Overall comments

Ma et al. proposed a RHtest-quantile approach to harmonize the observed and SunDu-derived incident solar radiation. This topic is important, and the Harmonized multi-source solar radiation data is valuable for the study of local dimming and brightening and multiple ecology processes. However, there are many major issues should be addressed. I have some comments that I hope can help improve manuscript quality.

Major comment

1. Comment:

Quantitative accuracy and uncertainty of the harmonized dataset are missing. Please show more metrics or evidence to present the accuracy and uncertainty of the proposed dataset. This is very important for users. Because the author harmonized the observed and SunDu-derived solar radiation simultaneously, so it's less convincing to use the comparison results of these two datasets before and after homogenization showing the feasibility and validity of the proposed approach. In addition, the figure showing comparison results (Figure. 4) needs to be improved because it's not easy to see the improvement of the close relationship between observed and SunDu-derived solar radiation after the homogenization.

Response：

Thanks for the reviewer's comments and we highly appreciate these constructive comments. In the revised paper, we rewrite the Introduction part and review more on the homogenization methods. In Section 2.2, more details in how to use the RHtest method to homogenize the raw R_s observations were added. Compare to simple method proposed by Katsuyama (1987), RHtest method provides more option for us to check the changepoints in the raw data series. We add three new figures (Figs. 4-6) to demonstrate the differences between observed R_s and SunDu-derived R_s after homogenization generally become smaller than those before homogenization. Furthermore, exploring the relationship between R_s and other independent variables such as clouds and aerosols provides an alternative way to determine whether the variation in R_s is reasonable. Based on this independent validation, uncertainties in homogenized series are explored and homogenized SunDu-derived R_s are proved to be more reliable in depicting the evolution of R_s. Finally, we highlight the differences of trends of R_s over Japan before and after homogenization.

2. Comment:

The methodology should be clarified clearer with more details. It's very difficult to follow the methodology part, especially how to find the inhomogeneity between the observed and SunDu-derived solar radiation and use the approach to adjust the dataset. It seems that the abstract section shows much more details on this harmonization than the methodology section. Please give more details in the methodology section.

Response: According to the reviewer's comment, we aaded more information int to Method Section 2.2 in Lines 172-203 for better understanding RHtest.

3. Comment:

The independent homogenization method proposed by Katsuyama was used to harmonize the SunDu-derived solar radiation to valid the accuracy of the proposed approach. I think Katsuyama's approach (Eqs. 2-3 is very simple and efficient), why not directly use this approach to harmonize this solar radiation? Please clarify it.

Response: We agree with the reviewer's comment that the homogenization method proposed by Katsuyama is very simple and efficient. However, the RHtest method provides more option for us to check the changepoints in the raw data series. We add Lines 213-220 to address this issue.

4. Comment:

For the data implications, it's better to give some examples to show the necessity of data harmonization for soar radiation for practical applications. For example, you can compare the trends of solar radiation before and after harmonization to show whether there are any significant improvements in the trend analysis.

Response: Thanks for the reviewer's constructive comment. Follow the refereee's

suggestion, we emphasized this issue in Introduction Section in Lines 139-142, Results in Section 3 in Lines 272-273 and Lines 355-368, Conclusions in Section 5 in Lines 417-419 and Lines 430-438.

Specific comment

1. Comment:

(1) L66-70, it's strange to shift the replacement of thermopile pyranometers in Japan to the instrument replacements-induced inhomogeneity in China.

Response: We rewrote the Introduction Section, and these sentences are reorganized. We first review the replacements issue in China, Italy, United States and central Europe, and then introduce the replacement of instruments in solar incident radiation observations happened in Japan. Details are in Lines 60-73 and Lines 105-117.

2. Comment:

(2) L171, what's the meaning of grid?

Response: We rewrite the Equation (4):

$$CCRE'(lat, lon, y, m) = CC'(lat, lon, y, m) \times CRE(g, m)/\overline{CC}(g, m) \quad (4)$$

Where (lat, lon) instead of grid are used to demonstrate the geographical information.

3. Comment:

(3) L172, what's the meaning of long-term mean cloud cover?

Response: We rewrite this sentence in Lines 236-237: $\overline{CC}$ is the climatology of cloud cover in 12 months.

4. Comment:

(4) L187-189, why not directly use the monthly data for comparison?

Response: We add an explanation in Data Processing Section in Lines 259-261:

As the brightening and dimming over Japan were the main concern in this study, monthly values were converted into annual values for calculation.

5. Comment:

(5) L190, it's quite difficult to find the following results from Figure 4. Please refine this figure to show the key message clearer.

Response: We added Figures 4-6 in the revised paper for better understanding the major improvements after homogenization. Details can be see the response to the first major comment in this document.

6. Comment:

(6) L198-200, rewrite this sentence, please present the key message clearer. For

example, the improved patterns of time series of surface incident solar radiation after homogenization highlight the necessity and feasibility…

Response: We corrected this sentence according to reviewer's comment in Lines 290-292.

7. Comment:

(7) L204-208, remove this paragraph, it's not consistent with the sub-title

Response: We move this paragraph to the Section 2.3, which is closely related with clouds.

8. Comment:

(8) L207, with the previous results (i.e. Figure 4 in Tsutsumi and Murakami, 2012)

Response: We corrected it in Lines 251-253: The regional average cloud amount over Japan in Figure 10 (blue line) increases at a rate of 0.7% per decade from 1960 to 2015, which is consistent with the previous results (Figure 4 in Tsutsumi and Murakami (2012)).