Overview of the RRFS/CMAQ inline system

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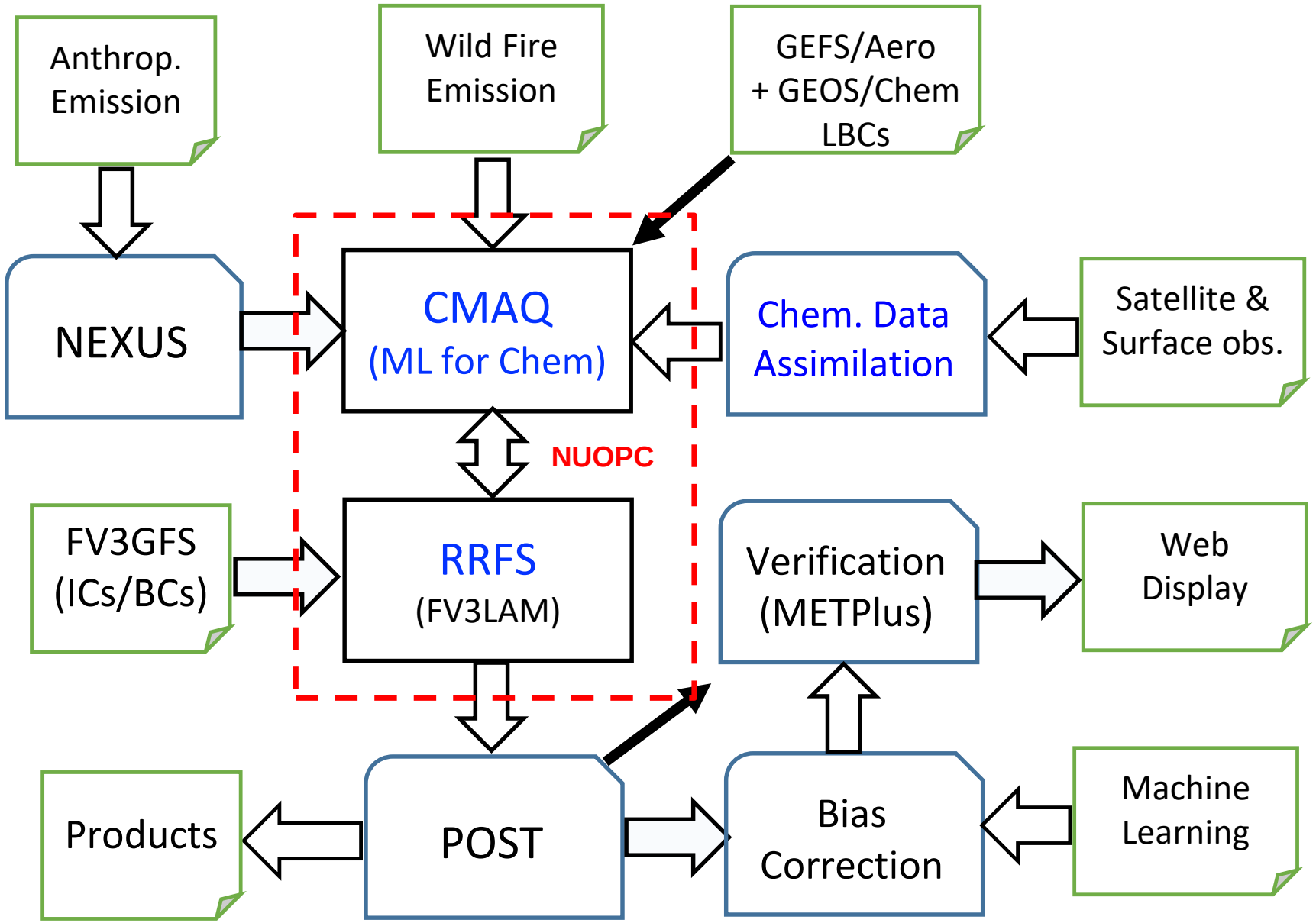
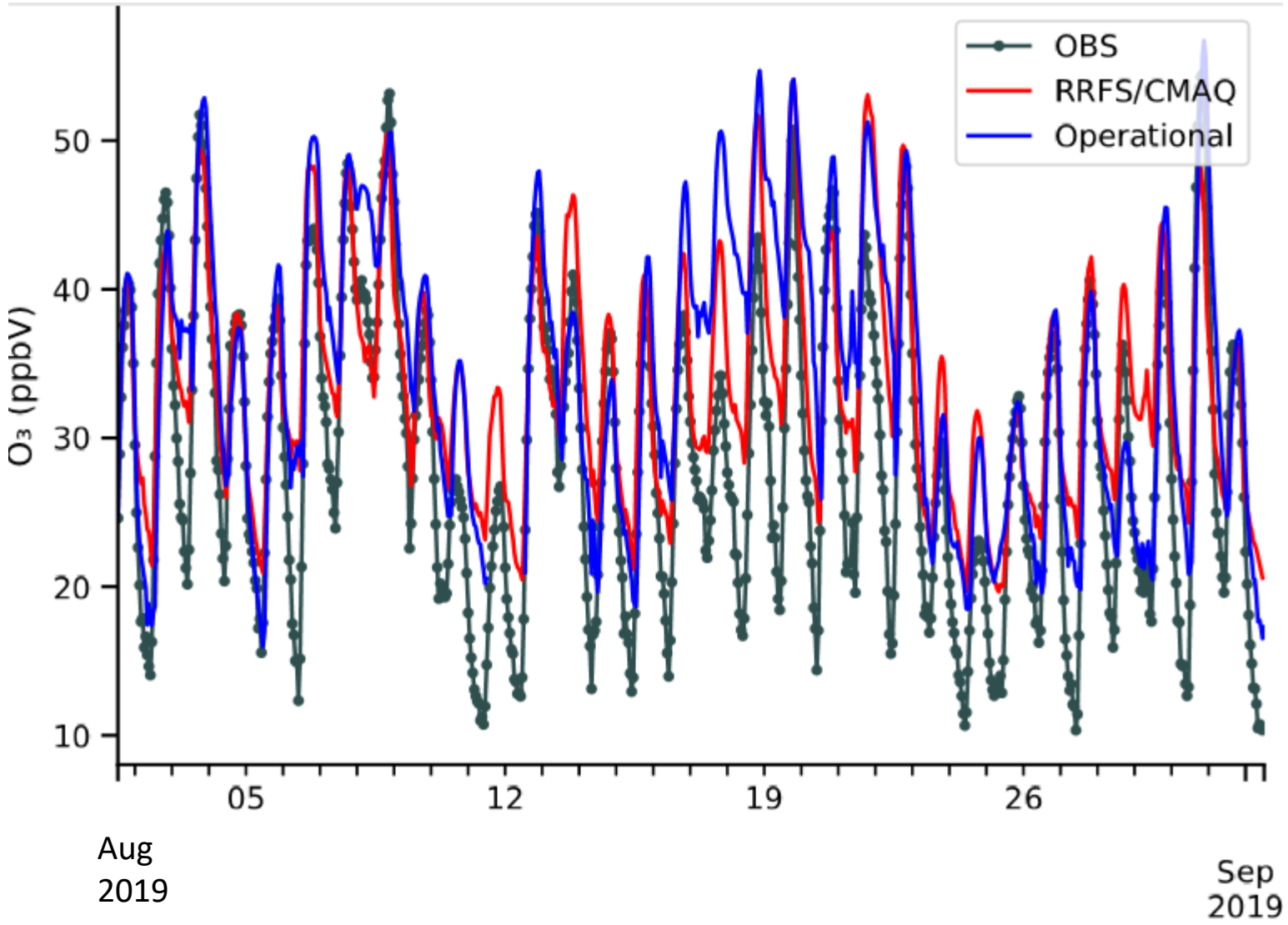
A flowchart of the RRFS/CMAQ inline system

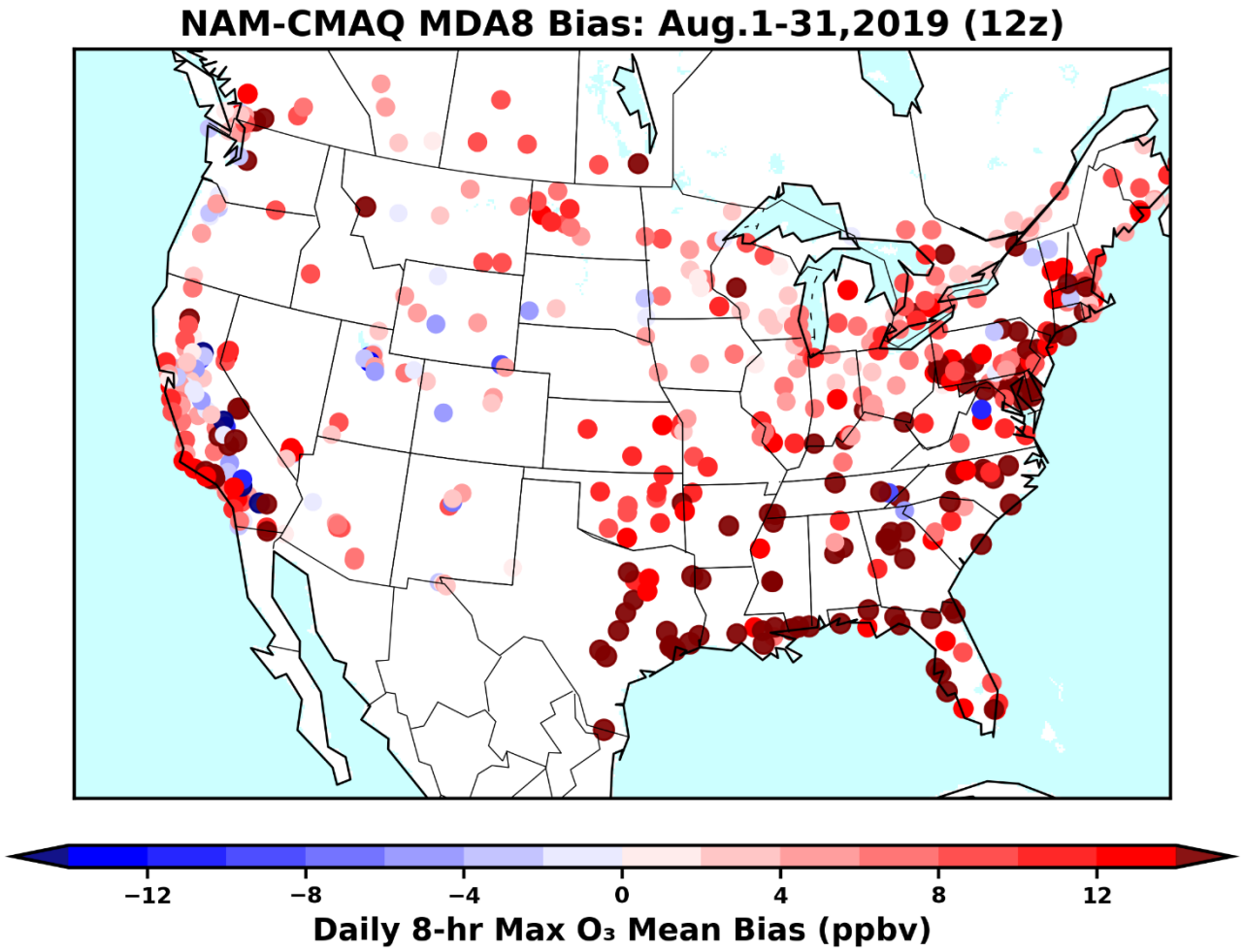


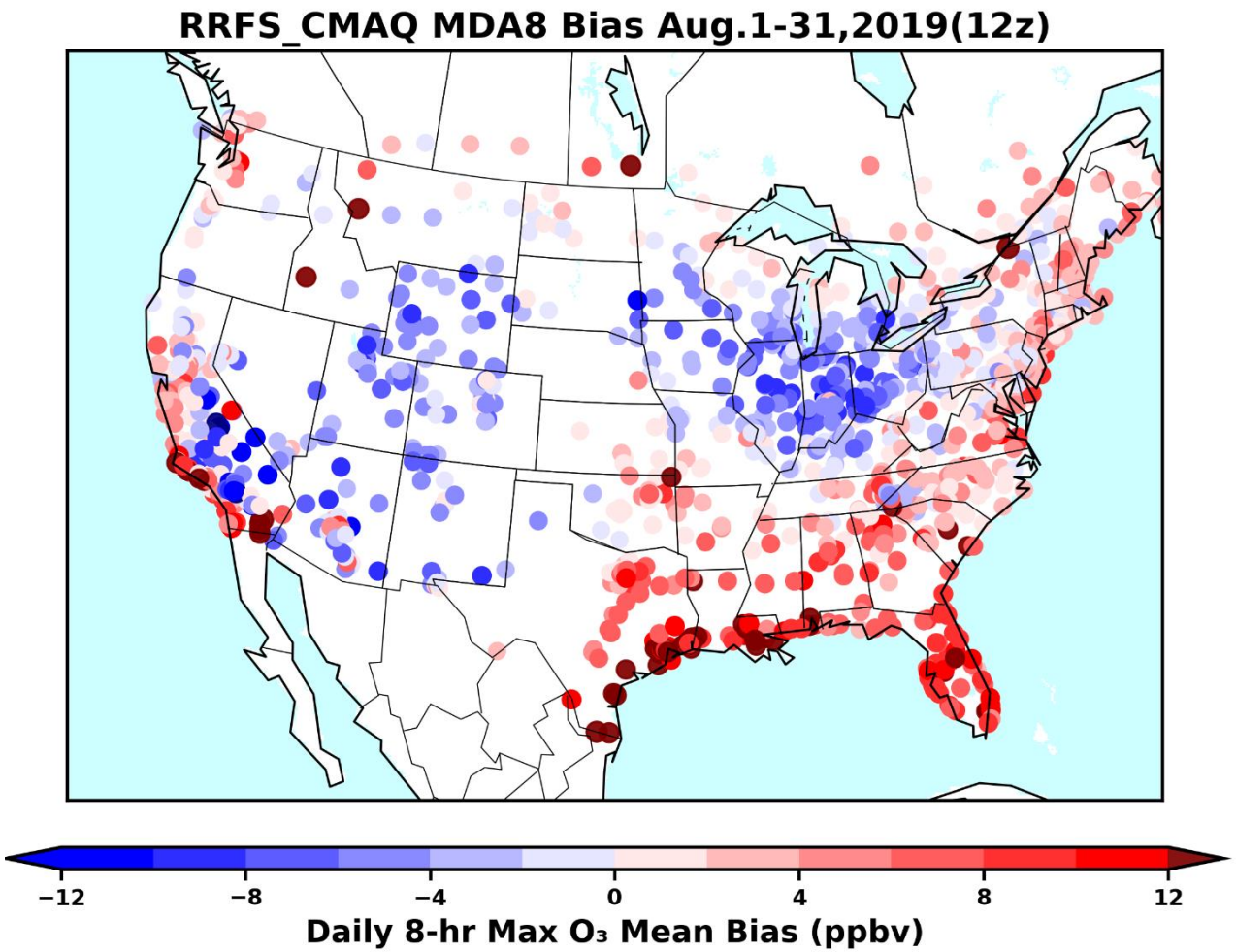
A comparison of operational model and RRFS/CMAQ configurations

	Operational (2019)	RRFS/CMAQ
Met Driver + CMAQ	NAM + CMAQv5.0.2	FV3GFSv15 + CMAQv5.2.1
Grid_Spacing and vertical levels	CONUS_12km (G148) / 35 levels	CONUS_13km / 65 levels
Gas-Phase + Aerosol module	CB05 + Aero5	CB06r3 + Aero6
Anthropogenic Emissions	NEI-2016 (SMOKE) (with plume rise)	NEI-2016 (NEXUS) (no plume rise)
Wildfire Emissions	HMS + BlueSky (diurnal variation, turned off gas species emissions)	GBBEPx (without diurnal variation, turn on gas species emissions)
Atmospheric Physics	NAM Physics	GFS v15
Chemical LBCs	GEOS-Chem for gas species + GEFS/Aero for aerosol	GEOS-Chem for gas species + GEFS/Aero for aerosol



A comparison of hourly surface O_3 between NAM/CMAQ (operational, blue), RRFS/CMAQ forecast (red) and observations (black, AirNow) over the CONUS in August 2019.

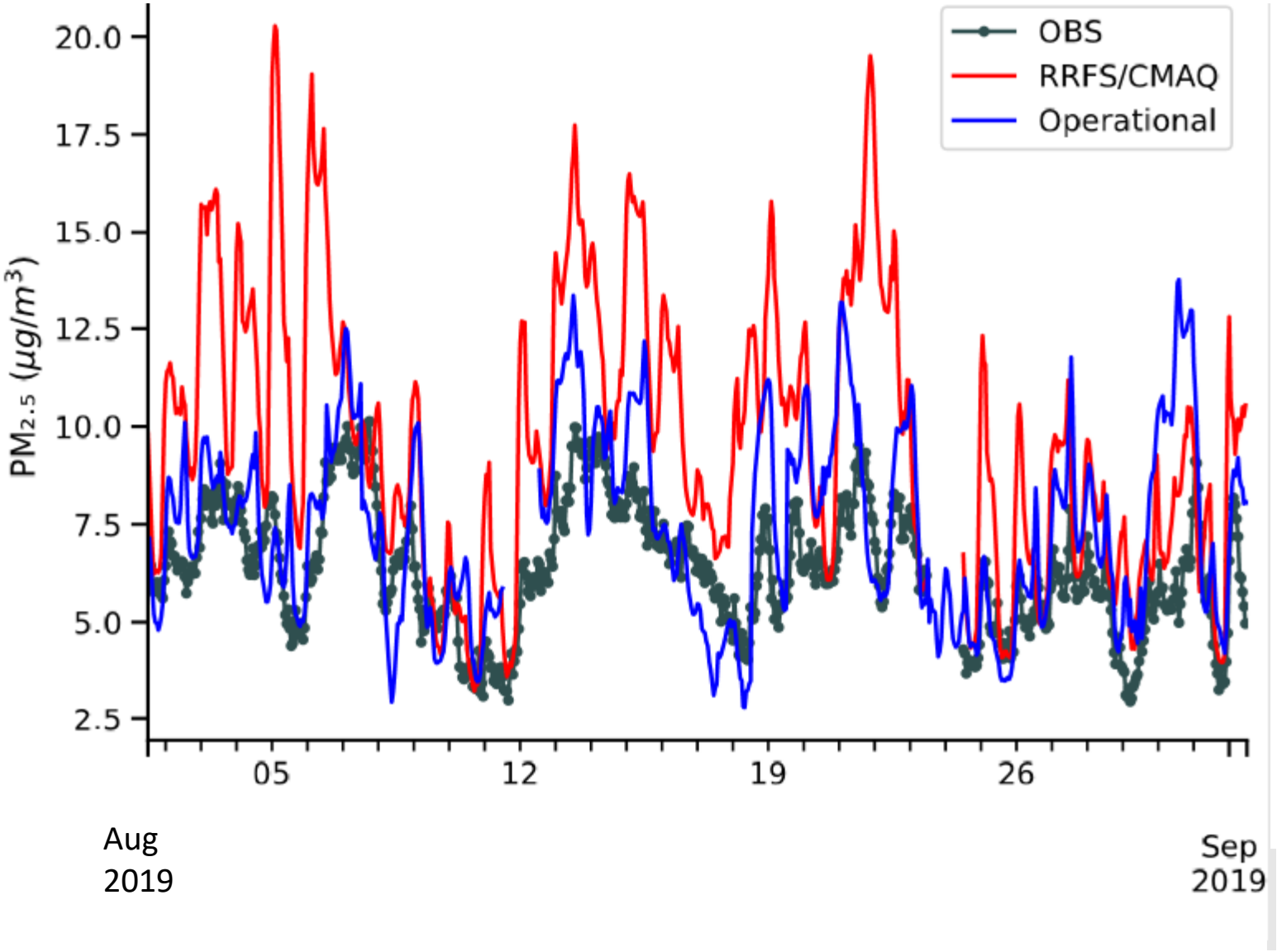




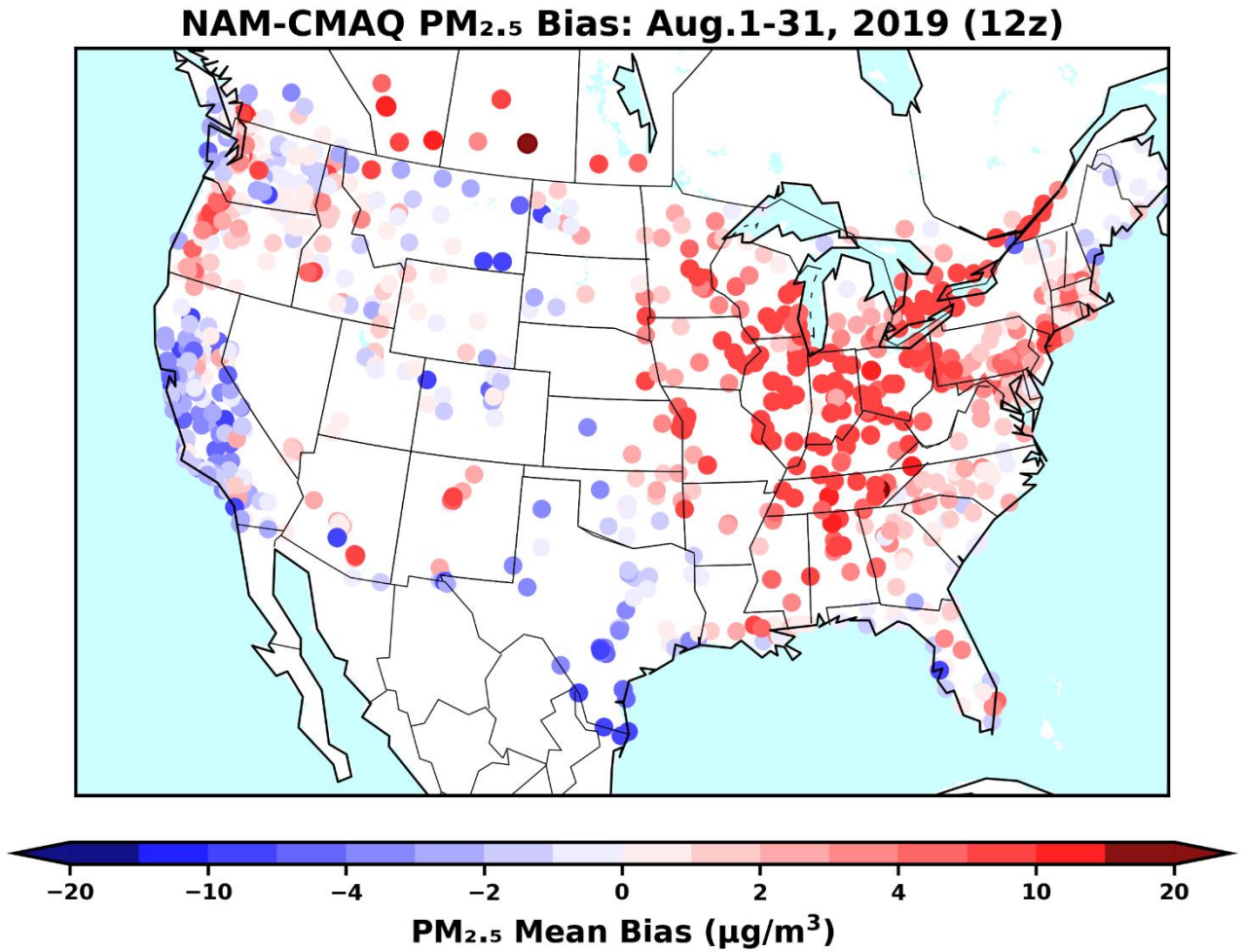
A comparison of monthly mean daily 8-hr maximum surface O_3 (MDA8) forecast bias (forecast – obs.) between NAM-CMAQ (operational, left) and RRFS/CMAQ (right) in August 2019.

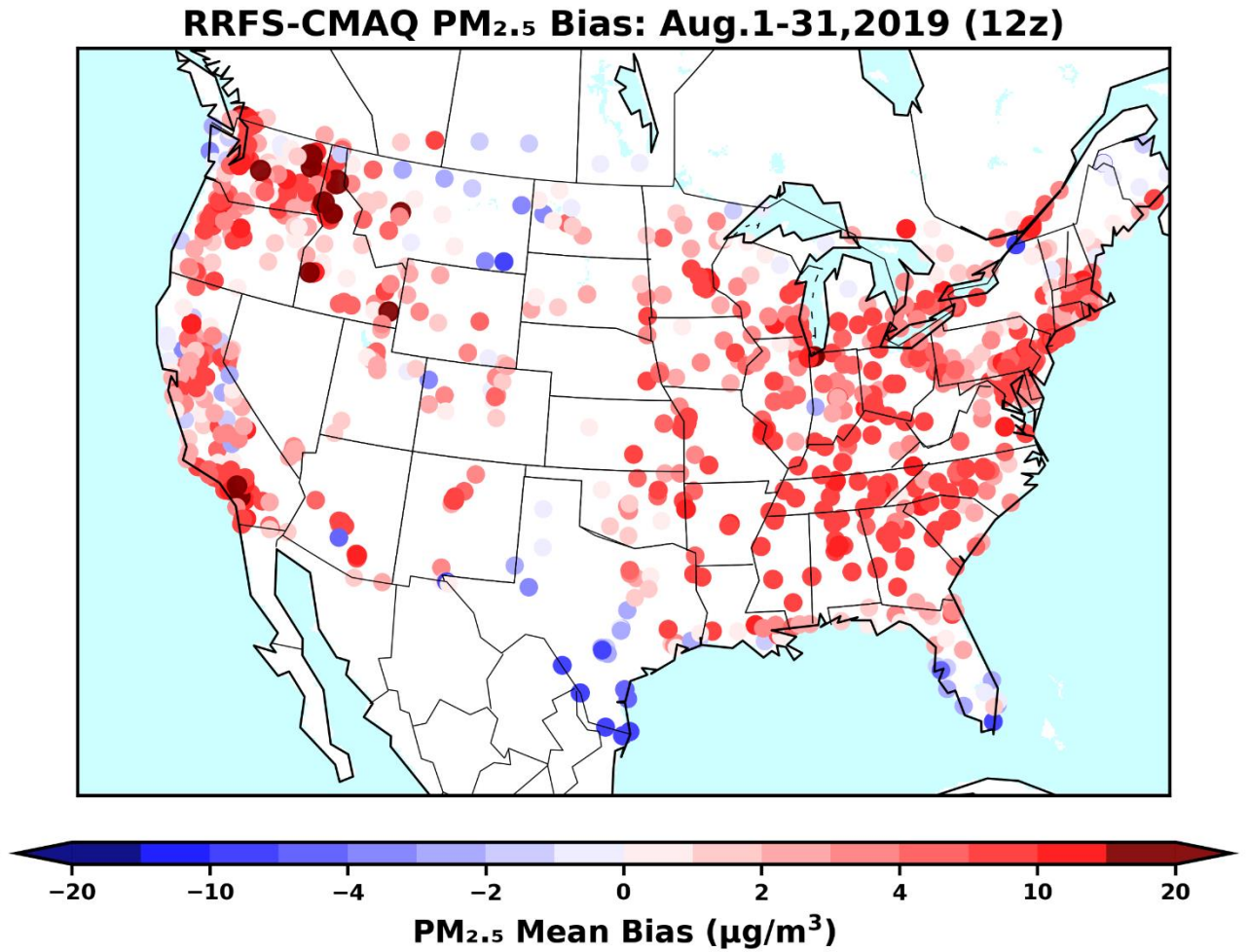
Possible reasons causing over-prediction of $PM_{2.5}$

- No diurnal variation of wildfire emissions which put all fire emissions near surface during nighttime
- No plume rise for anthropogenic emissions



A comparison of hourly surface $PM_{2.5}$ between operational model (blue), RRFS/CMAQ (red) forecasts and observations (black, AirNow) over the CONUS domain in August 2019.





A comparison of monthly mean 24-hr average surface $PM_{2.5}$ forecast bias (forecast – obs.) between operational model (i.e., NAM-CMAQ) and RRFS/CMAQ in August 2019.

Statistical evaluation of RRFS/CMAQ vs. operational forecasts (CONUS, Aug. 2019)

Statistics Parameters	Surface O_3		$PM_{2.5}$	
	Operational	RRFS/CMAQ	Operational	RRFS/CMAQ
Mean Bias	3.02 (ppb)	1.25 (ppb)	2.02 $(\mu g\ m^3)$	4.57 $(\mu g\ m^3)$
Normalized Mean Bias (%)	7.21 (ppb)	2.93 (ppb)	28.60 $(\mu g\ m^3)$	63.86 $(\mu g\ m^3)$
Root Mean Squared Error	9.49 (ppb)	9.04 (ppb)	5.50 $(\mu g\ m^3)$	10.54 $(\mu g\ m^3)$
Index of Agreement	0.85	0.84	0.51	0.35
Pearsons Correlation Coefficients	0.76	0.74	0.34	0.35

Summary

- The RRFS-CMAQ inline system is being tested by EMC for the CONUS domain at a horizontal spacing of 13 km (on-going project)
- It can beat the offline CMAQ system from engineering perspective (it takes 1 hour 15 minute for 2-day forecast for 13-km CONUS domain with 24 nodes versus the previous operational system with 50 minutes PREMAQ + 50 minutes for CMAQ)
- The inline system shows a competitive performance on surface O_3 prediction as compared to the previous operational forecast (NAM-CMAQ) in August 2019.
- Surface $PM_{2.5}$ is over-predicted by the inline system in comparison with the previous operational model mainly due to missing diurnal variation of wildfire emissions and plume rise in anthropogenic emissions.

Outlook

- To implement diurnal variation of wildfire emissions and plume rise for power plant or point sources.
- To improve chemical initial conditions with data assimilation (i.e., $PM_{2.5}$ and NO_2)
- To optimize chemistry and bias correction through machine learning technique
- To complete one-year or longer time period retrospective runs
- To set up near real-time runs
- To test 2-day forecast at high-resolution of 3-km horizontal spacing.