

Atmos. Meas. Tech. Discuss., referee comment RC1
<https://doi.org/10.5194/amt-2022-204-RC1>, 2022
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Comment on amt-2022-204

Richard Allan (Referee)

Referee comment on "Assessing the consistency of satellite-derived upper tropospheric humidity measurements" by Lei Shi et al., Atmos. Meas. Tech. Discuss.,
<https://doi.org/10.5194/amt-2022-204-RC1>, 2022

Review of "Assessing the consistency of satellite derived upper tropospheric humidity measurements" by Shi et al.

An assessment of four satellite upper tropospheric humidity (UTH) data sets are made with a focus on interannual variability and the effect of El Nino Southern Oscillation (ENSO) on spatial anomalies. Although the spatial anomalies associated with ENSO variability are well known, the strength of this article is in comparing 4 contrasting datasets. In general, users of these or similar datasets will probably wish to know the best dataset for their application so any statements on the relative quality of the datasets and any issues such as inhomogeneities or artificial drifts will add value to the paper. In particular, are there any spurious jumps or trends such as HIRS before and after 2000 or jumps in the CMSAF record? It would also be useful to comment on whether there are systematic biases for any particular meteorological regimes (e.g. convective, anvil, descent, etc).

Specific comments:

Abstract: some more quantitative statements would be useful in assessing the magnitude of differences.

L45 - application for model evaluation and processes understanding studies could be highlighted

L131 - presumably non-linearities in the UTH calculation affect the computation of UMIAMI UTH from gridded data and this will affect the absolute magnitude but probably not the anomalies

Fig.1 - it is expected that HIRS UTH will be lower than microwave estimates since they sample systematically drier, clear-sky scenes. Can the lower UMIAMI values compared to FIDUCEO and CMSAF be explained by the method, in which case why is UMIAMI used as the baseline since it is not computed using swath data?

L147 and throughout - more quantification of the difference between datasets would be helpful

L153 - please provide quantification of "good agreement"

L155 - how close is "close to each other" in the context of their use?

L157 (and L256) - is the smaller variability in HIRS linked to the fact it is not sampling the full scale of meteorological regimes (e.g. clear-sky only and so sampling less of the tropical deep convective regions)?

Section 3.1 - Variability in UTH and RH in a range of datasets are shown in Figures 6-8 of Allan et al. (2022) which could be commented on. Can the shifting of wet regions more over land during La Niña and more over the ocean contribute to changes in the biases since the retrieval over land and ocean may differ subtly? Or does it relate more to the changing proportion of "dry" and "humid" regions that are sampled differently by the different instruments (particularly HIRS)? A metric for proportion of the tropics with $UTH > X$ and $UTH < X$, where X could be 50% or a suitable mid-range value, would be interesting.

Fig. 2 - panels c and d do not seem to add much to a and b so could be removed since they are barely referred to

Fig. 3 - there seems to be a change in the anomaly characteristics in NCEI after 2000. Does this relate to the unusual series of La Niña events associated with slower global warming in the 2000-2012 period or are there changes in the instrument? Interestingly the anomaly characteristics of the microwave data after 2000 seem more like the pre-2000 NCEI record than the coincident post-2000 period. A similar change in anomaly characteristics seems present in Figure 8c of Allan et al. (2022) <https://doi.org/10.1029/2022JD036728> for zonal means with less positive anomalies after around 2000, though it is rather a subtle change (particularly a decreasing trend in UTH 30-60°S with positive anomalies before 2000).

Fig. 4/5 and 6/7 - a scatter of precipitation anomalies (possibly as % changes) verses UTH anomalies with some quantification of the relationship may be instructive and quite novel. It is not clear what the goal of the El Niño and La Niña comparisons are since these teleconnections are well known. If the goal is to evaluate the differences between datasets it is not so obvious from these plots. La Niña minus El Niño may be another way to present similar information in half the number of plots.

Fig. 8 suggests that CMSAF trends are inconsistent with the other datasets with increases in UTH over the whole region. Can this be quantified for the whole tropics and is this understood as the change in satellite offsets as implied. Was there no attempt to intercalibrate the satellite records by CMSAF?

Conclusions - some statements on the strengths and weaknesses of the datasets and possible issues identified would be welcome.

L324 - state that this is the CMSAF dataset which exhibits moistening trends relative to the other datasets

Will future work make comparisons with reanalyses and CMIP6 models?