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Comment on angeo-2021-5

Anonymous Referee #1

Referee comment on "Performance of BDS B1 frequency standard point positioning during the main phase of different classes of geomagnetic storms in China and its surrounding area" by Junchen Xue et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2021-5-RC1, 2021

The paper analyzes the BeiDou B1 frequency standard point positioning in China and its surrounding area during selected magnetic storm events from 2015 to 2018 and they pointed out that positioning accuracy was deteriorated during the storm. The positioning error was larger for stronger magnetic storms. The root mean square error (RMSE) in position for the different magnetic storms in the East, North and Up directions were also presented. This topic has been discussed previously in the literature and the original contribution of this paper is the fact that the data were from Beidou B1 frequency. Some improvements and clarifications need to be done before the paper could be accepted to Annales Geophysicae. Please see the below comments.

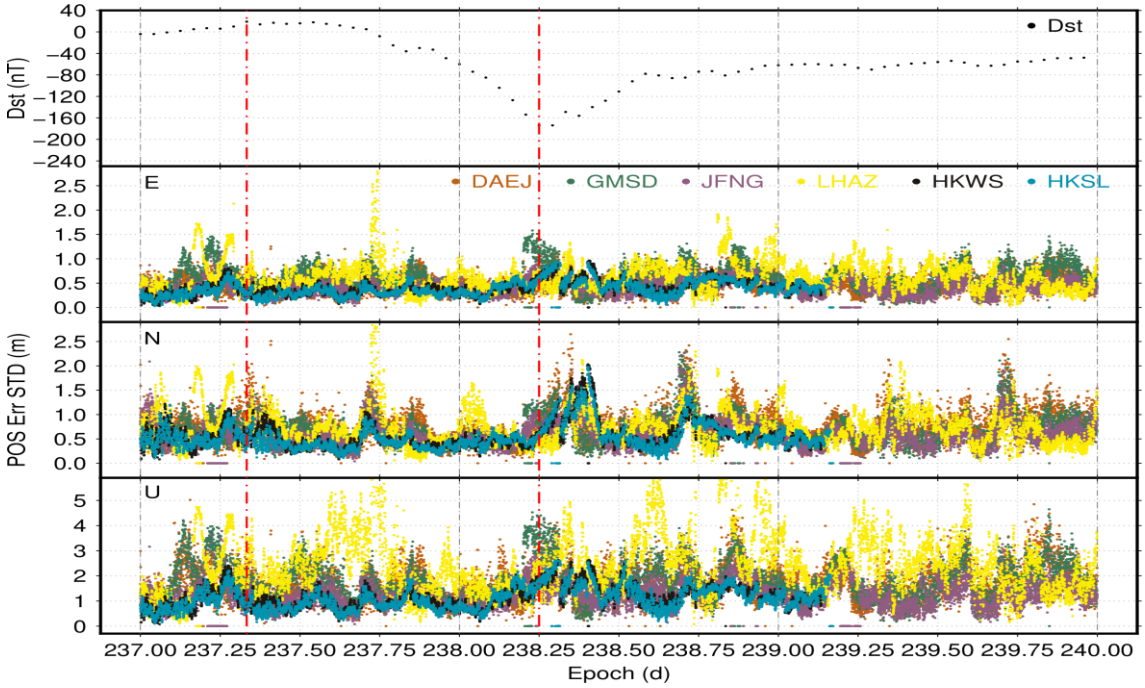
– The authors just analyzed the Bias and the bias RMSE (Figures 1-3 and Tables 4 â‟ 6). They did not provide the precision of the positioning, that come from the Covariance matrix;

- Would be quite important also to show the precision from the adjustment, as well as the quality control of the adjustment;

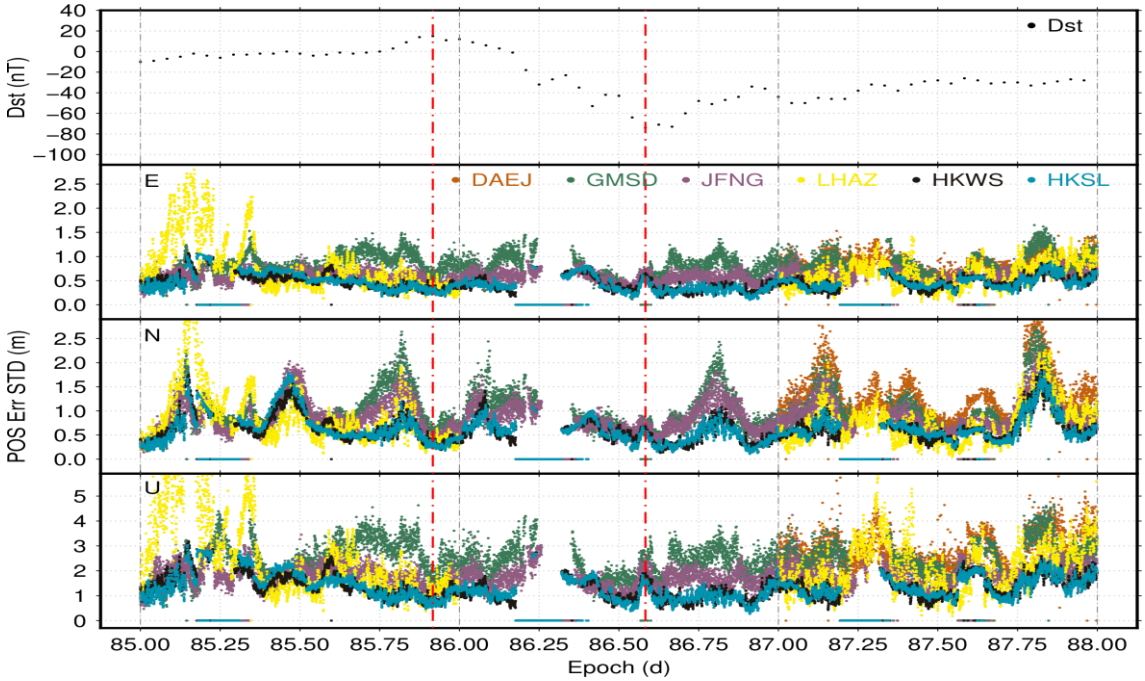
- Why the standard deviation was not shown? The coordinate obtained has an uncertainty, which in some cases may even be greater than discrepancy. In this case, it appears that the uncertainty (standard deviation) was considered to be zero or disregarded. Not being zero, the standard deviation impacts in the coordinate accuracy;

A: As indicated by the reviewer, the standard deviation (STD) is quite important to show the quality control of the adjustment. The STD can be shown but it is only the reference for the application. The comparison of estimations with the true ground coordinates from IGS or ITRF is the final and accurate validation, which provides the actual positioning accuracy. That’s why most of the literature show the external accuracy validation with IGS or ITRF products. The indices for validation are BIAS and RMSE or MAE.

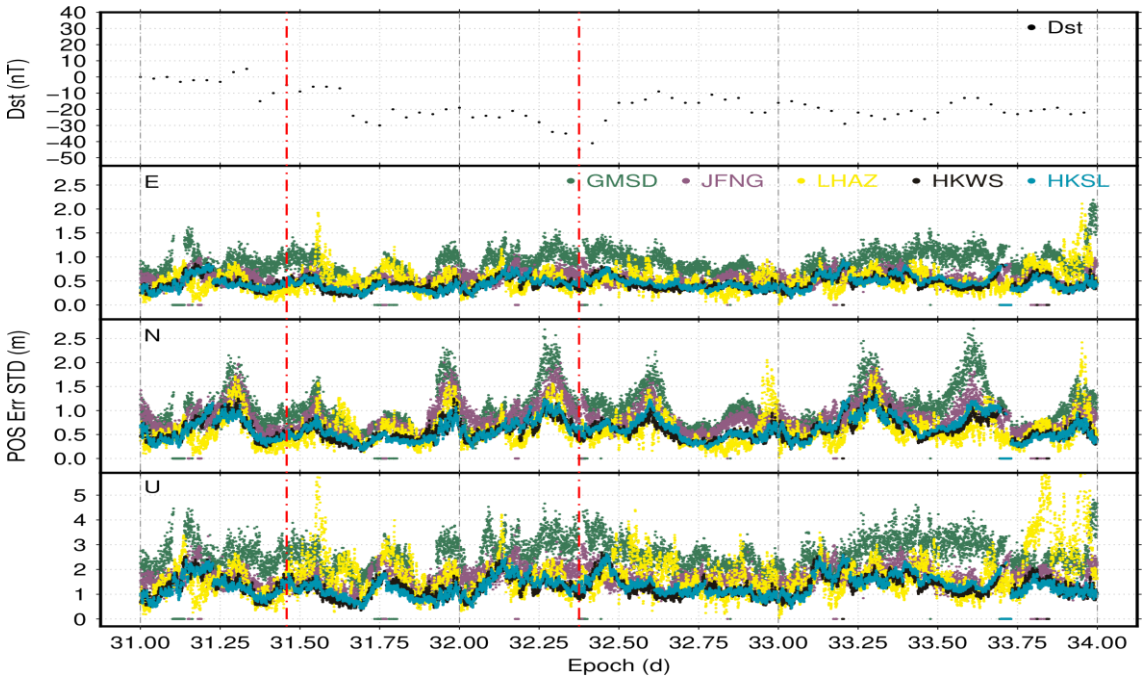
We have computed the standard deviation from the adjustment and exemplified them below. But how to show them in a table is a big issue. It seems that they should not be put together with indices like BIAS, RMSE, etc for the external validation.



Time series of positioning error STDs for BDS B1 frequency during a strong storm around DOY 238, 2018 (X–axis in GPST, Y–axis in meters)



Time series of positioning error STDs for BDS B1 frequency during a moderate storm around DOY 086, 2017 (X–axis in GPST, Y–axis in meters)



Time series of positioning errors STDs for BDS B1 frequency during a weak storm around DOY 032, 2017 (X–axis in GPST, Y–axis in meters)

What is the Klobuchar model contribution to the positioning error since it corrects about 40 to 50% of the ionospheric effect? A discussion or even some quantitative values should be presented in the paper;
A: The mean correction precision of the Klobuchar-style ionospheric navigation model used in BDS is better than 65%. That is better in middle latitudes than in low latitudes. The details can be found in (Wu, Hu et al. 2013)(Wu, X., et al. (2013). "Evaluation of COMPASS ionospheric model in GNSS positioning." Advances in Space Research 51(6): 959-968.). The related discussion has now been inserted in the 'Introduction' part.

- Figure 2: there is no data for LHAZ between day 86 and day 87 during the moderate storm. Mention this fact and explain the reason of this lack of data;
A: This fact was already mentioned in the manuscript. But the reason for the missing data is unavailable as there are no descriptions regarding this in the IGS data centers.

- Figure 4: I would expect it to be explored in the paper;
A: please see lines 110-117 in the modified manuscript.

- Figures 1 to 3: plot in the top the simultaneous DST or even better, if available, the SYM H (instead of Dst) that has a time resolution of 1 minute;
A: The Dst has been appended to the top of each figure.

- Explain in details what could be the ionospheric activity at low latitudes mentioned at line 145 and include the explanation in the paper;
A: As a comparison, there were no big changes in the positioning errors for other stations (GMSD, JFNG) which lie in the higher latitude. So the sentence here is a reasonable guess for the issue. The related sentence has been modified in the manuscript.

- The title should include recovery phase since results from this storm phase are also presented. As a suggestion, even though it is too large (try to shorten it) : âœPerformance of BDS B1 frequency standard point positioning during the main and recovery phases of different classes of geomagnetic storms in China and its surrounding areaâ□□;

A: The main part in this manuscript discusses the statistics of positioning errors during the main phase of the storm. In our opinion, the title of this manuscript should not be changed.

- Are there severe storms according to Astafyeva et al., 2014 classification (Dst>> caused 019 include here the Aarons paper (see reference below) * 104 check if there is Solar Radio Burst (SRB) around 01 LT since SRBs can cause positioning errors

A: There were no severe storms during that time. Please see the Dst values in Table 2. We have checked the SRB events from the NOAA database. There was no SRB event around 01 LT. In addition, if there was a SRB around 01 LT, the stations in the night-side of hemisphere will not be disturbed.

119 What is the effect of different versions of the receiver hardware on the positioning calculations?

A: The noise of observations depends on the version of the receiver hardware. In some challenging situations like ionospheric scintillation, receivers with different hardware versions will experience different effects like on signal tracking.

125 Table 4 â" Table 6 (just missing one space) 131 1 â" 4 m (just missing one space) 138 range of 1 â"3 m (just missing one space)

A: As suggested by the reviewer, the tables have been corrected and updated in the revised manuscript.

148 same of line 104: check the possibility of Solar Radio Burst (SRB) occurrence 163 complicated >>> complex * Aarons J (1991) The role of the ring current in the generation or inhibition of equatorial F-layer irregularities during magnetic storms. Radio Sci 26:1131â"1149

A: The indices events were checked around DOY 2016/330 but no SRB events which can affect the positioning of GNSS signals were found.