

Review for “**Retrieval of the land-sea contrast of cloud liquid water path by applying a physical inversion algorithm to combined zenith and off-zenith ground-based microwave measurements**”, submitted to Atmospheric Measurement Techniques

Synthesis:

This study presents a method that can be applied to microwave radiometers operated close to a water surface to determine differences in cloud liquid water path over land and water. The results of the newly developed algorithm for the ground-based microwave radiometer is compared to satellite observations.

In the current form, I do not recommend the study to be published. There are several points that should be addressed, in particular a thorough uncertainty analysis. Please find my comments below.

General comments:

- The study lacks a thorough uncertainty analysis, from the brightness temperature uncertainties to the retrieval errors. You discuss the error sources in Chapter 3.2, but you do not provide any values for the different errors which would be crucial for interpreting the results. The LWP differences in your study on the order of much less than 10 g/m² are well within the error ranges (both bias and random errors). Please provide a detailed uncertainty analysis including error bars in Figures 6, 7, 9, 10, and 11 !
- For your cloud retrieval you set up a so-called “cloud area of interest” which is between 1 and 4 km above ground. In general, there are many shallow clouds over the sea with both base and top below 1 km which would be completely neglected by this study. This is also confirmed by the cloud base observations used in the study (see line 481). It would be important to consider using lower elevation angles for the microwave radiometer to also catch the lower clouds. Otherwise, too many clouds are just not sampled for this study and a meaningful comparison with satellites becomes nearly impossible.
- The setup of the study lacks some comparison to land areas for the low elevation angles. It would have been good to also perform scans to the other direction (i.e. south-west) to check if the algorithm performs well over land, too. With a HATPRO microwave radiometer these bi-lateral scans can be performed easily. This would have provided a reference area to see whether the results between zenith and slant observations are in fact caused by the different surface conditions.
- The assumptions for the physical algorithm are very rough and the information on the forward model is quite sparse. The a-priori profiles (page 6, lines 191-192) are not described. Where do you get these profiles from, especially also the information on cloud liquid water? Which assumptions are used concerning clouds? And what are the absorption models used in the study?
- I’m not convinced by the definition of the scaling factors F_1 and F_2 . You are assuming that the vertical distribution of clouds is the same over all the years. Other factors like air or water temperature anomalies, as well as the precipitation patterns (dry/wet months) will strongly influence the cloud distribution of a special month which makes it very difficult to believe

that these scaling factors are stable for a special month. Did you see inter-annual differences for the period of the cloud base height dataset? If so, this would add uncertainty to the scaling factors. Furthermore, in Figure 6 it can be seen that the scaling factor depends very much on the location where the cloud base height has been taken. Also, it can be seen that there is quite a strong monthly variability. Do you have an explanation for this behaviour?

- Did you compare your LWP from the physical retrieval with statistical approaches? I would be interested to see whether there are differences, as you provided a new (physical) algorithm here.
- For the LWP bias correction (Figure 7), why are there sometimes considerable differences between zenith and off-zenith observations, and sometimes not (e.g. 2020 in June vs. July?). Are you sure that your bias correction algorithm is working properly? What might be the reason for these differences?

Minor comments:

- Page 2, lines 40-46: Too much detailed information
- Page 5, line 125: I would use the term “approach” instead of “algorithm”
- Page 5, line 145: What do you mean by “model form”?
- Page 12, lines 315-316: Why do you think that the LWP contrast is the same for cloud scenes with different cloud base heights? I don’t think that is a valid assumption!
- Page 17, line 452: I don’t understand what you want to say here. Do you mean that the sensitivity is instrument specific? If so, then please write it that way.