Atmos. Chem. Phys. Discuss., 12, C11022–C11027, 2012
www.atmos-chem-phys-discuss.net/12/C11022/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observationally-constrained estimates of global small-mode AOD" *by* K. Lee and C. E. Chung

Anonymous Referee #2

Received and published: 24 December 2012

This paper needs significant additional work, in my opinion. It addresses an important problem, but there are several high-level issues that apply to the paper in general, and I also offer a few point-by-point details.

Main Points

1. The idea that fine-mode particles can be equated with "anthropogenic" aerosol is an oversimplification that matters for the application here. Although most anthropogenic aerosol is sub-micron in diameter, the converse is not true. Dust, wildfire smoke, natural sulfate and secondary organic particles all make the dominant contribution to the fine mode aerosol load in some places and times. For decadal-scale trend analysis, this must be taken into account. This needs to be clarified in the Abstract and the Introduction, but more importantly, it should be dealt with in the analysis and conclusions.

2. The uncertainties in the results need to be explored and discussed. The Quality Statements and related papers covering the measurement products were not taken into account, as they must be to obtain meaningful results. Uncertainties in the model are dismissed rather than assessed. As a consequence, incorrect conclusions about the data products are drawn, even in the early sections of the paper.

3. Sampling is a major issue for many applications, especially for trend analysis. MODIS, MISR, and AERONET have very different measurement patterns and coverage frequencies that depend on geographic location. These differences must be taken into account, as, for example, MISR is likely to under-sample some regions at 0.5ËŽ x0.5ËŽ on a monthly basis. Applying corrections based on data that have been aggregated globally, rather than dealing with differences in retrieval conditions regionally, is likely to produce larger errors than those in the original products.

4. There are several major aerosol trend papers that should be studied and referenced. (1) Zhang and Reid, 2010. A decadal regional and global trend analysis of the aerosol optical depth using a data-assimilation grade over-water MODIS and Level 2 MISR aerosol products. Atmos. Chem. Phys, 10, doi:10.5194/acp-10-1-2010.

This paper does essentially the job proposed in the present study – combining MODIS, MISR, and AERONET data to assess AOD trends – but they do it much more carefully. The Level 2 data are used, as they must be to properly treat sampling (see Point 3 above), and issues with each aerosol product are assessed and accounted for in the analysis. They include a measure of the uncertainty in the derived trends, and conclude that, given the length of the available time series and uncertainties in the products, it is premature to assess AOD trends over land. The challenge for the current paper is to contribute something beyond this study.

(2) Mishchenko, M. I. and Geogdzhayev, I. V., 2007. Satellite remote sensing reveals regional tropospheric aerosol trends. Opt. Exp. 15, 7423–7438.

This paper assesses trends over water using AVHRR data, and identifies regional be-

havior similar to what is deduced in Zhang and Reid 2010. So this paper should be referenced too, but more importantly, the current paper needs to establish that it is contributing something new.

More Detailed Comments

1. Abstract, sentence 1. Anthropogenic aerosols are mostly “small,” but not the converse. Fine-mode is not an indicator of anthropogenic aerosol in many places.

2. Abstract, 3 lines from bottom. Saying the results “quantify the overall anthropogenic aerosol emission. . .” seems overstated.

3. Introduction, P31665, lines 10-12. This is not accurate. See Main Point 1 above.

4. Introduction, P31666, lines 2-3. You can use AERONET to address some of the biases in the satellite data, but it is not correct to say that the resulting data are “at the level of the AERONET data accuracy.”

5. Introduction, P31666, lines 11-14. For air quality, you need the near-surface component of the total column AOD. MODIS, MISR, and AERONET all provide only the total column AOD. The following reference shows how these produces can be applied to air quality, by taking vertical structure into account: Van Donkelaar et al., 2010. Global estimates of average ground-level fine particulate matter concentrations from satellite-based aerosol optical depth. Environ. Health Perspect. 118, 847-855.

6. Section 2.1, P31667, lines 4-5. MODIS retrieves fine-mode fraction only over water. Over land, FMF is not retrieved; it is assumed, based on an AERONET climatology. See: Levy et al., 2010. Global evaluation of the Collection 5 MODIS dark-target aerosol products over land. Atmos. Chem. Phys. 10, 10399-10420, doi:10.5194/acp-10-10399-2010.

7. Section 2.2, P31668, lines 7-8. According to the Data Quality Statement, MISR retrieves three-to-five size bins, depending on conditions, and aerosol microphysical property information diminishes for AOD < 0.15 or 0.2. This is also discussed in Kahn et

al., 2010. Multiangle Imaging SpectroRadiometer global aerosol product assessment by comparison with the Aerosol Robotic Network. J. Geophys. Res. 115, D23209, doi: 10.1029/2010JD014601. As such, evaluating AE as a quantitative rather than a categorical variable is over-interpreting the MISR data.

8. Section 2.3, P31668, lines 22-23. AE is a slope, so extrapolating to fill a missing end-value is very risky, and entails significant uncertainty.

9. Section 2.4, P31669, lines 10-18. What are the uncertainties in making these assumptions about SSA and AE globally? They are likely to be quite large, and the results might not be sufficiently accurate to calculate meaningful decadal-scale trends. The statement on P31670, line 5, that “the accuracy of these GOCART products is not a major concern” needs to be established rather than just asserted. In particular, it will depend on how much interpolation is needed as well as the accuracy of the underlying satellite data, and these in turn probably vary regionally, and maybe also temporally.

10. Section 3.1, P31670, lines 13-14. There is much more subtlety to the MODIS-MISR AOD comparison. The differences vary regionally, and depend on places where specific assumptions in the MODIS and/or MISR algorithms are violated. See, e.g., Kahn et al., 2009. MISR Aerosol product attributes, and statistical comparisons with MODIS. IEEE Trans. Geosci. Remt. Sens 47, 4095-4114.

11. Section 3.1, P31670, line 24. Validating monthly satellite products must take account of differences in sampling, and the results will depend heavily on the way the aggregation is performed (e.g., the use of mean, median, etc., and how the individual measurements are weighted – by area, data quality, counts, etc., see: Levy et al., 2009. A critical look at deriving monthly aerosol optical depth from satellite data. IEEE Trans. Geosci. Remt. Sens., 47, 2942-2956.)

12. Section 3.1, P31671, lines 5-8. MISR monthly sampling at 0.5ËŽ x 0.5ËŽ is likely to be too sparse in some places for trend analysis, and performing statistical analysis based on too few samples will lead to erroneous conclusions. Also, some dusty regions

such as parts of north Africa, and some heavily polluted regions, such as parts of eastern China and northern India, have AOD > 1.0 much of the year. So assuming that AOD > 1.0 is due to cloud contamination in these places is generally not correct.

13. Section 3.1, P31671, line 23 - P31672, line 9. If you fail to take account of the enormous sampling differences between MODIS, MISR, and AERONET, you will of course derive large biases – but this is less an indication of data quality than of AOD variability at a given location, convolved with the measurement frequency of each instrument. This is why you need to consider the number of measurements per bin when using Level 3 satellite data for trend analysis (see Points 11 and 12 above).

14. Section 3.1, P31672, lines 10-11. These “errors” are primarily due to sampling, and the aggregation approach used. To use these data sets correctly, these factors much be taken into account. This is done in some of the papers cited above.

15. Section 3.1, P31672, lines 20-27. Biases need to be corrected regionally, because MODIS and MISR each have strengths and issues that depend on retrieval conditions. Where MISR sampling is limited, it is often better to rely on MODIS, whereas over land, MISR AOD tends to be more accurate than MODIS. Simply adding a “global” factor to MISR will produce wrong results in most places. For trend analysis, especially with a relatively short time series, the considerations discussed above are important. You need to show that your conclusions are robust relative to these factors.

16. Section 3.1, P31673, equation 2. It is not clear what the “grid” is. MODIS and MISR are area values, whereas AERONET are point values.

17. Section 3.2, P31673, lines 16-24. You need to read the Quality Statements and as appropriate, the references cited therein, before using these products. MISR SSA is reported as qualitative – two to four bins, depending on retrieval conditions, and should be considered only when AOD > 0.15 or 0.2. Similarly, the AERONET SSA is considered valid only when AOD_440 > 0.4, and the solar zenith angle is above 50ËŽ.

18. I’ll stop here, as there are many issues with the method that need to be addressed first.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 31663, 2012.