Atmospheric Measurement Techniques Discussions

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Review of "The SPARC water vapor assessment II: Assessment of satellite measurements of upper tropospheric water vapor" by William Read et al.

Anonymous Referee #1

Referee comment on "The SPARC Water Vapor Assessment II: assessment of satellite measurements of upper tropospheric humidity" by William G. Read et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-300-RC1, 2021

In this study, the authors presented the results of comprehensive intercomparison of water vapor based on the twenty-one satellite-based measurements, frostpoint hygrometer balloon sondes, and Vaisala-RS92 radiosondes in the upper troposphere, which covers the pressure range from 300 to 100 hPa. The comparison methodologies used in this study are robust, and the results are well presented. This work will certainly be used as an essential reference by a wide scientific community. However, there are some technical details of the work that I would recommend the authors revisit before it is ready for the final publication. Please find my general and the specific comments below.

General Comments:

- I believe the authors have the vast knowledge on the water vapor measurements in the upper troposphere and stratosphere. General comments on the importance of long-term measurements of upper tropospheric and stratospheric water vapor on climate and climate change would be appreciated.
- I believe there are newer versions of data from some of the instruments used in this study, e.g., MLS, which became available recently. I think it would be useful to add some insights on how the retrieval versions of each instrument are chosen and how the results presented here will or will not be sensitive to the different versions of data. Another comment related with newer generation instruments, e.g., SAGE III on ISS, which is not included in this study, could potentially added as well.

- On technical aspects, please revisit the color schemes of line figures and try to find a way to emphasize the lines that are note-worthy. This will help identify the key results in this work more easily.
- I think adding references where it is relevant would greatly improve the richness of this manuscript. I think many of them are missing. Some of them are pointed out in my specific comments.

Specific Comments:

P1, Abstract: I would recommend using consistent nomenclature for water vapor instead of using three separate ones, *e.g.,* humidity, water vapor and H2O. This applies to the rest of the manuscript.

P1, L10: Here, do 'average ~30% agreement' and 'additional ~30% variability' refer to the differences in the averages of the data?

P2, L17: increase in satellite missions -> increase in the number of satellite missions. It would be necessary to add a sentence here mentioning that not only the number of instruments but also the measurement techniques are improved since 2000.

P2, L17: It would be helpful to add a few references at the end of this sentence.

P2, L19: Again, citations are needed at the end of this sentence.

P2, Section 2: References for the Vaisala-RS92 are needed here. It would be helpful to add one more column at the end of Table 1 to show references for each satellite data set.

P4, L44: I would recommend rewrite this sentence for clarity.

P4, Section 3: I would recommend adding time periods for the comparison as each satellite measurement covers different time periods. Also how was the quality control done for each data set?

P4, L47: ‘the weighting…sounder’ – It would be useful to have this as a number in km.

P4, L49: I am curious to know if all instruments are prone to drifts in the water vapor retrievals or it only applies to a certain technique.

P4, L56: ‘Many scientific…’ - A few references for these types of studies would be useful here.

P6, L92: What are the time periods of data used in Fig. 3?

P7, Fig. 2: I think this figure looks crowded because of all the equations included in the figure. I am wondering if this figure and the explanation in the text (L80-90) can be simplified.

P7, L113: I am wondering why this is true only for the MIPAS-Oxford retrieval.

P7, L115: ‘support the above result’ – A reference for this statement would be useful.

P10, L156: I believe MLS v5 is publicly available. A relevant citation would be helpful here.

P12, Fig. 6: It would be helpful to add a comment about the outliers in this figure.

Figs. 6 & 7: It is hard to see the MLS-Aura lines (yellow) in these figures. Use a different color for MLS-Aura to emphasize the feature. This can be done by switching the color with another instrument.

P19, Fig. 12: Is the reason why the agreement is better in Boulder related to the number of available measurements is higher in Boulder than the other stations?

Figs. 14 & 15: I am wondering what the best-fit lines for 178 and 147 hPa would look like and if it is still useful to show.

P21, section 4.3: Time periods used in this comparison should be mentioned here as different satellites cover different time periods.

P21, L220: A reference for MERRA is needed here and elsewhere.

Figs. 16-18: It is interesting to note that only the MLS *vs*. AIRS comparison in Fig. 16 shows the second peak in the pdf distribution below 178 hPa when the air is dry (< 10 ppmv).

P23, L240: 'and inter…down' – A little more explanation about this would be helpful.

P23, Section 4.4: It would be helpful to add a paragraph describing the differences that one can expect between MLS and AIRS because of the differences in the measurement techniques and sampling patterns, etc. This is described in the first paragraph on Page 29, which can potentially be moved to the beginning of Section 4.4.

P32, Section 5: Figure 23 contains a lot of information and I think it is extremely useful. I think it would help to split this section into discussion and conclusion or subsections for simplicity. This section contains many details that need time to digest.