Latitudinal distribution of the Sub-Auroral Polarization Streams observed by the SuperDARN Hokkaido Pair of (HOP) radars

SuperDARN 北海道-陸別第一・第二レーダーで観測されたSAPSの緯度特性

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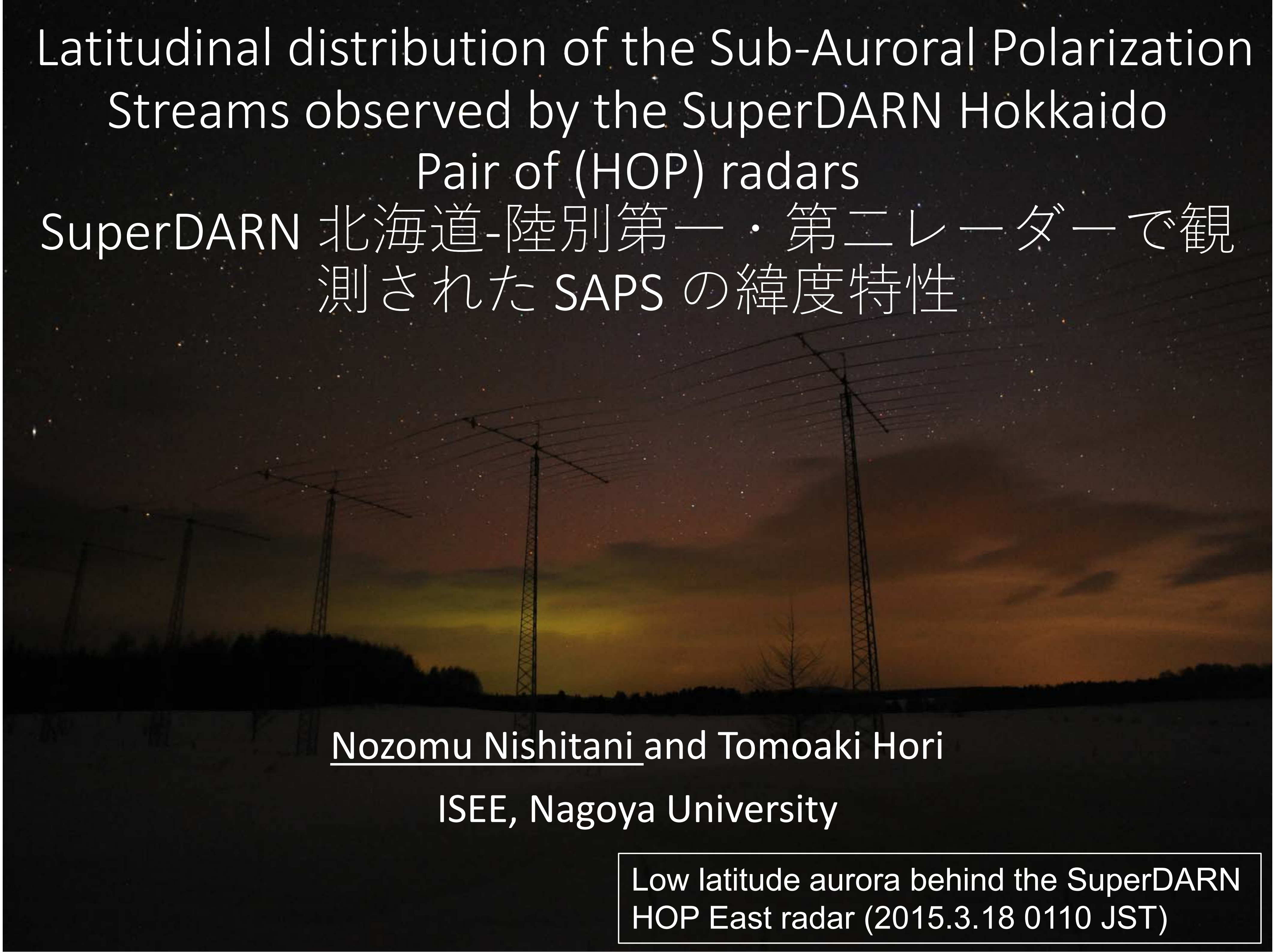


Low latitude aurora behind the SuperDARN HOP East radar (2015.3.18 0110 JST)

SAPS (Sub-Auroral Polarization Stream) and SAID (Sub-Auroral Ion Drift)

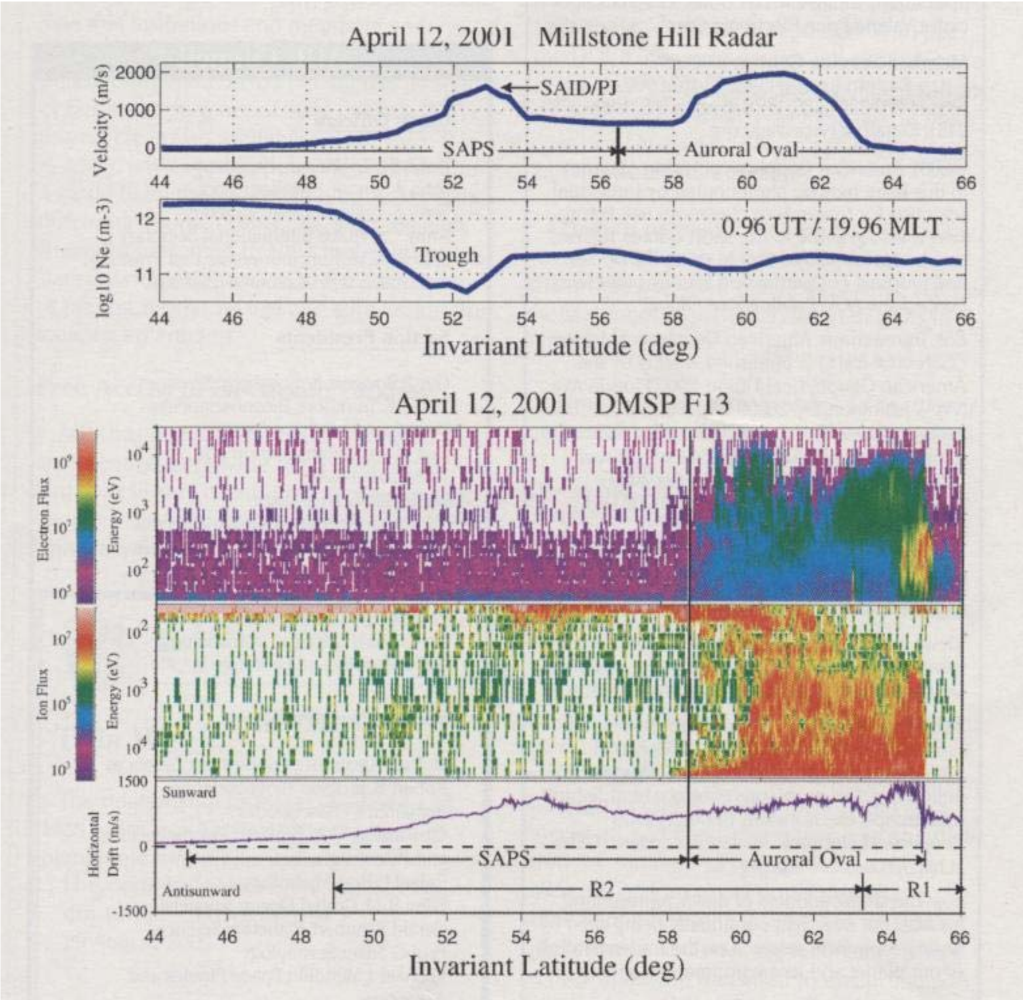
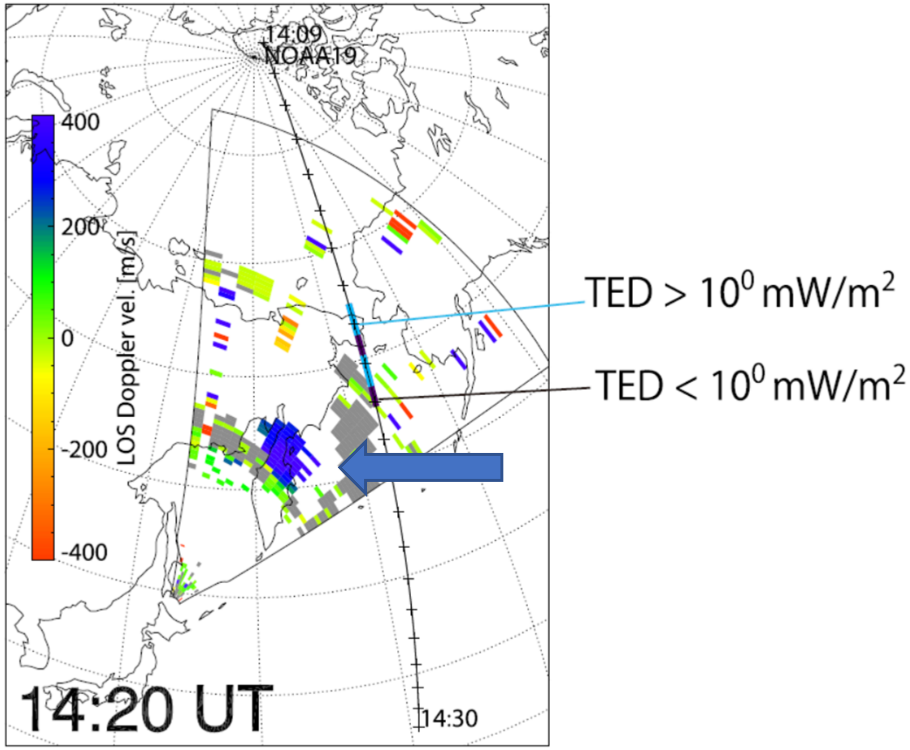


Fig. 1. Simultaneous radar and in situ measurements of auroral and SAPS plasma characteristics were acquired during a dusk overflight of the Millstone Hill incoherent scatter radar by the DMSP F13 satellite near 01:00 UT on 12 April 2001. The SAPS is seen as a broad region of sunward plasma convection centered at 53°Λ.

(Foster and Burke, EOS, 2002)

- SAPS: very fast westward flow located equatorward of the auroral oval, broadly distributed in latitude ranging from afternoon to postmidnight sectors



(Nagano et al., EPS, 2015)

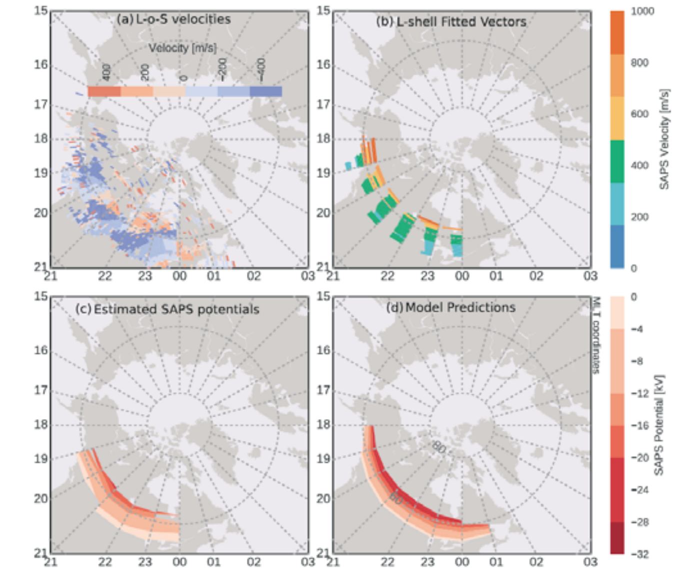
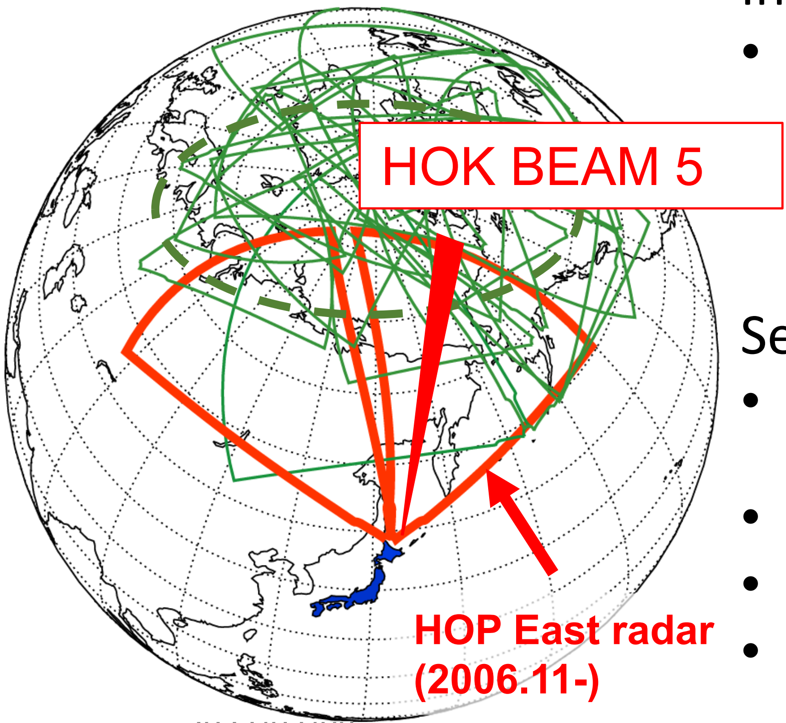


Figure 14. Model data comparison for a SAPS event observed by the midlatitude SuperDARN radars, on 2 February 2015. Panels (a) and (b) present actual line-of-sight velocities and L-shell fitted vectors from a SAPS channel, observed by the U.S. midlatitude SuperDARN radars, respectively. Panel (c) presents SAPS potentials derived from actual observations, and panel (d) presents SAPS potentials predicted by the model. SuperDARN = Super Dual Auroral Radar Network; SAPS = subauroral polarization streams; MLT = magnetic local time.



Distribution of SAPS

Previous studies

- Kunduri et al. (2018) used North American SuperDARN radars – their FOV is limited to >~ 52 MLAT
- Erickson et al. (2011) used Millstone Hill IS radar – their results also show only the points poleward of ~52 MLAT
- Kataoka et al. (2009, AG) used SuperDARN Hokkaido East radar – there was limited data accumulation (only about 2 years)

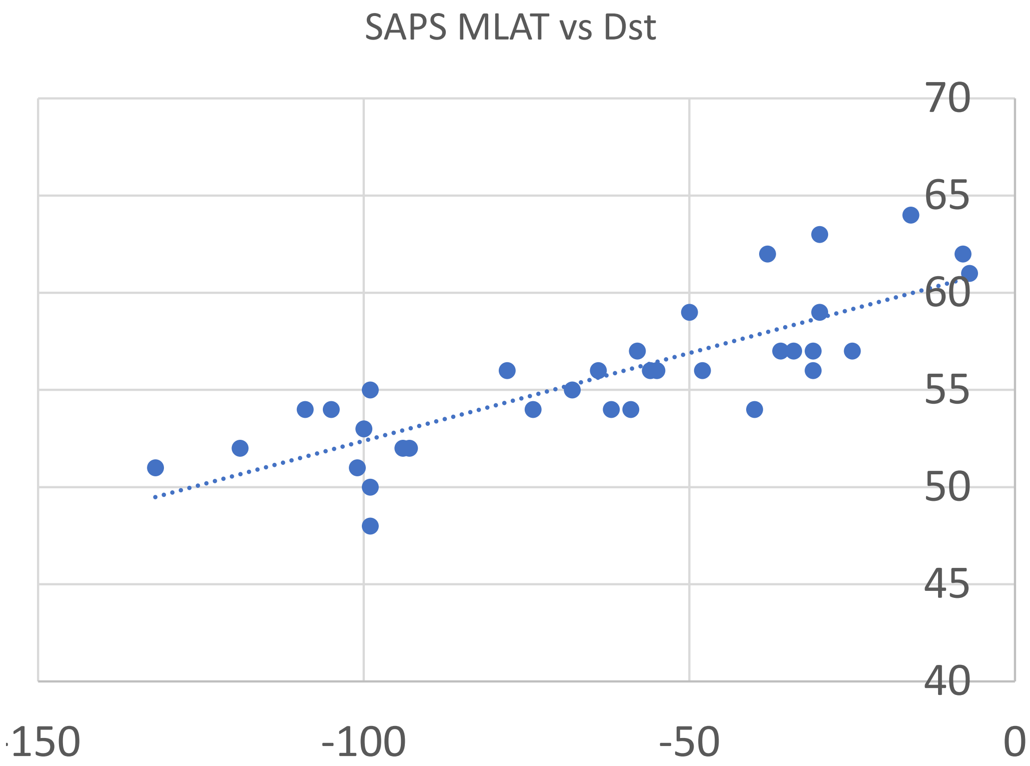
In this study,

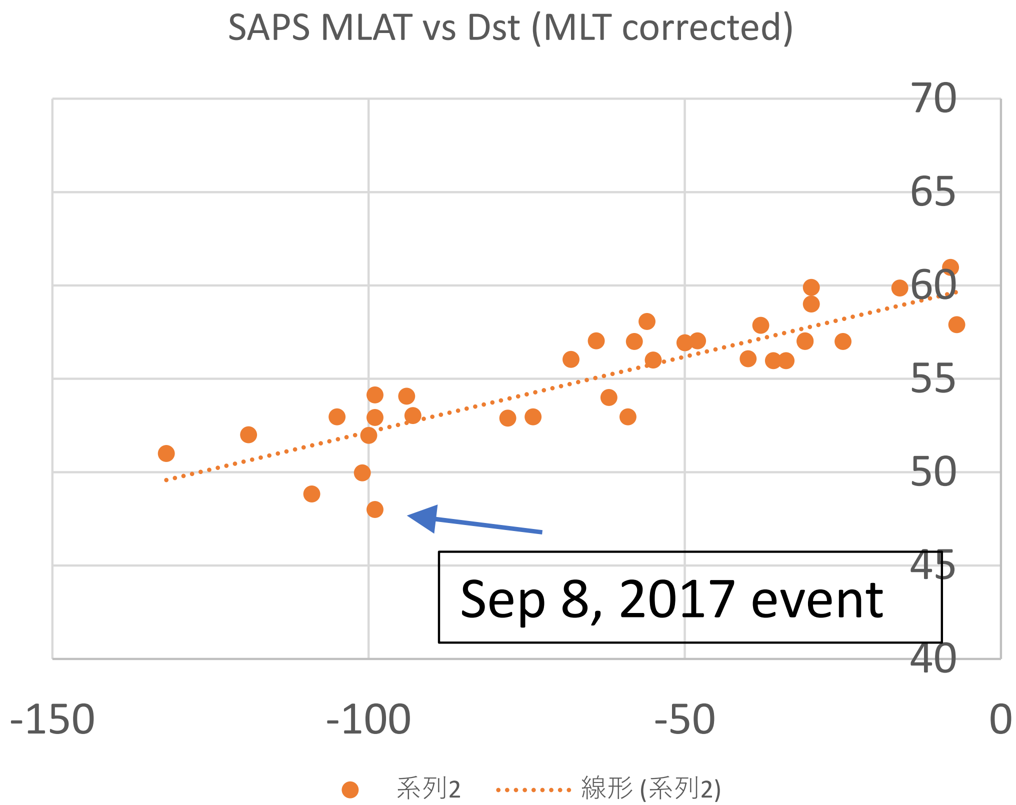
- We use SuperDARN Hokkaido East radar database for 11 years, covering the region poleward of ~40 MLAT, to investigate the statistical characteristics of the SAPS geomagnetic latitude distribution

Selection of SAPS events for 2012-2022

- Located equatorward of 65 deg MLAT, Beam 5 LOS > 300 m/s
- Duration > 1 hour
- Total 34 events found
- MLAT: lowest value of the equatorward edge

HOK SAPS MLAT vs MLS (left: original, right: MLT corrected)

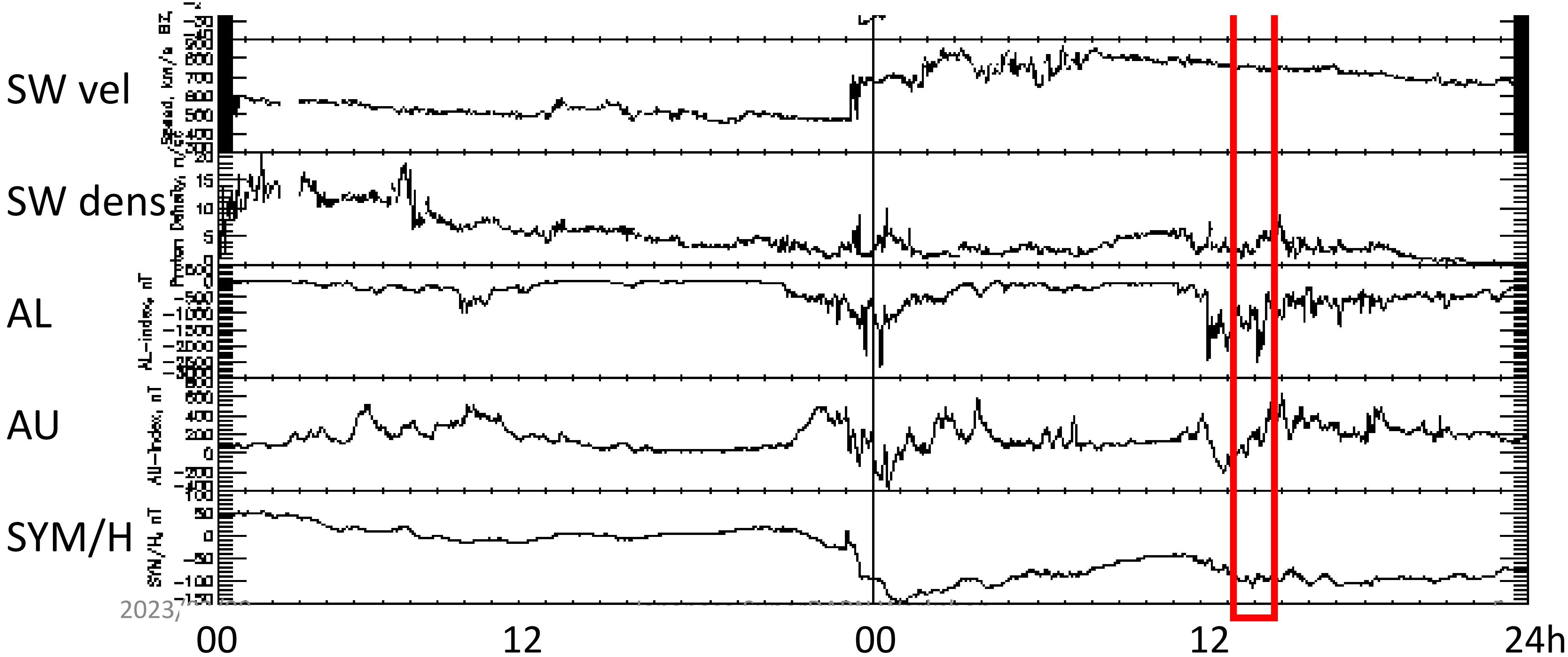




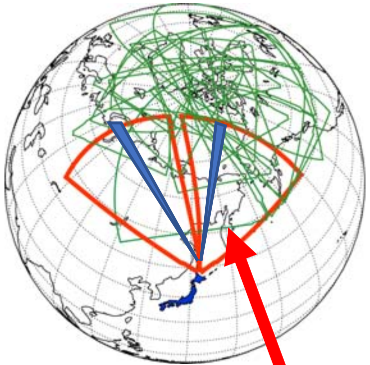
Sep 08, 2017: solar wind / geomagnetic activity (@OMNIWeb)

Period of interest: around 14 UT on Sep 08 , 2017

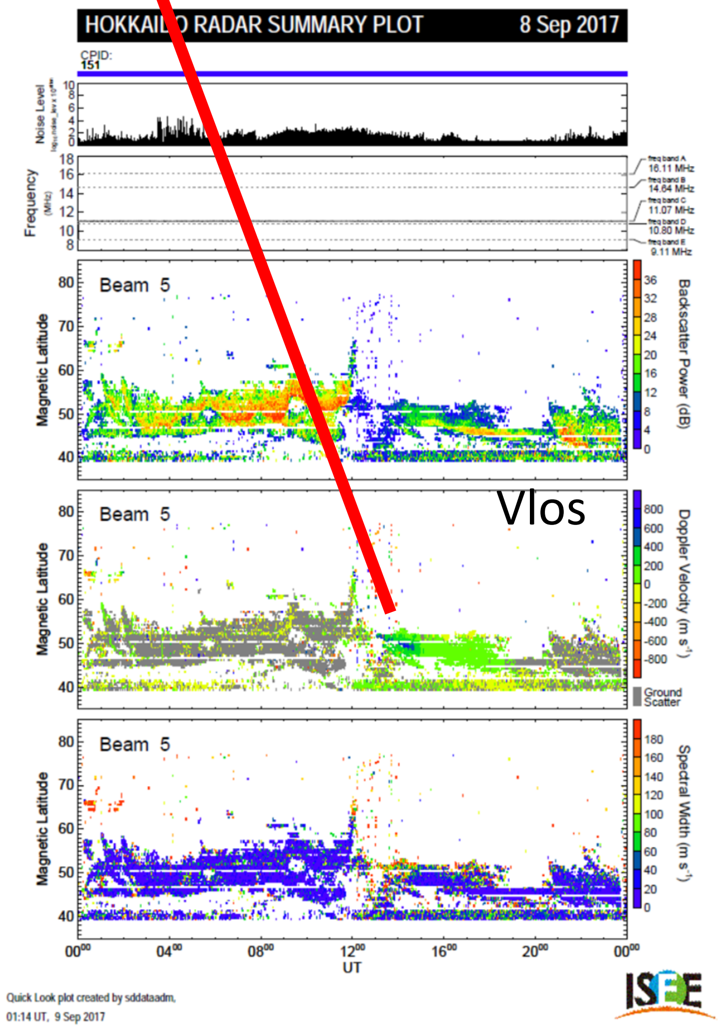
- Main phase of weak geomagnetic storm, preceded by a bigger one (at ~ 0 UT)
- IMF was strongly southward (less than -10 nT)
- AL/AU were very active (min. AL ~ -2000 nT)



2017/09/08 Hokkaido East quicklook plot and SD convection map movie



SAPS extended up to 48 MLAT at about 14 UT



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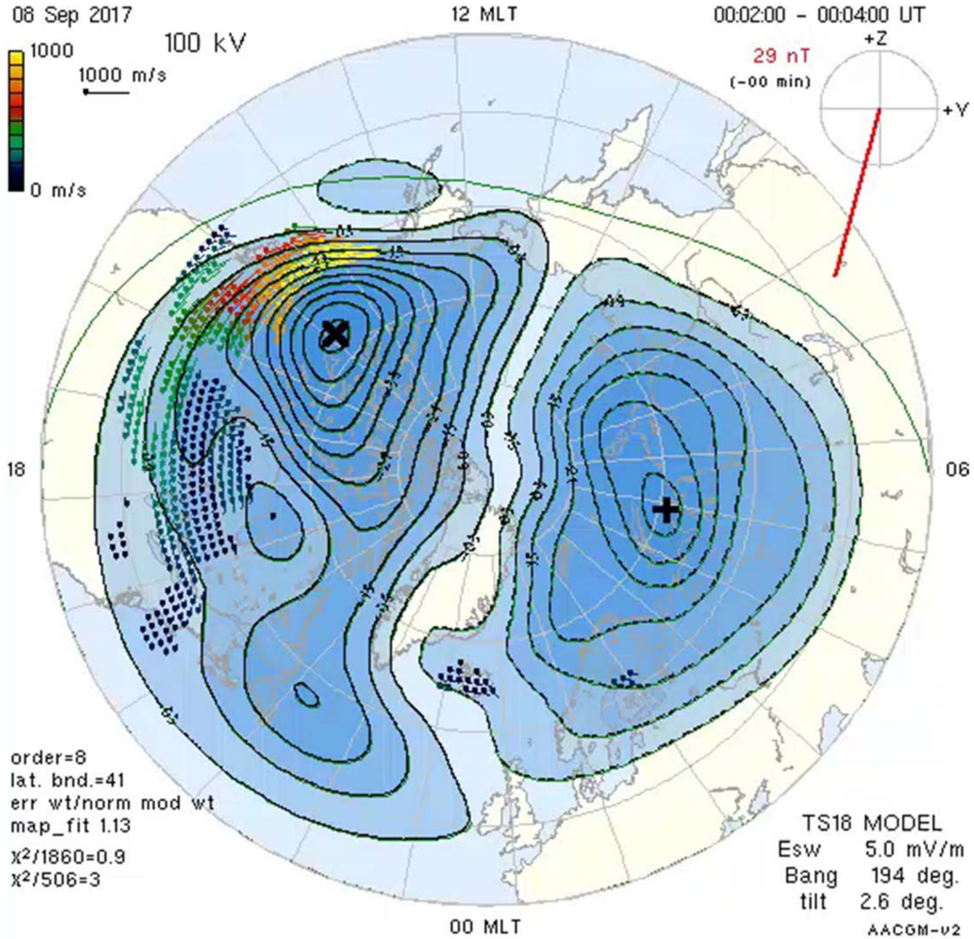

Obana et al. (2019, SW) discussed the unusual erosion of the plasmasphere during the September 2017 storm, and compared the Arase data with the numerical modeling and SuperDARN observations

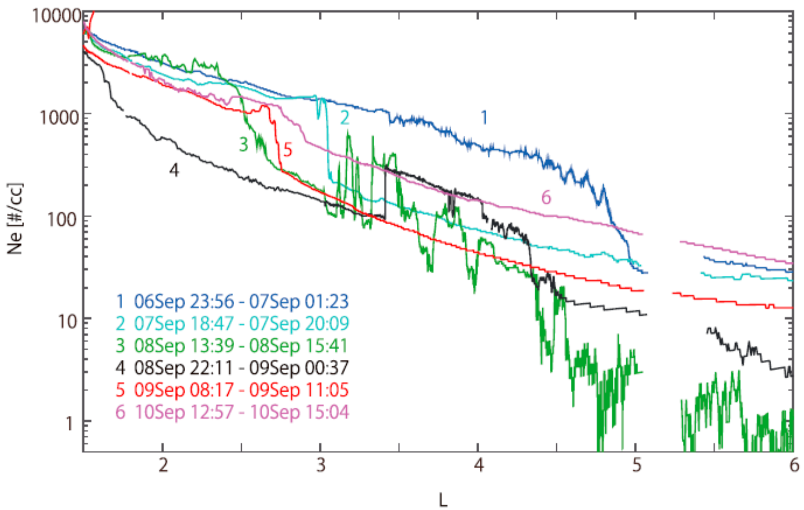

Figure 3. Arase observations of cold electron density profiles as a function of McIlwain's L parameter. The exact times of each observation are shown in the figure. All observations are from outbound orbits. Blue: quiet time plasmasphere before the storm, being spread to $L = 4.8$–5.0. Cyan: initial erosion of the outer plasmasphere at $L = 3.0$–5.0 and the plasmapause steepening at $L = 3.0$ as the storm progresses. Green: the plasmapause pushed further equatorward at $L = 2.5$ during the first cross polar cap potential drop enhancement. Black: the most severely eroded plasmasphere with the plasmapause being pushed even further at $L = 1.6$–1.7 immediately after the second recovery phase. Red: partial recovery of the severely eroded plasmasphere at 9 hr after the density profile #4 (black).

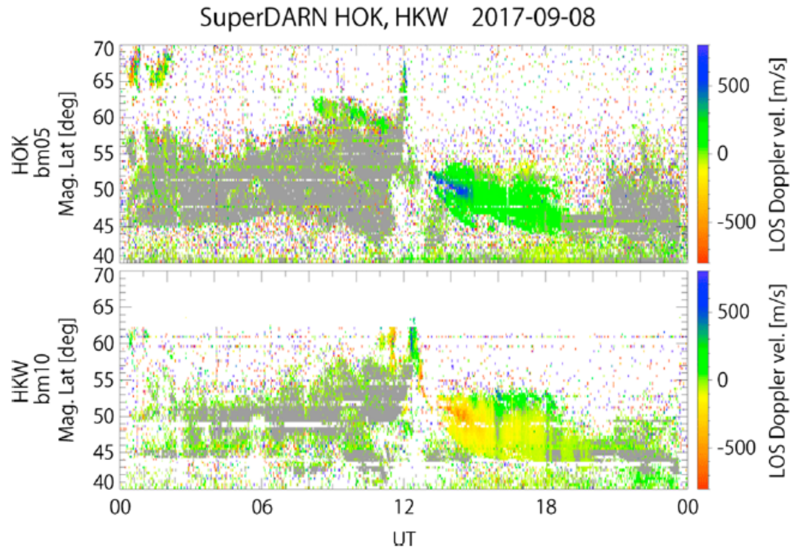

Figure 8. The range-time-intensity plots of the line-of-sight Doppler velocities (positive toward radars) obtained by the Super Dual Auroral Radar Network (SuperDARN) Hokkaido East (top, beam 5) and West (bottom, beam 10) radars on 8 September 2017. Strong positive (negative) velocity regions can be identified between 1300 and 1500 UT around 50° magnetic latitude. Beam 5 of the east radar and beam 10 of the west radar roughly direct the magnetic northeast and the magnetic northwest, respectively; thus, the strong velocity can be interpreted as a strong westward flow. The usual velocity flow with the same direction continued until 2000 UT at 44–53° magnetic latitude. Thus, we confirm that the enhanced northward electric field penetrated to <50° magnetic latitude, a much lower latitude than usual, even if we consider relatively high negative D_{st} values.

They proposed that this unusual plasmasphere erosion was due to the deep penetration of the electric field, although its cause is still unknown.

Discussions and conclusions

- SuperDARN Hokkaido Pair of radars (East and West) are powerful tools for investigating the spatial temporal variation of the SAPS type flows.
- 11-year statistical analysis (including 34 events observed by the SuperDARN Hokkaido East radar) shows that the SAPS geomagnetic latitude is generally highly correlated with the MLT and Dst index.
- One of the few exceptions is the 2017 Sep 08 event, where the SAPS type flows observed by the HOP radars were located a few degrees equatorward of the statistical location.
- The above unusual characteristics could be due to:
  - ➢ Abrupt southward turning of the IMF, which cause the sudden intensification of the ring current (Dst index) leading to the equatorward expansion of the SAPS structure.
  - ➢ A previous storm event (that occurred 12 hours before), which possibly set up a pre-conditioning for the unusual equatorward expansion of the SAPS flow region.
  - ➢ At 2022 Fall AGU Meeting, Larry Lyons commented that a substorm might play a crucial role, where the auroral streamer structure push the SAPS structure further equatorward. It is necessary to check the substorm activity during the event.
- More detailed study is necessary.