

# ***Interactive comment on “Urbanization effect on sunshine duration during global dimming and brightening periods in China” by Yawen Wang et al.***

## **Anonymous Referee #1**

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This paper uses the sunshine duration data from 1960 to 2013 over 344 stations in China to analyze (1) if the solar “dimming” and “brightening” is global or local, and (2) the urbanization effects on the “dimming” and “brightening” trends. While this paper reports some interesting features and includes large amount of data and auxiliary information, there are several fundamental shortcomings of this work, including the methods and the conclusions. My major concerns are listed below.

1. Sunshine duration and dimming/brightening: These terms are used interchangeably sometimes in the paper and yet they are differentiated other times, which causes confusing. For one thing, the sunshine duration is mostly determined by the cloud cover. If the authors want to use the sunshine duration as a surrogate for downwelling solar

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radiation reaching the surface, they should at least stratify the sunshine duration according to the cloud cover, e.g., at cloud fraction <5%, <10%, or 20%, in order to get information on the role of pollution and clouds on sunshine duration. Without this first step, the results and conclusions about the urbanization effect on sunshine duration, which is a center focus of this paper, cannot be substantiated.

2. Urban and rural pair: Why is pairing necessary? It makes no sense to me to come up with those pairs. What is the criterion for pairing? Distance, or wind direction? Many of them are very close with each other and it is impossible to link one rural site to a particular urban site to form a meaningful pair. Also, I cannot find any advantage of using the pairs in the analysis presented in the paper. It would make more sense to just categorize the available sites into “urban” and “rural” instead of pairing them. In this way, you don’t have to exclude any sites due to the lack of “partner”, such as Beijing, Shanghai, and Tianjin.

3. Urban or rural: It is not clear how the sites are defined; considering the fast urbanization level shown in Fig. 5 from <20% in 1960 to >50% in 2013, is there any rural sites in the 1960s became urban sites in later years? How is the information on urbanization level, urbanization speed, urban population, and population density used consistently at the places where these indicators are showing different indications? For example, Fig. 7 shows that the urbanization level is among the highest but the urbanization speed, population, and population density are among the lowest in the nation in the most northeast province (Heilongjiang)?

4. Urbanization vs. cloud cover change: The authors concluded that the trends of sunshine duration cannot be explained by the change of cloud cover, since both sunshine duration and cloud cover show decreasing trends before 1990, and after 1990 sunshine duration does not seem to change but cloud cover has increased. Rather, they attribute the sunshine duration trends before and after 1990 to urbanization and environmental regulation. This conclusion has several problems. First, as I suggested above in comment 1, the analysis should be stratified with cloud fraction. Second, Fig.

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4 clearly shows anti-correlation between the interannual variation of sunshine duration and cloud cover: less cloud fraction, more sunshine duration, even though the trends do not seem to be consistent. Third, the urbanization levels have three distinct time periods according to Fig. 5: 1960-1978 (almost no change), 1978-1995 (moderate increase), and 1995-2013 (faster increase), which does not correspond to the sunshine duration trends, especially before 1978.

5. Dimming and brightening time periods: This is another confusing point. On the one hand, the authors claim the two periods of 1961-1989 and 1990-2013 that are “global dimming and brightening” periods, sounded like they are determined by the trends of downwelling solar radiation at the surface globally; on the other hand, it is stated in the paper that the periods are defined by the change point of sunshine duration trends in China. So, these two periods should not be called dimming or brightening periods, but the sunshine duration decreasing and no change periods. However, it is clear from Fig. 2 and also stated in the paper that half of the country is continuously showing the decrease of sunshine duration in the second period of 1990-2013, which indicate that the apparent “stable” trend of sunshine duration in 1990-2013 is not really stable but misleading, since is a result of averaging the positive and negative trends at different places.

6. Global or local: This argument is pointless. The authors use the sunshine duration trends over paired “urban” and “rural” sites in China to determine if the dimming/brightening are global or local phenomenon: If the paired sites are showing different trends then it is “large scale” (note: the authors do not call it “global”), but if the trends are different it could be considered as “local”. This is kind of meaningless, because a) the “local” spatial scale is not defined, and b) even if all sites have the same trends, it still does not mean global, since all sites are located in China. This paper should just focus on the trends from >50 years of data, rather than discuss if the trends are global or local.

7. Urbanization and pollution emissions: There are many emission datasets available

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for the study period. It would be illuminating to see how the sunshine duration trend at low cloud cover conditions corresponds to the emission trends of pollutants.

Overall, it requires major revision of the current paper. The analysis and methods should be redesigned to get meaningful results and conclusions.

Specific comments:

Page 1, line 14: Not clear how the dimming and brightening phases are determined.

Page 1, line 16: I am not aware of anyone had suggested urban dimming/rural brightening.

Page 2, line 27-28: You should at least check if AOD and API available in recent years are consistent with the sunshine duration, so you may use the sunshine duration as a proxy for pollution levels.

Page 3, line 2: “inhomogeneity” of what?

Page 3, line 7-8, objective (2): so the dimming and brightening are “global”? How do they relate to sunshine duration?

Page 3, line 16-17: Do you define the two periods according the sunshine duration trends? How do you explain the different trends in different areas (Fig. 2)?

Page 4, line 7: difference of 0 deg N and 0 deg E means the rural and urban stations are in the exact same locations? Why do you want to replace 19 stations? This is confusing. Also, as I mentioned earlier, you have not explain why selecting pairs are necessary.

Page 5, line 4-5: On page 3 the authors stated that the dimming and brightening periods were determined “according to the change-point in the early 1990s in sunshine duration trends in China evidenced by recent studies”, but it is said here that the time periods were “GLOBAL dimming and brightening” periods! It is confusing and it should really be clarified how the two time periods were determined and why.

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Page 5, line 9, large scale or local phenomenon: Need to be more specific about the scale – is provincial scale considered as local or large scale? I suggest use “. . . a wide spread phenomenon. . .” to be more appropriate.

Page 5, line 17-20: If only half of China is brightening while the other half is still dimming, why do you decide this is the phase of brightening, not dimming?

Page 5, line 25-27: But you just said a few line above that half of China is still dimming! Does it mean that the transition from dimming to brightening is a local scale phenomenon, not a countrywide phenomenon?

Page 5, line 30: Repeating the question I had earlier: does urbanization convert any rural sites to urban sites? Does the fixed urban/rural sites make sense for the entire 54 years?

Page 6, line 4-5 and 14: “stabilize” or “stable” are not used properly. Do you mean constant or unchanged?

Page 6, line 7: explain what “pre-reform” period is.

Page 6, line 12-13: What kind of environmental protection laws? How many of them are related to pollutant emission regulations that are relevant here? How effective are they? Why the regulations work differently in China as half of the country showing the increase of sunshine duration but another half continuously showing the decrease? Can you use the pollution emission datasets to corroborate with the effectiveness of the law?

Page 6, line 14: I don’t understand the argument here – why is the strongest decline of sunshine duration in the 1980s when the environmental regulations started being implemented?

Page 6, line 16: clarify what you mean by “transition from extensive to intensive”.

Page 6, line 26: There is not enough evidence to support the conclusion of urbanization

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effect on sunshine duration. Showing their respective trends does not mean causal relationship.

Page 6, line 31: Where is this “widening urban-rural contrast” shown? Fig 4A does not seem to suggest a “widening” trend.

Page 7, line 10, first sentence: not substantiated.

Page 7, line 16-17: I cannot see these relationships between Fig 2 and 7. For example, the dimming/brightening trends in the NW province (Xinjiang) have the same size as the trends in the eastern coastal provinces shown in Fig 2, but the urbanization level, speed, population, and population density in Fig 7 are very different between Xinjiang and eastern coastal provinces.

Page 8, line 14-15, (1): no air pollution emissions are shown in the paper.

Page 8, line 15, (2): is this a conclusion?

Page 8, line 19: clarify what “a large overlap” is.

Page 8, line 10-21: How big is the region to see the “regional phenomenon”? Certainly it is not the entire China.

Page 8, line 28-29: “As a consequence...” Not true. The apparent insignificant trend is the consequence of averaging half positives and half negative trends together to make the overall mean trend flat. There is no solid analysis provided in this paper showing the effectiveness of the air pollution control on the sunshine duration.

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