

We have turned to a person with good written English to revise our languages when prepared the revised manuscript.

And the editor told us that they will offer English language copy-editing for final revised accepted papers. Followings are our responses to your comments:

1. Consider using the term integrated water vapour, IWV, instead of PWV.

Response: In our opinion, IWV has the same meaning as PWV. And “GPS PWV” seems to be used together more widely in many articles. So we choose the term “PWV” rather than “IWV”.

2. Section around line 65: Is it well established that global empirical Tm models without Ts components are less good? If so give some references. If not, include some of them in your comparisons of different sources of global Tm. We want to know whether your dataset is the best global set for Tm estimation around for the moment, or just better than other Ts-Tm based sets.

Response: We have included Tm estimations from GPT2w model in all of our comparisons. GPT2w model is a global empirical Tm models newly developed by Bohm in 2015 (Bohm et al., 2015). And the results still indicate that our Ts-Tm model has accuracy advantages over other Tm estimation models. Detail statistics are included in the revised manuscript.

3. Notice that in numerical weather prediction one in general uses GPS ZTD, not PWV. PWV is important for climate monitoring, and for meteorologists doing weather forecasting combining information from weather prediction models and observations.

Response: Thank you for your kind suggestion. We have modified our expressions about the use of GPS PWV in weather prediction. (Around line 80 in revised version)

4. around line 100: Did you take into consideration that water vapour pressure (and density) varies approximately exponentially with height when doing the integral in eq. 4. It is not likely to have a large impact, but the fewer RS levels you have access to, the larger the effect. 5 levels is not a lot.

Response: Yes, we have considered the temperature and water vapor pressure’s variations with height. Between two neighbor RS observation heights, we calculated the water vapor pressure at the middle height for equation (4) by

exponential interpolation of the two RS heights' water vapor pressure, while we estimated the temperature by linear interpolation. We have added some explanations in our revised manuscript. (Around line 125~130 in revised version)

4. around line 120: "geoid height" should be "geometric height". The reference surface doesn't matter for the integral.

Response: Revisions have been made. (Around line 155 in revised version)

5. around line 150: There are several places where text is not properly separated, here E180. etc., text of figure 3 is another example.

Response: Revisions have been made. (Around line 195, 210, 345, 420 in revised version)

6. Figure 1. It is hard to see properly the RS circles. Consider making the figure little bit larger, and draw a thin black line around the RS circles, in order that one can see them also where they agree with ERA.

Response: Figure 1 have been plotted bigger. Actually our figures are vector graphs, so readers can zoom in on them to see the plots more clearly. (Around line 200 in revised version)

7. At many places in the text and in the figures units are missing.

Response: Revisions have been made.

8. Figure 6: Are the colors plotted in a particular order, such that for example large rms will be plotted on top of small rms? If so, do a check that plotting in the opposite order yield almost similar plots. Otherwise enlarge.

Response: We have enlarged our plots in figure 6 to ensure that no color point is covered by others. The figures are vector graphs, so readers can also zoom in on them to see the plots more clearly. (Around line 300~315 in revised version)

9. Figure 6: Regarding the RS ERA comparisons. Is anything done to handle altitude offsets between RS surface and ERA surface?

Response: In Equation (5), which is the time-varying Ts-Tm model, there are eight coefficients ($a, b, m_1, m_2, n_1, n_2, p_1, p_2$) which are estimated at each ERA-I grid node. In figure 6, we evaluate the performance of equation (5) at each RS site. Considering the horizontal offsets between RS sites and ERA-I grid nodes, we obtained the eight coefficients ($a, b, m_1, m_2, n_1, n_2, p_1, p_2$) at each RS location by horizontally interpolated the ones of RS site's four neighbor ERA-I grid nodes.

However, we think that the height differences between RS sites and its neighbor ERA-I surfaces have little impact on our Ts-Tm model. Such impact on Ts-Tm model can be compensated by the Ts input, which should be changed with altitude.

10. Around line 280. At 10.82 % of the sites inclusion of the time variations in ERAI resulted in poorer results. That indicates ERAI has particular problems at these locations. If you plot them on a map, do you see any systematics in their location?

Response: GPT2w model has been added in our comparisons and we modified our results in the revised manuscript.

Unfortunately we found that there is no obvious characteristic in the distribution of RS site with poorer results. The reasons for such poorer results seem to be complicated and need specific study in the future.

11. Around line 310. The pressure used to determine ZHD should be the pressure at the GNSS antenna level, not surface pressure. Did you do something to correct for height offsets, or is the barometer installed at the same altitude as the GNSS antenna at these locations?

Response: The air pressure for each ZHD calculation was measured by the barometer equipped together with GNSS antenna at the GNSS site. Their locations are considered to be the same. (Around line 375 in revised version)

12. Similarly the Tm integral should in principle run from the antenna level and up, not from the surface. In almost all cases that is not likely to create problems, but there will be locations where the difference between the surface altitude of ERA and the altitude of a GNSS site is huge. I'm not familiar with the location of IGS sites, but for GNSS reference sites in general the altitude difference can be more than 1000 m between a GNSS site and an NWP model with higher horizontal resolution than ERAI.

Response: We have considered such height differences in our comparisons. We interpolated (or extrapolated) ERA-I profile to GNSS antenna's location, and then started the Tm integral from GNSS antenna's altitude.

13. Around line 385: It would be nice if in the final article you could add an extra line with a link to your dataset. It seems very useful to many people.

Response: A link to our model has been added. (Around line 465 in revised version).

Reference:

Bohm, J., Moller, G., Schindelegger, M., Pain, G., and Weber, R.: Development of an improved empirical model for slant delays in the troposphere (GPT2w), *Gps Solutions*, 19, 433-441, [10.1007/s10291-014-0403-7](https://doi.org/10.1007/s10291-014-0403-7), 2015.