Toward developing global aerosol modeling and data assimilation capabilities at NOAA/NCEP for improving weather and air quality forecasts

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NCEP recently implemented the NEMS GFS Aerosol Component (NGAC) for global dust forecasts. With further development, NEMS GFS can be used for modeling and assimilating aerosols and reactive gases on a global scale. The global modeling/assimilation efforts not only allow aerosol impacts on weather forecasts and climate predictions to be considered, but also enable NCEP to provide quality atmospheric constituent products serving a wide-range of stakeholders, such as health professionals, aviation authorities, policy makers, and solar energy plant managers.

NCEP's global in-line aerosol forecast system

NASA's bulk aerosol scheme (an in-line version of the Goddard Chemistry, Aerosol, Radiation, and Transport model [GOCART], Chin et al., 2002; Colarco et al., 2010) has been incorporated into the NOAA Environmental Modeling System (NEMS) to establish the first interactive global aerosol forecasting system, NEMS GFS Aerosol Component (NGAC), at NCEP (Lu et al., 2013). The NGAC was added to NCEP's production suite in 2012, providing 120-hour daily global dust forecasts. A major NGAC upgrade (multi-species forecasts for dust, sea salt, sulfate, and carbonaceous aerosols using near-real-time satellite-based smoke emissions) is slated for operational implementation in late 2015.

The rationale for developing the global aerosol forecasting capabilities at NOAA includes: (1) to improve weather forecasts and climate predictions by taking into account aerosol effects on radiation and clouds; (2) to provide a first step toward aerosol data assimilation and reanalysis; (3) to improve assimilation of satellite observations by properly accounting for aerosol effects; (4) to provide aerosol (lateral and upper) boundary conditions for regional air quality predictions; and (5) to produce quality aerosol information that addresses societal needs and stakeholder requirements, e.g., UV index, ocean productivity, visibility, air quality, and sea surface temperature retrievals.

Applications of NGAC products

The Consensus International Cooperative for Aerosol Prediction (ICAP) multi-model ensemble (ICAP-MMES, Sessions et al., 2015) became pseudo-operational in 2014, using four complete aerosol forecast models from the European Centre for Medium-Range Forecasts (ECMWF), Naval Research

Laboratory (NRL), Japan Meteorological Agency (JMA), and NASA Global Modeling and Assimilation Office (GMAO) as well as three dust-only models from NCEP (i.e., NGAC), U.K. Met Office (UKMO), and Barcelona Supercomputing Center (BSC). Figure 1 shows the dust AOD from the ICAP Multi- Model Ensembles (ICAP-MME), valid at 12 UTC 1 August 2013.

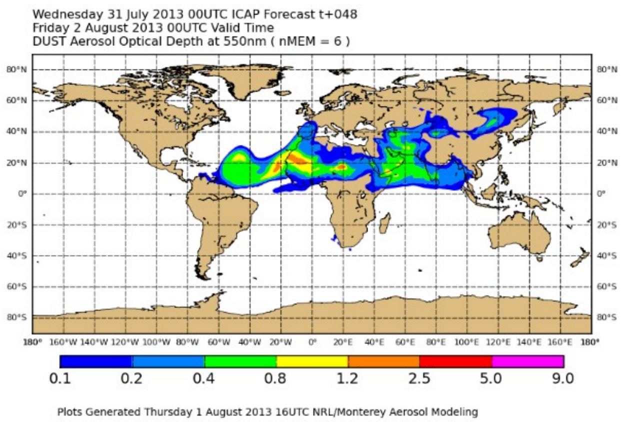

Figure 1 Dust AOD valid at 12 UTC 1st August 2013 for ICAP MMEs (6-members, including NGAC).

Efforts are under way to couple NGAC with NCEP's regional air quality system, which is the Community Multi-Scale Air Quality (CMAQ) model driven by NCEP's North American Mesoscale (NAM) model. Figure 2 shows the observed and modeled surface fine particulate matter (PM2.5) at Miami. The baseline run uses static LBCs and the experimental run uses dynamic LBCs from NGAC. It is found that the inclusion of long-range dust transport via dynamic LBCs leads to an improvement in CMAQ forecasts during dust intrusion episodes.

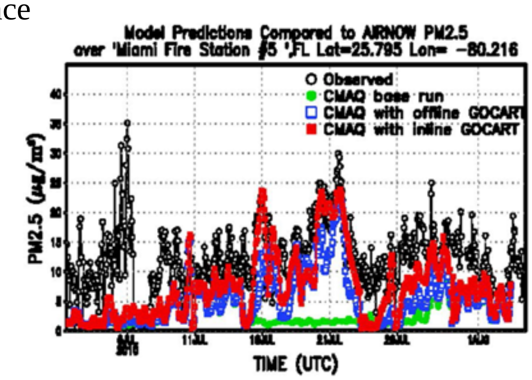

Figure 2 PM2.5 at Miami for two CMAQ runs.

Future Directions

As NGAC introduces a prognostic aerosol capability at NCEP, several aerosol-related activities are on-going or planned. These include but are not limited to: (1) extending the aerosol forecast system to include aerosol observations in an effort to initialize the aerosol model; (2) improving the representation of aerosol processes, cloud microphysics, and aerosol-cloud-radiation interaction in NCEP global models; (3) exploring how much complexity is needed to accurately represent the aerosol processes and effectively account for aerosol effects during data assimilation; (4) developing an observation-based diagnosis package to evaluate physically-based aerosol-cloud schemes; (5) providing global aerosol products for various downstream applications, such as using global aerosol fields as LBCs for regional air quality models and linking aerosol forecasts with UV index, sea surface temperature retrievals, and solar electricity production forecasts.