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Supporting Information for

A Ground-Up Data-Driven Approach to Distinguishing Magnetospheric Sources of Geomagnetically Induced Currents > 10 A during the 17 March 2013 Event

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**Introduction**

The Supporting Information includes figures of the SuperDARN Line-of-Sight velocity keogram (Figure S1) at Hankasalmi, DMSP SSUSI emission maps (Figure S2), and MetOps Satellite particle precipitation data from the Medium Energy Proton and Electron Detector (MEPED) instrument (Figure S3). Movie S1 shows an animation of SuperMAG global maps between15-19 UT. Five of the timestamps are shown in Figure 5 in the main manuscript.

The MetOps data panel was generated using <https://cdaweb.gsfc.nasa.gov/>. Further information about the description of the algorithms and procedures used to

transform the output from the MEPED telescopes on the POES/MetOp satellites into higher level data products such as differential particle flux can be found here - <https://www.ngdc.noaa.gov/stp/satellite/poes/docs/NGDC/MEPED%20telescope%20processing%20ATBD_V1.pdf> .

A screen shot of a graph

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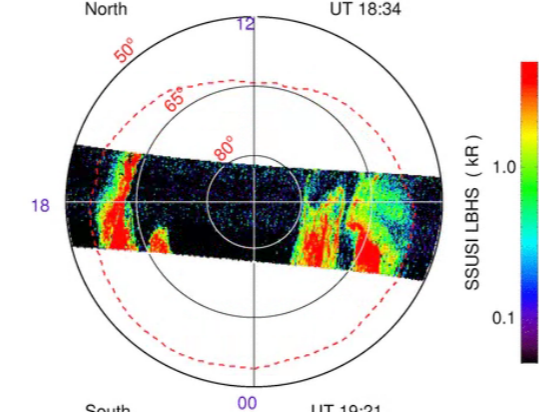
Figure S1. Spatio-temporal evolution of SuperDARN LoS velocity at Hankasalmi. Typically, E region echoes are observed at short ranges of 300–700 km (radar range gates 2–10) while F region echoes are observed at far ranges of 700–1,500 km (range gates of 10–30). A SuperDARN range gate typically extends 45 km in distance from the radar, or in range, and the distance to the start of the first range gate is typically 180 km. (Milan et al., 1997).

**Key takeaway:** We can see mostly E-region activity, identified by short-range echoes, at G1 (around 16 UT) and E and F region activity, identified by mid-range echoes between 18-19 UT.

A close-up of a radar

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Figure S2. DMSP SSUSI plots showing emission maps corresponding to the peak time instance of GIC spikes. The duskside auroral oval shows precipitation across a large area at 16:01 UT in the southern hemisphere whereas a split in the auroral precipitation is seen at G2 and G3.

Key takeaway: Broad latitudinal range (55-75 MLAT) of particle precipitation in the dusk sector.

We acknowledge Johns Hopkins University Applied Physics Laboratory for Defense Meteorological Satellite Program data.

A screenshot of a graph

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**Figure S3.** **MetOps2 Satellite particle precipitation data.** From top to bottom: First panel: Electron flux at 40,130, 287, 612 keV energy channels from 0-degree telescope. Second panel: Same as first, but from 90-degree telescope. Third panel: Proton flux at 39, 115, 332, 1105, 2723 keV energy channels from 0-degree telescope. Fourth panel: Same as third but from 90-degree telescope. Fifth and sixth panel: Magnetic latitude and local time respectively. Orange dashed lines show the location of MAN (57 MLAT and 18 MLT around16 UT). The pink outlined box shows the 20-minute period over which the 10 A GIC spike rises and falls. Black dotted line at 16:04 UT shows onset of sudden increase in electron flux in both telescopes.

**Key takeaway:** Figure S3 shows a sudden increase in electron flux at 16:04 UT which is consistent with the time at which SuperMAG vectors rotate poleward forming upward FAC. The increase in precipitating electron flux is consistent with upward FAC poleward / north of MAN.

We acknowledge the NOAA National Geophysical Data Center and the Space Weather Prediction Center and NASA CDAWeb for making these data available.

Movie S1. SuperMAG movie from 15-19 UT.

The SuperMAG movie shows the spatial evolution of the electrojet patterns over time. The orientation is as follows – top: noon, left: dusk, bottom: night, right: dawn.

Key Takeaway: The dynamic changes in the patterns over Mäntsälä (57 MLAT moving from dusk towards midnight). Strong eastward electrojet followed by deflection in north-south direction can be seen between 15:50-16:15 UT. Three clear vortex structures appear to form and dissipate between 18-19 UT.