



**NATIONAL
WEATHER
SERVICE**

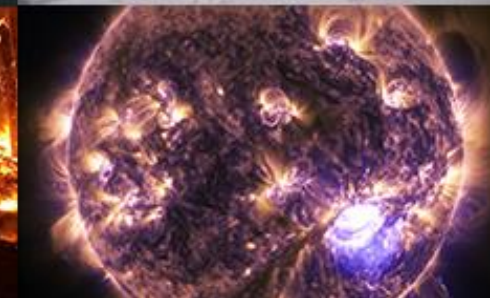
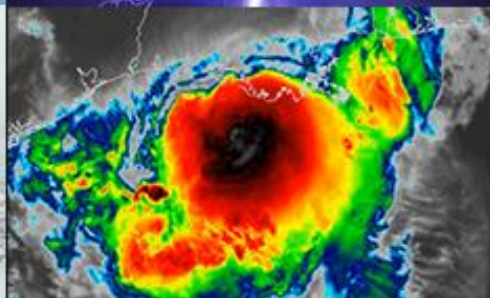
Operational Air Quality and Aerosol Predictions

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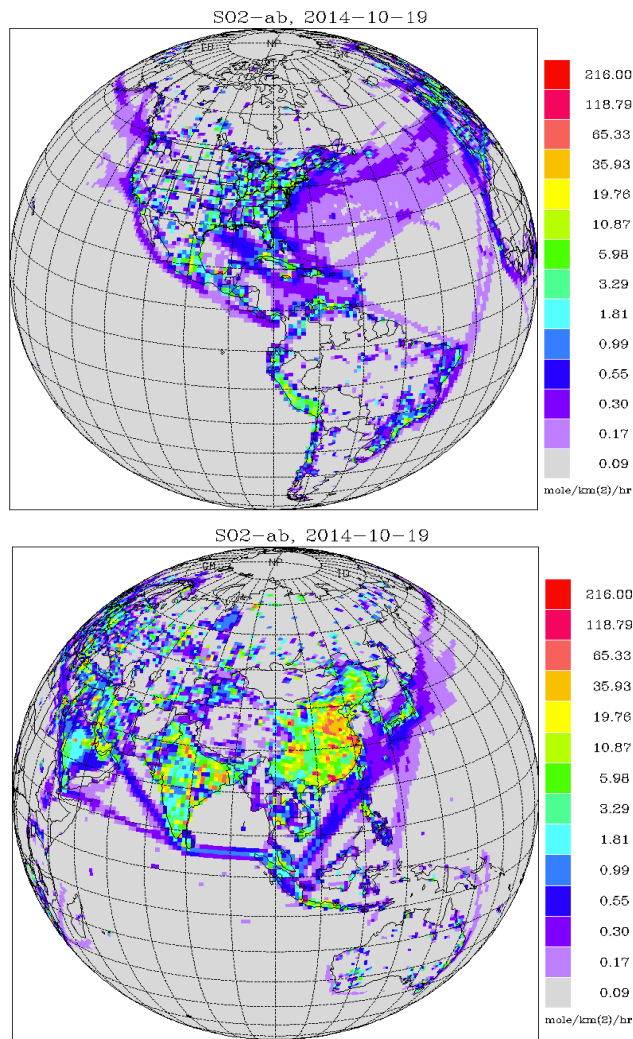
with contributions from air quality and
atmospheric composition teams

NASA ACCP AQ Workshop

March 17, 2021



Global: GEFS-Aerosol member



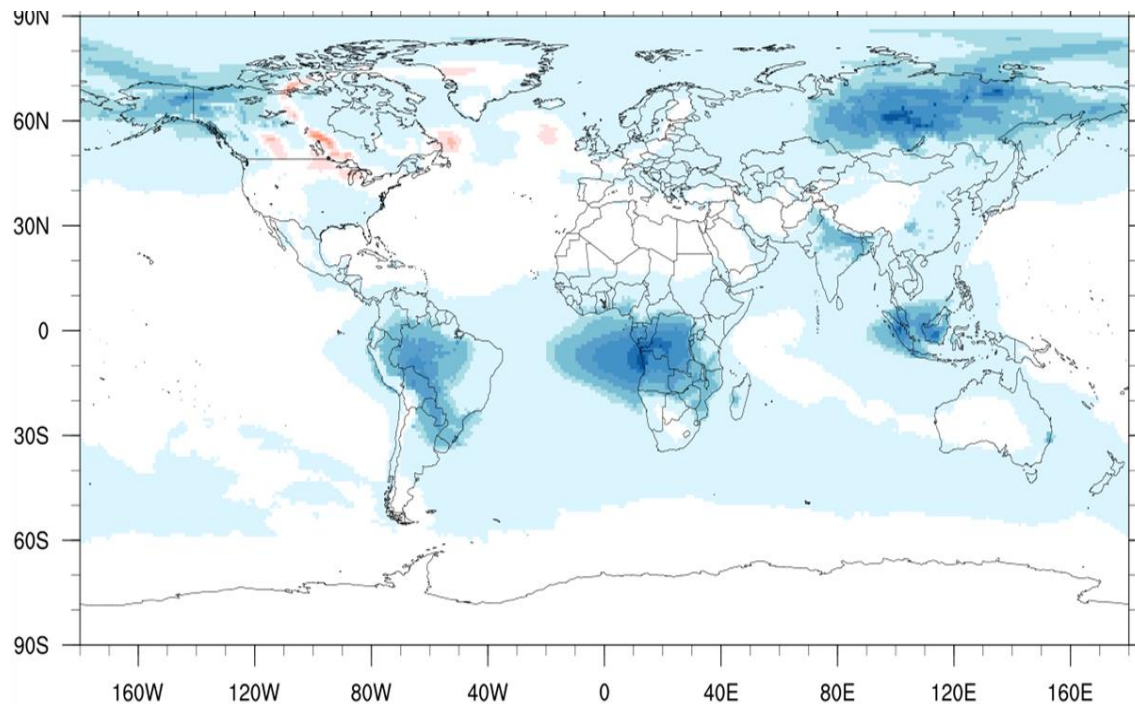
CEDS-2014 SO2 emissions

- Online aerosol representation based on NASA's GOCART
- Implemented into operations in September 2020 in the first UFS coupled model: GEFS with Aerosols and Waves.
- GEFS-Aerosol member:
 - Meteorology (based on **GFS**v15) at C384 (~25 km), 64 levels, to 120 hrs, 4x/day
 - **GOCART**: Sulfate, Organic Carbon, Black Carbon, Dust, Sea Salt
 - Emissions: CEDS-2014 (SO2, PSO4, POC, PEC), **GBBEPx biomass burning**, FENGSHA dust, GEOS-5 sea salt, marine DMS
 - Initial conditions: cycled for aerosols (**no data assimilation**), but from GFSv15 analysis for meteorology
 - Smoke plume rise: Wind shear dependent 1-d cloud model to simulate tilt of plume. Fire Radiative Power is used to calculate convective heat flux and determine injection height
 - Tracer transport and wet scavenging are included in Simplified Arakawa-Schubert (SAS) scheme. Fluxes are calculated positive definite. Scavenging coefficient is $\alpha=0.2$ for all aerosol species.

Improved mean behavior

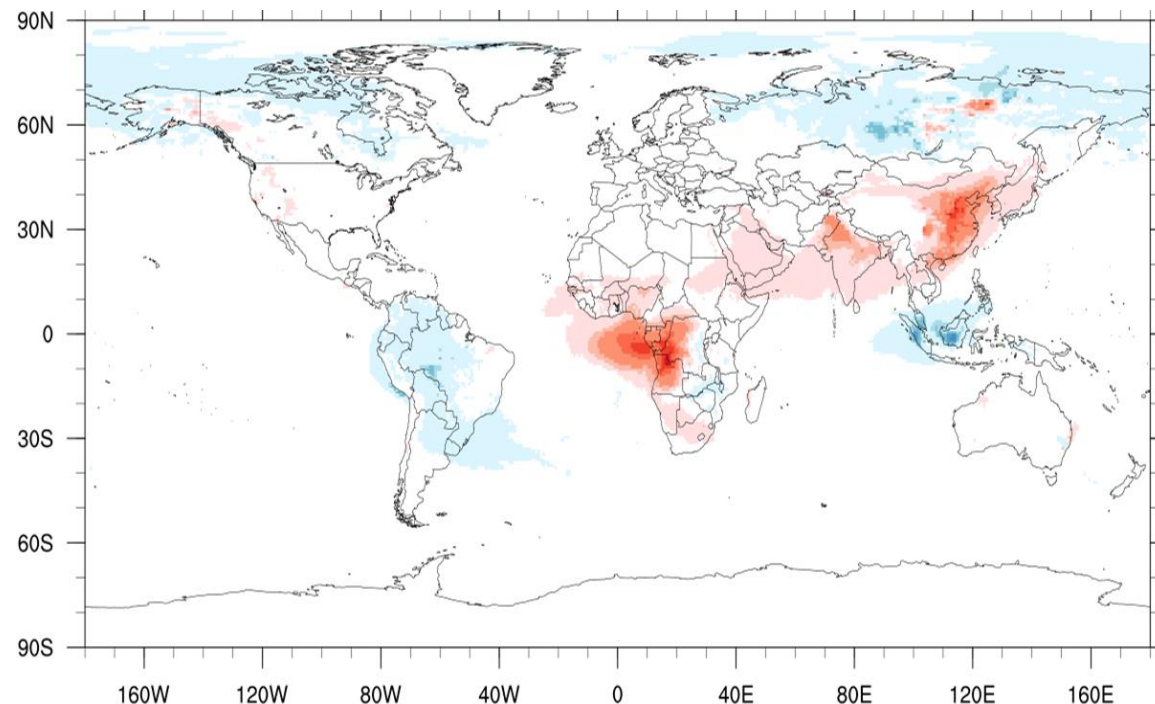
NGAC day 1 prediction – GEOS-5 analysis

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

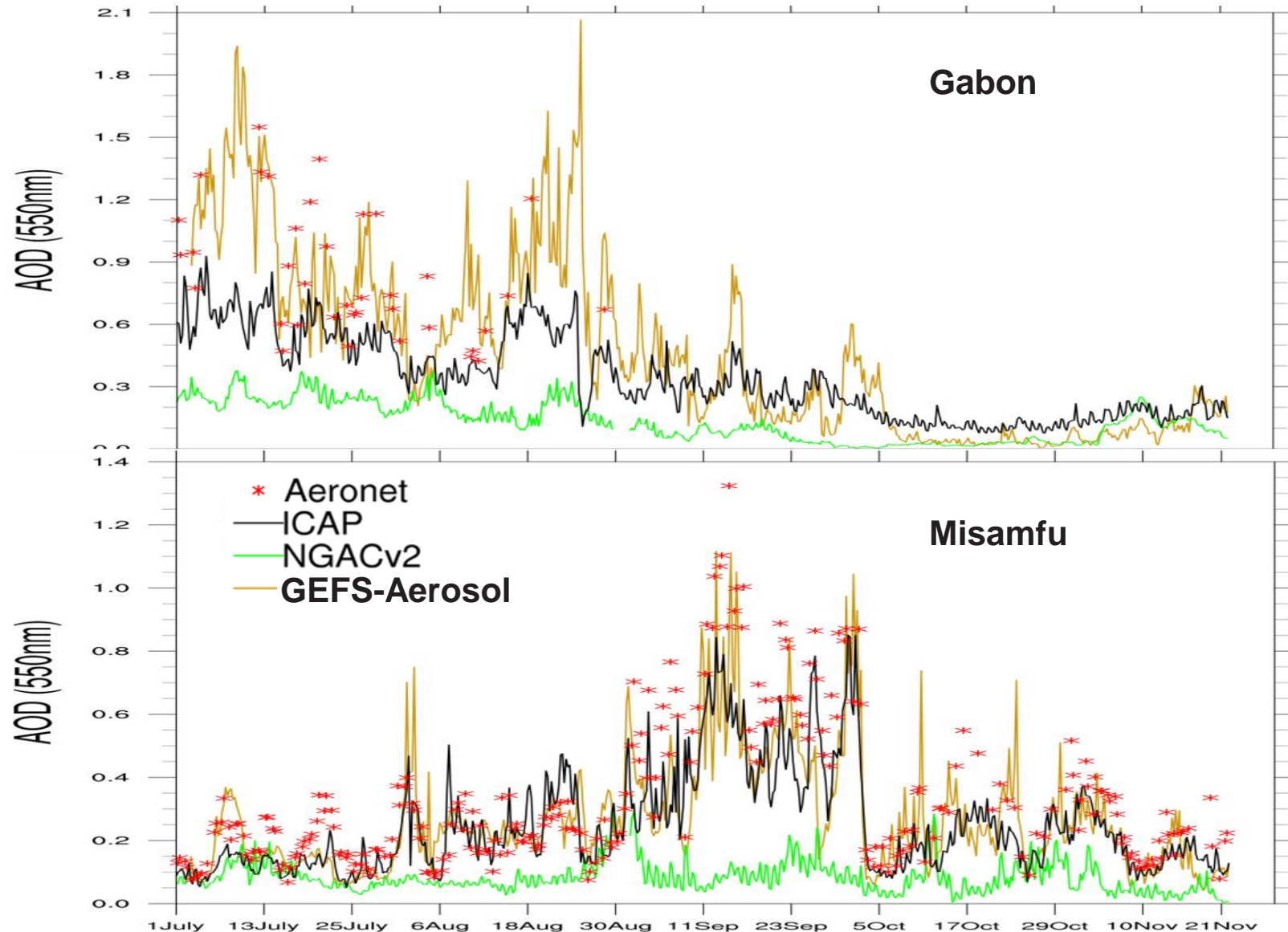


- Organic carbon AOD biases with respect to GEOS-5 analyses are smaller for GEFS-Aerosols (right) than those for previous operational system NGAC (left).
- Same is true for dust and sulfate (not shown).

Improved 😊



Improved variability: biomass burning



Comparison against AERONET AOD in biomass burning impacted region in Africa.

GEFS-Aerosol predicts observed total AOD magnitude and variability much better than NGAC in western (Gabon) and eastern (Misamfu) Africa.

Improved 😊

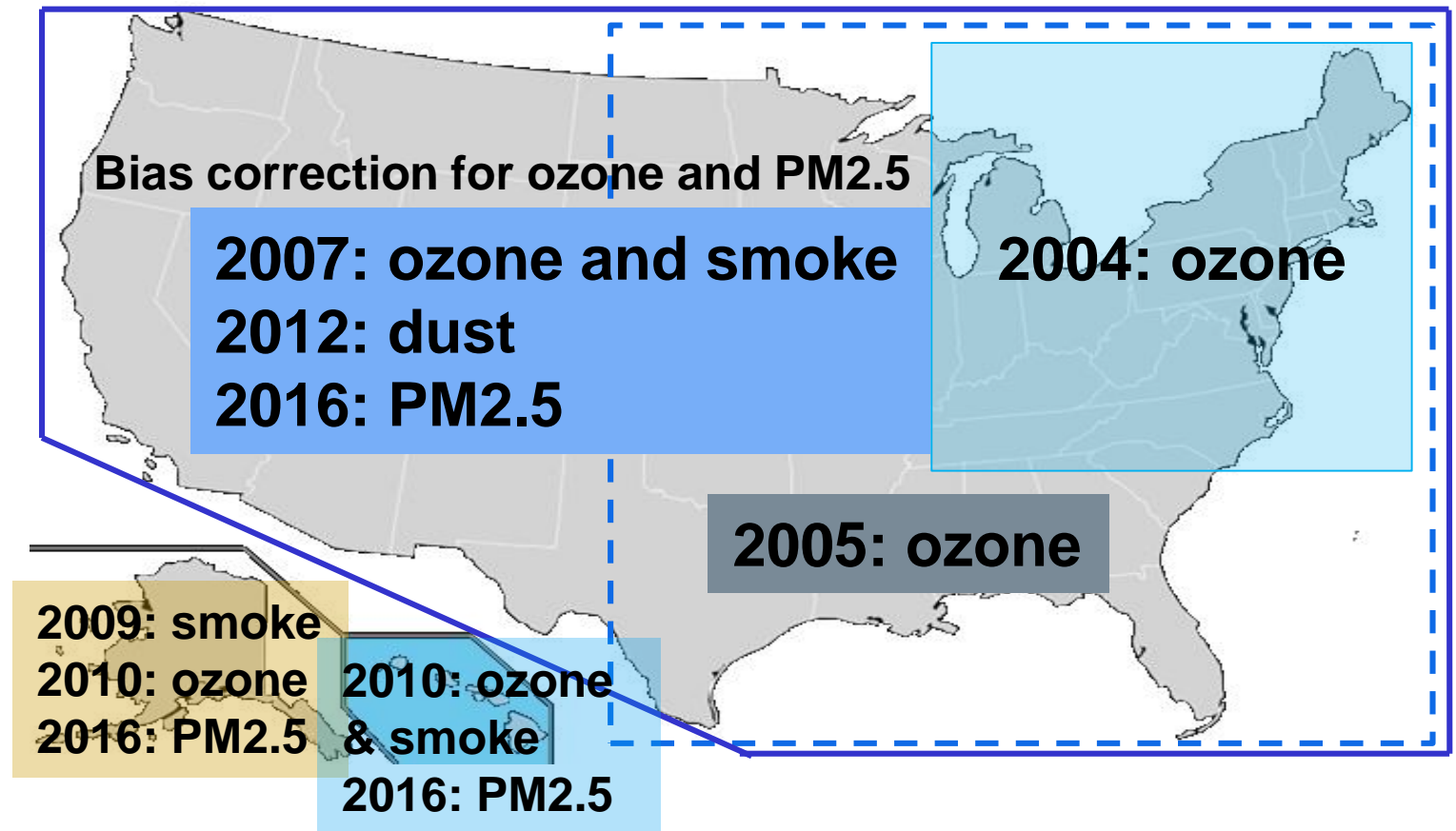
National Air Quality Forecast Capability

- Improving the basis for air quality alerts
- Providing air quality information for people at risk

airquality.weather.gov

Prediction Capabilities:

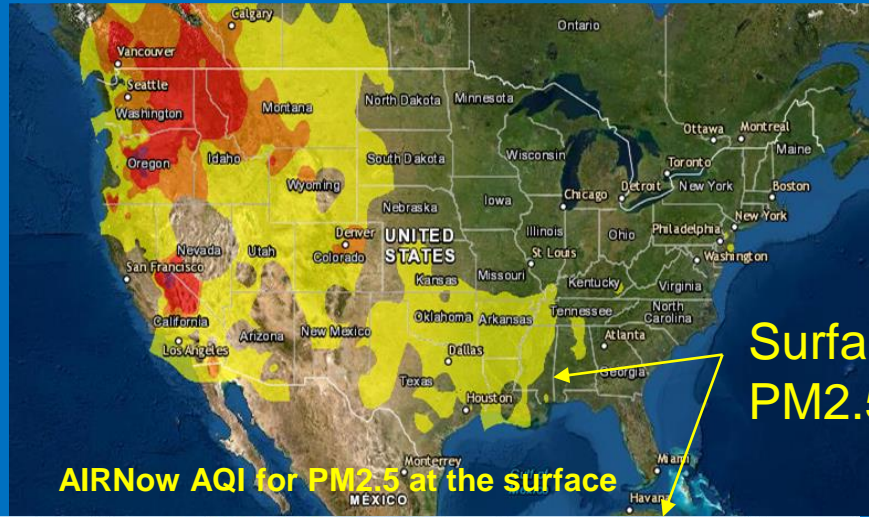
- **Operations** (all driven by NAM meteorology):
 - 48 hour predictions at 12 km resolution
 - Ozone nationwide - CMAQ
 - Fine particulate matter (PM2.5) nationwide - CMAQ
 - Smoke nationwide - HYSPLIT
 - Dust over CONUS - HYSPLIT
- **Testing of improvements:**
72 hour predictions of ozone and PM2.5 - CMAQ driven by GFS





Smoke from western wildfires on September 18, 2020

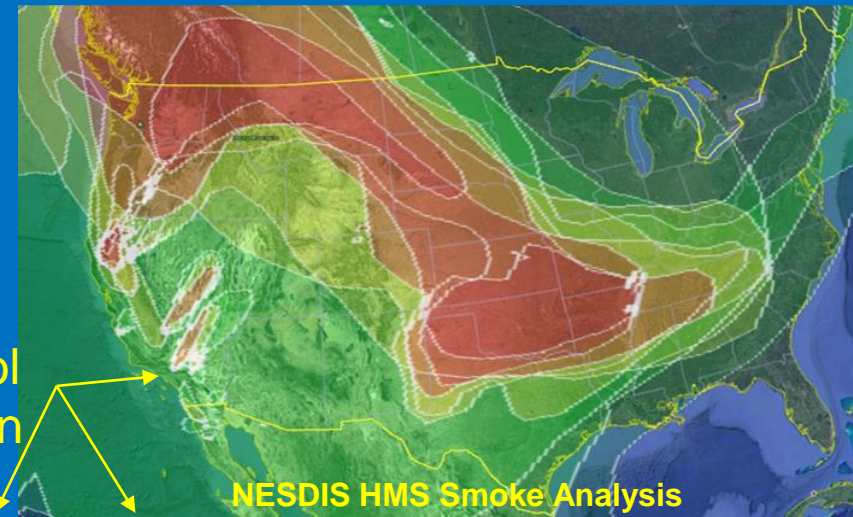
Observations



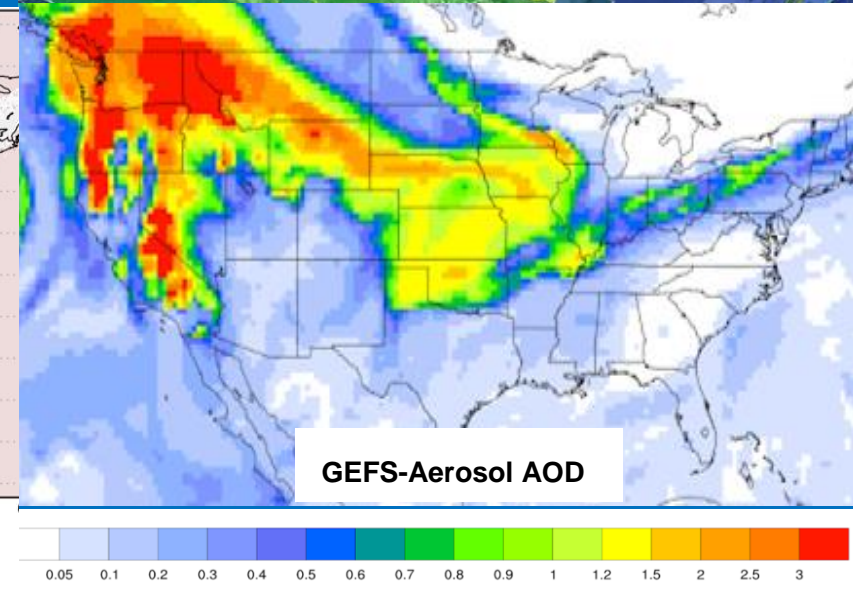
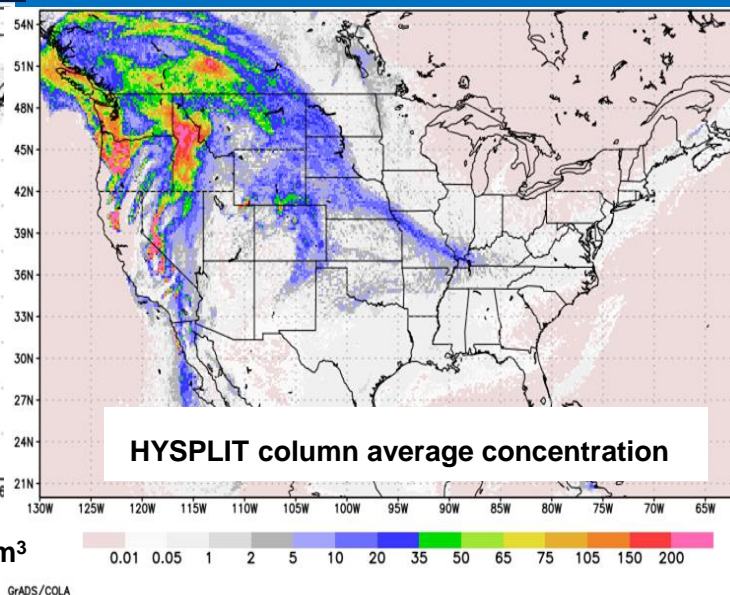
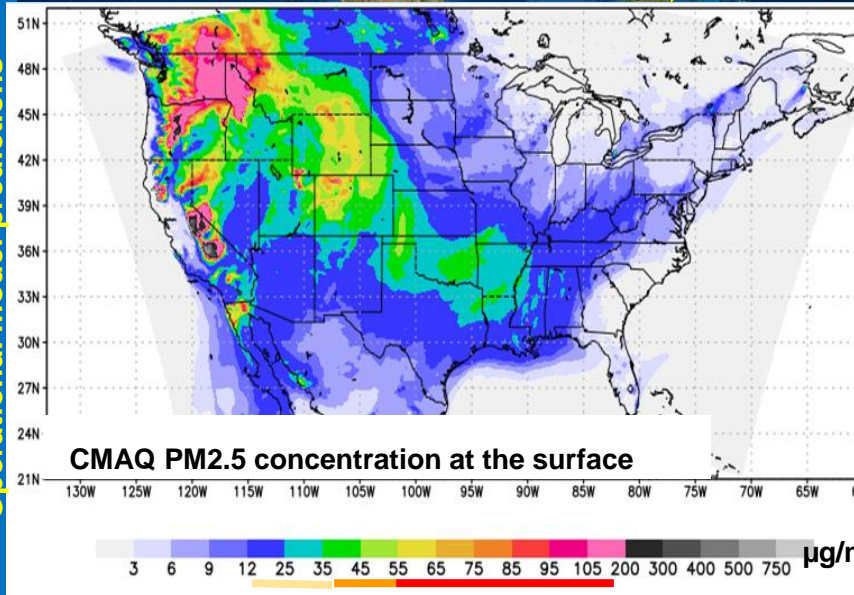
Surface PM2.5

Spatial extent of smoke impacts is well captured. CMAQ surface concentrations agree well with AIRNow observations

Aerosol Column

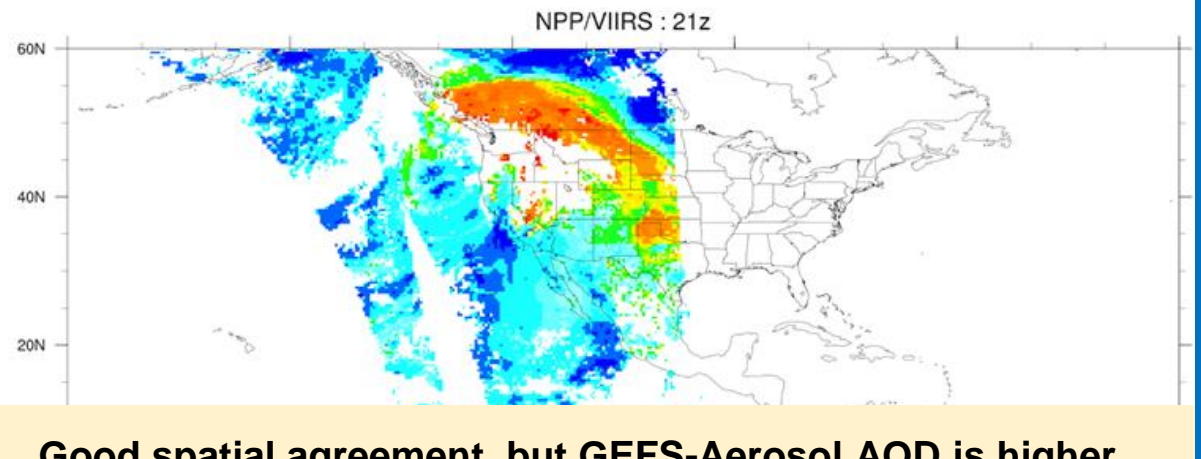
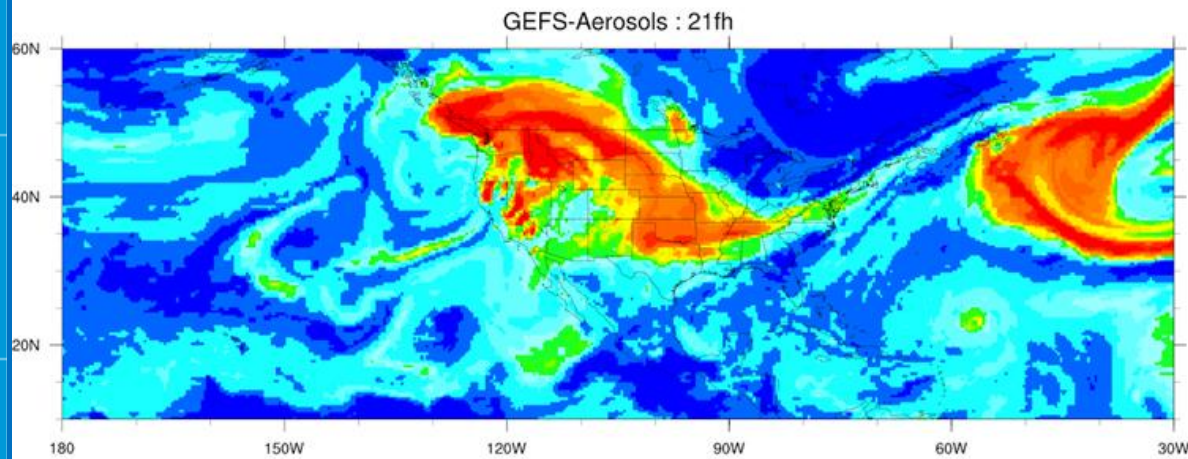
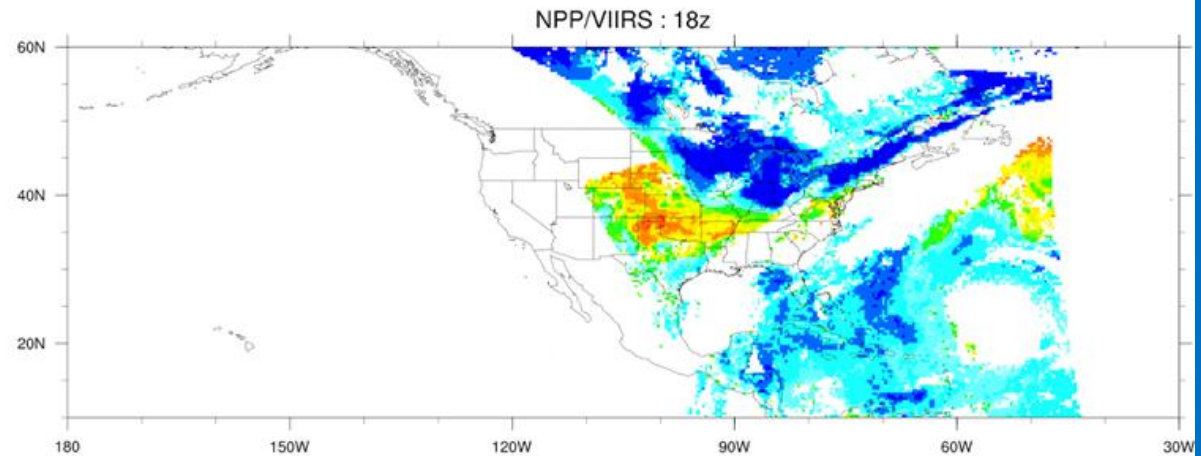
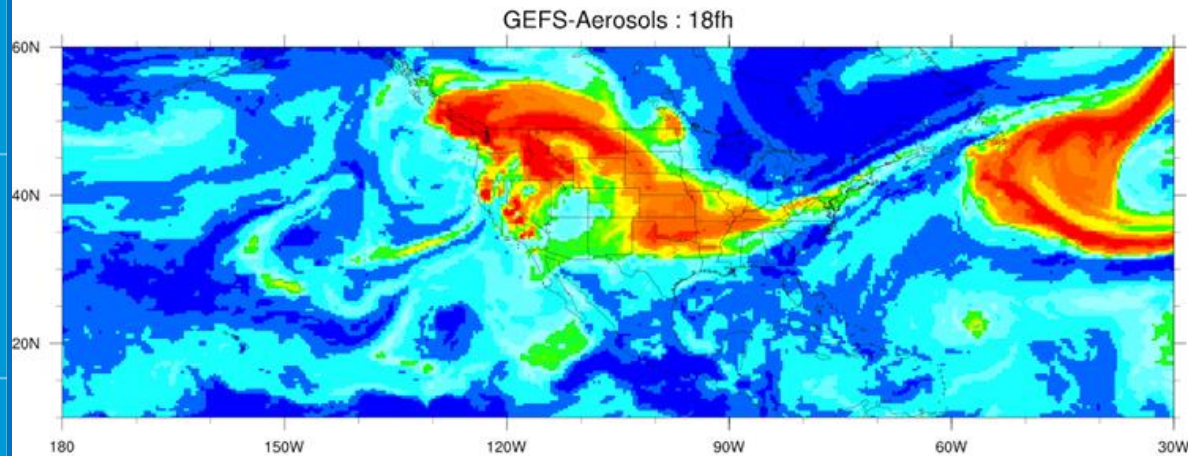


Operational model predictions

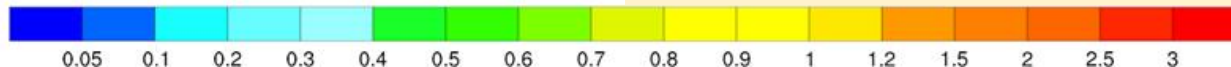


AOD: GEFS-Aerosol predictions vs VIIRS observations

18th September, 2020 (Total AOD)



Good spatial agreement, but GEFS-Aerosol AOD is higher



Summary

Operational AQ predictions are used by state and local AQ forecasters to protect public health and lives. Other users: general public, EPA, CDC.

Improved operational global aerosol predictions - GEFS-Aerosol member:

- Higher resolution, newer emissions, improved vertical transport, smoke plume rise
- Improved, reduced bias with respect to GEOS-5 analyses for dust, organic carbon and sulfate
- Better agreement with AERONET AOD variability

NAM-CMAQ, NAM-HYSPLIT and RAP/HRRR provide national operational predictions of air quality, wildfire smoke or dust dispersion.

Testing of GFS-CMAQ:

- Allows extension of ozone and PM2.5 predictions to 72 hours
- Removes dependence on HMS fire detections and frozen NAM

Plans (1)

Global predictions:

- Extend GEFS-Aerosol member to Subseasonal to Seasonal (S2S) predictions
- Improve representation of biomass burning emissions (combine observations, predictions and climatology)
- Develop assimilation of AOD data
- Include and evaluate interactions of aerosols with radiation on S2S time scales

Emissions:

- A unified system NEXUS for NOAA global and regional models based on NASA and Harvard HEMCO
- Evaluate potential for data-driven rapid refresh capability for emissions

* use od satellite data *

Plans (2)

Regional predictions:

- CMAQ online with high-resolution Rapid Refresh Forecast System (RRFS) for wildfire impacts on air quality: PM2.5 and ozone
- Improved diurnal cycle and plume rise for fire emissions
- Improved initialization: assimilation of AOD and NO2 data
- Machine learning emulator for chemistry in air quality forecasts
- Improved diurnal cycle and plume rise for fire emissions and Fire Weather Index
- Models will be evaluated using FIREX-AQ data
- This is a highly coordinated NOAA effort among EMC, NESDIS-STAR, several OAR labs, university partners and USRA on 3 projects.

Biomass burning emission improvements:
Scaling factors, plume rise, diurnal behavior

