Review on gmd-2021-17
Anonymous Referee #3

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-RC3, 2021

This manuscript evaluates the performance of MODIS Above-Cloud AERosol retrieval algorithm (MOD06ACAERO) in the Southeastern Atlantic for biomass burning aerosols using Multi-Sensor Cloud and Aerosol Retrieval simulator (MCARS). Lack of aerosol retrievals in cloudy conditions is a well-known problem in the aerosol community. This study helps address this issue using a closure study of MOD06ACAERO above-cloud Aerosol Optical Depth (AOD). The paper meticulously describes the observations and model and discusses the limitations and strengths of the retrieved AOD for different filtering conditions based on cloud cover, zenith angle, and pixel-level retrieval uncertainty. The results from this study are beneficial for model evaluation studies and design of future satellite missions.

Filtering conditions and related error metrics from this study provide an opportunity to test the model performance from assimilation of MOD06ACAERO AOD retrievals. Availability of code and data will make it easier to test this approach for other satellite instruments and aerosol types. The paper is well-written and easy to read. However, there are some major revisions that need to be addressed before the paper is published.

Major Revisions:

- Differences in the aerosol model between MOD06ACAERO retrievals and GEOS-5 need to be discussed in the analysis section. This can be included before describing the results from the sensitivity tests (before line 290).
- What are the uncertainties/biases in the retrieved AOT (using MCARS) from this study? What are the factors influencing the uncertainties over land and ocean for the retrieved AOT using MCARS synthetic radiances? It is not clear if the algorithm is useful for clear-sky conditions or can be used only in cloudy conditions.
- Figure 2. Shows real data example of MOD06ACAERO Aerosol Optical Depth (AOD) retrieval and MODIS Dark-Target (DT) aerosol retrieval. It is clear that the data gaps are reduced in panel c). However, there are differences in AOD values between panel b) and c) even in areas where MODIS DT clear-sky retrievals are available. What are the reasons for these differences?
How does the retrieved AOD compare against MODIS DT in clear-sky conditions?
Figure 4-10 – it is not shown what do colors represent in the panels. Do they represent probability density values? Adding a colorbar and description of the colorbar in the caption is necessary.

Minor Revisions:

- In general, it will be interesting to assess the performance of retrieved AOD in the Atlantic for dust transport from Africa above the clouds. For this paper, it will be helpful to include comments/references on the performance of MOD06ACAERO for other aerosol types.

- Although the goal of this paper is to evaluate MOD06ACAERO, comparison of the results against ORACLES data will strengthen the paper.
- Line 71 add reference – reference is missing. “... daily mean cloud fraction greater than 50% in the MODIS Daily Level-3 gridded product (add reference)”.
- Lines 277-280: It is understandable that GSNR is a free running model and any resemblance to real data is a coincidence. Please elaborate (or rephrase) lines 277-280 to include comments on a similar comparison of cloud amount/distribution in MODIS granules and GSNR. Spatial distribution of clouds and cloud optical properties between GSNR and MODIS granules can affect the retrieved AOD. How is this addressed? (see Le Blanc et al., 2020).
- Line 270 – “from from the simulation offers”. Remove one.
- Figure 4-10 - colorbar is missing. Since the data density between panels a and b change in these figures, it would be more meaningful to include normalized error metrics in these figures such as normalized mean bias or normalized RMSE, fractional gross error. Please add what colorbar represents in the figure captions (perhaps, probability density values)?

References