Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2020-97-RC2, 2020


Atmospheric Measurement Techniques Discussions

# *Interactive comment on* "Assessment of global total column water vapor sounding using a spaceborne differential absorption radar" *by* Luis Millán et al.

**Anonymous Referee #2**

Received and published: 24 June 2020

General comments:

This manuscript described a feasibility study of a differential absorption radar operating near a water vapor absorption line (183 GHz) in measuring total column water vapor from space. The considered radar system combined two tones (167 & 174.8 GHz) near the vapor absorption line and had potential radar powers ranging from 0.1 to 100 W. The radar system performances including measurement approaches and environment conditions were numerically simulated based on basic radar principles and global CloudSat observed hydrometeor and ECMWF atmospheric temperature, pressure and humidity profiles. Various measurement sensitivities and uncertainties were simulated.



Results showed that with 20 W radar transmitted power satisfied measurements could be obtained for both land and ocean areas. This kind of satellite measurements could potentially provide additional global water vapor observations, particularly over land, besides passive infrared and microwave vapor soundings over oceans. This study was straight forward, and the manuscript was basically written well.

Based on the importance of water vapor observations, especially over global rural land and polar regions, for weather and climate studies, and the general and specific comments listed below, a minor revision is recommended.

1. The authors should clarify certain simulation procedures in obtaining the simulated random and systematic errors of total column water vapor measurements. Were those errors obtained based on uncertainty parameterization like Eq. 6 or the detailed radar signal propagation processes? Did they simulated the processes of the radar signal generation, transferring through the atmosphere, and reflecting at the surface with all adequate noise and uncertainties added in individual parts of the signal propagation processes? For example, when passing through atmosphere, what turbulence was considered for radar signals?

2. For the radar system considered, what was the swath of spaceborne radar? The NRCS of surfaces may drop with increased scanning angle quickly. Could it scan like the precipitation radar onboard TRMM satellite? A related question is the sampling rate (or revisit time period) for a particular location.

Specific comments:

There are some editing issues throughout the manuscript. Thorough proof-reading is required. 1. Abstract, Line 14:, '.. a fractional yield better than 0.7'. It is not clear what exactly this 'yield' means here. The authors defined this at a very late stage.

2. Pg2, Line 8: add 'a' after 'using'.

3. Pg2, Line 9: add 'for' before 'all surfaces' It would be better if change 'all surfaces'

to ‘all surface types’ .

4. Pg2, Line 22: The authors wrote: ‘. . .. absorption line, respectively. . .’ It would improve the readability if moving the ‘respectively’ to the end of this statement.

5. Pg2, Line 25: It sounds like there are some issues with the assumption of ‘0.16 dBZ radar precision, and around a -30dBZ minimum detectability’. Could the authors provide details on these issues, please?

6. Section 2, pg 3 and 4: this part could be shortened because of many cited papers and previous studies.

7. Pg3, L14: add ‘parameter’ after ‘where C(ïĄő) is the radar system’.

8. Pg4, L1: No need to make subsection 2.1. All in Section 2 would be fine.

9. Pg4, L12 and 25: The authors used a 66-us chirped pulse. This is a pretty long pulse. How big are the sidelobes of the pulse returns after coherent integration (or correlator)? Could the radar backscatterers at different ranges affect each other? What is the impact of those sidelobes? For example, what is the potential bias these sidelobes could produce when rain drops are considered?

10. Pg4, L20: The authors mentioned NT value is, at least, 2. Is it possible for the designed radar system to transmit the two tones together? If yes, what is the potential of cross-talks? If not, provide reasons besides cross-talks due to transmission and amplification.

11. Pg4, L26: change ‘table’ to ‘Table’ for consistency. Also, please check other places such as line 7 in page 5.

12. Fig. 1: Need enlarge the symbols of half circle and triangle. They are hard to read now.

13. Pg5, L14: What was the cited reference ‘Partin 2007’ exactly? A thesis or internal report? In either case, a link to the document is needed.



14. Pg5, L16: For radar operation frequencies of 167 and 174.8 GHz, could the authors let readers know how big the atmospheric gaseous attenuations at these frequencies are for some typical clear atmospheric profiles such as those with total column water vapor values of 35, 45 and 55 mm? What are the percentages of vapor attenuations on the totals?

15. Pg5, L18 to 21: The study used two vapor profiles: wet and dry. It seems that the dry profile was not for zero vapor amount. Could the authors let readers know what the total column water vapor values were used in the simulation for wet and dry conditions? Also, how about other meteorological conditions such as the surface temperatures?

16. Fig. 3: the colors in the figure were not easy to read due to inconsistency from cold to warm colors. The authors need change the color code.

17. Pg6, L5 to 8: only 4 panels were shown. Please check this statement. Also, this statement may be too complicated and should be split into shorter sentences.

18. Eq. 17: Please provide references or a brief derivation to obtain this equation. Was the uncertainty used in the manuscript a variance or mean square error? What assumptions did the authors used in deriving this equation? This was confusing since it was not clear if the means or bias errors were included.

19. Pg7, L8: no need of the subsection 4.1.

20. Pg7, L15: ‘. . .. also provided by CloudSat.’ Did the authors mean ‘. . . also provided by CloudSat-ECMWF product.’

21. Pg7, L17: Wi was a water vapor state variable. Readers expected it to be a vector for the water vapor profile. However, the iteration parameter ïĄij1 ïĂ■ Wi+1 / Wi ïĄij made it looked like a scaler. Was this value the total column water vapor? Please clarify this.

22. Pg7, L19 to 24 and Eqs. 19 and 20: Were instrument and measurement noises added when calculating the simulated radar returns?

23. Pg8, L2: The authors mentioned precision here. Could the authors clarify if the retrievals had bias errors when only instrument and measurement noises were used? Many factors could introduce biases. For example, as mentioned previously, sidelobes could cause bias errors. If the answer is yes, how small or big are these biases?

24. Pg8, L4: '.. the impact of not knowing of temperature and pressure by using climatological values' How could this happen? People would think the authors or users of the spaceborne radar measurements should have products of numerical weather forecasts, assimilations and/or analyses of these temperature and pressure profiles? It is understandable to have certain uncertainties (or random and bias errors) associated with these modelled values, but it seems to pretty extreme to think without information on these values during environmental science satellite operations.

25. Pg8, L15 to 17: Could the authors move the discussion on Fig 5 (SNR) after Fig. 4 discussions. That is, move these lines to the end of line 21.

26. Pg8, L18: The authors defined 'yield' here. For increasing readability, it should be defined much earlier when the first time it was used.

27. Pg8, L19 and 20: change the words 'used before' to 'as those shown in left panels' .

28. Pg9, L9: define 'pT'.

29. Pg9, L25 and 26: The authors cited Meshkov (2006). The reference showed that this was a thesis. There was an article with the same title by Meshkov and De Lucia (2005). Were the essential contents of these two articles the same? If yes, the authors should cite the latter because of easier to obtain for readers.

30. End of pg9 and beginning of pg10: The authors found that potentially current uncertainties (4%) in the line width of the water vapor absorption line could cause about 1.4 mm total column water vapor bias errors. For this kind of significant systematic errors, can calibration and validation of the measurements of the instrument or even



using an airborne radar at the frequencies considered over tropical regions or during midlatitude humid summer periods identify the bias and correct this potential systematic error? From random error analysis, it seems possible with long enough averages. If yes, the authors should make some comments and explanations, especially at the summery, on this, which would increase the feasibility of the instrument.

---

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-97, 2020.