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Comment on amt-2021-415

Anonymous Referee #1

Referee comment on "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" by Vladimir Kostsov et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-415-RC1, 2022

Comment on „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" by Vladimir S. Kostov et al.

Summary

In this paper microwave radiometer (MWR) measurements at a coastal location in Northern Europe are utilized to derive liquid water path (LWP) information using a physical retrieval approach for the cloud liquid water content (LWC). Differences in zenith and off-zentih observations are attributed to a land-sea contrast and compared to satellite data for a multi-year period.

General Comments

The authors dedicate large parts of the paper to the description of a physical retrieval and a scaling approach based on the theoretical positioning of clouds relative to their measurement geometry to account for different cloud base heights (CBH). This aims towards an improvement (compared to previous studies) of the complex task to accurately quantify spatial cloud liquid water contrasts using a single MWR. Despite this effort, the methods and assumptions applied here still encompass large uncertainties, which makes it difficult to interpret the highly variable quantity of interest as described below.

In the motivation it is mentioned that previous findings of a positive trend in the land-sea LWP contrast and a diurnal cycle during June and July need further research (l. 95). These points are not addressed further and no explanation is given on why this trend is not evident in the current study. Furthermore the high variability of bias values and LWP differences visible in Fig. 7, 9, 10 is not explained. Discussing the influence of different synoptic situations or even deriving an IWV retrieval (zenith only) would add more value to the paper.

For the presented discussion and conclusions drawn here Fig. 11 would be sufficient, but a general agreement with SEVIRI data (except for August) has been shown already in Kostov et al. (2020). The LWP differences (not scaled) of the physical retrieval seem to be in the same range as the ones retrieved from a regression retrieval (comparing Fig. 9 from the present study and Fig. 18 from Kostov et al. (2020)).

The setup of the physical retrieval is not clear to me, in particular why LWC is retrieved (instaed of LWP) despite the low information content of a MWR to the vertical distribution of cloud liquid water and how the LWC prior information was derived without knowing the cloud boundaries. An error related to the misplacement of clouds is mentioned, but assumed to be the same for zenith and off-zenith observations (l. 361). Also the cloud altitude range has been modified to 1-4 km for the zenith retrieval. To my knowledge this makes it inconsistent with other prior information and could introduce a bias in the resulting LWP contrast, especially regarding the fact that most observed CBH are below 1 km (Fig. 5). A discussion on the retrieval error should be added in order put the LWP differences into context.

It is mentioned that information about temperature in liquid water cloud layers is an advantage of the physical retrieval (l. 131), but the rather smooth MWR profiles do not accurately account for that.

Suggestions for a further improvement of the retrieval performance include using nearby radiosonde data, or the LWP from a regression retrieval as a first guess. Since the focus is on the summer period, the retrieval setup could be done only using prior information from that season.

The 19.2° elevation angle was removed from the analysis, although it still probes a significant amount of the designated area of interest. According to the hypothetical cloud scheme it would also contain information on high clouds over water and could be compared to lower elevation angles. One hypothesis could be that the contrast remains similar if high clouds are decoupled from the underlying land-sea contrast. Also, the assumption that the contrast for low and high clouds is zero (l. 293) and that the true value is always larger does not hold for the case of advected clouds. For the described case 1 for example, low level and relatively low LWP clouds advected over from the water into the off-zenith observations would cause a LWP contrast.

The scaling factors for the "true" LWP land-sea contrast are based on human observer CBH statistics, which was derived over several years and averaged data from three different stations are shown (Fig. 6). The factor represents the ratio of the number of all clouds to only medium height clouds (1-4 km), but it includes observed clouds at 2.5 km and above, since no more distinction is made. The applied assumptions make this scaling highly uncertain, while the general conclusion remains the same other than a better agreement to SEVIRI data. It would be good to know the standard deviation of this value and demonstrate the resulting uncertainty for the scaled LWP contrast alongside with an uncertainty estimate for the SEVIRI results.

The LWP bias assessment is made using a threshold of 5 g/m² for identifying liquid water cloud free cases ("clear sky" might not be the right term). How does this value compare to the corresponding retrieval uncertainty? If it is chosen too low the bias would be underestimated. Although it is not possible for off-zenith observations due to the low temporal resolution, the method of using the LWP standard deviation from zenith observations could be used as an additional criterion to identify liquid water cloud free cases. Accurate estimates of the bias for zenith and off-zenith observations is important

for the assumption that there is no contrast in the case of liquid water cloud free cases (l. 289).

Specific Comments

Figure 1: a reference to Kostov et al. (2020) might be sufficient here and this figure could be removed

Section 1.1: Referencing of different scanning radiometers could be shortened. Instead literature related to the topic of land-sea contrasts should be presented.

Fig. 6(a) is not relevant since the scaling factor from this station was not used

Section 5: Validation of the off-zenith bias assessment using the FTIR instrument is difficult and could be removed, since no spatial information on clear sky conditions is obtained.

Fig. 7, 9, 10: the choice of showing monthly values while using a 10 day averaging period might not be ideal and information on the number of included cases is missing

Based on the comments above I don’t recommend publishing this paper in its current form. The authors present similar conclusions about a land-sea contrast compared to a previous study using a regression retrieval for LWP and use highly uncertain assumptions for their physical retrieval approach and cloud scheme, while questions about the variability of the detected land-sea contrast still remain.