A global empirical model was designed in this paper to estimate the zenith troposphere delay in different altitudes. The ERA5 reanalysis data, MERRA-2 and other data were applied for validation. However, some more details are need improving the manuscript before the possible publication:

Response: Thank you for your letter and for the reviewers comments 'concerning our manuscript. Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. We have studied comments carefully and have made correction which we hope meet with approval. The main corrections in the paper and the responds to the reviewer's comments are as flowing:

1. in Line 158: "This may be due to the complex climate variations in these areas causing more dramatic ZTD variations." authors please provide more supplement to prove that the "complex climate variations" are the caution of the ZTD. Besides, when we talk about the climate, we usually focus on the statistical state of the regional or global weather characteristics, such as the monthly/annual mean the air temperature, wind speed/direction, humidity, ... and also the extreme weather conditions in a certain region over a period. However, in my understanding, the weather variables that affect ZTD may be more in their immediate state than in their climatic state, so using "meteorological variables" seems more reasonable in this part of discussion.

Thank you very much for your comments. It turns out that our description of the complex changes in ZTD is too simplistic, and after a careful review of the literature, we find that this is due to a number of factors, For example, "meteorological variables", " topography", "thermodynamic circulation"...

We have revised the description and added references **in L169**:

"This may be due to the fact that these regions are located at the junction of the ocean and land and are in the same direction as the northeast (Northern Hemisphere) and southeast (Southern hemisphere) equatorial trade winds (Yao et al., 2012), indicating that the distribution of ZTD is not only related to meteorological variables and topography, but also influenced by thermodynamic circulation (Yao et al., 2013)."

Yao, Y., Zhu, S. and Yue, S.: A globally applicable, season-specific model for estimating the weighted mean temperature of the atmosphere. Journal of Geodesy, (86), 1125–1135. https://doi.org/10.1007/s00190-012-0568-1. 2012.

Yao, Y., He, C., Zhang, B., and Xv, C.: A new global zenith tropospheric delay model GZTD. Chinese Journal of Geophysics, 56(7), 2218-2227. https://doi:10.6038/cjg20130709. 2013.

2. the equations in the GZTD-P and GGZTD-P are provided in the section 3.3 and 3.4. Although both of them are empirical model, more introduction of the physical images and model explanations still need to be provided to us, either in the main draft or in the supplement. Otherwise, as an article on model development, it may be difficult for us to better understand the basis of those eqs 1-8.

Your suggestion will help us a lot to improve our manuscript. In order to make it easier for all to understand, we have added a flow chart of the model, and give a more detailed description. We have modified it **in L202**:

"ERA5 atmospheric reanalysis data ZTD on the surface will be uniformly converted to the position of the sliding window's average elevation. This conversion is based on the piecewise global ZTD vertical profile model, GZTD-P model, taking into account the elevation position of each window. The model is based on the ZTD values at the sliding window's average elevation. Utilizing the GZTD-P model, ZTD data for all window from 2012 to 2016 were vertically interpolated to calculate the ZTD value at the average elevation of each window after correction. The detailed process is shown in Fig. 7. To estimate the coefficients in each window, the least-squares adjustment is utilized, considering the annual, semi-annual, daily, and semi-daily variations, as well as the latitude factor. Finally, the global ZTD empirical grid model (GGZTD-P) is developed based on a piecewise expression, with a resolution of 1°×1°. The model can be expressed as follows:

$$ZTD_t = \begin{cases} ZTD_r * \exp\left(H_{s1} * \left(H_t - H_r\right)\right)\left(H_t < 3\text{km}\right) \\ ZTD_3 * \exp\left(H_{s2} * \left(H_t - 3\right)\right)\left(3\text{km} \le H_t < 8\text{km}\right) \\ ZTD_8 * \exp\left(H_{s3} * \left(H_t - 8\right)\right)\left(8\text{km} \le H_t < 16\text{km}\right) \\ ZTD_{16} * \exp\left(H_{s4} * \left(H_t - 16\right)\right)\left(H_t \ge 16\text{km}\right) \end{cases} \tag{6}$$

$$\begin{aligned} MP = A_0 + A_1 \cdot \cos\left(2\pi \frac{HOD}{24}\right) + A_2 \cdot \sin\left(2\pi \frac{HOD}{24}\right) \\ + A_3 \cdot \cos\left(4\pi \frac{HOD}{24}\right) + A_4 \cdot \sin\left(4\pi \frac{HOD}{24}\right) \end{aligned} \tag{7}$$

$$\begin{aligned} A_i = \alpha_1 + \alpha_2 \cdot \varphi + \alpha_3 \cdot \cos\left(2\pi \frac{DOY}{365.25}\right) + \alpha_4 \cdot \sin\left(2\pi \frac{DOY}{365.25}\right) \\ + \alpha_5 \cdot \cos\left(4\pi \frac{DOY}{365.25}\right) + \alpha_6 \cdot \sin\left(4\pi \frac{DOY}{365.25}\right) \end{aligned} \tag{8}$$

In Eqs. (6) (7) and (8), MP stands for the ZTD value at the average elevation, 3 km elevation, 8 km elevation and 16 km elevation, and A_i stands for the daily period coefficient. a_i stands for the constant, latitude, annual and semi-annual period correction factor, φ stands for latitude, DOY stands for year day, HOD stands for time."

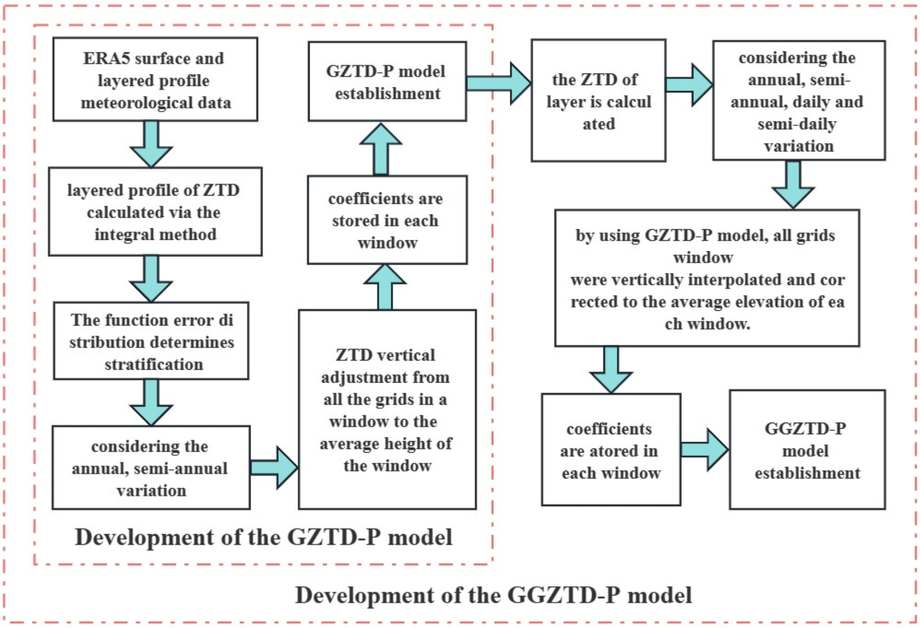

Figure 7. Flowchart depicting the development and use of the model.