Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-49-RC1, 2020

Atmospheric Measurement Techniques Discussions

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.

Anonymous Referee #1

Received and published: 9 May 2020

This manuscript reports a method for providing three-dimensional (3D) cloud macro- and microphysical properties, using observations of shortwave spectrometer, microwave radiometer, lidar, radar and dropsondes taken from the German research aircraft HALO. The basis and practical implementations of the methodology, including determinations of cloud boundaries and microphysical cloud profiles, are detailed. Examples are shown using data from the recent field campaign. While this work has not been evaluated against in-situ measurements, the retrieval and 3D reconstruction are checked through intercomparisons between the observed and simulated radiances. As indicated in the Conclusion section, the work can be applied to the future EarthCARE satellite mission, which is exciting and will have great scientific impacts.

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Discussion paper

I have had high hopes for this manuscript. The authors are thorough about the details and are candid about the limitation of the method, which is greatly appreciated. However, the presentation of the manuscript is disappointing. I must confess that I feel it is a bit unkind to submit the manuscript in the current form. I know this comment may be hard to take, but I hope the authors can understand my frustration. The manuscript lacks a clear logic flow and is disorganized and hard to follow. The material and figures are not carefully chosen. In-depth discussions and insights are lacked in the current form. I really feel it is a missed opportunity, because this is excellent work, but the manuscript didn't do it justice.

Some specific comments –

The introduction lacks a direct, clear focus and logic flow, as we can tell by references that were not introduced in a proper order. We can also tell that the introduction is not right, when the abstract is all about 3D, but the word of "3D" didn't get mentioned until the fifth paragraph. I would think that the uniqueness of the method is about 3D, so perhaps the introduction can focus on 1) the importance of cloud inhomogeneity and 3D information in terms of quantifying cloud radiative effect and understanding the role of clouds in the weather and climate system, 2) why this work is one of the few that can provide 3D cloud fields, and 3) how exactly the advance in these retrievals can help to improve models.

The Discussion and Conclusion section includes some information that is either not found or somewhat inconsistent with the main body of the text. For example, it states that microphysical profiles within the clouds are determined using the HAMP measurements, which can mean quite a few things because HAMP includes passive and active sensors. Indeed, radar reflectivity is passed to non-nadir pixels, but I don't see how it is used in helping constrain cloud microphysical properties. If radar data is only used for detecting multi-layer clouds as described in the manuscript, then radar data is underused and the synergy between passive and active is actually quite minimal. Also, the conclusion section highlights the values of cloud droplet number concentrations, but

this is not mentioned in the main text (although I might miss it). The effective radius profile is said to be constant, but the whole section 3.3 is talking about how to determine effective radius profile. Some clarification and consistency check are necessary.

I understand section 3.3 is one of the key components, but the current material can be found in textbooks so it is better to be summarized in a more concise way. Also, it is more useful and important to provide discussions about the impacts of the assumptions, and the understanding of the accuracy required in the input parameters in order to make useful retrievals. For example, how accurate do cloud base height and cloud top height need to be? How does that affect the capability of the retrieval method in satellite applications in which dropsondes are not available?

The material in section 4 can be condensed, and the flow should be reorganized, i.e., talking about PCA first and then introducing the matching process. In fact, PCA fits better in section 2 when the instrument/data were introduced. Why talking 18 PCA components, and then immediately, it is decided to use 50 components? Additionally, the authors sometimes use "not change much" or "visually no difference", which is not a scientific way to present results because readers cannot replicate. How much is not much, and how small is small? I would suggest describing things more clearly.

In the end, the method seems to aim for providing one profile for one scene. It would be good to have some discussions on the usefulness of such retrievals.

The manuscript needs some serious clean-up. The subtitles are not informative, and their orders didn't make sense. I am afraid that the symbols are a mess. For example, symbol 'a' is used for both radius of cloud droplet and the degree of entrainment. N is used as a constant and as a function of droplet size. Effective radius is sometimes a function of height, and sometimes not (e.g., equation 17).

Figures:

Figure 6: This illustration doesn't add much. It does not provide information on what

determines a good match and a bad match. While the matching process is based on passive radiance spectrum, the illustration seems to show either radar/lidar column information, which can be misleading. Additionally, readers cannot see what is going on for the good match pixel, so I am not sure what this figure can achieve.

Figure 7: I spent a lot of time on reading back and forth, and still cannot figure out what dashed lines represent here, and what the key point is.

Figure 8: Is (a) just a plot of 600m in red and 0 in black? Why does it deserve to be a plot? Shouldn't it be more informative to explain why it is OK to use infrequent dropsondes with coarse spatial sampling for the entire cloud scene? The physics behind and the impact on retrievals?

Figure 13: Suddenly, figure captions mention a cloud scene, and no further descriptions. Is it the same scene used in other figures? This figure is quite important and interesting but lacks some details. Without that, it is hard to know if the filtering process is too strict, and why it is OK to assume one profile for a 10x10 km area.

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

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