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Atmospheric Measurement Techniques Discussions

Interactive comment on "Integrated water vapor and liquid water path retrieval using a single-channel radiometer" *by* Anne-Claire Billault-Roux and Alexis Berne

Anonymous Referee #3

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General Comments

1.) It's very good and important to see, that an approach has been made to derive a globally valid retrieval algorithm for IWV and LWP observations from single channel microwave observations. This can be beneficial for different science applications, e.g. weather & climate but also in astronomy and radio propagation.

2.) The paper is well written and makes clear points. It nicely addresses the fact, that the combination of microwave radiometry in synergy with re-analysis output and standard environmental conditions can be advantageous.

3.) Although I strongly favor short and concise papers, the results presented here

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Discussion paper

(especially in Sections 5 and 6) are – to an extent – kept rather minimal. The paper would benefit from a more detailed and quantitative discussion. See also my specific comments below.

Specific Comments

Section 1

Lines 25-27: If the authors are referring to TBs in the microwave spectrum, please omit "radiative contribution of . . . aerosols"

Section 2

Lines 68 onward: I assume you performed a quality control for the radiosonde profiles used for retrieval development, if not please consider doing so. Depict checks concerning range (e.g. min/max) of atmospheric parameters, maximum ascent height, consistency checks concerning pressure and/or temperature gradient, etc..

Line 76: Please discuss what the relatively low vertical resolution could imply for the retrieval development. E.g., the coarse resolution of the relative humidity profile will influence where and how many liquid layers are detected. What happens if this is significantly different for different radiosonde sites? This discussion could also be part of Section 3.1.

Lines 92/93: Describe how far WProf and HATPRO were apart (in meters) and if you expect any corresponding uncertainties during retrieval application.

Section 3

Section 3.2: I am missing a specification of the absorption models used for water vapor, oxygen and cloud liquid water. As previous studies have shown (e.g. Cimini et al. 2018, https://doi.org/10.5194/acp-18-15231-2018), this can be decisive for the absolute accuracy of your retrieval results. This aspect is nowhere discussed in the paper, should be, however.

Line 127: Please specify at which LWC (together with the assumed parameters of your gamma distribution, specify these as well), Mie effects become non-negligible and in how many cases in your data set this threshold is exceeded.

Section 4

Section 4.1: I don't find any indication in the manuscript of how you are dealing with random uncertainty of your measurement variables, e.g. radiometric noise and T/q/p sensor uncertainty. If you want to simulate a realistic retrieval behavior, you need to put noise on your measurements (training, validation and test data set), otherwise you are assuming a "perfect relationship" between measurement and LWP/IWV, which you will never have in reality.

Line 140: Since the relation ship between LWP/IWV and the TBs is, well I'd say, linear to moderately non-linear, I ask myself why you need to use TBˆ4? Can you quantify the retrieval improvement when using only TB and TBˆ2 in comparison to higher order terms?

Line 157: You mention "a strong bias of the retrieval toward low LWP values". Please quantify and compare to the retrieval with equally distributed LWP so you can justify this procedure.

Section 5

Begin with introducing your results in a general positive sense, make the reader feel like you are now going to present some great, interesting and relevant plots (which you mostly do!). I wouldn't begin Section 5.1 with two sentences that actually belong in the figure caption.

Section 5.1: I assume Figure 5 illustrates the retrieval including all input parameters? Please state this clearly in the text and figure caption.

Lines 188 – 190: I think Figure 5 would benefit from two additional sub figures showing the bias as a function of binned IWV and LWP. Then you could quantify the statement

you make in these two lines and elaborate a bit more on the bias behavior for smaller IWV.

Lines 191 – 194: I'm a bit puzzled by Figure 6a. If you only use the 89 GHz TB then ERA5 performs significantly better. So, is there any sense of using this TB at all? I think you need to perform a retrieval without TB, just with all other parameters and add this one to your plots. This would help in putting the value of the 89 GHz TB in context. Then you need to discuss your results in more detail.

Lines 196 and following: When you mention the RMSE of 86 gmˆ-2, I assume you are applying the retrieval derived from the equally LWP-distributed training data set to the equally distributed test data set? I'm not sure.. please make clear.

Lines 199 – 201: You write: "with however a bias for low LWP values, which are slightly overestimated, and for large LWP (> 800 g m−2) which are underestimated". Please apply my comment to Lines 188 – 190.

Line 211: You write: "but only in a minor way does it increase the LWP retrieval's accuracy". But it does!? Going from noERA-noIWVpred-noGeo-noSurf to ERA-noIWVpred-noGeo-noSurf reduces the RMSE from roughly 140 to 90 gmˆ-2. Or am I misinterpreting something wrong here?

Section 5.2: I like the idea of showing the sensitivity to instrument calibration offset, but only when I look at Figure 7, do I only see that you have looked at the effects for all different retrieval configurations and for continuously rising TB offset. Here again: please describe and discuss your results with more detail. To make your discussion complete, please add the "only-TB" retrieval to Figure 7a and 7b.

Section 5.3: Do you have any interpretation as of why the results over the Indian Peninsula are so much worse than elsewhere, even compared with sites at similar latitude? Is it possible that this is associated to the quality of the radiosondes or is there any other reason you can think of?

Line 242: Please describe how you think “humidity and temperature conditions” can lead to the discrepancy.

Figure 9: Can you explain the outliers (especially the vertical and horizontal “bar structures”) in Figures 9a and 9b?

Section 6

I’m missing a discussion of Figure 11. One point would be, e.g. as also seen in Figure 6a, that the reanalysis performs better than the TB-only retrieval. Here, again it would help if you added a retrieval derived without any TB to discuss the overall TB value. Comparing such a retrieval against your ERA-Geo-Surf would tell you something about the impact of 89 GHz TB and if it’s sensible to use it at all if you have the other parameters available.

Line 261: Please quantify the “constant bias”

Lines 296 and following: In Fig 12, I’d also include results from a retrieval without TB. Another possibility for ERA5 outperforming the retrievals could maybe be fog? Could you include a discussion of the weather during ICE-POP?

Section 7

Can you elaborate a little on what the alternative would be to using the re-analysis? If, e.g. you would need quasi real-time retrieval results.

Figure 2

X-axis labelling of Figure 2b needs to read “LWP”, not “IWV”

Figure 6

Do you need to make the bars orange with diagonal lines – just orange would probably make the text easier to read?

Figure 9

It would help if you included in-plot statistics such as number of cases, bias, RMSE and R^2. Best do consistently with Figures 5 and 13.

Figure 10

I think the ordering of the text in the bars is swapped, otherwise the plots make no sense to me.

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