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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assessment of the effect of air pollution controls on trends in shortwave radiation over the United States from 1995 through 2010 from multiple observation networks" *by* C.-M. Gan et al.

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The authors have combined a wealth of relevant data to assess the effect of air pollution controls on trends in short wave irradiance measured at seven BSRN sites in the USA between 1995 and 2010. Their results are interesting and innovative with somewhat speculative explanations suggested. Hopefully the following comments will help clarify and enhance this study.

We thank the reviewer for the overall positive assessment of the analysis presented in

the manuscript and for the suggestions, which have led to a much improved manuscript.

23720 lines 21-22 repeat lines 17-18

Lines 17-18 refer to all-sky variables while lines 21-22 refer to clear-sky variables.

23723 lines 23-28 A brief explanation of the methods used to estimate daytime cloudiness is required. In view of its importance citing references is not sufficient.

A brief explanation has been added in the revised manuscript.

The cloud cover for an effective 160o field of view is derived based on the analysis of surface measurements of total and diffuse downwelling SW irradiance (Long et al. 2006). Along with the already identified clear-sky data (Long and Ackerman, 2000), those optically thicker overcast cases are identified, after which an empirically derived formulation is used to estimate the fractional sky cover for the remaining measurements. The retrieved cloud cover time series is then assessed to mitigate times of inconsistent minute-to-minute behavior caused by the most difficult identification range of the radiation parameter used for the thick overcast screening versus empirical formula determination of cloud cover amount. The details of the cloud cover retrieval is available in Long et al., 2006.

23724 lines 11-14 how many years data was removed?

The data completeness requirement did not result in removing any years from our analysis. The only effect was to discard the first year of measurements at some of the SURFRAD locations since these measurements did not cover the entire year. The length of the observation record at each site listed in Table 1 already reflects this adjustment, i.e. none of the years contained in the listed time spans were removed from the trend analysis. This has been clarified in the revised manuscript.

2.5 Trend estimation Measured data should be presented in addition to the anomalies which are examined. This would allow the reader to obtain a clearer picture of the magnitude and significance of the trends examined.

We presented the anomalies to show the consistency in the trend across the sites. We agreed with the reviewer that some readers may be interested in the magnitude at each site. For the sake of completeness, we now present this additional information in a supplement section to the manuscript. Please see supplemental material (page 2-7) with this reply. Figures 2, 4, 5, 6, 7 and 8 show time series of actual values rather than anomalies.

23728 Unclear why the usually recommended non-parametric statistical test (i.e. Mann-Kendall) was not used to establish the significance of the trends after pre-whitening the data to remove the effect of auto-correlation commonly found in climate data sets. This avoids the assumptions adopted.

This approach was adopted for consistency with recent studies on AOD trends by Hsu et al. (2012) and de Meij et al. (2012).

3. Results and discussion. Rather long, repetitive and diffuse. Shortening and clarifying perhaps by separating into two sections.

Thank you for the suggestion. Due to the complication of the study (i.e. various data sources), it will require a significant amount of effort and time to restructure this section. However, we are able to break this section into 3 sub sections to clarify the discussion.

The results presented in Figs. 2-8 should be replaced or supplemented by double mass plotting of the relationships between SO2, SO4, NOx, NO2, PM25 AOD and the fluxes of short-wave radiation. This would provide a direct and quantitative examination of the relationships at present discussed in a rather diffuse and general fashion

Double-y plots of AOD vs. clear-sky SW down and PM2.5 vs. clear-sky SW down are presented in the supplemental material (page 8). These variables illustrate a more comparable relationship with the clear-sky SW down because the AOD measurement corresponds to the total column while the PM2.5 represents all species in general. Thank you for the suggestion, this graph show a direct anti-correlation between AOD

with clear-sky SW down as well as PM2.5 with clear-sky SW down for both region. This graph has been added to the revised manuscript.

23732 line 10 the units of cloud cover (1yr-1) undefined and unclear.

Cloud cover is unitless in this study. Cloud cover (also known as cloudiness or cloud amount) refers to the fraction of the sky obscured by clouds when observed from a particular location. This definition is added into the revised manuscript (section3.3). In this study, the annual mean was calculated for all variables so all trends are per year.

23733 lines 15-16 'biasing the AOD retrievals low' unclear.

The increase of diffuse SW is caused by the cirrus cloud but not the actual aerosols in the atmosphere which leads to a bias in the AOD retrievals. Since the AOD observations from SURFRAD are derived from radiation (MFRSR) measurements rather than measured directly, there is a possibility that some amount of AOD may be caused by cirrus clouds rather than aerosols.

line 18 What does 'the' aerosol mean?

Anthropogenic aerosol

23736 line 19 unclear, word/s missing after/before clear sky.

Thank you for catching that. It means clear-sky SW radiation.

For all-sky SW radiation, the "brightening" occurs at the same time that cloudiness exhibits a decreasing trend suggesting indirect effects caused by the decreasing aerosols. The clear-sky SW radiation may be associated at least in part with a decrease in the direct effects of aerosols, particularly in the eastern U.S. where substantial reductions in anthropogenic emissions of SO2 and NOx, (Xing et al., 2012; Hand et al., 2012) resulting from the implementation of control measures have resulted in a decrease in the tropospheric aerosol burden.

Table 1 The co-ordinates and elevation of the sites needed.

We have added this information to Table 1.

Fig 1 It would be useful to add contours to this figure showing fossil fuel combustion in the USA over the 1995-2005 period under study.

Fig 1 is intended to show the geographical information of the sites of different networks, so adding the contours of fossil fuel combustion may make it difficult to read and add confusion. In the revised manuscript Figure 2 shows the site SO2 and NOx emission anomaly trends and Figure 3 shows the regional trends in emission magnitude. Trends in fossil fuel combustion in the east and west regions should be evident from these figures.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C9477/2013/acpd-13-C9477-2013-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 23719, 2013.