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Atmospheric Chemistry and Physics Discussions

Interactive comment on "An observationally-constrained estimate of global dust aerosol optical depth" *by* David A. Ridley et al.

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Comments on Ridley et al.

This is a potentially really important paper, with a sound methodology, for the most part. The issues come with the error analysis, which appears to substantially underestimate the errors. The paper also fails to provide context with previous studies. If these issues are fixed, the paper is likely to be extremely influential.

The main errors associated with knowing the dust aod come from: 1. errors with the retrieval algorithm, 2) spatial and temporal hetereogeneity in dust distribution, 3) spatial and temporal variability in dust composition and/or shape, 4) errors in detecting dust

versus other aerosols or clouds.

The authors seem to deal fairly well with the 4th of these, but seem to underestimate the errors in the other three. Please discuss the issues with the retrievals and all the problems with the retrieval algorithms. Are the algorithms making the same assumptions about dust properties? That would then add another error, which will be difficult to assess by just comparing different datasets. For example, if they assume all dust is one optical property, or spherical, or at particular altitudes, etc. Please describe these sources of errors.

In the comparison of the MODIS, MISR and aeronet, what is the rms error? This error represents a combination of the spatial and temporal variability as well as errors in the retrieval algorithms, and needs to propagate into the error in your final estimate. As it stands, only the mean bias propagates into your error estimate, which will underestimate your errors. If I look at Moon et al., 2015, the error bar on individual retrievals in MISR are at least 30%: how can you claim smaller error than that in your results? You seem to be assuming that these errors will average out, but this seems unlikely and this assumption would have to be justified.

You include a comparison of AOD across all sites in the world, with all types of aerosols. How does this comparison over just dusty regions compare? Is it better or worse, please explain.

Dust is not homogeneous in chemical composition, size and thus optical properties, but the retrieval algorithms assume that they are. You should explicitly discuss this point, and you could bound the error from mineralogy using Scanza et al., 2015, which suggest for the CAM5, the impact of spatially varying optical properties depending on mineralogy is 0.002 out of 0.033 aerosol optical depth or about a 6% error (1 sigma).

Then it would seem you would need to add all these errors to the total estimated error, without letting them cancel each other, and then it seems likely that you will get a reasonable value.

The last comment is to consider how this estimate differs from previous model/data comparisons (e.g. Cakmur et al., 2007; Albani et al., 2014 or Balkanski et al. 2007). There are two main differences. Here the primary spatial and temporal variability relationships come from the satellite remote sensing data vs. model results in those papers. And secondly, because the first two papers include comparisons to concentration and deposition data. To understand how important the second is, please provide a comparison of your 'constrained' AOD-implied concentration and deposition to available datasets. This can be done very simply, but just using, for example, the GEOS-CHEM dust AOD to deposition to surface concentration relationships, and your inferred AOD at that grid box. That will allow you to do a very simple comparison and show that indeed, your approach is (probably) fairly consistent with the other datasets. It probably won't be completely consistent, since none of the models seem to be able to match the AOD, concentration and deposition data the same time.This information could be added to the supplemental material and referenced briefly in the text.

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