Response to Review #2

Review of "Assessment of Severe Aerosol Events from NASA MODIS and VIIRS Aerosol Products for Data Assimilation and Climate Continuity"

General comments

The objective of this paper is to assess the differences between MODIS-based and VIIRS AOD products. In the context of a likely disruption of the MODIS product, assessing and documenting the consistencies and inconsistencies between MODIS and VIIRS data sets is essential for AOD data assimilation and to ensure the continuity of essential climate variable production. This paper provides a unique and meaningful documentation of the differences between products as well as their performances evaluated against AERONET at both global and regional scales. The analysis of the probability distribution function of each dataset provides a relevant statistical characterization on how the data sets compare each other in terms of capturing major aerosol events. The pairwise comparison informs on product differences for different AOD regimes that can be related to differences in each retrieval algorithm. Finally, the regional analysis allows to identify the product strengths and deficiencies for different regions. While the scientific contribution of this paper is strong and very relevant for its publication in AMT, several aspects of the paper, which are underlined below, should be improved prior to publication.

My main concern is about the description of methodology. There is no dedicated methodological section. The authors have chosen to separate the paper into the 3 types of analysis, namely: probability distribution function, regression and regional analysis, which include a brief method description along with the results and their interpretation. The author can keep that approach but should include a subsection dedicated to methodology in each analysis section or should consider having a separate section on method (similarly to the data one). Several aspects of the methodology should be better presented: what is the role of AERONET ? as far as I read it is involved in the regional analysis and not the global comparison ? Is it used as a reference data set in term of accuracy ? For the pairwise analysis, the method should be clearly explained, the reference to the past paper is not enough.

Response: *Thank you for your comments and review. We have added a methodology section (Section 3) to clarify what we are doing and how we use the data.*

Specific comments

- **The title is too long-**

Response: *Yes, we agree that it is a long title, but we do think it is to the point given the length of what we cover in the manuscript. We have not been able to come up with an alternate but are open to suggestions.*

- **Abstract: the role of AERONET is not clear, it is presented at same level as the satellite dataset but should be considered as a reference data set because of higher accuracy:**

Response*: Thank you for pointing this out. The role of AERONET is considered the closest form of validation to the satellite datasets. This is now stated in Line 30 of the abstract. This said, as is noted in the manuscript AERONET data as point data is aliased. Therefore, we examine the three satellite observations all together.*

- **Introduction**
  - For the sources of AOD retrieval uncertainty:
    - The measurement information content is a major source of uncertainties and it depends on geometry and the range of scattering angle which is sampled by the instrument
    - Cloud screening is a major source of uncertainty in aerosol retrieval and a large source of departures between products. This interacts in a complex manner with the differences in spatial resolution between products.

Response: *Yes, we agree that both of those are sources of AOD retrieval uncertainty. Section 5 addresses both of these uncertainties throughout the case studies in the regional analysis.*

- Regarding the definitions given for data assimilation, observation error and bias: I found it confusing. DA aims at correcting only small amount of random error that can be quantified by the SD of the differences between the observation and its model-simulated equivalent. Observation and model first guess should be unbiased in theory. Bias correction scheme aims at removing any systematic differences between the observation and the model.

Response: *Regarding observation error and bias for data assimilation, we are referring to using only the highest quality of data as input to a data assimilation model. Zhang and Reid (2006) discuss the importance of this and how using biased retrievals in data assimilation affects the accuracy of both local and regional analysis. As data sources transition from MODIS and VIIRS products, it is important to identify the differences between products based on instrument and retrieval algorithm differences.*

- VIIRS AOD: It should be clearly acknowledged that there are two distinct datasets for VIIRS: one produced by NASA and one produced by NOAA

  R*esponse:* *Thank you for bringing this point up. It is important to acknowledge that there are multiple products available. We included NASA in the title and added a reference to NASA in the section title, "2.2.3 VIIRS NASA Deep Blue." We also added the sentence, "There are two primary aerosol products produced for VIIRS by both NASA and NOAA, but this study only uses the NASA product." at line 260 in the revised manuscript.*

- The objective of the paper should be better explained.

  Response: *We think that the objective of the paper is best described in lines 110-132. With MODIS nearing retirement, there are going to be large changes required for those who use this data in the data assimilation community. Harmonization is going to be*

required as data sources transition from MODIS to VIIRS products. The objective of this manuscript is to serve as a starting point of how these datasets currently monitor severe aerosol events.

- The paper does not show/discuss the differences between product from same instrument but from distinct satellites: TERRA vs AQUA; S-NPP vs NOAA20. This is quite important in particular in the context of data assimilation when one product from one satellite can be biased due to radiometric uncertainties, I would suggest to include some results, if possible apply the intercomparison metrics separately to instrument and platforms.

  Response: *Yes, this is a great point to bring up. The purpose of this study was to focus on products that are in the same orbit or in close observation time to one another. Since Terra and Aqua are in a different orbit, so you can't do 1:1 matching between the two. To compare S-NPP and NOAA 20, there is not enough overlap during their operational periods. Such issues are being considered in ongoing work, but it is beyond the scope of this paper which is already long by most standards. Here we are making note of the nature of key differences, and that they can be quite large. We are working on bias correction methodologies that can be applied later.*

- **Satellite AOD (section 2): The description of AOD product is too long. The statements on MODIS instrument characteristics are not essential, the readers can refer to dedicated papers. Any references or statement on the differences between the NASA and NOAA products would be helpful. As well, I suggest to include a Table which summarize the main characteristics of each product and that would help to identify their differences. The YORI method is too detailed, please provide the essential information**

  Response: *Thank you for the comments on this section. Portions of the MODIS products descriptions have been shortened. The YORI method description has been edited and moved into the methodology section. We think it is important to emphasize the use of YORI given another reviewer has noted that we must stress how this product is different than other L3 products. We have also added clarity that we are using the NASA VIIRS product vs the NOAA VIIRS product as mentioned in the previous comment.*

- **Section 3.2 line 395-397: it is not clear what do the author mean with nonlineraties in AOD**

  Response: *It is meant to describe that at high AOD there is not often a direct relationship between the different datasets which makes using a linear regression less representative of the data. As AOD increases, it approaches optical depth semi-infinite and the ratio of radiance to AOD diminishes with increasing AOD. At that point intensive parameters like single scattering albedo become more important that AOD itself.*

- **Line 400-403: the sentence about dynamic range is not clear**

  Response*:* *The sentence is referring to the resulting sampling bias of using correlation coefficients for regions where there is a large range of AOD vs low a low range of AOD environments. That is, for a simple error model (e.g., a+B*AOD), simply by having a larger dynamic range (a wider span of relative lower to higher values) the r2 value will improve. Thus, r2, as is commonly used as a benchmark, inherently penalizes regions of low AOD.*

- **Use mean deviation (MD) instead of bias for product comparison, bias is generally used with respect to reference measurements (such as AERONET)**

Response: *Thank you for bringing up this point. It does make sense to use the terminology of mean deviation vs mean bias since we are comparing two unverified products. There have been changes made throughout the revised manuscript to reflect this comment*

- **Not enough analysis with respect to the impact of differences in cloud screening between products**

  Response: *Cloud screening is a large part of any aerosol algorithm so in studying the differences between satellite products we can see the impacts of cloud contamination in the L3 product we've created. An improved cloud bias analysis is underway and will appear in a separate paper. It is also important to note that using the highest quality flag for each of these does filter out a majority of the detected cloud fraction and these algorithms tend to lean clear sky conservative.*

- **Line 584-587: this statement is not specific to this paragraph**

  Response: *We respectively disagree and think that this statement is relevant to describing the list of differences described in the paragraph above.*