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Reply on RC1

Vladimir B. Belakhovsky et al.

Author comment on "Influence of different types of ionospheric disturbances on GPS signals at polar latitudes" by Vladimir B. Belakhovsky et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2020-93-AC1, 2021

We thank to the reviewer for the careful reading of our paper and helpful comments and remarks. Below are our answers to the remarks.

Reviewer:

«It is mentioned in the paper that 150 events have been considered, but there is only data from 5 events used in the paper. This raises doubt about whether the conclusion in the paper is generally valid, or only valid for this set of events. If 150 events have been analyzed, I would expect there to be at least some summary of the results included in the paper. It should include at least some key statistics derived from the analysis of the 150 events…»

Answer:

To describe statistically our research we have added 4 tables and section 3.5 to the paper. These tables include 121 events: 33 cusp/daytime precipitations, 36 substorms, 14 SSC events and 38 PCPs. It is less than 150 events which were mentioned in previous variant of the paper. But the tables already are quite large. We have selected mainly interesting events. Of course we have considered much more event for the 2010-2017 years. But the paper cannot include all of these events. The data from the tables confirms our case studies.

We have decided to remove Figure 8 because now it is too much Figures and Tables. At the same time the dayside PCPs were also observed during another considered event 22 January 2012. The characteristics of the 7 November 2013 event are presented now in the Table 4. We have changed numeration of the Figures.

We also have combined Figures 5 and Figure 6 on same plot to better compare the level of GPS scintillations on Svalbard and in Scandinavia. Now it is Figure 7.

Reviewer:

«There are numerous language issues throughout the paper. While the errors are not critical for the understanding of the paper, it would be significantly improved by careful proof-reading».

Answer:

We have tried to remove the language issues.

Reviewer:

«Lines 84-91: You define the phase scintillation index twice. Fortunately, the definitions are the same. But you may want to delete one of the sentences».

Answer: We have corrected. Now we present only one definition of the phase scintillation index in the paper (Line 92)

Reviewer:

«Line 125: The reference [Belakhovsky et al., 2019] does not match the reference list…»
Answer: We have corrected. Lines 130.

Reviewer:

«Line 147: "Possibly it's due to the field of view of EISCAT radar not coincides with the field of view of GPS receivers." It is clear that the radar and the GNSS observations cannot fully overlap.
But, is it possible to provide any more assessment of the degree of overlap?...

…for the case studies, have you checked which of the satellites (if any) actually passed through the region of the ionosphere that is observed by EISCAT?».
Answer: To show the degree of overlap of GPS satellites and EISCAT 42m radar we have plotted on Figure 4 the ionosphere projections of the GPS satellites, location of EISCAT radar and location of GPS receiver at NYA. Of course for the large scale disturbances (300-500 km and more) which was considered in the paper this overlap is not significant because several ionosphere projection points of GPS satellites (2-4) are always located near field of view of the EISCAT radar. So practically we have continuous measurements of the ionosphere parameters determined by the NYA GPS receiver.

Reviewer:

«Lines 187-188:
"The PCP is also identified in the aurora intensity variations as forms propagating from the polar to low latitudes in 630.0 nm (red line) emission (Figure 7) at 19.00-23.00 UT according to LYR all-sky camera observations."

The keogram seems to show multiple patches, not just one.
Are you using the abbreviation "PCP" to refer to a multitude of patches, instead of just

one patch?... ».

Answer: It is corrected. Now we use abbreviation "PCPs" everywhere in the paper.

Reviewer:

«Lines 191-192: "At latitudes of SKN (TRO) stations the PCP manifests itself as a long lasting substorm (more than 4 hours duration) with the amplitude 200-250 nT."

A patch is not the same as a substorm…»

Answer: Yes, we agree. We rewrote this sentence.

Lines 217:

«During appearance of PCPs near the Svalbard at latitudes of the SKN (TRO) stations a long lasting substorm (more than 4 hours duration) with the amplitude 200-250 nT is observed».

Line 319:

«Comparison of the EISCAT observations on Svalbard and in Tromso shows that during PCPs appearance on Svalbard a typical substorm at lower latitudes (Tromso) was observed. The level of the phase scintillations are quite comparable at high (Tromso) and polar (Svalbard) latitudes».

Reviewer:

«Line 195 (Daytime polar cap patches): For a CIR event, I am interested to know the approximate solar wind properties. In particular, what was the maximum value of the solar wind speed. It is not required to include a plot of the solar wind data, just state the value in the text».

Answer: The solar wind speed for this event was about 390 km/s according to the OMNI database. But we have decided to remove this event as mentioned above due to large numbers of Figures and Tables. The characteristics of the 7 November 2013 event are presented now in the Table 4.

Reviewer:

«Lines 204-205: "cusp precipitation has stronger influence on GPS phase scintillation when it combined with the PCP. Our analyses also confirm this finding." You stated that "PCPes were registered in time interval 06.00-12.00 UT".
…

You have not stated the presence of precipitation at any time interval for this event. To reach your conclusion, did you make assumptions regarding the particle precipitation also

for times when EISCAT did not directly observe precipitation? If so, please state the assumptions clearly in the text».
Answer: Yes, you are right. For the event 7 November 2013 there is no particle precipitation during PCPs appearance. We remove Figure 8 due to large number of Figures and Tables.

We rewrite this sentence (Line 261):

« [Jin et al., 2017] investigated the GPS scintillations around cusp region and found that cusp precipitation has stronger influence on GPS phase scintillation when it combined with the PCPs. Our analyses show that daytime PCPs can produce stronger GPS phase scintillations than cusp/dayside precipitations».

Reviewer:

«Line 217: "module of the interplanetary magnetic field". Do you mean "magnitude of the interplanetary magnetic field"?».

Answer: Yes, we mean magnitude of the interplanetary magnetic field. It is corrected. Line 196.

Reviewer:

«Line 219: Please spell out the abbreviation "SSC" in full at its first occurrence.

Answer: We have indicated (Line 192).

Reviewer:

«Lines 243-244: "Possibly low values of amplitude scintillations at high latitudes are caused by the low elevation angles of GPS satellites at these regions". Please explain how observing at low elevation decreases the amount/magnitude of amplitude scintillation».

Answer: This is only hypothesis. The plasma irregularities producing high-latitudes scintillations mainly formed along the geomagnetic field. At polar latitudes (near Svalbard) the geomagnetic field is close to vertical. So radiowave beam of GPS satellite penetrate through the ionosphere not along geomagnetic field. If we will have satellite with higher inclination angle the amplitude scintillation possibly can be detected. But this hypothesis needs to be tested. Line 290.