

Dear Editor,

Thank you very much for your help with the peer review of our manuscript. We are also very grateful to all the reviewers for their help to improve the quality of our manuscript. We have made a thorough revision of this manuscript according to the reviewers' recommendations. All modified content, including added or deleted parts, in the paper are marked with color (green) in the manuscript. Please see the following pages for a point-by-point response. We hope the revised manuscript is now suitable for publication in *Earth System Science Data*.

Kind regards,  
Jianping Huang

1. In eq.2,  $AI_{[m,i,j]}$  and  $AOD_{[m,i,j]}$  are aerosol index and aerosol optical depth, respectively;  $AE_{[m,i,j]}$  is the pseudo-Ångström exponent; and  $[m, i, j]$  represent the month, latitude, and altitude respectively. Note that to match the AE, AOD is also transformed into the vertical distribution (not the column parameter) (lines 280-283). Please add the process transforming the column AOD into the vertical distribution with MODIS-AOD data.

Response: Thank you for your suggestion. We have added the process transforming as follows in manuscript:

The innovation of this work is to obtain AI with vertical structure, which has not appeared in previous work, and data in this manuscript are all based on the vertical structural distribution of altitude-latitude. We use an observed relationship between CALIPSO extinction at 532nm and 1064nm to derive an altitude-latitude-based monthly climatology of Ångström exponent to compute altitude-latitude monthly climatology of vertical AI at 532nm and 1064nm between daytime and nighttime from 2007 to 2020, with vertical and horizontal resolutions of 60 m and  $0.05^\circ$ , respectively. As we focus on the characteristics of aerosols in the troposphere over the TP, we took samples from the surface at an altitude of 12km with a vertical resolution of 0.06km. We integrated the extinction coefficients of each two layers to obtain an AOD, which corresponds to the average of the AE values of each two layers. This achieves spatial matching between AOD and AE at vertical heights. In the later stage, when using the AI obtained from MODIS for comparative testing, we used the PDF and average values of AI for characterization display in order to facilitate comparison due to the differences in horizontal and vertical space.

2. The authors use the ground-based LIDAR (Light Detection And Ranging) detection data from the hinterland of Taklimakan Desert (not from the Tibetan Plateau) to verify the validity and accuracy of the low confidence aerosol removal method and the AI calculated by CALIOP detection data. Please add the discussions on the

uncertainties in this study caused with distinct differences the Taklimakan Desert and the Tibetan Plateau.

Response: Thank you for your suggestion. We have added the discussions on the uncertainties in the revised manuscript as follows:

In general, the quality and robustness of the aerosol parameter product have improved for EC and AI with some issues that still persist in the data set which we mention below:

As we do not have ground-based LIDAR detection data on the TP, we have selected ground-based LIDAR data from the center of the Taklamakan Desert for verification and evaluation. The objectives of the verification and evaluation include the removal of low reliability aerosol targets and the validation of the effectiveness and rationality of the constructed aerosol AI parameter results. Due to the limited detection data of ground-based LIDAR, we chose a typical aerosol process detected by ground-based LIDAR (July 11, 2021), but it did not match well with the transit time and scanning area of the CALIPSO satellite, resulting in significant errors. Therefore, we choose to compare and verify the results of the average values of July in all years within the central area of the transit Taklamakan Desert detected by CALIPSO (see the green box on the left in Figure 2). Minimize spatial errors caused by significant differences in spatial positions. This kind of error is inevitable in our data processing process and will affect the consistency of detection results to some extent.

Besides, although the monthly based AI correction significantly improves the comparison between CALIPSO and MODIS, we note somewhat a larger deviation maybe occurs in winter, and the effect after correction in summer is the best and significant, which may be related to the increased probability of mistaking clouds as aerosol particles due to more convective activities in summer. This helps us to refine our research on summer aerosols over the TP.

The English language. Please make the substantial improvement on English language

and usage in the manuscript. Below I list only a part of errors:

Response: Thank you for your suggestion. We have carefully revised language issues and invited experts who are native English speakers to review and check the manuscript.

1) Line 38: more reliable the> the more reliable

Response: Thank you for your suggestion. We have corrected it.

2) Line 40: “between daytime and nighttime” should be for daytime and nighttime

Response: Thank you for your suggestion. We have corrected it.

3) Line 44: please clarify “all those facts”

Response: Thank you for your suggestion. We have corrected it.

4) Line 48: what is “aerosol troposphere”?

Response: Thank you for your suggestion. We have changed “aerosol troposphere” into “tropospheric aerosols”.

5) Line 51: please modify “the recovered datasets”

Response: Thank you for your suggestion. We have corrected it.

6) Line 52: “the aerosol-cloud-radiation-precipitation interaction”? There should be the aerosol-cloud interaction(ACI) aerosol-radiation interaction(ARI).

Response: Thank you for your suggestion. We have corrected it.

7) Line 100: models>modeling

Response: Thank you for your suggestion. We have corrected it.

8) Line 107-108: please modify “and its”

Response: Thank you for your suggestion. We have changed the sentence into “The primary aerosol type over the TP is dust, which is primarily contributed to the Taklimakan Desert”.

9) Line 172: please correct “between our record and with different data sets”

Response: Thank you for your suggestion. We have changed “between our record and with different data sets” into “between our records and other public different data sets.”

10) Line 108: spatiotemporal pattern is primarily contributed to the Taklimakan Desert”.

Response: Thank you for your suggestion. We have changed the sentence into “The

primary aerosol type over the TP is dust, which is primarily contributed to the Taklimakan Desert”.