Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2017-306-AC1, 2018


Geoscientific Model Development Discussions

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Interactive comment

# *Interactive comment on* "The implementation of NEMS GFS Aerosol Component (NGAC) Version 2.0 for global multispecies forecasting at NOAA/NCEP: Part I Model Descriptions" *by* Jun Wang et al.

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Received and published: 17 March 2018

General comments:

This manuscript describes the implementation of the new version of the NEMS GFS Aerosol Component (NGAC) and shows some forecast results and impacts to some applications. The evaluations of the model are described in the companion paper. The authors describe the aerosol forecast and its applications. Especially, a vegetation fire event case is demonstrated to examine its performance. The aerosol model is based



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Discussion paper

on GOCART aerosol module (Colarco et al. 2010): it is not very new or innovative but well documented and utilized by previous studies and suitable for operational forecast. While the manuscript is easy to read and the general performance of the NGACv2 model seems good, I think some of the specific points of the model and results need more description and revision: please see my Specific comments. I recommend this manuscript to be published with a minor revision

- Response: The comments and suggestions from the referee #1 are greatly appreciated. All technical corrections have been made in the manuscript. Please see point-to-point response below for the specific comments.

Specific Comments:

p.5, line 16- : "Sources for sulfate are ... biofuel and fossil fuel emissions from Aerosol Comparisons between Observations and Models (AeroCom) anthropogenic emissions." This contradicts with Table 1, which lists sources of anthropogenic SO2 is EDGAR V4.2 and International ships SO2 is EDGAR V4.1.

- Response: We thank the reviewer #1 for pointing out the inconsistency between Table 1 and the text, the section 2.3 emissions has been updated to include sources for sulfur species and primary sulfate. Page 5, line 26 – page 6, line 3: "For sulfate aerosols, primary emissions of DMS, SO2, and SO4 are considered. Daily biomass burning emissions are taken from NESDIS GBBEPx dataset described above. Anthropogenic emissions of SO2 are taken from the Emissions Database for Global Atmospheric Research (EDGAR), version 4.1 (European Commissions, 2010). For anthropogenic emissions of primary sulfate, the AeroCom Phase II dataset (HCA0 v1, Diehl et al., 2012) is used. SO2 emissions from ocean-going ships are taken from EDGAR v4.1, and ship SO4 emissions, taken from AeroCom Phase II (HCA0 v1), are derived from gridded emissions data set of Eyring et al. (2005) using the EDGAR v4.1 SO2 ship emissions. Aircraft emissions of SO2 are derived from the AeroCom Phase II (HCA0 v1), which in turn is based on NASA's Atmospheric Effects of Aviation Program (AEAP) inventory. DMS emissions from marine algae are calculated from DMS concentrations and water-to-air transfer velocity (piston velocity). Monthly-varying DMS concentrations are taken from Lana et al. (2011). Piston velocity is computed from 2-m temperature and 10-meter wind following the empirical formula from Liss and Merlivat (1986). " We also made extensive revision on describing emissions sources of carbonaceous aerosols (page 6, lines 4-11) and sources of natural aerosols (page 6, lines 12-15).

p.5, line 18: "DMS source uses climatology of oceanic DMS concentrations": How do you treat water-to-gas exchange (piston velocity) of DMS?

- Response: Piston velocity is calculated from model temperature and wind following Liss and Merlivat (1986). Please see previous response on the corresponding manuscript revision.

p.5, line 19-20: The biofuel and fossil fuel emissions are stated "climatology". Specifically, which years are taken to make the climatology and is it reasonable to use for current forecast?

- Response: AeroCom emissions cover the period from 1979 to 2006. In NGACv2, we repeat the 2006 emissions. For real-time forecasts, the approach to use the latest available emission is widely used. In the manuscript, we add the following at section 2.3. Page6, lines 6-8: "For anthropogenic emissions, AeroCom Phase II data set (HCA0 v1) is used. This data set is based on gridded inventory from Bond et al. (2004) and yearly global emission trends compiled from Streets et al. (2008, 2009)"

p.8, line 26: Please expand the abbreviation ASRC at its first use.

- Response: suggested change is made in the manuscript. Page 10, line 4: Atmospheric Sciences Research Center (ASRC)

p.7, Section 4.2: The forecasted AOD by NGACv2 show reasonable agreement with MODIS and VIIRS retrieved AOD and the multi-model ensemble forecast. However, NGACv2 does not show large AOD over the south of the Great Lakes that is shown in the satellite retrievals and the MME.

- Response: It is true that NGACv2 show reasonable agreement with satellite data and the MME, but it does not catch the large AOD over the south of the Great Lakes while MME does. Less satisfactory performance in NGAC v2 with respect to ICAP-MME suggest the need for additional model tuning. The authors believe increased resolution and aerosol data assimilation (DA) in the future NGAC implementation can also help to improve the NGACv2 performance. However it is not surprising that the multi-model ensemble mean from ICAP-MME outperforms a single model without DA. Manuscript is modified to provide the explanation (page 8, lines 13-23). Page 8, lines 13-23: "ICAP-MME total AOD products are generated from aerosol forecasts from four well-established aerosol models, including NASA/GSFC, ECMWF, Naval Research Laboratory (NRL), and Japan Meteorological Agency (JMA). Near-real-time satellite based smoke emissions are used by the four ICAP core models, e.g., QFED2 for NASA/GSFC, Fire Locating and Modeling of Burning Emissions (FLAMBE) by NRL, and Global Fire Assimilation System (GFAS) by ECMWF and JMA. In additional, aerosol data assimilation has been utilized by all these models to constrain the modelled AOD errors and bring modelled AODs closer to the satellite observations. Less satisfactory performance in NGAC v2 with respect to ICAP-MME suggest the need for additional model tuning. However, the performance differences cannot be attributed to NGACv2 model deficiency alone. Lynch et al. (2016) reported that model tuning process is equally as significant as data assimilation on the model performance. Sessions et al. (2015) reported that ICAP-MME out performs the participating members, providing a valuable aerosol forecast guidance. Therefore, the results that multi-model ensemble from four well-established models with data assimilation capabilities outperforms a single model without data assimilation is somehow anticipated."

p.8, line 2: "The figure shows that using the NGAC forecast as the CMAQ lateral boundary condition significantly improved the CMAQ forecast": Figure 3 shows the impact of providing lateral boundary from NGACv2 to CMAQ, but this does not necessary means improvements since it is not evaluated with observations.

- Response: The Figure 4(Figure 3 before manuscript modification) is updated to show the impact of providing lateral boundary from NGACv2 to CMAQ forecast. Observations of PM2.5 (cycled dots) and synoptic condition (wind vector and pressure) are provided in the plots of CMAQ forecast with NGACv2 as lateral boundary condition (plots in the middle column). This figure shows that the CMAQ forecast with NGACv2 as lateral boundary condition matches observations better compared to BASE CMAQ forecast. The manuscript has been revised (page 9, lines 6-8). Page 9, lines 6-8 "The middle panel is the PM2.5 forecast from CMAQ during the same period using NGACv2 multi-species aerosols as the lateral boundary condition. PM2.5 observations (cycled dots) and synoptic condition (wind vector and pressure) are also shown in this panel to compare CMAQ forecast with observations."

p.8, line 4-: The inclusion of the lateral boundary from NGACv2 to CMAQ forecast does not seem to improve to reproduce the highest peak of PM2.5 in Fig. 4a and 4b.

- Response: while CMAQ forecast with NGACv2 dynamic LBC fails to capture highest peak in PM2.5, it produces the best agreement with observed PM among the three CMAQ experiments shown in Figure 5 (Figure 4 before manuscript modification). The manuscript has been revised. Page 9, line 20, adding "even though the peak of PM2.5 in this run is still lower than the observations."

p.8, Section 5.2 and 5.3: These results show sensitivities of the aerosol loadings to the SST retrieval and insolation on the Earth surface. However, these results do not guarantee the improvements of the real situations.

- Response: The authors agree that the sensitivities of the aerosol loadings do not guarantee improvement of the SST retrieval at this moment, but aerosol information provided by operational NGAC model makes quantitative evaluation possible of the aerosol impact on the SST retrieval and provides a path to develop statistical tools using the aerosol products to improve the SST retrieval. Section 5.2 is revised accordingly (page 10, lines 1-3). Page 10, lines 1-3: “The NGACv2 aerosol products make it possible to design the TTLS scheme; further development is required to improve the SST retrieval using aerosol products in real operation.”

However section 5.3 does show that with NGACv2 AOD at 660nm the GHI mean bias error is significantly reduced compared to the GHI MSE in other experiments. The authors do expect potential improvement of GHI estimation in the real situations. Following Manuscript is revised (page 10, lines 22-23). Page 10, lines 22-23: “The results indicate potential improvement in the operational insolation estimate using NGAC AOD at 660nm.”

p.9, lines 7-12: It is strange that the conclusions of the validation by the companion paper (Bhattacharjee et al. 2017) is written in the conclusion of this manuscript.

- Response: The authors would like to give general description on model, model performance and future work as a summary. Because future NGAC development work will be transitioned to the new FV3GFS based forecast system, the current model performance will be used as baseline for the transition. Following changes are made in the manuscript (page 10, lines 28-29 and page 11, lines 22-24). Page 10, lines 28-29: “Because the results will be used as baseline for some future development work described below, a general description of the NGACv2 evaluation is shown here.” Page 11, lines 22-24: “NGAC global aerosol forecast capability is now being transitioned to the FV3GFS system; the NGACv2 forecast performance described above will be used as baseline to evaluate the FV3GFS based aerosol system.”

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