Response to Editor

Dear editor,

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 checked our manuscript carefully for typos, missing co-authors and their affiliations, terminology, updates of data in tables, or updates of variables in equations. 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: Please clarify how the NGGTm model can be applied at "real-time" since the ERA5 data will not be available.

Response 1: Thanks for your comment. ERA5 data is really not available in "real-time". But the purpose of this study is to develop an empirical model, which uses historical data to model. When applying the model, it only needs to determine the user's spatial position and input time to estimate T_m without inputting any parameters of ERA5. The workflow of developing the "real-time" T_m model is shown in Figure 1. As mentioned in Section 1, T_m models are divided into meteorological and nonmeteorological parameter models. The meteorological parameter model requires input of "real-time" meteorological parameters, such as Bevis model (T_m=70.2+0.72T_s). Therefore, such models cannot achieve "real-time" performance. However, nonmeteorological parameter model do not require input of "real-time" meteorological parameters. The T_m model proposed in this study belongs to this type of model and can achieve "real-time" calculation and prediction of the future. The proposed T_m model consists of the following four Equations, which do not require the input of "real-time" meteorological parameters but only time.

$$\gamma^i = {A_0}^i + {A_1}^i \cos\left(2\pi \frac{DOY}{365.25}\right) + {A_2}^i \sin\left(2\pi \frac{DOY}{365.25}\right) + {A_3}^i \cos\left(4\pi \frac{DOY}{365.25}\right) + {A_4}^i \sin\left(4\pi \frac{DOY}{365.25}\right) \quad (1)$$

where i is the number of windows; γ^i is the lapse rate of T_m in the ith window; ${A_0}^i$ is the annual mean value of the lapse rate of T_m in the ith window; (${A_1}^i$, ${A_2}^i$) is the annual cycle coefficient of the lapse rate of T_m in the ith window; (${A_3}^i$, ${A_4}^i$) is the semiannual cycle coefficient of the lapse rate of T_m in the ith window; and DOY is the day of the year.

$$T_m^U = T_m^G - \gamma^i (H^U - H^G) \quad (2)$$

where T_m^U is the T_m value at the user height; T_m^G is the T_m value at the height of the gridded points from the reanalysis data; γ^i is the lapse rate of T_m at the window where the user is located; H^U is the elevation of the user; and H^G is the elevation of the gridded point from the reanalysis data.

$$T_m^G = B_0 + B_1 \cos\left(2\pi \frac{HOD}{24}\right) + B_2 \sin\left(2\pi \frac{HOD}{24}\right) + B_3 \cos\left(4\pi \frac{HOD}{24}\right) + B_4 \sin\left(4\pi \frac{HOD}{24}\right) \quad (3)$$

$$B_i = b_{i0} + b_{i1}\cos\left(2\pi\frac{DOY}{365.25}\right) + b_{i2}\sin\left(2\pi\frac{DOY}{365.25}\right) + b_{i3}\cos\left(4\pi\frac{DOY}{365.25}\right) + b_{i4}\sin\left(4\pi\frac{DOY}{365.25}\right) \quad (4)$$

where T_m^G is the T_m value at the gridded points; B_i is the daily variation coefficient of T_m; and HOD is the UTC time. After Eq. (4) was used to expand Eq. (3), b_{ij} (i=0,1,2,3,4 and j=0,1,2,3,4), which represents the 25 coefficient terms of the model, was calculated. DOY is the day of the year.

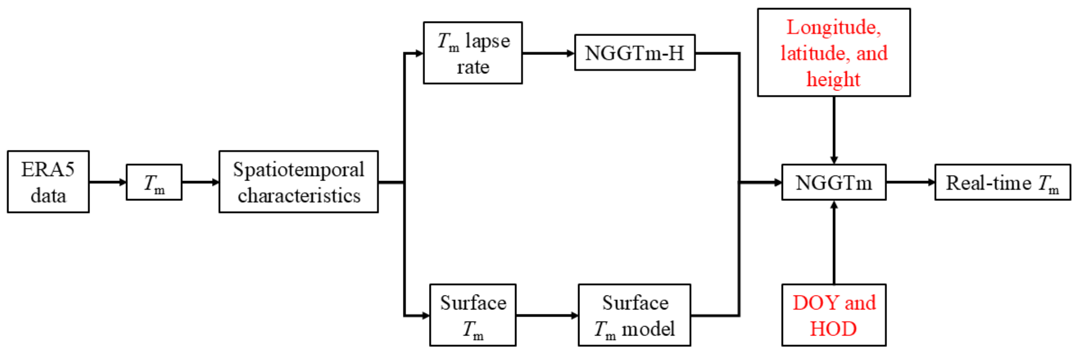

Figure 1 The workflow of developing the proposed T_m model.

Comment 2: What kind of data will be used to represent the temporal characteristics of "real-time" temperature, an important advantage of applying the NGGTm model to GNSS PWV retrieval tasks?

Response 2: Thanks for the question you raised. Although ERA5 data cannot be available in "real-time", we use historical ERA5 data to analyze the temporal variation characteristics of T_m and achieve "real-time" modeling through periodic functions. The proposed T_m model only requires inputs of day of year (DOY) and hour of day (HOD).