

Reply to reviewer 2:

Dear Authors,

Thank you for a well-written manuscript on your interesting and carefully performed study. The limitations of operational satellite retrievals for extreme events are well known but had never been exactly quantified. I have a few questions seeking clarity, and several minor corrections, but I think with minor revisions this study can be published. Thank you for your hard work.

Comments below are organized roughly by significance:

We thank the reviewer for your kind words and warm encouragement. We are happy that you think this work is interesting and important.

1. *Q: Would you say that your research results represent a lower bound on the low bias associated with the operational DT retrieval?*

We don't really understand this question. Our research product reduces the systematic low bias when compared against AERONET, especially at high AOD levels.

2. *Q: The MODIS Dark Target retrieval makes some assumptions about the impact of aerosol scattering and absorption at longer wavelengths. For $AE=1.8$, AOD_{550} of 5.0 corresponds to an $AOD_{2.1\mu m}$ of 0.45, which is quite substantial. I think you should discuss the ramifications of high AOD values on the assumptions of the MODIS DT retrieval, especially the reflectance ratios of longer wavelengths.*

In DT algorithm we match the measured top of atmosphere reflectance at 2.1, 0.66, and 0.47 μm with modeled reflectance. The surface reflectance at 2.1 μm as well as the contribution from aerosol is solved through equations (ATBD equation 42 a,b, and c <https://darktarget.gsfc.nasa.gov/atbd/land-algorithm>). We do not have to assume that the atmosphere is transparent at 2.1, only that the three wavelengths are related when solving the equations. In other words, the equations account for the influence of the aerosol loading at 2.1 μm , although AERONET makes measurements of aerosol in visible and NIR wavelengths (which are used to derive TOA aerosol properties), there are no real measurements of aerosol properties at 2.1 μm . We do not yet have a constraint on "how uncertain" this means for deriving the TOA reflectance at 2.1

3. *P5L29 and many other places. I don't like the term "failure metrics," because nothing is actually being measured. My preference would be to refer to this as the "cloud optical properties product MYD06 Collection 6 diagnostic quality flags," which is long but eliminated ambiguity. "Failure metrics" should be replaced with "diagnostic flags" or "quality flags" throughout the manuscript.*

We changed "failure metrics" to "diagnostic flags".

4. *P11L26: "an aerosol model might ... better capture the variability of smoke optical properties" What kinds of improvement would you expect to see with more data? What kinds of conditions are under-sampled with the existing dataset? Do you have suspicions about how your current results may be biased?*

The AOD dependency in the aerosol model is limited due to the lack of high AOD data in AERONET inversion data base in this study. We would like to have more AERONET inversion data in high AOD regimes, for example when AOD is greater than 3. With limited information

about aerosol properties when the AOD is high, we don't know if or how the absorption will change in higher AOD regimes. If the higher AOD means proportionally more scattering than absorption than our current extrapolation of particle properties suggest, then our retrieved high AOD will be biased high. If at a certain AOD, the scattering/absorption plateaued, then the current extrapolation is accurate and our retrieval will have less bias. Also, currently we are only able to create a model for the more prevalent white peat-burning smoke over our study domain. With more data, we can separate the non-absorbing white smoke from the brown smoke that was emitted by the flaming, and reduce the bias in our retrieval introduced by using the white-smoke model for situations that require a greater component of absorption. We added couple sentences as part of the uncertainty discussion in the end of chapter 5.

5. *P14L23: "multiple types of smoke optical properties" Are you suggesting there may be multiple modes of smoke particle optical properties? Or are you only saying that the smoke particle optical properties are highly variable?*

We changed this sentence to "multiple types of smoke with different absorbing properties"

6. *Figure 9. I recommend modifying the legend (and others) to read "C6 DT AOD" to assist future readers.*

Done.

7. *Page 2 line 26: "This new regional aerosol climatology" Is this referring to the updated empirical optical properties derived from AERONET? This should be clarified.*

We changed this sentence to "Using the newly developed research product, we investigated how our regional climatology was modified."

8. *P4L13 "information about the aerosol optical properties"*

Done

9. *P6L25 "Holben 2006 recommends a threshold of $AOD > 0.4$ at $0.44 \mu\text{m}$ for quality assurance of the AERONET inversion products; we followed the procedures of Holben, but used a higher more strict AOD threshold of $AOD > 0.4$ at $0.675 \mu\text{m}$."*

Done

10. *P11L15: "with 7 pixels in the last bin"*

Done

11. *P15L4: This last sentence can be phrased better, I think. If I understand, you are trying to say that the research retrieval has more than double the number of $AOD > 1$, and with those additional retrievals included, the bulk error statistics still show a large improvement.*

We changed this sentence to "the research retrieval has more than double the number of $AOD > 1$, and with those additional retrievals included, the bulk error statistics still show a large improvement."