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Comment on acp-2021-976

Anonymous Referee #3

Referee comment on "Evaluation of tropical water vapour from CMIP6 global climate models using the ESA CCI Water Vapour climate data records" by Jia He et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-976-RC2, 2022

Review of "Evaluation of tropical water vapour from CMIP6 GCMs using the ESA CCI "Water Vapour" climate data records" by Jia He, Helene Brogniez, and Laurence Picon

This study evaluates the fidelity of model-simulated and reanalysis-produced total column water vapor over the tropics using the ESA TCWV-COMBI data as a benchmark. Given the role of the water vapor feedback in amplifying greenhouse gas-induced warming, it is important to monitor the variability and change of water vapor on multiple time scales and to examine whether the physical processes governing the variability and change are accurately depicted in global climate models. However, there are some issues in the manuscript which the author need to clarify.

The main objective of this study is to evaluate tropical water vapor simulated from CMIP6 models under the AMIP configuration using the ESA TCWV-COMBI data as a benchmark. While this implies that the ESA TCWV-COMBI data are accurate and reliable, the main text seems to indicate the presence of temporal discontinuity (and also spurious trends) in the data set, especially, over the land regions. So I think the author first need to demonstrate the accuracy and stability of the dataset by comparing it with other independent data sets such as intercalibrated UTH datasets.

The discrepancies in TCWV between the ESA data and GCM/ERA5 are attributed in part to clear-sky sampling issue. I am wondering if the cloud-screened modeled and ERA5-produced TCWV is substantially different from the corresponding raw output (i.e., the scene selection is not applied). Please present some plots showing the difference. In addition, given the large difference in the horizonal resolution between GCMs (> ~1 deg) and the ESA dataset (0.05 deg), I am not sure whether the scene selection method described in the text is a suitable way.

Figure 2 indicates a much larger discrepancy between the data sets over the land than over the ocean. This might be caused by potential errors of IR-based TCWV. So please show that the IR-based TCWV is in good agreement with MW-based TCWV over the tropical ocean.

Although I agree with the authors that TCWV is influenced by large-scale atmospheric circulation over the tropics, the underlying surface temperature is also a major factor determining the magnitude of TCWV. However, this aspect is not accounted for in the analysis from Fig. 6 to Fig. 10 in which some panels exhibit physically unreasonable features. So I think the author first remove the thermodynamic component before analyzing the relationship between TCWV and large-scale atmospheric circulation.

L5: I am not sure whether the authors examined the "evolution" of the large-scale circulation in the manuscript. I think the authors just analyzed the interannual variability of TCWV as a function of 500-hPa vertical velocity.

L20: surface temperature "from" robust thermodynamical constraints – "via", "through" or other word instead of "from"?

L56: “both the complementarity between the sensors” and what?

L95: A subset of “seven” GCMs – I think the seven GCMs analyzed in this study are a subset of CMIP6 models.

L97: ESGF instead of ESFG?

L99: at the model vertical resolution – Do the ESGF websites provide model output at the model vertical resolution?

L151-152: “The TCWV data are sorted upon 10 hPa/day-bins of monthly values of w500” – The occurrence frequency could be substantially different across the bins, as shown in Fig. 6.

L163: the climatology – I don’t think Figure 2 shows the climatology.

L164: Please specify in which aspects the datasets agree with each other, as there are distinct mean biases between the data sets.

L166: a very weak interannual variability – Does this mean that the ENSO impact is small?

L168-173: I failed to understand these sentences. Given that the ESA dataset was constructed by excluding cloud-contaminated observations, the ESA TCWV is likely to be drier than both model simulations and the ERA5 data. Please clarify this inconsistency.

L173-174: Please clarify this sentence.

L180-182: Please clarify the inconsistency.

L184: situations – I am not sure what "situations" mean here.

L199: It doesn't seem that in ERA5, the year 2008 exhibits a distinct dry anomaly over all the TCWV range.

L207: the CMIP6 models "that" are evaluated under the AMIP scenario – remove "that"?

L209: concerned – what does "concerned" mean here?

L211: Please clarify this sentence.

L224: large-scale ascent is globally associated with a moister troposphere – The largest TCWV values are found over a weak subsidence regime for ERA5.

L228: difficulties – what does "difficulties" mean here?

L230-231: I don't think the authors demonstrate this point in the manuscript.

L236-237: while the most … with the moister troposphere (blue) – I don't agree with the authors. Please check ERA5, CanES5, CESM2, and CESM2-WACCM.

L243-244: Please provide more detailed information on “strong effective climate efficiency”.

L245: the transition dry/moist occurs – the transition of the dry/moist regime occurs?

L246: occurs around 60 hPa/day – I am not sure whether this statement is consistent with other figures in the manuscript.

L250: wet anomalies occur in 2010 for all of the data records – Moist anomalies are not distinct for the ESA data set, ERA5, and IPSL-CM6A-LR.

L252-255: Please clarify the description.

L259-261: Please reword the sentence.

L263: The verb is missing?

L265-266: Please clarify the sentence.

L268-271: Please clarify these sentences.

L272: I don’t think Figure 10 shows temporal tendencies.

L292: the drying trend being present for all regimes of w500 – inconsistent with L290.

L301-302: I don’t think the authors demonstrate this aspect in the manuscript.

L310: the use of AMIP scenario, defined from prescribed sea surface temperatures – please clarify the sentence.

L314: water vapour seems to be an easier parameter than cloud – please reword the sentence.

L315-317: Please reword the sentences.

Table 2: It is unlikely that Eyring et al. (2015) is an adequate reference for the ERA5 dataset.

Figure 1: The TCWV maps have some land regions where the data are missing. Why is that?

Figure 6: The units are incorrect in the figure.

Figure 7: The distributions for the ESA and ERA5 datasets are inconsistent with Fig. 6c.

There are typos and grammatical errors in the manuscript. Please correct them.