Response to Referee #1

We would like to thank the reviewer for the comments and suggestions, which help to improve the quality of our work. We have made revisions and have replied to all comments and suggestions. Please find a detailed point-by-point response to each comment.

Comment:

This manuscript describes a new approach to obtain SSR from satellites, and the proposed idea on how to combine MODIS and MTSAT data and offset their respective observation shortcomings indeed is very novel. Throughout the manuscript, the structure, elements, procedures, discussions and analyses all are well organized, and thereby it is fluent to read. In a word, I find the study is interesting and well sound and it is worth publishing in Atmospheric Chemistry and Physics. Even though I think the study is worth publishing in ACP, it may be still require some modifications.

Response:

We thank Referee #1 for the encouraging comments. All comments and suggestions have been considered carefully and well addressed.

Comment:

1. Generally speaking, if we want to retrieve the atmospheric states (e.g. cloud-related parameters) from satellite TOA (Top of the Atmosphere) observations, the surface states must be known or assumed in advance. However, in your method the cloud-related parameters are directly linked with TOA MTSAT observations by an ANN method. Are the fluctuations of surface states, such as different surface reflectance, required to be further accounted for in your retrieving scheme? Do you compare your cloud mask results with MTSAT TOA VIS images through visual identification, and are they in agreement each other?

Response:

I agree that the surface states must be known or assumed in advance when retrieving the atmospheric states from satellite TOA (Top of the Atmosphere) observations. This is especially significant when the air condition is clear sky, in which case the TOA radiances are affected greatly by the surface states. Under cloudy condition, the effects of clouds on TOA radiances are much greater than those of the surface states on TOA radiances. Thus, most retrieval algorithms for atmospheric states cannot work well, while the retrieval algorithms for cloud parameter are almost not affected by the surface states. Furthermore, MODIS cloud retrieval algorithm has accounted for the surface effects when retrieving cloud parameters. Therefore, we directly build relationships between MODIS cloud parameters and TOA MTSAT observations with an ANN method without considering surface states.

Yes, we randomly selected a few cloud mask pictures and compared with the corresponding MTSAT TOA VIS images through visual identification and found that they are generally in agreement with each other.

Comment:

2. You first use to MTSAT TOA 5 channel data to derive cloud parameters, and then use resulting cloud parameters to compute SSR. Why didn't you choose a more straight-forward way to obtain SSR, namely directly retrieving SSR from MTSAT TOA 5 channel data? You also can use MODIS cloud products and the algorithm of Qin et al. (2015) to obtain SSR, and then establish the direct relationship between SSR and MTSAT observations by an ANN method.

Response:

Generally, there are two types of methods to directly retrieve SSR from the MTSAT TOA channel data. One is the look-up table methods that use satellite signals to match a pre-established radiative-transfer database. These methods are widely adopted by many researchers (such as Pinker et al., 2003; Liang et al., 2006; Mueller et al., 2009; Lu et al., 2010; Huang et al., 2011; Ma and Pinker, 2012), but their computational efficiency are not high, and most of them only use visible channel data. The other is the statistical methods that directly link TOA radiance with the observed SSR at regional scale. For example, Using ANN technology, Lu et al. (2011) built the non-linear relationship between daily SSR measurements and MTSAT-1R all-channel radiances over China, and the evaluation results indicate that the relationship can efficiently estimate daily SSR from MTSAT-1R data. However, the non-linear relationship is not universal and needs local calibrations. To alleviate the weaknesses of the above methods, Qin et al. (2015) developed an efficient physically based parameterization algorithm to retrieve SSR. This algorithm can retrieve SSR quickly and be used globally. Qin et al. (2015) have applied the algorithm on polar-orbit satellite (MODIS Terra/Aqua), and this study attempts to apply the algorithm on geostationary satellite to map high spatio-temporal resolution SSR over China. To achieve this goal, we first use MTSAT TOA 5 channel data to derive cloud parameters, and then use the derived cloud parameters to compute SSR.

Your suggestion of using MODIS cloud products and the algorithm of Qin et al. (2015) to obtain SSR and then establishing the direct relationship between SSR and MTSAT observations by an ANN method may be equivalent to what we have done in this study. It is worth doing in the future.

Comment:

3. In the mid-latitude regions such as most parts of mainland China, the overpass times of Terra-MODIS and Aqua-MODIS respectively roughly are 11:00 and 13:30. Around these times, the solar zenith angles are relatively small. Therefore, the samples that you used to train ANN maybe lose representativeness for cases that solar zenith angles are large (e.g., the hours around sunrise and sunset). This may also influence your retrieval accuracy. Is this right? My questions may seem a little too harsh, but you should try your best to response them.

Response:

Good comment! We randomly selected a large number of data points to train the ANNs for cloud parameters estimation. These data points cover most of China and span all four seasons. We have checked the training data and found that the values of solar zenith angle (SZA) vary from about 7.1° N to 78.3° N. This range of SZA is sufficiently wide except for extreme cases such as the hours around sunrise and sunset, but the value of SSR is very small in the extreme cases. Also, it should be noted that the angle information is not the determinative factor in retrieving cloud parameters. As a matter of fact, the question you mentioned has been discussed among the authors when designing the ANN. The above discussion will be added into the revised manuscript.

Specific comments:

Comment:

1. P. 35202, L. 16: or 3.52.P. 35203, L. 26: "with inputs" may be more appropriate?

Response:

Accepted！

Comment:

2. P.35204, L. 1: Is it better to change "get their values at…" into "them with"?

Response:

Accepted!

Comment:

3. P.35204, L. 3: "their limited…" may be more appropriate?

Response:

Accepted!

Comment:

4. P.35205, L. 11: MTSAT1R is 135 degree and MTSAT2 is 140 degree, which one did you use?

Response:

MTSAT-1R is positioned at 140° E and MTSAT-2 is positioned at 145° E. In this study, both MTSAT-1R and MTSAT-2 data are used to map high spatio-temporal resolution SSR dataset (hourly, 5 km) over China from 2007 to 2014. The observed SSR data in 2009 are used to validate the retrieved SSR, which were estimated from MTSAT-1R data.

Comment:

5. P.35205, L. 25: Misleading phrase "The spatial resolutions of these MODIS products are 5 km", different MODIS products have different spatial resolutions.

Response:

The authors are sorry for this error. The spatial resolutions of the aerosol products (MOD04, MYD04), atmospheric profiles products (MOD07, MYD07) and albedo products (MCD43C3) are 5 km; whereas, the spatial resolution of cloud products is 1 km. Thus we resample the cloud products to a spatial resolution of 5 km in the original manuscript. This information will be added into the revised manuscript.

Comment:

6. P.35208, Sect. 3.2: Here the descriptions are a bit disordered. Maybe, the following revision is better. The conclusion "Comparison between … To improve… train the ANN" in the end of this paragraph, is adjusted into the end of next paragraph. You respectively describe the training data and validation data, and then conclude their similar behaviors, finally all data are used to train the ANN. between the L. 15 and L. 25, and the "observed ones" is "the MODIS derived", isn't it? In a word, these two paragraphs need to be rephrased.

Response:

Yes, you logic is right. Actually, the logic you suggested has been briefly described in the original manuscript as "The MODIS cloud products are randomly selected, and split into two parts: one for training and other for independent validation. Comparison between the two parts indicates that the trained ANNs behave similar to each other. To improve the generalization of the ANN model, we use all the data to train the ANN". Figure 3 and Figure 4 in the original manuscript use all the data to train the ANN. To avoid misunderstanding, we will add the text "After using all the data to train the ANN" in the second paragraph in the revised manuscript.

Yes, the "observed ones" is the "MODIS derived ones".

Comment:

7. P.35209, L. 23: 2.9 g cm^{-2} seems to be small. From my experience, under cloudy skies the absorption of water vapor usually is saturated. Maybe 3.5 g cm^{-2} is more appropriate.

Response:

Maybe you are right, but the PW effect is negligible under cloudy conditions because the cloud effect on the SSR is dominant. Therefore, we may expect that the using of 2.9 g cm^{-2} or 3.5 g cm^{-2} will produce negligible difference.

Comment:

8. P.35210, L. 22-24: Misleading phrase "The lack of three-dimension…", please rephrase it.

Response:

We will change this sentence to "The lack of three-dimensional radiative effects in the SSR retrieval algorithm and the appearance of broken clouds are the potential reasons for the hourly SSR bias" in the revised manuscript.

Comment:

9. P.35213, L. 4-5: I do agree with the reasons you presented here. "This would be due to the coarse spectral resolution of geostationary satellites…". I feel that maybe two factors contribute this phenominen. One is satellite observing TOA reflectance has saturated for too thick clouds. Subsequently TOA reflectances can not reflect the change of cloud optical depth, and result in overestimated atmospheric transmittance.

Another one is the “representative cloud” and “climatology average aerosol loading” are used in the calculation of SSR. This means extremely cases can not be accounted for, and a systematic underestimation in certain high value range and a systematic overestimation in certain low value range are certainly resulted in. Frankly, it is weird that GLASS SSR has such large systematic errors on a daily timescale. In summary, my overall recommendation is that this work could go further for publication provided the authors will provide a thorough rebuttal to the aforementioned issues.

Response:

I agree with you absolutely.