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Atmospheric Measurement Techniques Discussions

Interactive comment on "Investigating the liquid water path over the tropical Atlantic with synergistic airborne measurements" *by* Marek Jacob et al.

Anonymous Referee #1

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Marek Jacob et al. present retrievals of integrated water vapour (IWV), liquid water path (LWP) and rain water path (RWP) from airborne passive and active microwave observations collected using the German HALO aircraft during two campaigns over the tropical North Atlantic. The retrievals are developed using artificial neural networks trained on a dataset generated using radiative transfer simulations and atmospheric profiles taken from a cloud-resolving model. The IWV retrievals are evaluated using independent measurements of water vapour from dropsondes and Lidar, and a theoretical comparison using a separate dataset of modelled profiles and brightness temperatures. Analysis of the retrievals from flights conducted during the wet and dry seasons shows higher IWV during the wet season, but a higher frequency of clouds

with larger LWP and RWP during the dry season flights.

A slightly clearer distinction between total liquid water path, cloud liquid water path and rain liquid water path could be made throughout the paper. I would also like to see some more details of the distinction between cloud and rain liquid water path. This is hinted at on P7 line 17, which implies that it is taken from the ICON microphysics scheme, but it would be helpful to specify the difference in terms of the different size distributions etc.

Why are all the available microwave channels not used in the retrieval? I would expect that particularly the 183GHz channels would contain additional information on the IWV, including its vertical distribution, and the quasi-window channels on the far wings of the 118 and 50-60GHz O2 bands will also respond strongly to liquid water. Since the data are already screened for cloud ice then scattering at 183GHz should not be a concern here.

I would like to see some further discussion on the impact of surface wind speed (and the minor impact of surface temperature) on the retrieval of LWP and IWV. How does the frequency-variation of the brightness temperatures differ for surface wind speeds compared to that for IWV/LWP/RWP shown in figure 2? Is there any independent information content on the wind speed contained in the radiometer measurements, or does it effectively just add noise to the LWP/IWV retrievals?

I find it slightly surprising that there is more liquid water during the dry season than the wet. I would like to see some more discussion about how the results in sec. 6 may be influenced by the choice of flight paths during the two campaigns. If specific conditions were either targeted or avoided then this could significantly bias the results.

Minor points

The authors note that the WALES IWV measurements are only available in clear sky conditions so they only provide validation for the MWR retrievals when there are no confounding effects from liquid water. Is it possible to split the dropsondes into clear and cloudy scenes to demonstrate if there is any impact of liquid water on the quality of the IWV retrievals?

P6 line 18 Why is there a need to convert from water vapour number density to volume mixing ratio? It is the former that is required to calculate integrated water vapour mass.

P8 figure 2 I suggest using a logarithmic colour scale to show the relative frequency to highlight any detail away from the strong "clear sky" line

P9 line 31 Biases with respect to what?

It would be useful to have an indication of along-track distance on figure 4 rather than just time

P13 final paragraph – it would be nice to refer to fig 6 early in this discussion.

P14 discusses the impact of negative LWP retrieval values on the bias. These could be avoided by performing the retrieval in logarithmic space (I.e. retrieving log(LWP)). Would this have a significant impact on the results?

In figure 10 it might be clearer to plot the LWP and RWP on a logarithmic scale – in the current plot it is hard to see the cloud LWP retrieved by the MWR between 17:38:30 and 17:39:10 that is discussed in the text at the end of page 17

The paper is clearly written and generally easy to follow, although I find a number of sentences do not read well and should be redrafted. There are also a few typos:

P1 line 1 "...identified especially marine low level clouds to play a critical role for the climate."

P1 line 5 ". . .to better understand *the* LWP of warm clouds..."

P2 line 5 "Especially, shallow marine clouds are attributed to contribute largely to inter-model

spread of climate models"

P2 line 28 "Visible/near infrared techniques *such* as those applied to MODIS..."

P3 line 9 "...allow to study clouds with similar, however, more sensitive and higher spatially resolving instrumentation than available on satellites." Perhaps "...allow the study of clouds with similar, but more sensitive and higher spatially resolving, instruments to these available on satellites."

P3 line 13 "Their study shows *the* sub-footprint variability of spaceborne Special Sensor Microwave Imager/Sounder..."

P3 line 24 "The assessment of LWP (Sec. 4) reveals the importance *of using* ancillary measurements, e.g. lidar measurements for low LWP values and cloud radar measurements for lightly precipitating cases."

P3 line 26 ". . . between dry and wet *seasons*"

P4 figure 1 I think the caption mis-labels the thin and thick lines based on the dates in the legend (I.e. NARVAL 1 looks like it should be the thick lines)

P5 line 12 "more dominant in the higher *frequency* window channels"

P5 line 16 remove the comma after "both"

P6 line 9 "cloudy conditions as *well* as possible"

P6 line 25 "...prevent having data during some flights..."

P7 line 10 is ambiguous. Are all profiles with ice excluded, or only ones with ice water path above 1000g/m^2?

P7 line 11 "...the ocean *are* used"

P8 line 3 ". . . are *visible* as a line..."

P9 line 11 ". . .never deviates *more* than . . ."

P14 line 7 ". . . decided *to use* a retrieval"

P21 line 11 ". . . consistent *with*"

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