Development and evaluation of offline coupling of FV3-based GFS with CMAQ at NOAA

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1: NOAA/NCEP; 2: IMSG; 3: NOAA/ARL; 4: UMD/CICS, 5: NOAA/NWS/STI; 6: ERG

Oct. 24, 2018

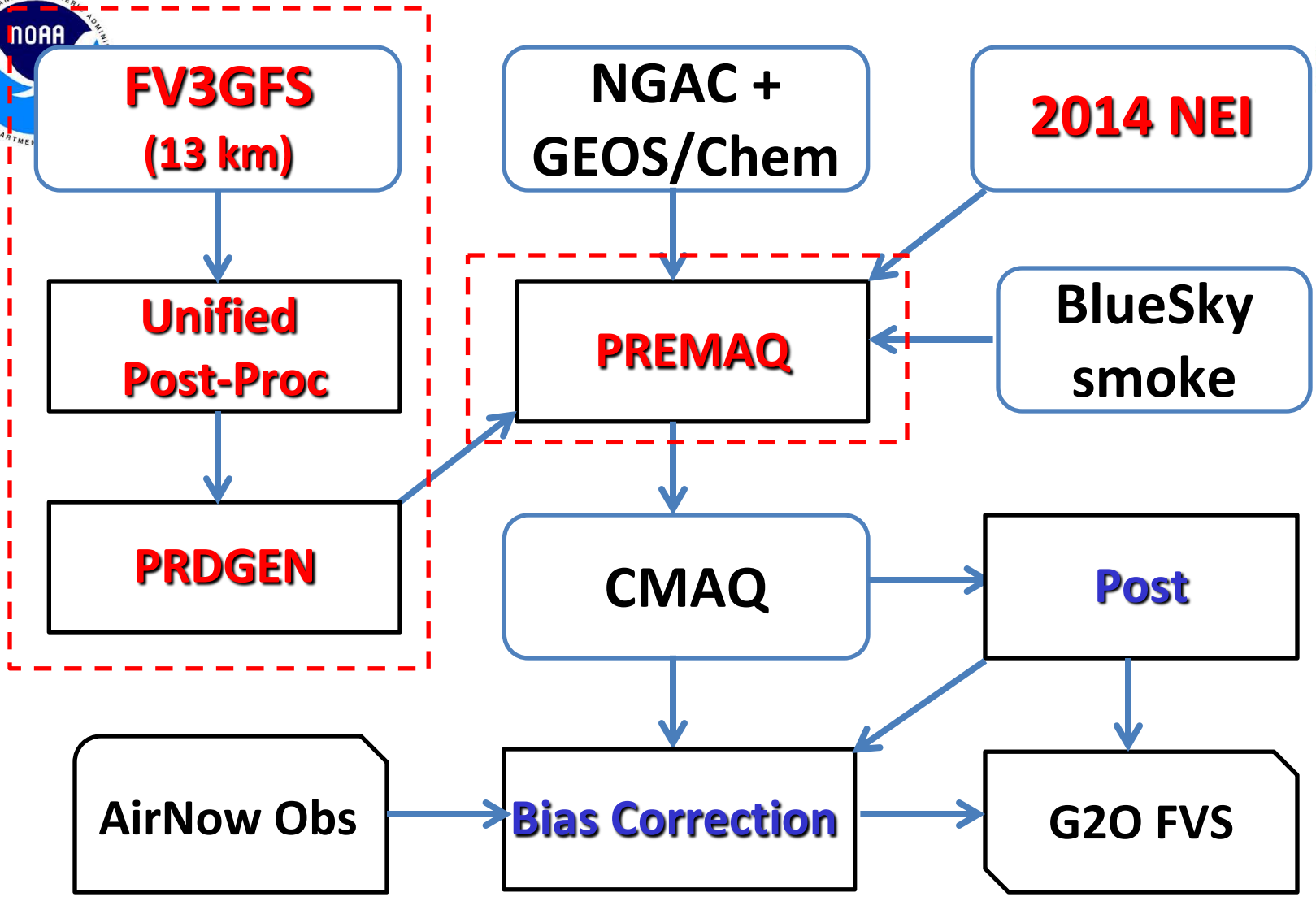
Motivation

- Within the framework of Next Generation Global Prediction System (NGGPS), the predictions with Global Forecast System built on GFDL Finite Volume Cube-Sphere (FV3) dynamical core (FV3GFS) are available for driving regional air quality model

- To evaluate impact of meteorological inputs (e.g., global model) on air quality predictions

- To be a benchmark of verifying the FV3CMAQ inline coupling system which is under development

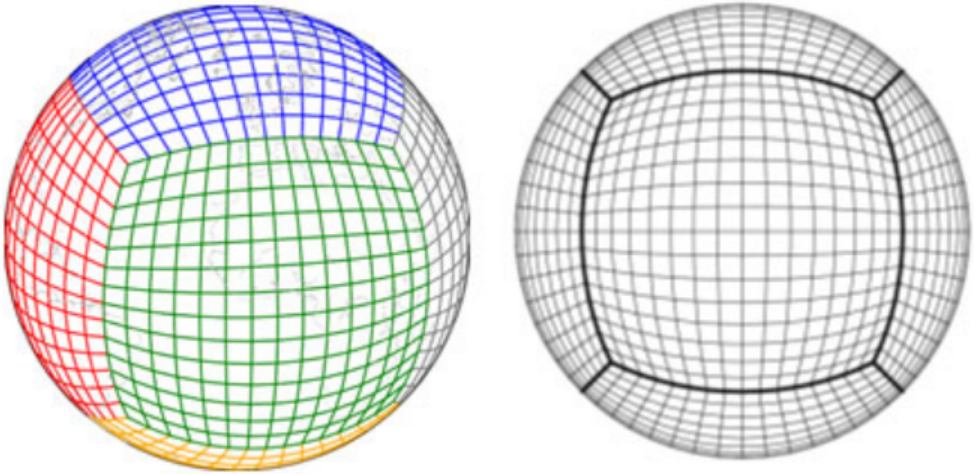
- To be a candidate of operational system in case the online system can not meet the operational time requirement.

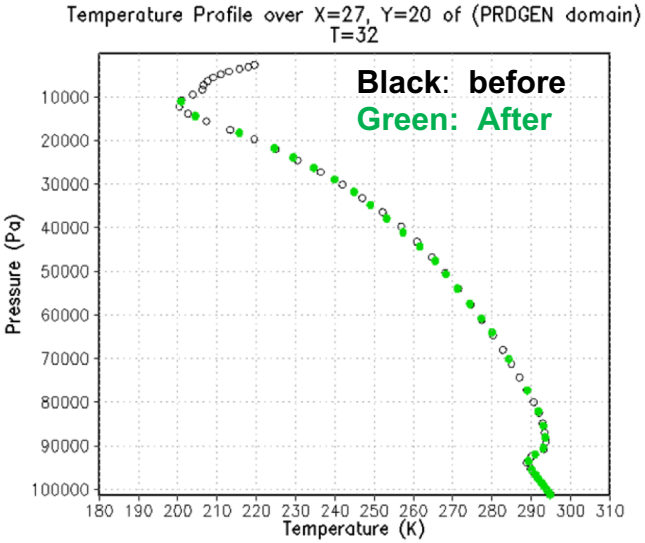


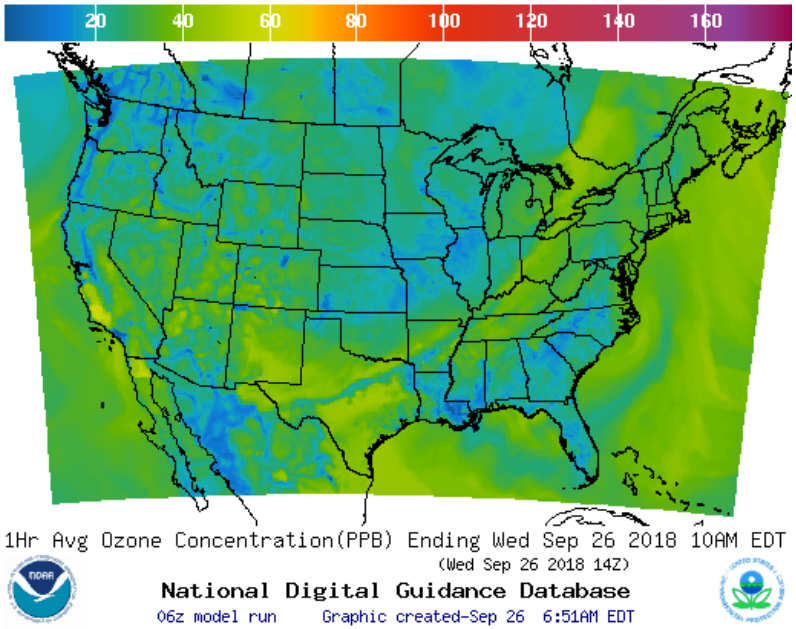
A flow-chart of the FV3GFS-CMAQ system

(new Changes as indicated by the red dashed boxes)

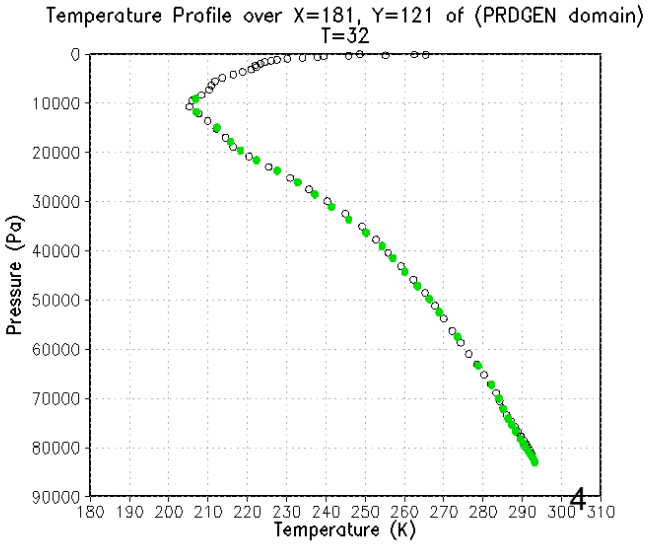
Offline coupling of FV3GFS/CMAQ







05 UTC on Aug. 15, 2018



Model configurations

- **FV3GFS**
  - 13 km, 64 Hybrid levels
- **CMAQ**
  - v5.0.2
  - CB05 gas-phase chemical mechanism, AERO6 aerosol module
  - 12 km, 33 sigma levels
- **Emissions**
  - Anthropogenic emission: NEI2014 with MOVE2014v2
  - Biogenic emission: BEIS3
  - Fire/Smoke emissions: Blue Sky wildfire smoke emission processing system
- **Verification**
  - Verification tool: METPlus + METview
  - Observational data: Hourly O_3 and $PM_{2.5}$ from EPA AirNow

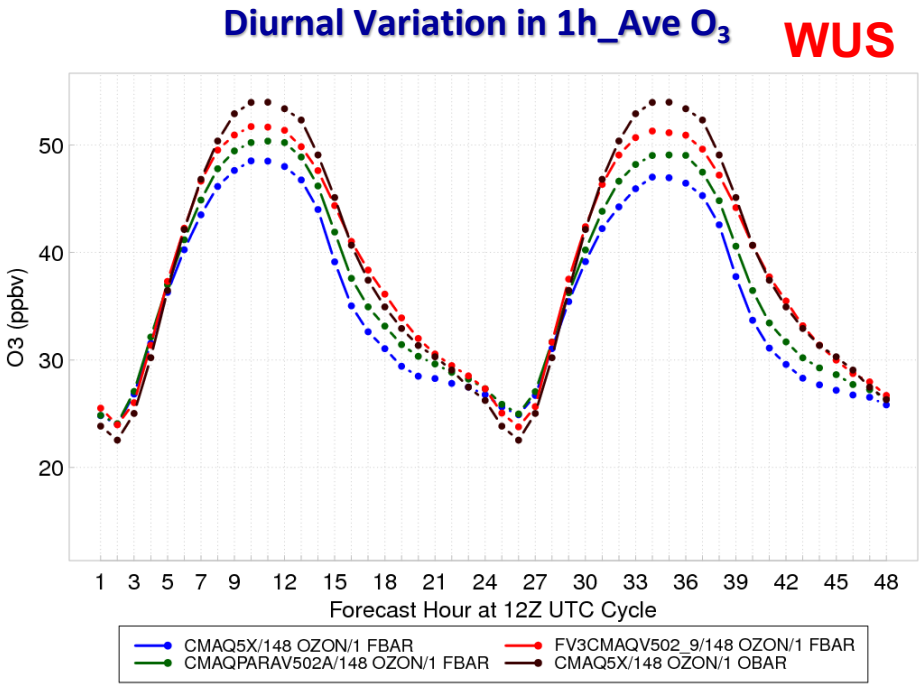
A summary of simulation cases

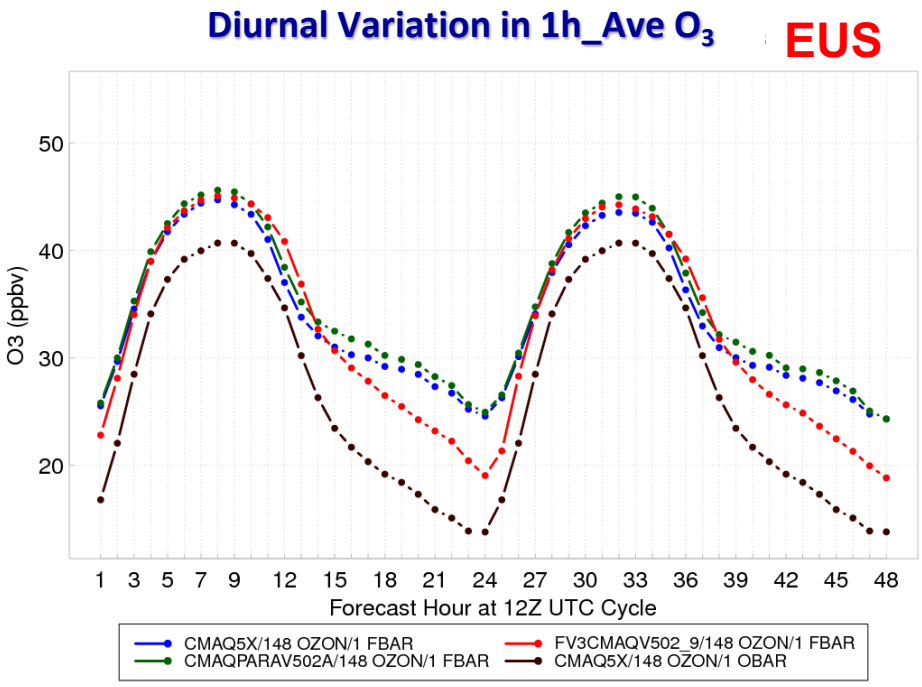
Cases	Met driver	Emissions	LBC for PM
Operational	NMMB (12km)	NEI2005/NEI2011	NGAC dust
PARA1	NMMB(12km)	NEI2014	NGAC dust
PARA2	FV3GFS(13km)	NEI2014	NGAC dust

NMMB: Nonhydrostatic Multiscale Model on B-grid
NGAC: NOAA Environmental Modeling System (NEMS) GFS Aerosol Component

Simulation Period: Aug.1–Sept.30, 2018

Evaluations of predicted Surface O_3 (Aug. 2018)





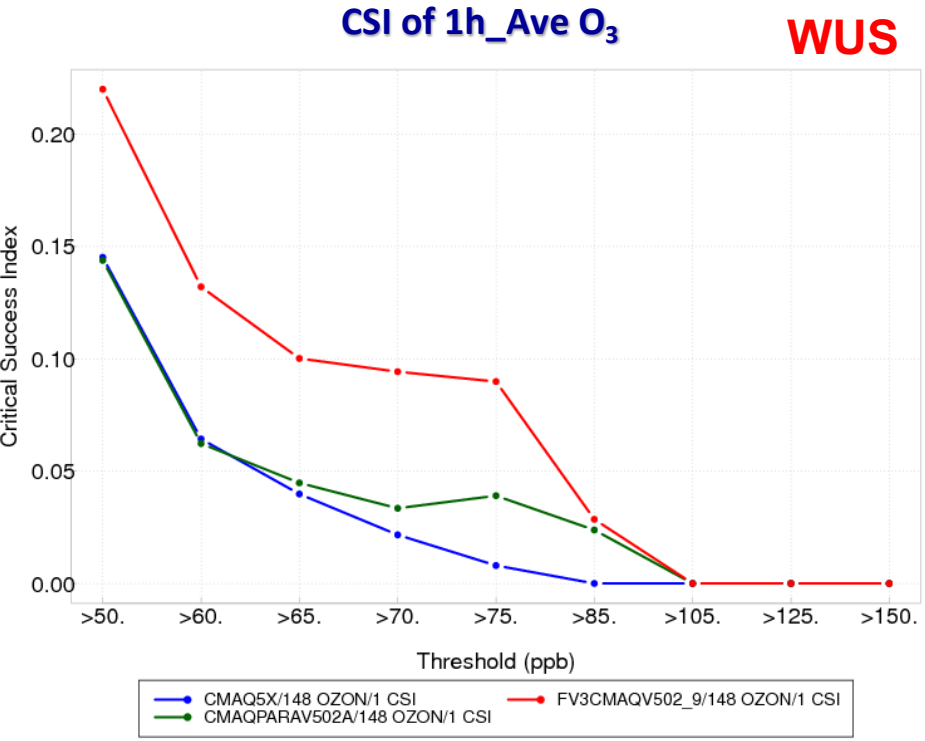
Observational

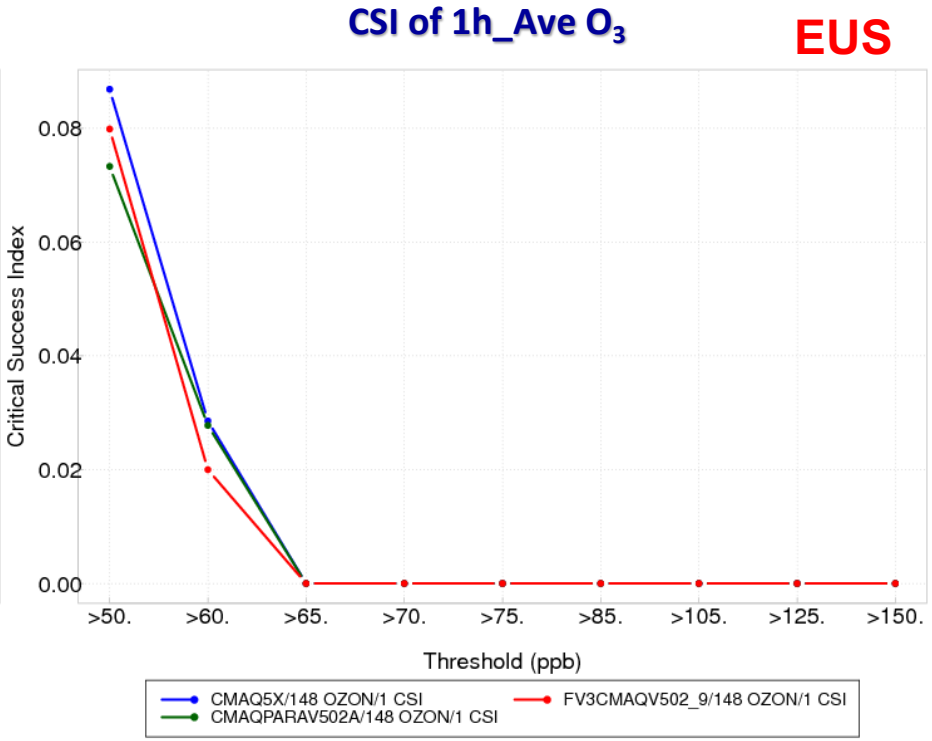
Operational

PARA1

PARA2

Evaluations of predicted Surface O_3 (Aug. 2018)



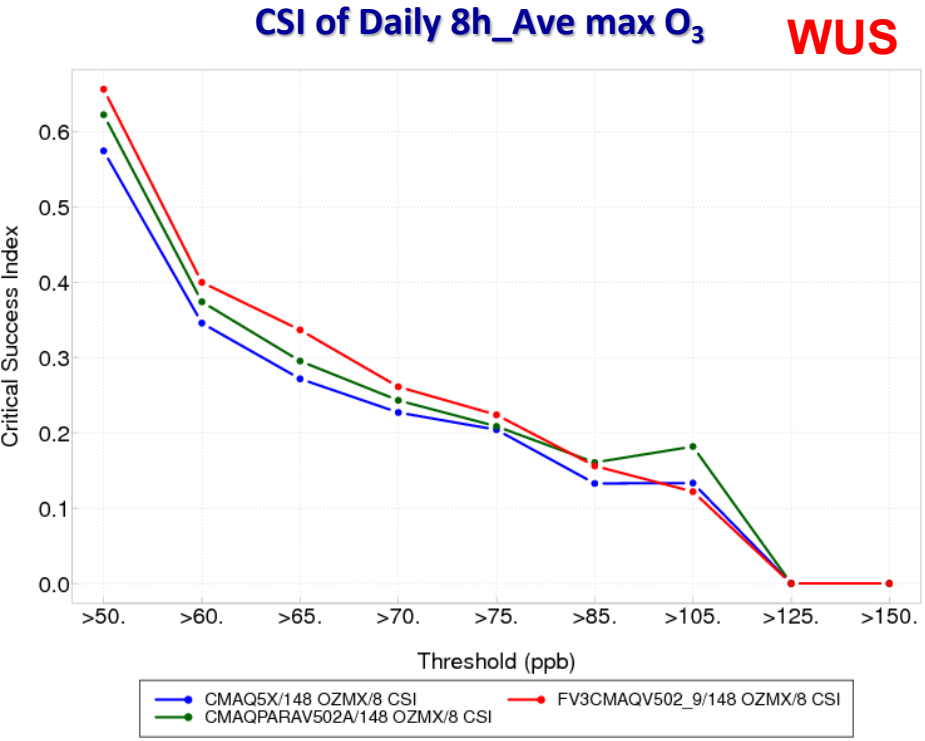


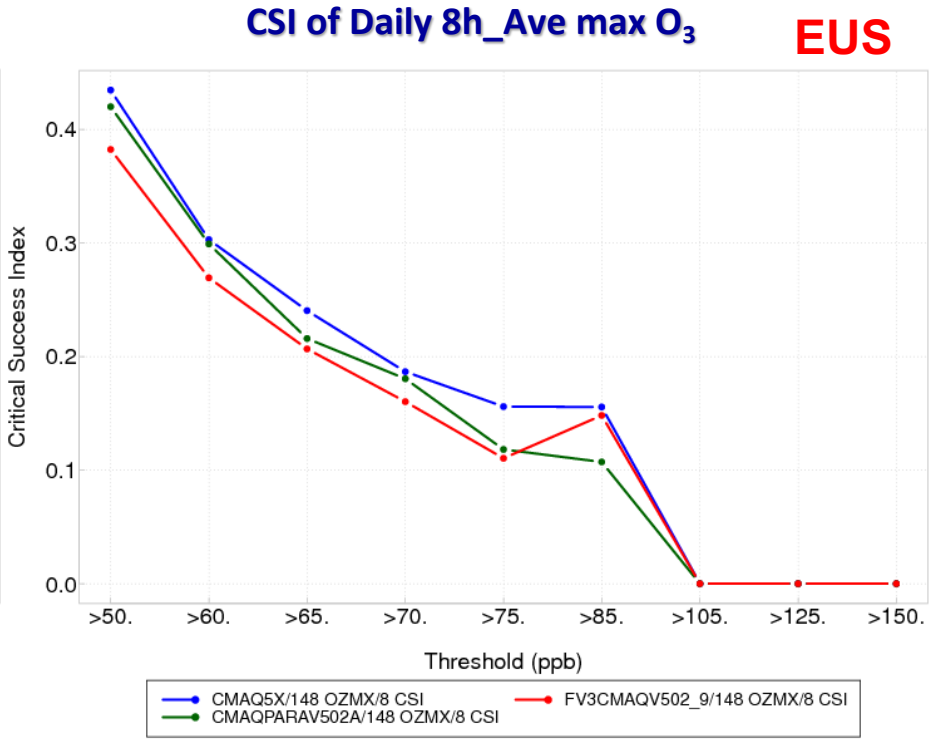
Operational

PARA1

PARA2

Evaluations of predicted Surface O_3 (Aug. 2018)





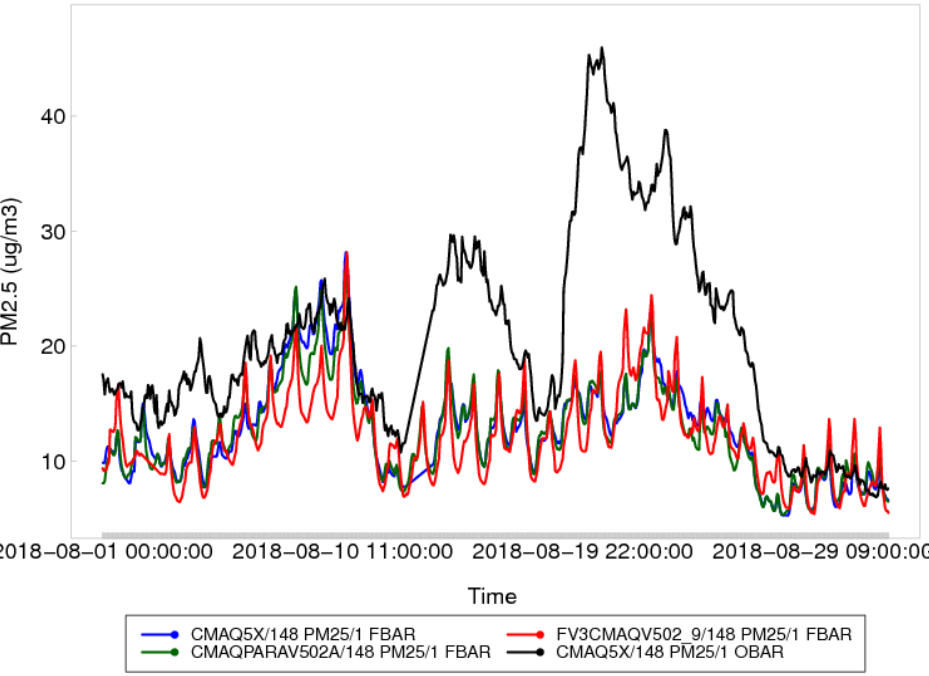
Operational

PARA1

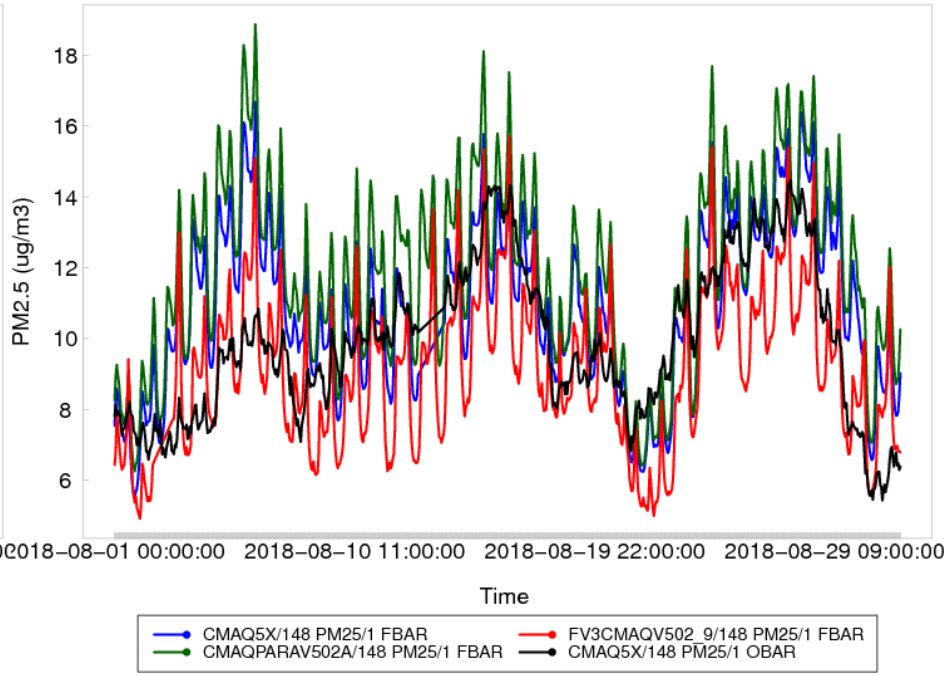
PARA2

Evaluation of predicted $PM_{2.5}$ (Aug. 2018)

Time series of 1h_Ave $PM_{2.5}$ **WUS**

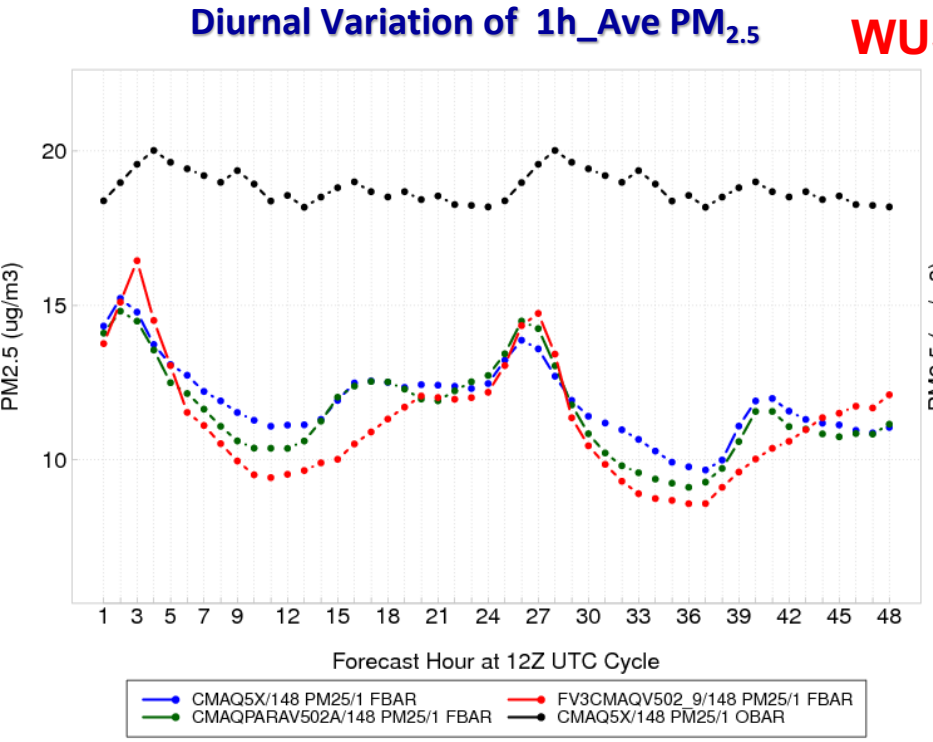


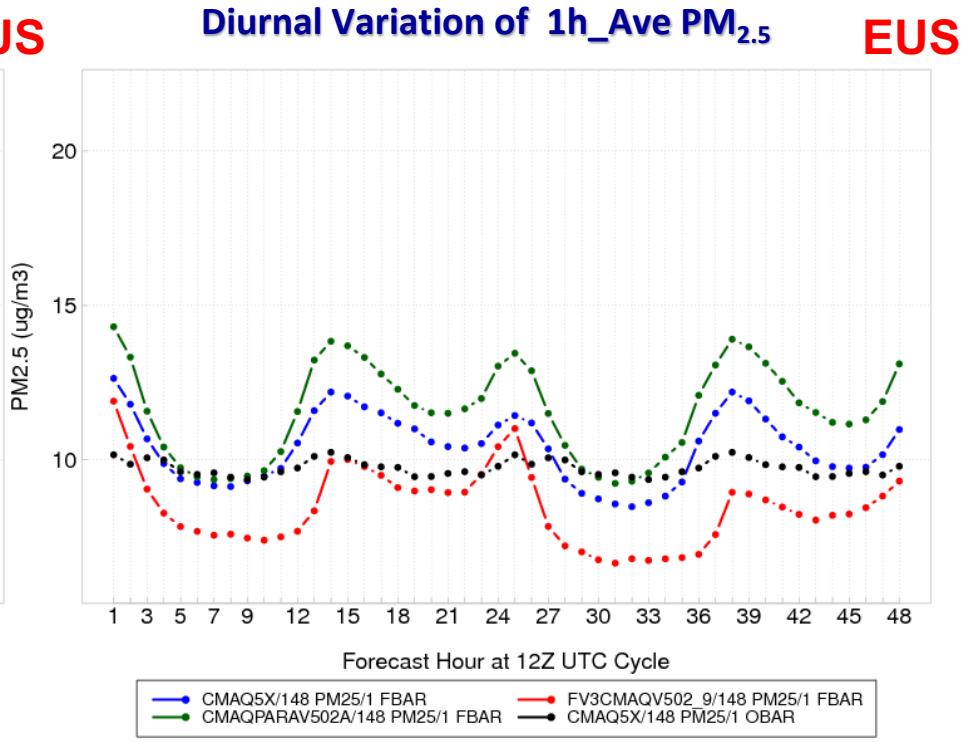
Time series of 1h_Ave $PM_{2.5}$ **EUS**



$PM_{2.5}$ under-predicted on the wildfire days over WUS and under-predicted rather than over-predicted over EUS

Evaluation of predicted $PM_{2.5}$ (Aug. 2018)





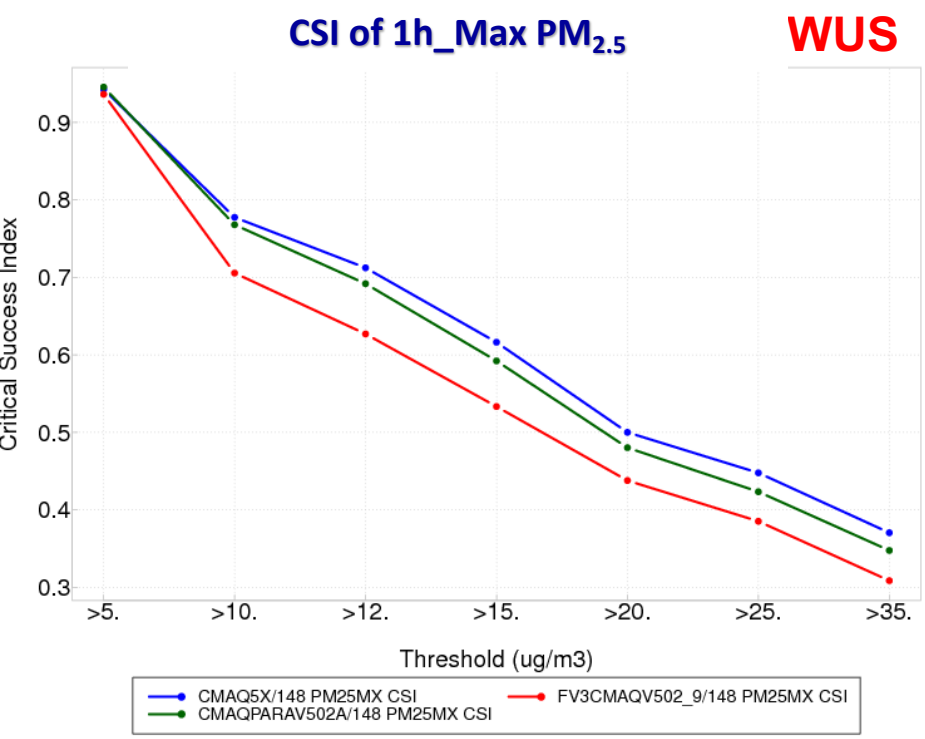
Observational

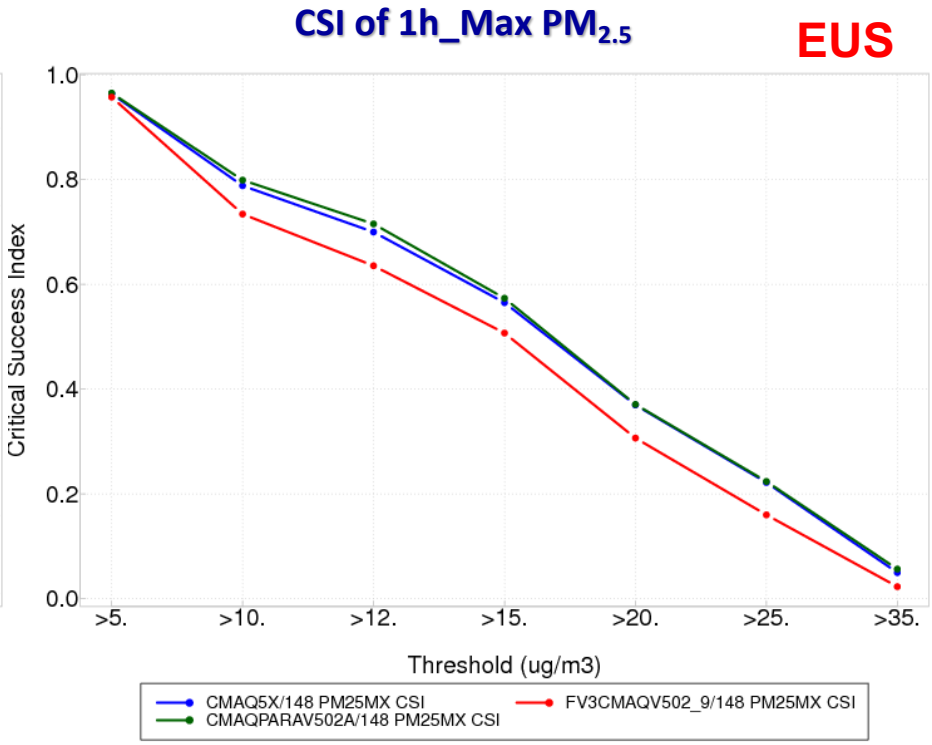
Operational

PARA1

PARA2

Evaluation of predicted $PM_{2.5}$ (Aug. 2018)





Operational

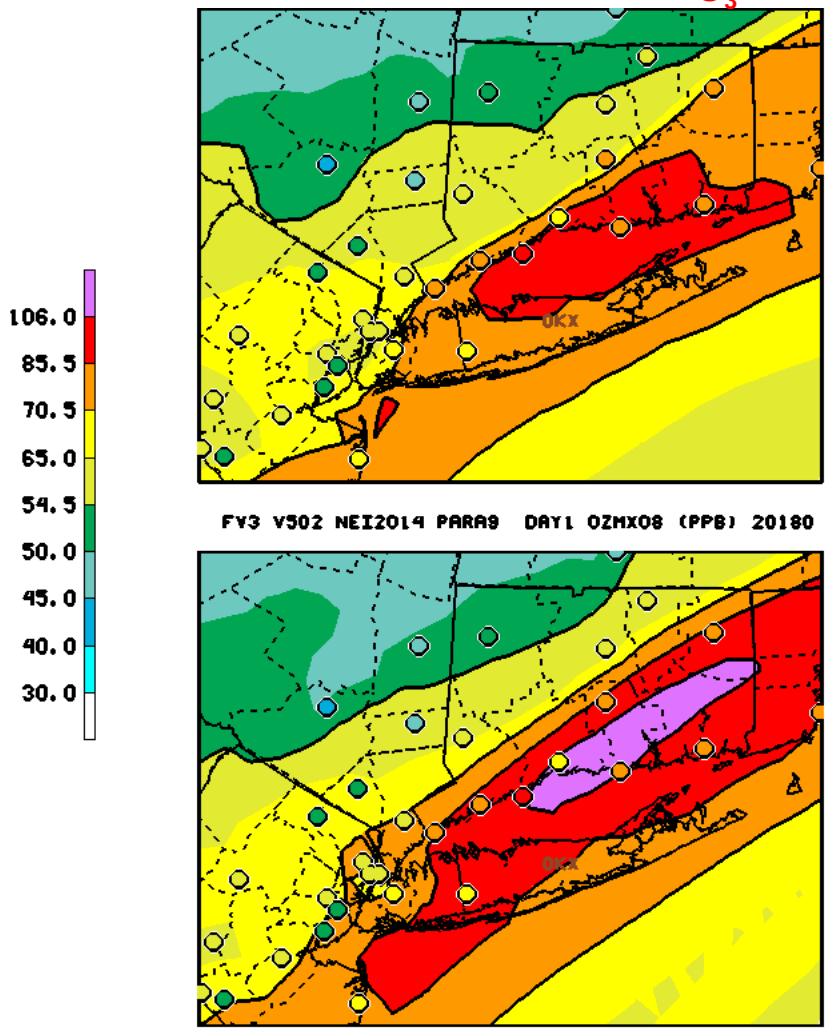
PARA1

PARA2

Case Studies (good)

Aug. 28, 2018

O_3



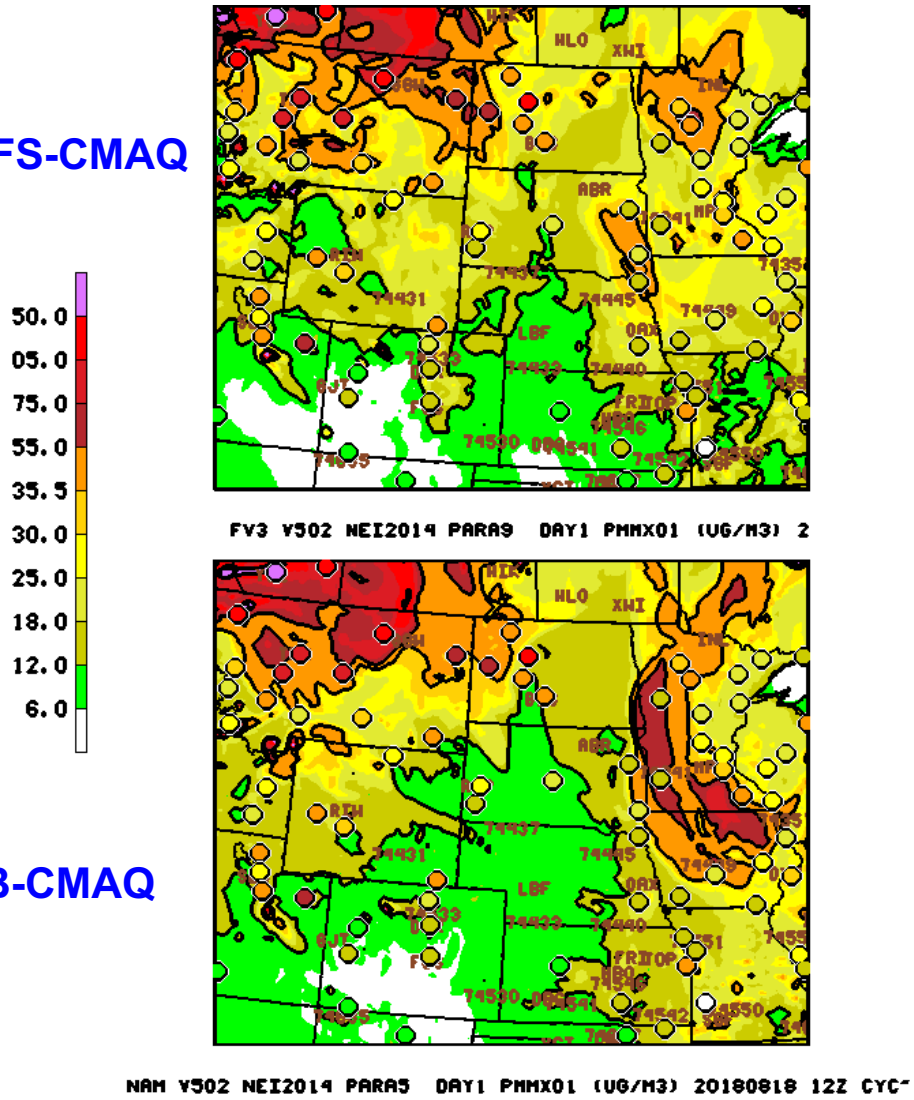
FV3GFS-CMAQ

NMMB-CMAQ

Overlay plots of daily 8h_Ave Max O_3

Aug. 18, 2018

$PM_{2.5}$

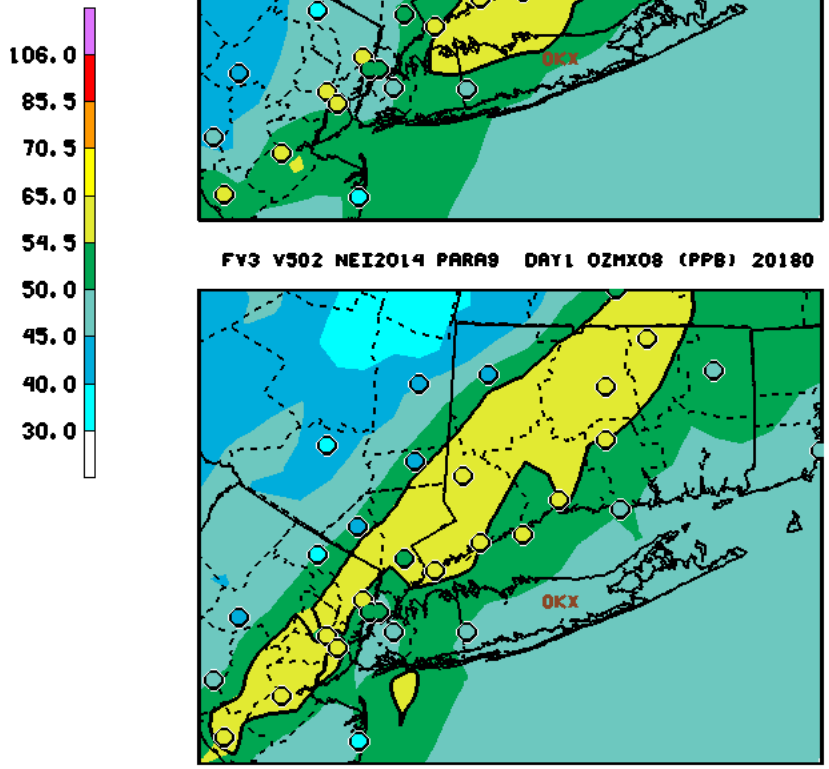


Overlay plots of daily 1h_Ave Max $PM_{2.5}$

Case Studies (bad)

Aug. 26, 2018

O_3



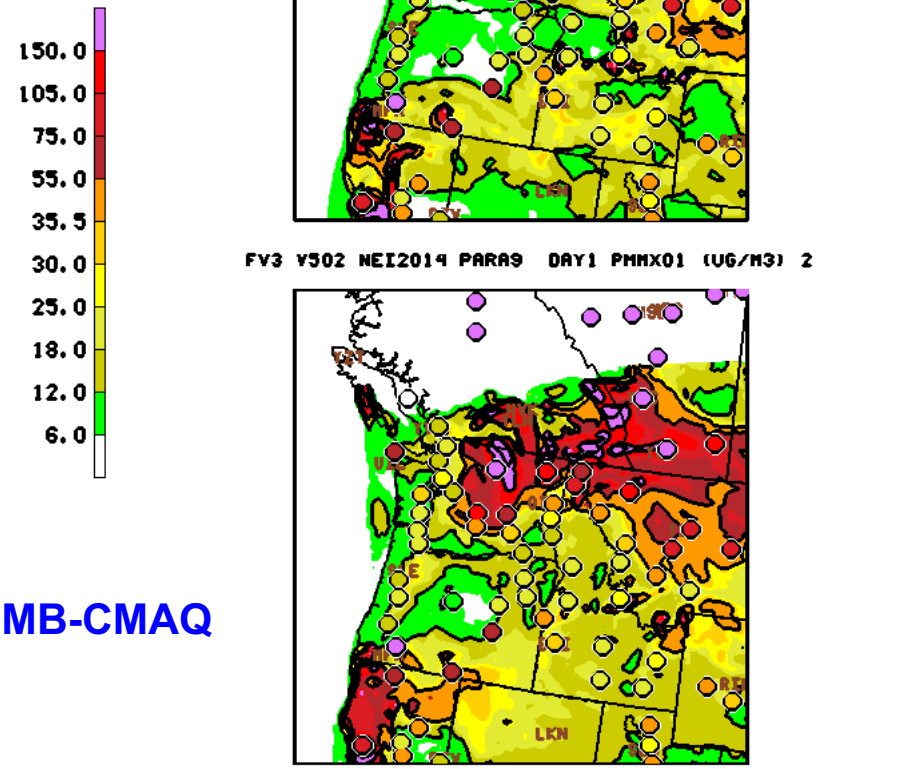
Overlay plots of daily 8h_Ave Max O_3

FV3GFS-CMAQ

NMMB-CMAQ

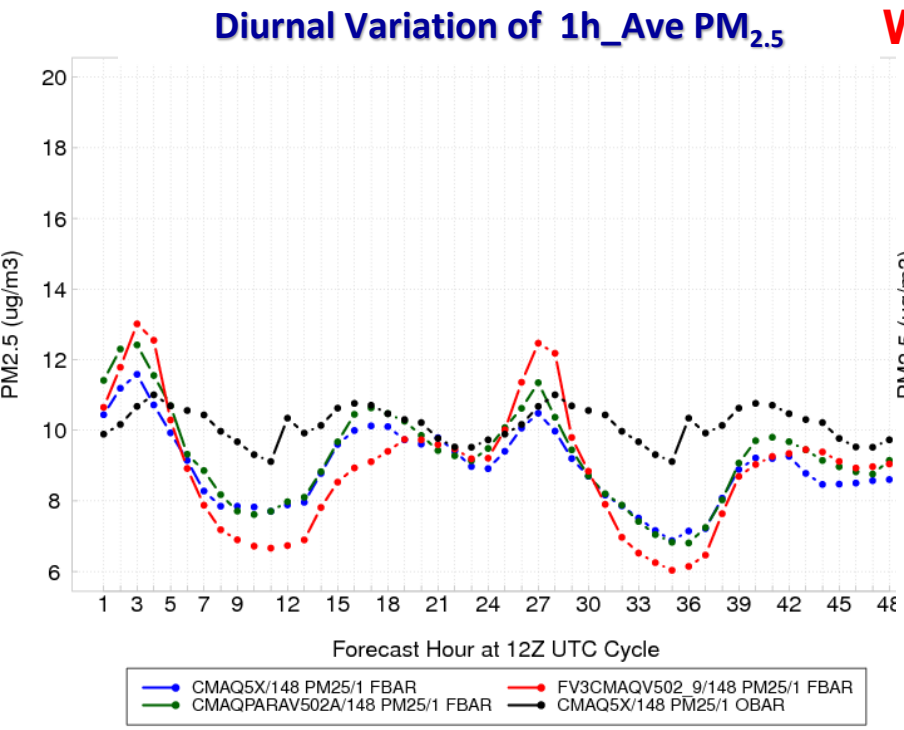
Aug. 18, 2018

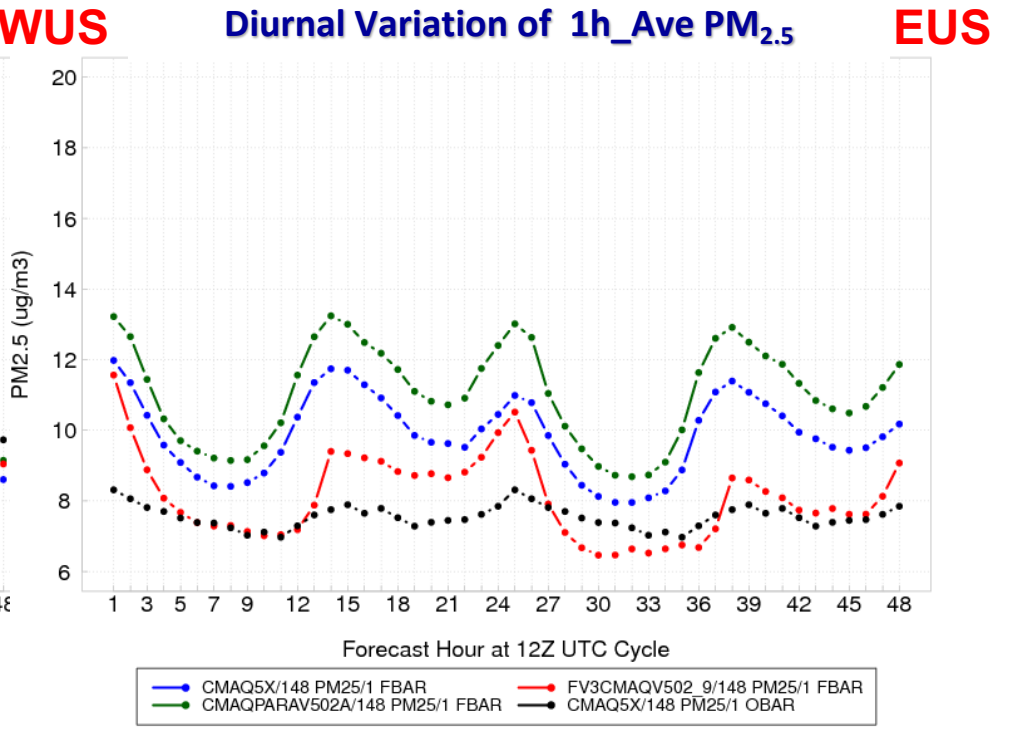
$PM_{2.5}$



Overlay plots of daily 1h_Ave Max $PM_{2.5}$

Evaluation of predicted $PM_{2.5}$ (Sept. 2018)





Observational

Operational

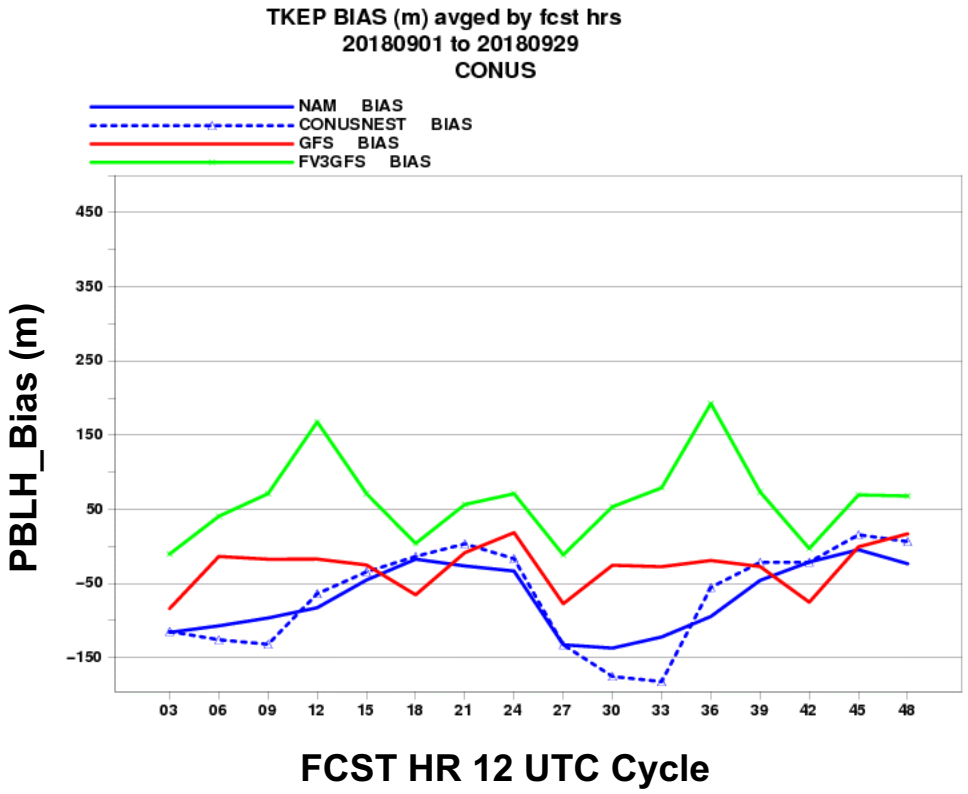
PARA1

PARA2

Summary

- Ozone predictions
  - Improve over WUS but slightly over-predicted over EUS
  - Overall performance of FV3GFS/CMAQ is competitive
- $PM_{2.5}$ predictions
  - Under-predicted during daytime on wildfire active days (August, WUS)
  - $PM_{2.5}$ predictions improved over EUS in Sept. and winter (needs to be confirmed)
- Remaining issues and next steps
  - Over-predicted PBL heights
  - Excluding cross-border transport of smoke from Canada
  - Too much mixing by FV3GFS TKE-based Eddy-Diffusivity Mass-Flux (EDMF) PBL scheme (?)
  - Stand Alone Regional FV3 or FV3-Nest (3-km)

Backup



Over-predicted PBL heights by FV3GFS