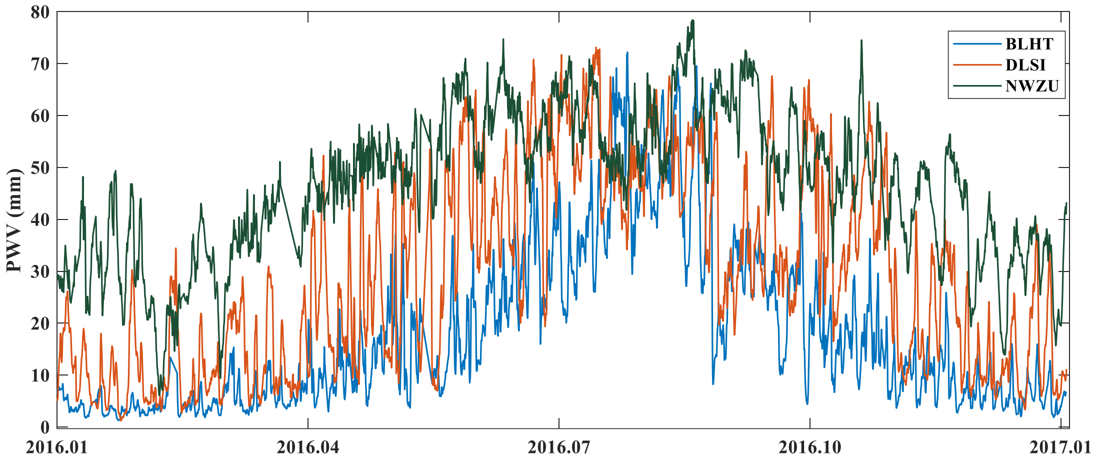
General Comments:

I think, in general, this article is very straightforward and should be accepted after some minor corrections. There are a few issues I raise in the paper and I have made lots of small corrections to the English. One thing I would recommend, is to include some yearly timeseries distributions of a couple of sites of PWV from different stations, as in Figure 12, but just for one year so that the reader can have a better idea of the accuracy and general climate in terms of humidity. Also, I thought your limits of PWV maximum and minimum values are a bit extreme (see below)

Response: Thank you for the constructive and encouraging comments regarding our manuscript. We have enclosed a carefully revised manuscript according to the comments and suggestions provided, and provide an item-by-item response to all comments in the accompanying rebuttal document. We added the time series of PWV in year of 2018 of three stations from different regions to reveals variation of humidity, and revise the manuscript accordingly: "In addition, we analyze the PWV series for the year 2016 at the GNSS stations BLHT, DLSI, and NWZU. The variation in PWV at BLHT is significantly greater than that observed at DLSI and NWZU. Furthermore, the station situated in a tropical monsoon climate, NWZU, consistently exhibits PWV values exceeding 20 mm. The highest PWV values across these stations occur around August, coinciding with the peak typhoon season."



Regarding the PWV values, we appreciate your concern about values near 0 mm and near 90 mm. Our analysis of the ERA5 dataset shows that PWV values in the specified regions and time frame vary widely, with some areas exhibiting values close to 0 mm and others reaching up to 90 mm. This finding is consistent with Figure A1 a,b in Yuan et al. (2023). Additionally, the literature supports the occurrence of even higher PWV values during typhoon events. For instance, Gao et al. (2024) and Zhao et al. (2018) have documented PWV measurements exceeding 90 mm, based on high temporal resolution data (5-minute intervals). Therefore, we believe that the range of PWV values presented in our study, including those near 0 mm and those around 90 mm, is realistic and aligns with both our dataset and existing researches. We cite the papers in our manuscript accordingly.

Zhao Q, Yao Y, Yao W. GPS-based PWV for precipitation forecasting and its application to a typhoon event[J]. Journal of Atmospheric and Solar-Terrestrial Physics, 2018, 167: 124-133.

Gao Y, Wang X. Analysis of the Response Relationship Between PWV and Meteorological Parameters Using Combined GNSS and ERA5 Data: A Case Study of Typhoon Lekima[J]. Atmosphere, 2024, 15(10): 1249.

Yuan P, Blewitt G, Kreemer C, et al. An enhanced integrated water vapour dataset from more than 10 000 global ground-based GPS stations in 2020[J]. Earth System Science Data, 2023, 15(2): 723-743.

Specific Comments：

Line 25. You should probably be a bit more precise here instead of just referring to "water vapor". With respect to water vapor as a variable, what is typically most valuable for modeling, weather prediction, global climate studies is its vertical distribution and the total column water vapor or "precipitable water vapor".

Response: Thank you so much for your suggestion. Amended.

Line 32. There have also been numerous field campaigns around the world employing GNSS meteorology, you should mention some from different regions of the world. I will let you choose and make no specific recommendation.

Response: Thank you so much for your suggestion. The GNSS campaigns launched different regions of world are listed from Line 44 to line 48.

Line 47. Write "Recent research has utilized GNSS ..."

Response: Thank you so much for your suggestion. Amended.

Line 48. What do you mean " project proposing water vapor products from ..." ? This idea is unclear.

Response: Thank you so much for your suggestion. We revised it as "e.g., Bosser et al.,(2021) proposing PWV products from 49 GNSS stations of the EUREC4A (Elucidate the Couplings Between Clouds, Convection and Circulation) project"

Line 74. Write " ...providing reference positions for coastal research..."

Response: Thank you so much for your suggestion. Amended.

Line 87 Write " At the outset, only observations from the GPS and GLONASS satellite constellations were available."

Response: Thank you so much for your suggestion. Amended.

Line 87 Write " In recent years, with the advancement of the Galileo..."

Response: Thank you so much for your suggestion. Amended.

Line 99 Write" ...University (Shi et al., 2008; Liu and Ge, 2003) using the static precise point position ..."

Response: Thank you so much for your suggestion. Amended.

Line 102 Write " and an elevation-dependent weighting function was applied."
Response: Thank you so much for your suggestion. Amended.

Line 110 Write "...ZTD consists of a hydrostatic part..."
Response: Thank you so much for your suggestion. Amended.

Line 111 Write " ...(pressure and temperature) provided by Global Pressure and Temperature...,"
Response: Thank you so much for your suggestion. Amended.

Line 114 This idea is a bit unclear. What do you mean by " Batch least-squares estimator" ?
Response: Thank you for highlighting the lack of clarity in Line 114. The "batch least-squares estimator" refers to a statistical method that processes all available data simultaneously to estimate parameters by minimizing the sum of the squared differences between observed and predicted values (known as residuals). In this specific context, it was applied to determine key parameters in GNSS processing. We revised it accordingly in the manuscript 'Batch least-squares estimation method was used to estimating the GNSS station static coordinate, epoch-wise clock offsets, and tropospheric delay."

Line 127 c. Validation of GNSS ZTDs based on ERA5 products
You do not have any local surface meteorological stations collocated or near the GNSS antennas?
You could use these surface met. stations for the surface pressure and to derive Tm with a simple model and then calcuate PWV. This would be good to compare against ERA5 since these ERA5 data are very smoothed in some respect (~ 25km x 25km grid
Response: Thank you for your valuable suggestion. We appreciate your idea of using local surface meteorological stations near GNSS antennas to obtain surface pressure and derive the mean temperature with a simple model for calculating PWV. Indeed, comparing these locally derived PWV values with ERA5 results would be highly meaningful, particularly given the smoothed nature of ERA5 data due to its approximately 25 km × 25 km grid resolution. Such a comparison could provide a more detailed and localized validation of our PWV estimates. Unfortunately, in our current study, we do not have access to collocated or nearby surface meteorological stations at the GNSS antenna sites. We attempted to secure additional data from such stations, but this effort was unsuccessful, either due to the absence of stations in the vicinity or because the data were inaccessible. We recognize the potential of this approach and plan to explore it in future work, possibly by identifying regions with available surface meteorological stations or by establishing collaborations to obtain the necessary data.
We are grateful for your input and will consider this approach as we continue to refine our research methodology.

Line 164 Your PWV limiting values for outliers are very strange (0.72 mm and 86.21mm)

It is not physically possible to have PWV values near 0 nor near 90mm. Even under typhoon/hurricane conditions, the maximum PWV should be near 80mm at the highest. And PWV can never be near 0mm in these region under any conditions.

Response: Thank you for your valuable feedback concerning the PWV limiting values of 0.72 mm and 86.21 mm identified as outliers in our study. We appreciate your concern that these values—near 0 mm and close to 90 mm—may appear physically implausible, particularly the suggestion that PWV cannot approach 0 mm in the studied regions under any conditions and that even under extreme typhoon or hurricane conditions, PWV should not exceed approximately 80 mm. To address this, we revisited our analysis and supporting evidence. Our PWV values are derived from the ERA5 dataset, which indicates a broad range of PWV across the specified regions and time periods. This includes values as low as 0.72 mm in certain areas, corroborated by radiosonde profiles from the same regions that also report PWV approaching 0 mm. These findings align with Figure A1 a,b in Yuan et al. (2023), which similarly documents such low PWV values. For the higher PWV value, our data shows PWV reaching up to 86.21 mm, and we note that values exceeding 90 mm are not unprecedented in extreme weather scenarios. Studies such as Gao et al. (2024) and Zhao et al. (2018) have recorded PWV measurements surpassing 90 mm during typhoon events, leveraging high temporal resolution data (5-minute intervals). These observations suggest that under intense atmospheric conditions, PWV can indeed exceed the 80 mm threshold you mentioned.

Therefore, we think that the PWV range in our study—spanning from near 0 mm to around 90 mm—is both realistic and consistent with our dataset and the broader literature. To enhance clarity and provide further support for these findings, we have updated the manuscript to include citations to Yuan et al. (2023), Gao et al. (2024), and Zhao et al. (2018). These references should offer additional context for the observed PWV variability.

Zhao Q, Yao Y, Yao W. GPS-based PWV for precipitation forecasting and its application to a typhoon event[J]. Journal of Atmospheric and Solar-Terrestrial Physics, 2018, 167: 124-133.

Gao Y, Wang X. Analysis of the Response Relationship Between PWV and Meteorological Parameters Using Combined GNSS and ERA5 Data: A Case Study of Typhoon Lekima[J]. Atmosphere, 2024, 15(10): 1249.

Yuan P, Blewitt G, Kreemer C, et al. An enhanced integrated water vapour dataset from more than 10 000 global ground-based GPS stations in 2020[J]. Earth System Science Data, 2023, 15(2): 723-743.

Line 166 " In addition, a station-specific outlier detection method was employed."

Response: Thank you so much for your suggestion. Amended.

Line 167 " the median PWV value was calculated within a 15-day moving window centered on the specific day." Why do you employ such a long moving window? It is typically hourly or daily change in PWV that is of interest.

Response: Thank you for your valuable suggestion. We appreciate your observation that hourly or daily changes in PWV are typically of interest. We employed the 15-day moving window, centered on the specific day, following the methodology recommended by Yuan et al. (2023). This approach enhances the robustness of our filtering process for our hourly PWV product. While our data is indeed generated hourly, the longer 15-day window serves a critical purpose: it allows us to verify that large PWV values are not isolated outliers but are instead consistently present over this extended period. By doing so, we can distinguish genuine PWV variations from anomalous data points that might otherwise skew our results. The outlier thresholds were defined as: Q1-3*IQR to Q1+3*IQR. This method ensures the reliability of our PWV product by confirming that significant values recur within the window, aligning with the robust filtering outcomes.

Yuan P, Blewitt G, Kreemer C, et al. An enhanced integrated water vapour dataset from more than 10 000 global ground-based GPS stations in 2020[J]. Earth System Science Data, 2023, 15(2): 723-743.

Line 182 I would not call ERA5 Numerical Weather model data. It is reanalysis data which include both observations and model output.

Response: Thank you for the clarification. We agree that ERA5 should be described as a reanalysis rather than as direct numerical-weather-model output. ERA5 is produced by assimilating a wide range of observations into the ECMWF Integrated Forecasting System (IFS); the resulting fields therefore combine model physics with observational information. We have revised the manuscript accordingly: “The study employed the ERA5 reanalysis from the European Centre for Medium-Range Weather Forecasts (ECMWF)”

Line 240 " Additionally, the quality of the RS profiles may contribute to the larger biases observed." Another thing to consider is that the RS can be biased if they rise through cloud/rainy conditions leading to higher PWV values than the GNSS PWV which has a large cone of observation (~20km diameter) can may contain clear skies in addition to the cloudy/rainy skies. These "saturated" soundings can be easily identified visually,

Response: Thank you so much for your suggestion. To quantify this effect we extracted ERA5 total-cloud-cover (sky-fraction, 0–1) for every GNSS–RS matchup and added the values to Table 2. Sites in the temperate-monsoon regime generally show lower cloud fractions; DXMN is an exception because most comparisons occur in spring. Consistently, larger cloud fractions (i.e., more ‘saturated’ soundings) coincide with larger GNSS–RS PWV differences, confirming that cloud-contaminated RS profiles contribute to the observed bias. The manuscript is revised accordingly: “We also examined total cloud cover from ERA5 (the fraction of the sky occupied by clouds, 0 – 1) at the comparison times. Stations in the temperate–monsoon regime generally show lower cloud-cover values than the other sites. The larger PWV biases seen at the cloudier stations likely stem from the differing sampling geometries of the two sensors: GNSS estimates average water vapor over a conical footprint roughly 20 km in diameter that can encompass both clear and cloudy areas, whereas the radiosonde ascends directly through the local cloud or rain column.”

RS Station	GNSS Station	RS PWV with 10 levels					RS PWV with 11 levels				
		Mean (mm)	STD (mm)	RMS (mm)	Number	Total Cloud Cover	Mean (mm)	STD (mm)	RMS (mm)	Number	Total Cloud Cover
45004	NSZN	0.48	2.08	2.14	4300	0.68	0.48	2.08	2.14	4300	0.68
54662	BLHT	1.38	2.06	2.48	3963	0.41	1.22	1.76	2.14	3209	0.39
54857	BXMD	1.44	2.13	2.57	3764	0.43	1.3	1.77	2.2	2575	0.36
58847	DCHM	1.8	3.4	3.85	4961	0.69	1.82	3.19	3.72	3439	0.68
59134	DXMN	1.67	2.66	3.14	1956	0.57	1.51	2.42	2.84	69	0.59
59316	NSTO	0.97	3.69	3.81	2915	0.63	0.29	2.6	2.56	24	0.51
59644	NBHI	0.01	3.07	3.07	1035	0.68	-0.03	3.04	3.04	1020	0.69
59758	NHKO	1.39	3.81	4.06	4723	0.61	1.2	3.74	3.93	3702	0.61
59948	NSYA	-0.45	4.73	4.75	821	0.60	-0.46	4.73	4.75	814	0.61
59981	NXSA	-0.64	5.45	5.48	2056	0.50	/	/	/	/	/

Line 325 Write "In addition, the spatiotemporal characteristics of coastal PWV in China were analyzed" And again, 0mm PWV values are not possible, there should always be a couple of mm of PWV even in very cold, dry weather in this region.

Response: Thank you so much for your suggestion. Our analysis of the ERA5 dataset shows that PWV values in the specified regions and time frame vary widely, with some areas exhibiting values close to 0 mm. This finding is consistent with Figure A1 a,b and Figure 6 in Yuan et al. (2023).

Yuan P, Blewitt G, Kreemer C, et al. An enhanced integrated water vapour dataset from more than 10 000 global ground-based GPS stations in 2020[J]. Earth System Science Data, 2023, 15(2): 723-743.