Statistical study of SAPS occurrence characteristics using the SuperDARN Hokkaido East HF Radar

K. Oya, N. Nishitani, and T. Hori (ISEE, Nagoya University)

Introduction

SAPS (SubAuroral Polarization Stream) is defined as a narrow channel of enhanced westward flow caused by strong poleward electric fields in the ionosphere, and is located equatorward of the auroral oval (the subauroral region) [*Foster and Vo, 2002*].

- Appears at the low electrical conductivity region [*Foster and Vo, 2002*].
- Mostly occurs during magnetically disturbed periods [*Huang and Foster, 2007*].
- SAPS flow channels move equatorward with decreasing Dst and increasing MLT [*Foster and Vo, 2002*].

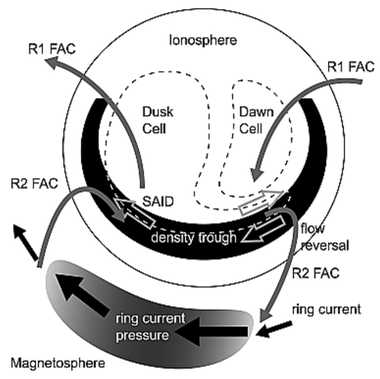

Fig 1. Schematic view of SAPS [*Kataoka et al., 2007*]

Instruments

➢**SuperDARN Hokkaido East radar**

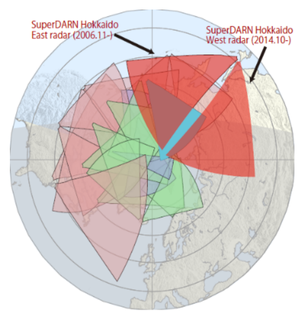

Fig 2. Field of view of the SuperDARN radar network.

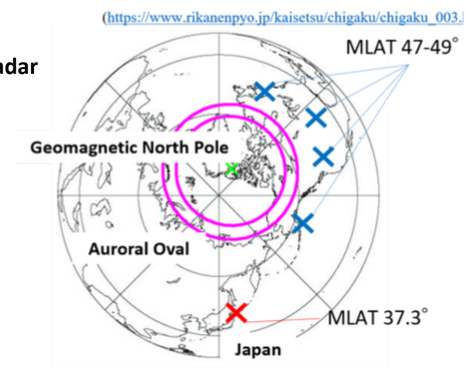

Fig 3. Schematic figure showing the difference of magnetic latitude between American radars and Hokkaido radar.

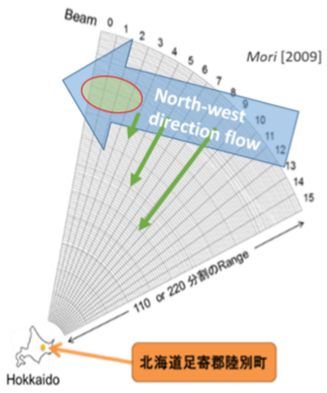

Fig 4. Schematic figure showing the data analysis method used in this study

- Location: +43.53˚, +143.61˚ (geographic coordinates)
- Time resolution: 1 s to 2 min
- Spatial resolution: 15 to 100 km
- Beam width: 5 degrees

Fig 5. Photo of the SuperDARN Hokkaido HF radar (by Dr. Nishitani)

Purpose

- It is not clear if SAPS behavior at other longitudes or lower latitudes shows similar characteristics to those found in the past studies.

➢To investigate **the global occurrence characteristics of SAPS**, we analyze data from the SuperDARN radar in Hokkaido, Japan, which is located in a region with the magnetic latitude and longitude greatly different from those of radars in North America used by the past studies.

Data analysis

●Identification of SAPS

- *LOS velocity > 80 m/s (positive LOS V mean westward)*
- *Echo Power > 3 dB* [*Nagano et al.*, 2015]

✓***Caution***

- **Assuming that the flow is East-west** oriented.
- Not checked **the relative position in MLAT to the auroral oval**.

➢The results of this study can contain **the occurrence characteristics of high-latitude convections**, rather than SAPS.

●Calculate the occurrence probability

- **We investigated the occurrence characteristics for each beam individually.** (see Fig 6.)
- To make comparison, we used the same formula as *Kunduri et al.[2017]*.

$$P_{saps} = N(MLAT, MLT, Dst)/Max[N(MLAT, MLT, Dst)]$$

P_{SAPS} : the probability of observing SAPS at a specific location and a given *Dst* value
N(MLAT, MLT, Dst) : the number of SAPS data points at a *particular* MLAT-MLT location and *Dst* bin
Max[N(MLAT, MLT, Dst)] : the maximum number of data points at *any* MLAT-MLT location for that same *Dst* bin

- The occurrence frequency is evaluated for each 1-hour MLT × 1-deg. MLAT bin.

Results of past study [*Kunduri et al.*, 2017] (left) vs this study (right)

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✓The first comprehensive statistical study of **SAPS** using measurements from **the U.S. midlatitude SuperDARN radars**.

◆Two important SAPS features [Kunduri et al., 2017]

①**Equatorward and duskward** (toward early MLTs) shift **with decreasing** Dst.

②**Equatorward shift** with increasing MLT for all Dst bin.

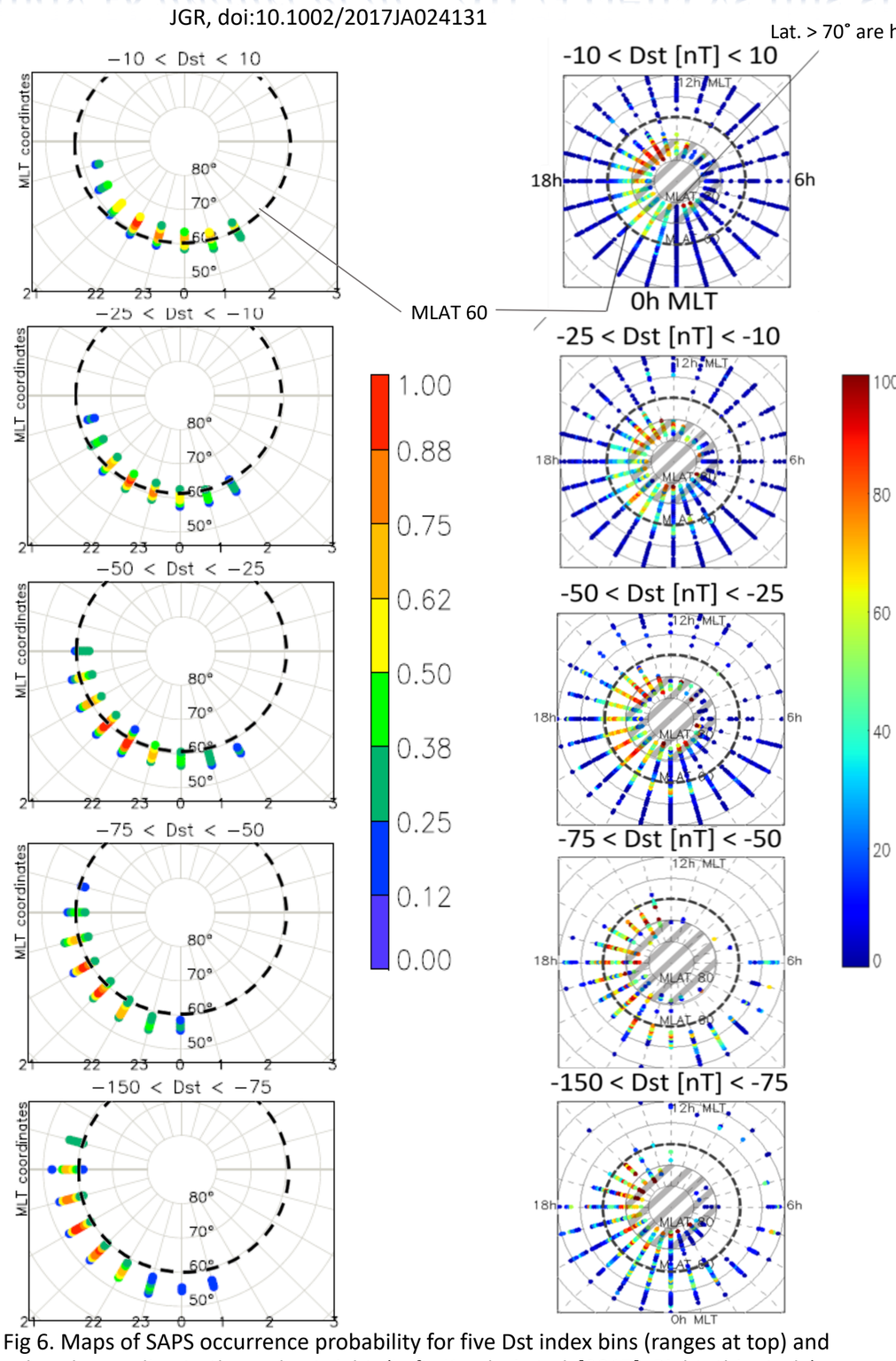

Fig 6. Maps of SAPS occurrence probability for five Dst index bins (ranges at top) and colored according to the scale at right. (Left: *Kunduri et al.* [2017], Right: this study)

✓The present results show not only basic SAPS features but also interesting characteristics different from the past study.

- **The basic features** mean that SAPS occur at lower latitude toward the dawn sector and with increasing geomagnetic activities.
- **The interesting differences** are summarized in the table.

Table 2. The main differences between this study and past study.

	This study	Past study [*Kunduri et al., 2017*]
SAPS latitude	• SAPS also appears at **lower latitudes than 60˚** during more disturbed periods.	• Fixed **around 60˚**.
Change in MLT distribution with Dst bin	• **No clear MLT shift was identified.** • SAPS spreads **from midnight to morning side**.	• Move to the **dusk** sector • **SAPS was not found on the morning side.**

●The causes of the different features can be attributed to be **the difference of radars' field of view (FOV)**.

➢This is because the FOVs of the US radars could miss plasma flows as they shift equatorward under disturbed conditions.

●This results may also demonstrate **the capability of Hokkaido East HF Radar especially at lower latitudes**.

※In the dusk sectors, SAPS is located **at higher latitudes** in this study.

Possible reasons are as bellow,

1.Geolocation error of echo region. [*Chisham et al., 2008*]

2.Insufficient identification of the subauroral region.

Conclusions

We statistically analyzed the SAPS data of Hokkaido East HF radar for 10 years from 2007 to 2016 in order to understand the characteristics of SAPS in the Far East Asian sector, and the main results are as follows.

- Basic SAPS features are consistent with the past studies.

  SAPS occurs **at lower latitude toward the dawn sector** and with increasing geomagnetic activities.

- Differences from the results of the North American sector

  1. From the Hokkaido radar**, SAPS are observed at lower latitudes and from midnight to morning sectors**.
  2. No clear MLT shift of the peak occurrence region.

Future Work

This study, although still in the preliminary stage, demonstrated **the capability of the SuperDARN Hokkaido radar, with the advantage of its extended field of view to lower latitudes**.

➢Further study using Hokkaido East HF radar or other SuperDARN radars can clarify the detailed occurrence characteristics of SAPS.

For example…

- Solar zenith angle (by using other radars) dependence
- Solar activity dependence or something else…