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 MOD0ACAERO 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.

This paper is a continuation of explorations in Wind et al 2013 and 2016. The differences between those specific aerosol models had been examined in great detail in Wind et al, 2016. Therefore we did not feel that a repeat discussion was warranted in this case. Additional reference to Wind et al 2016 has been added to the text in order to clarify.

General Comments:

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

Absolutely. If a model that serves as input to the simulation models specific emission sources as to location, amount and type of any particulate and radiative emission and any surface properties of emission source, those sources will be represented in the simulation. Our present simulations do not include fire/burned area information. Such information of course can be included if there is interest and funding for evaluation of an algorithm like MODIS Active Fire.

Specific Comments:

1. Line 62: There is evidence that neighboring clear sky AOD retrievals match the above cloud AOD: Shinozuka et al., 2020

Indeed there is. However that information would not be of much help in a situation presented in Figure 2. With average cloud cover in that specific area hovering between 60 and 80% during the burning season, it is difficult to perform clear-sky retrievals as standard clear-sky MODIS Aerosol product requires a 10x10 km box of clear sky pixels with the additional included retrieval requiring a 3x3km box of clear sky pixels. Such conditions often cannot be met when marine stratus deck is present in the area. Additional clarifying text has been added.

2. Line 71: please add the reference in the parenthetical "(add reference)"

Corrected. Thank you for pointing out the error.

3. Line 77-78: From reading of the figure it looks closer to 70-80% and 30-50% for June and September respectively.

Made corrections accordingly. Thank you very much.

4. Line 96: Redemann et al., citation can be updated to the overview paper: "Redemann, J., Wood, R., Zuidema, P., Doherty, S., Luna, B., LeBlanc, S., Diamond, M., Shinozuka, Y., Chang, I., Ueyama, R., Pfister, L., Ryoo, J., Dobracki, A., da Silva, A., Longo, K., Kacenelenbogen, M., Flynn, C., Pistone, K., Knox, N., Piketh, S., Haywood, J., Formenti, P., Mallet, M., Stier, P., Ackerman, A., Bauer, S., Fridlind, A., Carmichael, G., Saide, P., Ferrada, G., Howell, S., Freitag, S., Cairns, B., Holben, B., Knobelspiesse, K., Tanelli, S., L'Ecuyer, T., Dzambo, A., Sy, O., McFarquhar, G., Poellot, M., Gupta, S., O'Brien, J., Nenes, A., Kacarab, M., Wong, J., Small-Griswold, J., Thornhill, K., Noone, D., Podolske, J., Schmidt, K. S., Pilewskie, P., Chen, H., Cochrane, S., Sedlacek, A., Lang, T., Stith, E., Segal-Rozenhaimer, M., Ferrare, R., Burton, S., Hostetler, C., Diner, D., Platnick, S., Myers, J., Meyer, K., Spangenberg, D., Maring, H. and Gao, L.: An overview of the ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) project: aerosol-cloud-radiation interactions in the Southeast Atlantic basin, Atmos. Chem. Phys., 21, 1507–1563, doi:10.5194/acp-21-1507-2021, 2021."

Done. Thank you very much.

5. 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)

Both MOD06 and MOD06ACAERO forward lookup tables are generated at 64 streams. We increased resolution to 64 streams for one specific case where cloud bow effect was most visible in order to see if that artifact was due to insufficient computational resolution of the simulation. That turned out not to be the case. The rest of the simulations had been performed at 32 streams. We chose to generally increase the computational resolution over previous MCARS versions that ran at 16 streams in order to better resolve cloud phase functions as better computational resources became available and we could keep the same wall clock time while computing at higher resolution. MCARS is highly flexible and we can change computational resolution at will.

6. 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.

MOD06ACAERO retrievals were attempted over each of the 13.5 million points. They were of course not always successful. It can be an interesting side study to look at the failures of retrievals attempted and discern reasons as to why they failed. In order to do so however, no *new simulation data would need to be generated. The text has been updated to clarify that 13.5 million points refers to number of simulated radiances with known properties and does not mean that there were 13 million successful MOD06ACAERO retrievals. Number of points used for statistics in figures 4-10 is indicated on each figure.*

7. Figure 4-10: The 2 different panels seem to have differences in their representative color levels. Inclusion of a colorbar would be useful here.

All 2D histograms are normalized between 0 and 1. Figures have been updated to include the colorbar. Thank you very much.

References:

LeBlanc, S. E., Redemann, J., Flynn, C., Pistone, K., Kacenelenbogen, M., Segal-rosenheimer, M., Shinozuka, Y., Dunagan, S., Dahlgren, R. P., Meyer, K., Podolske, J., Howell, S. G., Freitag, S., Small-griswold, J., Holben, B., Diamond, M., Wood, R., Formenti, P., Piketh, S., Maggs-Kölling, G., Gerber, M. and Namwoonde, A.: Above-cloud aerosol optical depth from airborne observations in the southeast Atlantic, Atmos. Chem. Phys., 20, 1565–1590, doi:10.5194/acp-20-1565-2020, 2020.

Pistone, K., Redemann, J., Doherty, S., Zuidema, P., Burton, S., Cairns, B., Cochrane, S., Ferrare, R., Flynn, C., Freitag, S., Howell, S. G., Kacenelenbogen, M., LeBlanc, S., Liu, X., Schmidt, K. S., III, A. J. S., Segal-Rozenhaimer, M., Shinozuka, Y., Stamnes, S., van Diedenhoven, B., Van Harten, G. and Xu, F.: Intercomparison of biomass burning aerosol optical properties from in situ and remote-sensing instruments in ORACLES-2016, Atmos. Chem. Phys., 19, 9181–9208, doi:10.5194/acp-19-9181-2019, 2019.

Shinozuka, Y., Kacenelenbogen, M. S., Burton, S. P., Howell, S. G., Zuidema, P., Ferrare, R. A., LeBlanc, S. E., Pistone, K., Broccardo, S., Redemann, J., Schmidt, K. S., Cochrane, S. P., Fenn, M., Freitag, S., Dobracki, A., Segal-Rosenheimer, M. and Flynn, C. J.: Daytime aerosol optical depth above low-level clouds is similar to that in adjacent clear skies at the same heights: airborne observation above the southeast Atlantic, Atmos. Chem. Phys., 20(19), 11275–11285, doi:10.5194/acp-20-11275-2020, 2020.

We added the references suggested. Thank you very much.