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: *[…] 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.*

Answer to comment 1: Thank you for this comment. I agree to the lack of a clear logic flow, the disorganization, and the poor readability. This paper starts with an introduction describing the importance to reconstruct three-dimensional clouds and the different remote sensing instruments. The second section presents the instruments which I used in my research. The third section gives an overview of the necessary theoretical background and describes the sub-adiabatic cloud microphysical model. Section 4 shows how the different instruments can be combined and how the data amount can be processed. This section also explains how the three-dimensional macrophysics (subsection 4.1) and the three-dimensional microphysics (subsection 4.2 & subsection 4.3) is reconstructed. I inserted in the new version a new chapter for the quality of the reconstruction (Section 5). I have also adapted figures, and deleted figures that were not containing much information, and extended parts of the discussion.

Specific Comments

Comment 2: *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.*

Answer to comment 2: Thank you for this comment. Indeed, the focus of my introduction lies in the reconstruction of three-dimensional clouds. I have not seen this discrepancy until now and have adapted the introduction in the new version of this document. It starts now with the importance of cloud inhomogeneity and 3D information and shows why this work is one of the few that can provide 3D cloud fields. Also, how these retrievals can help to improve models should be clearer now.

Comment 3: *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 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.*

Answer to comment 3: Only the Liquid Water Path of the HAMP microwave radiometers is used to retrieve the Liquid Water Content profiles within the clouds. The HAMP (cloud) radar reflectivity was only used to identify multiple cloud layers. Unfortunately, available radar data was not suited to determine a, for example, more realistic Cloud Bottom Height due to the limited sensitivity to the small droplets. This information can be found in the conclusion section. It is good to hear that this part should be written more clearly. Now this information can also be found in Section 3.

The Cloud Droplet Number Concentration values are mostly a by-product, and yes, it is true that they do not disappear in the main body. I did not include more information since the paper is already very long and difficult to understand. Thank you for the comment. I already have criticised myself concerning this part. I have removed them from the conclusion in the new version.

The Cloud Droplet Effective Radius profile is determined using the sub-adiabatic theory of subsection 3.3 and the filtered Cloud Droplet Effective Radius values determined using Nakajima and King (1990) according to subsection 4.3. Since the filtering method eliminates many Cloud Droplet Effective Radius values, only a small subset can be used as constraints for the sub-adiabatic Cloud Droplet Effective Radius profile. Thus, only one Cloud Droplet Effective Radius profile is used for the considered case study shown in Figure 15. Saying that this profile is constant is not concise – I appreciate this comment. This has also been criticised by the second reviewer. I have adapted it accordingly.

Comment 4: *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?*

Answer to comment 4: I have summarized this section a bit. But I think it is very crucial to bring much details in it for readers that have not such a great experience in cloud microphysics.

Moreover, I think it is a great idea to include a discussion about the impacts of the assumptions and the accuracy of the input parameters. Your question, "[…] how accurate do cloud base height and cloud top height need to be?" is a tricky one. Which accuracy do we want in the first place? My first naive answer would be: as accurate as possible. In the case of satellite applications, one would need to estimate the Cloud Bottom Height from radiosonde profiles or model data. This should be investigated in a further study.

Comment 5: *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.*

Answer to comment 5: Thank you for your comment. It is, for me, not logical to introduce first the PCA and then the matching process, because one must first understand the matching process, since this process is made faster with the PCA.

I have written this part now clearer in the new version of the document.

Comment 6: *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.*

Answer to comment 6: The method aims to provide one Cloud Droplet Effective Radius profile for one scene since only a few retrieved Cloud Droplet Effective Radius values can be used to fit the sub-adiabatic model. However, for every atmospheric column (here with 15 m resolution) a Liquid Water Content profile is retrieved because the Liquid Water Path retrieved by HAMP is not or not much influenced by three-dimensional radiative effects (compared to the Cloud Droplet Effective Radius retrieval). It would be beneficial if more data, e.g. the Cloud Droplet Effective Radius from cloud bow or glory retrievals, are integrated into this method in the future. This data integration would make this method unique.

Comment 7: *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).*

Answer to comment 7: I have given better subtitles in the new version. I ordered them more appropriately and renamed the symbols.

Comment to 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.*

The answer of the comment to figure 6: I neither find three-dimensional figures very attractive since most of them do not show valuable information. However, as an overview of the method, I do like this image a lot, and sometimes a picture is worth more than a thousand words. In my opinion, it makes it much easier to understand the aim of this method, which is to transfer the nadir measured active or passive remote sensing information on the broader field-of-view of an imager spectrometer. Moreover, the reader must understand where the axes are, the spatial axis j and the temporal axis i (off-nadir pixel) and m (nadir pixel). I have changed the caption of the new version. When the reader is reading the text, I think it should be possible to understand that passive radiance spectra are compared to each other and in case of a small deviation, the measured nadir information is used for the off-nadir location.

Comment to 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.*

The answer of the comment to figure 7: This picture shows the shortwave infrared spectrum of specMACS, which ranges from about 1050 to 2500 nm. The red dashed lines show the spectrum where the measured Liquid Water Path is the same, but the measured Cloud Top Height is different. The critical point in this figure is to show that various macro- and microphysical properties of the clouds lead to a diverse measured spectrum. This fact is essential for the matching method, which would not work well when, for example, different measured Liquid Water Path values lead to the same measured spectrum. I have deleted the figure in the new version.

Comment to 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?*

The answer of the comment to figure 8: I have excluded the plot. Moreover, I have calculated the standard deviation of calculated cloud top height from all dropsonds of that day which can be found now in the new section 3.1. Also, an explanation why it is OK to use them can be found there. I do not understand your comment "the impact on retrievals".

Comment to 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.*

The answer of the comment to figure 13: Pardon! I have included more information now in the caption. Also, now, always the same cloud scene is shown in every figure.

I once again thank you for all the constructive comments.