Response Letter

Dear referee:

We feel great thanks for your professional review work on our manuscript. Thank you so much for inviting the expert in the same field to guide our paper. According to your and the other one professor's advices, we amended the relevant part in the revised manuscript. Some of your comments are answered below.

1. As viewing the sample images, there are some doubtful regions found around the sun in the original sample image for "Clear sky" shown in Fig.4a (First row). While these look like small clouds or reflected images of dome, the system judges these are no cloud.

Reply: Thanks for your concern. The sample image shown in Fig.4a is indeed the image of clear sky. The whole sky images used in experiment are captured by our all-sky imaging instrument as introduced in the Section 2. A plastic protective dome is added to the front of the imaging system to protect the device from dust and rain. However, after long-term field observation work, dust may fall on the protective dome and the protective dome has been some aged, which affects the imaging process and results in the existence of gray pixels that similar to cloud points.

2. An original image to be analyzed is fused with ten different exposure-photos (P3, L28-30). By using such a technique, it has a possibility to include cloud information around the sun. However, the paper shows no description on this effect when analyzing it. If the accuracy of cloud segmentation is improved by using the technique, please discuss it more, especially for aureole areas.

Reply: Thanks for your comment. The HDR technology do guarantee better imaging and high-quality whole sky images, but it belongs to the part of the imaging system of all-sky imaging instrument. This manuscript presented in this paper mainly focuses on the cloud image segmentation algorithm, so the HDR technology is not described in detail.

3. In the Tao et al.'s paper they have discussed the analysis system of cloud segmentation called the optimized U-Net, which looks like similar to the present SegCloud. Because several authors are overlapped with those of that paper and one is the leading author of the present paper, they should discuss the difference of both systems and analyzed results in this paper clearly.

Reply: Thanks for your comment. The manuscript presented in this paper is different from the Tao et al.'s paper. Tao et al.'s paper focuses on the all-sky imaging instrument (ASC), and the ASC hardware system is mainly detailed, including the imaging system, data analysis module, et al. On the basis of these hardware system, the U-Net model is introduced into the cloud cover analysis. However, this paper focuses on the theoretical

analysis of whole sky image segmentation algorithm. The new Convolutional Neural Network model named SegCloud is mainly proposed for accurate whole sky image segmentation. The proposed SegCloud has been compared to other algorithms qualitatively and quantitatively according to ground truth images, which demonstrates its accuracy and superiority. Thus, these two papers are totally different.

4. Tao et al. (2019) have described the new database created for the system. This database must be the same as in this paper. Therefore, in this paper they should write "This database has been used in the present analysis, created in Tao et al. (2019)". The referee thinks that it is not suitable to include the contribution of the database production for training the SegCloud (P3, L15-16).

Reply: Thanks for your reminder. The data are actually mentioned and briefly described in Tao et al.'s paper, but no further details are presented. We realize it's not appropriate to emphasize the contribution in this paper. We have removed the relative content about the contribution of the database production in this paper, and have corrected the text to "In this paper, the database used in Tao et al. (2019) is applied to train and test the proposed SegCloud model". But in order to keep the integrity of the proposed algorithm, this manuscript still presents the database in detail, including its advantage and features.

5. Tao et al. (2019) have discussed the relation between the U-Net results and the human observers' ones in detail. The similar discussion is found in the section 4.3 basically by using the similar data frame (This paper used the data only of July, 2018, and Tao et al. used the data of August to November, 2018. The data site is the same.) If both analysis systems are different, it is useful and effective to discuss the difference between both results, but if not, this section may not be required in the paper because the detailed discussion has been already performed by using much more data.

Reply: Thanks for your comment. In Tao et al.'s paper, the ASC instrument has been running stably at the airport (data site) for cloud cover observation in real time. The accuracy of real-time cloud cover observation is affected by both the U-Net algorithm and the observation system. So, in Tao et al.'s paper, the purpose of the cloud cover comparison between the ASC instrument and human observer is to verify the stability and reliability of the ASC instrument. As to the manuscript presented in this paper, the database used to train and test the proposed SegCloud algorithm is made by ourselves. To further demonstrate the persuasiveness and advantages of the proposed whole sky image segmentation algorithm, the human observer's cloud cover data is treated as ground-truth. At the same time, the whole sky images from ASC were downloaded and segmented, and then the cloud cover were computed and compared to with the data of human observation. As mentioned above, the purpose of the comparison with human observer's data in those two papers is different.

6. While the accuracy computed with respect to the ground truth is important and correctly reported, I would like to see more work regarding the comparison with other

algorithms. The fixed threshold algorithm cannot be directly compared with the CNN output simply because it has been built to be used with a camera with a shadow band. Then, the actual fixed threshold algorithm (Long et al., 2006) is much more complicated than a simple R/B threshold shown in Fig. 4, and accounts (at least partially) for most of the issues mentioned in the current manuscript (e.g., solar obstruction).

Reply: Thanks for your comment. During the experiments, in addition to the R/B threshold algorithm and the Otsu algorithm, some other clustering algorithms were tested for whole sky image segmentation, such as k-means algorithm and mean-shift algorithm. None of those algorithms has satisfactory performance. The reasons for these results are that they require pixels of the same class to have similar gray value but clouds appear to be opposite (the same reason with Otsu algorithm, as introduced in Line 25, Page 7). We also test the other threshold segmenting algorithm using Red and Blue channel values, such as R-B, but their performance is similar to R/B threshold algorithm. So in this paper, we just pick two typical algorithms and compare our algorithm with them. For most cameras, in order to protect the CCD from the direct sunlight and avoid the large sun circle, shadow band will be added during the imaging process. Different from other cameras, our instrument uses the light-cutting module and HDR technology, sun circle is small. So we think it's appropriate to use the R/B threshold algorithm as the comparison algorithm and it will not result in much bias. In Long et al.'s paper, the R/B threshold value is set as 0.6 through several tests performed on training images. But in our test experiment, we found the best threshold value is 0.77. Therefore, we choose 0.77 as the final threshold.

7. Since Tao et al. (2019) already showed validations results with respect to visual observations for August-November 2018, please remove this part from the manuscript. I suggest including some applications exploiting the R/B method and its potentialities. For example, comparison with cloud fraction (or cloud mask) estimated by satellites (e.g., Himawari-8, MODIS), analysis of trend/changes at different locations, adapting the same algorithm to images recorded by other cameras (since the method is based on CNN, it should be no so difficult).

Reply: Thanks for your suggestion. As we mentioned in comment #5, the purpose of comparison is different. Your suggestion all are great and they will be considered in our further study. Thank you again.

8. The reference of the second segmentation method is Otsu (2007). However, I think that the authors actually refer to Otsu (1979).

Reply: Thanks for your reminder. We have corrected the reference information.

9. The name of the two previous datasets showed in Fig. 2 are not mentioned in the text of the manuscript. In section 2, please include their names when their respective references are mentioned

Reply: Thanks for your reminder. The names of the two databases have been added to the location where the respective references are mentioned.