We would like to thank Dr. Reid for his comments. He is known as an expert in this field who provides honest and direct reviews (which is precisely why we suggested him as a reviewer for this manuscript), so although he doesn't view our study in a favourable way, we appreciate his review and take the comments in the spirit in which they were intended. As well as his formal review on ACPD, we have been in contact with him offline to discuss some of his specific concerns with the manuscript, and hope that we he will find our revision of the study to be worth publication.

The manuscript has been extensively rewritten as a result. Below, we have listed Dr. Reid's main concerns with the original submission, and discuss how we have modified the manuscript to account for them.

1. Lack of novelty

Dr. Reid felt that the original manuscript was not novel enough to warrant publication, particularly in regards to the earlier study Dubovik et al. (2002), hereafter D02, which examined microphysical/optical properties at different AERONET sites using an earlier version of the AERONET inversion algorithm. Firstly, in the revision we have altered the text to indicate some of the points at which our analysis found different results from D02 (due to the updated AERONET version 2 algorithm, as well as up to a decade more data). We also considered more sites than D02—Dr. Reid notes that some of these regions are discussed were covered by other studies we cited; by examining all the sites together with the same methodology, we wanted to present a more direct side-by-side comparison.

We have also added additional analyses in the revised manuscript, to discuss other aspects which were not considered by D02 and the other studies:

- Discussion of absorption Ångström exponent.
- Analysis of how well the climatologies for each site represent the optical properties retrieved at each site (i.e. intra-site variability).
- Analysis of how well the climatologies for each site represent the optical properties retrieved at the other sites (i.e. inter-site variability and distinguishability).
- Extension of optical models to include UV wavelengths.
- Calculation of lidar ratios for common lidar wavelengths, and their AOD-dependence.
- Two additional sites were added to the discussion. Firstly, Tomsk 22 serves as a useful secondary site for sampling of smoke in Siberian, alongside Yakutsk, both of which had smaller data volumes than most of the other sites considered. Secondly, we added analysis of summertime burning at Moscow from the years 2002 and 2010, which was more strongly influenced by peat burning than the other boreal sites. Although we realise that Moscow will have some local urban contributions to the aerosol loading too, we mention this limitation, and feel that our data selection gives confidence that smoke is optically-dominant for the selected AERONET inversions.

We feel that our revised manuscript is sufficiently novel to warrant publication, providing complete information on microphysical/optical properties required for many of the common scientific applications these aerosol optical models are used for, and hope Dr. Reid will agree with this.

2. Smoke evolution and bulk comparisons

Dr. Reid felt that our discussion of the evolution of smoke microphysical properties was poor, and the methodology of comparing bulk microphysical properties from different sites was not appropriate, due to the differing aerosol sources and chemical compositions at the different sites. We feel that these criticisms stem in part from how the study was framed, and the manuscript has been revised extensively because of this.

Specifically, for our main intended applications of interest (i.e. radiative transfer calculations, primarily for satellite remote sensing) it is the apparent optical properties (AOD, SSA, asymmetry parameter, and their spectral dependence) which are of greatest important, rather than the underlying microphysical properties (i.e. chemical composition and associated size, shape, mass, refractive index), as it is these optical properties affect the radiation seen at top of atmosphere (i.e. the remote sensing instruments operate in optical space rather than). As a result the title, much of the text, and several figures have been rewritten and redrawn to reflect the emphasis on optical properties. Microphysical properties are required as it is from these that the optical properties are calculated, but we have tried to be clear that it is an improved understanding of the variability of optical properties which is being sought; the amount of microphysical information which we can get out of AERONET is limited. The discussion on smoke formation and evolution has also been modified. We feel that comparison between smoke-dominated aerosol columns from different AERONET sites is warranted if optical properties are the focus, because again it is these optical properties which affect the radiation sensed by satellites.

A related criticism of Dr. Reid's is that a sampling bias is introduced because the AERONET dataset used only includes inversions for a fairly high AOD (440 nm AOD at least 0.4, which corresponds to a typical 550 nm AOD of 0.25-0.3 for smoke). To test this, we reran the analysis with a lower 440 nm AOD threshold of 0.2, for which retrieved size distributions are expected to still be reliable, and found similar results. It is difficult to state whether the refractive indices and so SSA would be systematically different for these lower-AOD cases, but for the main intended applications of these optical models (i.e. satellite radiative transfer) the importance of SSA diminishes as AOD decreases. We have mentioned this in the revised manuscript.

3. Discussion of bias in satellite AOD retrievals

Dr. Reid's comment was that biases in satellite-retrieved AOD in high-AOD conditions believed to be related to incorrect assumptions about aerosol absorption have been reported before. We agree with this, and have added the reference to Zhang and Reid (2006) to this section in the revised manuscript concerning over-ocean biases, which had been missing before (references in the original manuscript in this section were previously only over-land examples). He also states 'we need to keep on beating on developers to fix the problem', which we also agree with: part of the motivation for including this section was as another example to increase visibility of this issue among the user community. Related to this, these results were also provided to the MODIS/MISR algorithm teams prior to submission, and those of us (Sayer/Hsu) working on satellite AOD retrieval algorithms will be incorporating these optical models into our future datasets to mitigate this error source. We feel that this section of our paper was useful both for continuing to raise awareness, and as a self-contained quantitative demonstration of this issue. This section has also been revised for emphasis, and the Ascension Island satellite/AERONET comparison modified to, we feel, present this in a more direct and convincing manner.

4. Referencing

Dr. Reid's final comment was that he found the references cited by the paper too NASA GSFC-centric, and that some aspects were missed out or interpreted incorrectly in the discussion. We understand the importance of understanding and crediting the prior literature and are conscious of the dangers of being internally-focussed in referencing, especially when at a large institution such as NASA GSFC. We are sorry if this time we did not give a balanced treatment. As a result we have looked carefully at the paper and made an effort to read the existing literature in greater breadth and depth, which is

in part what has led the submission of this revision to take a long time, making a large number of changes in the revised manuscript as a result.

The concluding paragraph of Dr. Reid's review was as follows:
In conclusion, this review is not mean as a dump on the authors, rather perhaps some tough love that "have data tool will travel" mentality is inherently dangerous and only serves to force the recycling of old knowledge again and again. There are lots of opportunities to apply the data to remote sensing. But it does require a thorough understanding of the aerosol science behind it. If the authors want to create a better optical model for retrievals, perhaps they should attack that problem directly.

Dr. Reid has made valuable points in his review and subsequent discussion offline, which we have taken to heart when revising this manuscript. The study has been overhauled significantly as a result, as described above, and in our responses to the other reviewers. One key goal of our study was, as Dr. Reid indicates, better optical models to represent smoke-dominated aerosol columns for satellite retrievals. We feel that our revised analysis presents and discusses optical models in sufficient detail that they will be useful not just for us but also other researchers, and hope Dr. Reid will find this revision merits publication in ACP.