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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Multi-satellite aerosol observations in the vicinity of clouds" *by* T. Várnai et al.

Anonymous Referee #2

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This paper combines data from the passive MODIS imager, and the active CALIOP lidar, in attempt to better understand the observed reflectance enhancement near clouds. The transition zone between clouds and cloud-free atmosphere is explored using one yearlong global data from the two satellites, and two radiative transfer models, .

In the first part of this study, following the analysis of CALIOP color ratio, the particulate matter suspended in the atmosphere (aerosol and 'undetected' cloud droplets) is found to be larger when comparing the closest 5 km to the nearest low cloud (below 3 km) with the rest of the atmosphere, above oceans. Then, a comparison between MODIS and CALIOP reflectance biases in the closest 20 km from cloud provides indication of the 3D effect contribution to the total observed reflectance bias near clouds, for four different regions and aerosol types. Additional

3D Monte-Carlo simulations are conducted and show that the 3D effect contributes a significant portion of the total bias, up to 10 km from clouds. Finally, radiative transfer simulations show that the contribution of instrument blurring is limited to the very close vicinity of cloud.

The paper provides, for the first time, a quantitative estimation of the relative contributions of cloud radiative 3D effect and instrument blurring to the total reflectance enhancement near clouds, using remote sensing observation tools. This study's objectives are extremely important for the research of the transition zone between clouds and cloud-free atmosphere, which is essential for understanding the total radiative and climatic effect of clouds and aerosol.

Therefore, I recommend this paper for publication in *Atmospheric Chemistry and Physics*, with reservation to the authors' response to the comments below, in hope that my comments could help the authors to improve their paper.

General comment

According to the caption of Figure 1, the corresponding analysed data are limited for low clouds (less than 700 hPa), above oceans.

1. I do not understand from the text itself whether the whole study is based on the specific subset of low clouds above oceans. If this is the case, please add this statement along the paper, including the abstract. This critical information will prevent misuse of this study's results in future research.

2. In the same caption of Figure 1, it is also claimed that the limit of 700 hPa is equivalent to height limit of 3 km. When considering a global dataset between $60°S$ to $60°N$, the altitude of 700 hPa may vary by hundreds of meters. Please clarify within the text what criteria used for selecting the data subset used for

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each and every section of this study, and provide an approximated mean altitude for the 700 hPa height, based on your data geo-location.

Specific comments

1. P. 32040 line 14, and along the paper: please keep consistent terminology. The term "*particle population*" may mislead, as it may be understood as aerosol only. Therefore I think it should be clearly mentioned along the paper, as it is in most cases now. I also suggest keeping consistency and use either "cloud droplets", "cloud particles" or simply "clouds". I prefer "cloud droplets" (although I'm aware to the face that some of the observed clouds may contain ice particle).

2. P. 32042 lines 22-23: it is mentioned that past studies found that high relative humidity is limited to the closest vicinity of clouds. How close? Please provide a quantitative distance scale, if possible.

3. P. 32043 lines11-13: why was a 30° angle chosen for this section? It seems from Figure 5 that this angle is considered as the lower boundary of other parts of this study.

4. P. 32043 lines 19-20, and caption of Figure 2(b): I suggest replacing *(upper case 'x')* statements with the actual mathematical expression. It would take the same space and would be easier for the reader.

5. P. 32043 lines 22-24: it is assumed that $R_{0.65}$ characterizes aerosol particle concentration. Please clarify whether it is size or number concentration, and refer to studies that support this assumption.

6. P. 32046 lines 14-16 and P. 32050 lines 2-5: I think that the conclusion that "*3-D radiative processes and instrument blurring are insignificant farther than about 10 km from clouds*" is pretty important, and should be mentioned again in the

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summary section, as it provides an effective distance scale for considering these factors.

7. P. 32048 lines 5-6: why has the reference observation been chosen to be 20 km from the nearest cloud? Does this specific distance has some physical reason?

8. P. 32049 lines 20-22: I recall several past studies showing similar exponential functions for radiative properties near clouds (e.g. *Koren et al.*, 2007, already cited in this paper), these may support the selection of exponential function or even the shown fits.

9. P. 32049 lines 21-24, and P. 32050 lines 10-13: if there are still "*not-yet-considered 3-D effects*", I would like, as a reader, to get more information about them. Why were they not-yet-considered? How can we know they are 3-D effects?

10. Figure 5(a): I am curious to know if you can explain the abnormal behaviour of the Monte-Carlo (green curve) around distance of 5 km.

Technical corrections

1. All figures: please make sure that the fonts are large enough for easy reading, even when printed (extreme example – Figure 6).

2. Figure 2(a): since this is only a theoretical demonstration, and the Y axis has no units, I suggest rescaling the Y axis to the values of the lines in the plot.

3. Figure 2(a): I suspect that the X axis is linearly scaled, despite the label.

4. Figures 2(b) and 2(c) captions: please include within the caption text the definitions for: "far", "close", "$R_{0.47}$", and "$R_{0.55}$". Please rephrase the caption for panel 2(c) accordingly.

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5. Figure 3(b) caption: please include within the caption text the definitions for: “near-cloud”, and “relative” (far to near-cloud?).

6. Figure 4 caption: please include within the caption text the definitions for: “near-cloud”, and “relative” (relative to 20 km?).

7. Captions of Figure 5(a), Figure 6(a) and Figure 6(b): please mention in the caption that the enhancement is relative to the reflectance measured 20 km from clouds.

References

Koren, I., Remer, L. A., Kaufman, Y. J., Rudich, Y., and Martins, J. V.: On the twilight zone between clouds and aerosols, *Geophys. Res. Lett.*, **34**, L08805, doi:10.1029/2007GL029253, 2007.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 32039, 2012.