Review of “Analysis of the MODIS Above-Cloud Aerosol Retrieval Algorithm Using MCARS” by Wind et al.

Anonymous Referee #1

Referee comment on "Analysis of the MODIS Above-Cloud Aerosol Retrieval Algorithm Using MCARS" by Galina Wind et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-17-RC1, 2021

Summary:

This paper presents a method to quantify the accuracy of the MOD06ACAERO retrieval through the combination of a forward radiative transfer model built upon the GEOS-5 model. This manuscript is aimed at evaluating the MOD06ACAERO product for inclusion in a data assimilation scheme for GEOS-5. This aerosol assimilation would be quite useful considering the lack of continuous observations of aerosol over clouds in the South East Atlantic Ocean. The use of MCARS as a closure study illustrates quite well the needed filtering processes of MOD06ACAERO in order to be used as a data source for assimilation and puts both the MCARS and MOD06ACAERO in high regards. The data and methods are clearly defined, while the codes are not currently available in a public access repository, it is mentioned that it can be accessed by contacting the author.

The manuscript is very well written and is quite pertinent to model development, particularly GEOS-5. After review of the manuscript there are only very few minor revisions to be made, however one concern, which could be elevated to a major revision, regarding the underlying aerosol model and how it is represented in both the retrieval and GEOS-5 should be addressed before publication (see below). It is suggested that this manuscript is to be published with this one major revision.

Major Comment:

The MCARS application of building a retrieval OSSE on top of GEOS-5 seems to be very powerful, but there is limited discussion of the potential pitfalls of such an approach. Of immediate concern for interpreting the retrieval accuracy of MOD06ACAERO is the aerosol microphysical properties, notably the single scattering albedo (SSA) that may not be well represented in both the retrieval and GEOS-5, which could lead to an artificial inflation of the retrieval accuracy metrics, and potentially leading to inaccuracies in model assimilated fields. For the SEAO, it has been found that the SSA is much more variable, both dependent on the measurement method, and from case study to case study (See Pistone et al., 2019). Differences in MOD06ACAERO and ORACLES data can be partially attributed to the underlying aerosol model (SSA) used in MOD06ACAERO (see LeBlanc et al., 2020). This potential problem is identified in Line 305-306, but elaboration of the impacts could be expanded. Inclusion of a figure showcasing the differences in Single Scattering Albedo
output from GEOS-5 and used in MCARS as compared to the model from MOD06ACAERO (MOD04 DT), might be instructive here with an option to include the spread of SSA either from SAFARI2000 or from ORACLES as presented for few cases in Pistone et al., 2019.

**General Comments:**

- Of general interests, and idea for future directions: Can MCARS be used to evaluate the emission sources (maybe as represented as MODIS fire counts)?

**Specific Comments:**

- Line 62: There is evidence that neighboring clear sky AOD retrievals match the above cloud AOD: Shinozuka et al., 2020
- Line 71: please add the reference in the parenthetical “(add reference)”
- Line 77-78: From reading of the figure it looks closer to 70-80% and 30-50% for June and September respectively.
- Line 185-186, Why were the resolution of streams in DISORT increased from the somewhat standard 16 to 32or even 64? This change increases computation time, so it is likely needed to better resolve the radiances, but what was the metric used to determine this need. (especially for outside of the cloud bow region)
- Line 265: dataset number of points at 13.5 millions seems to present an inflated sense of statistics, it would be interesting to report the number of successful MOD06ACAERO retrievals that are used in the comparison.
- Figure 4-10: The 2 different panels seem to have differences in their representative color levels. Inclusion of a colorbar would be useful here.

**References:**


Pistone, K., Redemann, J., Doherty, S., Zuidema, P., Burton, S., Cairns, B., Cochrane, S.,