

Review: Estimation of Liquid Water Path in Stratiform Precipitation Systems using Radar Measurements during MC3E

By Authors: Jingjing Tian, Xiquan Dong, Baike Xi, Christopher R. Williams, and Peng Wu

General comments:

The authors present a scheme to retrieve rain liquid water path (RLWP) and cloud liquid water path (CLWP) beneath the melting layer in stratiform precipitation. It is known that LWP retrieved from traditional microwave radiometer (MWR) in rainy conditions might be invalid. The authors consider two situations: (1) no cloud detected below the melting layer; (2) cloud is detected below the melting layer. The retrieval of RLWP (namely, situation 1) is based on the method proposed by Williams et al. (2016). In situation (2), to retrieve CLWP they estimate the layer mean rain rate by using the differential velocity technique proposed by Williams et al. (2016), which is expected to be an improvement to the original method (Matrosov, 2009). Using the proposed technique, the authors found that the CLWP is the main contributor to LWP beneath the melting layer when cloud exists.

This is an interesting study that is relevant to the scientific community and is within the scope of AMT. Overall, this manuscript is well written, cites relevant literature and the proposed technique is novel. However, the authors should include a more detailed discussion about the retrieval uncertainty. I recommend it for publication in AMT if the authors take into account the following comments.

Major comments:

1) Given the generally recognized definition of liquid water path (LWP) is the integral of the liquid water in the whole atmospheric column, I suggest the authors highlight that the LWP in this manuscript is beneath the melting base in title, abstract and other places where misunderstanding might be induced.

2) I believe a more detailed retrieval uncertainty analysis for situation (2) is needed. I would love to see the retrieval uncertainty in Figure 4 and 5 (see examples in Figure 3 f, g, h). In addition, a more thorough comparison with (Matrosov, 2009) regarding the retrieved results as well as the uncertainty would be interesting.

In Figure 5c, the retrieved CLWP values can be as large as 2~3 kg/m². It sounds like very large values for me. Since the comparison to MWR LWP is a suspect due to radome wetting, could you compare your retrieved values to observations in non-precipitating warm clouds? It would give an idea of how realistic those values are.

3) Figure 1. Have you checked that how often the ceilometer signal is totally attenuated?

The black dots in Figure 1 seem indistinguishable from the melting layer for me. I suggest the authors to use a separate time series plot to show the heights of melting top/base and cloud base, which may help readers to understand the difference between situation 1 and 2 better.

4) Both RLWP and CLWP are dependent on the geometrical thickness of rain and cloud layers, have you considered the changes of the melting layer height? If there are significant changes of melting layer height, RLWP will be affected.

5) Figure 7. The retrieved LWP in Figure 7b seems to be weakly linked to rain rate, though high correlation between the rain rate and RLWP is shown in Figure 4 and 5. Can you explain this?

Have you tried to quantify by how much the MWR overestimates the LWP for cases with the

similar melting base height?

6) The authors compare their finding to the study of Lebsock et al. (2011). However, they study warm clouds while the presented research focuses on cold cloud precipitation. To what extent this comparison is meaningful?

Minor issues:

- Please check the references (e.g., line 582, should be 'J. Appl. Meteor. Climatol.'), and follow AMT's requirement on literature format.
- Figure 3 d. It seems to me that the negative differential velocity in the melting layer is a bit large. Have you checked the matching of the ranges between those two radars?
- Figure 4 and 5. Use standard format for time, such as 12:30 instead of 12.5.
- Figure 4b and 5b. It seems that the retrieved rain rate agrees better with more stable precipitation (e.g., 12.7 - 13.1 in Figure 4b). But what are the reasons for those obviously overestimated retrievals in Figure 5b?
- Figure 7. It seems to me that the use of error bar is a bit puzzling, since for a rain rate bin the retrieved/measured LWP are under different conditions (e.g., different melting base). Have you considered using a scatter plot to show the relations between RET and MWR with rain rate indicated by color?

- Line 39, 'with-cloud'
- Line 49, 'is still'
- Line 62, 'they are known'
- Line 109, '. However,'
- Line 136, 'bright band'
- Line 179, 'with the aid of'
- Line 229, 'limiting'
- Line 235, 'B'
- Line 292, 'relatively'
- Line 339, 'samples'
- Line 347-358, RLWP/CLWP > 2 in Lebsock et al. (2011) while in this study RLWP/CLWP is on average much smaller, how to explain such difference?
- Line 348, 'having not'
- Line 359, 'compared them'
- Line 363, 'possibly due to'
- Line 424, delete either of the 'separately'