Scientific questions

1. ln 32-33 – '... by iono-free combination techniques': a citation about such techniques should be useful, given the general audience to which the journal refers to.

Response: Thanks for your comment. We have added a citation about iono-free combination techniques as you suggested.It is 'Spilker, J. J. (1980). GPS signal structure and performance characteristics.Global positioning system, 1, 29-54.'

2. ln 37 – 'A more reliable'. The use of this expression would imply the fact that a model has already been presented above in the text (maybe 'more' could be dropped). Also, the use of 'In order to better exploit the modern development of geodetic techniques' and' to improve the accuracy and efficiency of [...] based on geodesy technique' in the same phrase is a bit redundant.

Response: Thanks for your comment. We have dropped 'more' in the expression as you suggested. We have rewritten the phrase 'In order to better exploit the modern development of geodetic techniques […]' to make it concise. The new phrase is 'In order to improve the accuracy and efficiency of the application in earth science based on space geodesy techniques, a reliable tropospheric delay model is required.'

3. line 40-57 – A (very) short description on the basic principles on which each model presented here is based (real time data, averaged trend from database, empyrical considerations...) would be helpful, along with their accuracy (which is already present).

Response: Thanks for your comment. We have shorten the description as you suggested, which is 'Some tropospheric delay models are developed to mitigate the tropospheric delay. The traditional models like the Hopfield model (Hopfield 1969), Saastamoinen model (Saastamoinen 1973) and Black model (Black 1978) require real-time meteorological data to reach a correction accuracy better than 10 cm. Given the location and time information, the UNB series models (Collins and Langley 1997, 1998; Leandro et al. 2006, 2008) and EGNOS model (Dodson et al. 1999; Penna et al. 2001; Ueno et al. 2001) use the empirical meteorological parameters in form of the latitude band table to estimate the ZTD with an accuracy of about 5 cm, while the IGGTrop model (Li et al. 2012) is based on the empirical three-dimensional parameters in form of the grids to calculate the ZTD with an accuracy of about 4 cm.'

4. ln 58 – '... required a number of' Which number? A large number of parameters? (If I correctly understand the context)

Response: Thanks for your comment. It is sorry to cause the confusion. The expression 'a number of' means 'numerous'. We have replaced it with 'a large number of' as you suggested.

5. ln 87 – 'the theoretical necessity'. I think that the use of analysis of data should show more the practical necessity, or the expression can just be omitted.

Response: Thanks for your comment. We have replaced 'the theoretical necessity' with 'the practical necessity'.

6. ln 116 – Do they represent the regions in the sense that they are representative? Or are they just example on how an expected diurnal cycle at different latitude should qualitatively be?

Response: Thanks for your comment. The six grid points are randomly selected at different latitude

regions to qualitatively show the global existence of the diurnal cycle.

7. The first time that day of the year (doy) is written, it should be written in the extended form.
Response: Thanks for your comment. We have written the extended form of doy.

8. Figure 2, captions and/or description – It is not very clear what error are represented by the vertical bars. Are they one standard deviation from the average?
Response: Thanks for your comment. The error bars denote the standard deviation from the average. We have added this explanation in the caption of Figure 2.

9. lines 171 - 179 – The fact that the new model is presented before its previous version makes this part not too easy to follow, at first. Maybe a swap between the two sentences, where the features of the older model are presented before the new ones could simplify things.
If I may add a comment, since the previous model has appeared only in (Yao et al.,2013) which is accessible only to chinese readers, a short introduction of this model at the beginning of this section (like the counterpart of formulae 1 and 2) can be useful.
Response: Thanks for your comment. We have added the short introduction of GZTD model at the counterpart of equation 1 and 2. The introductions are 'Our previous GZTD model only accounts for the annual and semi-annual variations of ZTD, whose first equation is similar to equation (1) but without the fourth term (diurnal term) on the right of equation (1).' and' The expansion equation of GZTD model is a 10-order and 10-degree spherical harmonic function which is 8 less order and degree than equation (2).'

10. line 181 – I don't get what this sentece mean, exactly. It is stated that the GZTD horizontal resolution is 18 degrees, but it is not clear if the diurnal variation above 5mm refers to the GZTD model or the expected diurnal variation which the model should usually solve. There are a couple of questions that should be answered, even if shortly, to clarify this part: how the horizontal resolution and ZTD resolution are related and what should be an optimal horizontal accuracy to get the most of the diurnal effects?
Response: Thanks for your comment. It is sorry to cause the confusion. The GZTD model doesn't have the diurnal term. The sentence means that the diurnal variations of real ZTD are very small while the 10 spherical harmonics adopted by GZTD model has a low resolution of about 18 °which should be modified. We have rephrased this sentence as 'The 10 spherical harmonics adopted by GZTD result in a resolution of about 18 °, which are too low for GZTD2 model to reflect the small diurnal variations'. For the same temporal variation parameters to be expanded, the higher order and degree of spherical harmonics would get higher accuracy for expansion. The number of order and degree of spherical harmonics determine the horizontal resolution of model parameters associated with the ZTD estimates, which is the way how the horizontal resolution and ZTD resolution are related. The diurnal effects are quit small and inhomogeneous globally. The low resolution (>15 °) is hard to describe the features. However the higher resolution of model will bring more parameters. To keep the balance between accuracy and the number of parameters, we have chosen the moderate resolution (about 10 °) as the optimal one.

11. ln 214 – I would drop the last 'in theory'.

Response: Thanks for your comment. We have dropped the last ‘in theory’ in this line.

12. ln 265 – I am confused by the term ‘climate change’. Do you mean that the statistics of the previous years that you include to set the parameter of GZTD2 and the other model are not representative of the year that you are using for the test? To me, the fact that the change in the ZTD has a relation with deep moist convection effects, whose specific occurence is impossible to predict using averaged data, and that are much more intense at the tropics, would seem sufficient to explain the increased error near the equator, at least qualitatively(so that they are related more to weather changes than to climate changes). If you are connecting it to climate change please explain better, possibly including some references.
Response: Thanks for your comment. We accepted your opinion that the increased errors near the equator are related more to weather changes than to climate changes. We have replaced ‘climate change’ with ‘weather change’ and rephrased the corresponding explanation as ‘These areas are near the equator where the deep moist convection effects related to the change of ZTD are more intense , so the weather change in these areas are more complex compared with other areas, resulting in difficulty for modelling tropospheric delay.’

12. line 345 and line 368 – ‘... is obviously superior ...’: I think that, even if ‘obviously’ is here clearly intended with the meaning of ‘easily seen’, its more common meaning of ‘of course’ can be a little misleading. I suggest to change it in some way.
Response: Thanks for your comment. For the clarity, we have replaced ‘obviously’ with ‘substantially’.

13. ln 373 - 376 – This phrase needs some adjustment, with more clear logical connections between the part that are now simply separated by commas.
Response: Thanks for your comment. We have rephrased the sentence as ‘In this paper, using the time series data of global tropospheric zenith delays provided by GGOS Atmosphere, we analyzed the diurnal variation in the ZTD which is neglected in the previous GZTD model, then we modified the model function to develop an improved model named GZTD2.’

14. ln 378 – The sentence starting with ‘The testing results ...’ is not very clear. I suggest to simplify and organize the informations better.
Response: Thanks for your comment. We have rephrased the sentence as’ The testing results of GGOS ZTD grid data show that the global average Bias and RMS for GZTD2 model are 0.2 cm and 3.8 cm respectively. The global average Bias is comparable to that of GZTD model, but the global average RMS has been reduced by 0.3 cm. Both the Bias and RMS are far better than EGNOS model and the UNB series models.’

Technical corrections
Response: Thanks for your comment. We have accepted all your suggestions and made the corrections.
1. line 12 – GNSS → global navigation satellite systems (GNSS)
2. ln 20 – RMS → Root Mean Square (RMS)
3. ln 56 – Predication → Prediction

4. ln 72-73 – '... parameters for storage like *the* above grid models ...'
5. ln 79 – girds → grids
6. ln 146 – '..., and is featured ...': 'and' has been removed.
7. ln 162 – 'P nm is ... ' → 'P nm are ... '
8. ln 171 – 'Different from' → 'In contrast with'.
9. ln 215 – 'GZTD model ...' → 'The GZTD model ...'
10. ln 289 – 'followed' → 'follows'.
11. ln 325 – 'The reduce for RMS ...' → 'The reduction of RMS ...'
12. ln 340 – 'the Bias and RMS are lager with height less than 500 m ...' → 'the Bias and RMS are larger for height less than 500 m ...'
13. ln 369 – 'improve' → 'improves'
14. ln 377 – 'testing with ZTD grid data' → 'testing with GGOS ZTD grid data'
15. ln 383 – 'show the Bias ...' → 'show that the Bias'
16. ln 384 – 'that of GZTD' → 'those of GZTD'