The implementation of NEMS GFS Aerosol Component (NGAC) Version 2: Global aerosol forecasting at NCEP using satellite-based smoke emissions

Jun Wang[1,2], Sarah Lu[3] , Xiaoyang Zhang[4], Shobha Kondragunta[5], Arlindo da Silva[6], Jeff McQueen[2], Partha Bhattacharjee[2,3], Shrinivas Moorthi[2], Andy Harris[5,7], Prabhat Koner[5,7], Yu-Tai Hou[2], and Vijay Tallapragada[2]

[1]: NCEP/EMC, [2]: IMSG, [3]: University at Albany, State University of New York, [4]: South Dakota State University, [5]: NESDIS/STAR, [6]: NASA GMAO, 7: ESSIC/UMD

Email: jun.wang@noa.gov

1. Introduction

Atmospheric aerosols have profound impact on weather, climate, human health, and the economy. The National Centers for Environmental Prediction (NCEP) has partnered with NASA's Global Modeling and Assimilation office (GMAO) and the NOAA/NESDIS Center for Satellite Applications and Research (STAR) to develop a global aerosol model NEMS GFS Aerosol Component (NGAC) to predict the distribution of atmospheric aerosols (Lu *et al.*, 2016). The development of a global aerosol forecast system paved the way to a full aerosol modeling system with forecast model and aerosol data assimilation capability at NCEP. The overarching goals for developing the global aerosol forecasting and data assimilation capabilities are to improve weather forecasts and climate predictions, provide boundary conditions for regional air quality models, sea surface temperature retrievals and UV index forecasts, as well as to serve a wide range of stakeholders such as health professionals, aviation authorities and policy makers.

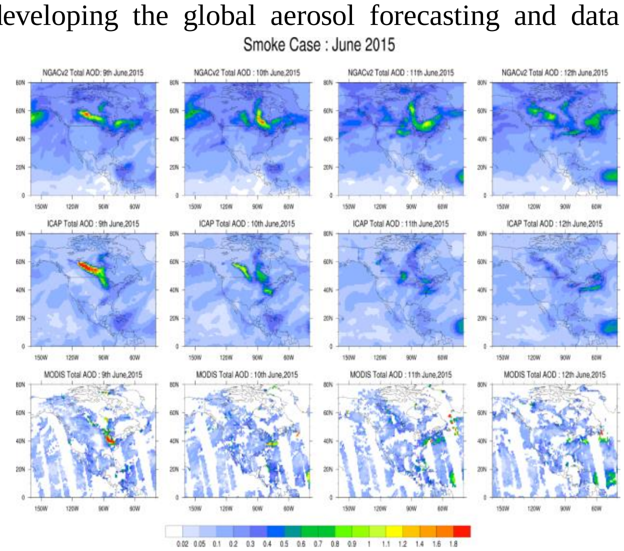

Fig.1 Total AOD from NGAC V2 (top panels), the ICAP MMEs (middle panels), and MODIS (bottom panels) during Jun 9-12, 2015.

2. Model description

The NGAC consists of two key modeling components: the Global Spectral Model (GSM) within the NOAA Environmental Modeling System (NEMS) architecture and the on-line aerosol module based on the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model (Colarco *et al.*, 2010). NGAC Version 1.0 has been providing 5-day dust forecasts at 1°x1° resolution on a global scale, once per day at 0000 Coordinated Universal Time (UTC), since September 2012. An NGAC upgrade (NGAC V2) is planned to be implemented into operations in 2016. This implementation extends the aerosol species from dust only to multiple species including dust, sea salt, sulfate, organic carbon and black carbon aerosols to provide a more complete global aerosol forecast. The major meteorological model physics updates include McICA radiation package in Rapid Radiative Transfer Model (RRTM), Eddy-Diffusivity Mass-Flux(EDMF) Planetary Boundary Layer (PBL) scheme and a Noah land surface update for canopy height scheme, soil moisture nudge and roughness length.

With support from the Joint Center for Satellite Data Assimilation (JCSDA), the NCEP-STAR-GMAO team developed a near-real-time (NRT) smoke emission product on a global scale. The smoke emissions are blended from STAR's Global Biomass Burning Emission Product from a constellation of geostationary satellites (GBBEP, Zhang *et al*., 2012) and GSFC's Quick Fire Emissions Data Version 2 from a polar orbiting sensor, providing daily global emission fluxes for CO_2, CO, OC, BC, PM2.5, and SO_4.

3. Results

A two year retrospective run has been conducted using NGAC V2 to provide multi-species aerosol simulations. The results show that NGAC V2 has comparable forecast skill for dust forecasts and captures the major pollution events over Asia and North America and matches closely with MODIS on total AOD. Figure 1 shows elevated aerosol optical depth (AOD) stretching from Canada to the Great Lakes and the Mid-Atlantic region during June 9-12, 2015. The increase in AOD corresponds to widespread fire activity in Canada that traveled across the continent throughout the period. AOD simulated by NGAC V2 is consistent with the International Cooperative for Aerosol Prediction Multi-Model Ensemble as well as observations from the space-borne Moderate Resolution Imaging Spectroradiometer (MODIS) sensor.

4. Applications

The implementation of NGAC V2 provides a full suite of 2-dimensional (2-D) and 3-dimensional (3-D) aerosol products for various downstream applications. Figure 2 shows aerosol information application in physical deterministic retrievals of Sea-Surface Temperature (SST). Aerosol column density (ACD) of all aerosols is included in the state vector for the MODIS-Aqua SST retrieval. Additional channels available for MODIS, combined with a 3-element reduced state vector, offers the prospect of testing a variant of the Truncated Total Least Squares (TTLS) approach. A comparison between results for the 2-component [SST, total column water vapor (TCWV)] for the Modified Total Least Squares (MTLS, Koner *et al.*, 2015) algorithm and 3-component [SST, TCWV, ACD] state vectors is shown in Figure 2. It can be seen that the RMSE (dashed standard deviation lines in Figure 2) is improved noticeably when ACD is a retrieved parameter. A further consequence of including ACD in the state vector is that algorithm sensitivity is significantly improved. This is demonstrated by the increase in the degree of freedom in retrieval (DFR) values to 0.75 and above.

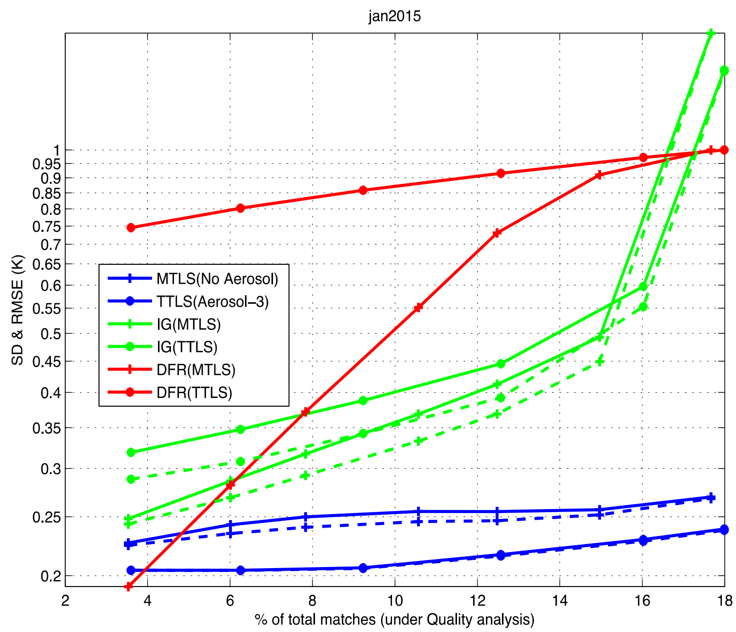

Figure 2. Comparison of retrieval accuracy (blue lines) and algorithm sensitivity (Degrees of Freedom in Retrieval, red lines) of MTLS (crosses) without aerosol and Truncated Total Least Squares (solid circles) using aerosol optical depth in the state vector for MODIS-Aqua data for January 2015. Evaluation is done against *i*Quam buoy data. Initial Guess (IG) SST accuracy (green lines) is also shown.

References

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