Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
https://doi.org/10.5194/amt-2021-111-RC2, 2021

Reviewer 2 comment

Anonymous Referee #2

Referee comment on "Spaceborne differential absorption radar water vapor retrieval capabilities in tropical and subtropical boundary layer cloud regimes" by Richard J. Roy et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-111-RC2, 2021

Review of manuscript #AMT-2021-111 entitled 'Spaceborne differential absorption radar water vapor retrieval capabilities in tropical and subtropical boundary layer cloud regimes' by Richard Roy, Matthew Lebsock, and Marcin Kurowski.

The manuscript provides a detailed evaluation of the potential of a differential absorption radar (DAR) operating in three tones around the 183 GHz water vapor absorption line for PBL humidity profiling inside clouds, precipitation and for measuring integrated water vapor (IWV) in clear air regions. While the concepts presented by the authors are innovative, I believe the study overlooks a few effects that would have a considerable impact on the results (see major comments below). Given this, my recommendation is to reject the manuscript in its current form and invite the authors to submit a revised manuscript when these effects are simulated.

Major comments:

- I believe the authors have omitted to consider the spaceborne range weighting function in their forward simulations. Past literature has shown that the range weighting function of long pulsed radars effectively stretches along, or in other words vertically smooths, any vertically-narrow cloud or precipitation feature. I believe this would affect the forward simulated radar observables that the authors present and rely on to assess their technique. Beyond vertically stretching/smoothing the fields, the range weighting function should be expected to introduce covariance of the random error. The authors correctly introduce random error after the retrievals are performed based on the linearity of the transfer function from the state vector to observations (Page 15); however, I believe this only represents one source of the true error, which should also include error caused by the covariances along range especially if the observations are to be oversampled by a factor of 4 of the true radar resolution to achieve the desired range gate spacing.
- The authors discuss the use of a spaceborne DAR system operating a long pulse with frequency modulation like that used in RainCube. Based on my limited knowledge of RainCube's performance, I would expect that such a radar would suffer from contamination by the surface echo and range side lobes in the lowest kilometer of observations above the surface. Yet the authors failed to mention anything about how

the proposed radar would be impacted by these two effects (surface echo and range side lobes) and about how this may impact the sensitivity of this radar to low level targets and the overall performance of the proposed retrieval in the boundary layer.

- While it is interesting to consider the use of intelligent sampling using a passive/active sensor synergy, I believe the authors need to discuss more of the key aspects of such an endeavor to prove that it would even be feasible. For one, the authors did not discuss how a 2-m dish antenna will be configured to perform intelligent pointing. Overall, I believe a lot more information needs to be presented regarding this theoretical intelligent scanning technique. I would even argue that it should be the topic of a separate study.

Minor comments:

- P2, L14: The authors claim that they performed detailed orbital simulations. Please elaborate on what detailed information about the satellite orbit is used in this study beside the satellite altitude and velocity.
- P3, L31: I think the word "Table" is missing in front of "1".
- P6, L1: A formal study has been published based on Tatarevic et al., 2019 report. As such, I believe it is more appropriate to cite Oue, M., Tatarevic, A., Kollias, P., Wang, D., Yu, K., and Vogelmann, A. M.: The Cloud-resolving model Radar SIMulator (CR-SIM) Version 3.3: description and applications of a virtual observatory, Geosci. Model Dev., 13, 1975–1998, https://doi.org/10.5194/gmd-13-1975-2020, 2020
- P7, Fig. 1: Why did the authors not consider the Self-Similar Rayleigh-Gans Approximation (SSRGA) for the snow radar forward scattering modeling. Here is a useful reference: Hogan and Westbrook, 2014: Equation for the Microwave Backscatter Cross Section of Aggregate Snowflakes Using the Self-Similar Rayleigh-Gans Approximation, Journal of the Atmospheric Sciences, 71(9), 3292-3301.
- P9, Fig. 2: Is it possible that the precipitation and cloud mixing ratio labels are mixed up in the right panel of figure a? I find it difficult to believe that the rain is elevated and higher in magnitude than the cloud mixing ratio.
- P9, Fig. 2: I would recommend not showing the water vapor retrievals before presenting section 2 that describes the retrieval.
- P16, Fig. 3: The caption for panel d is missing.
- P18, Fig. 5: I believe the surface echo and range side lobe should be visible in this figure. Afterall this is a chirp radar and its sensitivity is very high (better than CloudSat) and as such I would expect contamination of at least all the sub-cloud layer.
- Can you comment on the ability of the technique to capture the mesoscale organization of the humidity field?
- P21, F9: I believe the stretching effect of the range weighting function should be visible in this figure. A useful reference to visualize this effect is Lamer, K., Kollias, P., Battaglia, A., & Preval, S. (2020). Mind the gap–Part 1: Accurately locating warm marine boundary layer clouds and precipitation using spaceborne radars. AMT, 3(5), 2363-2379.