

Interactive comment on “Validation and application of optimal ionospheric shell height model for single-site TEC estimation” by Jiaqi Zhao and Chen Zhou

Anonymous Referee #2

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1 General comments

This article presents a novel approach to estimate GPS permanent stations DCBs in a radius less than 2000 km from a mid-latitude IGS station. It is a validation of a technique recently developed by the same authors. An optimum ionospheric shell height is estimated using the assumption that the IGS DCBs represent reliable values. This study covers a complete solar cycle for the estimation of the ionospheric shell height at a reference station and one year for the tests with additional stations. I think that the manuscript in its present form lacks of necessary discussion on the limitations of the assumptions made in this work and that a number of points need to be explained

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deeper. I therefore suggest major revisions.

2 Specific comments

The ionospheric height for the reference station GOLD appear to be very high: in average it is 712 km. By an ionospheric point of view, the shell height should correspond to the height of the ionosphere barycentre, i.e. higher than hmF2 of about 100-150 km. There is a long-lasting debate on the operational shell height to use for the thin shell approximation of the ionosphere and the authors recall many of the publications discussing this problem. While it is true that some authors allow altitudes as high as 1200 km, care should be taken to understand if the obtained shell height are reliable. In this work an elevation mask of 15° has been used. Under many conditions this elevation mask could be too low and introduce a large uncertainty on the optimum shell height (see for instance the discussions of Rama Rao et al. 2006, recall that under some conditions they even obtained unphysical negative shell height).

It is not clear why the technique proposed for ionospheric shell height estimation cannot be implemented to isolated GNSS receivers not belonging to IGS stations (line 107).

A Fourier model of the shell height is constructed for GOLD and PTBB for a complete solar cycle between 2003 and 2013. This model does not include any input regarding solar activity. It is well known that the current solar cycle is considerably less strong than the previous one. The ionosphere development has also been substantially lower. Thus it is also expected the the optimum shell height should follow a different pattern. A discussion on this point is essential for the correct understanding of this work.

line 52: the work of Sardón et al. (1994) was not oriented towards real-time ionospheric VTEC, but to develop a technique of prediction of DCBs under adverse conditions (antispoofing, ionospheric disturbances).

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line 77: specify that the Nava et al. (2007) technique uses multiple stations to obtain a “coinciding pierce point”.

line 125-126: the polynomial model is referred to Lanyi and Roth (1988). However the expression used in this article does not correspond to the one used by those authors.

Line 132: does the regional center of the model correspond to the location of the receiver?

line 134: it is not clear why 9 VTEC models are applied per day. It should be specified that a VTEC model is generated over 3 hours of time.

line 166: I suggest to indicate explicitly that the 40/L corresponds to a period of 100 days.

line 178: why only stations providing P1 code measurements of pseudorange were used? Will the result be significantly different if any station would have been selected regardless of the measured code?

On figure 2 an anomaly appears at the end of 2010, where a gap (or values outside the vertical axis limit ?) appears on the estimated shell heights. In this article there is not a discussion about this strange behaviour, but in the previous article (Zhao and Zhou 2018), figure 3 shows that all stations have simultaneously anomalous DCBs during a few months. I suggest to make a deeper investigation on why this happen, but clearly these DCBs values are not reliable. Some hypotheses: an error in CODE processing chains; an error in the receivers firmware that affect the time estimate; some error at GPS system level. . . The impact to the results of this article concern the Fourier model to represent the whole solar cycle behaviour of the shell height, but should not affect the station comparisons of 2014.

Additional comments on Figure 2: -the spreading of daily shell height values is extremely large (>200 km) with strong variations from one day to the other. How this spreading is affected by the choice of elevation mask angle? -If there is such a high

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variability, what is the benefit of using a Fourier model up to order 40? A much lower order could provide comparable results. On the other hand, the fast variability is not achievable with this model. -both stations show the limits of the proposed approach: the distributions on the right panels present each a missing tail, suggesting that the imposed shell height limits are not adequate. For GOLD station we could expect shell heights higher than 1000 km and for PTBB shell heights lower than 100 km, which are unphysical, because outside the ionosphere.

Figure 4 and 5 top panels show the difference of the DCBs of 2014 in the reference station with the predictions of the Fourier model. However this model has been presented earlier only in term of shell height. It is therefore difficult to understand if it is a good prediction or not. I think a more explicit discussion of the whole validation approach is needed.

3 Technical corrections

line 108: I think “it is intuitional and practical” should read “it is intuitive and practical”

line 191: correct “the receiver type of GOLD have been changed” into “the receiver type of GOLD has been changed”.

line 197: I suggest to indicate in the caption that the stations in black are the reference stations for the study. I would also suggest to include in both maps of figure 1 circles centered on the reference station to indicate the distances, e.g. 300, 600, 900, 1200 km, or whichever choice the authors think is significant.

line 201: I suggest to indicate more explicitly that in the table the column of “Receiver type” includes the date of change of the receivers in the reference stations.

Figure 2 vertical axis label contains a typo: Scarge instead of Scargle

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lines 239-241: the description of figure 4 repeats the concept expressed in the previous sentence. To avoid confusion I suggest to simplify the text writing something like: "The results of this comparison are shown in Figure 4".

line 252: I suggest to rewrite the sentence "Note that some days no result because of missing data", for instance: "Data gap on the figure correspond to days when data from that station are not available".

lines 254-256: I suggest to simplify the sentence to avoid the cumbersome expression "is more concentrated distributed around 0 in a statistical sense".

lines 256-258 the wording "can be improved" at that position in this sentence is not grammatically correct.

line 320: correct "GLOD" into "GOLD".

Many bibliographic records appear to be incomplete, either the title of the article or the volume number, or doi is missing. Doi should be included without the "https://doi.org/" prefix.

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