Review of "The impact of GNSS Zenith Total Delay data assimilation on the short-term precipitable water vapor and precipitation forecast over Italy using the WRF model" by Torcasion R.C., Mascitelli A., Eralini E., Barindelli S., Tagliaferro G., Puca S., Dietrich S. and Federico S. (Manuscript ID: NHESS-2023-18)

The current study examines the impact of assimilating GNSS-ZTD data on the performance of the WRF model in terms of simulating PWV and rainfall. The topic may be of interest, but it has been quite extensively addressed in previous studies, even in Italy (Lagasio et al., 2019; Mascitelli et al., 2019, 2021), which is the study area of the present paper. Unfortunately, the current study does not add something new to the existing literature, either with respect to the methodology nor concerning the results. A widely used (and relatively simple compared to 4Dvar, 3D-EnVar etc.) data assimilation (DA) system has been employed for performing very short-term DA experiments that cover the period from 2 to 31 October, 2019. In the framework of highlighting the novelty of the current study (Lines 82-85), this period is characterized as "longer" compared to previous studies. However, Mascitelli et al., (2019, 2021) also performed 1-2 month-long DA experiments. Further, the use of 388 GNSS receivers in the current study is highlighted, but Lagasio et al. (2019) also used 375 GNSS stations (in addition to satellite data) for their DA experiments. Based on the above, it is clear that the novelty of the present paper is lacking. I suggest the authors to reframe the conceptualization of their work considering the notes on future studies they suggest (Lines 419-425), as well as other pathways that can add value and novelty to their study.

Besides the above critical issue, other major and minor review points are highlighted below.

Major

- Study period: Please provide more information on the "moderate to intense precipitation events" that took place within October 2019 (dates, sums of precipitation, synoptic conditions etc.). This is important, because previous studies showed mixed ZTD DA impact, depending on the characteristics of the simulated events (e.g. synoptic-scale vs. convective).
- ZTD observations: National and regional networks were used for deriving the ZTD observations. Thus, a critical question arising is related to the accuracy of each network. This is important because the observational errors affect the DA process and the final outcomes. Please clarify if any accuracy assessment and pre-processing was performed for the ZTD observations and justify the selection of a fixed value of 5 mm as ZTD error for all networks.
- Lines 211-221: Please clarify why PWV is calculated using the observed ZTD and WRF-modeled ZHD. Is this computation corresponds to the forecasted PWV? Please clarify how the observational based PWV is computed.
- Case study analysis: The case study results are examined on the basis of maps comparison. Please provide a statistical evaluation of the results (as in the whole period analysis).
- Results and discussion: Please enrich this section in terms of interpreting the results and placing them in in the context of the related literature.

Minor

Overall, the paper is well written and structured, but some points can be improved. These include the frequent use of separate lines instead of longer paragraphs. For instance, the Abstract should be a single paragraph. Further,

- Abstract: Lines 23-25 (about the results) should be placed before Lines 21-22 (about the results). Further, it seems that there is repetition in Lines 21-22 and 28-30. Please be more specific concerning "showed an improvement of the precipitation forecast in different ways". Please revise "model 4.1.3" to "model, version 4.1.3,".
- Introduction: The first paragraph lacks a conceptual connection to the content provided in the next paragraphs. This is also true for the sentence in Lines 68-69 (please refer to the countries) in relation to the previous paragraph. Please make clear that the studies of Lagasio et al. (2019) and Mascitelli et al. (2019, 2021) were performed over Italy (Lines 76-81). Please provide abbreviations for the terms 3DVar, 4DVar etc.
- Lines 112-113: The "background simulations" usually refer to those for deriving the model background errors for DA. Thus, I suggest renaming the experiments without DA to "control simulations".
- Please provide a map in Appendix A showing the locations of the rain gauges used for evaluating the model results.
- Please specify the reason of examining the innovations during the case study analysis (Lines 248-262). To my understanding this is done to highlight that the ZTD DA assimilation leads to actual modeled differences related to PWV that are not random.
- Figure 5: Please indicate the axis of the cross-section.

References

Lagasio, M., Parodi, A., Pulvirenti, L., Meroni, A.N., Boni, G., Pierdicca, N., Marzano, F.S., Luini, L., Venuti, G., Realini, E.,Gatti, A., Tagliaferro, G., Barindelli, S., Monti Guarnieri, A., Goga, K., Terzo, O., Rucci, A., Passera, E., Kranzlmueller, D., Rommen, B.: A Synergistic Use of a High-Resolution Numerical Weather Prediction Model and High-Resolution Earth Observation Products to Improve Precipitation Forecast. Remote Sens.-Basel, 11, 2387. https://doi.org/10.3390/rs11202387, 2019.

Mascitelli, A., Federico, S., Fortunato, M., Avolio, E., Torcasio, R. C., Realini, E., Mazzoni, A., Transerici, C., Crespi, M., Dietrich, S.: Data assimilation of GNSS-ZTD into the RAMS model through 3D-Var: preliminary results at the regional scale. Meas. Sci. Technol. 30, 055801 (14pp). https://doi.org/10.1088/1361-6501/ab0b87, 2019.

Mascitelli, A., Federico, S., Torcasio, R. C., Dietrich, S.: Assimilation of GPS Zenith Total Delay estimates in RAMS NWP model: Impact studies over central Italy. Adv. Space Res., https://doi.org/10.1016/j.asr.2020.08.031, 68, 12, pp 4783-4793, 2021.