Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-311-RC1, 2020

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 #1

Received and published: 13 September 2020

General comments:

The authors developed an algorithm to retrieve liquid water path (LWP) and integrated water vapor (IWV) from ground-based passive microwave observations at 89 GHz. The algorithm is based on a neural network approach and uses synthetic cloud data derived from global radiosonde observations of atmospheric profiles. The algorithm is tested at two locations – Switzerland and South Korea, and the testing results are reasonably good. Because location and time information are used in the input of the algorithm, the algorithm can be used anywhere over the globe without further tuning required. The algorithm is targeted for the WProf radar-radiometer instrument, which

was deployed during the ICE-POP 2017 field experiment. I found that the work is quite useful, and the writing is generally clear. However, I do like to see some revisions before recommending publication. In particular, I'd like the authors to clearly state the fundamental limitation of the approach: the 89 GHz observation is not optimized for IWV retrieval, most of the IWV info gained from the algorithm is from secondary input parameters, such as surface temperature/humidity obs, ERA reanalysis, or even the correlation between LWP and IWV. I recommend minor revision, but would like to see the authors clearly address the above comment.

Specific comments:

Lines 9-11. The description of algorithm performance is too qualitative (don't carry much information). Please use some quantitative measures, such as R2, Bias, RMSE. Specify the performance separately for IWV and LWP retrievals. Also, indicate which input parameter(s) has (have) the most impact on the algorithm's performance.

Line 27. Aerosols contribute to millimeter wave radiation?

Line 40. I don't understand why physical model is "computationally heavy and cannot implemented accurately when only one frequency is available". I think the fundamental problem is that you have only one piece of information (TB), and yet you want to obtain two unknowns (IWV and LWP). You need secondary info and/or climatological relation between the unknowns. It is a highly statistical problem anyway; there is no need (not helpful) to go through the physical route.

Section 3.1: Please give more detailed info on how "clouds" are created based on atmospheric profiles, in particular, on how LWP depends on temperature and humidity. Since the observation is TB from one channel only, it cannot separate between liquid and vapor information. Therefore, if there is a correlation between humidity (or temperature) and cloud liquid, the retrieved LWP will be always correlated with IWV because the relation is built in the a priori training dataset. This correlation may not be valid in natural clouds, at least for some types of clouds. So, the authors should let readers

know about this issue, so that readers can take precaution when interpreting retrieved results. I suggest that the authors rewrite this section, provide full information on the liquid cloud model.

Lines 140-141. Higher order terms of TB are used as input of the algorithm. Why? Do the higher order terms actually have "the greatest importance"? I didn't see the importance has been shown in the sensitivity test section. Please clarify.

Line 145-146: I am concerned about the algorithm replying on reanalysis data, in particular directly replying on IWV and LWP in the reanalysis. This makes the "observation" completely mixed with "model", something worries me if I try to use "observation" to validate models.

Line 152: What are considered to be "strong rain events"? 0.1 mm/hr, 1 mm/hr, or 10 mm/hr? If I am a data user, I will stop using the retrieval when rainrate exceeds 0.1 mm/hr because all assumptions used in the algorithm development become invalid once rain/drizzle starts. So, I wouldn't call "strong rain" here.

Line 157. I am not sure I understand why if clear cases are left in the training set, "the training phase will result in a strong bias of the retrieval toward low LWP values." I thought the algorithm should be able to retrieve zero LWP (clear) cases. If all/most cases in the training set are cloudy cases, will the retrievals be most likely to have LWP>0? That is not what really happens in nature. For most locations, clear-sky has more frequency of occurrence than cloudy-sky. The fact that the case counts in Fig.2b is the same values for LWP from 0 to 600 g mˆ-2 also puzzles me. Maybe I misunderstand the concept here. Please explain.

Line 168. What is the difference between validation set and testing set?

Fig.6: Explanation to Fig.6 is severely lacking. It is really hard to understand what input are critical, although I guess the purpose of having this figure is exactly tended to show the importance of each input variable. Please think a better way to explain. But one

thing seems to be clear – no extra inputs but TB alone will result in a horrible retrieval. It also seems to me that ERA and the combination of Geo+Surf are redundant, i.e., you only need either, but doesn't have to have both, although the authors didn't conclude in such a way. If my interpretation is correct, I would get rid of ERA in the algorithm, and wouldn't say "the most important secondary feature is ERAs estimates." (lines 192-193).

Section 5.1. I would like to see a test in which you only use secondary info (without TB observation), and see how IWV and LWP "retrievals" will look like. I'd guess IWV retrievals could be reasonably good. If that is true, it means TB observation does not add much info to the retrievals.

Lines 245-247. Any ideas why error in these areas are large? Underrepresentation of radiosonde profiles in the training set, or cloud model not suitable for these regions?

Lines 261-262 "This . . .stage". This sentence doesn't make sense to me. ERA5 just happened to have IWV bias in this region for this time period, or ERA5 generally has IWV bias in general?

Fig.10. I have difficulties to interpret the results of the lowest two rolls in Figs.10c and d. Adding ERA data makes LWP results worse? I am confused here.

Lines 296-297. I always believed that the 89 GHz is not a good frequency for IWV. It works well for LWP. When IWV and LWP are not well correlated, IWV retrievals will suffer.

Lines 303-304. I am not sure that the results in this paper indicated this statement. Please explain.

Section 7. The summary appears mostly focusing on IWV retrieval. Please also mention some results on LWP. To repeat my main concern: I think this instrument is not good for IWV, but rather good for LWP. I hope that the authors can state something to reflect this point.

Technical comments:

Fig.2. The x-axis label in Fig.2b should be “LWP (g mˆ-2). Fig.3 and Table 1 are not explained well in the text. I am not sure what the curves and symbols mean. Please explain more as not everyone is familiar to the Keras library in Python.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-311, 2020.