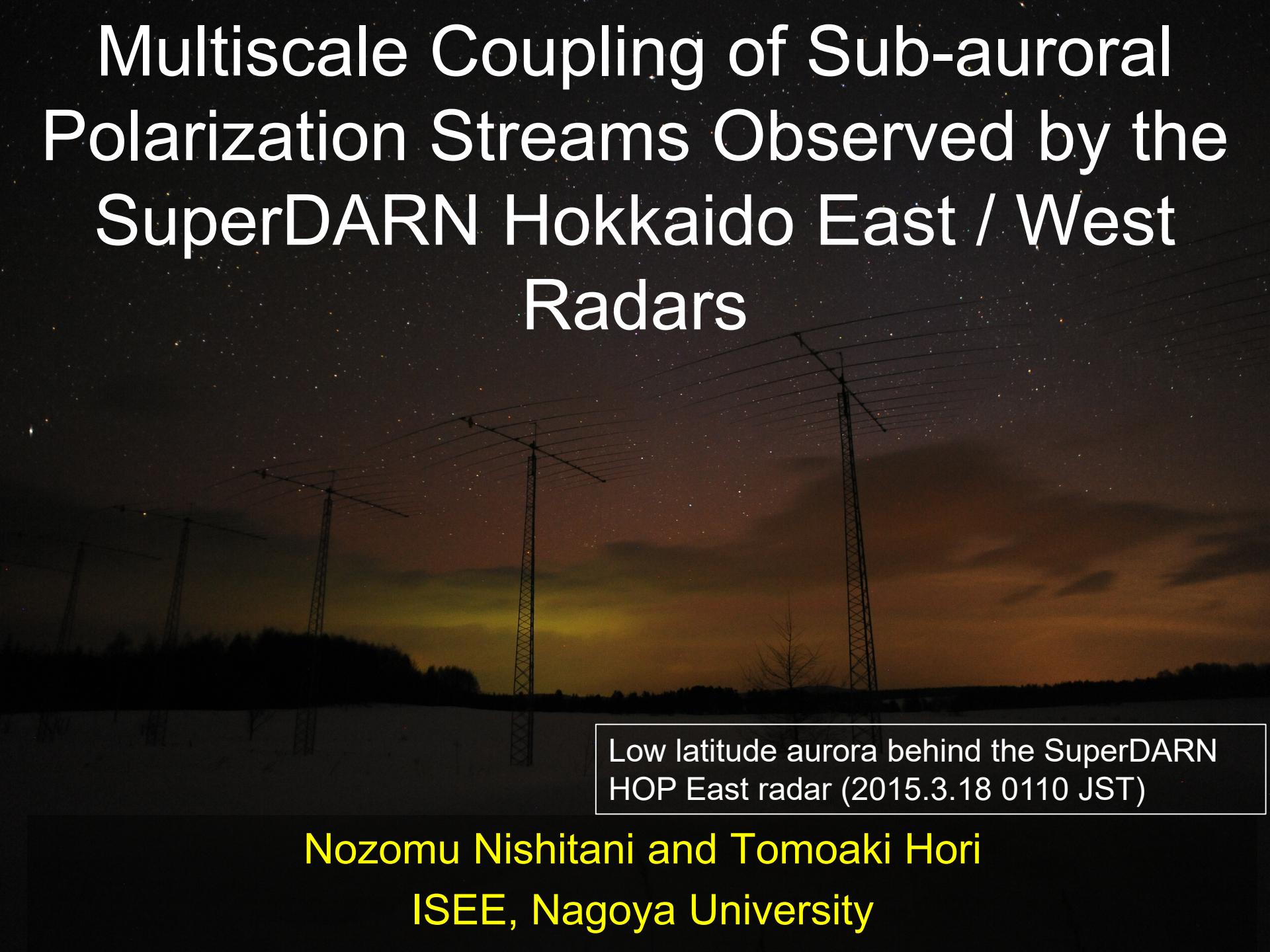
Multiscale Coupling of Sub-auroral Polarization Streams Observed by the SuperDARN Hokkaido East / West Radars



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

Nozomu Nishitani and Tomoaki Hori

ISEE, Nagoya University

Contents of the talk

- Overview of SAPS/SAID oscillating structure
- Medium (~5 min) period SAPS/SAID oscillation
  - 2018/08/26 event (HOP East)
- Long (~10 min) and short (~1 min) period SAPS/SAID oscillation
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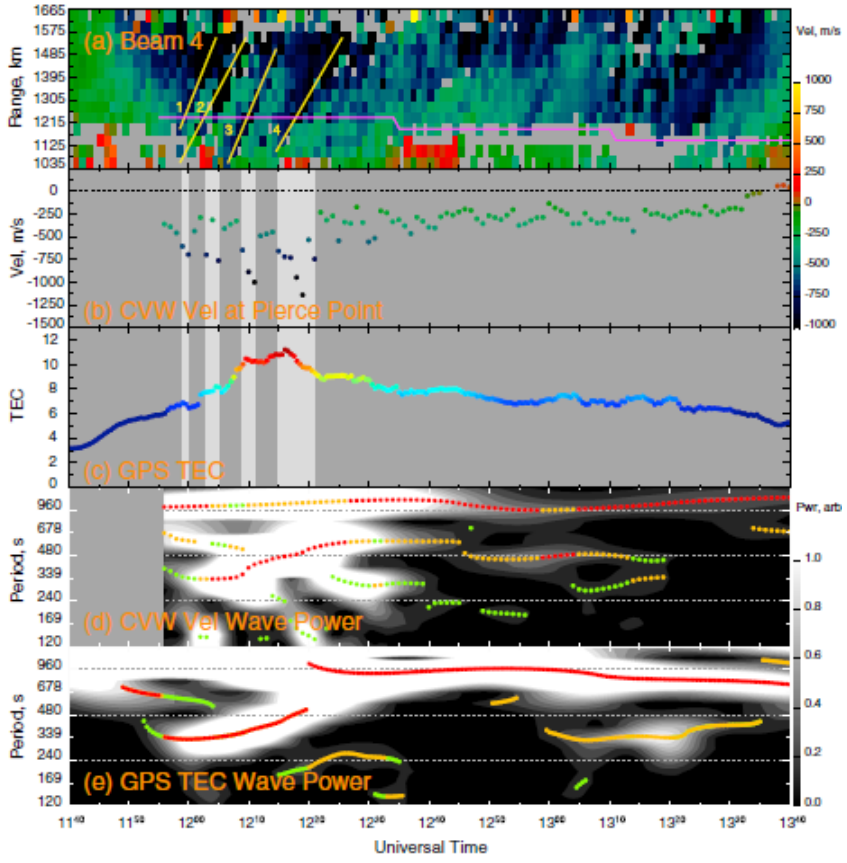
- Summary

Makarevich and Bristow (2014): mid-latitude SuperDARN observation of Sub-Auroral Polarization Streams (SAPS) wavy structure



- SAPS are fast westward flows in the afternoon to postmidnight subauroral ionosphere, presumably generated as a result of both magnetospheric E-field mapping and ionospheric feedback mechanism.
- They discussed the characteristics of wavy structure (with 5-10 mins) signature together with GPS TEC variations.
- Reported on the relationship between TEC and flow velocities demonstrating the importance of ionospheric feedback process.
- Similar event was studied using the 2D multiple SuperDARN data and Arase satellite by Hori et al. (GRL, 2018).

See also the recently published mid-latitude SuperDARN review paper by Nishitani et al. (PEPS, 2019).

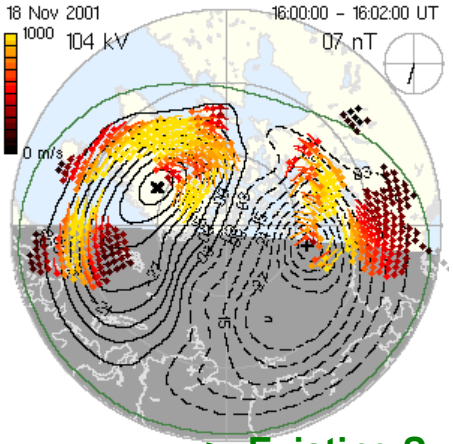
Possible parameters for determining SAPS intensity

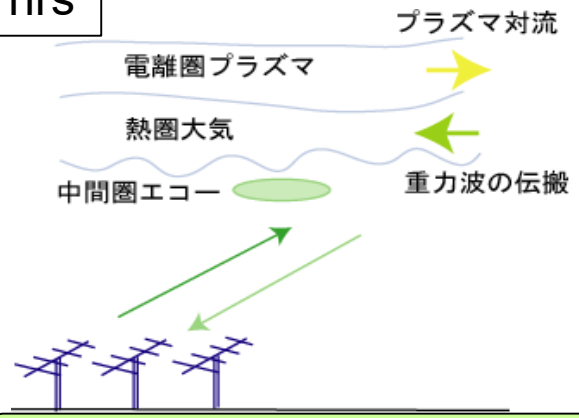
- Ionospheric origin
  - Ionospheric conductivity due to
    - Solar radiation (EUV etc.)
    - Energetic particle precipitation
- Magnetospheric origin
  - IMF effect
  - Substorm / storm effects (particle injection, ring current)
- Remaining Questions:

1. What is the relationship between the SAPS / global convection and the IMF changes / substorms?
2. What is the 2-dimensional distribution of SAPS perturbations?
3. What is the relationship between the perturbations in the SAPS structure with different temporal scales?

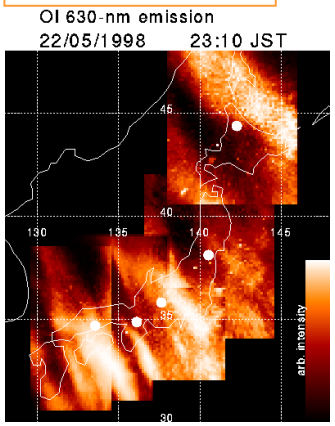
SuperDARN Hokkaido Pair of (HOP) radars (2006.11-)

MLT ~ UT + 9 hrs





Airglow imagers



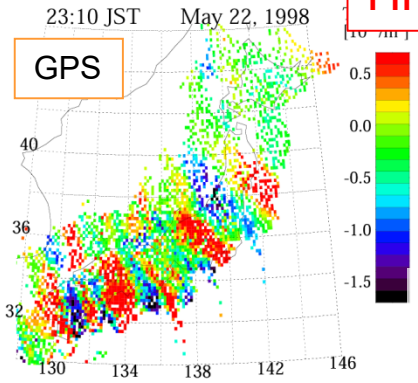
Existing SuperDARN network

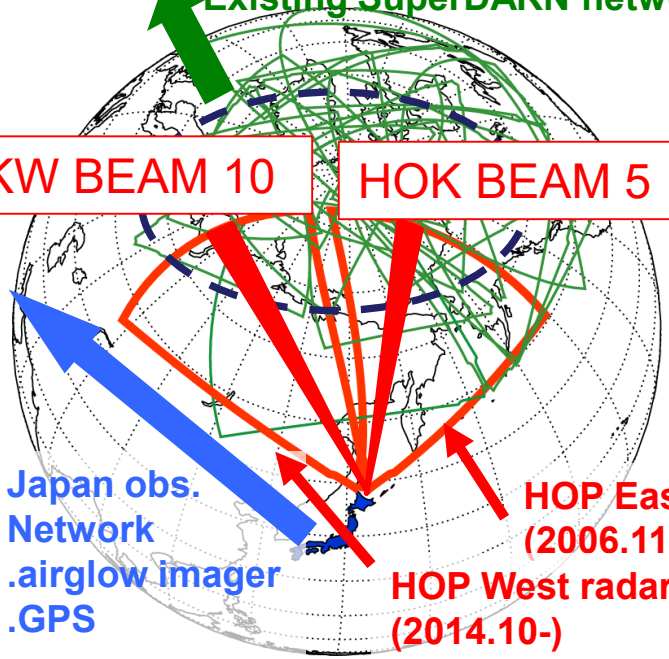
Study of ionosphere, thermosphere and upper mesosphere

HKW BEAM 10

HOK BEAM 5

GPS





Japan obs. Network
.airglow imager
.GPS

HOP East radar (2006.11-)

HOP West radar (2014.10-)

Unified understanding of the dynamics of the high- to mid-latitude upper atmosphere

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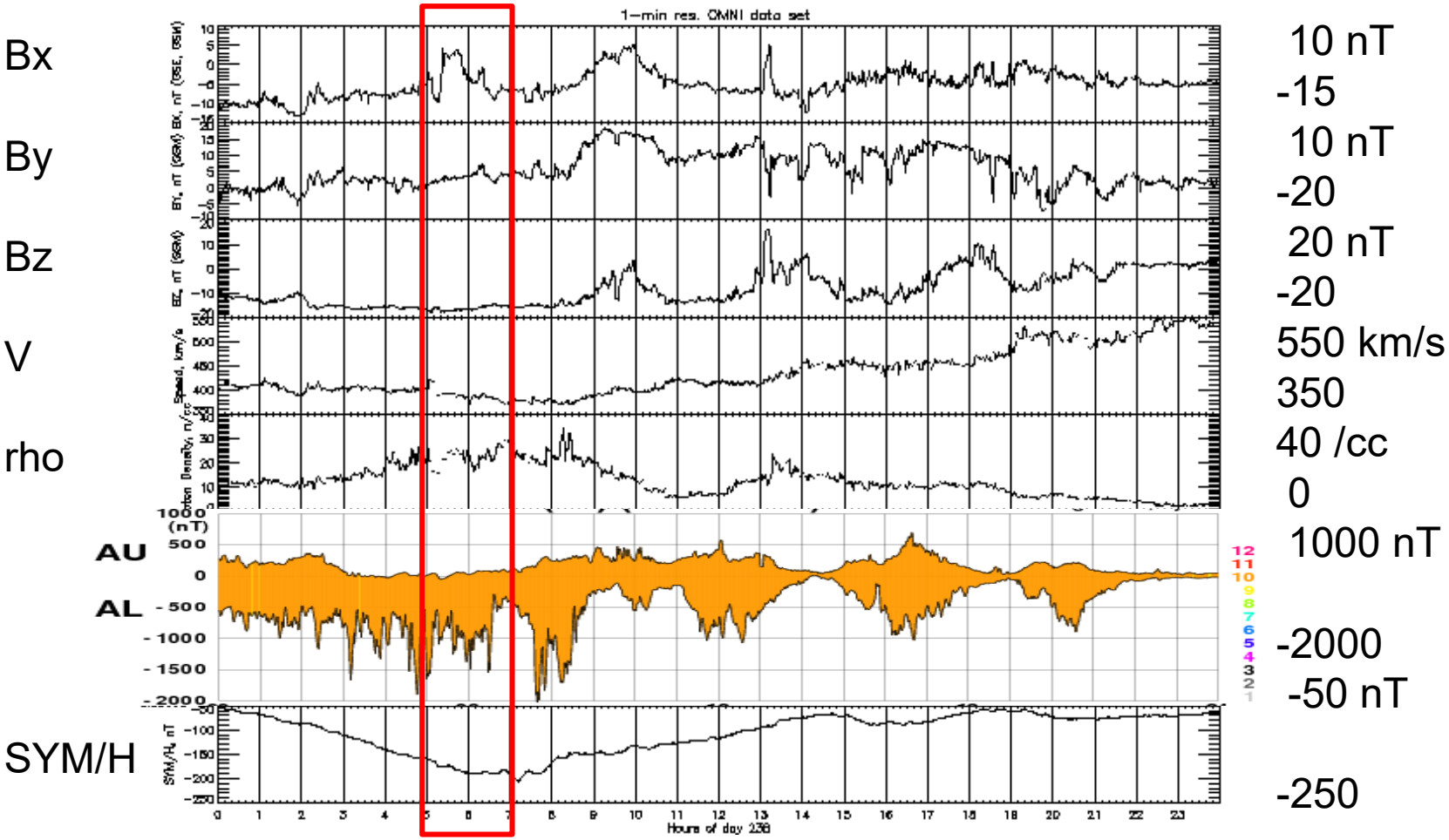
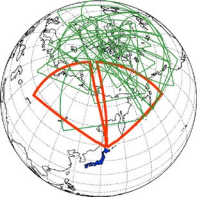
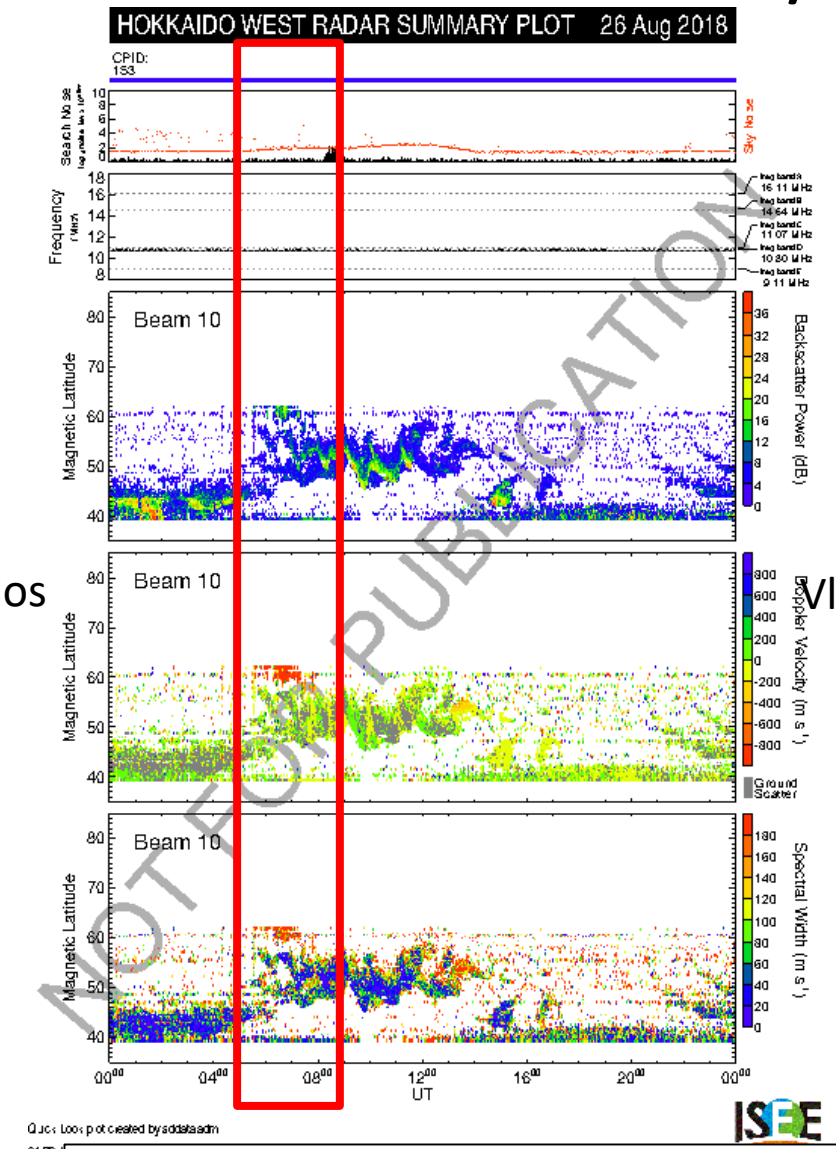
IMF / solar wind / geomagnetic activity on 26 Aug 2018 (0-24 UT)



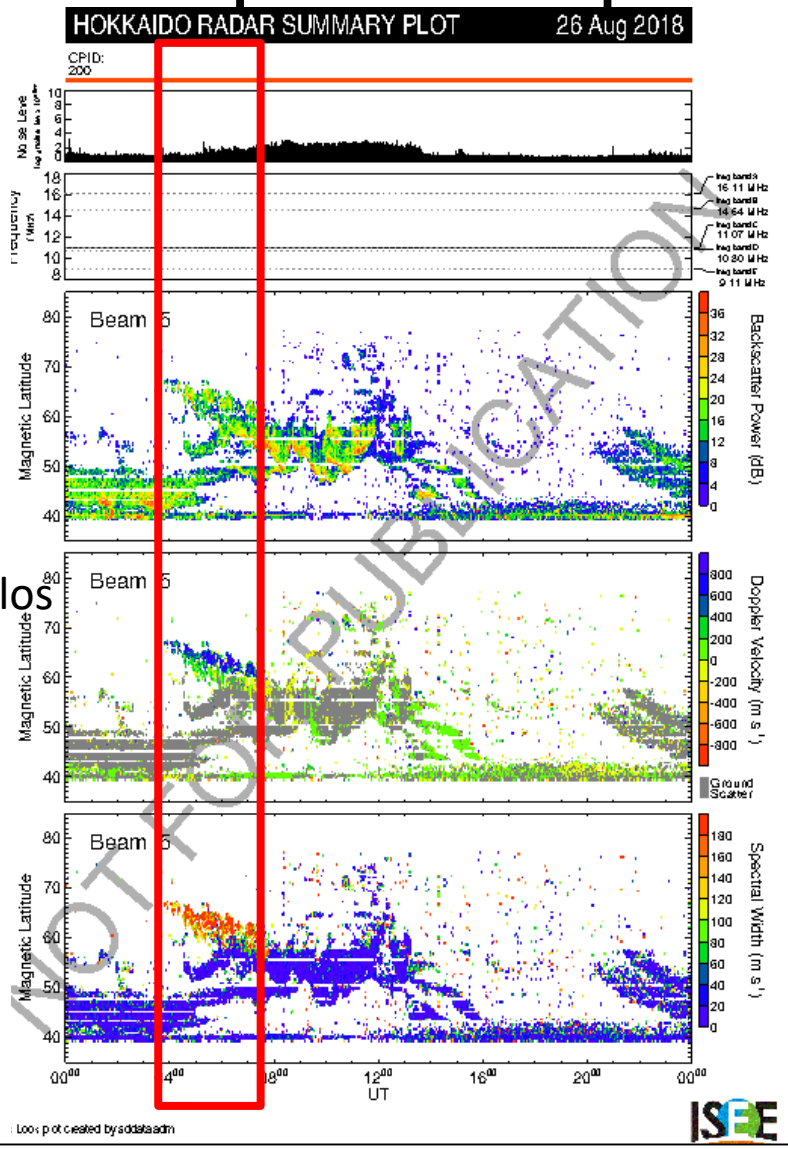


August 26, 2018 0-24 UT (09 – 09 LT)
Hokkaido West / East quicklook plots

Vlos

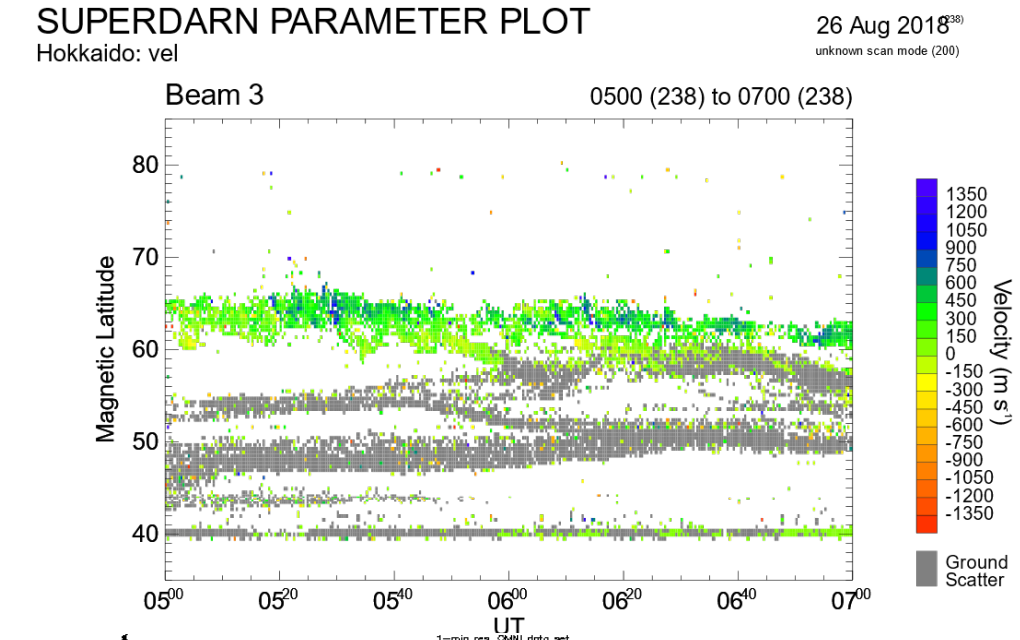


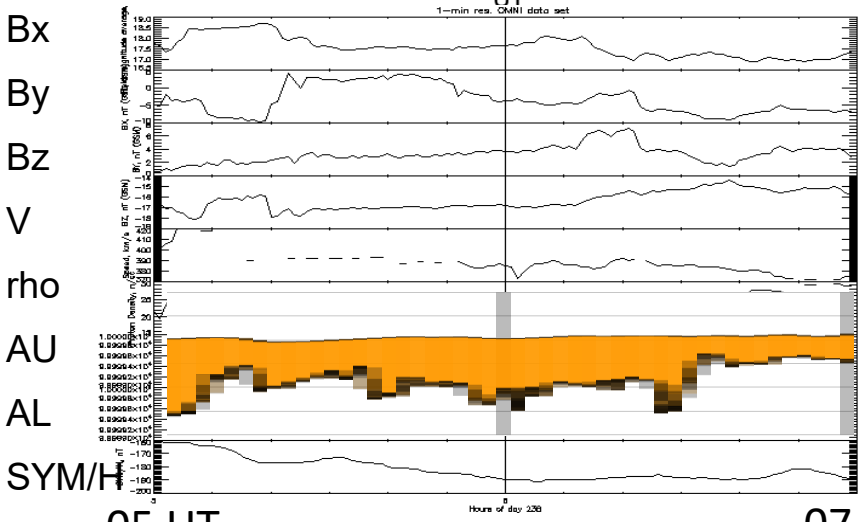
Vlos



SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

2018/08/26 event characteristics





05 UT

07 UT

MLT ~ UT + 9 hrs

- SAPS observed by both Hokkaido East / West radars
- Flow speed > 1000 m/s
- Perturbation with a few to ten min periodicity was observed (left figure, similar to Foster et al., 2004 and Hori et al., GRL, 2018)
- Hokkaido West observed SAPS but no perturbation (spatially localized?)
- There is no corresponding signature in the IMF/SW although SW density is highly variable.

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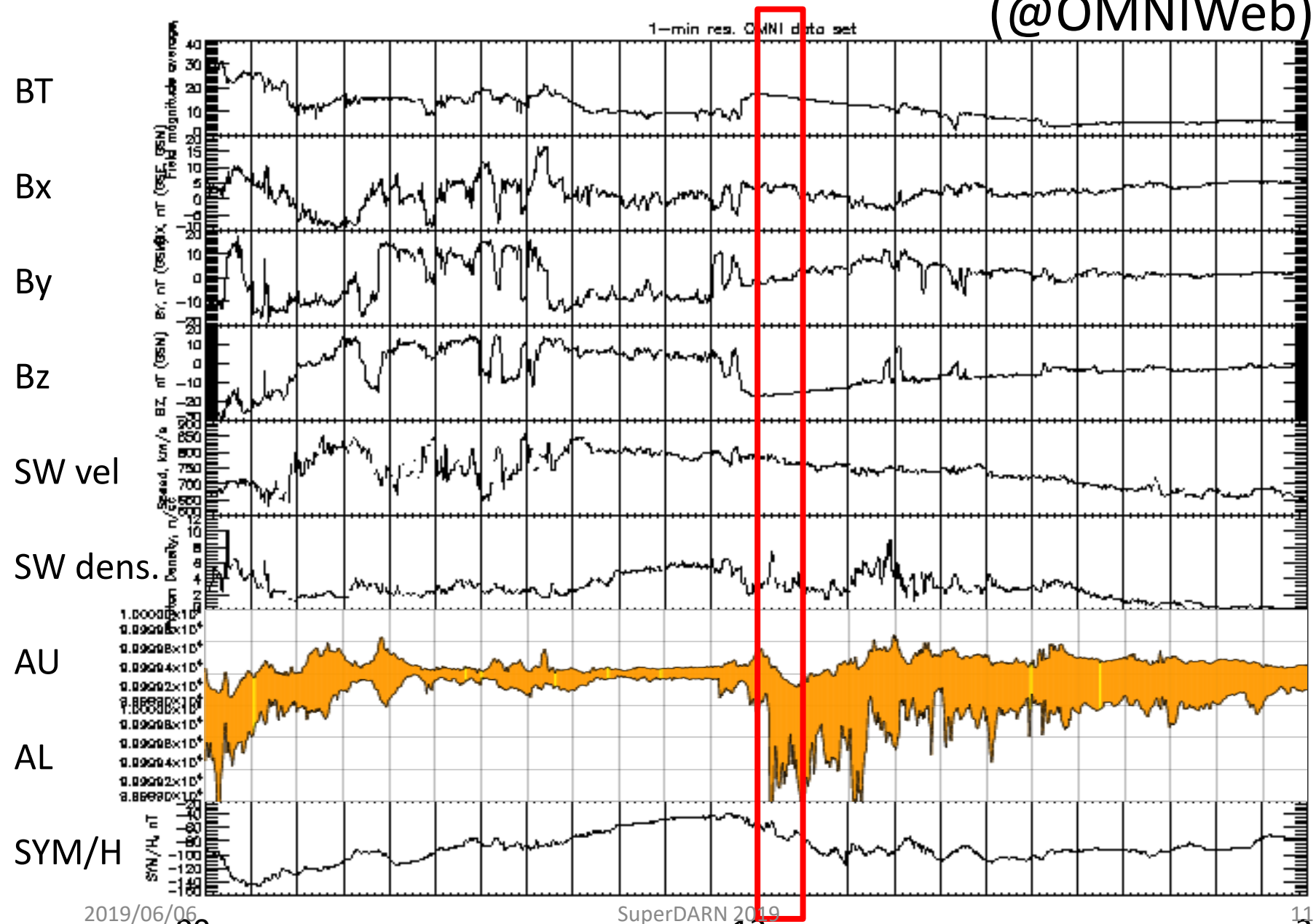
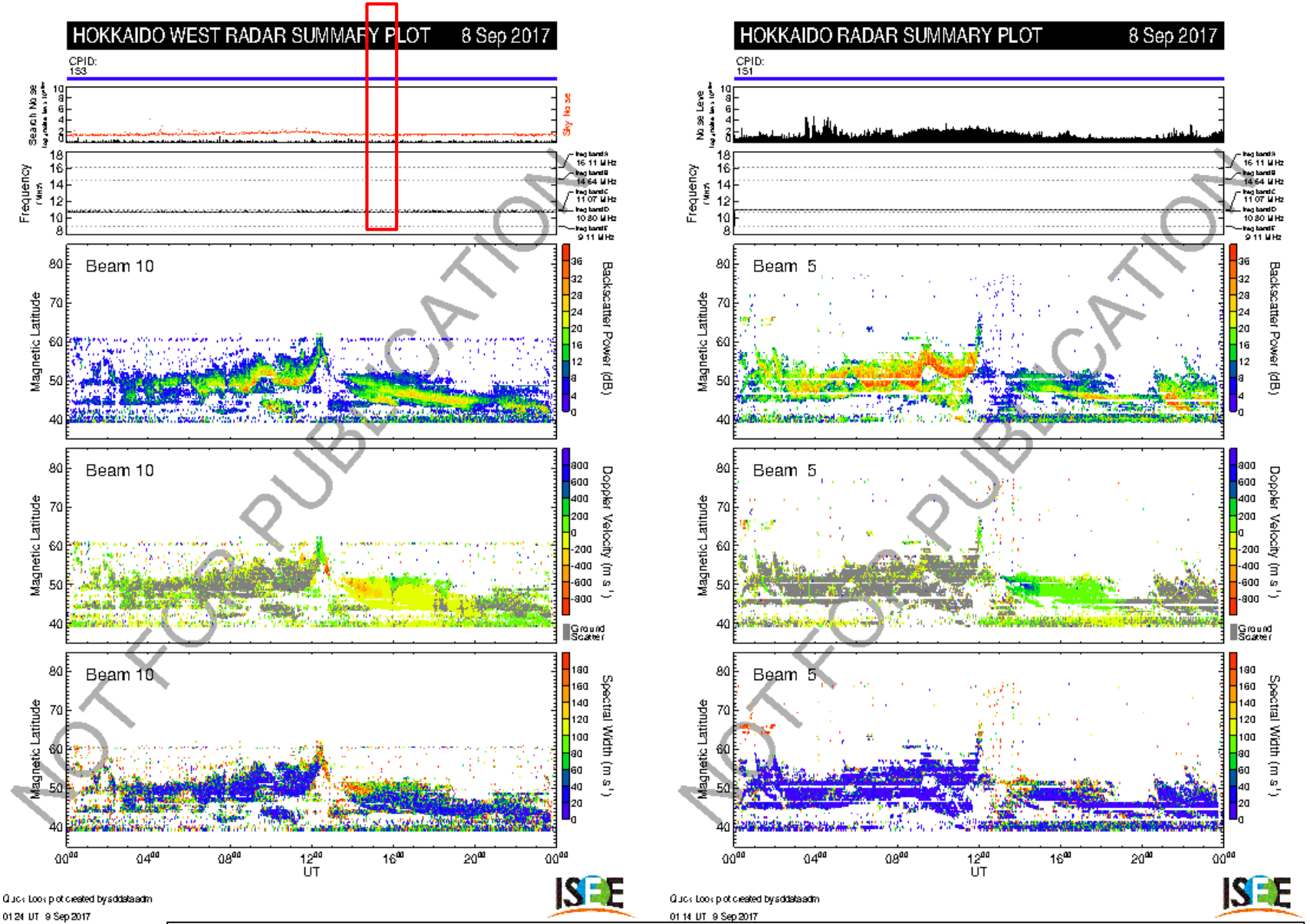
Sep 08, 2017: solar wind / geomagnetic activity (@OMNIWeb)

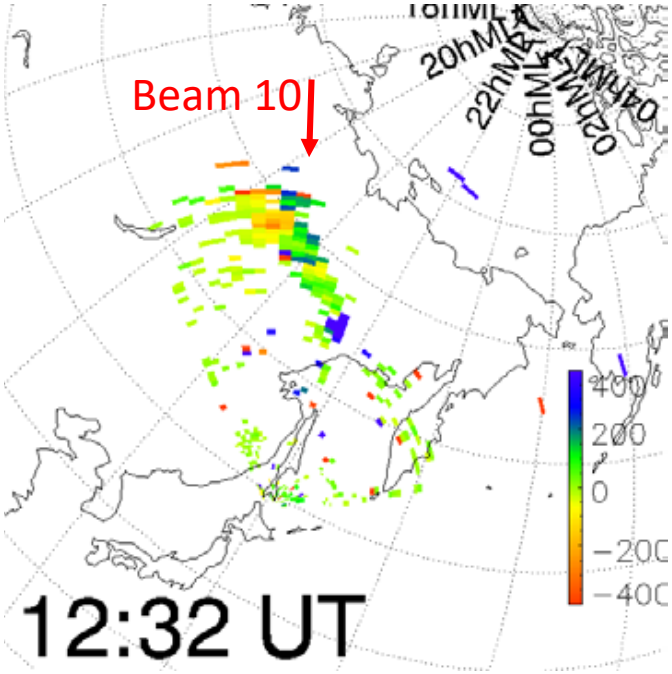


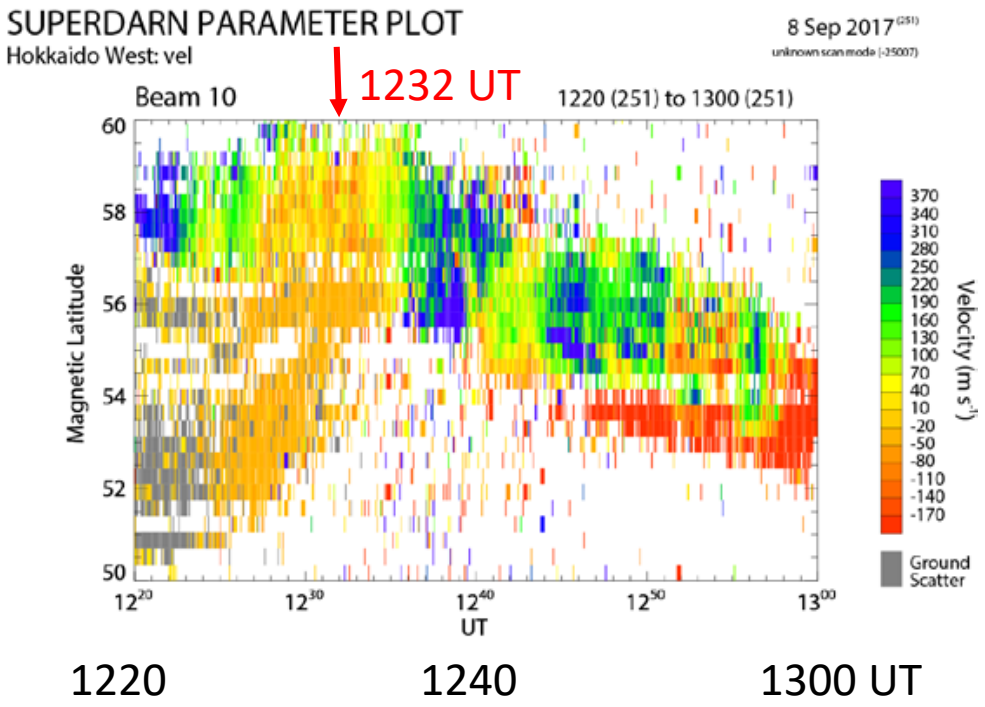
HOP West / East 2017/09/08 quicklook plots



SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

Stereo-mode observation of SAPS structure using the SuperDARN Hokkaido West radar (8 Sep 2017)





- Hkw observed SAPS variations with temporal scale ranging from 1 minute to a few tens of minutes.

MLT ~ UT + 9 hrs

IMF / solar wind / geomagnetic activity on 08 Sep 2017 (10-14 UT)

Bx

By

Bz

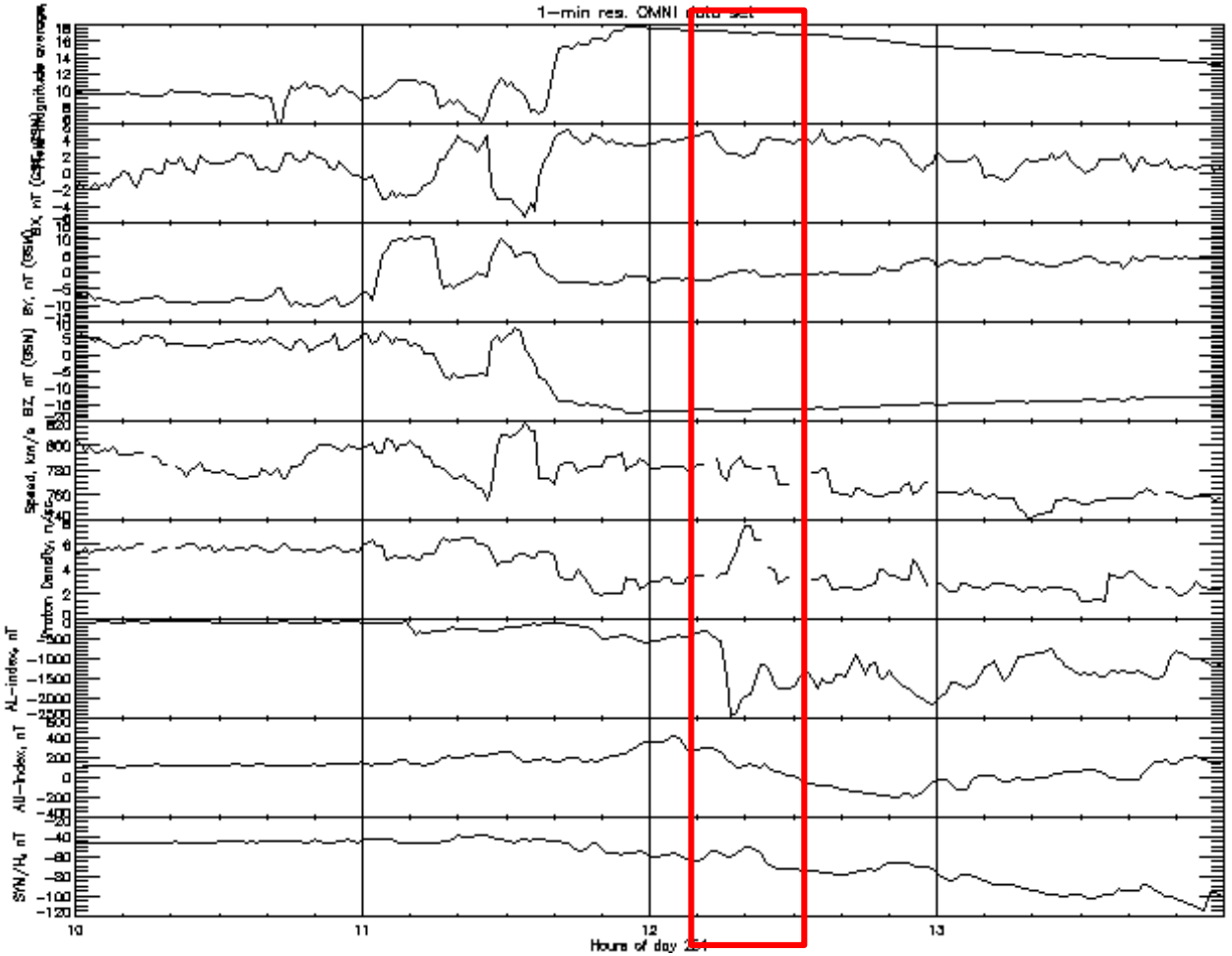
V

rho

AL

AU

SYM/H



Discussions: 2017/09/08 event

There are various temporal scales of the subauroral flow variations, with main scales at several tens of mins, ~10 min and ~1 min.

- Several tens of mins variations
  - Seem to be directly related to the solar wind pressure pulse and concurring substorm expansion.
- 10 min variations
  - Similar to Foster et al. (2004) and Makarevich and Bristow (2014) SAPSWS although the present event has slightly longer period.
- 1 to 1.5 min variations
  - Very similar to Pi2 pulsations, but…
    - The longitudinal wavelength (~ 10 degrees: m-number ~ 36, corresponding to propagation speed of 0.85 km/s) is much smaller than the typical Pi2 pulsations.
    - The Pi2 pulsation peak in the geomagnetic data is about 10 minute earlier (Norlisk magnetometer data, courtesy of Alexey Pashinin at ISTP RAS SB).
  - High m-number poloidal waves (e.g., Le et al., 2017 GRL and references therein)?
    - Similar period (>~ 100 s) and m-number (>~15), whereas their event continues longer (up to ~45 min) than the present event (~ 10 min).
  - Intermittent particle injection (e.g., Hori et al., 2018 GRL)?
  - The generation mechanisms of these variations have not been fully understood.
- All of these variations seem to be associated with solar wind dynamic pressure pulse or substorm expansion onset, although further investigation is necessary.

Summary

- (Mid-latitude) SuperDARN is a powerful tool for investigating the ionospheric convection dynamics at subauroral and mid-latitudes.
- There are several kinds of SAPS variations with temporal scale ranging from ~1 min to several 10s of mins.
- SAPS variations with different temporal scale sometimes coexist.
- Whether (and if so, how) they are related to each other is a subject of further study.

Acknowledgements:
- Solar Wind / IMF data were obtained from OMNIWEB.
- AU/AL data were obtained from WDC for Geomagnetism, Kyoto University.
- SuperDARN data were analyzed using the SPEDAS SuperDARN plugin software.