Advancement of the National Air Quality Forecast Capability Using the NOAA Global Forecast System: Model Development and Community Applications

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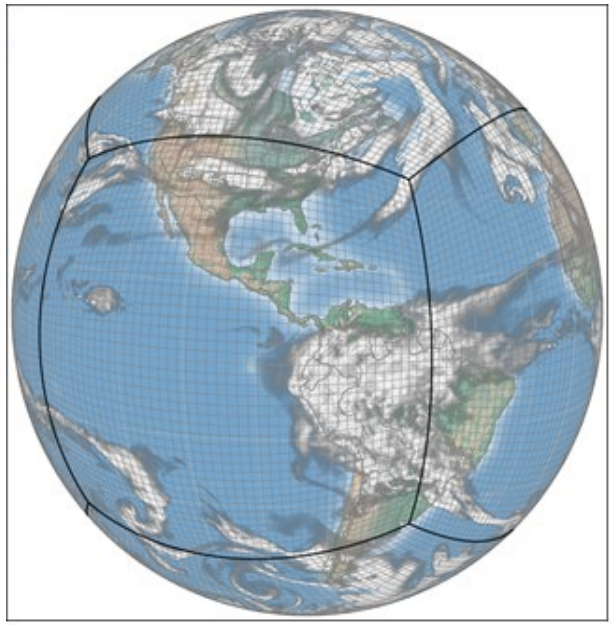
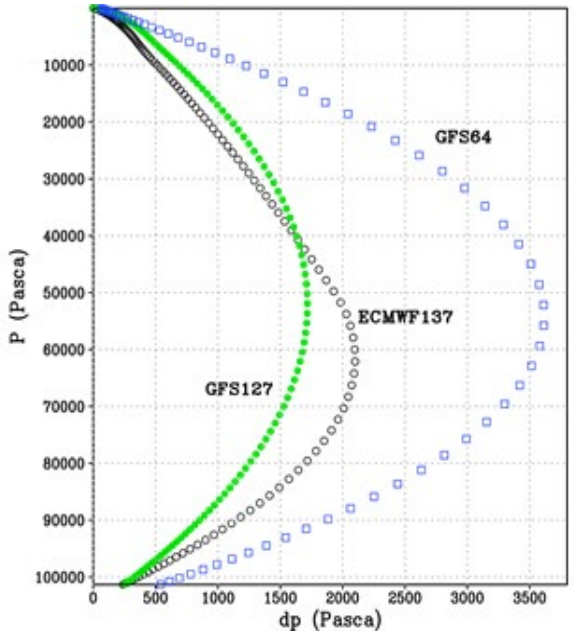
Introduction & Motivation

- The National Air Quality Forecast Capability (NAQFC) has been operational since 2004.
- The Finite Volume Cubed-Sphere (FV3) dynamical core is used in the NOAA Global Forecast System (GFS).
- NOAA is running GFS Version 16 (GFSv16) operationally.
- Streamlined development of the GFSv16 for an advanced, state-of-the-science, NAQFC.
- Improve community options to use NOAA GFSv16 products for air quality applications.



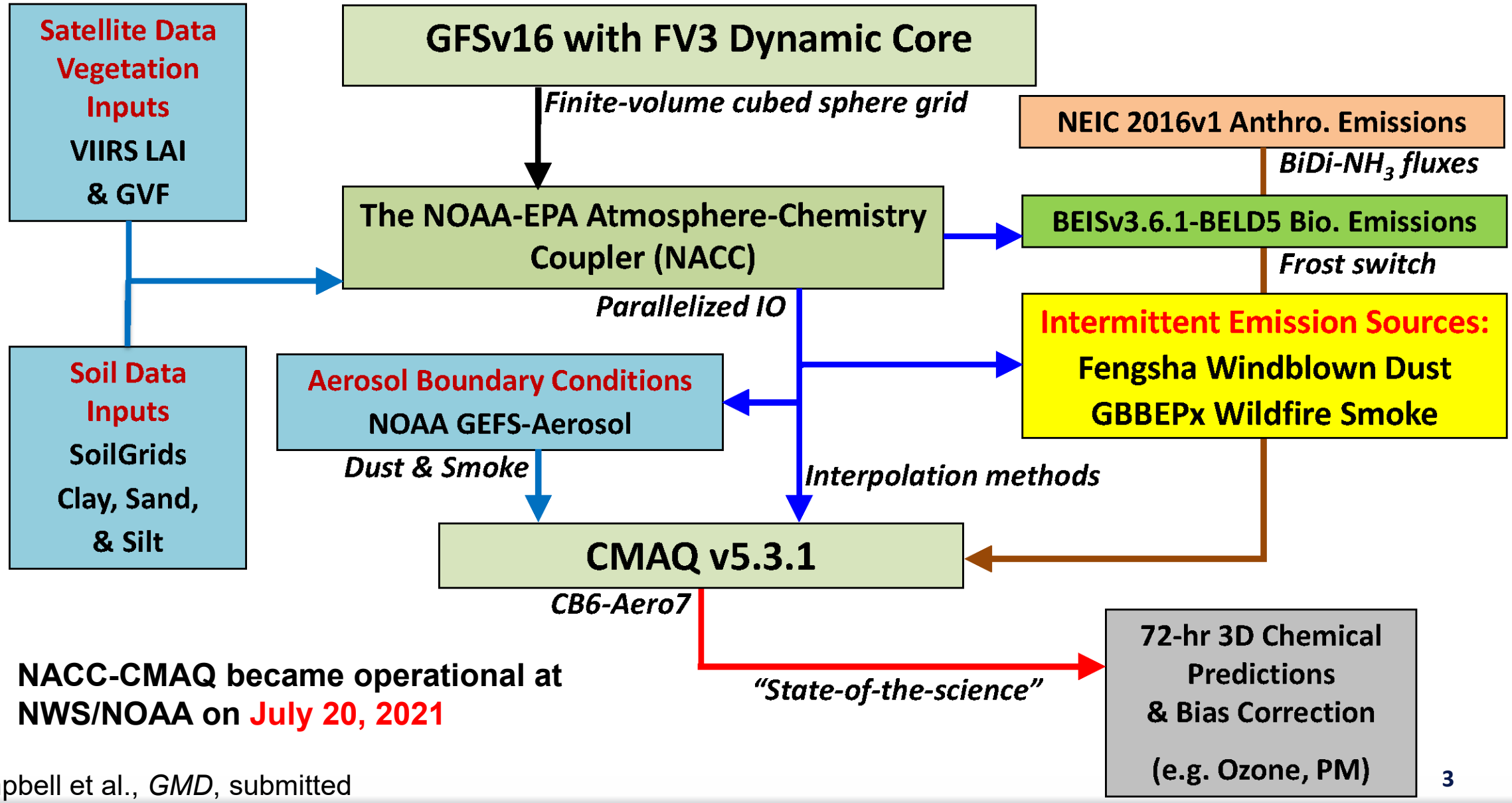
FV3 gnomonic cubed-sphere grid



GFSv16 127L vertical structure

Campbell et al., *GMD*, submitted

The Advanced NAQFC: NACC-CMAQ



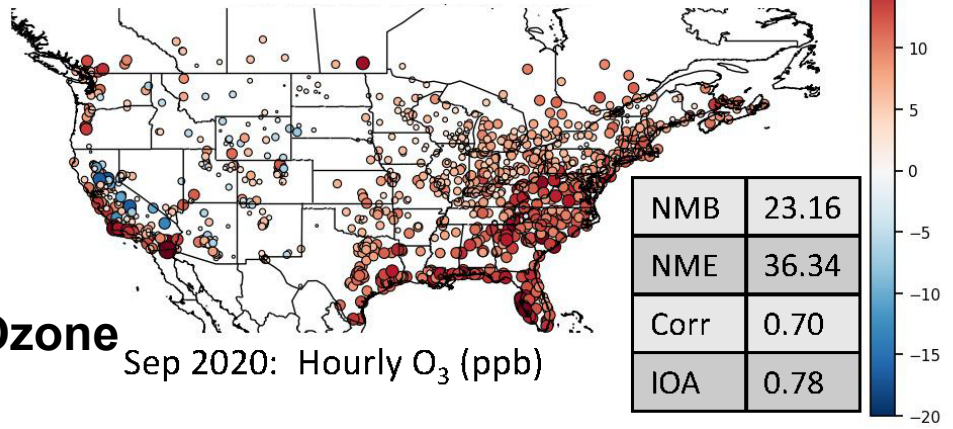
NACC-CMAQ became operational at NWS/NOAA on July 20, 2021

Campbell et al., *GMD*, submitted

Model Evaluation Versus Prior NAQFC

Day 1 Mean Bias (Model-AirNow) Plots and Domain-Wide Statistics

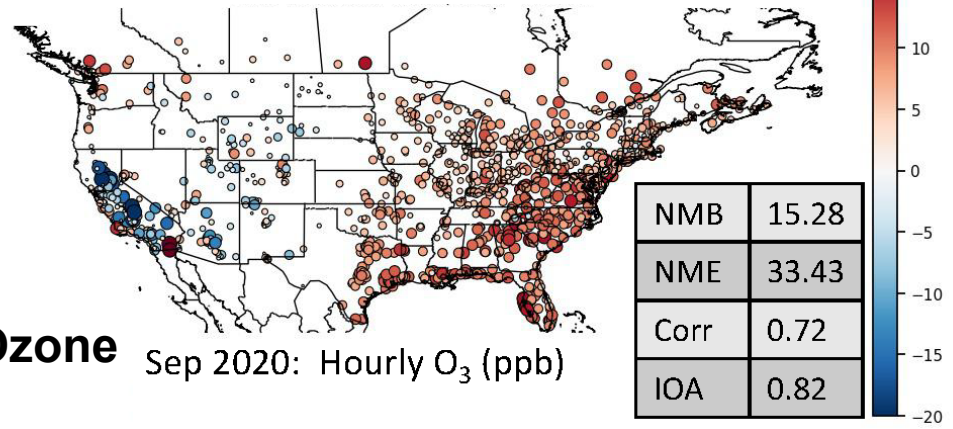
NAQFC



NMB	23.16
NME	36.34
Corr	0.70
IOA	0.78

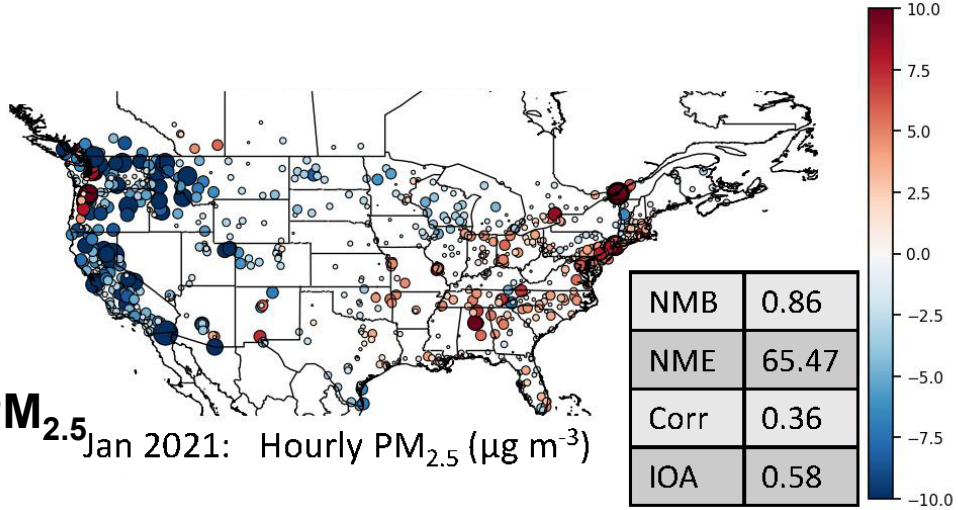
Ozone Sep 2020: Hourly O_3 (ppb)

NACC-CMAQ



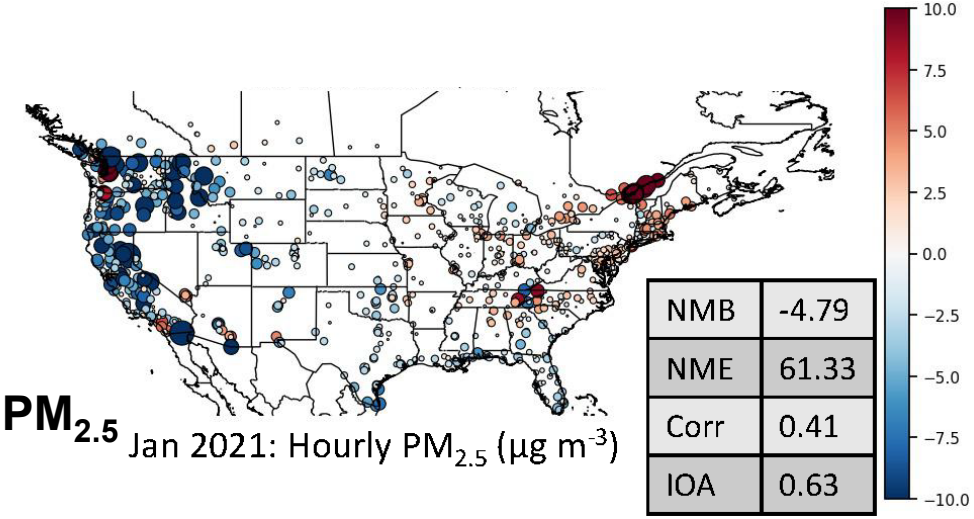
NMB	15.28
NME	33.43
Corr	0.72
IOA	0.82

Ozone Sep 2020: Hourly O_3 (ppb)



NMB	0.86
NME	65.47
Corr	0.36
IOA	0.58

$PM_{2.5}$ Jan 2021: Hourly $PM_{2.5}$ ($\mu g\ m^{-3}$)



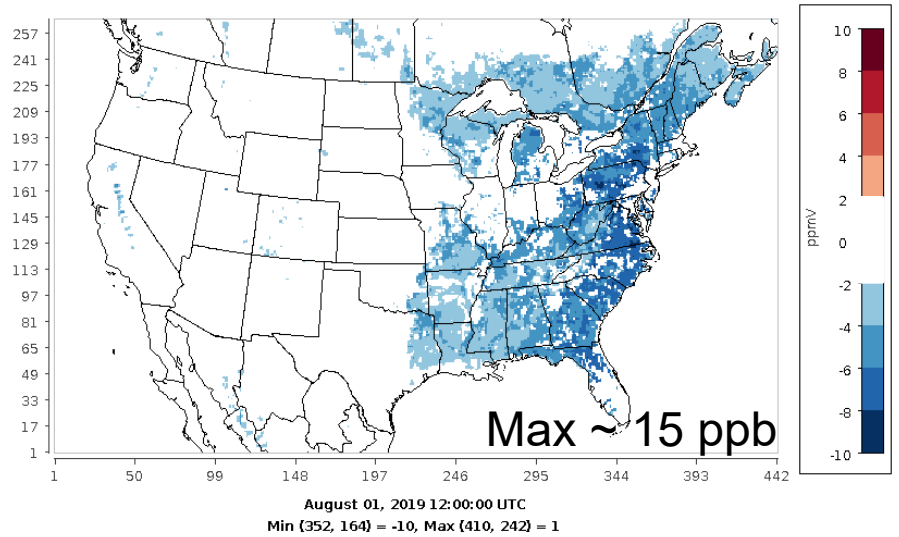
NMB	-4.79
NME	61.33
Corr	0.41
IOA	0.63

$PM_{2.5}$ Jan 2021: Hourly $PM_{2.5}$ ($\mu g\ m^{-3}$)

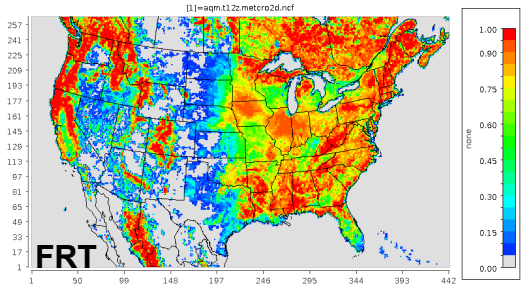
Campbell et al., *GMD*, submitted

Testing In-Canopy Effects in NACC-CMAQ

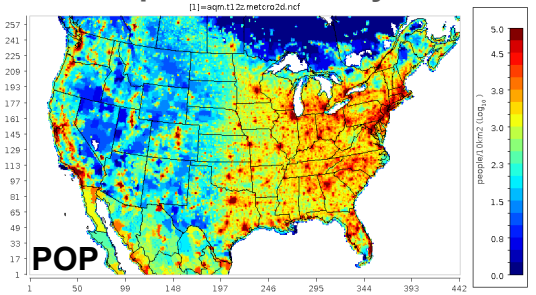
August 2019 Ozone (ppb)
Canopy – No Canopy



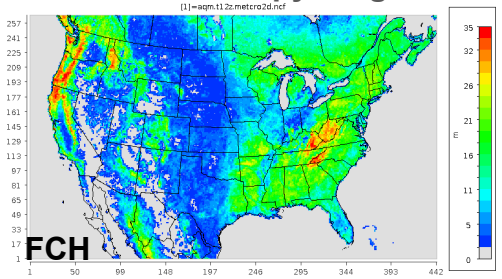
Forest Fraction



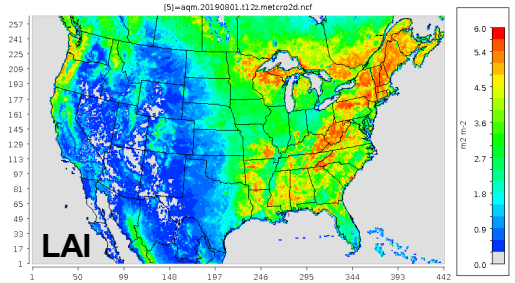
Population Density



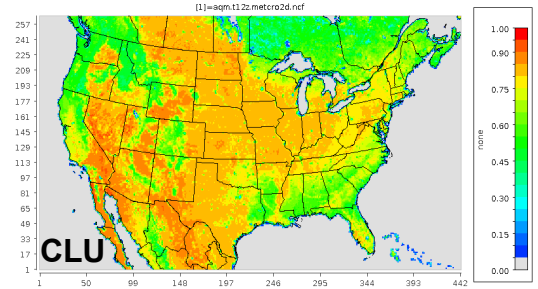
Forest Canopy Height



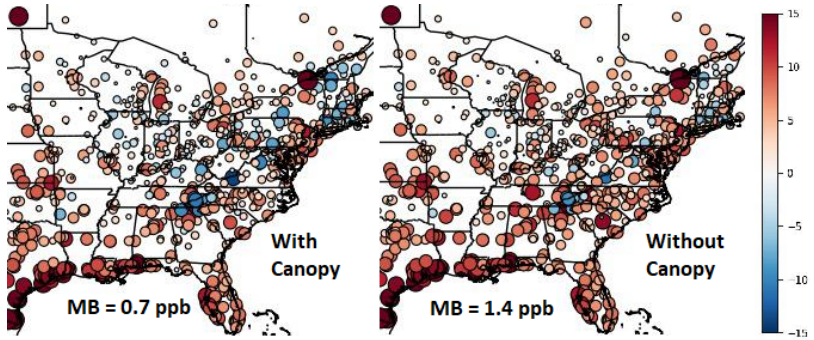
Leaf Area Index

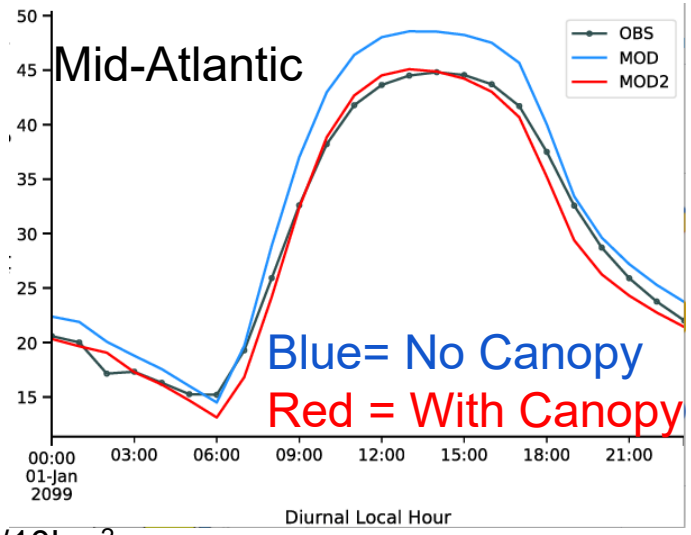


Clumping Index



August 2019 Ozone (ppb)
Mean Bias (AirNow)





Conditions for contiguous forest canopy: FCH > 10 m & LAI > 0.1 & FRT > 0.5 & POP < 10000 people/10km^2 & P (θ) < 45 % & FCH > 18 m (Makar et al., *Nature*, 2017)

Community Applications and Research

- Developing a prototype for NACC data to be available “In the Cloud” (2021-2022).

- Facilitates GFS-driven CMAQ applications for the greater research community:

1. Access CMAQ-ready NACC outputs for NAQFC domains (e.g. 12km CONUS).
2. Access GFS inputs to run “NACC-in-the-cloud” for any user-defined domain globally.

- Potential Benefits:

✓ Interface directly with a NOAA operational GFSv16 global dataset (no data download required).

✓ New research tool for any regional domain globally and avoid downscaling/running WRF.

✓ Rapid applications of CMAQ-ready meteorology for recent air quality events/applications.

- Tests of NACC-CMAQ vs. WRF-CMAQ have been performed → NACC-CMAQ performs as good or better than WRF-CMAQ.

Summary

- An advanced FV3-GFSv16/NACC-CMAQv5.3.1 AQF system is developed.
- The updated NACC-CMAQ system has advantages over the prior NAQFC.
  -Tested with in-canopy effects on chemistry and scalar transport (reduces ozone overpredictions).
- NACC-CMAQ became operational at NWS/NOAA on **July 20, 2021**.
- NACC-CMAQ may form a new research option to avoid WRF downscaling.
- "NACC-in-the-cloud" for user-defined GFS-driven CMAQ is being developed.

Acknowledgments and Data Availability

- We would like to acknowledge our colleagues at the U.S. EPA for years of development and collaboration on the PREMAQ and MCIP systems that were pivotal to the development of NACC.

- 2D and 3D GFSv16 and NAQFC output are archived at NCEP/NOAA and can be made available by request.

- The operational NAQFC output may also be viewed at:

https://airquality.weather.gov/ (NWS Air Quality Forecast Guidance)

https://digital.mdl.nws.noaa.gov/airquality/# (Interactive Air Quality Maps)

- The NACC-CMAQ (Campbell et al.) manuscript is submitted for publication in GMD.