

Response to Editor and Reviewers

Dear editor and reviewers,

Thank you for offering us an opportunity to improve the quality of our submitted manuscript titled “**A hybrid-grid global model for the estimation of atmospheric weighted mean temperature considering time-varying lapse rate in GNSS precipitable water vapor retrieval**” (gmd-2024-21). We appreciated very much your constructive and insightful comments. In the following, we include a point-by-point response to the comments. We have improved the English writing of this manuscript. Unclear phrases and related sentences have been revised, particularly the sections for analyzing and constructing a model for the T_m lapse rate. In the revised manuscript, all the changes have been highlighted in red. We hope the revised manuscript has now met the publication standard of your journal.

Comment 1: A major issue is the confusing description of T_m , which is defined as a vertically weighted mean temperature, i.e., no vertical dependence. The vertical correction is included to consider the varying topography height to better reflect h_{bot} in Eq. (1), isn't it? However, many sentences refer to T_m as a "vertical dependent" variable. These sentences must be clarified to deliver the concept of "adjusting the given T_m at starting height to the target height" (line 278). I only listed the sentences I found, but please carefully revise all the sentences with such an issue. Can the authors avoid using "elevation of T_m "? Also, "user height", "target point" and "gridded point" need clear definitions and are used consistently. Is the elevation of a target point the same as the altitude of the GNSS ZTD receiver? Since this study inverts PWV with GNSS ZWD information, there should be a clear sentence that defines how to consider the altitude of the ground-based GNSS receiver.

- Line 166: vertical T_m variation? Since T_m is a vertically weighted mean temperature, there is no vertical dependence. Please revise this sentence.

- Line 167: vertical T_m information.

- Line 168: layered T_m data and elevation of T_m . Is the "elevation" here the same as the h_{bot} in Eq. (1)?

- Line 176: The term "grid-level" is constantly used, but it is not well defined. Is this referred to the surface grid?

- Same for the caption of Fig. 1.

- Line 243: Is the height in this sentence referred to as the height of the surface grid? Same question for the elevation.

- Line 278: surface Tm model, whose h_{bot} is at the surface?

Response 1: Thanks for your suggestion. We agree with you. We have revised the sentences you mentioned and other unclear sentences. The phrase “elevation of Tm” have been changed to “Tm height”. The words "user" and "target" have been unified as "target". In this study, the height of a target point is the same as the altitude of the GNSS ZTD receiver. We have explained the "target height" (see line 166).

- Line 166: The phrase “vertical Tm variation” has been changed to “Tm variation in the vertical direction” (see line 165).

- Line 167: We have corrected this sentence to “it is necessary to correct Tm vertically” (see lines 166).

- Line 168: The "elevation" here is the same as the h_{bot} in Eq. (1). The phrase “between the layered Tm data and elevation of Tm” has been changed to “between the layered Tm data and corresponding height” (see line 167).

- Line 176: The term "grid-level" is not the “surface grid”. "grid-level" has been changed to “layered” (see line 169, 174 and 175).

- Line 243: The word “elevation” has been changed to “height”. H^T is the height of the target point; and H^G is the height of the gridded point (see line 241).

- Line 278: Yes, the height of surface Tm model is at the surface. This sentence have been corrected to “it is necessary to develop a Tm model whose height is at the surface (named as surface Tm model)” (see line 274).

Comment 2: Line 48-58: The relationship between PWV and ZWD should be better structured. Maybe starting with a sentence like "The inversion of PWV uses the wet component of the zenith total delay", followed by more explanations about ZTD.

Response 2: Thank you for pointing this out. The relationship between PWV and ZWD has been structured to “PWV can be inverted by multiplying the wet component of the zenith total delay (ZTD) with the water vapor conversion factor. The ZTD consists of two parts: the zenith hydrostatic delay (ZHD) and the zenith wet delay (ZWD)” (see lines 47-49).

Comment 3: A brief paragraph should be included at the end of the introduction to explain the structure of this paper.

Response 3: Thanks for your suggestion. We have explained the structure of this paper at the end of the introduction (see lines 114-117).

Comment 4: Line 93: Since T_m is a weighted mean temperature, how can it be corrected to a certain height? Please revise this sentence. I think you want to say "correcting T_m to consider the varying topography height".

Response 4: Thank you for pointing this out. We have revised this sentence to “the T_m lapse rate is an effective means of correcting T_m to consider the varying topography height” (see line 91).

Comment 5: Lines 218-219: What did the authors mean by "poor performance in spatial difference" based on Fig.3?

Response 5: Thanks for the question you raised. What we want to emphasize is “the variation law of the lapse rate of T_m differs spatially” rather than “poor performance in spatial difference”. We have revised this sentence to “the above analysis demonstrated that the variation law of the lapse rate of T_m differs spatially. This makes it difficult to accurately grasp the variation law of the lapse rate of T_m in developing a global uniform model for the lapse rate of T_m ” (see lines 216-217).

Comment 6: First paragraph on Page 11: I assume the ERA5 analysis is used to construct the coefficients in Eq. 9 with least square fitting. If that's correct, please clearly specify the statement. Once the coefficients are determined, the model can be executed in real-time. The ability to execute the model at real time should be emphasized in the summary.

Response 6: Thanks for your suggestion. We have clearly specified the data used to calculate the five coefficients (see line 246). In addition, the ability to execute the model at real time has been emphasized in the summary (see line 437).

Comment 7: Line 400: It is difficult to tell that Fig. 9d has smaller RMSEs than Figs. 9a-9c! Please double-check the arrangement of the subplots.

Response 7: Thank you for pointing this out. The inconsistent color bar range makes it difficult to compare for model performance. The color bar range has been adjusted to be consistent (see line 387).

In addition, we have also checked and revised other phrases and related sentences. Please refer to the revised manuscript for details. Thanks again for your constructive and insightful comments.