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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Synergy of Active- and Passive Remote Sensing: An Approach to Reconstruct Three-Dimensional Cloud Macro- and Microphysics" *by* Lucas Höppler et al.

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Dear Referees,

I would like to appreciate the time and the effort you invested in reading and reviewing my very first paper. The comments are inspiring and will improve my publication significantly. In the following, I quoted your comments and tried to answer them as precise as I could.

General Comments Comment 1: "[. . .] However, often frustrating to the reviewer, the paper feels unfinished at times, particularly in the results section. The paper has a

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Discussion paper

number of co-authors and it is surprising that some of the quite obvious issues with the paper have not been ironed-out. As a simple example, many of the figure captions need work to be clear; the captions of Fig. 10. and 11 feel rushed and it is not clear if the figures are from the same cloud field."

Answer to comment 1: Thank you for your comment. I have changed the captions of Fig. 10 and Fig 11. They can be found in Figure 6 of the new version.

Comment 2: "The manuscript does not contain sufficient information to reproduce the results in its current form. How many different scenes were used to generate the statistics in Table 1? Is the same scene used in all the Figures?"

Answer to comment 2: Table 1 only refers to the case study, which is shown in figure 15. This reference should be made also be more concise. I have improved the information.

Comment 3: "How was the radar used in the study? There is a brief mention in the introduction on page 3 line 17 'The radar is used to determine multiple cloud layers', and then is not mentioned again (apart from to define its frequency in Section 2.2). Could the radar be used to define a more accurate cloud base? Could the profiling information of the radar be used to improve the microphysical retrievals?"

Answer to comment 3: My apology. I have not properly introduced the radar itself and will do it in the next version. As I wrote in the conclusion section, unfortunately, the cloud radar was not suited to determine a more realistic cloud bottom height due to the limited sensitivity to the small droplets. If the radar would be adjusted appropriately and build better, it might be used to define a more accurate cloud base and could be used to improve the microphysical retrievals. Sadly, I could not use the radar for more than just determining multiple cloud layers. I hope in the future campaigns the radar information is more suitable. I have adapted the information written in the publication.

Comment 4: "The introduction lacks focus, particularly in relation to '3D'. How will 3D cloud fields help reduce uncertainties in cloud processes? What other 3D cloud retrievals are available? Answer to comment 4: I appreciate this comment. The first reviewer also suggested this and I have changed the introduction accordingly which focus now more on 3D."

Comment 5: "The abstract makes a subjective claim that the consistency check shows ‘good agreement’. Do you think that can be claimed given the disagreements in the radiance histograms i.e. Fig 16c) and 16f)? What would be a good agreement? Does the method outperform a ‘dumb’ retrieval of assuming a constant cloud base height (perhaps by taking the average cloud top height seen by the lidar for a given cloud scene)?"

Answer to comment 5: I have introduced a plane-parallel 3D cloud field in section 5.3 in the new version of this document as you suggested. I also compared now the developed retrieval to the “dump” retrieval.

Comment 6: "How justifiable is the assumption of constant cloud base between dropsondes? Answer to comment 6: Over the ocean, the temperature and dew points vary not too much over large areas, which causes a widely constant Cloud Bottom Height. For example, figure 2 of Li, J. M., et al. (2013) shows a mostly stable Cloud Bottom Height for maritime boundary layer clouds for a larger area. I have discussed this issue shortly in the new section 3.1. The mean absolute CBH difference between all dropsonds on the day I focus in the paper was 59 m. Since I interpolate linearly between two calculated CBH, the error should be smaller."

Comment 7: "Would an infra-red channel allow cloud-top temperature to be used to better retrieve cloud top height as is done for e.g., MODIS cloud top height retrievals? If an infra-red channel was available on HALO would the method become obsolete? Perhaps I am not understanding something here."

Answer to comment 7: I have no experience in this cloud-top temperature retrieval. When there would be an infra-red channel available, and the Cloud Top Height is retrieved using this channel, then the quality of this retrieval needs to be compared and evaluated first. This comparation and evaluation could be done using active sensors such as the lidar. In the end, a combination of this retrieval with the retrieval presented in this paper could be a good complement. I have not seen any CTH retrieved from a thermal infrared imager, but I have included your comment in the discussion section of the new version.

Comment 8: "The discussion of ‘shadowing’ in the paper could be elaborated. In the introduction you state ‘Shadow effects can be eliminated’, which led me to think that the method would somehow account for shadowing in the retrieval, but I don’t think this is the case - perhaps ‘Shadow affected clouds can be removed. . .’ would be more appropriate. How much does solar zenith angle affect the results?"

Answer to comment 8: Thank you for this comment. I have written now “shadow affected cloud parts can be removed.”

Specific Comments

Comment 9: "I do not think that the diagram of specMACS in Fig 1 adds much to the paper. Would it not be more useful to include a schematic/flow diagram of how the method works?"

Answer to comment 9: I agree with that comment. It only shows how it looks from the outside and where the cameras are located. I think a reference to the publication of Ewald et al. (2013) is sufficient. I have removed the figure.

Comment 10: "What does ‘flight security’ mean on page 5 line 22?"

Answer to comment 10: Dropsonds are thrown from the aircraft into a region where other passenger aircrafts fly. Flight security means that the dropsonde can only be thrown from the aircraft if there are no other objects in the airspace. This is meant by “flight security”. I have included it into the new version.

Comment 11: "In Fig.5 Why does the liquid water content for a=0.5 appear more than half of a=1.0? Perhaps it appears that way because the axes do not start at ‘0’."

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Answer to comment 11: Thank you for this comment. This is a typo and should be a=0.6. I am sorry for that. I have corrected it.

Comment 12: "What does ‘m’ mean in Fig 6?"

Answer to comment 12: The index m indicates the temporal axis of the nadir pixels. I have written it more precisely in the new version. âĂČ Comment 13: "What data/measurements are used as input to Fig 7? This figure would be impossible to reproduce without this information!"

Answer to comment 13: These are data measured on the nadir track. Five different measured spectra were used. Three spectra, where the WALES CTH was constant and the LWP varied. Two spectra were taken where a constant LWP was measured, but different WALES CTHs. Thank you for this comment, I got also comments that this figure does not give any information at all. Thus, I have removed it.

Comment 14: "What does ‘px’ mean in the figures? Pixel? How is that a time? Why is the range different in Fig 16. Compared to Fig 18 (0-300 vs 0-1600)?"

Answer to comment 14: Thank you for this comment. Pixels indicate the size of the image. Indeed, it is not a very good quantity for time. I have adapted the axis in the new version.

Comment 15: "Would other statistics., e.g., RMSE, be useful in evaluating the reconstructions in Section 5.5? How is the error of 10% in effective radius (page 29 line 12) justified when the previous paragraph says 20%?"

Answer to comment 15: What might be more interesting might be to compare the retrieval with a “dump” two-dimensional one and estimate the differences, as you and I have written above. I have decided to use the Mean Average Error. An error of 10 % in Cloud Droplet Effective Radius is not justified when the previous paragraph says 20 %. I have improved the new version accordingly

Comment 16: "In Fig 12., wouldn’t a shallower sun angle be more appropriate to show an example of the shadow mask? SZA=3.6 degrees is almost overhead, where shadows would be minimized anyway."

Answer to comment 16: A shallower sun angle would be more appropriate. I have added the scene I used in Figure 6 now everywhere. The solar zenith angle is in this case about 21.5 degree.

Comment 17: "Why isn't the cloud mask applied before reporting the cloud effective radius in Fig 10? It would be useful to see what cloud effective radius is retrieved near cloud edges."

Answer to comment 17: I got several comments that I should show the whole scene without the cloud mask in conferences. I have applied the cloud mask now for the Cloud Droplet Effective Radius (Figure 6 now).

I hope I answered all your comments and thank you once again for all the constructive comments.

References: Li, J. M., et al. "A new approach to retrieve cloud base height of marine boundary layer clouds." Geophysical research letters 40.16 (2013): 4448-4453.

Please also note the supplement to this comment:
https://amt.copernicus.org/preprints/amt-2020-49/amt-2020-49-AC2-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-49, 2020.