

Review – Konjari et al., Water Vapor Climatologies in the UTLS...

This paper provides a method for adjusting a long record – nearly thirty years! (1994-2022) – of water vapor measurements in the upper troposphere (UT) and lowermost stratosphere (LMS) acquired from sensors flown aboard commercial passenger aircraft. The adjustment of the long IAGOS-MOZAIC and -CORE (IMC) dataset, which utilized a compact capacitive humidity sensor (ICH), is achieved through a carefully constructed comparison with data from IAGOS-CARIBIC (ICB), which used a more sophisticated and sensitive frostpoint hygrometer (WaSul). The validity of the ICB measurements is separately verified via comparison with research quality data acquired by a Lyman-alpha hygrometer (FISH) compiled in the JULIA database. The purpose of the adjustment is to improve the accuracy of the long IMC record and to generate a more highly resolved climatology of water vapor in the Northern Hemisphere UT/LMS from this dataset suitable for scientific study and analysis.

The comparison and correction of the IMC dataset is complicated by the fact that the IMC and ICB data were acquired by sensors on different platforms flying at different times and locations. The methodology developed here attempts to correct for the impact of atmospheric variability by creating binned-average data differentiated by height above the tropopause, equivalent latitude, month, as well as concomitant temperature and ozone ranges, to facilitate comparison of water vapor measurements in dynamically and compositionally similar airmasses.

The goal of this work – to produce a high-resolution research-quality dataset of UT/LMS water vapor from the long record of IMC measurements – is ambitious, and the effort is substantial. However, the data mapping methodology is clever, defensible, and probably about the best that can be done. In the final section of the paper (4.3) prior to the Conclusions, the adjusted climatologies are evaluated. The spatial and temporal variability of water vapor in the resulting dataset is found to be consistent with expectations, indicating that the adjusted climatologies may be useful for further study. The paper constitutes an important contribution to the field, especially as it addresses the difficulties and limitations of measurements made on board passenger aircraft and presents a clever and well-reasoned attempt to overcome them. However, I have some significant reservations that should be addressed before I can recommend publication.

Comments/Questions/Concerns:

- The discussion of the actual adjustment procedure was difficult to follow. Please try to provide more clarity and detail.
- Is the adjusted dataset publicly available? I strongly believe it should be made available with a summary of the mapping methodology and a comprehensive list of caveats. See below...
- I find the statements regarding the “better resolution of temporal and spatial variability” to be misleading. The averaging in the adjustment process and derivation of the climatology limits the effective resolution of the product. In particular, the temporal resolution of this climatology is poor given that it relies on *multi-annual monthly mean values*. MLS, which provides daily, near-global profiles of water vapor from the UT to the mesosphere, has far superior temporal resolution, where monthly means from different years can be compared to examine inter-annual variability.
- Also, any assessment of trends in water vapor concentrations/changes in dynamical processes, etc. over this 30-year period is likely impossible given the limitations of the dataset. This constraint should also be emphasized.

Minor comments/suggestions:

Lines 8/9 – data set or dataset?

Line 8 – “applying” sounds a bit odd, maybe “utilizing” or “employing”?

Line 9 – add a space here “hygrometer (ICH)”

Line 26 – consider: “...and a corresponding **total stratospheric water vapor radiative feedback parameter** of 0.2 – 0.3 W/m² per 1 Kelvin of surface warming.” (?)

Line 30 – consider: “...UT/LMS H₂O, as well as trends **at** high temporal...”

Line 38 – consider: “...passenger aircraft flights, **enabling the resolution of** strong...”

Line 48 – consider: “In this context, **the large quantity in-situ H₂O measurements provided by IAGOS is important to improving the accuracy of...**”

Lines 52 and 53: spell out CORE and CARIBIC?

Line 55: “...measurements by a **compact capacitive humidity sensor...**” (replace all locations of humidity capacity sensor with capacitive humidity sensor)

Line 58: “...were found to **lose** precision...”

Line 63: “This lower detection limit for the ICH instrument **was later determined to be 30 ppmv** by means of a dedicated...”

Line 78: “...H₂O variability in the UT/LMS at northern mid-latitudes.”

Section 2.1: please spell out all acronyms?

Line 96: “...and **derived** H₂O mixing ratios.”

Line 110: spell out “PA” in “PA-laser spectrometer”

Line 126: “...ERA5 data **are used at reduced** resolution...”

Figure 2 caption: “...the probability density in coordinates relative...”

Line 142: “measurement quantity” here is confusing... I believe what is meant is “magnitude of RH_{liq} measured by the ICH” and not the quantity of measurements. So, consider: “...closely linked to the magnitude of RH_{liq} measured by the ICH sensor.”

Lines 171+: consider: “We use a measurement mapping method to evaluate MOZAIC&CORE with respect to CARIBIC, focusing on the primary variable measured by MOZAIC&CORE, RH_{liq}.”

Line 173: remove space after the open parenthesis (500 flights)

Line 177: consider: “These factors particularly affect the UT...”

Line 186: consider: “, and the corresponding H₂O mixing ratio.”

Line 231: “This trade-off factor shows **that fewer measurements** are needed to constrain... providing **confidence in our approach.**”

Line 241: “...serve as **a** reference...”

Line 288: what does the (2) refer to?

Line 292: "...for which this intercomparison is valid."

Figure 7 caption: "...the plots (c) and (d) show the derivation..." (delete "exemplary")

Line 329: "...consist of a large number of measurements **on** the order of..."

Line 330: "...state." (delete comma)

Line 336: "For every one..." or "For each..."

Line 359: "...is calculated."

Section 4.2: There are a lot of separate paragraphs here, is that intentional?

Line 374: consider: "The adjusted MOZAIC&CORE-based H2O climatology offers the advantage of a longer record and greater spatial and seasonal sampling than the datasets of CARIBIC and JULIA, enabling more detailed analysis of the drivers of H2O variability. However, the adjustment of mean values requires... ."

Line 379: "." (?)

Line 383+: consider: "Despite the good agreement shown in Figure 8, the adjusted MOZAIC&CORE H2O incorporates uncertainties associated with (1) the measurement itself and (2) the adjustment methodology."

Line 387: "...is on the order of..." ("on" not "in")

Line 388: consider: "Uncertainties in the mapping method result from the small number of..."

Line 390: "...despite the fact that the sampling strategy should reduce the impact of uncertainties..."

Line 392: consider: "The uncertainty of the mapping method is determined as follows: The bias derivation... is performed for each season separately. In the next step, ...from the four seasonal means. Finally, these standard deviations are used to do derive the mean standard deviation as a function solely of RHliq."

Figure 9 caption: (dashed line) not (solid line)

Line 397: "The uncertainty... **varies** depending on the.."

Line 407: clarification: "...same **geographic** latitudes."

Section 4.3: Again, there are a lot of separate two-sentence paragraphs here, is that intentional?

Line 409+: consider: "From fall to spring the highest values in the mid-latitudes... . Higher H2O amounts occur over the Atlantic than over continental regions during the winter half of the year, associated with greater low pressure activity over this area, and the resulting large scale uplift of moist and relatively warm airmasses (UT)... ."

Figure 10: Is the red box in panel (a) meant to highlight the isentropic mixing of moist air into the LS?

Line 415: "...Figures 11a-d show adjusted multi-annual monthly means of adjusted H2O, plotted in coordinates of..."

Line 417: extra space before 100 ppmv?

Line 419+: The wording here is clunky and the discussion is perhaps too simple. In addition to the seasonal change in H2O along the 340 K potential temperature surface, there is a distinct shift in the tropopause height, such that 340 during the summer/fall it is near the tropopause level and during the winter/spring it is >20K above. Also, I see H2O for Jan in the range from 10-20 not 5-10? Perhaps I'm not reading the color bar correctly?

Line 423: mid-latitude not mid-latitudinal (?)

Figure 11 caption: extra space after H2O and before (e-h)

Line 432+: consider: "Finally, we examine how well sampled the UT/LMS is over the North Atlantic, given..."

Line 436: "Overall, good coverage is found."

Line 441: ...adjust H2O climatologies (?) or H2O data (?)

Line 447: consider: "For the comparison, a mapping approach was utilized, where measurements were grouped into bins with similar dynamical origins and properties. Consideration of equivalent latitude, season, and height..., were used to derive mean RHliq values... ."

Line 455: "...showed good agreement in the..."

Line 456: distance to the tropopause is hard to parse here... consider: "However, in the LMS, the average values were generally biased, with the magnitude of the bias increasing with distance above the tropopause, reaching relative differences of 300% for H2O at around 5 ppmv."