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Interactive comment on "High-latitude crochet: solar flare-induced magnetic disturbance independent from low-latitude" *by* Masatoshi Yamauchi et al.

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Thank you for the encouraging comment. We first corrected section numbering (3.1 => 4, 3.2 => 4.1, 4 => 4.2, 4.1 => 4.3, so on).

>The paper presents a new type of the solar flare effect > on the dayside ionospheric current at high latitudes > equatorward of the cusp during quiet periods. Right after > the X9.3 flare on 6 September 2017, magnetic stations > at 68-77° geographic latitudes near local noon detected > northward geomagnetic deviations (ΔB) for more than> > 3 hours, with peak amplitudes >200 nT, without any > accompanying substorm activities.

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Discussion paper

>The paper is interesting and may be accepted for > publication after addressing the minor comments below.

The below is our answer.

>There could be many solar flares of this type. >Then how this particular one produced such a large ionospheric > current lasting over 3 hours and producing peak ΔB >200 nT?

This is the question we still have no solid answer yet. Obvious candidates are "duration of high radiation flux at high-latitudes" that is indicated from good correspondence between the duration of high radiation flux in the ionosphere, which depends on the intensity of flare itself (we examined X-ray flux but it could be different wavelength), the solar zenith angle Z (more precisely, cos(Z)), and background conductivity (as is suggested from substorm-related enhancement).

To make this question clear, we add at the top of "§4.2. Need solid statistics and global perspective (section was miss-marked as §4), something like: "There are many questions to answer on this phenomenon. One obvious question is the condition to occur. When we made a survey using quick plots, we compared only with the X-ray flux (red lines in Figure 6) but solar zenith angles, season, and geomagnetic latitude must also be examined."

To answer this, we at least need to examine all X flares and geomagnetic disturbances at high-latitude (around 70-75° geographic latitudes). So far, we have looked Norwegian geomagnetic plots (to avoid dipole tilt effect from the statistics) for all >X2 class flares since 1996, but could not conclude anything because of too few X flares when we limit season and UT (to remove solar zenith angle effect). One solution to increase the statistics to examine global network data covering different local times, but such a work is time consuming and beyond the scope of the current work (we plan to do this as the next study).

Instead, we looked at AU index for over 70 events (Table 1), and have an impression that the duration of high-latitude crochets have a relative good coincidence with the duration when the X-ray flux is >M3 level. However, this impression is quite difficult to quantify and we therefore chose mention the coincidence only for the 2017-9-6 event.

>Title says 'independent from low-latitudes'. >But the effect is also observed in ASY indices (Figure 2a), > is it consistent with the title?

Yes, it is new because the deviation observed by ASY represents the low- and mid-latitude ionospheric current system (blue color in Figure 3a and westward arrow in figure 4b) which is independent (i.e., opposite flowing direction) from the current system detected at high-latitude (red color in Figure 3a and eastward arrow in figure 4d). We will mention it in the conclusion like "is located at higher latitude than the subsolar crochet (cf., Figs. 4b and 4d)"

>Figures 1-3 are included with the text and other Figures are put > at the end. It would easy if all Figures go with the text.

Unfortunately, Annales Geophysicae's Latex package (to produce the manuscript) could not put these figures in the text, but this technical problem is definitely solved when publishing.

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