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Interactive comment on "D-region impact area of energetic particle precipitation during pulsating aurora" *by* Emma Bland et al.

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We thank the referee for raising important items for further discussion and improvements to the figures. Point-by-point responses to each comment are given in italics below.

1. Figure 3. This bar graph plot is ordered in magnetic longitude. It would be useful to plot the same data in a second panel, but this time ordered in latitude.

   We will add a second panel to Figure 3 with the data sorted by magnetic latitude, and update the manuscript text accordingly.

Printer-friendly version

Discussion paper

2. Figure 7. A similar commment. I would have thought that this plot would best be shown with site latitude on the y-axis, and longitude on the x-axis. As it is the ordering is mostly longitudinal on both axis, apart from DCE, which is an outlier. Thus the plot misses the chance to show a reasonably clear representation of the precipitation region extent, for events centred on Syowa.

   We agree that this figure would be much more useful with the stations ordered in both longitude (x-axis) and latitude (y-axis). We will update the figure in the revised manuscript as shown in the figure below. We have also reversed the order of radars on the horizontal axis to be west to east rather than east to west.

3. Characterising the size of the EEP region during pulsating auroral events is an important step in identifying the contribution of EEP forcing to natural climate variability. However, care should be taken to note that in the event of climate modelling using an actual EEP data stream from a satellite (for example POES) the electron fluxes would be at least partially included [Orsonlini et al., 2018]. Whereas, to properly capture the long-term impact of EEP on natural climate variability, EEP fluxes are typically modelled using geomagnetic indicies [van de Kamp et al., 2016; Matthes et al., 2017] and the statement on Line 249 "we note that there is no obvious correlation between geomagnetic activity and the size of the EEP impact area" clearly empasises that understanding this form of EEP is important in order for it to be propoerly included in EEP models for long-term impact studies.

   We agree that these points deserve greater emphasis in the manuscript. In the introduction and discussion sections, we will clarify that the EEP fluxes are usually described by geomagnetic indices for long-term modelling studies, and that this is unlikely to capture the contribution from pulsating aurora.

   Our observation that the PsA spatial extent does not appear to be correlated with geomagnetic activity (lines 248-249) should indeed be put into the above context of atmospheric modelling. We will add this information on line 249.

4. Once the EEP region size has been estimated it would be useful to contrast it with the characteristics of substorm precipitation studies (rather than pulsating aurora studies) undertaken previously. Using riometers, Berkey et al. [1974] found that the substorm precipitation region covered a corrected geomagnetic latitude range of 60–74°, with only a small dependence upon Kp. This work was expanded by Cresswell-Moorcock et al. [2013] using POES electron precipitation observations, finding that some substorm precipitation events could extend to much higher latitudes.

   We agree that it would be useful to compare our results with studies of the substorm precipitation region, especially since pulsating aurora are commonly observed in the substorm recovery phase. The latitude band reported for substorms by e.g. Berkey et al [1974] and Cresswell-Moorcock et al. [2013] is similar to the latitudinal coverage of pulsating aurora, except that PsA tend to remain further equatorward until the morning MLT sector. Cresswell-Moorcock et al. [2013] reported that the $>$30 MeV electron fluxes at L$>$15 in the morning sector are enhanced 1-2 hours after the substorm onset time, which is likely to correspond to the substorm recovery phase when pulsating aurora are commonly observed. Therefore, some of the very high latitude EEP fluxes in their study are probably related to pulsating aurora. The latitude extent of these morning sector substorm-related EEP fluxes matches well with our observations of HF attenuation at magnetic latitudes as high as 75-77° in connection with PsA at Syowa Station. The manuscript will be updated to include this information in the discussion section.

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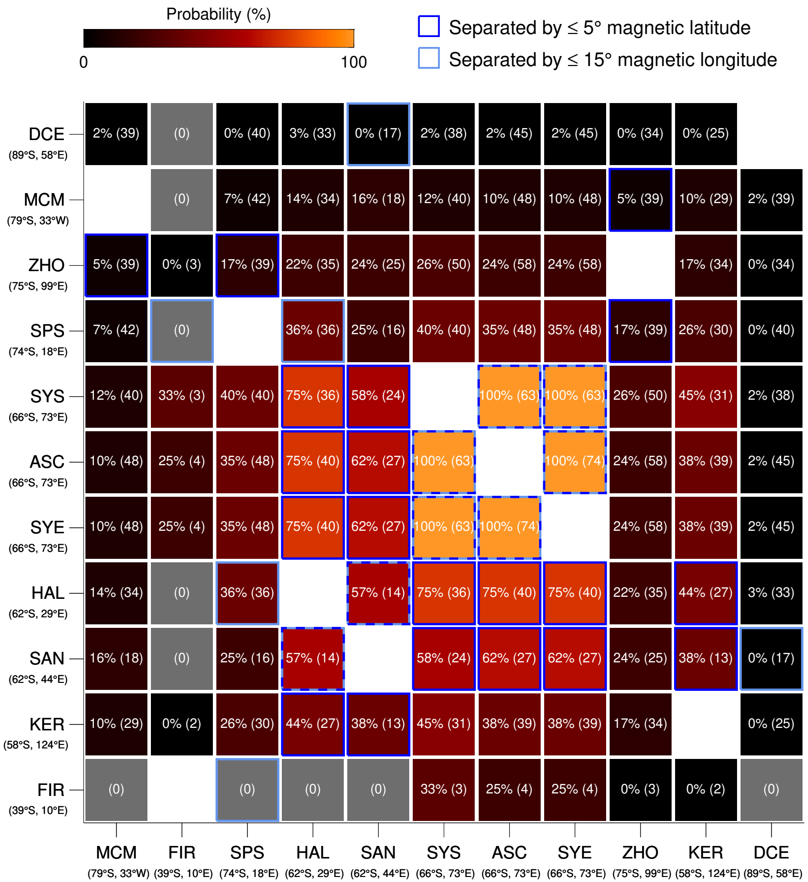
Probability (%)
0
100
Separated by ≤ 5° magnetic latitude
Separated by ≤ 15° magnetic longitude
DCE (89°S, 58°E)
MCM (79°S, 33°W)
ZHO (75°S, 99°E)
SPS (74°S, 18°E)
SYS (66°S, 73°E)
ASC (66°S, 73°E)
SYE (66°S, 73°E)
HAL (62°S, 29°E)
SAN (62°S, 44°E)
KER (58°S, 124°E)
FIR (39°S, 10°E)
MCM (79°S, 33°W) FIR (39°S, 10°E) SPS (74°S, 18°E) HAL (62°S, 29°E) SAN (62°S, 44°E) SYS (66°S, 73°E) ASC (66°S, 73°E) SYE (66°S, 73°E) ZHO (75°S, 99°E) KER (58°S, 124°E) DCE (89°S, 58°E)
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Fig. 1.