Point-by-point Responses for Reviewer 1 for hess-2023-301

We appreciate the insightful comments and suggestions from both reviewers. Following their guidance, we have made significant changes to our manuscript to enhance its clarity, accuracy, and robustness. A brief outline of the major revisions includes:

1. We refined our analysis of temperature and total precipitable vapor (TPW) discontinuities in reanalysis datasets. Instead of using regional averages, we applied the Penalized Maximal F (PMF) test to each grid over the ocean. Our analysis now encompasses the trends and variations in TPW and temperature for the periods 1958-2021 and 1993-2021, respectively. Additionally, we provide detailed trends, including the uncertainties at 95% confidence levels.

2. In response to Reviewer 2's suggestions, we revised our change point detection method, leading to the deletion of the original Tables S1 to S4 from the supplement. Consequently, Figures 1 to 6 in the main text have been updated, and Figures S1 to S5 have been added to the supplemental material.

3. We have carefully incorporated all the references and citations recommended by the reviewers into our revised manuscript.

The authors have used regular fonts for the Referee's comments (which might be divided into two or multiple comments), blue fonts for our responses, and red fonts with quotation marks to show the revised text. The line number in Reply refers to the new revision without tracked changes.

Reviewer 1 # Comments

The authors provide a valuable update in the regional changes in atmospheric water vapour content and surface temperature since 1958 based on state of the art reanalysis systems. While earlier attempts to use reanalyses demonstrated serious defects in homogeneity over time, the newer products appear more reliable and the analysis presented is complimentary to other work. Nevertheless, as noted in the discussion, the early satellite era may contain spurious variability related to changes in the observing system assimilated into the reanalysis model while the early record may be closer to a dynamically nudged "amip" atmosphere-only climate model simulation with prescribed SST and sea ice, though radiosonde information should provide some observational input in well sampled locations. The present work provides valuable information for studies interested in evaluating climate model simulations of moist processes including water vapour feedback. There is also recent interest in discrepancies between simulations and observations of low level moisture over arid and semi arid regions that could be mentioned (Simpson et al. 2023 PNAS doi:10.1073/pnas.2302480120). Despite the improvement in water vapour changes, other aspects of hydrological cycle such as precipitation show spurious global variability sincec 1979 (Allan et al. 2020 NYAS doi:10.1111/nyas.14337) so I wonder if there is any insight into this based on the water vapour evaluation? Overall, this is a well written and presented analysis that I recommend to be published with only minor modifications. A list of suggestions and comments is provided below.

Response: Thank you, Dr. Richard Allan, for your thorough review. Your encouragement and insights are valuable and substantially improved the quality of our paper. We agree Simpson et al. 2023 PNAS is an excellent reference for arid and semi-arid regions. We added two sentences in our revision in L179 as follows:

"In addition, Simpson et al. (2023) found that near-surface water vapor, as measured by surface observations, hasn't increased over arid and semi-arid regions since 1980, a discrepancy compared to predicted results from simulations. These findings indicate there might be misrepresentations of hydroclimate-related processes in simulations since climate models showed moistening trends associated with the increase in water vapor-holding capacity of a warmer atmosphere."

In terms of water vapor change in both near-surface and surface-to-top-of-atmosphere, we would think the discrepancy between them is complicated and dynamic (scales). However, findings from surface observations by Simpson et al. provide us with references for those trends in arid and semi-arid regions in the world. Therefore, we also calculated TPW trends from 1980 to 2020 in reanalysis and discussed with observation results in Simpson et al. 2023. We added sentences in L193 as follows:

"In terms of TPW trend over arid and semi-arid regions from 1980 to 2020 in reanalysis dataset (figure not shown), it also shows a different trend, comparing observation from Simpson et al. 2023, that only TPW over southwest United States in ERA5 and central African in JRA-55 significantly decreased."

1) L10 should this be water vapor responses to lower tropospheric temperature (the thermodynamic causal route)? Radiative cooling rates affected by water vapor will also feedback on temperature but I don't think this is meant here?

Response: Thanks, we rewrote the sentence in L9 as

"Global responses of the hydrological cycle to climate change have been widely studied but uncertainties still remain regarding water vapor responses to lower tropospheric temperature."

2) L11 "improved" is ambiguous and can be removed

Response: done

3) L13 is the trend for the whole period?

Response: No, the period for radiosonde is from 1979 to 2019. The periods for Atmospheric Infrared Sounder (AIRS), and Microwave Satellite (SSMI(S)) observations are from 2003 to 2021. We rewrote the sentence in L10

"Here, we investigate the trends in global total precipitable water (TPW) and surface temperature from 1958 to 2021 using ERA5 and JRA-55 reanalysis datasets and further validate these trends by using radiosonde data from 1979 to 2019, and Atmospheric Infrared Sounder (AIRS) and Microwave Satellite (SSMI(S)) observations from 2003 to 2021."

4) L26 O'Gorman & Muller could be referred to on dTPW/dT

Response: Yes, we added O'Gorman and Muller (2010) reference in L28.

5) L28 "strengthened greenhouse effect"; could mention that changes higher in the troposphere are more important for the feedback while changes at low levels are strongly linked with precipitation

Response: This clarity is insightful. We rewrote the sentence in L28 as

"…due to the greenhouse effect (Held and Soden, 2006, O'Gorman and Muller, 2010) particularly in upper troposphere whereas changes at lower levels are strongly linked with precipitation patterns, influencing the frequency and intensity of extreme weather events (Trenberth, 1998; Trenberth et al., 2003)."

6) L35 see also the GPS network eg Douville et al. 2022 reference

Response: We have included Douville et al. (2022) in L59 as

"… with better accuracy, and relatively fewer homogeneity issues as both assimilate a huge amount of conventional and satellite-based observations (Hersbach et al., 2020; Kobayashi et al., 2015; Douville et al., 2022)."

7) L45 although reanalyses are much improved over earlier versions there remain some homogeneity issues eg before the mid 1990s over the tropical ocean eg Allan et al. 2022.

Response: We agreed that there remain some homogeneity issues in reanalysis datasets and rewrote the sentence in L62

"Many studies have confirmed that ERA5 is the best or among highest-performing reanalysis products (Taszarek et al., 2021; Yuan et al., 2023) although inhomogeneity still remains; for example, water vapor associated with changes in SSMI instruments (Trenberth et al., 2015) and unreliability of tropical water vapor in ERA5 and ground-based observations before 1993 (Allan et al., 2022)."

8) L141 - consistent --> inconsistent since the ERA5 decline in TPW in the 1980s is not consistent with SMMR/SSM/I microwave satellite data and appears to originate in the tropical lower troposphere over the ocean.

Response: Thank you, we corrected it in L141:

"A notable decrease in TPW is shown during the 1980s to 1990s over tropical regions in ERA5, which is consistent with ERA-interim (Allan et al., 2014) but inconsistent with satellite microwave data (Allan et al., 2022). This discrepancy seems to originate in the tropical lower troposphere over ocean."

9) L150 can the turning points be linked to phases of Pacific Decadal "Oscillation"? The jumps in TPW also seem to coincide with rapid increases in global temperature.

Response: Thank you, the change of TPW can be explained by the interdecadal Pacific oscillation (IPO). Study reveal that the trend during 1988-2003 was likely associated with the decadal variation of IPO from a warm period (1977-1998) to a cold period (1999 to 2003) (Dong and Dai, 2015). The PW trend for recent period including 1997/98 event will likely be similar (Wang et al. 2016). In addition, Patel and Kuttippurath (2023) also shows a strong correlation (0.81) between PDO and TPW variability in the tropics. We added sentences in L164 as follows:

"The trend of TPW during 1988-2003 was likely associated with the decadal variation of Interdecadal Pacific Oscillation from a warm period (1977-1998) to a cold period (1999 to 2003) (Dong and Dai, 2015). The TPW trend for recent period including 1997/98 event will likely be similar (Wang et al. 2016). In addition, Patel and Kuttippurath (2023) also shows a strong correlation (0.81) between Pacific Decadal Oscillation and TPW variability in the tropics."

10) L167 the North Atlantic cooling seems to be most prominent in the northern hemisphere winter (Allan & Allan 2020 JGR doi:10.1029/2019JC015379) while it is more a warming "hole" in the summer. Some have liniked this with changes in ocean circulation rather than heat fluxes though this is based more on modelling (e.g. Drijfhout et al. 2012 doi:10.1175/JCLI-D-12-00490.1).

Response: We rewrote the sentence in L208

“Meanwhile, the North Atlantic cooling appears most significant in February in the northern hemisphere while it becomes net warming in August (Allan and Allan, 2020). Some studies connect this phenomenon to changes in ocean circulation based on modeling results (Drijfhout et al., 2012). In addition, based on model simulations without considering variable ocean currents, He et al. (2022) explained that the warming hole is driven by enhanced surface westerly wind removing heat from ocean surface. ”

11) L190 the rapid Arctic warming is consistent with large increases in water vapour that can be menioned here (also discussed briefly in Allan et al. 2022) or signpost to the next section.

Response: We added the following sentence in L236:

“The Arctic warming is concentrated in the lower troposphere (Allan et al. 2022), and reached ~0.74 K dec^{-1} after 1993, thus leading to increases in water vapor as shown in Fig. 2a.”

12) L195 the reduction in relative humidity related to land/sea warming contrast could also be mentioned (e.g. Byrne & O'Gorman 2019 PNAS doi:10.1073/pnas.1722312115).

Response: We rewrote the sentence in L246 as follows:

“Byrne & O'Gorman (2018) further extended Joshi’s theory in a quantitative way. They investigated the contrast of land/ocean warming from surface observations and model simulations at the global scale and indicated that amplified land temperature increases were the consequence of reduced relative humidity over land.”

13) L206 O'Gorman & Muller (2010) would also be appropriate to cite here

Response: We added this reference in the sentence:

“… is constant (Trenberth et al., 2005; O’Gorman and Muller, 2010).”

14) L210 some regions are likely to exhibit more realistic trends where there is a greater density and homogeneity of data (e.g. N America, Europe)

Response: We added the sentence in L268:

“Regions with higher data density and homogeneity, such as North America and Europe, are likely to exhibit more realistic trends.”

15) L215 it could be noted that (e.g. wet part of circulation moves from one location to another). This could be investigated based on reanalysis vertical motion fields for example.

Response: We rewrote the sentence in L269:

“Negative dTPW/dT occurs over the southern tropical ocean, where sea surface temperature was increased (Fig. 3) but precipitable water appears to be decreased slightly (Fig. 1); thus, the TPW change is contrary to what might be expected from the thermodynamic response to changes in temperature. Water vapor moves from one location to another through circulation, and the trend of vertical motion at 500 hPa could be further investigated to reveal the ascent and convective activity as well as its relationship to decreasing water vapor (Zveryaev and Allan, 2005).”

16) Figure 5 colour bar is not very intuitive to me (red implies drier to me)?

Response: To be consistent with response to reviewer 2, we deleted the TPW response to surface temperature (T_s), and calculated the ratio using data from 1993 to 2021. Figure R1 now serves as new Figure 5 in revision.

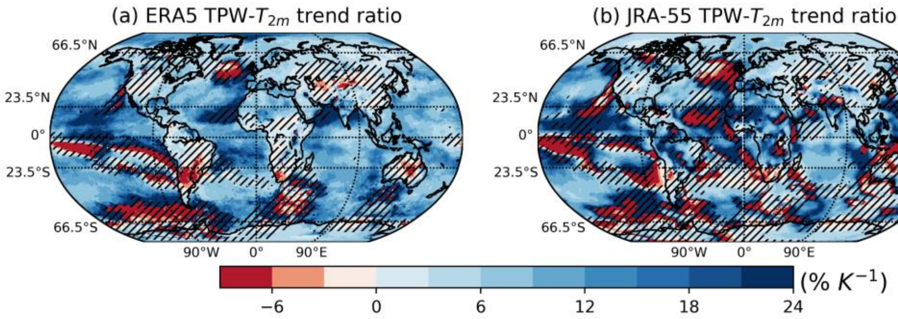

Figure R1. (a) The ratio (% K^{-1}) of TPW trends and surface air temperature (T_{2m}) trends from 1993 to 2021 in ERA5. **(b)** Same as **(a)** but for JRA-55**.** The hatch areas represent ratios that are not statistically significant at the 95% confidence level.

17) L253 - I think the SSM/I satellites only began in 1987, well after 1977?

Response: Thank you for pointing out this. You are correct. In the original table, the row was shifted downward by mistake when filled. However, based on reviewer 2's suggestion for achieving a more reliable detection, the table was deleted in our revision. We reanalyzed the discontinuity of each grid over the ocean instead of a regional average. The results are shown in Figures R2 and R3 and along with the following text added in L311, and Figures R2 and R3 serve as Figs. S2 and S3 in our revision.

"In order to get a general picture of discontinuities in the reanalysis data, we calculated the discontinuity from 1958 to 2021 for each grid box of temperature and TPW over the ocean, where there is a strong relationship between water vapor and temperature along with significantly increased trends (Figs. 1 and 3). We applied the PMF test on each grid of the reanalysis dataset and selected the significance level of 0.01 to detect discontinuities (Zhou et al., 2021). The years with detected discontinuities (after counting all change points within the same year) of both temperature and TPW are shown in Figures S1 and S2. Discontinuities for temperature are relatively frequent before 1980 in both reanalysis datasets (Fig. S1a, b) and are relatively less frequent after 1980 for ERA5 except for 1992-1995, 1998, and 2015 when strong EI Niño (1992, 1998, 2015) or La Niña (1995) events or a volcanic eruption (1992) occurred (Fig. S1c). It reveals that the detected change points during 1990-2021 in ERA5 might be associated with the result of abrupt climate changes. Previous studies also demonstrated the reliability of ERA5 air temperature for the warming trend of the global ocean (He et al., 2023; Wang et al., 2019). For TPW, discontinuities show a similar pattern as the temperature in ERA5, in which water vapor before 1980 has relatively more discontinuities. In addition, change points are fewer after 1980 except for the largest discontinuity in 1991-1992 (Fig. S2a) in ERA5 and in 1996-1997 in JRA-55 (Fig. S2b). Trenberth et al. (2015) highlighted that the discontinuity and inaccurate values in 1992 are the result of changes in satellite instruments. A strong agreement between SSMI(S) observations and ERA5 is shown after 1993 (Allan et al., 2022), and fewer discontinuities are presented from 1993 to 2021 (Fig. S2a). Meanwhile, discontinuities in JRA-55 are larger and distributed in all decadal periods even in normal years (Fig. S2b, c). Because TPW is highly dependent on temperatures and has a strong relationship with temperature over ocean, we further detected TPW discontinuities by comparing TPW and the expected TPW (TPW_{ept}) calculated from regression with temperature (Figure S3) during 1981-2021 when temperature shows fewer change points (Figure S1). The discrepancy points between TPW and TPW_{ept} are obvious over

1987, 1998, 1999, and 2015 in both analysis data, indicating the strong effect of ENSO events on the change of TPW. For ERA5, these discontinuities occurred in 1992 and 1995 when TPW_{ept} increased but TPW decreased in ERA5 (Fig. S2), in which the discontinuity in 1992 also existed in ERA-I (Trenberth et al., 2015). For JRA-55, discrepancy points occurred in 1984 and 1995. Due to lack of reliable observations before 1979, it is not recommended to use adjusted or statistically homogenized timeseries for trend analysis without metadata confirmation (e.g., the homogenized observations) (Wang and Feng, 2013). Although several discontinuities are detected in years after 1993 for TPW (Fig. S2), a strong agreement of TPW between ERA5 and SSMI satellite might indicate reliable TPW trends (Allan et al., 2022).”

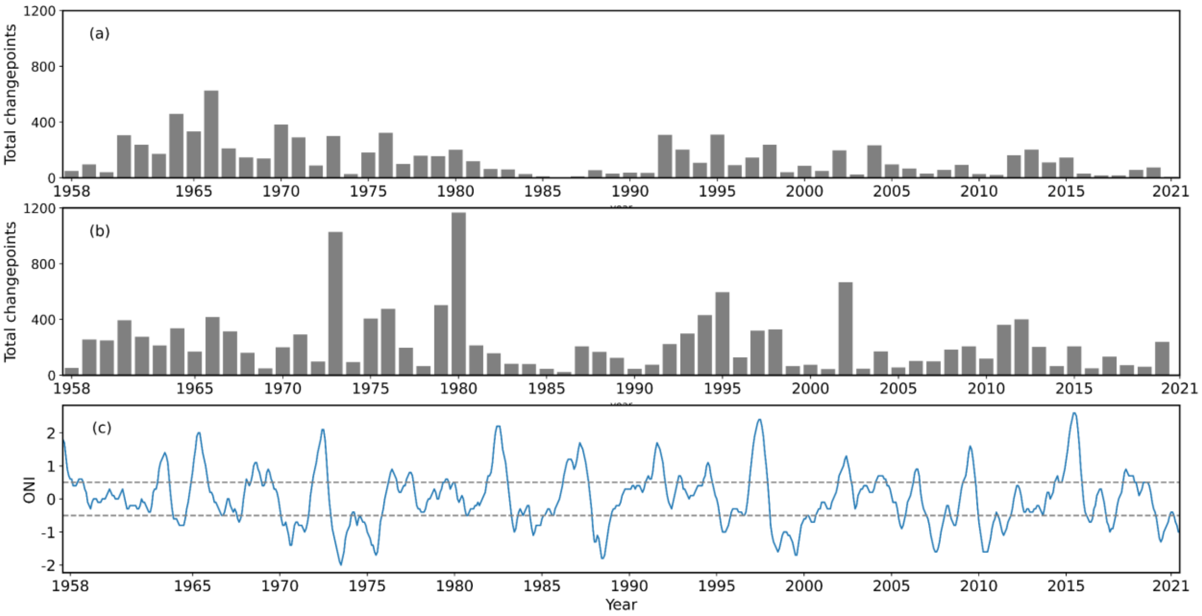

Figure R2. Detected change points for monthly temperature during 1958-2021 in (a) ERA5 and (b) JRA55. (c) The timeseries of Oceanic Niño Index (ONI) from 1958 to 2021. There is total 21,307 of grids for PMF-test over the ocean.

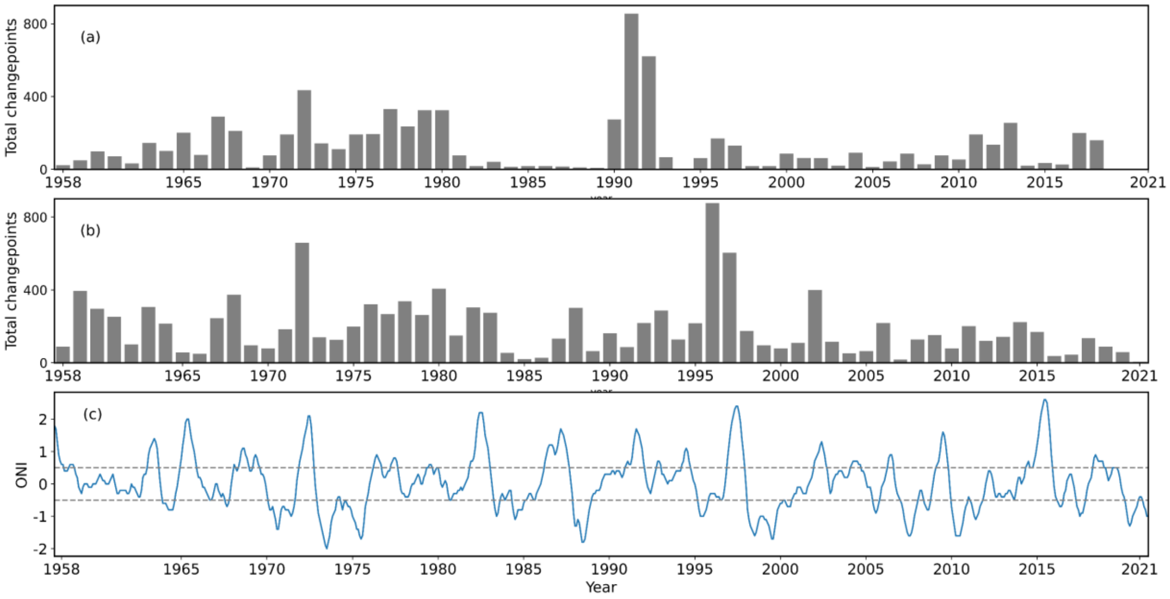

Figure R3. The same as Figure RS5 but for monthly total water precipitation.

18) 267 - can the homogeneity tests be used to assess uncertainty in the computed trends (above the structural differences between reanalyses)? Trends also should be reported with at least statistical error bars relating to the linear fit

Response: This is an excellent question. The homogeneity tests are to detect the positions and magnitudes of change points, which are relevant to uncertainties of computed trends, but it is difficult to use them to assess the uncertainty of the trends. We agreed that trends should be reported with statistical error bars at a certain confidence level (e.g. 95%).

19) L270 - I am surprised that the radiosonde data is not assimilated in reanalyses? Is there a reason for this?

Response: The Radiosounding HARMonization (RHARM) Data Set applies the new algorithm to the Integrated Global Radiosonde Archive (IGRA) data, while IGRA is assimilated into reanalyses (Durre et al., 2018). The phrase "independent of reanalysis data" here refers to the way they used to calculate and adjust the systematic effects on fields (temperature and humidity). We rewrote the sentences in L101 and L343 as follows:

"We also used *in-situ* observations from the Radiosounding HARMonization (RHARM) dataset (Madonna et al., 2022) which applied the new algorithm to the Global Climate Observing System Reference Upper-Air Network (GRUAN) data and used observation measurement instead of reanalysis data as a reference to calculate and adjust for systematic effects on temperature and humidity."

"The RHARM radiosonde observations (Madonna et al., 2022), which are mostly located in the NH and available from 1979-2019, are independent of reanalysis data in terms of calculating and adjusting temperature and humidity."

20) L274 - why are trends reported in mm/decade here but %/decade earlier?

Response: To be consistent, the unit of TPW trend should be in %/decade. However, as reviewer 2 suggested that the quantile-matching (QM) procedure adjustment method we used is more appropriate for individual radiosondes. Therefore, we deleted the adjustment of reananlysis and only discussed the discontinuities. Sentences are added in L247 as response to Q17.

21) L284 - presumably the long term (1958-present) trends are mostly determined by recent rapid warming and moistening since the 1980s? It could be made clear that the values quoted here are since 2003?

Response: Yes, the trends over the long term (1958-present) are likely primarily influenced by the rapid warming and increased moisture levels observed since the 1980s from temperature variability in Figures 1 & 4 in main text. The values quoted here are from 2003 and we rewrote the sentence in L356 as follows:

"The surface air over tropical oceans increased in water vapor at a rate of 1.6 % dec^{-1} for ERA5 and 1.9 % dec^{-1} for JRA-55 on average, with a similar moistening rate shown in SSMI(S) (1.1% dec^{-1}) but not in AIRS data (0.05% dec^{-1}) since 2003."

22) L297 - are the decreases in the subtropical ocean cumulus transition zones explained by shifts in large-scale atmospheric circulation or changes in stability? It is noteworthy that the observed warming pattern is unlike coupled simulations, with warming more in the tropical warm pool which can increase stability in these subtropical subsidence regimes e.g. Andrews et al. 2022 JGR doi:10.1029/2022JD036675

Response: Following this comment, we added one sentence in L370 as:

"… registered as negative. The observed warming pattern is unlike coupled simulation, with warming more prominent in the tropical warm pool, which can increase stability in these subtropical subsidence regions (Andrews et al., 2022). When considering TPW …"

23) L308 - the link between Arctic warming and moistening could be usefully mentioned here

Response: We rewrote the sentence in L380

"Arctic warming was particularly pronounced, registering three times the global average during 1958-2021, and escalating to around four times from 1979 to 2021 and around 6.5% K^{-1} of water vapor response to temperature."

24) L315 - a line of wider implications of the conclusions and future work would be welcome. Note that an intercomparison of TPW datasets is underway by Trent et al. https://doi.org/10.5194/egusphere-2023-2808. Some additional references that could also be considered are listed below:
Douville & Willett (2023) Sci. Adv. https://doi.org/10.1126/sciadv.ade6253
Patel & Kuttippurath (2023) OLA Research https://doi.org/10.34133/olar.0015
Shao et al. (2023) ACP https://doi.org/10.5194/acp-23-14187-2023
Ding et al. (2022) LNEE https://doi.org/10.1007/978-981-19-2588-7_27

Response: We added a short new paragraph at the end of Conclusion section as

"Because of the importance of atmospheric water vapor in the global energy balance and hydrological cycle, it has received much attention in recent years (this study; Trent et al., 2023; Douville and Willett, 2023; Patel and Kuttippurath, 2023; Shao et al., 2023; Ding et al., 2022). In the near future, results from these studies need to be synthesized to further quantify atmospheric water vapor, its relationship with surface temperature, and associated uncertainties. These results can then be used to better evaluate climate models and constrain these models' future projection."

References below are citations we added in our revision except papers with ** that are only used in this point-by-point response:

Allan, D. and Allan, R. P.: Seasonal Changes in the North Atlantic Cold Anomaly: The influence of cold surface waters from coastal Greenland and warming trends associated with Variations in subarctic sea ice cover, Journal of Geophysical Research: Oceans, 124, 9040–9052, https://doi.org/10.1029/2019JC015379, 2019.

Allan, R. P., Liu, C., Zahn, M., Lavers, D. A., Koukouvagias, E., and Bodas-Salcedo, A.: physically consistent responses of the global atmospheric hydrological cycle in models and observations, Surveys in Geophysics, 35, 533–552, https://doi.org/10.1007/s10712-012-9213-z, 2014.

Andrews, T., Bodas-Salcedo, A., Gregory, J. M., Dong, Y., Armour, K. C., Paynter, D., Lin, P., Modak, A., Mauritsen, T., Cole, J. N. S., Medeiros, B., Benedict, J. J., Douville, H., Roehrig, R., Koshiro, T., Kawai, H., Ogura, T., Dufresne, J.-L., Allan, R. P., and Liu, C.: On the effect of historical SST patterns on radiative feedback, Journal of Geophysical Research: Atmospheres, 127, e2022JD036675, https://doi.org/10.1029/2022JD036675, 2022.

Byrne, M. P. and O'Gorman, P. A.: Trends in continental temperature and humidity directly linked to ocean warming, Proceedings of the National Academy of Sciences, 115, 4863–4868, https://doi.org/10.1073/pnas.1722312115, 2018.

Ding, J., Chen, J., and Tang, W.: Increasing trend of precipitable water vapor in Antarctica and Greenland, in: China Satellite Navigation Conference (CSNC 2022) Proceedings, Singapore, 286–296, https://doi.org/10.1007/978-981-19-2588-7_27, 2022.

Dong, B. and Dai, A.: The influence of the Interdecadal Pacific Oscillation on temperature and precipitation over the Globe, Clim Dyn, 45, 2667–2681, https://doi.org/10.1007/s00382-015-2500-x, 2015

Douville, H. and Willett, K. M.: A drier than expected future, supported by near-surface relative humidity observations, Science Advances, 9, eade6253, https://doi.org/10.1126/sciadv.ade6253, 2023.

Drijfhout, S., Oldenborgh, G. J. van, and Cimatoribus, A.: Is a decline of AMOC causing the warming hole above the North Atlantic in observed and modeled warming patterns?, Journal of Climate, 25, 8373–8379, https://doi.org/10.1175/JCLI-D-12-00490.1, 2012.

**Durre, I., Yin, X., Vose, R. S., Applequist, S., and Arnfield, J.: Enhancing the data coverage in the integrated global radiosonde archive, Journal of Atmospheric and Oceanic Technology, 35, 1753–1770, https://doi.org/10.1175/JTECH-D-17-0223.1, 2018.

He, C., Clement, A. C., Cane, M. A., Murphy, L. N., Klavans, J. M., and Fenske, T. M.: A North Atlantic warming hole without ocean circulation, Geophysical Research Letters, 49, e2022GL100420, https://doi.org/10.1029/2022GL100420, 2022.

He, M., Qin, J., Lu, N., and Yao, L.: Assessment of ERA5 near-surface air temperatures over global Oceans by Combining MODIS Sea Surface Temperature Products and In-Situ Observations, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 16, 8442–8455, https://doi.org/10.1109/JSTARS.2023.3312810, 2023.

Patel, V. K. and Kuttippurath, J.: Increase in tropospheric water vapor amplifies global warming and climate change, Ocean-Land-Atmosphere Research, 2, 0015, https://doi.org/10.34133/olar.0015, 2023.

Shao, X., Ho, S.-P., Jing, X., Zhou, X., Chen, Y., Liu, T.-C., Zhang, B., and Dong, J.: Characterizing the tropospheric water vapor spatial variation and trend using 2007–2018 COSMIC radio occultation and ECMWF reanalysis data, Atmospheric Chemistry and Physics, 23, 14187–14218, https://doi.org/10.5194/acp-23-14187-2023, 2023.

Simpson, I. R., McKinnon, K. A., Kennedy, D., Lawrence, D. M., Lehner, F., and Seager, R.: Observed humidity trends in dry regions contradict climate models, Proceedings of the National Academy of Sciences, 121, e2302480120, https://doi.org/10.1073/pnas.2302480120, 2023.

Trenberth, K. E.: Atmospheric moisture residence times and cycling: implications for rainfall rates and climate change, Climatic Change, 39, 667–694, https://doi.org/10.1023/A:1005319109110, 1998.

Trenberth, K. E., Dai, A., Rasmussen, R. M., and Parsons, D. B.: The changing character of precipitation, Bulletin of the American Meteorological Society, 84, 1205–1218, https://doi.org/10.1175/BAMS-84-9-1205, 2003.

Trenberth, K. E., Zhang, Y., Fasullo, J. T., and Taguchi, S.: Climate variability and relationships between top-of-atmosphere radiation and temperatures on Earth, Journal of Geophysical Research: Atmospheres, 120, 3642–3659, https://doi.org/10.1002/2014JD022887, 2015.

Trent, T., Schroeder, M., Ho, S.-P., Beirle, S., Bennartz, R., Borbas, E., Borger, C., Brogniez, H., Calbet, X., Castelli, E., Compo, G. P., Ebisuzaki, W., Falk, U., Fell, F., Forsythe, J., Hersbach, H., Kachi, M., Kobayashi, S., Kursinsk, R. E., Loyola, D., Luo, Z., Nielsen, J. K., Papandrea, E., Picon, L., Preusker, R., Reale, A., Shi, L., Slivinski, L., Teixeira, J., Vonder Haar, T., and Wagner, T.: Evaluation of total column water vapour products from satellite observations and reanalyses within the GEWEX water vapor Assessment, Climate and Earth System/Remote Sensing/Troposphere/Physics (physical properties and processes), https://doi.org/10.5194/egusphere-2023-2808, 2023.

Wang, C., Graham, R. M., Wang, K., Gerland, S., and Granskog, M. A.: Comparison of ERA5 and ERA-Interim near-surface air temperature, snowfall and precipitation over Arctic sea ice: effects on sea ice thermodynamics and evolution, The Cryosphere, 13, 1661–1679, https://doi.org/10.5194/tc-13-1661-2019, 2019.

Zhou, C., Wang, J., Dai, A., and Thorne, P. W.: A new approach to homogenize global subdaily Radiosonde Temperature Data from 1958 to 2018, Journal of Climate, 34, 1163–1183, https://doi.org/10.1175/JCLI-D-20-0352.1, 2021.

Zveryaev, I. I. and Allan, R. P.: Water vapor variability in the tropics and its links to dynamics and precipitation, Journal of Geophysical Research: Atmospheres, 110, https://doi.org/10.1029/2005JD006033, 2005.