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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global and regional trends in aerosol optical depth based on remote sensing products and pollutant emission estimates between 2000 and 2009" *by* A. de Meij et al.

Anonymous Referee #4

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Review of paper: "Global and regional trends in aerosol optical depth based on remote sensing products and pollutant emission estimates between 2000 and 2009" by A. de Meij et al.

This paper starts by presenting a global, decadal trend analysis of AOD retrieved from the MODIS MISR aboard Terra, as well as from a selection of AERONET stations around the globe. Different resolutions (Level 3 and then Level 2) are used for the satellite data products. Statistically significant negative trends are seen over eastern North America and Europe, with some less robust, but positive trends over South and

East Asia. The paper then relates the AOD trends to changes in emissions of various precursor species, such as decreasing emissions of SO2 and NO2 over Europe and North America, and increasing pollutant emissions over Asia.

I find this paper ambitious. Combining MODIS + MISR + AERONET + emissions is a step forward in the community, and work is timely and very important as the world discusses future environmental impacts. The attempt to quantify trends both at Level 3 and Level 2 is a very good idea.

Unfortunately, I think the paper falls far short of the mark. It is poorly organized, and has a tendency to lead the reader off on tangents. Global and regional single scattering albedo, while given one sentence in the abstract, is not really discussed in the paper (no figures). There are obvious omissions to the cited literature discussing aerosol trends based on satellite data (e.g. many papers by Mishchenko and AVHRR teams). Some of the cited literature (e.g. Zhang and Reid) seems to be cited based on abstracts, without actually reading the papers. While tests for statistical significance are one way to determine robustness of trends, the paper makes no attempt to determine if trends are due to increased "background" AOD values, or increased number of high AOD "events". Trends are also less "believable" due to the use of incomplete annual cycle (Feb 2000-Nov 2009). Waiting until end of Jan 2010 at least look at entire years would have been better idea. Finally, while it is important to trace AOD trends to emission trends, the chemistry and physics of these processes is complicated and nonlinear. Detailed analyses of chemical transport models are probably necessary. The captions on the figures tend to be incomplete. Also, this is kind of strange, but it took me until the middle of the paper, to realize that the comparisons were being made over land only!

I cannot know from reading the paper, but it seems to me that data from MODIS and MISR were used in a carefree way, without much interaction with the satellite science teams. For example, both MODIS and MISR data were made "operational" in Feb of 2000, however it was not until March or April of 2000 that the data were considered sta-

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ble. The Zhang and Reid (ACP, 2010) paper (cited here) shows that at least part of the MODIS AOD trend can be traced to changes in the MODIS instrument itself (calibration drifts?). Levy et al., (ACP, 2010) show that MODIS AOD comparison with AERONET has changed over time. Although the general corroboration between MODIS, MISR and AERNOET helps this paper's case, it should be acknowledged that instrument artifacts will impact a global or regional trend.

Specific comments:

1. Abstract: In general the abstract is qualitative, not quantitative. I think the readers want some specific numbers. The SSA analyses seems unrelated to rest of paper (AOD). I would even suggest removing SSA analysis throughout the paper, because of likely huge uncertainties and lack of validation. The linkage of AOD and emissions is really a modeling effort, and there is too much speculation ("it appears that", "emissions may become", "may have weakened"..)

2. Introduction: Needs a more thorough literature search. Also, is this a study over land only? Or over both ocean and land?

3. The paper should clearly explain what Level 3, Level 2, etc is. It should be done ONCE! Also, why was MODIS-Terra used and not MODIS-Aqua?

4. Methodology section: might be easier to read if some of it was bulleted.

5. For collocation why was geographical range of $\pm$15-30 km chosen? (Reference?) What is the temporal collocation protocol?

6. AERONET section: Probably the errors will not be too large, but AERONET team (e.g. Eck et al., 1999) suggests using quadratic interpolation to retrieve AOD at 550 nm.

7. MISR section: Does small sampling of MISR Level 2 lead to artifacts in Level 3 data?

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8. MODIS section: MODIS isn't really a "camera", it is an imager. The point is that it measures only on a single geometry for each ground target.

9. MODIS section: There is a "deep blue" algorithm (Hsu et al., 2004) that retrieves AOD over bright desert surfaces. At least mention it, and say it is not used here.

10. Emissions inventories: Are there any uncertainty estimates?

11. Results: Here is where I believe that the Zhang and Reid paper (ACP, 2010) was cited, but never read thoroughly. Zhang and Reid clearly stated that they had to do a lot of cloud screening and product screening in order to believe the MODIS AOD product. Are any similar screening/massaging techniques performed here?

12. Results: Entire section! AOD has a strong seasonal cycle in many regions. Care must be taken when attempting to ïňĄt a linear trend to a time series that is dominated by a cyclic variation, especially if the time series doesn't span an integer number of cycles (Feb 2000 to Nov 2009). The seasonal cycle must be accounted for, or at least some statements made as to potential impacts.

13. Results: More quantification is necessary. Statements like "the trends are similar" are not sufficient. A fundamental problem is that the trends from level 2 and 3 MODIS data are plotted for different resolutions. For level 3 the closest 1x1 degree pixel to each AERONET station is used, while for level 2 it is data within a 15-30 km radius. Are differences due to averaging/sampling/aggregation methods?

14. MODIS L2 and emissions: Why are chemical equations listed here? Why not the introduction, if at all? Also, gas to particle conversions are not really as linear as a few chemical equations suggest. There are many more, plus interaction with clouds and hydrologic cycles. Chemical transport models should be used or at least acknowledged.

15. Figures:

a. Fig 1. Really makes no sense for the difference between red dots and blue dots

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b. Fig 2. Why plot the same information 2 or 3 different ways? Bottom row of panels is really confusing. The x-axis suggests confidence > 95% but the plot shows values from -1 to 1.

c. Fig 3: What are the locations? Are these AEROENT sites? These are plots of satellite trends, what about the trends from the AERONET sites? Do they agree?

d. Fig 4: Incomplete year cycles are a problem. The fonts are too small to be read clearly. Maybe by "deasonalizing" (normalizing with respect to average seasonal cycle), the trends would be much clearer.

e. Fig 5: Same questions as Fig 3, and the caption is even less descriptive.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 30731, 2010.