Response to Review from Anonymous Referee #1

We thank the referee for the careful review of our paper. Our responses are embedded below.

The manuscript studies the impact of satellite swath width on the global and regional AOD statistics and trends. The study uses the MODIS AOD climatology as the base- line, and then re-samples AOD from this baseline with different strategies (such as MISR and CALIOP). The manuscript concludes that "future aerosol satellite missions having significantly less than full-swath viewing area unlikely to sample the true AOT distribution well enough to determine decadal-scale trends or to obtain the statistics needed to reduce uncertainty in aerosol direct forcing of climate".

Overall, the manuscript is well written and the contrast analysis between 'sampling- then-average" vs. "average-then-mask" is revealing. The manuscript has 18 figures and looks into several important issues (such as AOD trend, cross-scan bias in AOD, etc.). I would recommend the manuscript be accepted after several minor but important revisions. Below are specific comments.

1. The analysis presented here focuses primarily on the issues related to spatial sampling, but assumes that AOD retrieval quality don't change with swath width (or inherently sensor capability). It is ok to make such assumption, but is a good idea to acknowledge such important assumption upfront (preferably in the abstract). Currently, view-angle artifacts are mentioned in the abstract. But sensors with limited spatial coverage may have different (likely higher) accuracy in AOD retrievals and the manuscript is not considering this in the analysis.

In the abstract we note that we are analyzing the MODIS dataset and results of an aerosol transport model (the latter added in the revision). This strikes a balance, we hope, between observations of the real aerosol field (with an imperfect instrument) and the possibility of an unbiased dataset (in the sense of a MODIS-like instrument) from the model. We are not discussing the possibilities of better retrievals from future instruments, although we certainly hope for that and acknowledge that likelihood. We write in Section 4:

"Other measurement approaches would enhance retrieval of aerosol properties over bright land surfaces. Future aerosol instruments will undoubtedly improve upon MODIS in these and other respects, such as providing enhanced information about aerosol single scattering albedo and particle size, other important drivers DARF (e.g., Loeb and Su, 2010). It was not our intention here to demonstrate the benefit of those enhanced capabilities, but rather to investigate the limits imposed on the measured AOT by one aspect of any future measurement strategy, its spatial coverage."

2. Similar like temperature, extreme events are part of the climatology. The manuscript looked into how well the min and max of AOD differ due to the spatial sampling bias, which is very good. However, some discussion is needed in section 4, as ultimately the comparison needs to be made for PDF of AOD.

We appreciate this comment, but are presently constrained by the limitations of the "sample-then-average" method of aggregating the MODIS data, which is confounded by the MODIS view angle artifact. Perhaps this could be explored in the aerosol transport model, although we have to acknowledge the possibility that the model itself does not well represent extreme events (see the AERONET comparison PDF in Figure S6). So in Section 4 we write:

"Our analysis was focused on seasonal-regional spatial sampling artifacts, which capture aspects of the mean aerosol distributions. Folded into these mean field properties is variability occurring on much smaller spatiotemporal scales, including extreme events (i.e., volcanic eruptions, wildfires) that could be missed depending on the spatial sampling. The "average-then-mask" method employed for our MODIS along-track results would carry events to the sub-samples more completely than would be the case for the "sample-then-average" approach that more realistically represent the sampling of an actual instrument. Because of the aforementioned limitations of the "sample-then-average" dataset we do not fully assess here the sub-regional distribution of AOT and how that is impacted by spatial sampling, but this is an issue that needs further consideration."

3. In section 4, the width of swath is recommended as an important factor to be considered in the future mission planning for studying aerosol forcing. However, as mentioned in the introduction of the paper, aerosol forcing estimate requires knowledge of both particle composition (single scattering albedo) and particle size, and in some many cases, the vertical profile of these parameters as well. So, it is good to mention these important factors in the discussion. It is important to study if the spatial coverage of AOD is still the first-order cause of the forcing uncertainty, given that most global models constrained by satellite data have also made good progress in the last decade toward simulating the climatology of AOD.

Future instruments would presumably provide higher-quality information about aerosol single scattering albedo and particle size than is available from current instruments. We might expect with that information that those properties (SSA, effective radius) vary on larger spatial scales than the aerosol load, but then again, maybe they don't. In either case, there is still information needed from the wider swath. Please see our response to point #1 above for how we address this issue in our paper.

4. The contextual biases over the ocean were briefly discussed in the end of the manuscript, but other studies have found such contextual bias over the land (Hyer et al., AMT, 2011) and over the coastal regions (Anderson et al, Tellus, 2013). It is recommended to include these studies in the discussion as well.

Thank you for pointing this out. We write:

"We note that the MODIS data set does not capture all aspects of the actual aerosol field, in part due to contextual limitations of the measurement technique, such as the lack of diurnal observations and the inability to retrieve AOT under and in the immediate vicinity of clouds (e.g., Zhang and Reid, 2009). Others have identified contextual issues with the MODIS dataset over land (Hyer et al., 2011) and in coastal sites (Anderson et al., 2013)."