Atmos. Chem. Phys. Discuss., 12, C4724–C4732, 2012
www.atmos-chem-phys-discuss.net/12/C4724/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric impacts on climatic variability of surface incident solar radiation" *by* K. Wang et al.

K. Wang et al.

kcwang@bnu.edu.cn

Received and published: 15 July 2012

The authors would like to thank Dr. G. Stanhill for his detailed and helpful comments. Below are our point by point responses to his comments.

OVERALL

1) Comment: This ambitious study relates changes in mean monthly and decadal values of sunshine duration measured at over 1000 stations between 1982 and 2008 to changes in global radiation, cloud cover and aerosol optical depth in an attempt to assign causes for the observed changes. It concludes that cloud cover controls variation on monthly time scales whereas aerosols are the major factor determining decadal variability. Unfortunately the methods used and the findings derived are not clearly

presented so that substantial revision is required before publication of this manuscript can be recommended.

Response: The authors thank Dr. Stanhill for his comments on our work and his detailed and helpful comments to improve the readability of this paper.

GENERAL COMMENTS

2) Comment: Changes in cloud cover and aerosol load both influence global radiation but their interaction, the important part that aerosols play in the formation of clouds and in determining their radiative characteristics, makes it difficult to separate their roles: this complicating interaction is not discussed in the paper. Neither is it explained how cloud cover can control global radiation on a monthly time scale without influencing it on a decadal basis nor how aerosols can exert a control on a decadal time scale without influencing monthly values. A general comment based on Ockham's Razor (âĂŘEntities are not to be multiplied without necessityâĂŘ) applies to two specific points: the symbols used and the literature cited. Many years ago the World Meteorological Organization in its Guide to Instruments and Methods of Observation recommended the nomenclature and symbols to be used for sunshine duration and global radiation; there is no reason for the authors not to use them. The authors frequently cite recent publications, often their own, to document facts clearly established many years ago; an example is the close relationship between sunshine duration and global radiation established by Kimball in 1919 and Angstrom in 1924. By contrast the extensive literature dealing with quadratic forms of this relationship, reviewed by Akinogle in 2008, is ignored despite their relevance to this study.

Response: It is very difficult to separate the impacts of clouds and aerosols on surface incident solar radiation. It is more complicated by the interaction between clouds and aerosols. This paper does not intend to do this. We only try to illustrate that (1) sunshine duration derived surface incident solar radiation (Rs) reflects the impact from both clouds and aerosols; (2) which one is more important on different time scales?

ACPD

12, C4724–C4732, 2012

Impact of clouds on Rs is substantial and it is also the case for changes of cloud cover in short time periods, such as hourly, daily and monthly. Therefore, its impact on Rs is obvious. However, changes of cloud cover may be insignificant at annual or decade scales. Under this condition, its impact on long-term variation of Rs is also small. However, although aerosol impacts on Rs are small, its impact on the long-term variation of Rs may be important if atmospheric aerosol loadings keep increasing or decreasing, as in China and Europe. In this paper, we show that sunshine duration derived Rs can capture these impacts of aerosol on Rs in Europe and China.

We searched World Meteorological Organization (WMO) Guide to Instruments and Methods of Observation by Google and found that the document has been removed from the website of WMO. We did look for its new version (Measurement of Meteorological Variables, 2008). The major difference between this WMO guide and our paper is that we use "surface incident solar radiation" instead of "global radiation". Currently, surface incident solar radiation is widely accepted by meteorologists, hydrologists and ecologists. We have to use "global" to refer "the whole earth" or "the land of the earth" in this paper. It may introduce some misunderstandings to use "global radiation".

We did cite some old papers, such as Angstrom (1924) and Prescott (1940). However, these old references are generally inaccessible to the authors and the readers. It is also the case for the book chapter. We thank Dr. Stanhill for pointing out Akinoglu (2008) and we found Kimball (1919) in this book chapter. Both references will be cited in the revised paper. In addition, earlier references generally regarded sunshine duration as a measurement of cloud cover and did not address the impact of aerosols on sunshine duration.

Akinoglu, B. G.: Recent Advances in the Relations between Bright Sunshine Hours and Solar Irradiation, in: Modeling Solar Radiation at the Earth's Surface, edited by: Badescu, V., Springer Berlin Heidelberg, 115-143, 2008. Kimball, H. H.: Variations in the total and luminous solar radiation with geographical position in the United States, Monthly Weather Review, 47, 769-793, 10.1175/1520-0493(1919)47<769:vittal>2.0.co;2, 1919.

ACPD

12, C4724–C4732, 2012

SPECIFIC COMMENTS

3) Comment: p.14013 line 4 This early reference is to global radiation under clear sky conditions, i.e Rc not Rs as defined here which is now used after Prescott's modification for all sky conditions.

Response: We checked Angstrom (1924) and Akinoglu (2008), and found that Angstrom (1924) did address the Rs but with a different definition of Rc, surface incident solar radiation under a perfect clear day. Kimball (1919) will be cited here in the revised paper.

4) Comment: p. 14013 line 9âĂŘ p.14014 line 4. Unclear why Yang's 2006 study is presented here and what is its relevance to this study. Where does the Rc data come from?

Response: We found this equation from Yang et al. (2006) and our method generally follow Yang et al. (2006). Rc is calculated from surface meteorological observations of temperature, relative humidity, which is described in Yang et al. (2006). These data are from the National Climate Data Center Integrated Surface Hourly Database. We will add this information into the revised paper.

5) Comment: p.14014 line 9. Unclear; the basis for the statement concerning relative quality of data needs to be given.

Response: We claimed this because of the discussion in Section 3.3 (related information will be added into the revised paper).

6) Comment: p. 14015 lines 6âĂŘ19. Unclear, what does this analysis refer to? The statistics of the relationships presented in Figs. 2 and 3 are needed.

Response: Here we are discussing Figs. 2 and 3, and Table 1. The statistics of the relationships presented in Figs.2 and 3 are shown in Table 1. Table 1 also shows the statistics for other stations.

ACPD

12, C4724–C4732, 2012

7) Comment: p. 14016 lines 9âĂŘ17. Unclear, the Chinese radiation data is clearly not reliable before the network was upgraded and therefore should not be used in any way.

Response: We are not saying that Chinese radiation data is unreliable before the network upgraded. We are saying that the replacement of China-made pyranometer with Russian-made pyranometer introduced data discontinuity in the early 1990s, i.e., 1990-1993. Data before or after this period time are both reliable.

8) Comment: p. 14017 lines 1âĂŘ2. Unclear what is the basis for the poor agreements as the reference cited reports a correlation coefficient of 0.926 and a root mean square error of 5% for mean annual values of global radiation estimated from a linear regression on annual sunshine duration.

Response: Here we are referring to the long-term variations, such as decadal variations. We found the following sentences in the Abstract of Stanhill and Cohen (2005): It is concluded that the U.S. sunshine duration database shows little evidence for a significant trend in solar forcing at the earth's surface during the twentieth century. To reconcile this discrepancy with reports of decreases in EgâĘŞ measured in the United States during the last half century requires a more detailed understanding of the influence of clouds and aerosols on sunshine duration.

As Dr. Stanhill is the first author of the cited paper and he has raised this comment. We plan to remove the related sentences from the revised paper.

9) Comment: p. 14017 line 7. Not so, Fig. 1a shows the limited global coverage of sunshine duration measurements.

Response: Fig. 1a shows that stations where data are available to us. We mentioned this in the figure caption of Figure 1. A lot of countries did not report their sunshine duration data to WMO, such as Australia. We plan to revised "worldwide" into "in many regions" in the revised paper.

ACPD

12, C4724–C4732, 2012

10) Comment: p. 14017 lines 15âĂŘ16. Unclear basis for division.

Response: We tried to merge the data into regional averages. The regions are shown in the caption of Figure 1. We divided the land into these six regions according to their geographical locations and data availability, as shown in the caption of figure 1.

11) Comment: p. 14018 lines 5âĂŘ12. Unclear exactly what data used. The relationship between relative sunshine duration and cloud cover has been documented on a diurnal, daily, weekly and monthly basis and there is some evidence that this is so for annual time scale as is logical to expect.

Response: Here are referring to Figure 10. The data used here are from the National Climate Data Center Integrated Surface Hourly Database. We will add this information into the revised paper. Figure 10 shows the conditions on the monthly scale. The conditions for annual or longer time scales are shown in Figures 9 and 11. See also our response to "GENERAL COMMENT".

12) Comment: p. 14018 line 14. No correlations are presented in Fig. 11

Response: We would like to leave no correlations for Fig. 11 as conditions changed with time.

13) Comment: p.14019 lines 9âĂŘ10. Was the data preâĂŘwhitened before applying the MannâĂŘKendall test? As less than half of the stations had significant trends these merged results are unconvincing.

Response: We did not pre-white the data. We agree with Dr. Stanhill on the significance of the trend.

14) Comment: p.14021 line 1. 1982âĂŘ2002 hardly constitutes a long term series.

Response: 1982- 2008 is the data we studied here. Sunshine duration is more widely available both temporally and spatially. We will revise the related sentences to: SunDu is much more widely available and provides a long-term time series dataset where

ACPD

12, C4724–C4732, 2012

direct measurements are not available, such as in South Asia and South America. Akinoglu (2008) further pointed out that it is the only long term, reliable and readily available measured information that can be used to accurately estimate Rs. Thus, estimation of Rs by SunDu is useful as a complement to the globally sparse direct measurements, even in Europe where its direct measurements have the highest density. In this study, we investigated the variability of Rs derived by SunDu from 2002 to 2008.

15) Comment: p.14021 lines 15âĂŘ20. Unclear and unconvincing.

Response: Thanks for pointing this out. We will revise the sentence as follow: As such, they would be useful to constrain climate model parameterizations that generate Rs variability. Monthly variability of Rs is controlled in most regions by variability of cloud cover. The decadal variability of Rs in Europe, China, and North America (primarily Canada and Mexico), is dominated by variations in tropospheric aerosols.

16) Comment: p. 14026 Table 1. Table heading not clear, if the 6th, 7th and 8th columns represent the statistics of linear regressions of estimated on measured global radiation the very high correlation coefficients contrast with the significant bias and standard deviation terms. They are particularly questionable from China if the early, unreliable pyranometer data was used. The anomalies correlated are not defined, their bias is not shown and it is unclear what the last column refers to.

Response: These results are calculated. The bias and standard deviation are small compared with multi-year averaged Rs as shown in the last column. We are not saying that Chinese radiation data is unreliable before the network upgraded. The replacement of China-made pyranometer with Russian-made pyranometer introduced data discontinuity in the early 1990s, i.e., 1990-1993. However, both data before or after this period of time are reliable. This discontinuity did not impact much on the statistical result. Monthly anomalies are calculated by removing the seasonal cycle. We will add this information into the revised paper. For the comparison between monthly anoma-

ACPD

12, C4724–C4732, 2012

lies, the bias does not have a physical meaning because the averages of anomaly are zero. As mentioned, the last column is the multi-year averaged Rs at the station.

17) Comment: p. 14035 Fig. 6 Linear trends cannot be derived statistically from fiveâĂŘyear smoothed data and are in any case obviously inappropriate for the time series shown.

Response: The linear trend is calculated from annual anomalies rather than five-year smoothed data. We will add this information to the revised paper.

18) Comment: p. 14036 Fig. 7 Clearly shows that the earlier Chinese pyranometer data should not be used.

Response: This figure shows that the replacement of China-made pyranometer with Russian-made pyranometer introduced data discontinuity in the early 1990s, i.e., 1990-1993. However, data before or after this period time are both reliable.

19) Comment: p.14037 Fig. 8 Unclear what baseline stations means. Did the pyranometers used differ from the rest of the Chinese network?

Response: These stations belong to the regional centers of Chinese Meteorological Administration, and maintained at a higher level. We don't have information on the pyranometer.

20) Comment: p.14038 Fig. 9 Basis for division into six regions unclear.

Response: We tried to merge the data into regional averages. The regions are shown in caption of Figure 1. We divided the land into these six regions according to their geographical locations and data availability, as shown in the Caption of Figure 1.

21) Comment: p. 14039 Fig. 10 This figure would be much more informative if cloud cover fractions and not cloud cover fraction anomalies were correlated and their distribution plotted. Information is needed on the source of the data used and which sites had low and statistically non significant correlations.

ACPD

12, C4724–C4732, 2012

Response: We believe the anomalies are better as they remove the seasonal variations. We will add the data information. We will discuss the reason for the non significant correlations in the main text.

22) Comment: p.14040 Fig. 11 Caption very unclear

Response: We will make it clearer.

23) Comment: p.14041 Fig. 12 Last sentence of caption misleading; correlation should not be made with data that is not independent such as the fiveâĂŘyear smoothed data used here. Even if independent data was used the fact that at nearly half of the stations changes in AOD accounted for less than 25% of the changes in global radiation argues against the claim made in the last line. Finally if all correlations were carried out with independent data, were statistically significant and had coefficients of determination of R2 = 1.00 âĂŘcorrelation is no proof of causation.

Response: Yes. We agree with Dr. Stanhill that the correlation is no proof of causation. However, the aerosol optical depth (AOD) and Rs are physically connected and changes of AOD can introduce changes in Rs. This has a solid physical meaning.

23) Comment: p.14042 Fig. 13 Unclear

Response: We will make it clearer.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 14009, 2012.