Preliminary Results from NOAA's UFS Global Aerosol Forecast

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Introduction

In the last decade, major Numerical Weather Prediction (NWP) centers have begun offering prognostic aerosol forecasts for the short to medium range, aimed at issuing air quality alerts and providing lateral boundary conditions for several operational regional air quality models. In collaboration with NASA/Goddard Space Flight Centre (GSFC) and NOAA's Office of Oceanic and Atmospheric Research (OAR) laboratories, NCEP has successfully implemented three global aerosol models that deliver aerosol forecasts at high resolutions. Table 1 summarizes all past and ongoing global aerosol model development activities at NCEP/EMC.

	Model	Resolution and Forecast length	Dust emission	Smoke Emissions	General Comments
NGACv1 (dust only)	Global Spectral Model (GSM GFS)	T126 (~1 deg), globally up to 5 days	GOCART dust	No fire emission	Operational in 2012 (Lu et al., 2016)
NGAC v2 (total five species of aerosol)	GSM-GFS	T126 (~1 deg), globally up to 5 days	GOCART dust	GBBePx fire emission from NESDIS	Operational in 2018 (Wang et al., 2018)
GEFS-Aerosols (v1) (total five species)	FV3 GEFS (single member in GEFSv12)	C384 (~0.25 deg), globally up to 5 days	FENGSHA dust	GBBePx fire emission from NESDIS (v 3)	Operational in 2020 (Zhang et al., 2022)
GEFS-Aerosols v2 or UFS Aerosol (experimental)	FV3 GEFSv13	C384 (0.25 deg)	FENGSHA dust (with updates)	GBBePx fire emission from NESDIS (v 5), use of blended fire emission for longer lead time	Planned implementation in 2026

UFS Aerosol: Model Setup

NOAA, in collaboration with other partners, has developed the Unified Forecast System (UFS), a comprehensive community-based coupled Earth modeling system designed for both research and NOAA's operational forecasting applications. The upcoming implementation of GEFSv13 is envisioned as a fully coupled atmosphere/land/ocean/sea-ice/wave/aerosols application of the UFS. The system will utilize the FV3 dynamical core and a CCPP-based atmospheric physics package, along with the Noah-MP land model, MOM6 ocean model, CICE6 sea ice model, WAVEWATCH III wave model, and the aerosol model described below.

As part of the GEFSv13 development, a coupled aerosol model component has been developed in collaboration with NASA/GSFC and NOAA OAR labs (GSL, CSL, ARL, STAR), and with implementation planned for 2026 (NOAA office Note, 510). The UFS-Aerosols component incorporates NASA's second-generation Goddard Chemistry Aerosol Radiation and Transport (GOCART) model, utilizes an updated FENGSHA dust scheme and an updated biomass burning emission (GBBePx) from STAR.

During the development of the GEFSv1, prototype runs are conducted with the coupled system for up to 35 days to test changes in model physics, coupling infrastructure, and initial conditions. The latest prototype (EP5r2) employs the High Resolution (HR3) GFS physics package, utilizing replayed ICs for one

control member and ten ensemble members. These were initialized every week between October 2017 and September 2019 with each of the runs out to 35 days. For the Aerosol component, MERRA2 aerosol is used for initial conditions, along with blended emissions for biomass burning aerosol. We verified the Aerosol Optical Depth (AOD) from the EP5r2 simulation using European Centre aerosol reanalysis data (CAMS) for 90 cases between 2017 and 2019 (Figure 1).

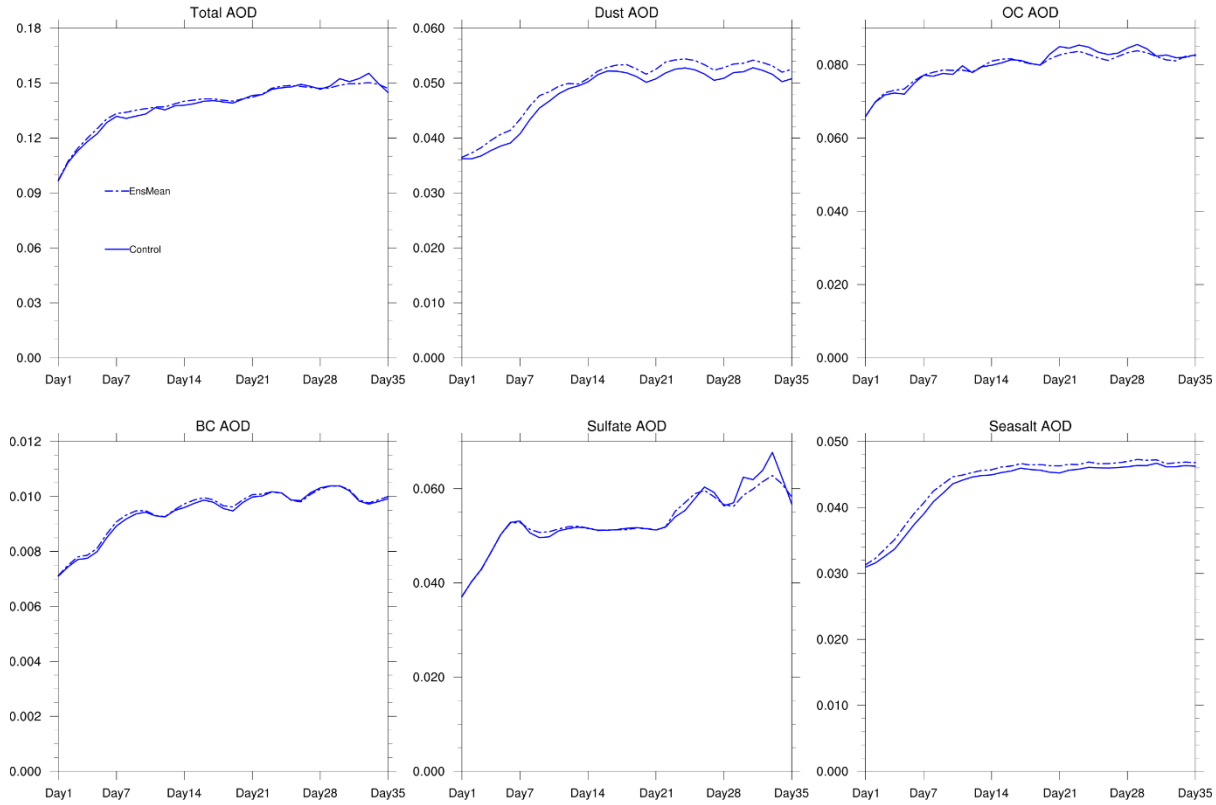

Figure 1. Global RMSE of AOD from Ensemble Prototype (EP5r2) compared against CAMS reanalysis. Solid line represents control member and dotted line represents ensemble mean.

References

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