Multidecadal trend analysis of aerosol radiative properties at a global scale
Coen et al.

This manuscript collates data from a number of ground stations making aerosol measurements around the world. The authors are to be commended on the effort of making these data as consistent as possible. Doing this work is extremely important. Most of the major conclusions about trends are already known but it is a solid piece of work.

I have two major concerns with the manuscript and some other general concerns. The first major concern is overstatement about the global scale of these data. The second is a lack of the context provided by satellite data.

First, the manuscript claims in the title to be at a global scale and makes statements about global trends (for example page 25 line 5 "leading to global positive median trend of 0.02%/y"). There is just no way that the stations in the manuscript represent the global scale. In figure 12, there are 46 stations, 32 of which are in North America or Europe. Other figures are very similar. That means about 2/3 of the data are from less than 7% of the area of the Earth. In Figures 4 through 11 there are no stations in South America, none in the vast majority of Africa, and none on the main continent of Australia. You can't claim a global scale when entire continents are missing. Furthermore, the station locations are probably biased to regions with decreasing trends. Regions with recent decreasing trends in aerosols, such as North America and Europe, are heavily represented. On the other hand, regions with increasing trends in aerosol in the last decade or two, such as India and the Mideast, are not represented in the figures.

One specific statement is the conclusion (page 24 line 40) "Results from this study provide evidence that the aerosol load has significantly decreased over the last two decades in the regions represented by the 52 stations" is very misleading and should be changed. It should read something more like "The stations considered confirm decreasing trends in North America and Europe. Trends elsewhere are scattered, with too few stations to understand global trends." The rest of the manuscript should be similarly less definite about a global scale.

Second, the manuscript perpetuates an unfortunate situation in the literature that the in-situ and satellite researchers rarely make use of the other. I often tell satellite researchers they need to consider the in-situ data. Here the in-situ researchers need to consider the satellite data. Why should this manuscript be the one to do that? It claims a "global scale", and that definitely means including some satellite data.

In the present manuscript, satellite data are dismissed saying the ground stations have longer records (line 16, page 3). This is mostly untrue. MISR and MODIS both have 20 years of data, making their record longer than all but a handful of ground stations (and almost all of those handful are in the United States). SeaWifs has an even longer data record (Hsu et al., 2012). for the entirety of satellite data, the manuscript has only one oddly chosen reference about measurements in South Korea.

MISR and the newer MODIS retrievals provide aerosol optical depth over land as well as ocean. They measure more than optical depth. MODIS measures the Angstrom coefficient for scattering. MISR has a measure of the single scattering albedo, with some difficulties in the measurement but good enough for trends in some locations.

I am not asking for a major review of how satellite data relates to long-term, ground-based measurements. I do think it is reasonable to ask you to show a figure with a map of satellite-derived trends in optical depth, Angstrom coefficient, and possibly aerosol absorption (optional, since the satellite absorption data are a bit trickier). The period could be something like 2009-2018 or 2004-2018 to match most of the ground sites. Then use that figure to put your ground stations in context. It isn't that hard to produce such figure. Out of 40+ authors there should be somebody who has experience using satellite data. If there isn't, it says something about our field. I'm copying one of your figures next to some satellite context below.

For discussing the context from satellite data, one important reference is Zhao et al. (Environ. Res. Lett, 2017) because it shows trends in not only optical depth but also detailed optical properties such as single scattering albedo for the Eastern US, Europe, and China. At a quick glance, those trends seem consistent with the ground stations; you can do a better analysis.

Environ. Res. Lett. **12** (2017) 054021 Letters

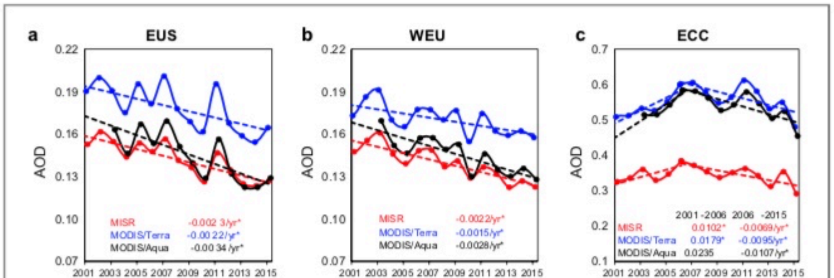


Figure 2. Annual mean AOD during 2001–2015 observed by MISR, MODIS/Terra, and MODIS/Aqua in three target regions. The dashed lines and the numbers in the legends represent trendlines and slopes (yr^{-1}) determined by linear regression, respectively. The slopes are marked with a star (*) if they are statistically significant at the 0.05 level based on Student's *t*-test. The trends and their statistical significance determined by the Mann–Kendall test associated with Sen's slope are shown in table S1.

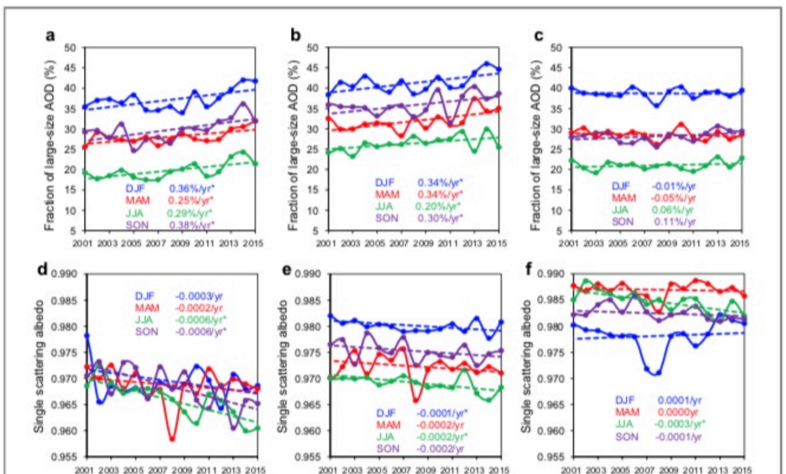


Figure 5. Seasonal mean fraction of the large-size AOD and single-scattering albedo during 2001–2015 observed by MISR in three target regions. The fraction of large-size AOD: (*a*) EUS, (*b*) WEU, and (*c*) ECC. Single-scattering albedo: (*d*) EUS, (*e*) WEU, and (*f*) ECC. The dashed lines and the numbers in the legends represent trendlines and slopes (yr^{-1}) determined by linear regression, respectively. The slopes are marked with a star (*) if they are statistically significant at the 0.05 level based on Student's *t*-test. The trends and their statistical significance determined by the Mann–Kendall test associated with Sen's slope are shown in table S3.

Alfaro-Contreres et al. (2017), Wei et al. (2019), and Murphy (2013) show the context that the region from the Mideast to India (with no ground stations) has had increasing trends in aerosol.

R. Alfaro-Contreras et al.: A study of 15-year aerosol optical thickness **13857**

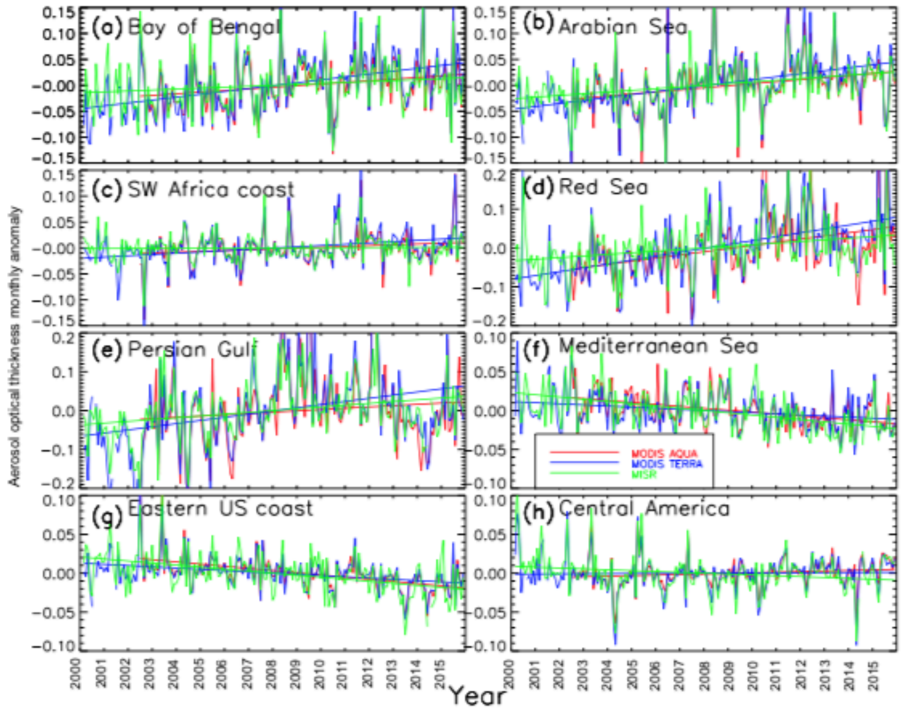
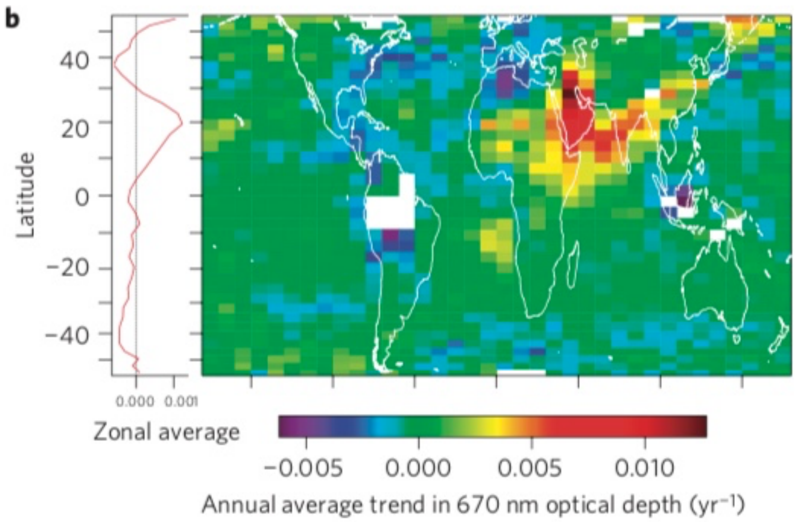


Figure 4. The deseasonalized, monthly and regionally averaged AOTs for eight selected regions utilizing MODIS C6 DT and MISR aerosol products. Straight lines are linear fits to the monthly data.



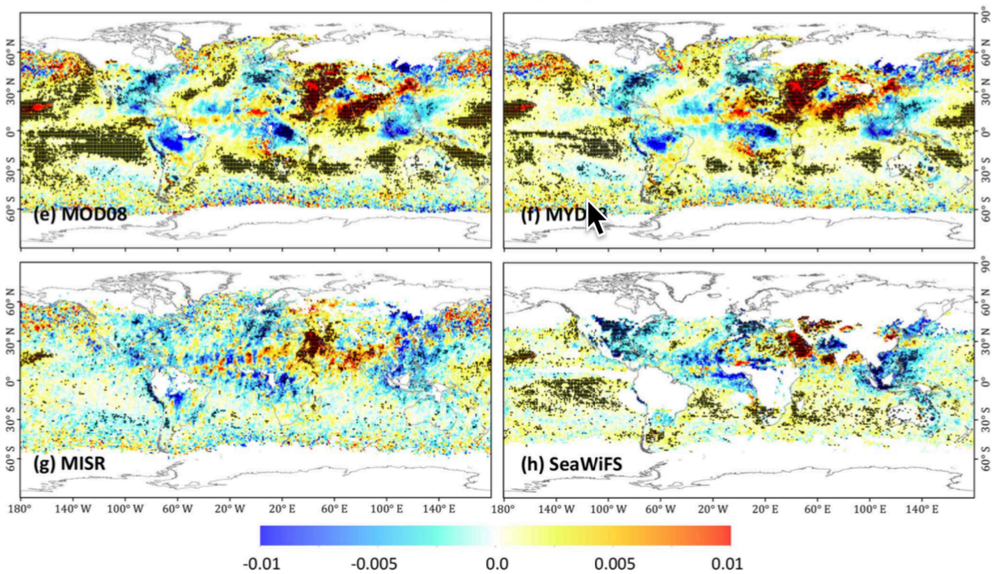
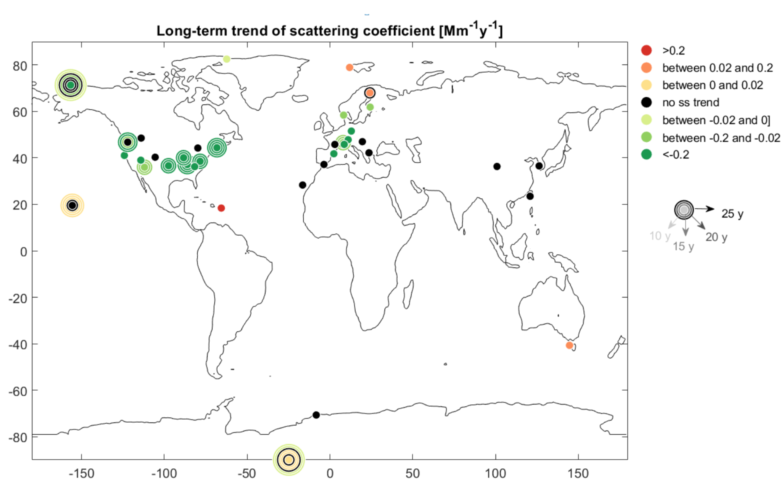


Figure 14. Linear trend based on deseasonalized monthly AOD_S anomalies from 2003 to 2010. Units are AOD yr^{-1}. Black dots indicate a significant trend at the 95 % confidence level ($p < 0.05$).



igure 4: MK trends results for the scattering coefficient. Black symbols correspond to stations

You can also look at Mehta et al., Remote Sensing of the Environment, 2016 Kahn and Gaitley JGR 2015, Hsu et al., ACP, 2020, “Global and regional trends…”, Wei et al., ACP, 2019, “Intercomparison in spatial distribution and temporal trends”. This is not a comprehensive list.

Finally, I have two lesser general concerns. The first is to think about how extreme events can affect trends. There are aerosol events that are so large they can change even a decade-long trend with a single event. I would bet that the recent Australian fires were big enough to change the trends for that region, indeed large swaths of the Southern Hemisphere, for an entire decade. The 1997-98 Indonesian fires also were big enough. There may be other such events in your data series. This doesn’t disprove the validity of your statistical analysis, just look at the time series and comment if appropriate.

The other general comment is that most of section 4.4 is speculation without supporting evidence.