Manuscript number: **#ACP-2021-421**

Title: **Longwave Radiative Effect of the Cloud-Aerosol Transition Zone Based on CERES Observations**

Submitted to: **Atmospheric Chemistry and Physics (ACP)**

Dear Reviewer,

On behalf of all authors, I would like to kindly thank you for your very constructive comments and suggestions, and as well for spending your precious time on reviewing our manuscript.

We are very pleased about the fact that the reviewer finds our manuscript interesting, sound and well written. All suggestions for minor refinements will be considered in the potential future submission of the manuscript. Please find below our answers to your major inquiries.

Note that the list of references mentioned in this document is given in the last page.

Sincerely yours,
Babak Jahani

C#1.1) It is important to clarify the sentence in Lines 90-91, which says “Indeed, for these pixels neither aerosol nor cloud optical property retrievals exist, yet they are classified as containing a cloud (Lost A), a non-cloud obstruction (Lost B), or were not processed at all in the cloud masking (Lost C).” Specifically, it should be clarified whether the study considers 1 km-size MODIS pixels as “cloudy” or “Lost” (most likely “Lost A”) if the MYD06 cloud product does not include a positive retrieved value in the Scientific Data Set (SDS) “Cloud_Optical_Thickness”, but includes a positive retrieved value in the SDS named “Cloud_Optical_Thickness_PCL”. This occurs for partly cloudy 1 km-size pixels, in which clouds were detected for some, but not all 250 m-size subpixels. Clarifying this would be important because if such pixels were considered “Lost”, CERES footprints containing many small clouds could be included in the transition zone statistics even if their total cloud fraction was well above 10% and their longwave effects came from cloud elements for which the MODIS cloud product did provide cloud property estimates.

A#1.1) Thank you for your constructive comment. For this analysis, we have followed the methodology presented in Schwarz et al. (2017) which is based on the variable labeled as “Cloud_Optical_Thickness”. It is true that there may exist some conditions with developed scattered clouds in the subpixel scale of the MODIS pixels labeled as Lost A. It is also true that these small cloud fragments have an influence on the estimated radiative effects.
In addition, in line with this comment, **C#1.3** and **C#2.4** we have performed a statistical analysis, evaluating the links between the estimated RE_{trz} values and the cloud fraction in the CERES transition zone footprints. The results of this analysis are presented below, in Figure 1.1. From the information provided in this figure, it can be seen that RE increases with cloud fraction, which confirms the abovementioned statement about the effect of clouds on the calculated RE_{trz} values. However, the information provided in this figure also shows that for more than 75% of the CERES transition zone footprints that we have analyzed, the cloud fraction is below 5%. This implies that although subpixel clouds may have had an influence on our results given in Figure 3, their effect on the overall results of the analysis presented in section 6 should be rather small.
In the potential future submission, we will clearly state that we have performed our study based on the variable “Cloud_Optical_Thickness” and will add Figure 1.1 along with the discussion given above.

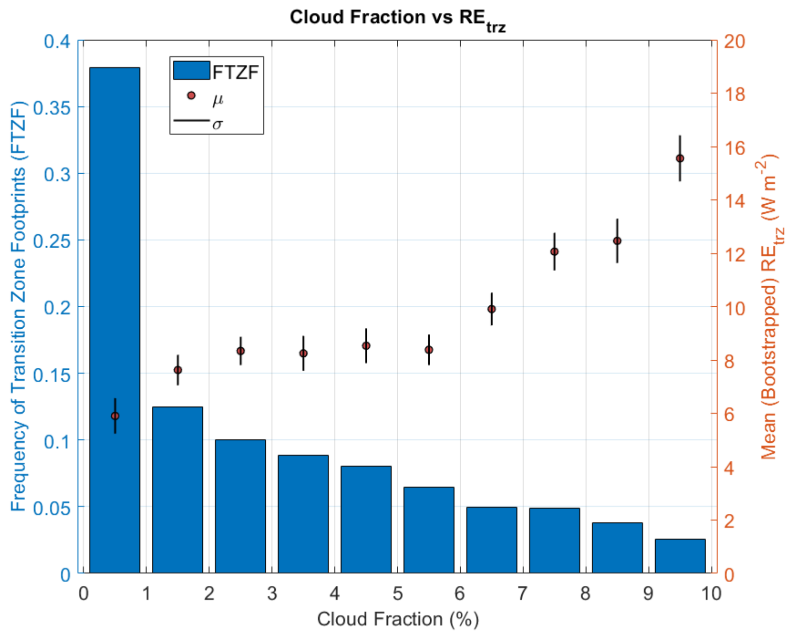

Figure 1.1. RE_{trz} as a function of cloud fraction. Each cloud fraction bin given in this figure is 1% wide and the bar charts indicate the frequency of the transition zone footprints falling within the limits of each cloud fraction bin. The red circles and black vertical lines indicate the (bootstrapped) mean RE_{trz} and the corresponding standard deviation for each cloud fraction bin, respectively.

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C#1.2) Line 250 explains that the low-level transition zone effect of 0.8 W/m2 was calculated using the first four temperature difference (dT) bins in Fig. 4. However, it is not clear why four bins were used, rather than three, five, or more than five. This is a significant issue because Figure 4 suggests that the number of dT bins included into the low-level category can affect the results. It would help to explain why using the first four dT bins is a good choice. For example, could it be linked to a certain altitude range? It would also help to mention how the definition or the extent of the low-level category compares to the definition or extent in Eytan et al. (2020), which provided the radiative effect estimate of 0.75 W/m2 that was close to the 0.8 W/m2 in this paper.

A#1.2) In line 250, our aim was just to provide a quantitative comparison between our results and those found by Eytan et al. (2020). It should be noted that as you are aware (and mentioned in the manuscript), there are differences between our study and that of Eytan et al. (2020). One important difference is the fact that the study of Eytan et al. (2020) quantifies the radiative effect of the transition zone conditions occurring in the adjacency of the warm shallow cloud fields (defined as liquid-phase clouds with top temperatures warmer than 275 K). Whereas in our manuscript, we are studying the transition zone conditions with different characteristics occurring at different altitudes. Thus, for comparing our numbers with those of Eytan et al. (2020), we had to choose some of our studied transition zone conditions which could potentially match those analyzed in Eytan et al. (2020).

We have used the data corresponding to the CERES transition zone footprints falling within the limit of the first four dT bins for this comparison because it covers the dT range (dT ≤ 3-4 K) which can be derived from Figure 2 given in Eytan et al. (2020). Indeed, the latter figure shows the cloud top brightness temperature and albedo along with the sea surface temperature for an example scene of what is defined as low cloud by them. This reason for selection of these four dT bins will be clearly mentioned in the potential future version of the manuscript. As the referee mentions, it is obvious that dT is connected with altitude, therefore, and also in line with a comment from the second referee, we will also modify Figure 4 by adding an additional X axis at the top to associate dT with altitude (please see **A#2.4**), and the term "low-level" used in other parts of the manuscript will be put in context. The altitudes given in this figure are calculated following the estimates of the mean tropospheric temperature lapse rate for the study area (6.1 K/km) given in Mokhov & Akperov (2006).

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C#1.3) The transition zone statistics include CERES footprints where up to 10% of MODIS pixels have neither aerosol nor cloud data. This criterion is very reasonable, but it allows including footprints where the cloud fraction can reach 10% (or much higher, depending on the treatment of partly cloudy MODIS pixels, as discussed in Point #1 above). Therefore, it could be interesting to discuss whether the transition zone radiative effect shows any statistical relationship to cloud fraction within the CERES footprint. This could be done either for all dT bins combined or for selected dT bins only.

A#1.3) Thank you for your constructive comment which is connected with your fist comment C#1.1. Therefore, please refer to our previous answer **A#1.1**. In particular, Figure 1.1. (above) corresponds to what the referee is asking: there is indeed a relationship between RE_{trz} and the residual cloud fraction that may be present in the analyzed CERES footprints. As already mentioned, we will provide this information in the potential future submission of the manuscript. To clarify one point, however, statistics that we have provided correspond to the CERES transition zone footprints which consist of those with a "Lost" fraction (all lost classes together) greater than or equal to 90%, so there are only up to 10% of MODIS pixels which eventually have cloud data. In other words, in each analyzed CERES footprint at least 90% of MODIS pixels do not have cloud or aerosol data (they are "lost" pixels) while the contribution of all other classes combined ("Difficult", "Cloud", "Aerosol", "Clear") is less than or equal to 10% in these footprints. Therefore, the maximum cloud fraction in one of the analyzed CERES footprints might be 10% (and, as it can be seen in Figure 1.1 above, for more than 75% of the CERES transition zone footprints that we have analyzed, the cloud fraction is below 5%).

References

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