 km CONUS and AK nests → **Much less 'spin-up' time**
- Use of Lightning and Radar Reflectivity-derived temperature tendencies in initialization
 - **Improved short-term forecasts of storms at 3 km**
 - **Improved 00-12 hr QPF**
- New satellite radiances, satellite winds → **Improved Inital Conditions**



DA: Data Assimilation Cycle



SEER



CMAQ Version 5.0 Status as of 02/17/17



Project Information & Highlights



Schedule

Leads: Jeff McQueen & Jianping Huang (EMC), Steven Earle(NCO)

Scope: Upgrade CMAQ to Cray with improved aerosol chemistry and emissions with 2011 base year estimates; Update BlueSky smoke emission system; Include 24 h pre-analysis run for smoke initialization; Use NGAC dust aerosol lateral boundary conditions; Update PM bias correction.

Expected benefits: AQM is improved and unified through improved chemistry, emissions and physics. Improved smoke emissions.

Dependencies: Transition code from ARL; BlueSky outputs from Hysplit

| Milestones & Deliverables | Date | Status |
|---|----------|----------|
| Freeze system code; deliver to NCO if applicable | 12/15/16 | Complete |
| Complete full retrospective/real time runs and evaluation | 2/13/17 | Complete |
| Conduct CCB and deliver final system code to NCO | 2/17/17 | On track |
| Issue Technical Information Notice | 3/15/17 | On track |
| Complete 30-day evaluation and IT testing | 5/15/17 | On track |
| Operational Implementation | 5/30//17 | On track |



Issues/Risks

Issue: reproducibility issue between Cray machines.

Resolution: module versions differed (resolved, 2/15/17)

Risk: Not enough time remaining to test O-Conus updates;

Mitigation: do not upgrade O-Conus system: defer to FY18 (resolved)



Resources

EMC | NCO |

Staff: 0.8 Fed FTEs + 2 contractor FTEs; including Dev + ARL 0.8 Fed FTEs + 1.9 contractors FTEs

Funding Source: ST/NAQFC

Compute: Dev: 120 nodes(+40);Para: 40 nodes (+15);

Ops: 20 nodes/cycle (+10)

Archive: Ops: 1TB/day (No change),



Management Attention Required



Potential Management Attention Needed



On Target



Summary of work performed



| TASK | F | M | A | M | J | J | A | S | O | N | D | J |
|--|---|---|---|---|---|---|---|---|---|---|---|---|
| Evaluation of updated BlueSky for HYSPLIT/CMAQ <ul style="list-style-type: none"> Additional BlueSky emission processing for 6Z Completed installation on <i>WCOSS Phase II</i> <p style="text-align: right;"><i>Ho-Chun Huang & ARL</i></p> | | | | | | | | | | | | |
| Coupling/testing ECCC smoke emissions w/HYSPLIT <ul style="list-style-type: none"> Evaluation of different default Canadian fuel classes <i>Combined EC & CONUS BlueSky emissions (deferred)</i> <p style="text-align: right;"><i>Ho-Chun Huang & ECCC</i></p> | | | | | | | | | | | | |
| Transition V5.0.2/Updated Emissions <ul style="list-style-type: none"> Transition to Cray Rewrite scripts to NCO stand job flow/env. variables Develop direct GRIB2 postprocessor NAM-X Grib2 input coupler <p style="text-align: right;"><i>Jianping Huang & ARL</i></p> | | | Q1FY17→ Q3FY17 <ul style="list-style-type: none"> Code delay Redo Script merging w/ops codes PM LBC/array bounds error Slowdown on Cray Cray reproducibility Grib2/wgrib2 library issues O-Conus scripts | | | | | | | | | |
| Transition KFAN Bias Correction <ul style="list-style-type: none"> experiments w/ # members/training period <p style="text-align: right;"><i>Jianping Huang & ESRL</i></p> | | | | | | | | | | | | |
| Maintain operational/experimental graphics/verification (o3, pm, bias corr. pm) <ul style="list-style-type: none"> VIIRS AOD into op. data stream GOES Combined AOD product | | | | | | | | | | | | |



Evaluations Performed

Ozone and PM

- ARL Preliminary: Aug. 2015/Feb. 2016
- EMC Real-Time: July 2016 → Present
- EMC NAM-X Retrospectives : July 2016
- EMC/ARL NO_x emissions adjustments : Aug-Sept. 2016 retros

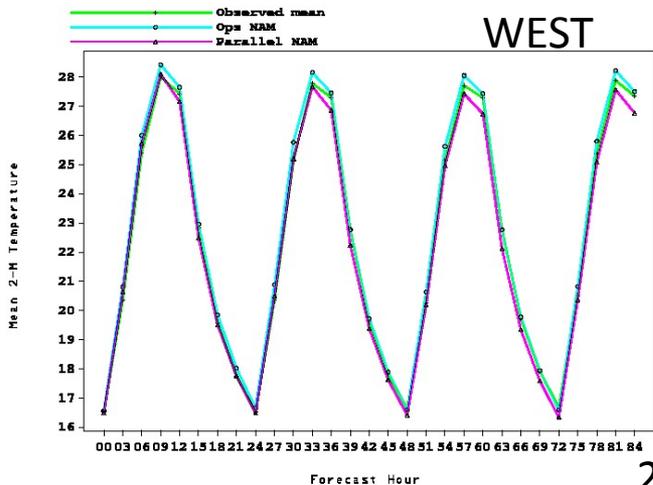
- NWS/STI & AQ Focus Group: Aug. Retros + RT runs
 - EMC maintains NRT comparison graphics and verification web sites
 - EMC provides daily ascii text predictions at monitor sites to following state forecasters :
 - AL, AZ, CA, CT, DE,GA, IA, MD, ME, NY, OH, PA,TN,VA



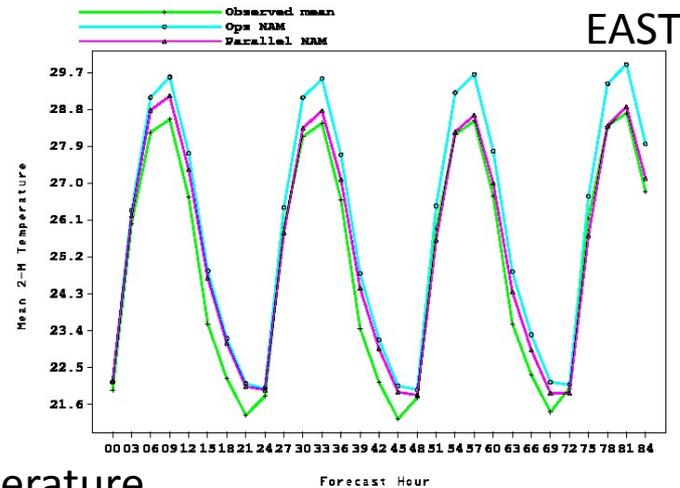
Upcoming NAM Q3FY17 Upgrade



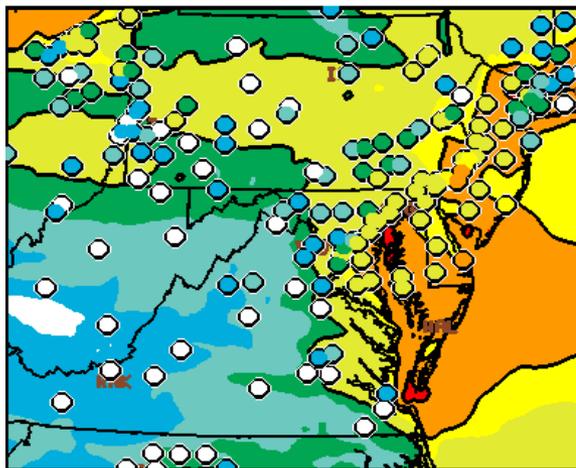
Mean 2-M Temp vs. sfc obs (12Z cycle) over the Western US for ops NAM and p11 NAM forecasts from 201607190000 to 201608291200



Mean 2-M Temp vs. sfc obs (12Z cycle) over the Eastern US for ops NAM and p11 NAM forecasts from 201607190000 to 201608291200

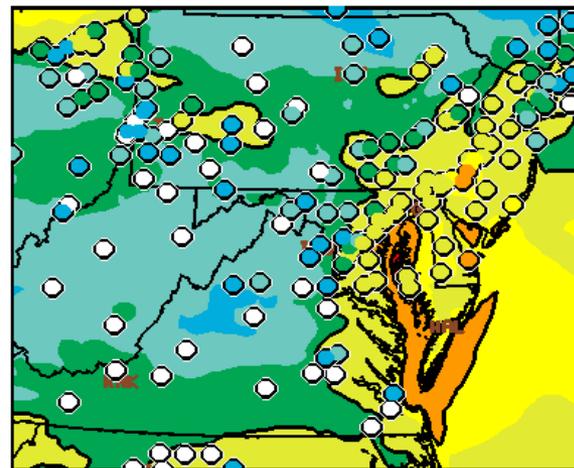


2 m Temperature



PROD DAY1 02HX08 20160708 12Z CYC~

NAM - CMAQ V4.7



OPARA DAY1 02HX08 20160708 12Z CYC

NAM-X - CMAQ V4.7

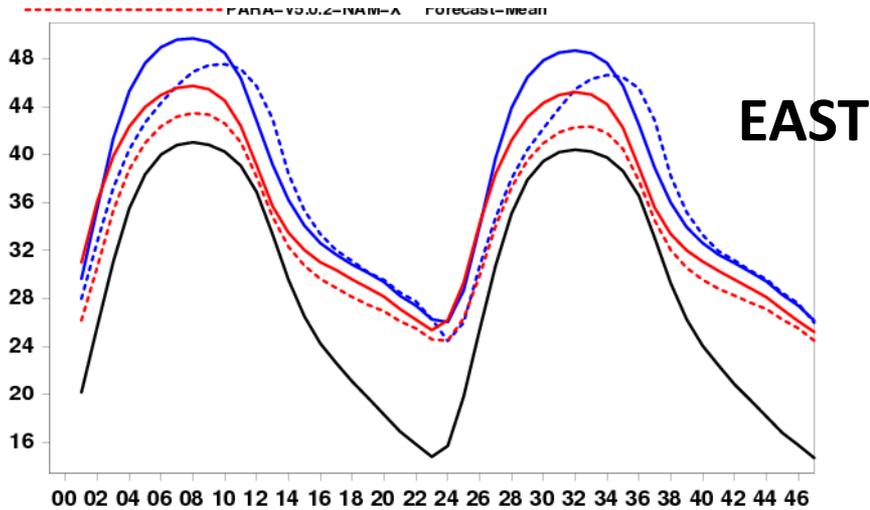
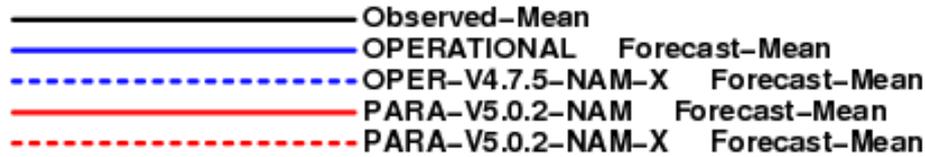




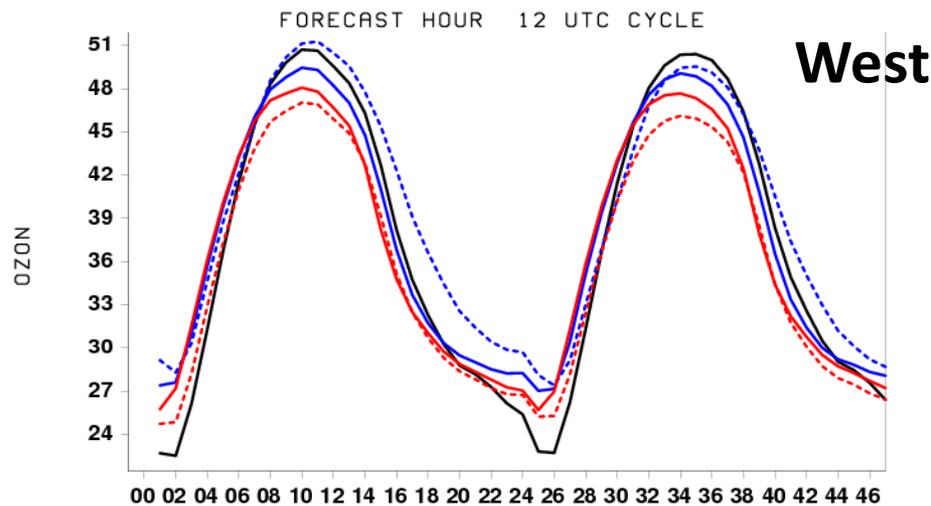
July 2016 NRT CMAQ Prod vs V5.0.2



1 h avg Diurnal Ozone



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



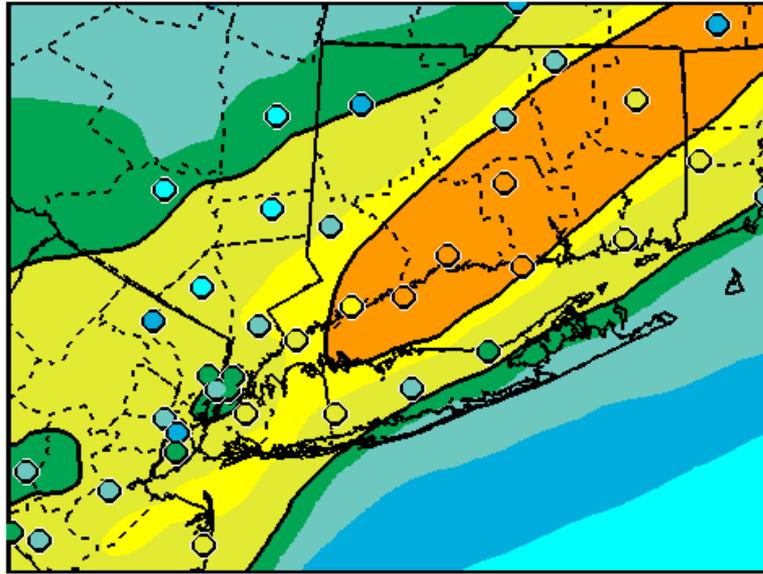
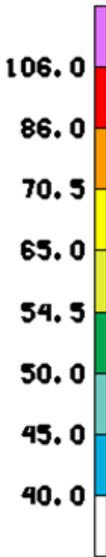
- **CMAQ V5.0.2 NAM-X: Strongest underestimate over West**

- **Meteorological impact nearly as large as CMAQ/Emissions upgrade**



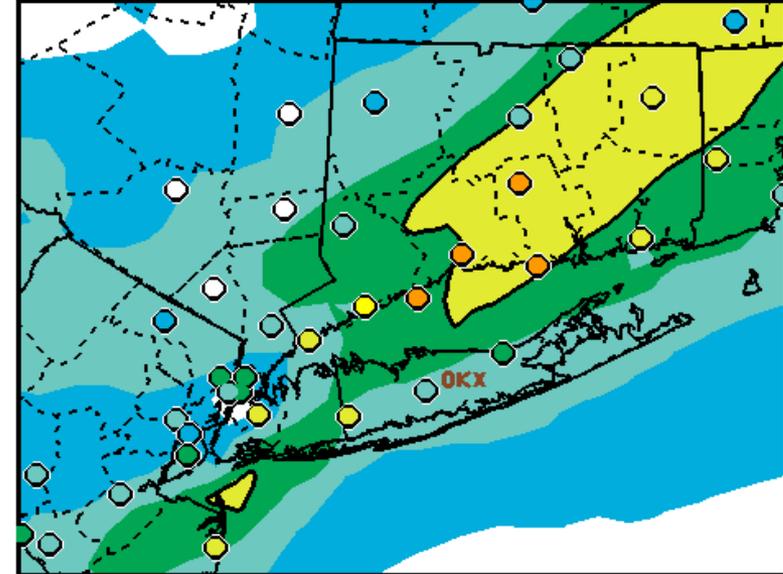
Day 2 8h O3 Daily Max

August 12, 2016



PROD AQH DAY2 OZMX08 20160811 12Z CYC-

Operational



PARA2 CMAQ.V5.0.2 DAY2 OZMX08 20160811 12Z CYC

EMC Parallel w/ NOx Emissions reduced

CT/PA DEP Noted numerous mixed exceedences with V5.0.2 Near Real-time parallels



Experiments to address missed exceedences

- **No NO_x Adjustment for Mobile Emissions (green line) NAMX**
 - Cross State Air Pollution Rule (CSAPR) 2011 Mobile Emission
 - Should result in increased ozone product

- ***Gridded NO_x Mobile emission adjustment (red line) NAMX***
 - Adjustment factor also considers fine-scale features by taking into account the 12 x 12 km grid-by-grid satellite-observed NO_x to NAQFC forecasted NO_x ratio

- **V5.0.2 Para** : State wide NO_x adjustment using NAM

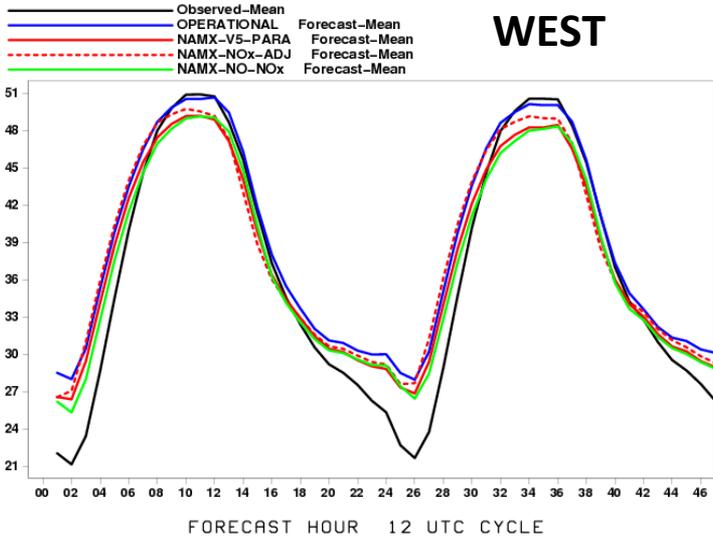


August 2016 East vs West Ozone

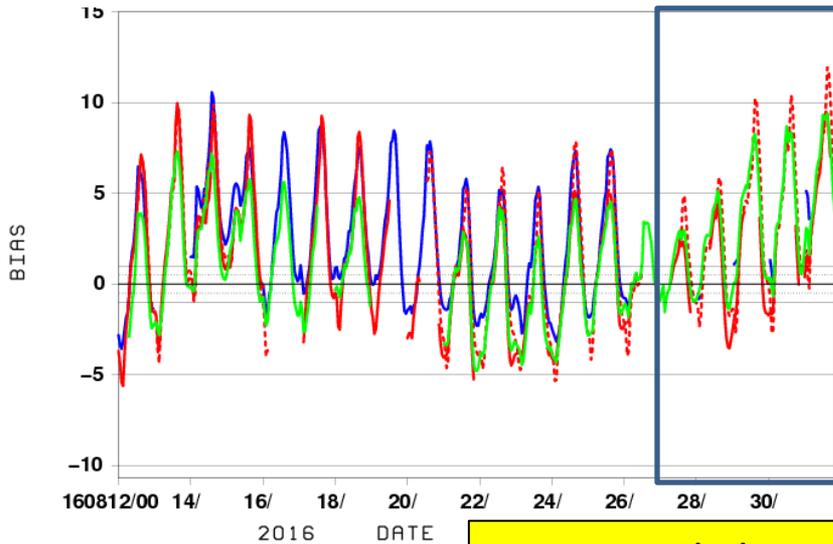
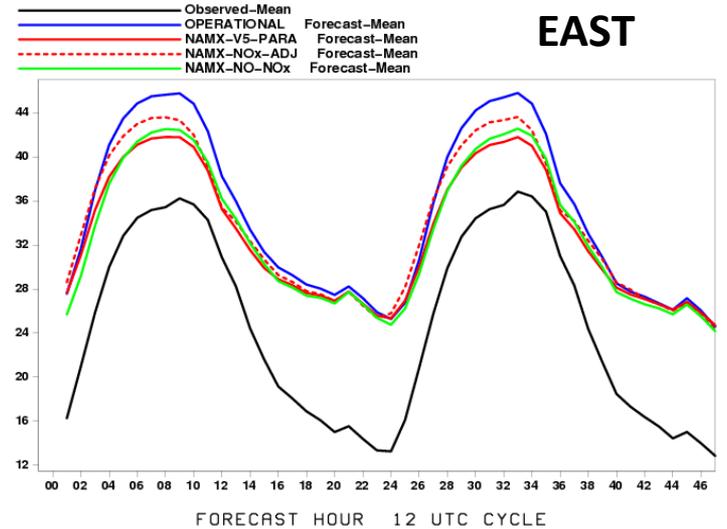


1-h Avg OZON obs (PPB) avged by fcst hrs
20160812 to 20160831
West-US

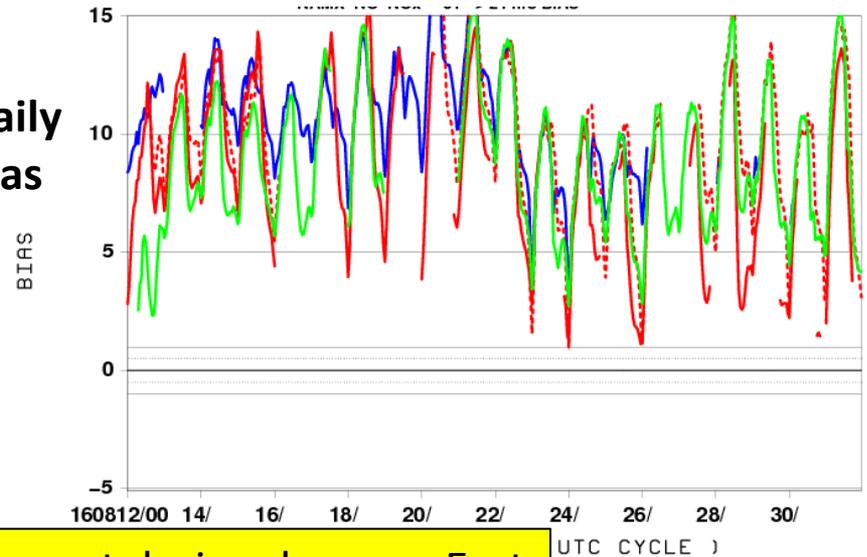
1-h Avg OZON obs (PPB) avged by fcst hrs
20160812 to 20160831
East-US



DIURNAL



Daily Bias



**No-NOx: Slight improvement during day over East
Slightly better over West late August**

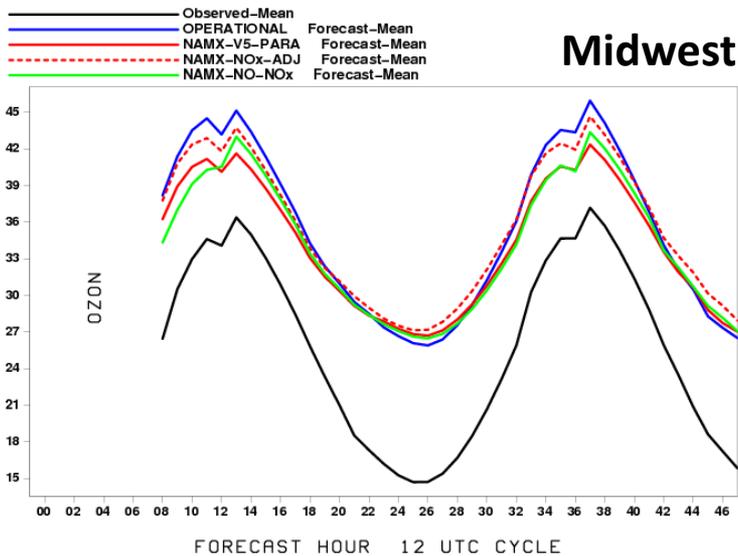


August 2016

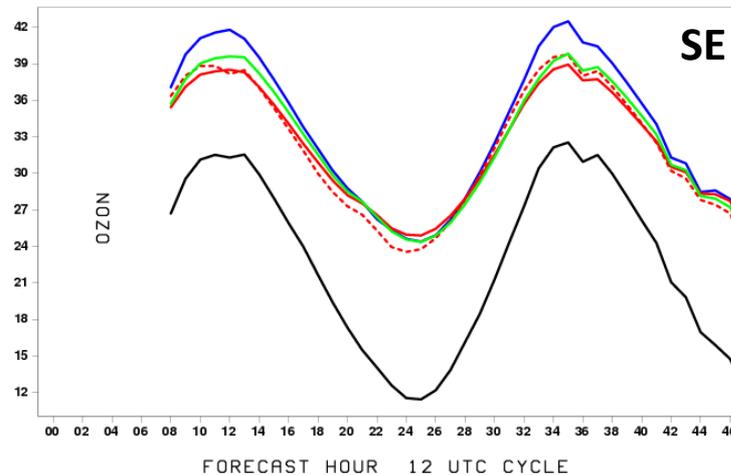
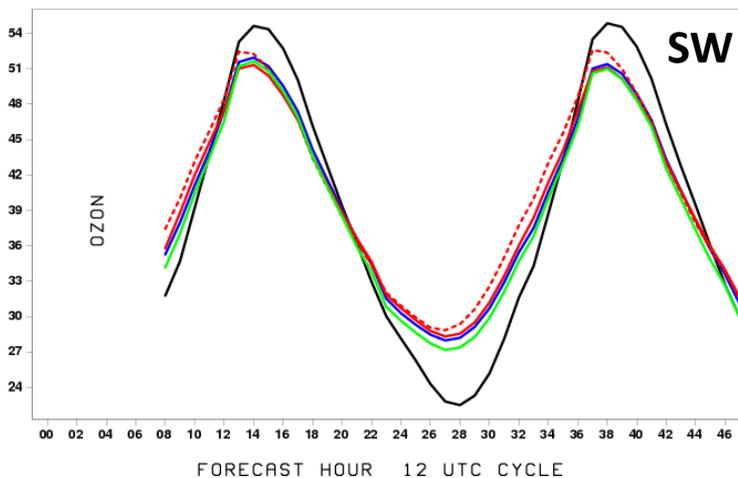
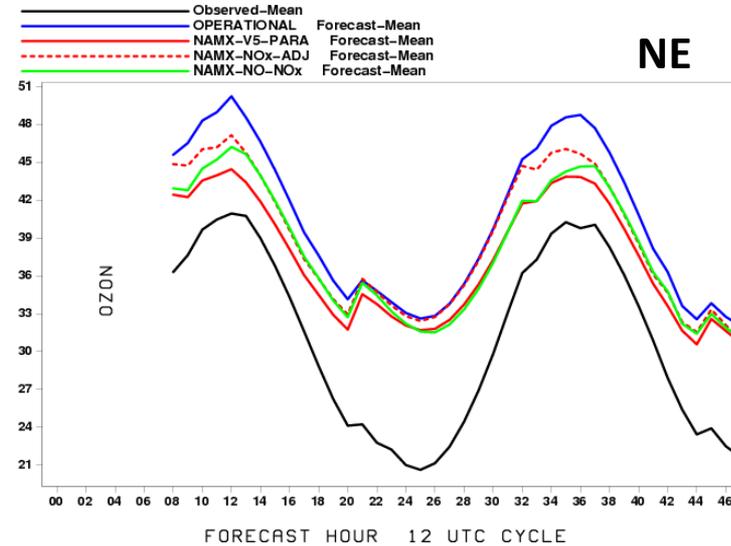


Sub-region Ozone Diurnal plot

8-h Avg OZON obs (PPB) avged by fcst hrs
20160812 to 20160831
Midwest



8-h Avg OZON obs (PPB) avged by fcst hrs
20160812 to 20160831
Northeast



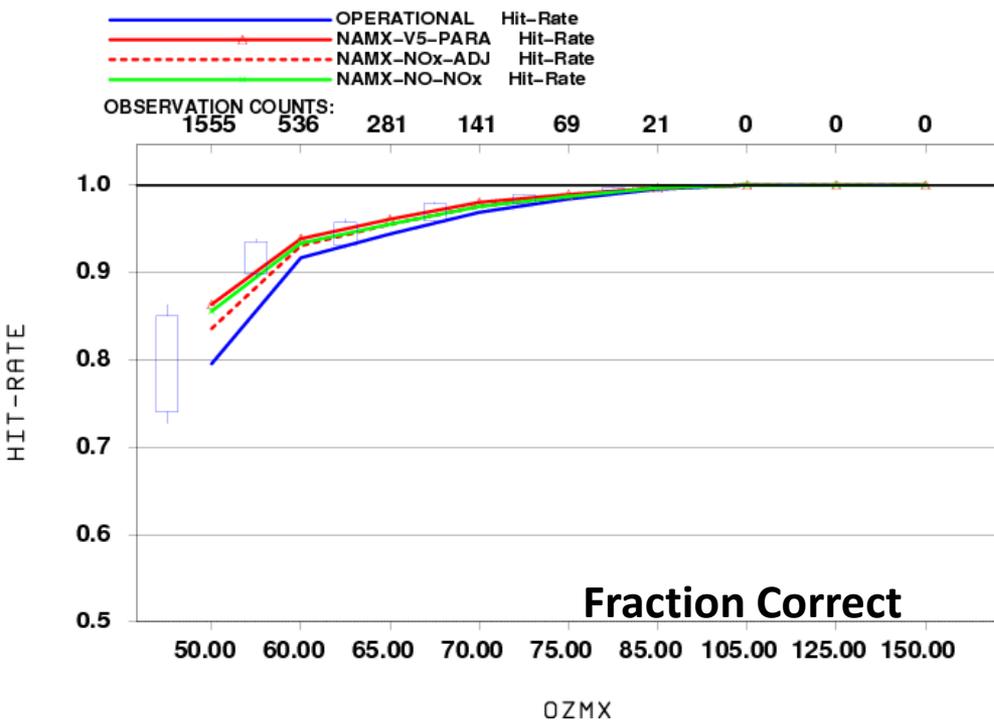
No-NOx: slight improvement during day over NE/MW



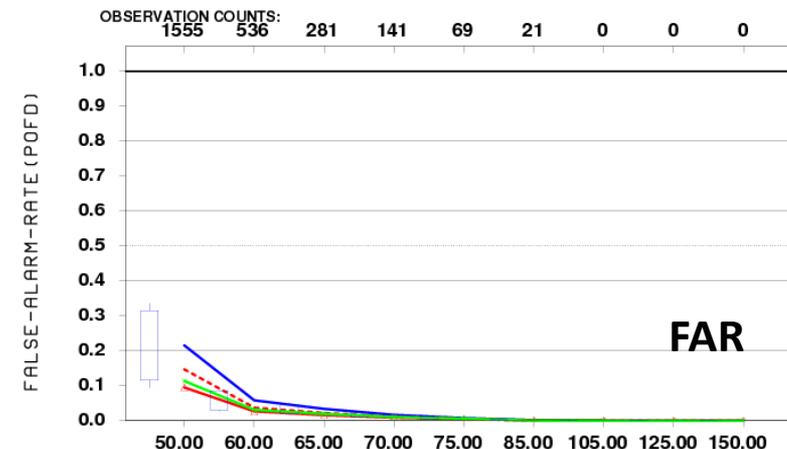
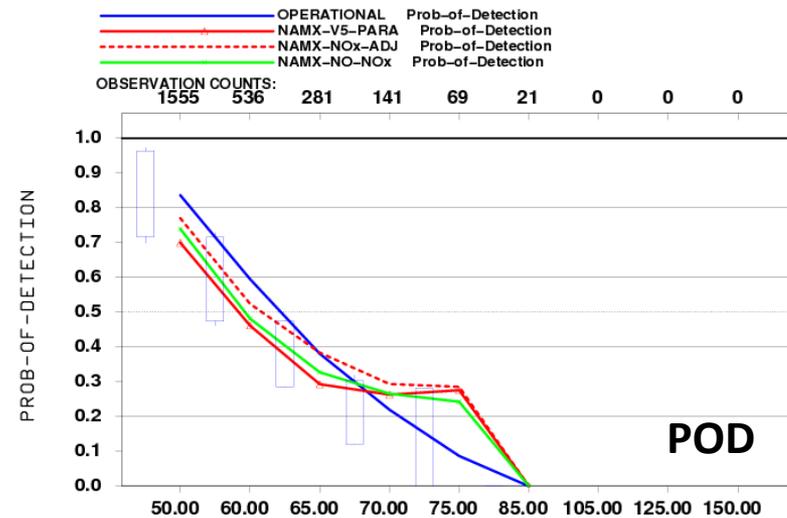
Skill Score statistics

CONUS Ozone August 2016

DAY 2 8h-avg OZMX/8 Hit-Rate avged by Threshold
20160812 to 20160831
CONUS

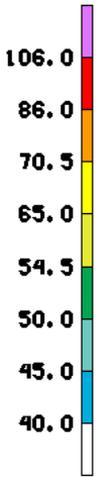
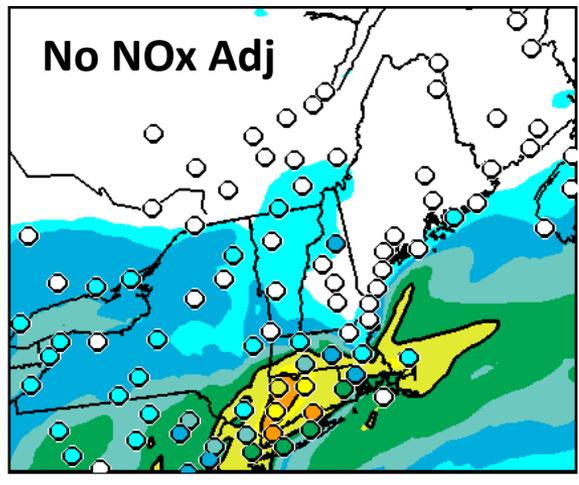
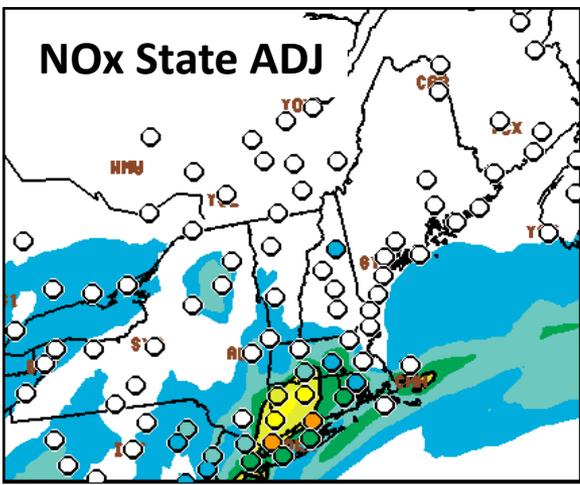


DAY 2 8h-avg OZMX/8 Prob-of-Detection avged by Threshold
20160812 to 20160831
CONUS



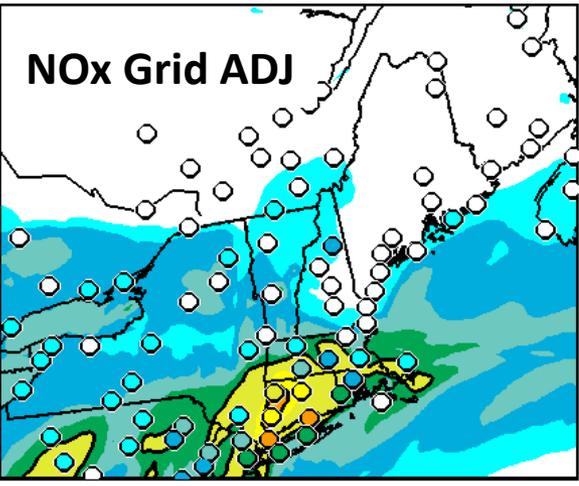
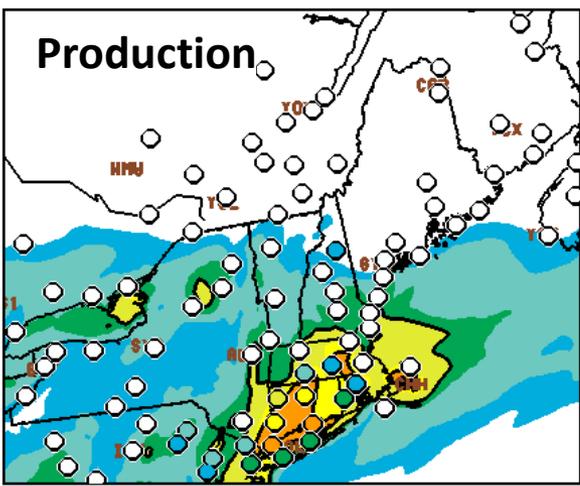
NOX-Adj & Oper runs highest POD but also highest FAR

NE Ozone exceedences



PARA2 CMAQ.V5.0.2 DAY1 OZMX08 20160813 12Z CYC

PARA JIANPING.HUANG DAY1 OZMX08 20160813 12Z C



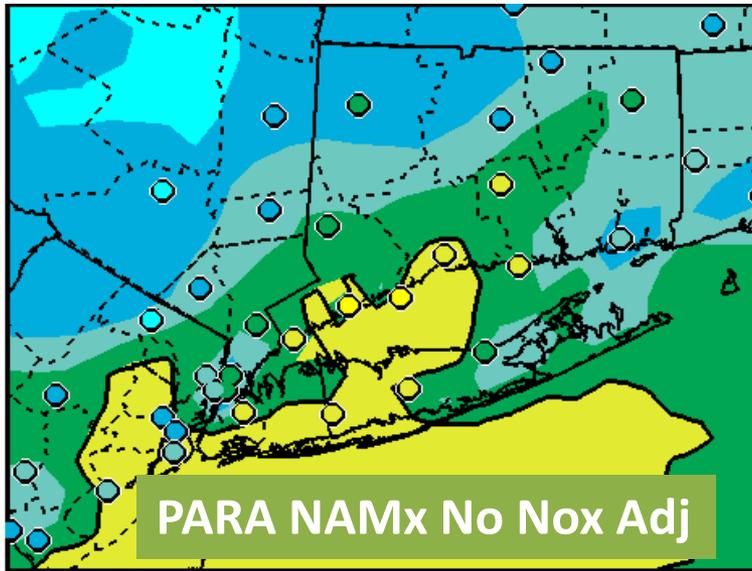
PROD DAY1 OZMX08 20160813 12Z CYC

ANLF48E25 NAQFC DAY1 OZMX08 20160813 12Z CYC

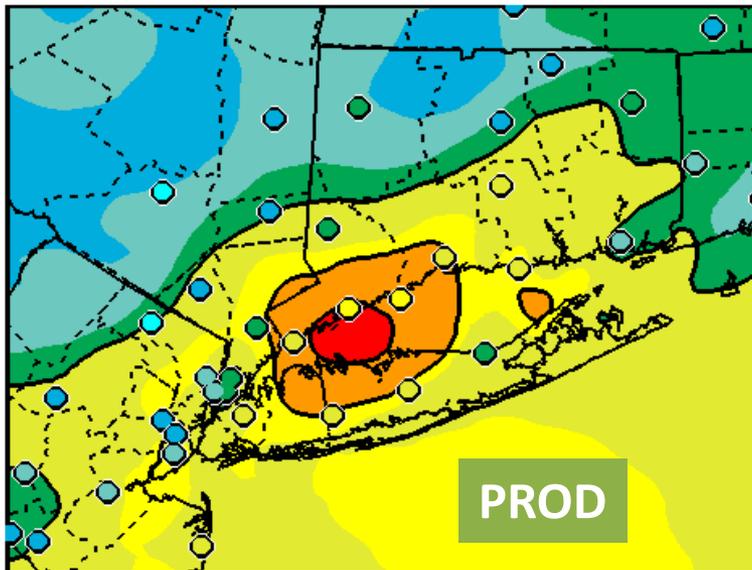
- Prod: Overprediction; NOx State Adj: Misses event
- NOx Grid Adj: Misses coastal CT exceedence



August 18, 2016 Day 1



PARA 4X-DAY NAM-X NONOX DAY1 02MX08 20160818 12Z CYC



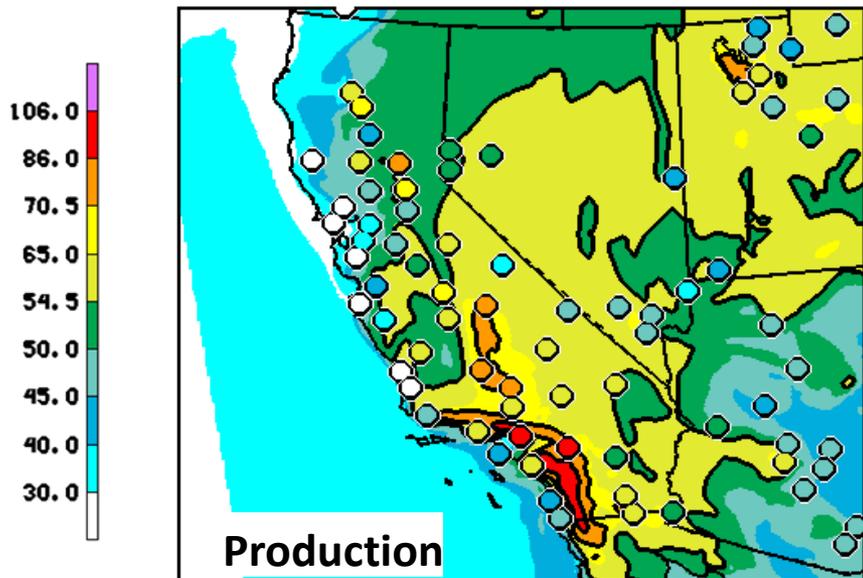
PROD AQH DAY1 02MX08 20160818 12Z CYC

- NAMx showed a great improvement over PROD;
- NAMx eliminated the four false alarms.

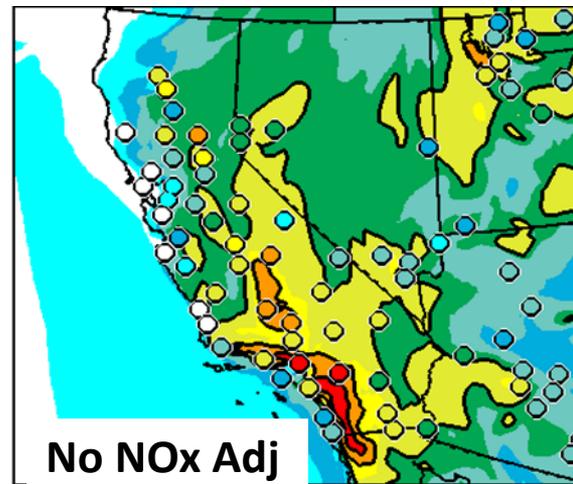
*Courtesy Mike Geigart,
CT DEP*

August 30, 2016 Day 1

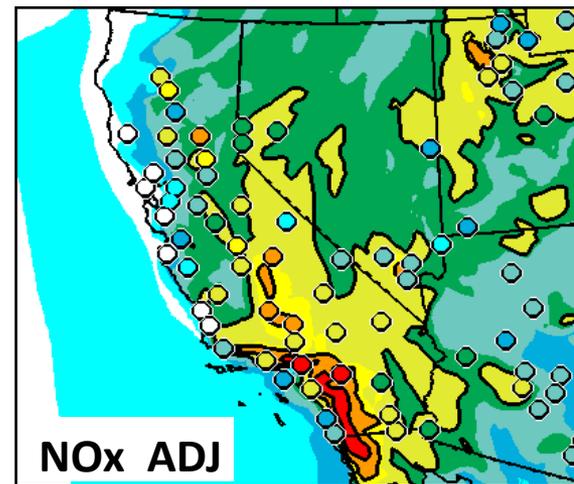
California



PROD AQH DAY1 OZMX08 20160830 12Z CYC~



IRA 4X-DAY NAM-X NONOX DAY1 OZMX08 20160830 12Z

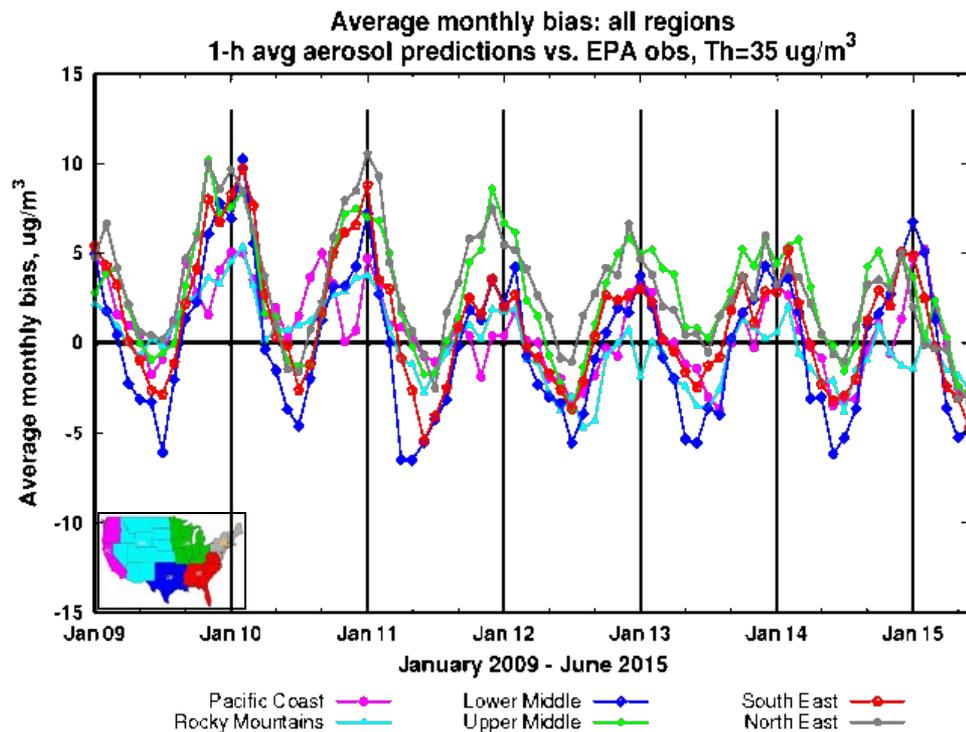


ANLF48E25 NAQFC DAY1 OZMX08 20160830 12Z CYC

- All similar → less ozone over Ut/NV with parallel runs

Current issues of PM_{2.5} predictions

- Significant **seasonal bias**
 - over-prediction in winter
 - under-prediction in summer
- Sources of the bias
 - Emissions ?
 - Met (PBLH) ?
 - CMAQ chemistry ?
 - LBCs?

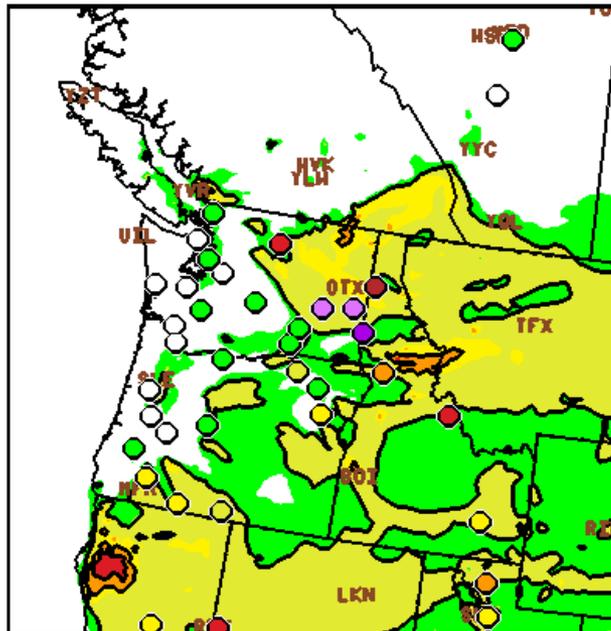


Over-prediction in winter is improving and Under-prediction in summer is unchanged

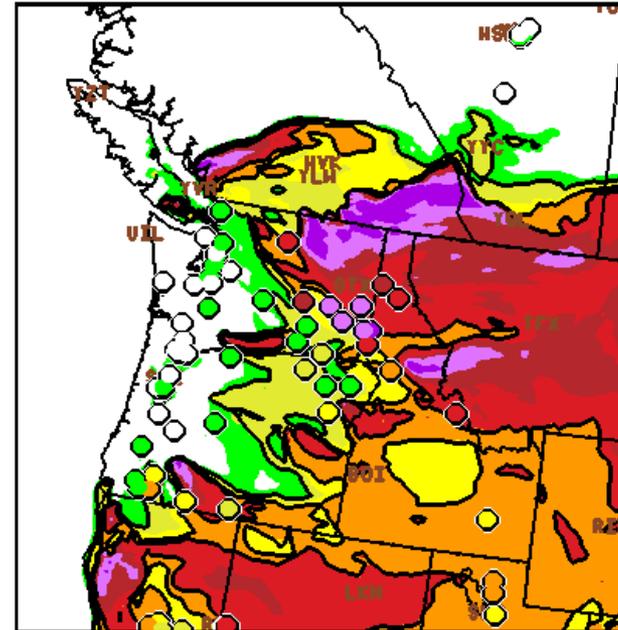
Western Fires

August 21, 2015 1hr PM2.5 Max

Operational V4.7



BlueSky v3.5.1 &
Current day locations



Operational runs: Most sites impacted by fire smoke are severely under-predicted.
Experimental tests: Updated BlueSky and use of current day fire info



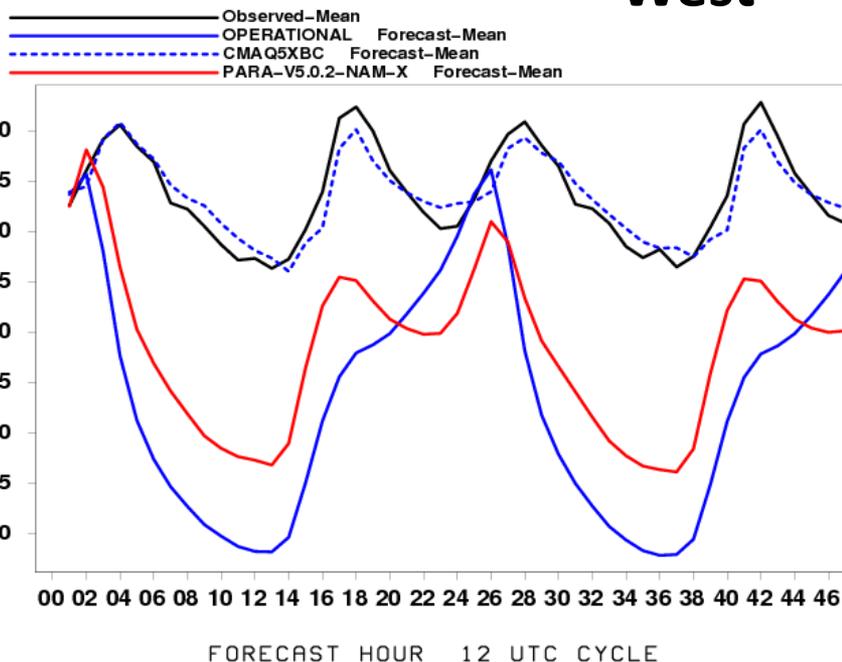
JULY 2016 PM Predictions



1 h avg PM

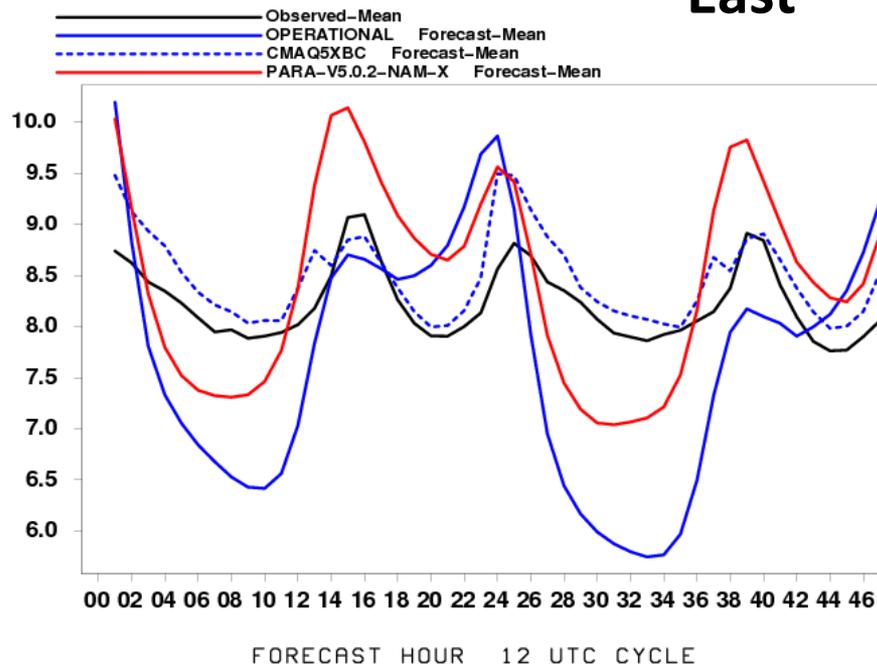
1-h Avg PM25 obs (ug-m3) avged by fcst hrs
20160701 to 20160731
West-US

West



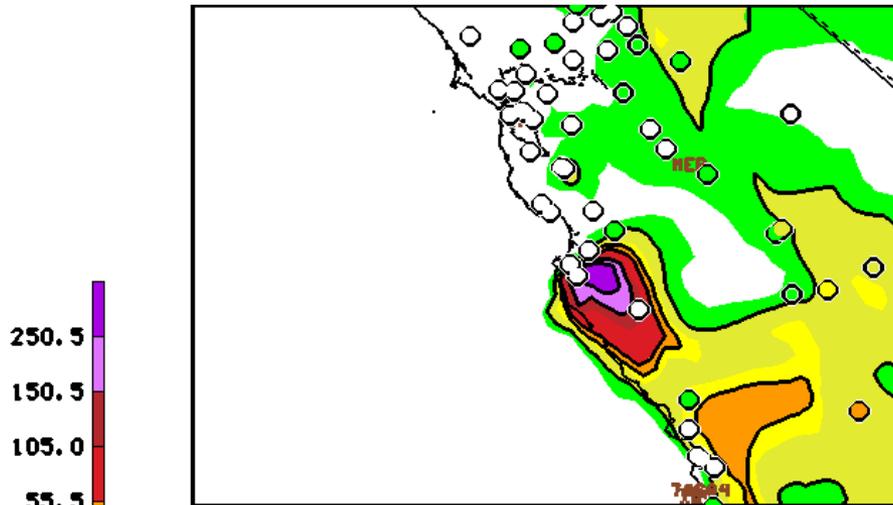
1-h Avg PM25 obs (ug-m3) avged by fcst hrs
20160701 to 20160731
East-US

East

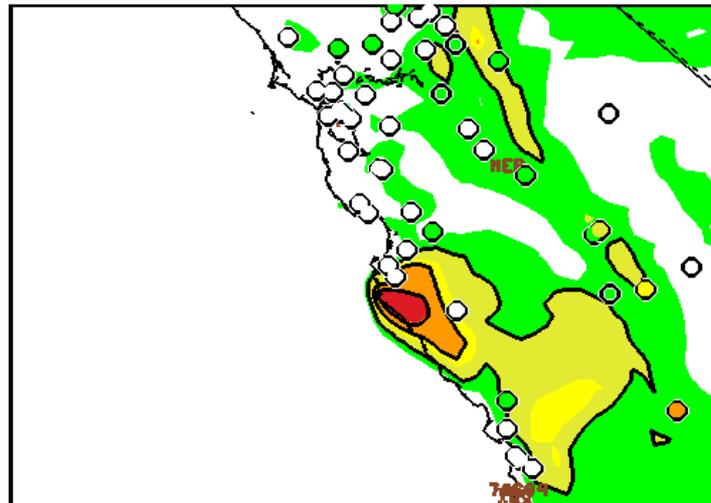
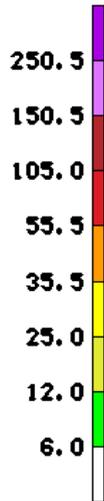


- Underpredict PM over Western U.S.
- Slight overprediction over Eastern U.S.
- *Bias Correction* strong improvement

July 29, 2016 Big Sur Fire forecast and comparison to PM measurements



PARA2 CHAQ. V5. 0. 2 PM2501 FRI 160729/1300V001



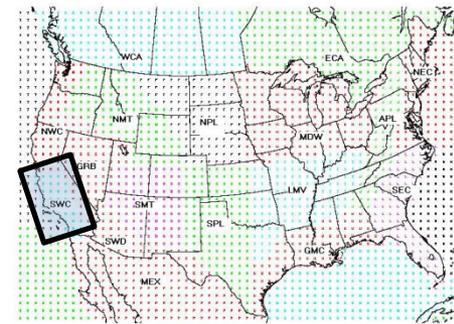
PROD AQH PM2501 FRI 160729/1300V001

- Smoke Emissions
- Location
 - Magnitude
 - Ejection height
 - Diurnal evolution

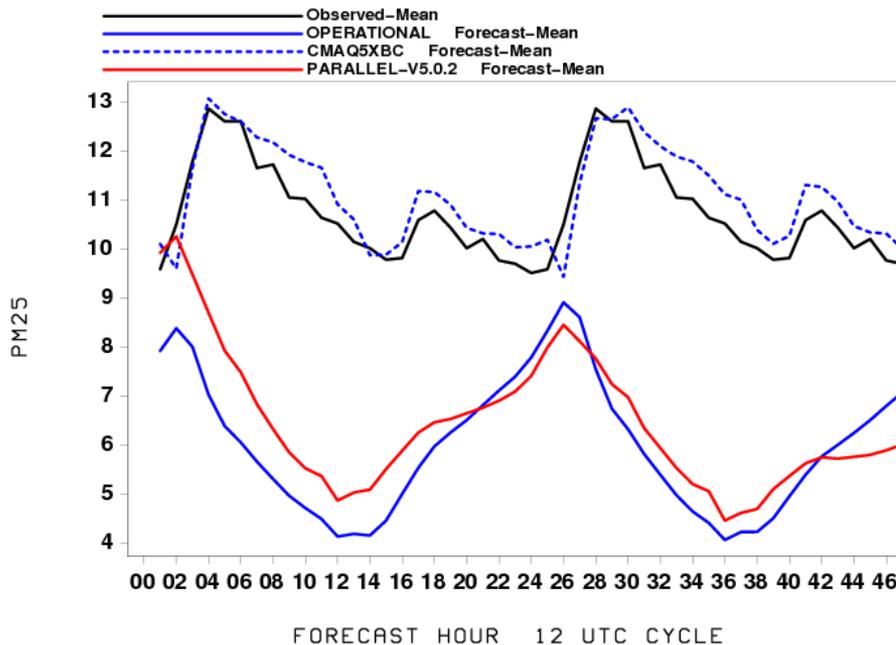


JULY 2016 PM Predictions

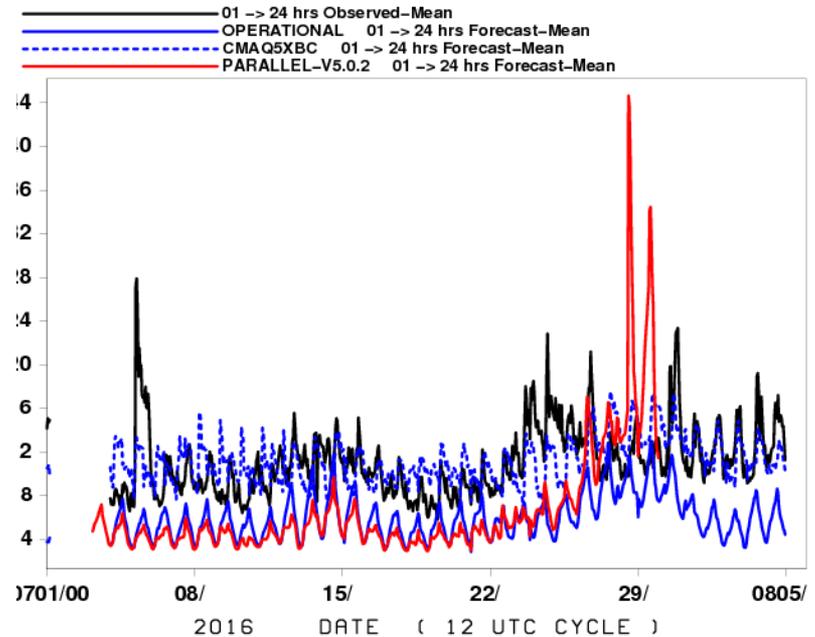
1 h avg PM : South West U.S. Fires



1-h Avg PM25 obs (ug-m3) avged by fcst hrs
20160701 to 20160805
SWEST-Coast



DAY 1 1-h Avg PM25 obs (ug-m3)
SWEST-Coast



South West Coast

- Underprediction (except *Bias corr*) in general BUT :
- Overprediction of wild fire smoke events in morning
 - No diurnal emissions profile used



November 2016

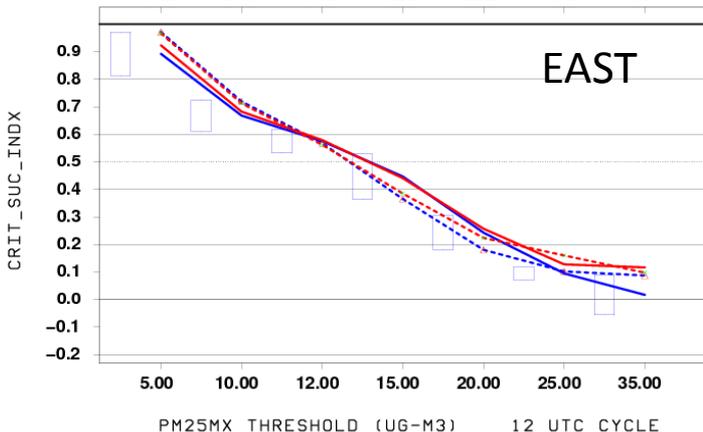


East vs West PM and Bias Corrected PM

DAY 2 01h-avg PM25MX Crit_Suc_Indx avged by Threshold
20161101 to 20161130

OPERATIONAL Crit_Suc_Indx
 OPERATIONAL-Bias-corrected Crit_Suc_Indx
 PARA-V5.0.2-NAM-X Crit_Suc_Indx
 PARA-V5.0.2-NAM-X-Bias-corrected Crit_Suc_Indx

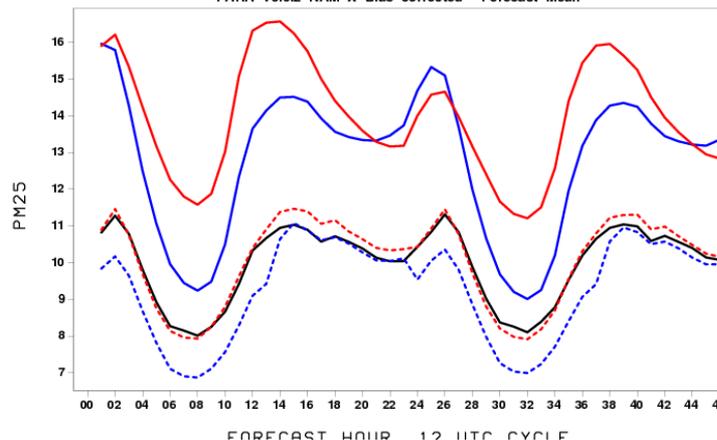
OBSERVATION COUNTS:
1153 919 756 525 282 179 69



1-h Avg PM25 obs (ug-m3) avged by fcst hrs
20161101 to 20161130

East-US

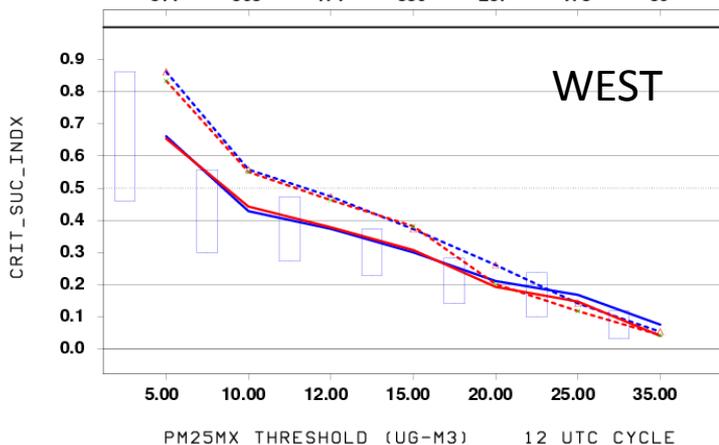
Observed-Mean
 OPERATIONAL Forecast-Mean
 OPERATIONAL-Bias-corrected Forecast-Mean
 PARA-V5.0.2-NAM-X Forecast-Mean
 PARA-V5.0.2-NAM-X-Bias-corrected Forecast-Mean



DAY 2 01h-avg PM25MX Crit_Suc_Indx avged by Threshold
20161101 to 20161130

OPERATIONAL Crit_Suc_Indx
 OPERATIONAL-Bias-corrected Crit_Suc_Indx
 PARA-V5.0.2-NAM-X Crit_Suc_Indx
 PARA-V5.0.2-NAM-X-Bias-corrected Crit_Suc_Indx

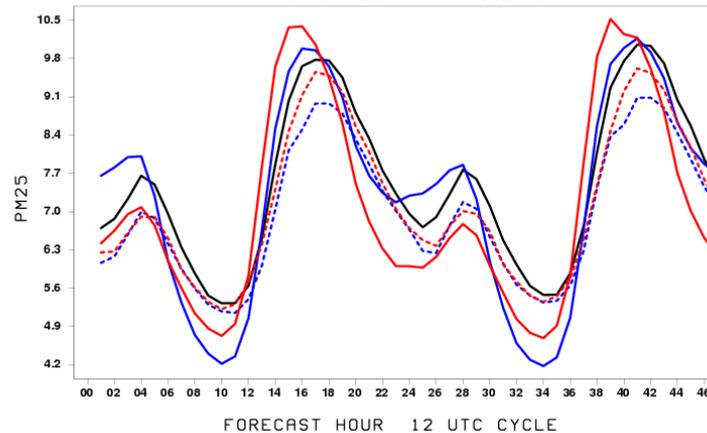
OBSERVATION COUNTS:
811 563 474 389 257 173 80



1-h Avg PM25 obs (ug-m3) avged by fcst hrs
20161101 to 20161130

West-US

Observed-Mean
 OPERATIONAL Forecast-Mean
 OPERATIONAL-Bias-corrected Forecast-Mean
 PARA-V5.0.2-NAM-X Forecast-Mean
 PARA-V5.0.2-NAM-X-Bias-corrected Forecast-Mean



V5.0.2 - *KFAN BC* follows diurnal profile closely

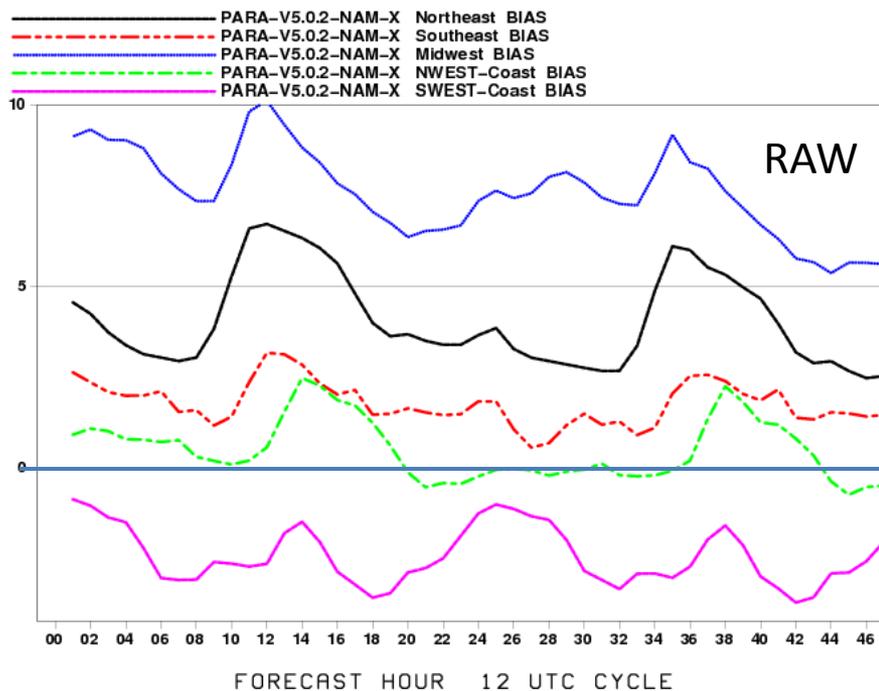


November 2016

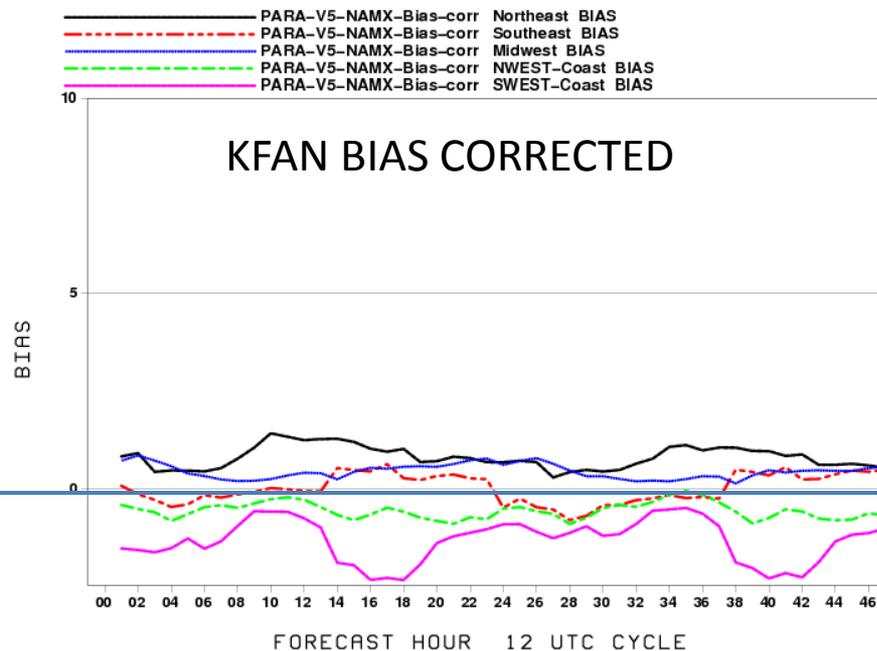


Parallel Run PM BIAS by Region

1-h Avg PM25 BIAS (ug-m3) avged by fcst hrs
20161101 to 20161130

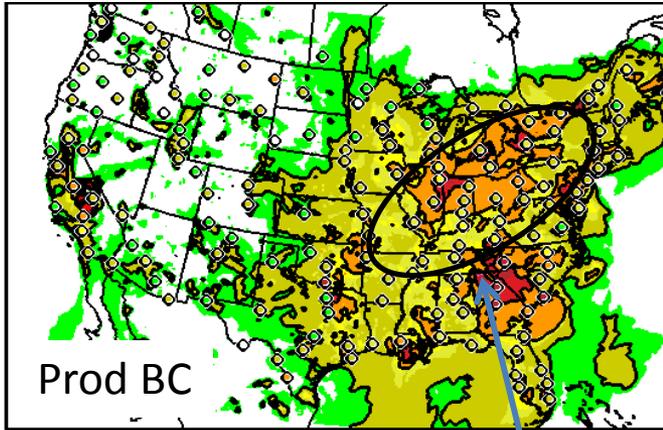
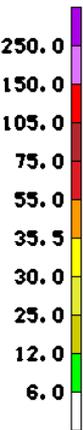


1-h Avg PM25 BIAS (ug-m3) avged by fcst hrs
20161101 to 20161130

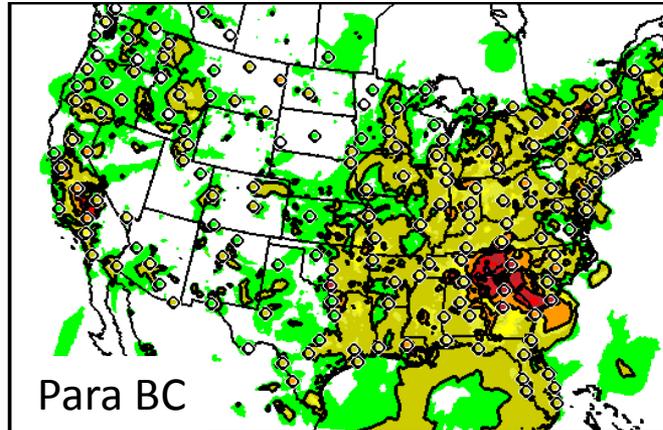


Overprediction for NE and MW improved compared to Raw

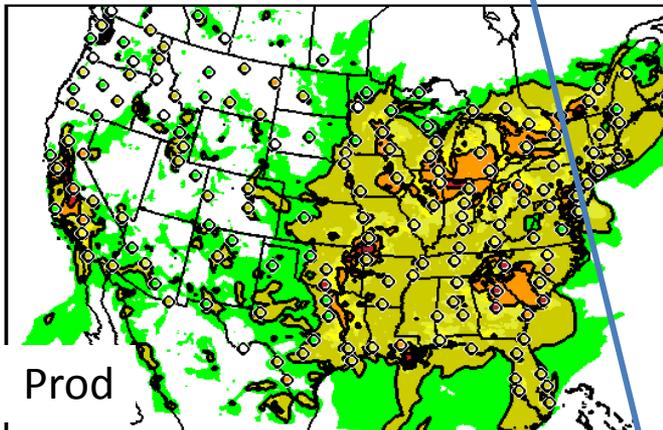
South East U.S. Fires: Midwest impact



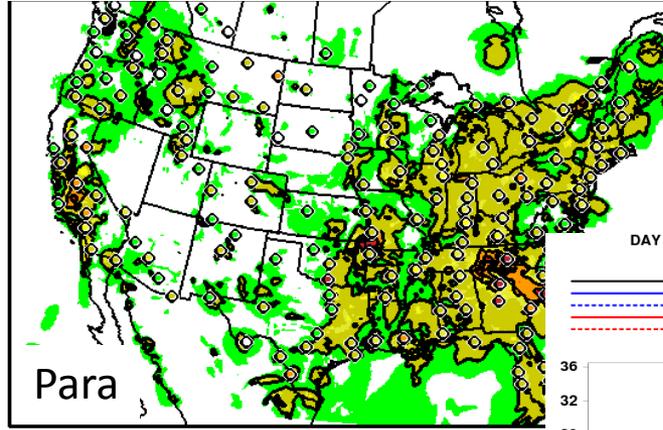
PARA 4X-DAY DAY1 PMX01 20161115 12Z CYC



PARA BIAS BIAS COR DAY1 PMX01 20161115 12Z CYC

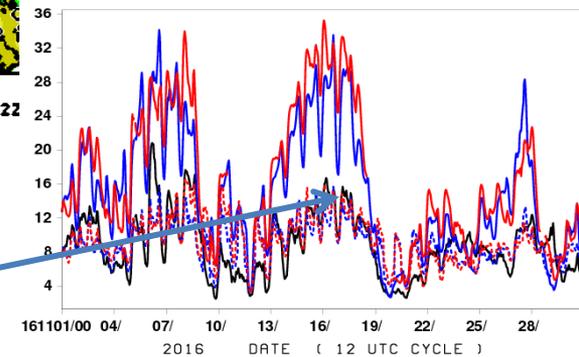
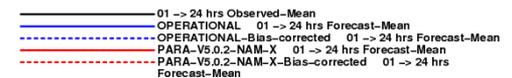


PROD AQH DAY1 PMX01 20161115 12Z CYC



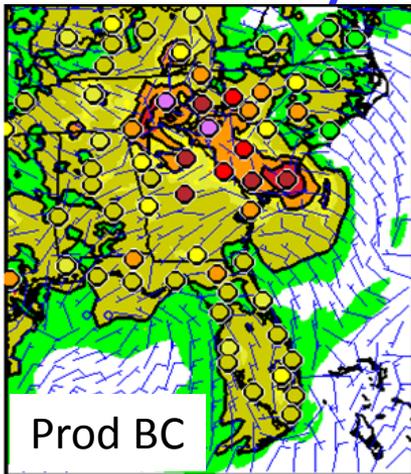
PROD BIAS COR DAY1 PMX01 20161115 12Z

DAY 1 1-h Avg PM25 obs (ug-m3)
Midwest

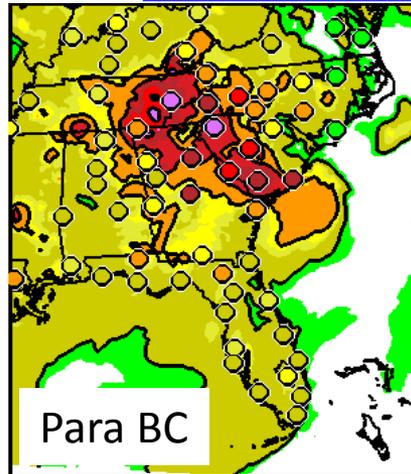


- Is smoke from fires moving too far downwind (Midwest)
- BC does good job for correcting in prod & para runs

1 h Daily Max PM : South East U.S. Fires

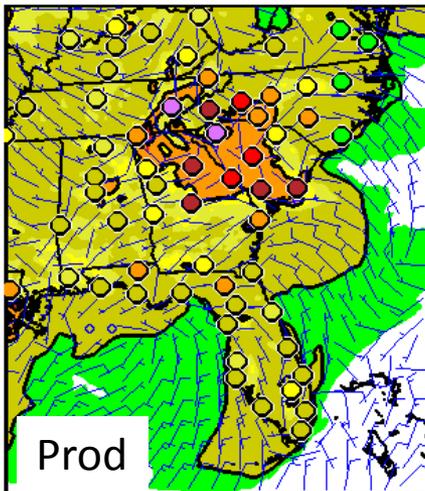


PROD BIAS COR DAY1 PMX01 20161115 12Z

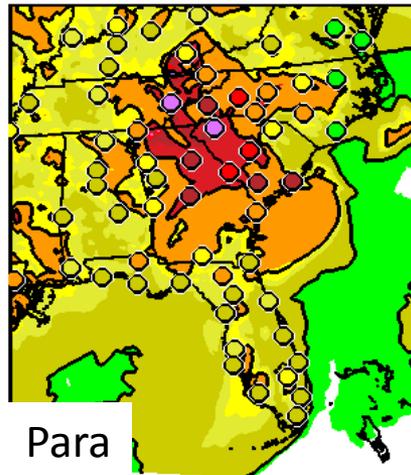


PARA BIAS BIAS COR DAY1 PMX01 20161115

- BC underpredicts fire events, but still closer than other runs



PROD DAY1 PMX01 20161115 12Z CY



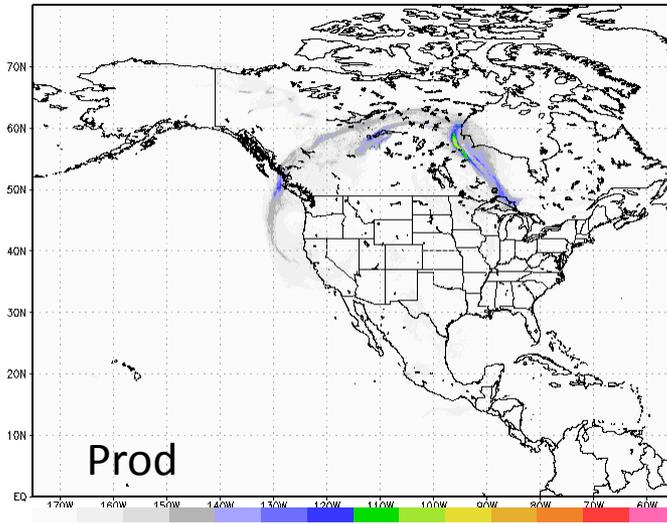
PARA 4X-DAY NAM-X DAY1 PMX01 20161115 |



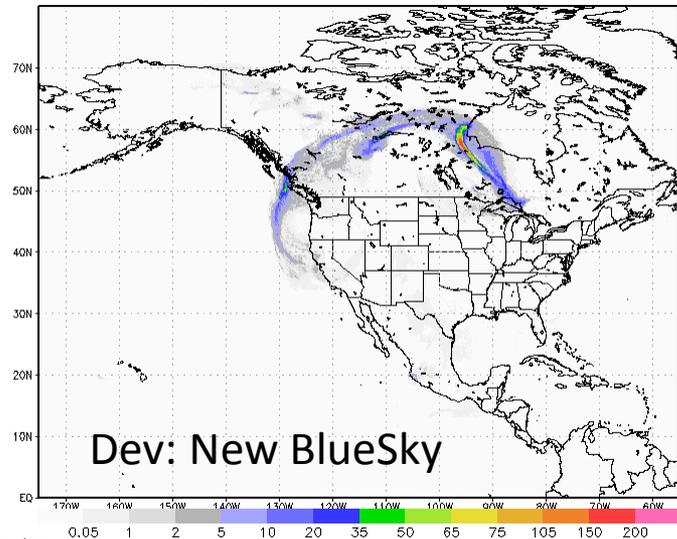
HYSPLIT Blue Sky Evaluation



HYSPLIT PROD t06z pbl smoke 20160521/1800V012 conc ug/m³

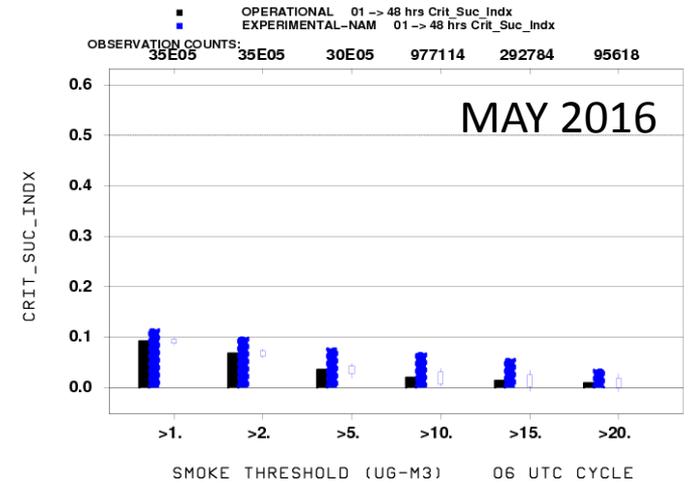


HYSPLIT DEV t06z pbl smoke 20160521/1800V012 conc ug/m³

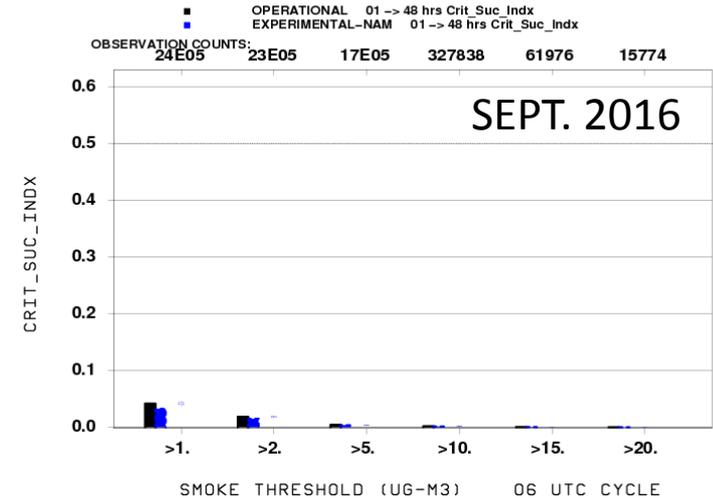


8@DS: 00LA/0ES

DAY 1 01h-avg smoke Crit_Suc_Indx avged by Threshold
20160501 to 20160531
CONUS



DAY 1 01h-avg smoke Crit_Suc_Indx avged by Threshold
20160901 to 20160930
CONUS





Summary

– *V5.0.2 Ozone w/ NAM-X*

- Improvement correcting over-prediction esp along coasts
 - Long Island Sound (CT DEP analysis)
 - » 7 False Alarms compared to 17 from production for NYC area
 - Lake Erie/Michigan and Ohio Coastline
- Much improved for Southwest and marginal or non-events
- Missed exceedences in NE corrected after removing NOx adjustments

– *PM*

- Large positive impact near forest fires :
 - Updated BlueSky and 24 h pre analysis run
 - Underprediction when external sources (Saharan dust, Canadian fires) are impacting CONUS
 - Emission timing and ejection height uncertainties
- Continued overprediction in Winter from raw predictions

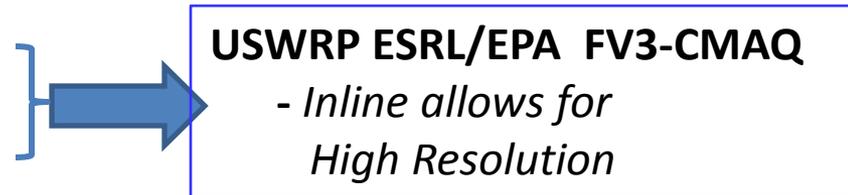
– *Updated NAM alone strongly improves ozone forecast*

- 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, Mexican & external source impacts
 - Top down (satellite) vs Bottom up (BlueSky) approaches
 - Improved temporal profiles and plume rise algorithms
- NGAC full aerosol boundaries
- **Unification of AQ systems**
 - HYSPLIT smoke/dust → NGAC Aerosol
 - CMAQ ozone & total PM
 - HRRR-smoke
- Extend Kalman Filter bias correction to *ozone*
- Improved Evaluations
 - Use of VIIRS/GOES-R/AERONET AOD, CALIPSO aerosols
 - Evaluate Operational models for field experiments (ESRL FireX 2018, FASMEE)





BACKUPS



Web pages

CMAQ V5.0.2

- Real-time parallel runs (July 2016-Present)
 - <http://www.emc.ncep.noaa.gov/mmb/aq/cmaq/web/html/max.html>
- No NOx adj/NAM-X/4x-day cycling (Aug. 7-Sept 10)
 - <http://www.emc.ncep.noaa.gov/mmb/aq/cmaqnox11/web/html/max.html>
- Gridpoint NOx adj/NAM-X/1x-day cycling (Aug. 1-Sept 10)
 - <http://www.emc.ncep.noaa.gov/mmb/aq/cmaqnox/web/html/max.html>
- Verification statistics (prod,para, cmaqnox11, cmaqnox)
 - <http://www.emc.ncep.noaa.gov/mmb/aq/fvs/web/html/regular.html>



Impact of Experimental NAM on smoke

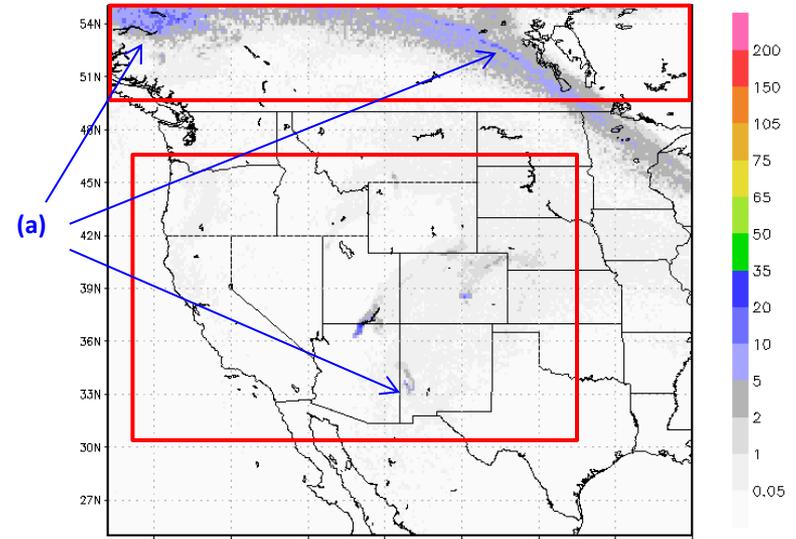
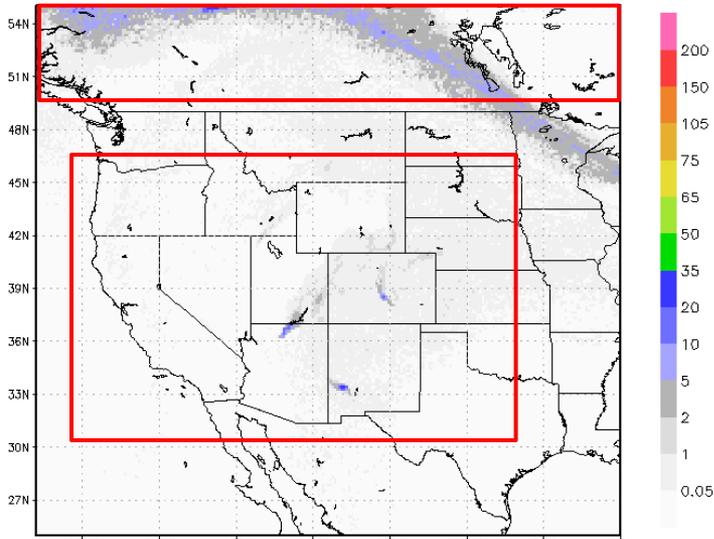


NAM PROD (left panel) and updated NAM Parallel (right panels)

20160717 06Z at FCST HR 36 and 48

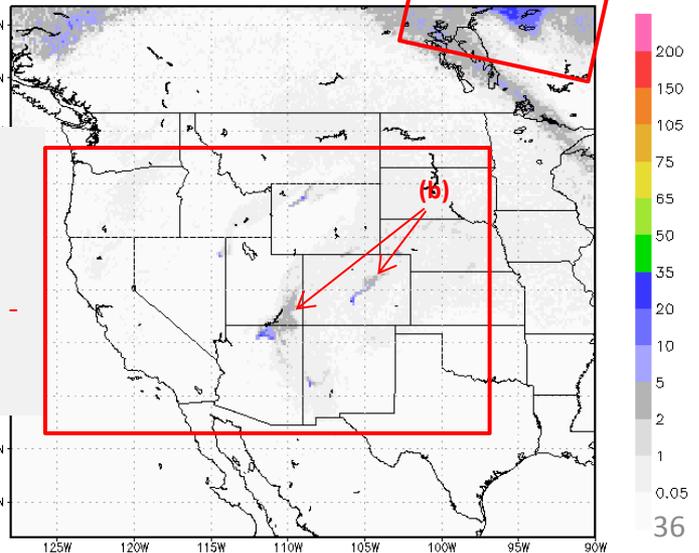
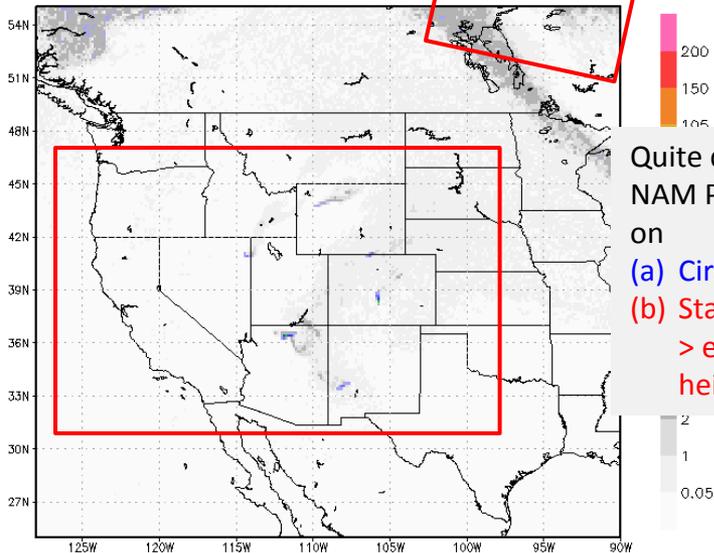
HYSPLIT PROD t06z pbl smoke 20160718/1800V036 conc ug/m³

HYSPLIT TEST t06z pbl smoke 20160718/1800V036 conc ug/m³



HYSPLIT PROD t06z pbl smoke 20160719/0600V048 conc ug/m³

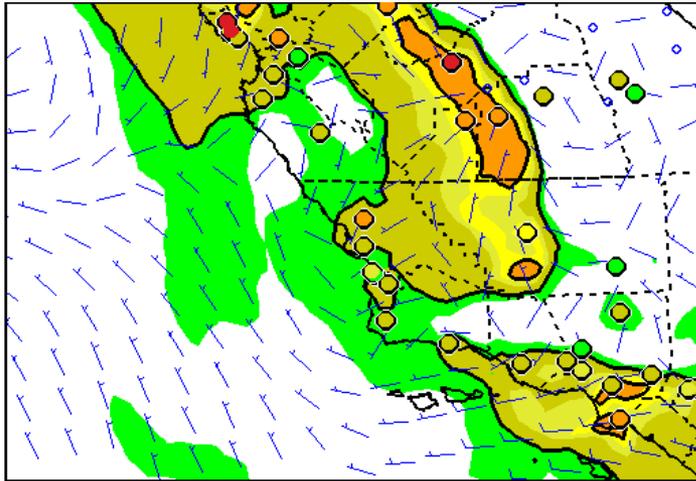
HYSPLIT TEST t06z pbl smoke 20160719/0600V048 conc ug/m³



Quite different between
NAM Prod and NAM Para
on
(a) Circulation pattern
(b) Stability -> plume rise -
> emission release
height

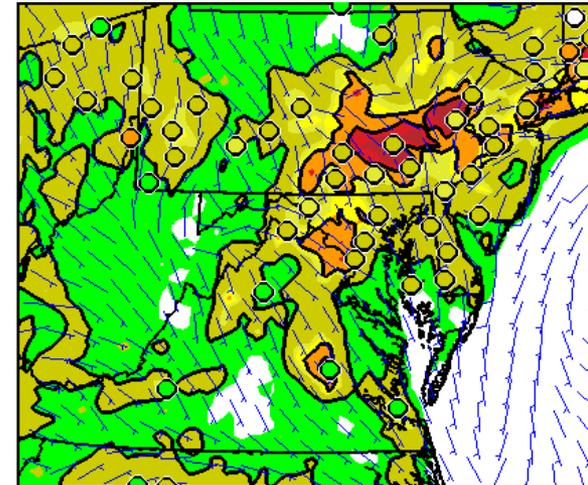
Winter Time PM

Southern CA, Jan. 17, 2017

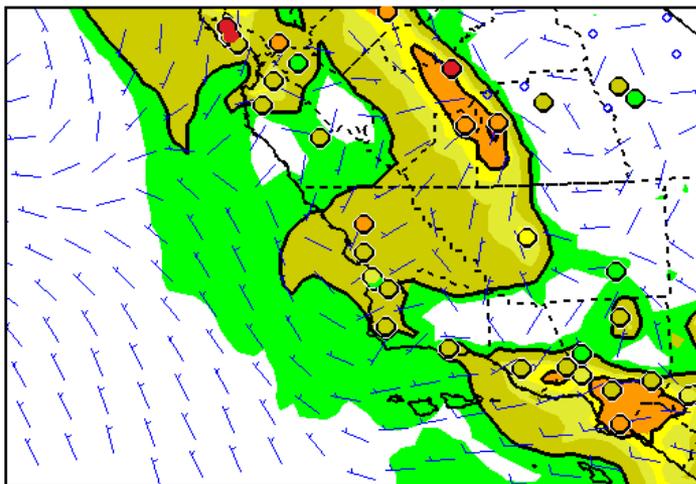


PARA 4X-DAY NAM-X DAY1 PMMX01 20170117 12Z CYC

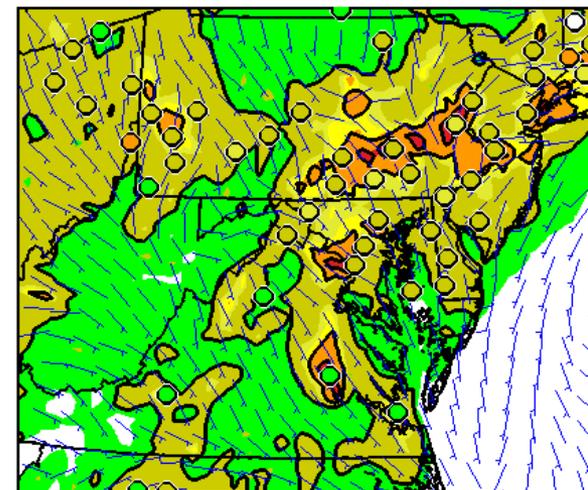
Mid Atlantic, Jan. 21, 2017



PARA 4X-DAY NAM-X DAY1 PMMX01 20170121 12Z CYC



PROD DAY1 PMMX01 20170117 12Z CYC



PROD DAY1 PMMX01 20170121 12Z CYC

- Improved out west, but overprediction sometimes worsened over East