Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
https://doi.org/10.5194/acp-2022-345-RC2, 2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

Comment on acp-2022-345

Anonymous Referee #2

Referee comment on "Water vapour and ozone in the upper troposphere–lower stratosphere: global climatologies from three Canadian limb-viewing instruments" by Paul S. Jeffery et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-345-RC2, 2022

Review of "Water vapor and ozone in the upper troposphere – lower stratosphere: Global climatologies from three Canadian limb-viewing instruments" by P.S. Jeffery et al.

This paper co-locates water vapor and ozone mixing ratio output from the nudged Canadian Middle Atmospheric Model (CMAM39-SD) with measurements by three limb-viewing satellite instruments, ACE-FTS, MAESTRO and OSIRIS (ozone only), to evaluate the consistency between the three sets of satellite data. The model output and satellite measurements are 2-dimensionally binned using equivalent latitude (5° bins) in the horizontal and potential temperature relative to the tropopause (10 K bins) in the vertical. "Zonal" mean values over 3-month periods are computed for each bin using 14 years of satellite data (2004-2018) to create "zonal mean" climatologies for water vapor and ozone in different seasons, although only summer and winter data (DJF/JJA) are presented. Model data are sub-sampled to correspond to the times and locations of measurements by each of the satellite instruments, with model vs model comparisons indicating that differences between some of the measurement climatologies are due to the different instrumental sampling patterns. Differences between model and measurement climatologies are also presented for DJF and JJA, but these can (should) only be used to evaluate the consistency of the 2-dimensional differences across all three (two for water vapor) satellite instruments, not the differences themselves because the model output itself may be (is likely) biased.

General Comments:

My major sticking point with this method of comparing the measurements of ACE-FTS and MAESTRO is that there should be no need to involve climatologies or a model since the

two instruments "share the same sun tracker and optical bore". Why can't the spatially and temporally coincident measurements of these two instruments be compared directly? I was looking for an explanation of this in the paper but did not find one. If there is a good reason why direct comparisons cannot be made between the two SCISAT-1 instruments, please add it to the paper. The complexities of determining climatologies and including a model are more warranted in comparisons with OSIRIS, which is on a completely different satellite and samples the globe in a very different way from the other two instruments.

I fully support plotting relative differences in the Figures because of the large dynamic ranges of water vapor and ozone mixing ratios in the UTLS. However, I find that the color scales used in these Figures don't provide enough resolution to show the greatest amount of detail. Can other colors (like green) be incorporated in the color scales to increase the visual resolution of the plotted data? Also, the color scale for the CMAM – satellite relative differences include white, and large areas of these plots are white, which could lead some readers to mistakenly assume that there are no biases in those areas instead of there being inadequate data populations in those areas.

Figure captions should identify the content of the graphs so they can be better understood - like which panels show "ACE-FTS v4.2 (top row), ACE-FTS v3.6 (middle row), and MAESTRO (bottom row)", not the body text (Line 504). The body text should provide explanations of what the graphs indicate through their interpretation. For Figure 1, there's no need to include "ACE-FTS v4.2 (top row), ACE-FTS v3.6 (middle row), and MAESTRO (bottom row)" in the caption because each panel already identifies the instrument and season.

In certain sections of the paper (e.g., Lines 541-548; Lines 727-736) the flow of the presentation gets very bogged down by an overload of numbers (statistics) that appear in the text. A remedy for this problem would be to include tables where these statistics can be presented, allowing the implications of these numbers to be presented in the text instead of the numbers themselves.

There are ample opportunities to condense multiple sentences into one, reducing the "wordiness" of the paper. Here are two examples, but there are many more places in the paper where repetitive text can be reduced. This would make the paper more concise and easier to read.

Lines 479-482: For each satellite instrument, the JJA and DJF water vapor climatologies differ, mainly due to the seasonal cycle in tropical cold point temperatures that determine the amount of water vapor entering the tropical lower stratosphere.

Lines 596-599: The ozone climatologies for different satellite instruments (Fig. 4, columns 1 and 2) share common features, especially the large mixing ratio increases from a relatively uniform 0.05-0.1 ppmv below the tropopause to values nearly ten times that above 70 K.

My final general comment is to question if ACP is the correct journal for this satellite measurement comparison paper. I think AMT would be a better fit, but I will leave it to the authors and the ACP editor to decide this.

Other comments:

Line 2: What does this study include data only through May 2018 since it is now July 2022?

L21: consolidate to "by 30-35% and 25%, respectively"

L23: One might ask why are all three limb sounders are necessary?

L29: It is difficult for model output and observational datasets to be "similarly composed" since the data origins are completely different. Please explain further what you mean here.

L30: How about the use of climatologies for trend evaluations?

L42: "mixing processes that do arise" is vague. Please be more precise.

L45: please briefly define "tropopause layer"

L52: why are the strengths of their "greenhouse gas efficiency" so high in the UTLS?

L56-58: replace "ground" with "surface" since water covers 75% of Earth. Add "following the lapse rate" after "upwards to the tropopause". Replace "away" with "poleward".

L60: add “in the tropical middle and upper stratosphere” after “the oxidation of methane”

L70: Typical “radiosondes” struggle to measure RH in the UTLS because it is very cold and relatively dry. Perhaps you instead mean “frost point hygrometers”. Omit “of trace gases” since water vapor and ozone are the focus of this sentence.

L77: I think “characterized” is too soft here. Model simulations must be “validated” against measurements.

L93: A paper by Read et al. was recently published that compares frost point hygrometer and satellite measurements in the UT.

Read, W. G., Stiller, G., Lossow, S., Kiefer, M., Khosrawi, F., Hurst, D., Vömel, H., Rosenlof, K., Dinelli, B. M., Raspollini, P., Nedoluha, G. E., Gille, J. C., Kasai, Y., Eriksson, P., Sioris, C. E., Walker, K. A., Weigel, K., Burrows, J. P., and Rozanov, A.: The SPARC Water Vapor Assessment II: assessment of satellite measurements of upper tropospheric humidity, Atmos. Meas. Tech., 15, 3377–3400, https://doi.org/10.5194/amt-15-3377-2022, 2022.

L103: “can possess water vapor differences >10%”. Do climatologies “possess” differences”? Differences from what?

L109: add “down” before “into the UTLS”

L114: add “some of” before “this variability”. What are “similarly driven data”?

L123: I think “well constrained” is too strong. “reduced” is more appropriate.

L170: I have no idea what “and has an improved rate of change” means in this context.

L198: Aren’t the biases between all instrument pairs dependent on the comparison instruments?

L200: FTIR vertical resolution is, at best, extremely coarse. How can a UTLS bias be

determined using FTIR retrievals when the water vapor gradient is so strong in this region?

L202: See comment for line 70.

L256: “flagged with values between 4 and 7” has no tangible meaning for most readers

L260: “conflict”? “philosophy”? This dilemma is true of all data filtering, so there’s no conflict or philosophy. The more stringent the quality control, the lower the data population available for computing meaningful statistics.

L426 and throughout: “deviation” can easily sway readers to think about variability, while “difference” cannot be misconstrued. “Mean difference” might also be called “bias” that is also very straightforward.

L433: “most robust” is too strong. Direct comparison would be the “most robust” method because no model output is needed. Your method allows for a greater number of the satellite observations to be part of the comparison, but is not necessarily the “most robust”.

L461: add “with altitude” after “VMR”. The first “effect” (dehydration) quite possibly accounts for >95% of setting the stratospheric entry mixing ratios for water vapor.

L469: Why compare in situ water vapor production in the stratosphere to mixing ratios in the troposphere? The water vapor added to the LS at higher latitudes by the transport of water from CH4 oxidation by the downward branches of the Brewer Dobson circulation can be as much 100% (3.5 -> 7 ppmv), so there is a significant influence on the UTLS distribution of water vapor at higher latitudes.

L473: change “deposition of water vapor from” to “transport of water vapor by”

L481: what is “seasonal dehydration”? Dehydration occurs year-around. Might you be referring to a change in tropical cold point temperatures?

L487: change “in regions such as the span above 50 K” to “in the 50-100 K region”

L492: Why does ACE-FTS v4.2 have “the most tightly confined region …”

L495: Is the cause “variations in vertical transport”, or “variations in tropical cold point temperatures”?

L505: change to “large relative differences”

L511: It would be worth adding one sentence here explaining why you’ve chosen to not elaborate on the model-satellite biases in the paper.

L545: change to “ranges poleward of approximately 45° in each hemisphere”

L600: If not stated before, include the fact that ozone is mainly produced in the tropical middle and upper stratosphere, the main reason there’s a positive gradient in the stratosphere.

L670: change “does” to “do”

L674: change to “ACE-FTS and MAESTRO measurements”

L680: consolidate sentences: “Greater differences, 9% on average and as large as 76% in the UT, are found in the subsampled model results and OSIRIS measurements.”

L727-736: This is another overload of numbers that would greatly benefit from a table.

L756: change to “some sources of variability”. Change “distribution” to “distributions”.

L758: “reference” is too strong, implying that the model output is some sort of “gold standard”, which it is not. See the definition of a “climate reference network”. I recommend omitting “reference” here and throughout the paper for this reason.