



National Air Quality Forecast Capability prediction updates and current operational skill

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- (7) US Environmental Protection Agency
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- (9) Eastern Research Group Inc.

with contributions from the entire NAQFC Implementation Team



NAQFC related presentations at this meeting



- An improved National Air Quality Forecasting Capability using the Global Forecasting System. Part 1: model development and community application; by Patrick Campbell
- An improved National Air Quality Forecasting Capability using the Global Forecasting System. Part 2: science advancements and evaluations; by Youhua Tang
- A methodology to model wildfire emissions for operational NAQFC consideration verified in the Firex-AQ campaign; by Pius Lee



National Air Quality Forecast Capability



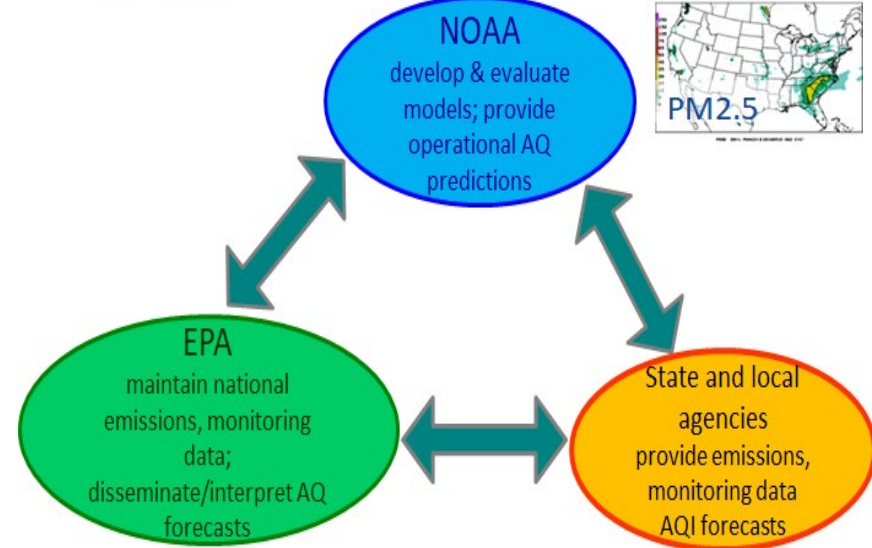
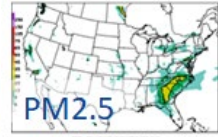
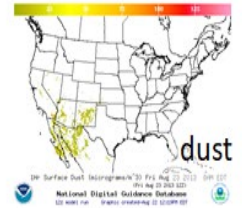
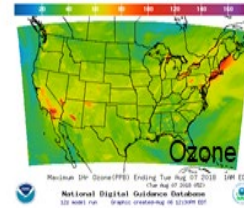
We improve the basis of air quality alerts and provide air quality information to people at risk to further NWS mission of protecting life and property and the enhancement of the national economy.

National Air Quality Forecast Capability (NAQFC) develops and implements operational air quality forecast guidance for the United States.

Current operational Prediction Capabilities are:

- Ozone nationwide
- Smoke nationwide
- Dust over CONUS
- Fine particulate matter (PM2.5) nationwide

These capabilities rely on a strategic partnership with the Environmental Protection Agency (EPA) and state and local air quality forecasters.





National Air Quality Forecast Capability



Model: Linked numerical prediction system

Implemented on the NCEP operational supercomputers

- *NOAA NCEP North American Mesoscale (NAM) numerical weather predictions*
- *NOAA/EPA Community Multiscale Air Quality (CMAQ) V5.0.2 model for ozone and PM2.5 predictions*
 - *Chemistry: CB05, AERO6*
- *NOAA HYSPLIT model for smoke and dust predictions*

Observational Inputs:

- *NWS weather observations; NESDIS Hazard Mapping system (HMS) fire locations, BLUESKY; climatology of regions with dust emission potential*
- *EPA emissions inventory: NEI 2014 V2*

Gridded forecast guidance products:

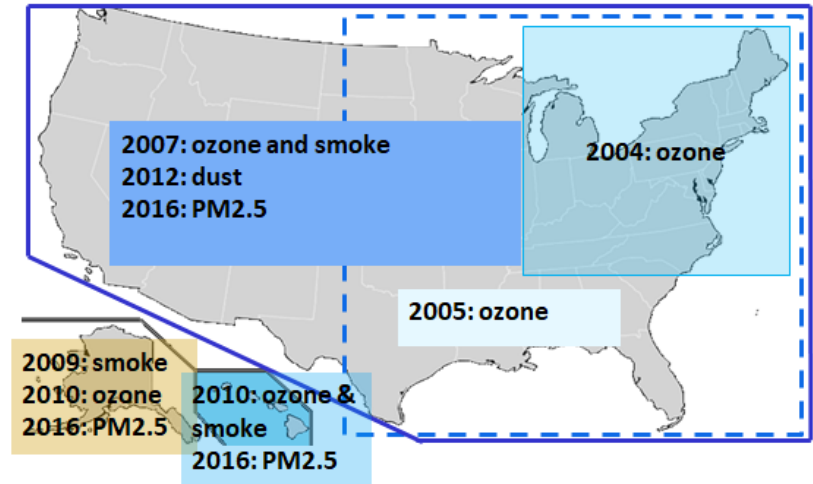
- *On NWS servers: airquality.weather.gov and ftp-servers (12 km resolution, hourly for 48 hours)*
- *Updated 2x daily*

Verification basis, near-real time:

- *Ground-level AIRNow observations of surface ozone and PM2.5*
- *Satellite observations of smoke and dust*

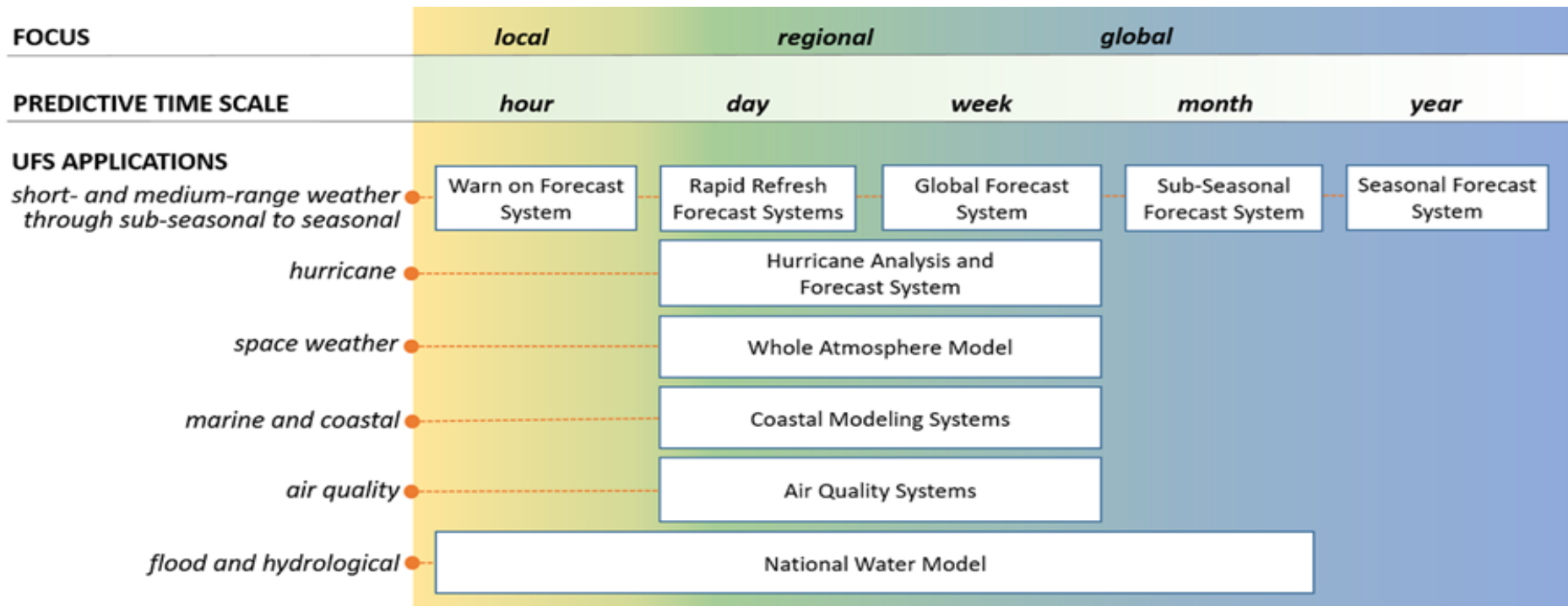
Customer outreach/feedback

- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*



Unified Forecast System (UFS)

- We are part of a system that is moving toward unification.



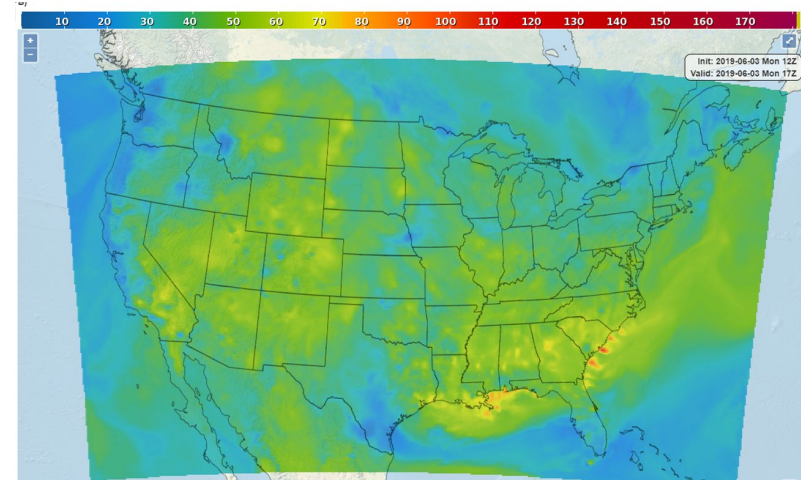
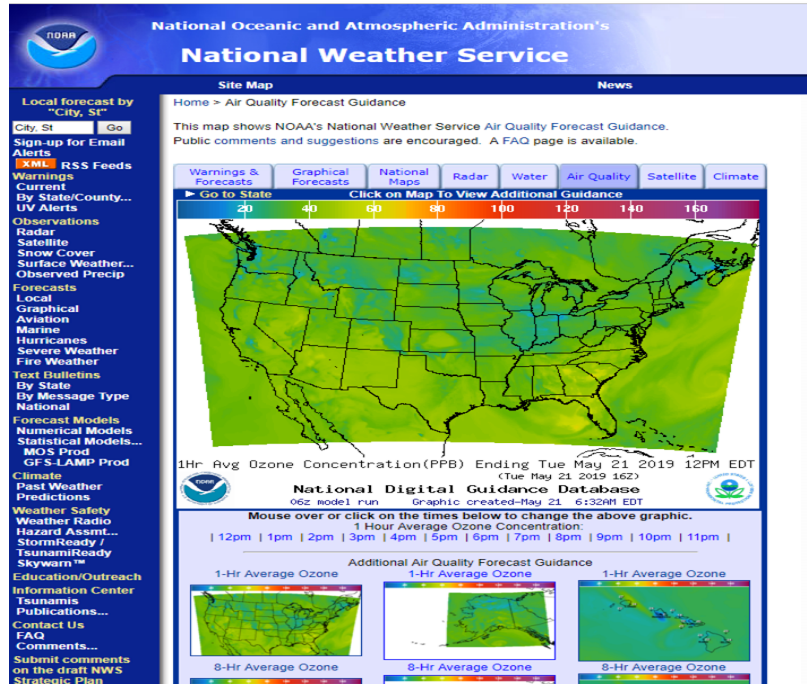


Our products are available @



Realtime images @ airquality.weather.gov and
as GRIB files from
<ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/D>
<F.gr2/DC.ndgd/GT.aq/AR.conus/>

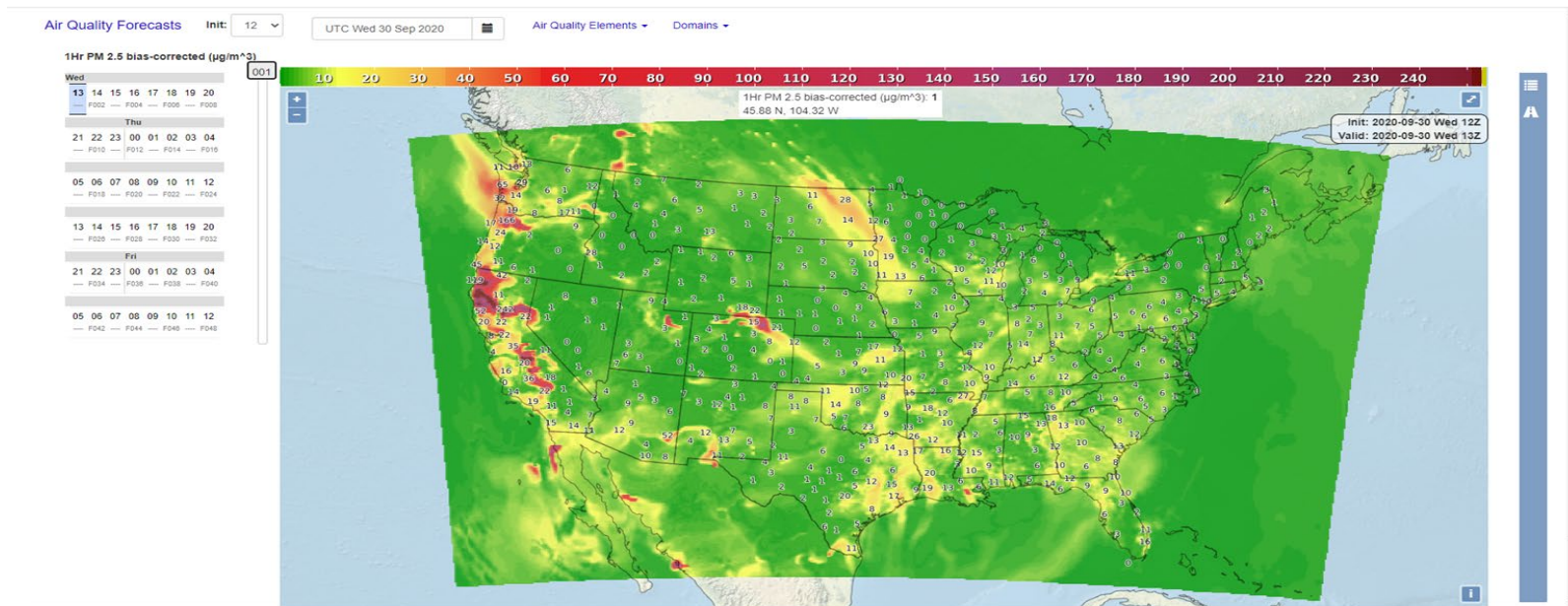
In GIS format @
https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings



Historical database available from the National
Digital Guidance Database@
<https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/national-digital-guidance-database-ndgd>

New AQ Digital Forecast Service

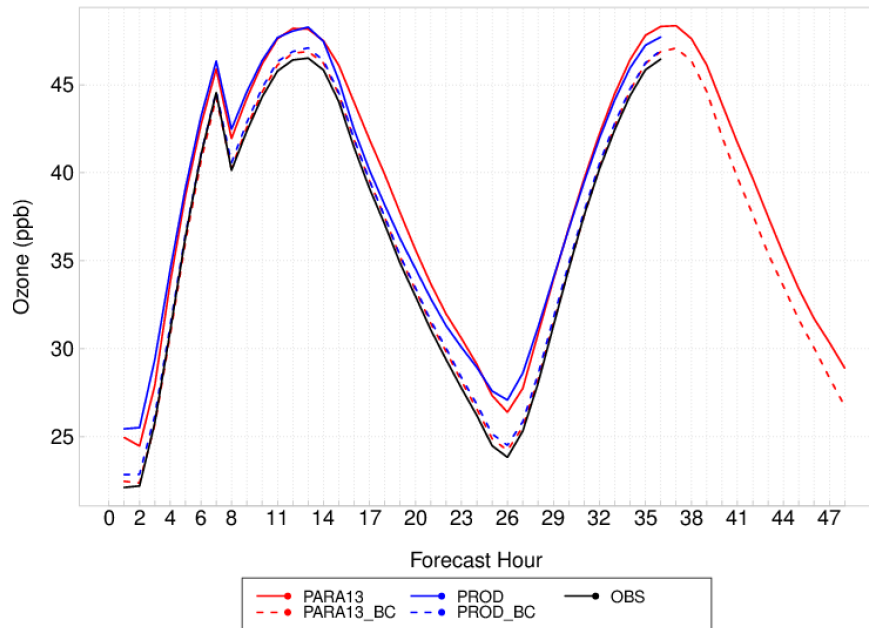
<https://digital.mdl.nws.noaa.gov/airquality/>



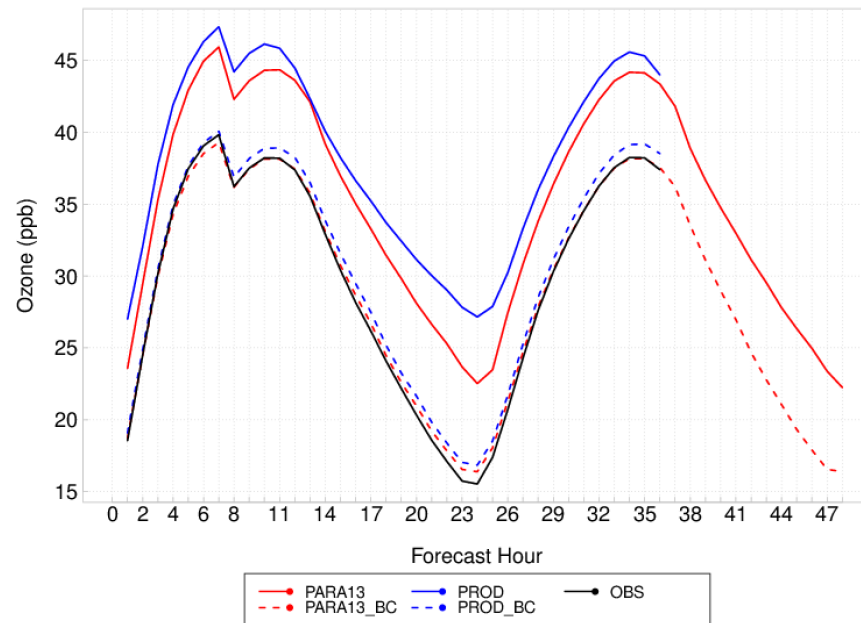
- Displays PM 2.5 which is not available @ airquality.weather.gov
- Extended Map View Options

Performance of Ozone predictions: Observed vs predicted 1 hr averaged Diurnal variability, July 2020

Average OZCON (2020-07-01 – 2020-07-30; 12z cycle; Western CONUS)



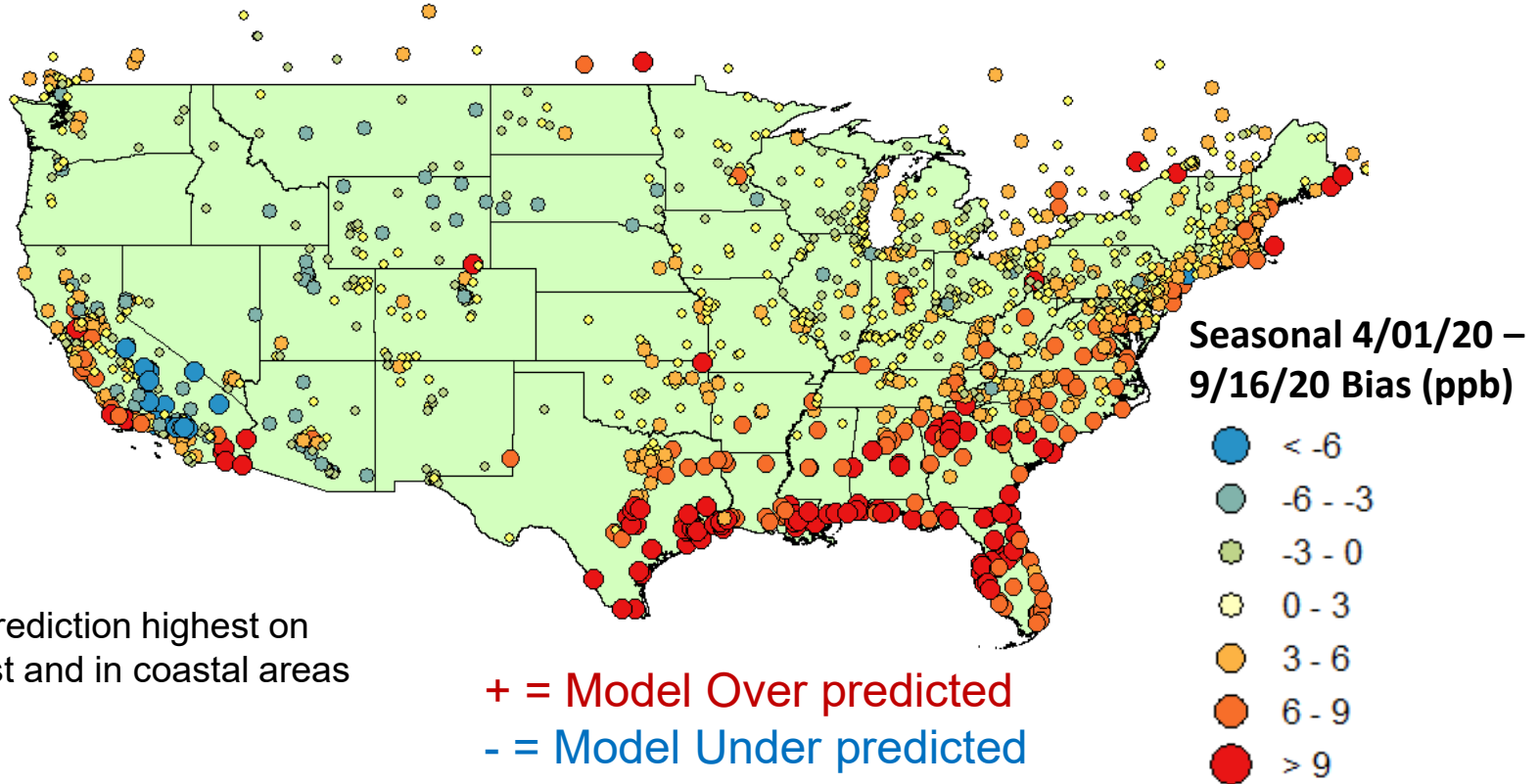
Average OZCON (2020-07-01 – 2020-07-30; 12z cycle; Eastern CONUS)



- Better performance on the west overall, bias correction improve significantly all sectors
- Operational (PROD) and experimental (PARA) overpredict more on the east

Seasonal BIAS – 8hr average Ozone raw predictions

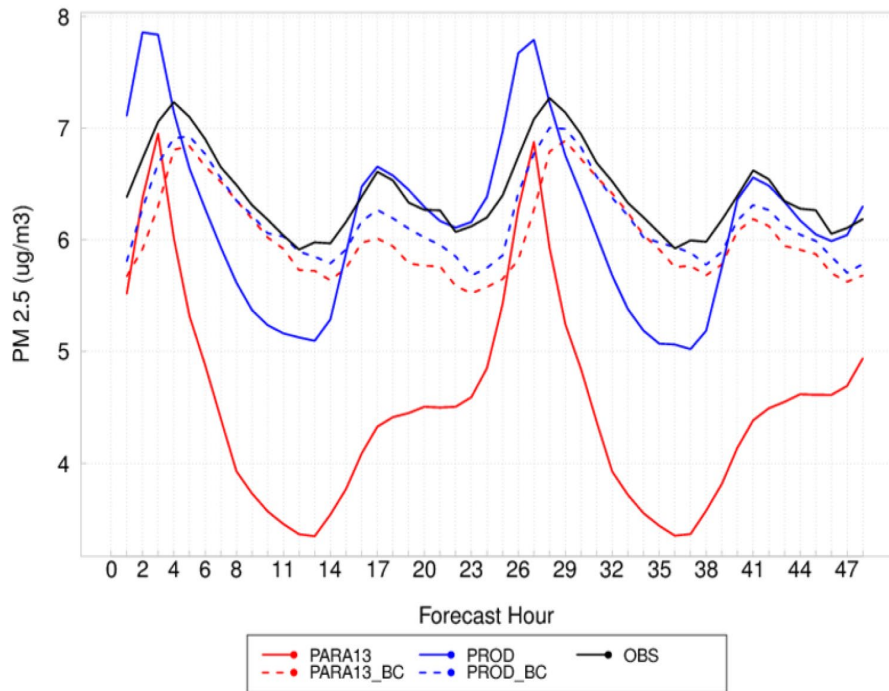
12Z: Day 2



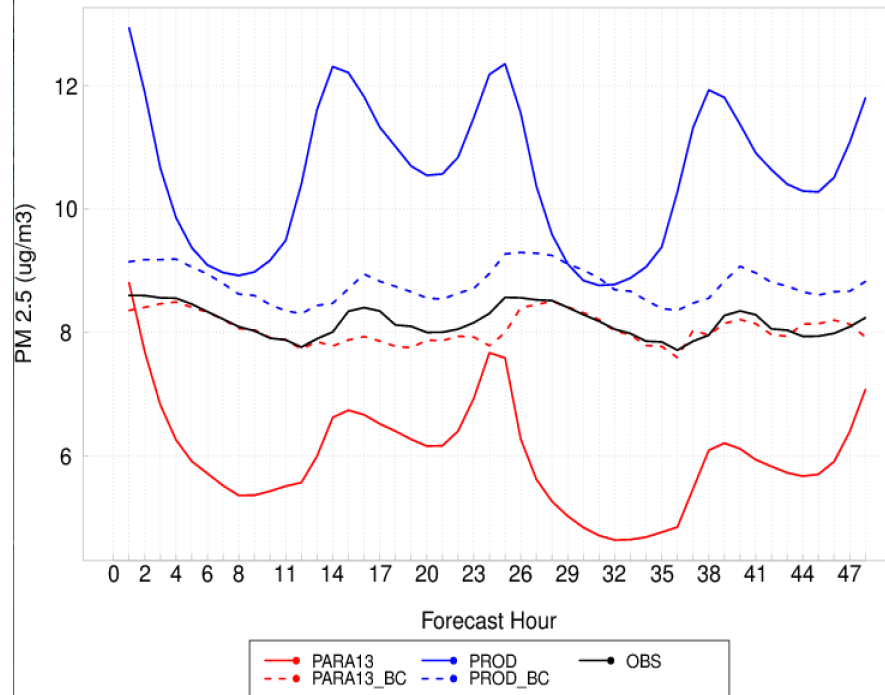
- Over prediction highest on the east and in coastal areas

Performance of PM predictions: Observed vs predicted 1 hr averaged diurnal variability, July 2020

Average PMTF (2020-07-01 – 2020-07-30; 12z cycle; Western CONUS)

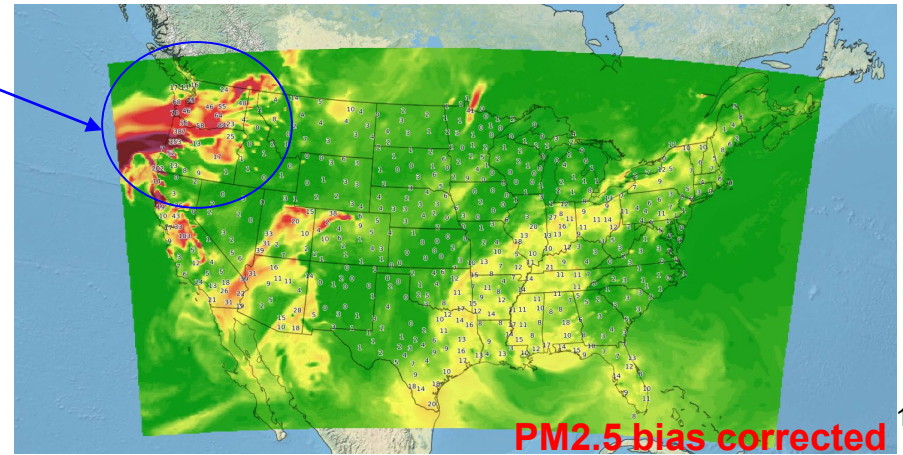
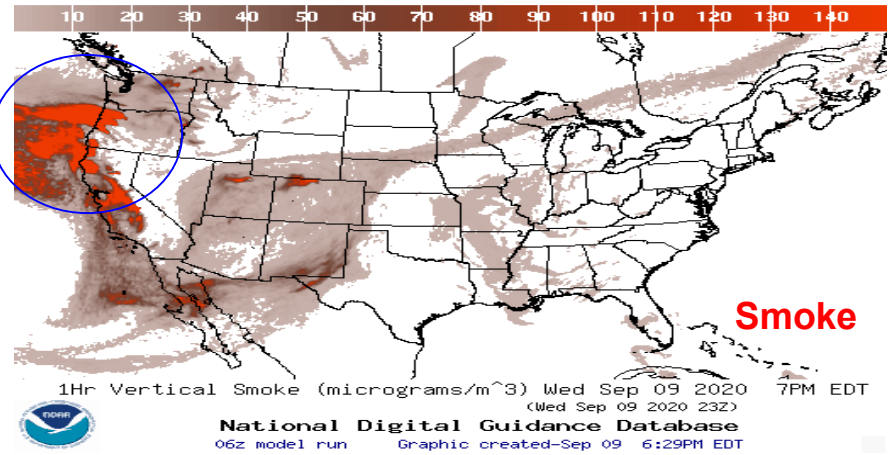
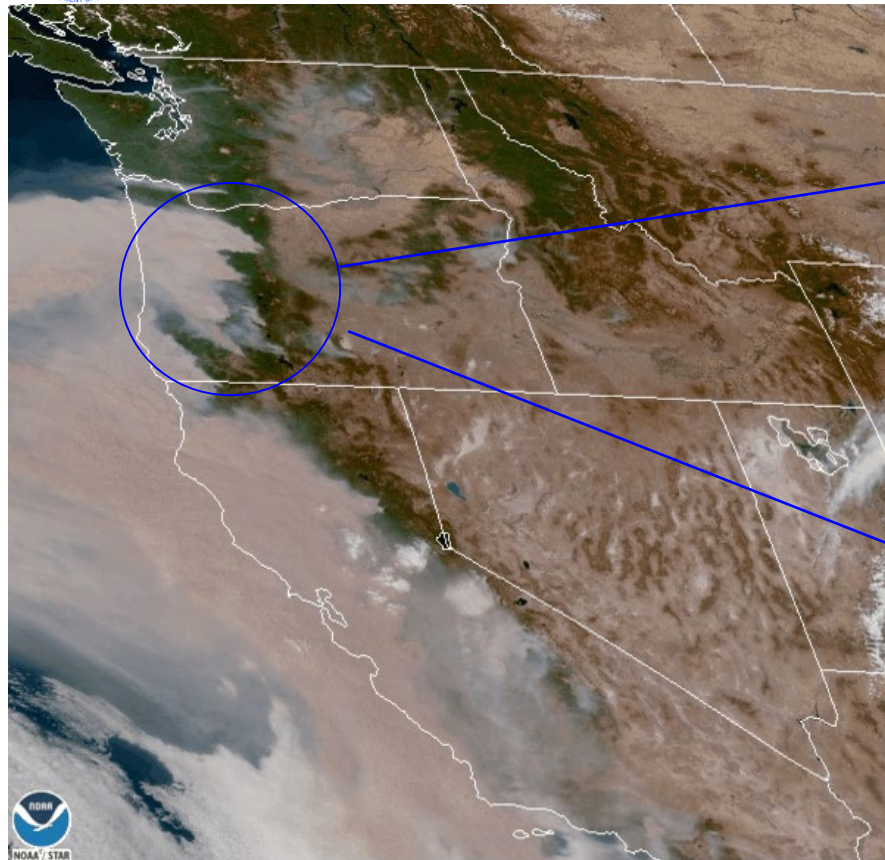


Average PMTF (2020-07-01 – 2020-07-30; 12z cycle; Eastern CONUS)



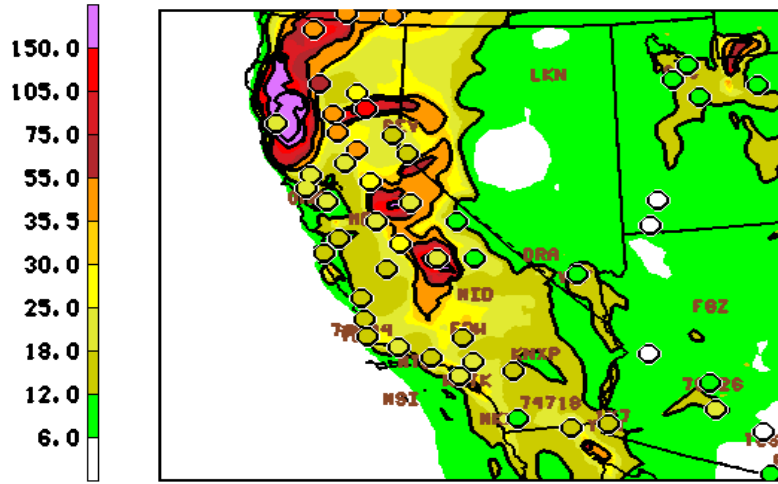
- Similar for PM_{2.5}, but with challenges during extreme events like wildfires and dust episodes

Recent fire event 9/9/2020

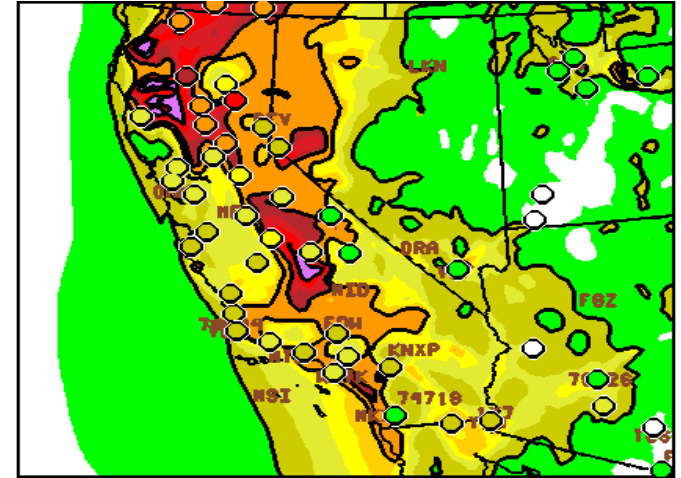


The Western U.S. 2020 fires

24 h avg $PM_{2.5}$ 9/5/20 12 UTC run



PROD DAY1 PMAY24 (U6/H3) 20200905 12Z CYC~
Production, bias corrected

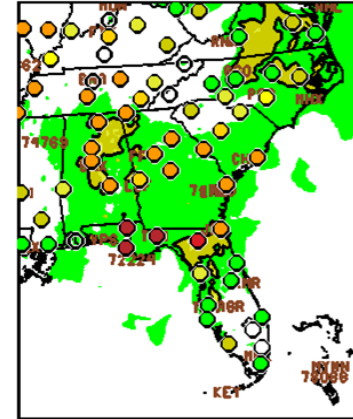
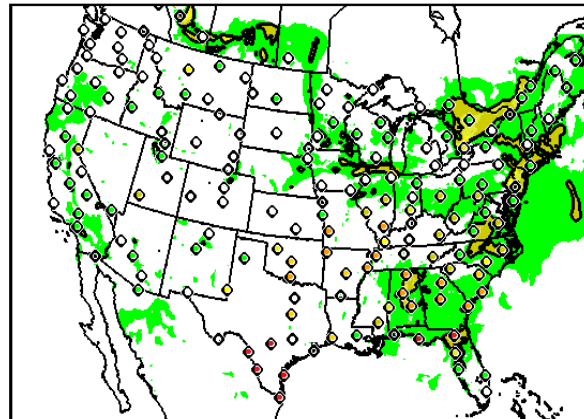
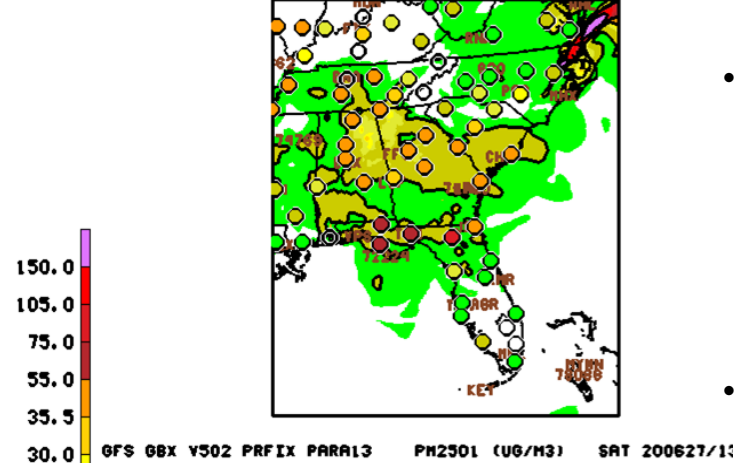
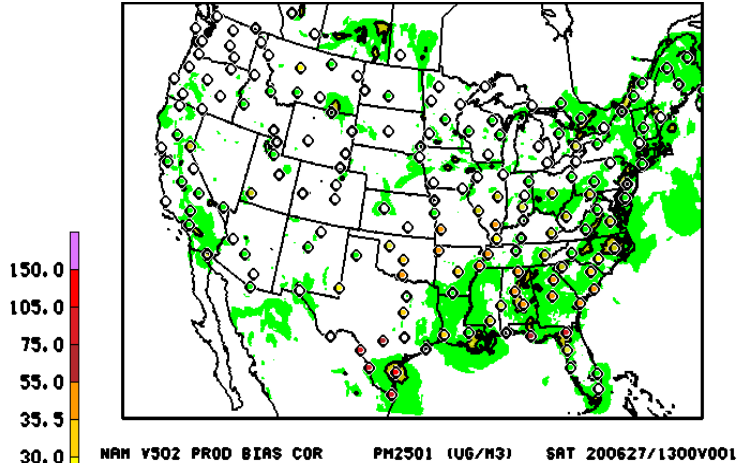


NACC 6FSV16-CHAQV5.3.1 DAY1 PMAY24 (U6/H3) 20200
V16 (Para6)

- Our operational model (production) slightly over predicted $PM_{2.5}$ in some areas during the fire event in this case.
- Experimental run (PARA6) have a higher over prediction, but is not bias corrected.

Saharan Dust intrusion event

- Under predicted Saharan Dust event compared to observations (filled circles)
- The bias corrected image on the top left did not show significant improvements for this extreme event





NAQFC Future updates and work in progress

- Develop a new chemistry coupler: NOAA-EPA Atmosphere-Chemistry Coupler (NACC).
- Couple and drive CMAQ with FV3-based GFS, NOAA's Next Generation Global Prediction System.
- Extend the range of CMAQ predictions from 48 hours to 72 hours
 - Including the KFAN/Bias corrected products
- Updates to fire emission scheme (Global Biomass Burning Emissions Product eXtended (GBBEPx))
- Use of GEFS-Aerosols output for lateral boundary conditions of aerosol species
- Updates to our air quality verification system, including a new web interface

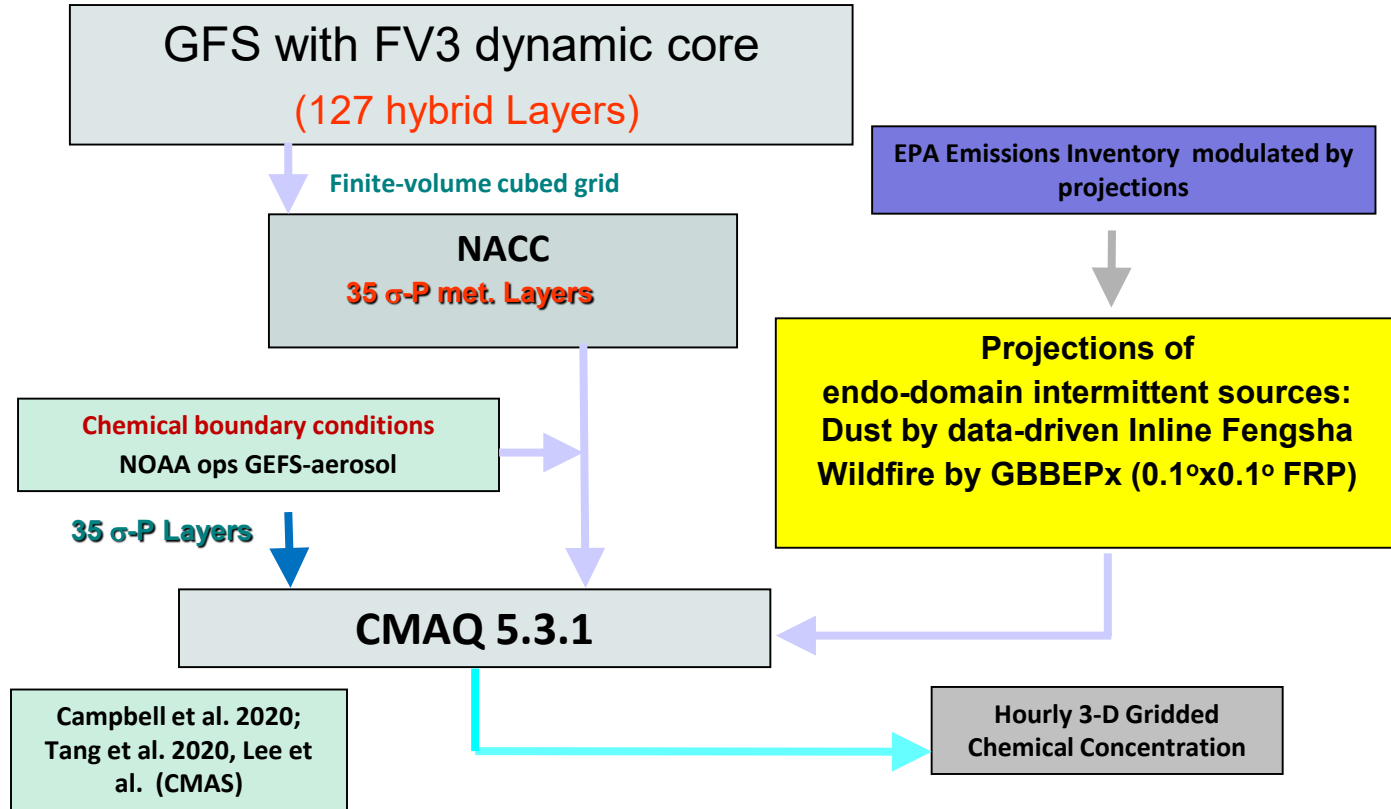


NOAA-EPA Atmosphere-Chemistry Coupler (NACC)

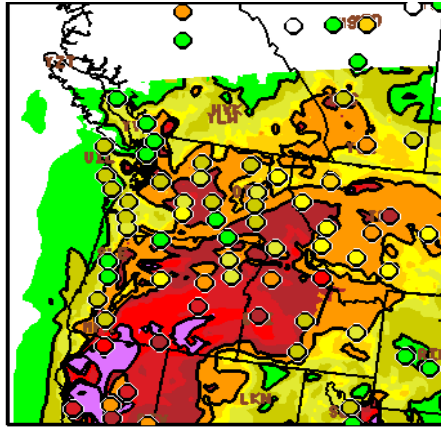
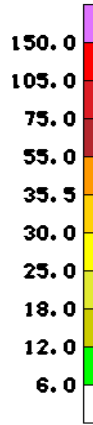


- NACC couples NOAA's GFSv16 with the Community Multiscale Air Quality Model, version 5.3.1 (CMAQv5.3.1)
- It will bring many changes and upgrades including:
 - Updated gas phase and aerosol chemistry (CB06, AERO-7)
 - Updated high resolution satellite land cover characterization (soil type, vegetation)
 - Updated fire emissions (GBBEPx)
 - Fengsha Inline Windblown Dust Emissions
 - Dynamic aerosol boundary conditions (GEFS-aerosols)
- Developed by ARL in collaboration with the EPA, currently being tested in Parallel at EMC.
- Could be operationally implemented in January 2022.

GFSFV3-NACC-CMAQ sequential processes

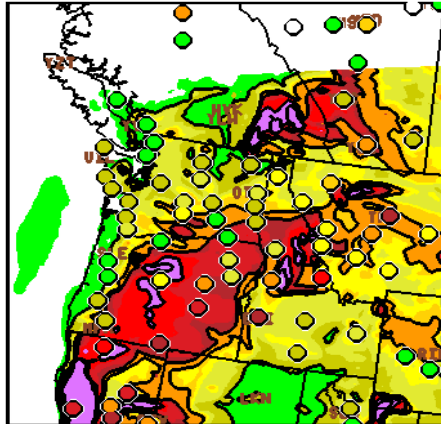


Experimental runs of NACC



GFS-NACC-CMAQ

PARA6 NACC 6FSV16-CMAQV5.3.1 DAY1 PMX01 (UG/M3) 20200905 12Z



NAM-CMAQ

PROD DAY1 PMX01 (UG/M3) 20200905 12Z CYC-

- Currently being tested @ NOAA/EMC
- Consistent results overall with current operational version.
- Preliminary testing show PM overprecion by the New system during this extreme event (recent west coast wildfires)



GEFS-Aerosol Member



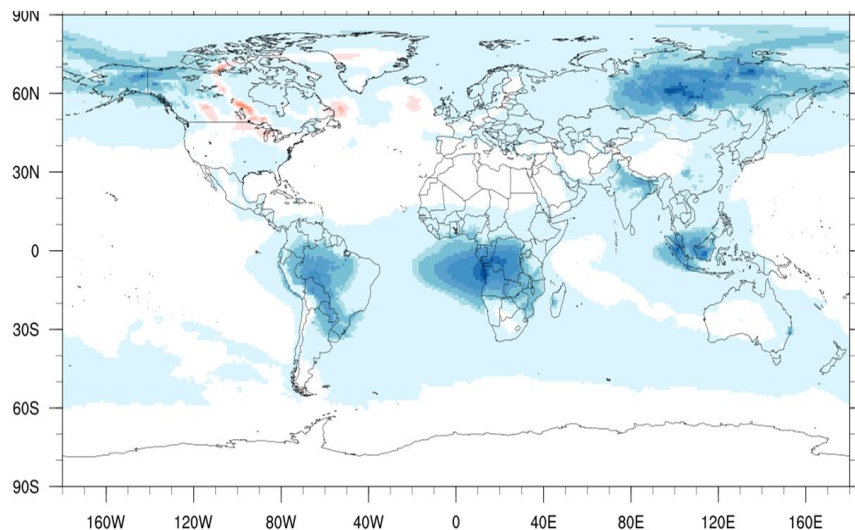
- Collaboration of EMC, GSL, CSL, ARL, and NESDIS
- Replaced operational NGACv2 in September 2020
- GEFS meteorology (FV3) at C384 (~25 km), 64 levels, to 120 hrs, 4x/day
- GOCART: Sulfate, Organic Carbon, Black Carbon, Dust, Sea Salt
- Smoke plume rise: Wind shear dependent 1-d cloud model to simulate tilt of plume.
- Emissions: CEDS-2014 (SO₂, PSO₄, POC, PEC), GBBEPx biomass burning, FENGSHA dust, GEOS-5 sea salt, marine DMS
- Initial conditions: cycled for aerosols, but from GFSv15 analysis for meteorology
- Will provide improved lateral boundary conditions for the regional CMAQ.

https://www.emc.ncep.noaa.gov/emc/pages/numerical_forecast_systems/gefs_aero.php

New GEFS-Aerosol Forecast

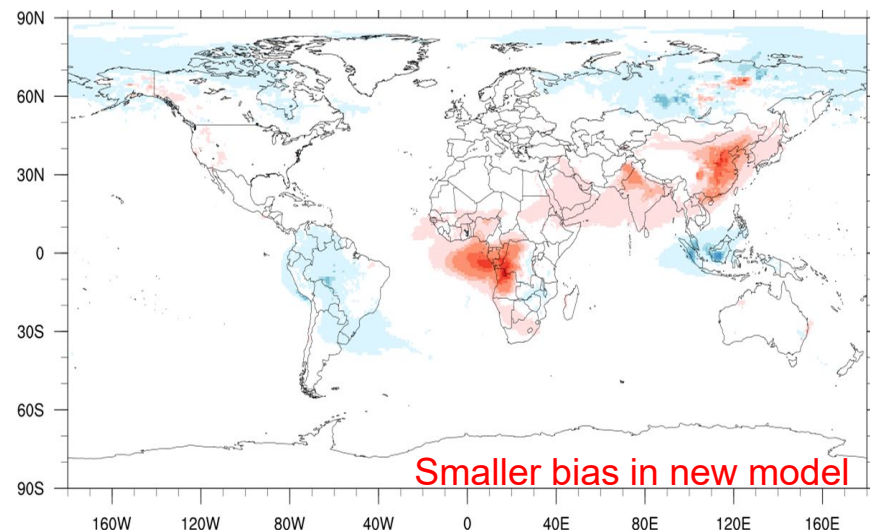
NGAC day 1 prediction – GEOS-5 analysis

550 nm AOD, 7/5/19-11/30/19

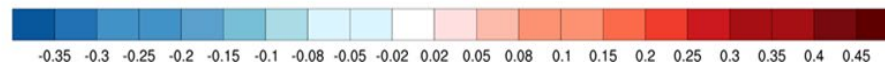


GEFS-Aerosol day 1 prediction – GEOS-5 analysis

550 nm AOD, 7/5/19-11/30/19



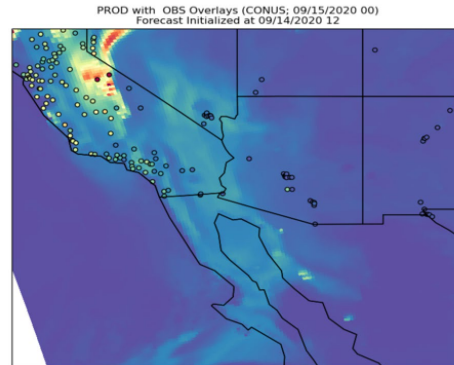
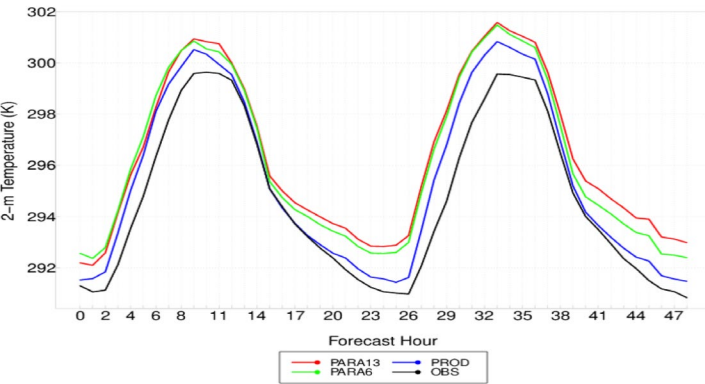
Smaller bias in new model



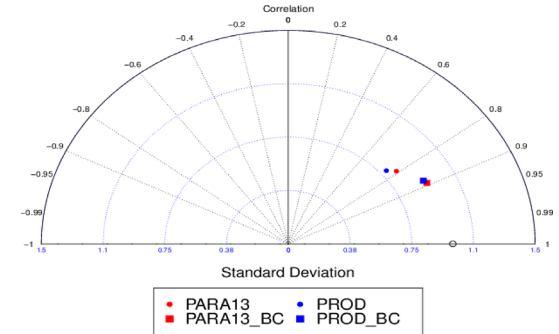
Updates to Air Quality Verification System

- We are working on improving our air quality verification capabilities
- Several examples provided below
- We will also have a new web interface for the verification system

TMP Verification (2020-08-25 – 2020-08-27; Southwest Coast)



Ozone (ppb): 2020-08-01 – 2020-08-30 (Full Domain)





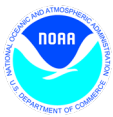
Long term plans (3-5 years)

- All new developments within the Unified Forecast System framework.
- Global predictions:
 - Extend GEFS-Aerosol member prediction from 5 days to Sub-seasonal to Seasonal (S2S) time scales
- Regional predictions:
 - Online CMAQ in high resolution Rapid Refresh Forecast System for PM2.5 and ozone predictions evaluated for FIREX-AQ
- Unified focus for both:
 - Unified emissions system & evaluate potential for data-driven rapid refresh capability for emissions
 - Interaction of aerosols with radiation
 - Assimilation of satellite and other data
 - Improved representation of biomass burning emissions



Long term plans (10+ years)

- Unified global and regional AQ/AC modeling
- Coupled model ensemble with a more comprehensive representation of composition
- Increase in the number of pollutants/constituents/aerosol species in the model
- Coupling of aerosol-radiation-microphysics interactions
- Development of computationally more efficient approaches for comprehensive air quality simulations (e.g., ML/AI)
- Assimilation of more observations using advanced techniques

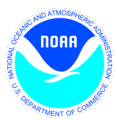


Summary

- We provide real time hourly predictions of ozone, particulate matter, smoke and dust to the nation
- Our work relies on a strategic partnership with the Environmental Protection Agency (EPA) and state and local air quality forecasters.
- Our products are freely available online (airquality.weather.gov, others)
- Predictions now available @ <https://digital.mdl.nws.noaa.gov/airquality>
- Aerosol-member in GEFS V12 has been implemented

Work in progress:

- Future improvements will include coupling of CMAQ with FV3GFS, extension to 72 hour predictions and new fire emissions processing and inline dust
- Development of the NACC coupler
- Updates to verification system
- Unified global and regional AQ/AC modeling within the UFS framework



Thank you for your attention

Questions?

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