# Study of ionospheric convection associated with low-latitude auroras during low geomagnetic activity using the SuperDARN HOP radars

## SuperDARN北海道-陸別第1・第2レーダーによる
## 低緯度オーロラに伴う電離圏対流の地磁気活動依存性

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# Outline of this talk

- **Introduction**
  - The Aurora Event on March 26, 2025
  - Research Objectives
  - Several Background data
- **Observation Data**
  -Description of Observation Data
  -Observation Data (March 26, 2025)
  -Observation Data (January 1, 2025)
- **Discussion**
  - Ionospheric Convective Variations and Geomagnetic Activity Dependence
  - Factors Contributing to Aurora Occurrence in Hokkaido
- **Conclusions**

# Introduction

# Introduction

**Hokkaido Rikubetsu**
**(Magnetic latitude: approximately 36.9 degrees)**
**Date: March 26, 2025**
**Aurora viewing times: 22:27-23:12(JST)**

**“13:27-14:12 (UT)”**

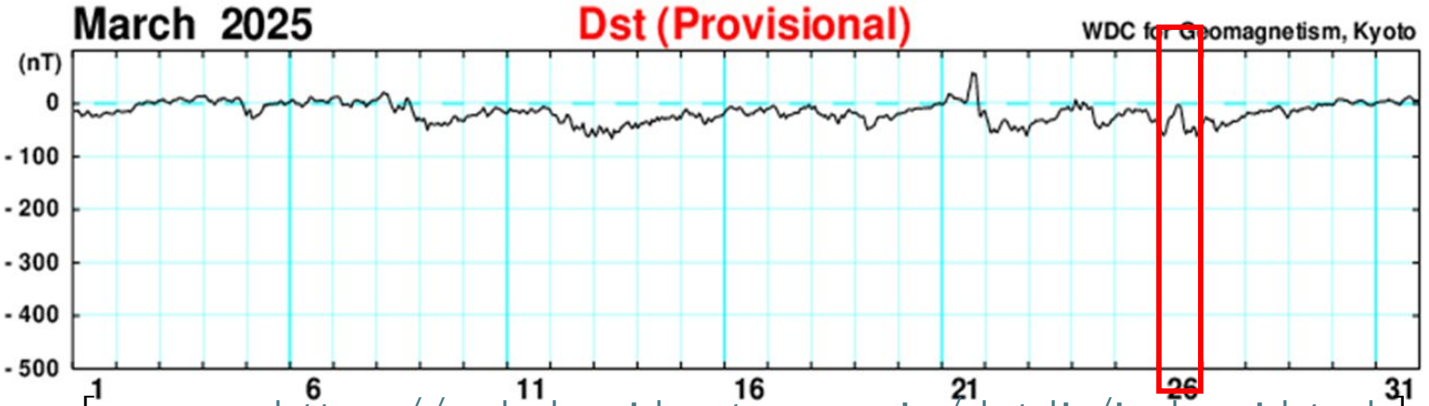
**Rikubetsu camera Information**
placement location: Installed on the north window of the shed housing the radar transceiver system
⇒ Photographing the northern sky

Shooting interval: This camera takes pictures every five minutes.

# Introduction

The Table summarizing the lowest Dst index values on days when auroras were observed in Rikubetsu over the past five years

## Dst index (nT)




[source: https://wdc.kugi.kyoto-u.ac.jp/dstdir/index-j.html ]

⇒ **-60 [nT] (March 26, 2025)**

Why were auroras visible in Rikubetsu despite low geomagnetic activity?

**Research Objective: To elucidate the causes of aurora generation during the auroral event occurring on March 26, 2025, during a period of low geomagnetic activity, and to clarify the dependence of ionospheric convection on geomagnetic activity.**

| year | date | Dst index (nT) |
|---|---|---|
| 2025 | March 26 | **-60** |
| | January 1 | -212 |
| 2024 | November 9 | -101 |
| | October 11 | -333 |
| | August 12 | -188 |
| | July 28 | -107 |
| | June 11 | -406 |
| 2023 | December 1 | -108 |
| | November 5 | -163 |
| | April 24 | -213 |
| | February 27 | -132 |
| 2021 | November 4 | -105 |

# Introduction

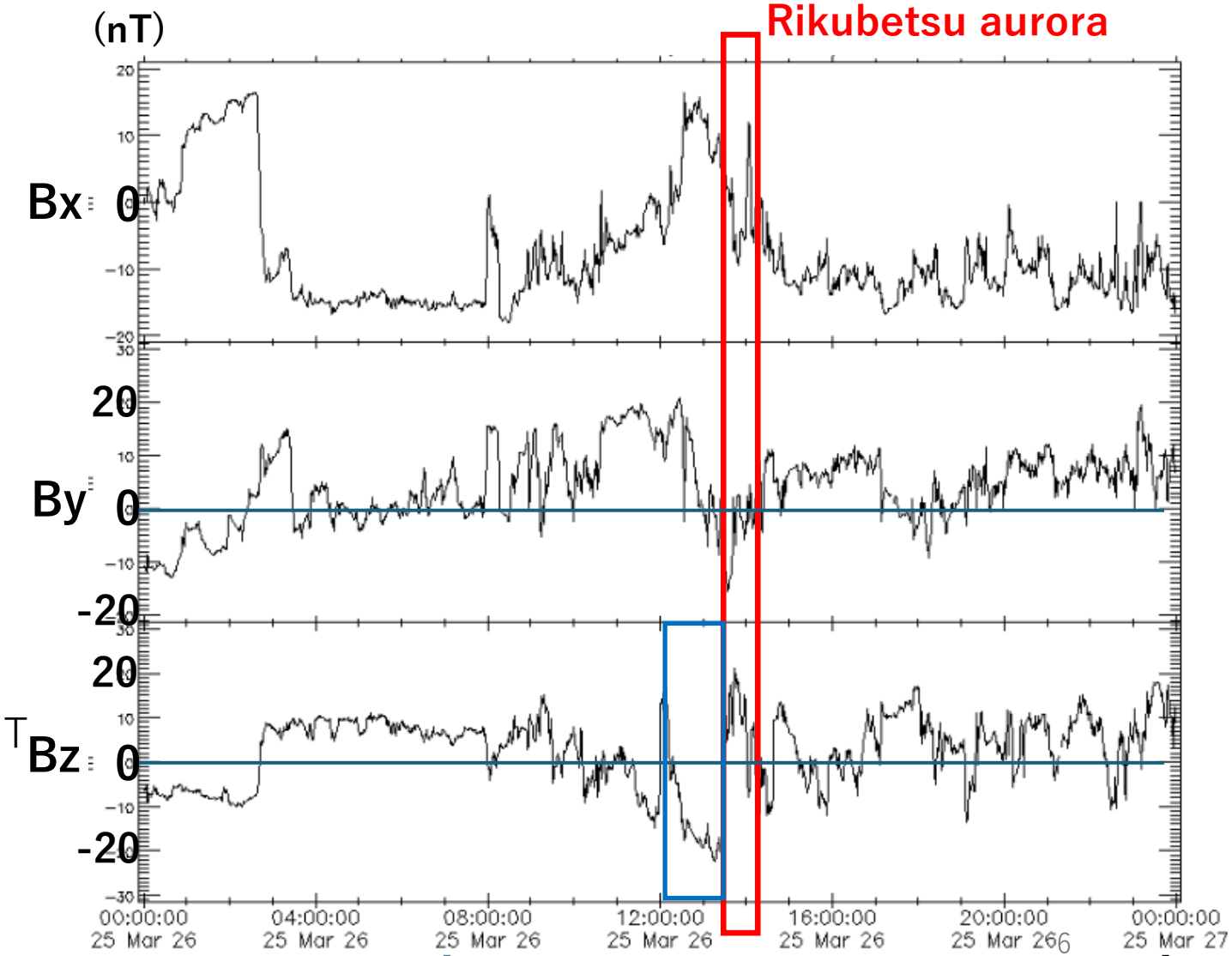
- **IMF (Interplanetary Magnetic Field )**

**Bz：** The most important factor to consider when assessing the impact of the IMF

This component takes on a large negative value,

Geomagnetic disturbances are more likely to occur.

Bz (March 26, 2025)
Rikubetsu Aurora：13:27~14:12 (UT)
12:20~13:30 (UT)：approximately 20 nT to -20 nT (sharp decline)

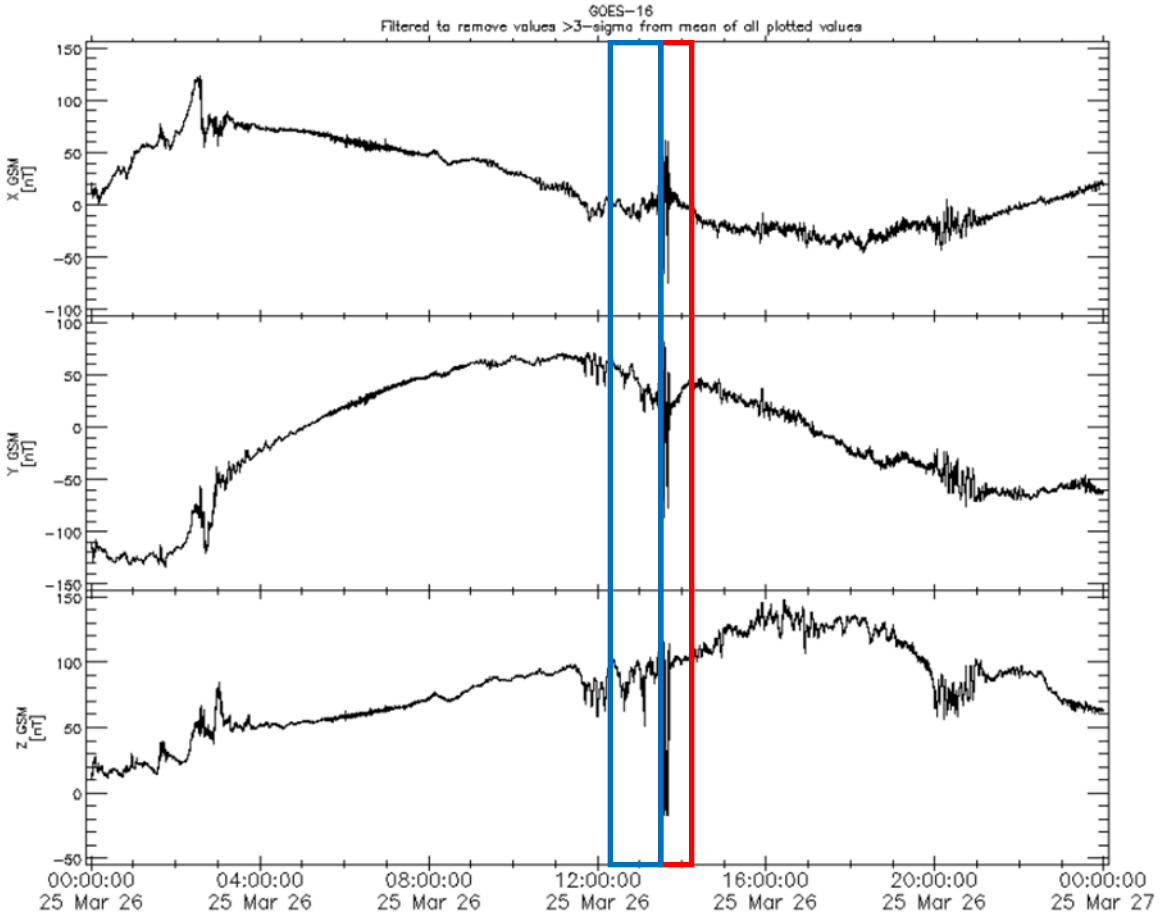



[https://cdaweb.gsfc.nasa.gov/cgi-bin/eval2.cgi ]

# Introduction

## Magnetopause crossing

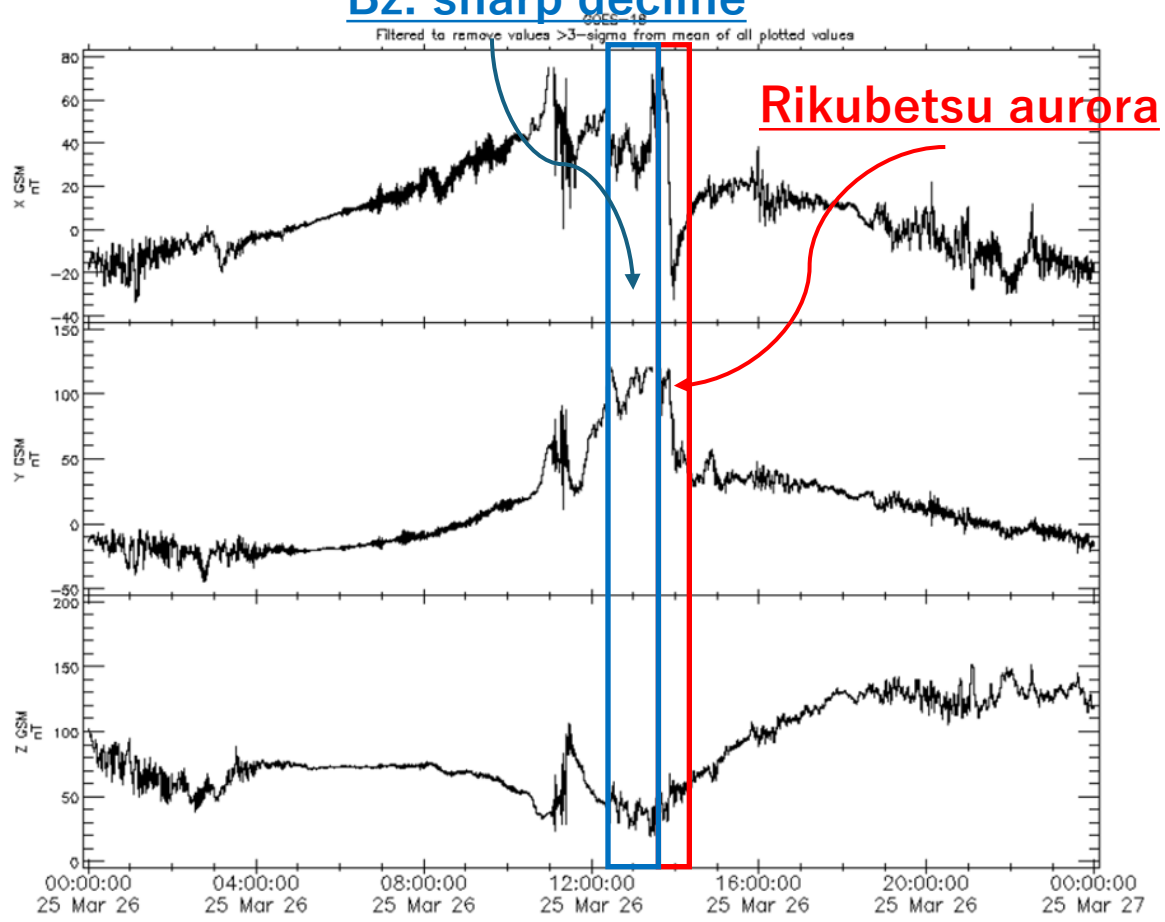
GOES-16_MAGN-L2-HIRES_DN




GOES-18_MAGN-L2-HIRES_DN

Bz: sharp decline

Rikubetsu aurora




[https://cdaweb.gsfc.nasa.gov/cgi-bin/eval2.cgi ]

# Introduction

Rikubetsu aurora

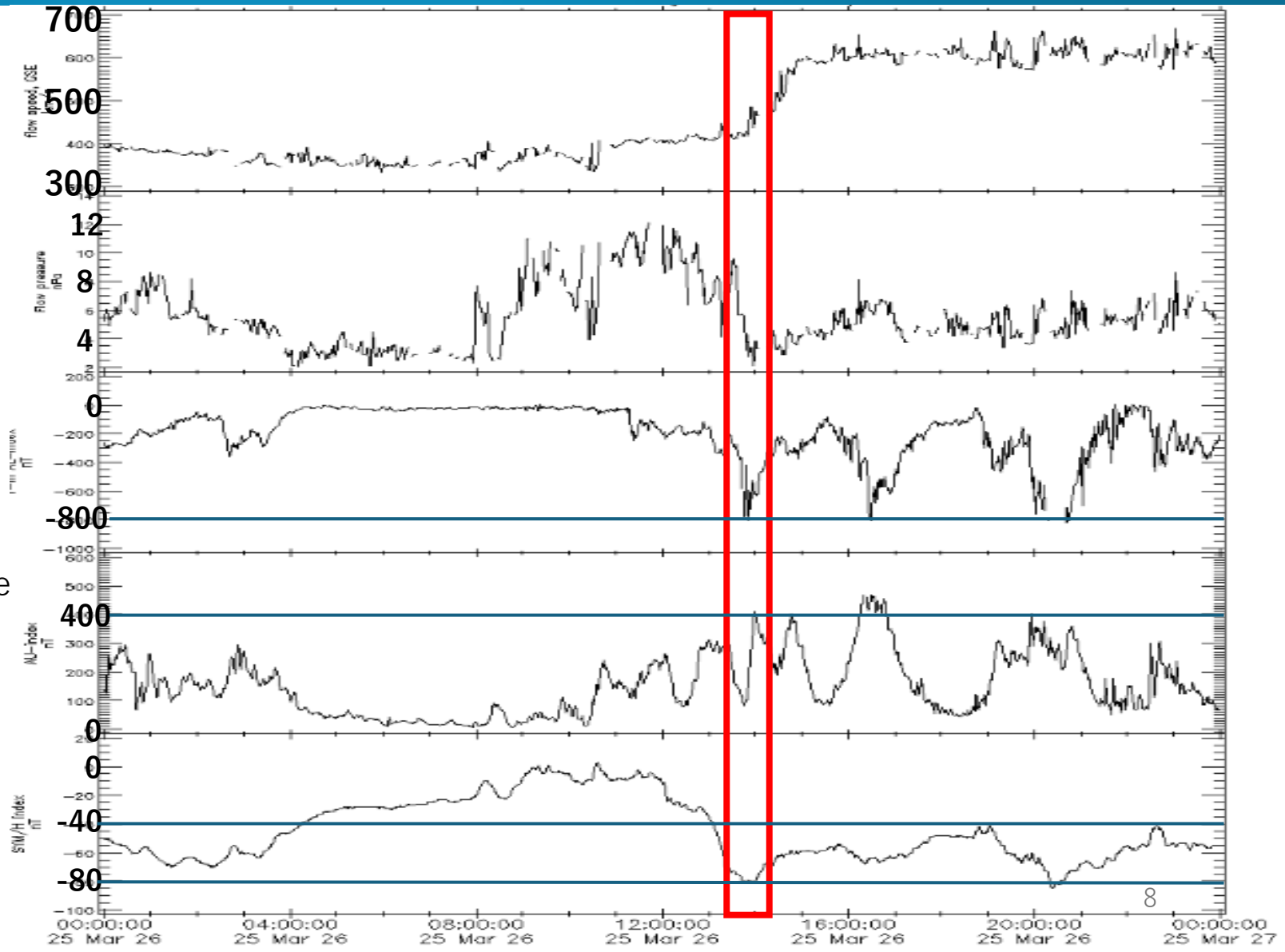
・**Solar wind flow speed [km/s]：**
The value indicating how fast the solar wind is

・**Solar wind dynamic pressure [nPa]：**
The value indicating how strongly the solar wind pushes the magnetosphere

・**AL-index [nT]：** The index indicating the maximum value of the westward current, captured by the most negatively oscillating magnetic field change

・**AU-index [nT]：** The index indicating the maximum value of the eastward current captures the most precisely oscillating magnetic field changes

・**SYM/H index [nT]：** The index created by averaging data from multiple geomagnetic observation points at low latitudes, indicating the strength of geomagnetic storms.

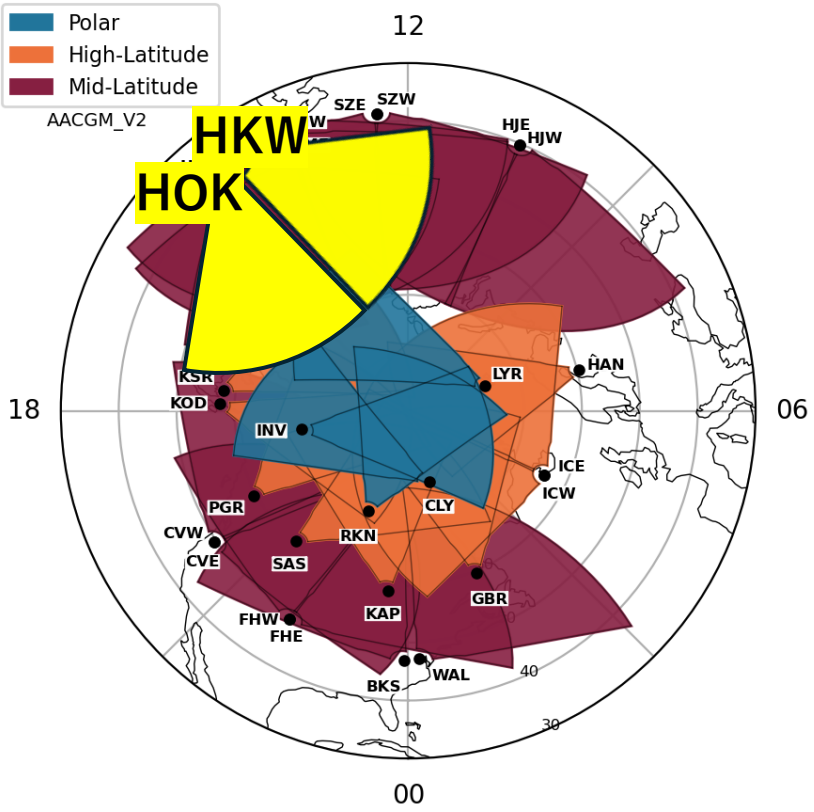


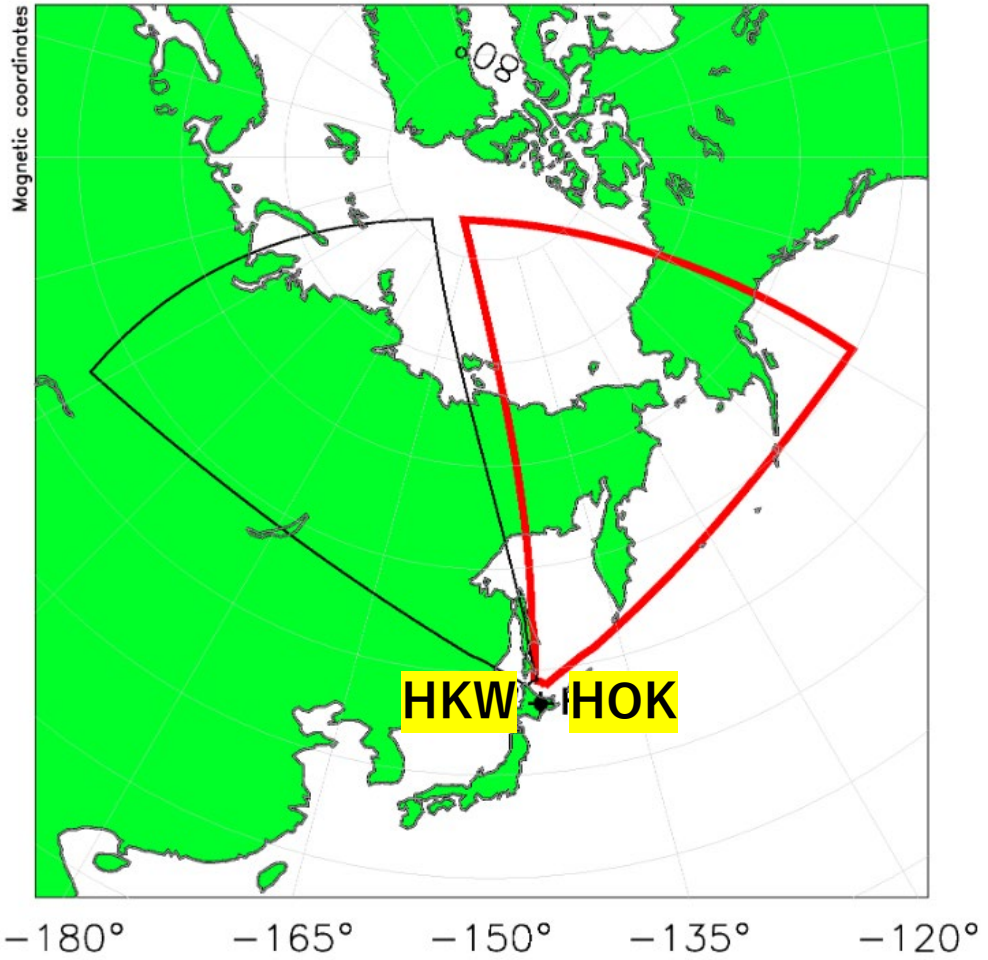
# Introduction

## SuperDARN Hokkaido Pair of (HOP) Radars (HOK,HKW)

**HOK**: Hokkaido East Radar

**HKW**: Hokkaido West Rader




[ http://vt.superdarn.org/ ]

# Observation Data

-Description of Observation Data

-Observation Data (March 26, 2025)

-Observation Data (January 1, 2025)

# Observation Data
## -Explanation of How to understand the Figure

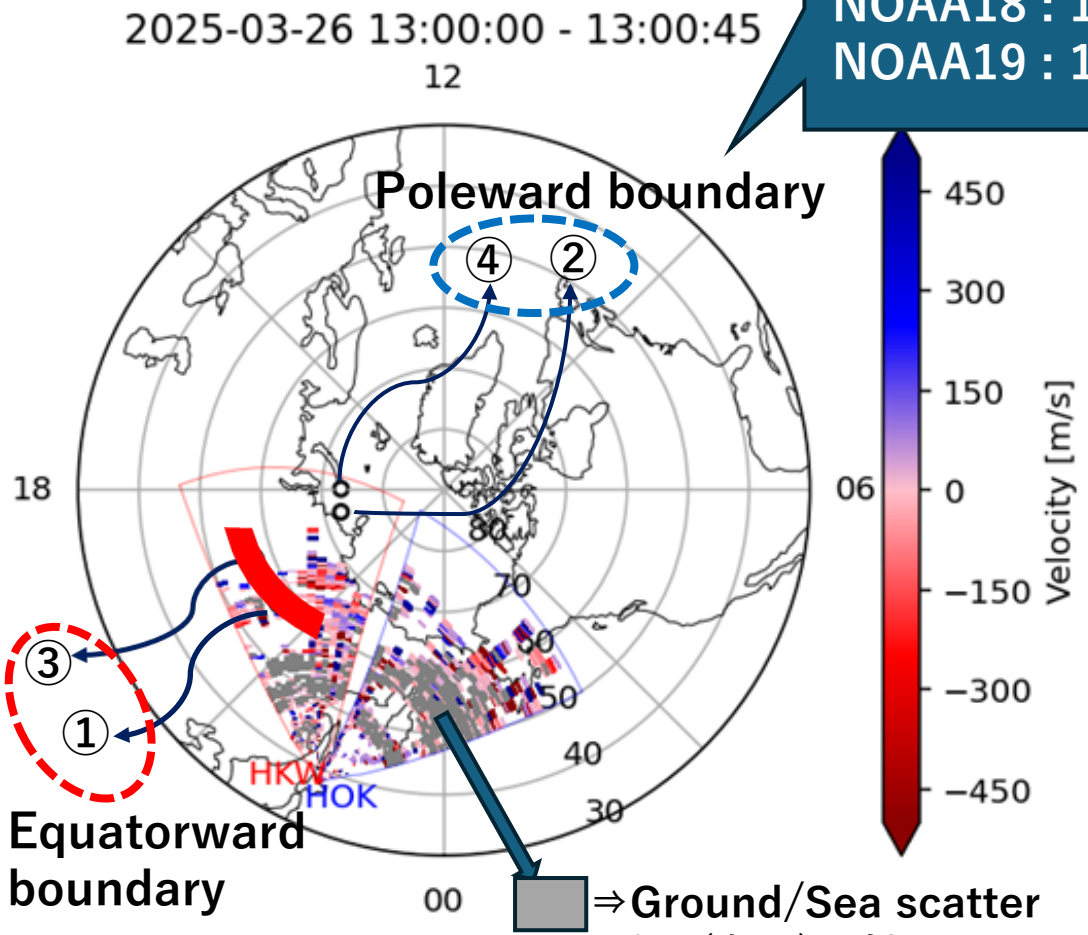
Time period when passing thorough the Aurora Oval
**NOAA18 : 14:31~14:37 (UT)**
**NOAA19 : 14:23~14:29 (UT)**

**Aurora time ：13:27~14:12 (UT)**

⇒Direction approaching the radar

⇒Direction away from the radar

(The darker color indicates a larger velocity component.)



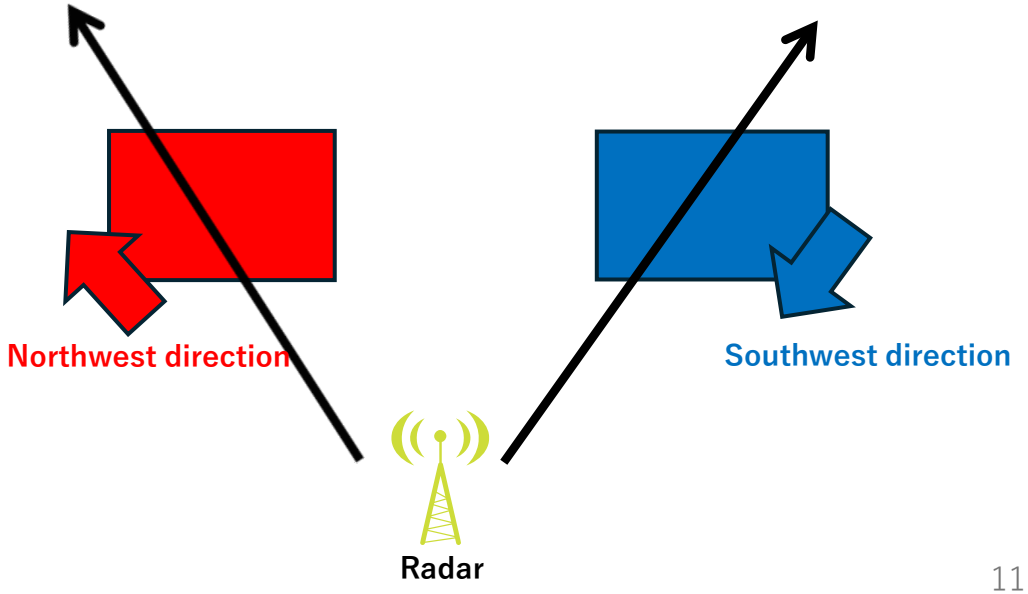

**Poleward boundary**

④ ②

③ ①

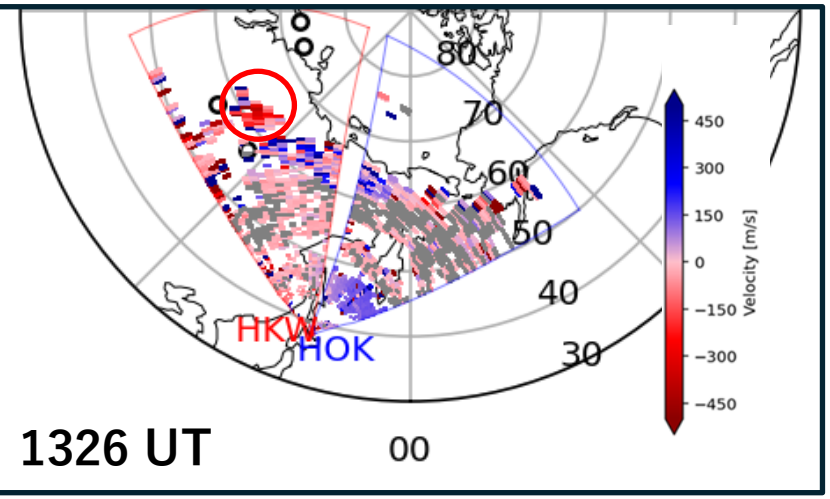
**Equatorward boundary**

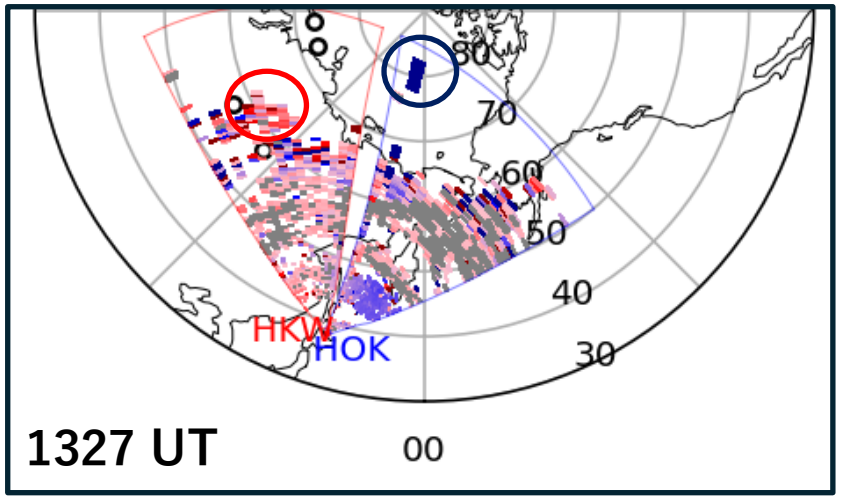
⇒**Ground/Sea scatter**
**地面(海面)反射エコー**

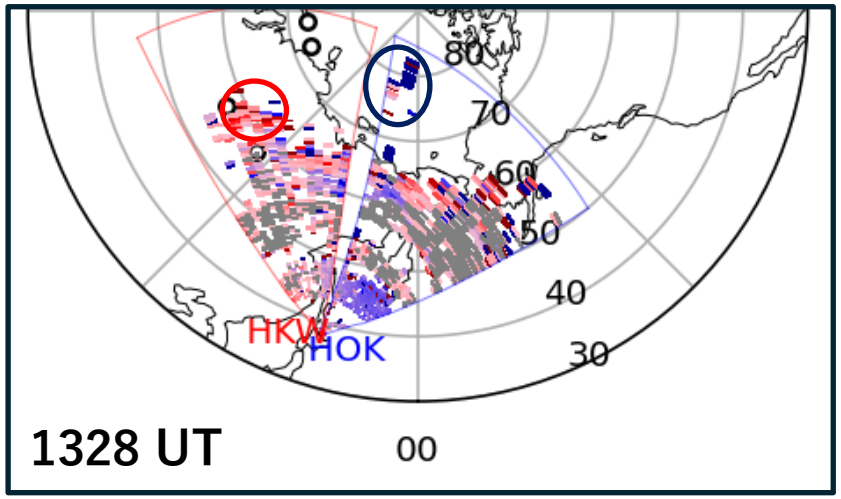


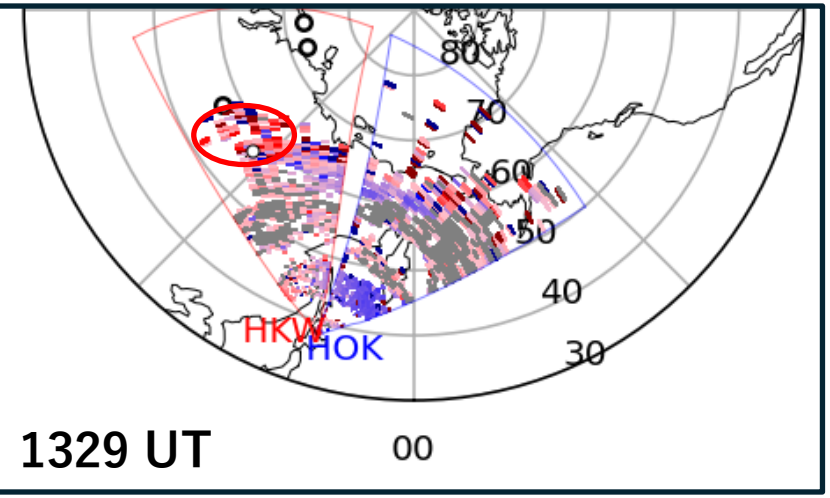
# Observation Data – March 3, 2025

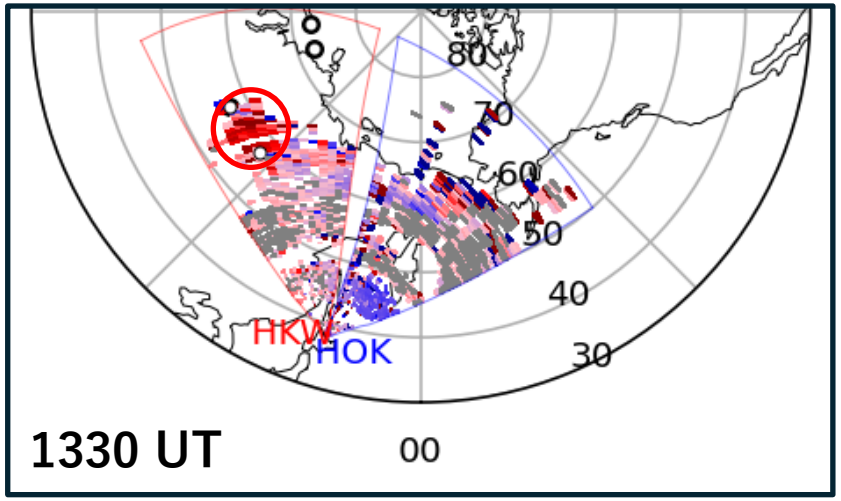
Aurora time (UT) : 13:27-14:12

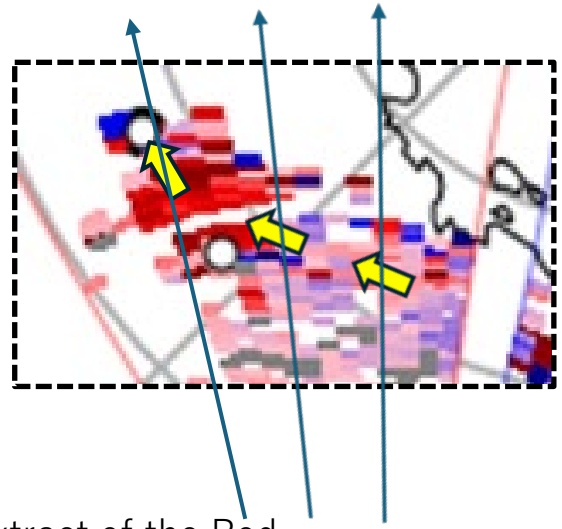


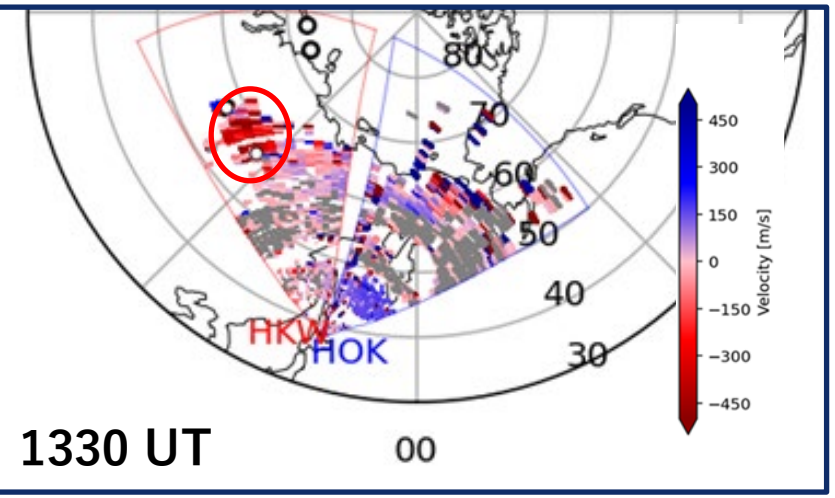



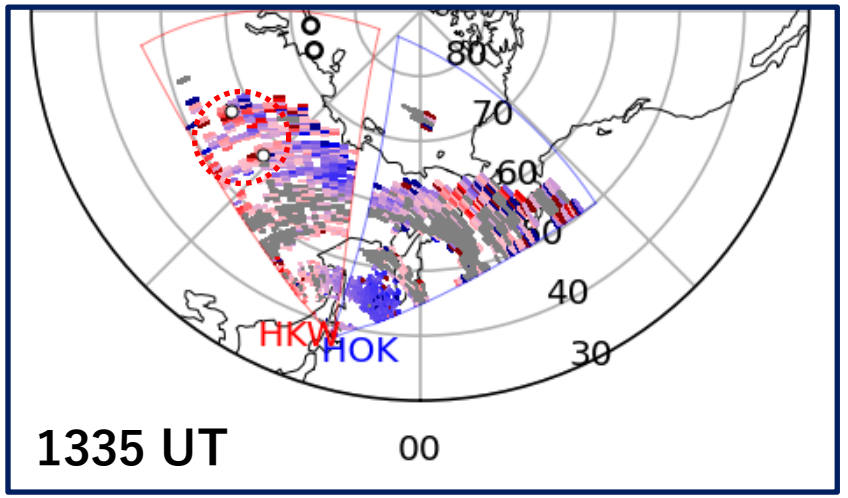



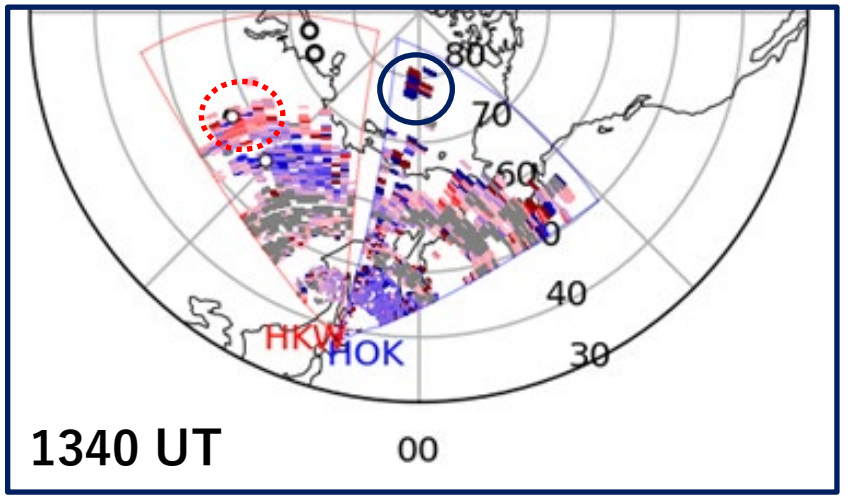
＊Extract of the Red Echo Region at 1330 UT

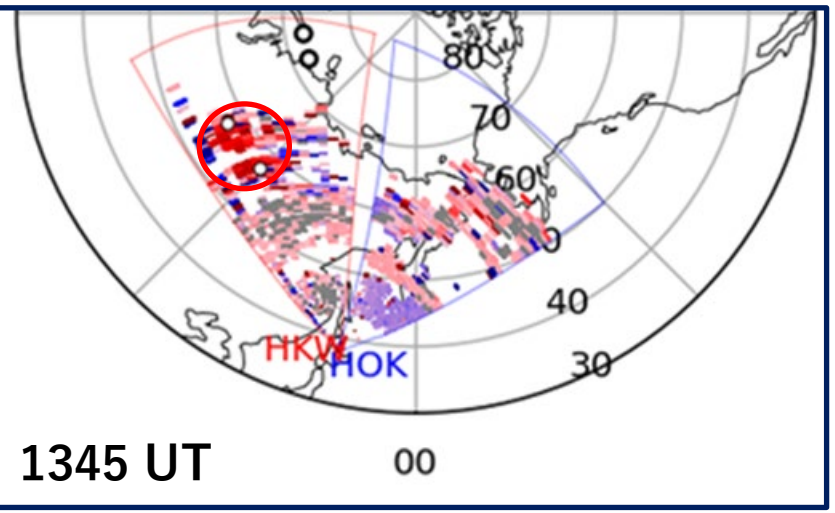
# Observation Data – March 3, 2025

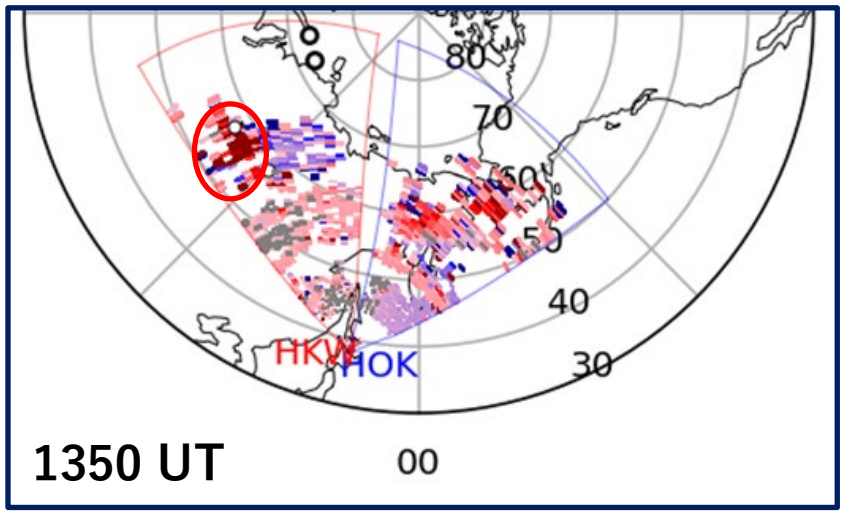
Aurora time (UT) : 13:27-14:12

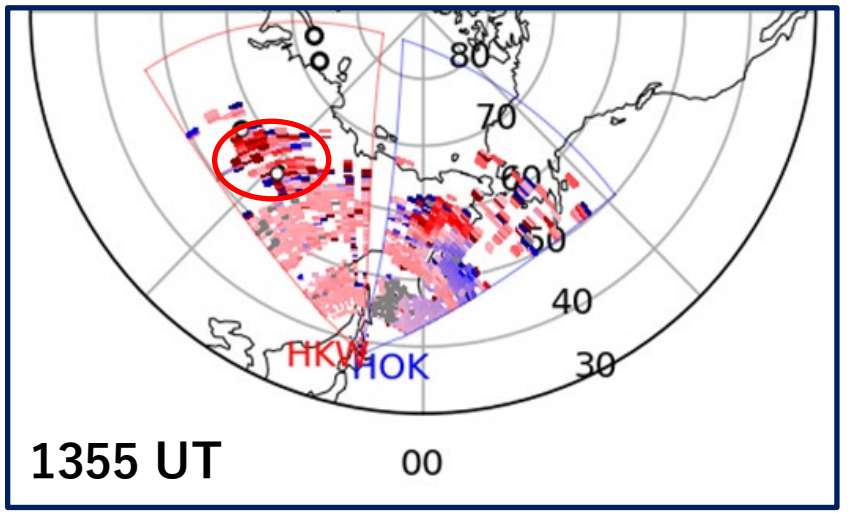


# Observation Data – January 1, 2025

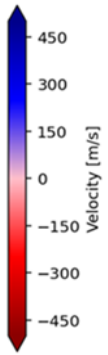
Date: January 1, 2025
Minimum Dst : **-212 nT**

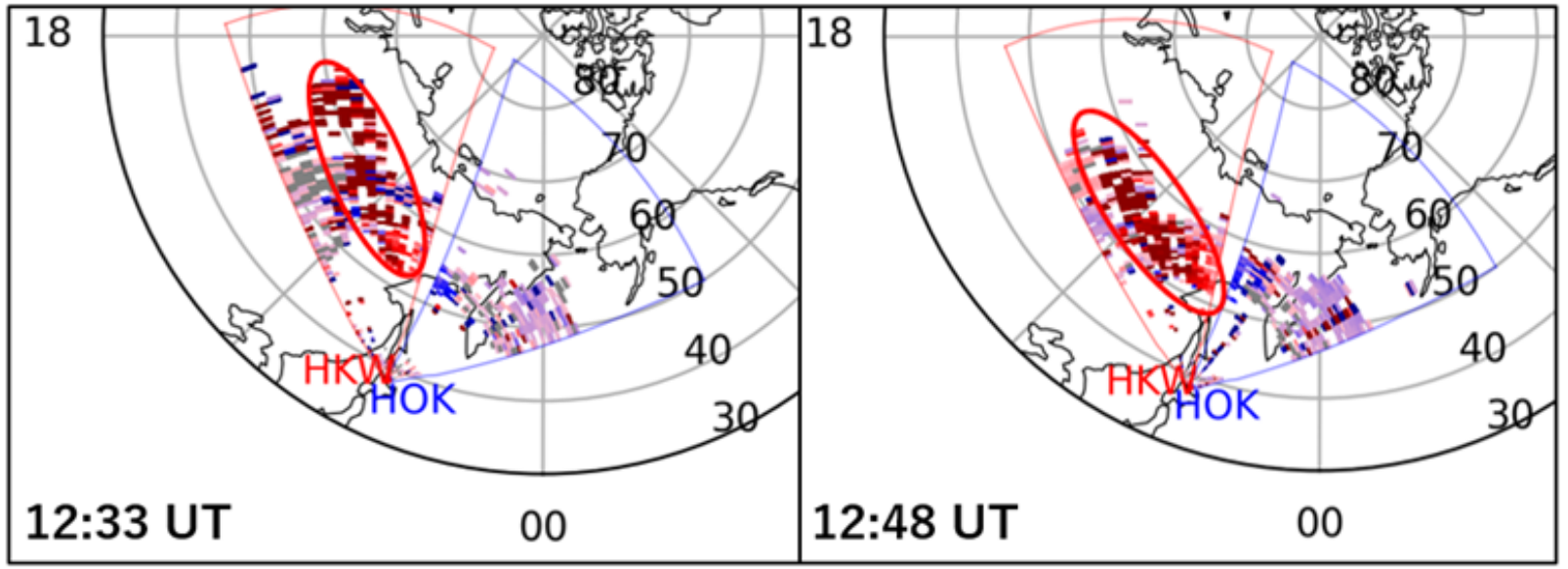
Aurora viewing times
1/1 21:30~1/2 6:00 (JST)

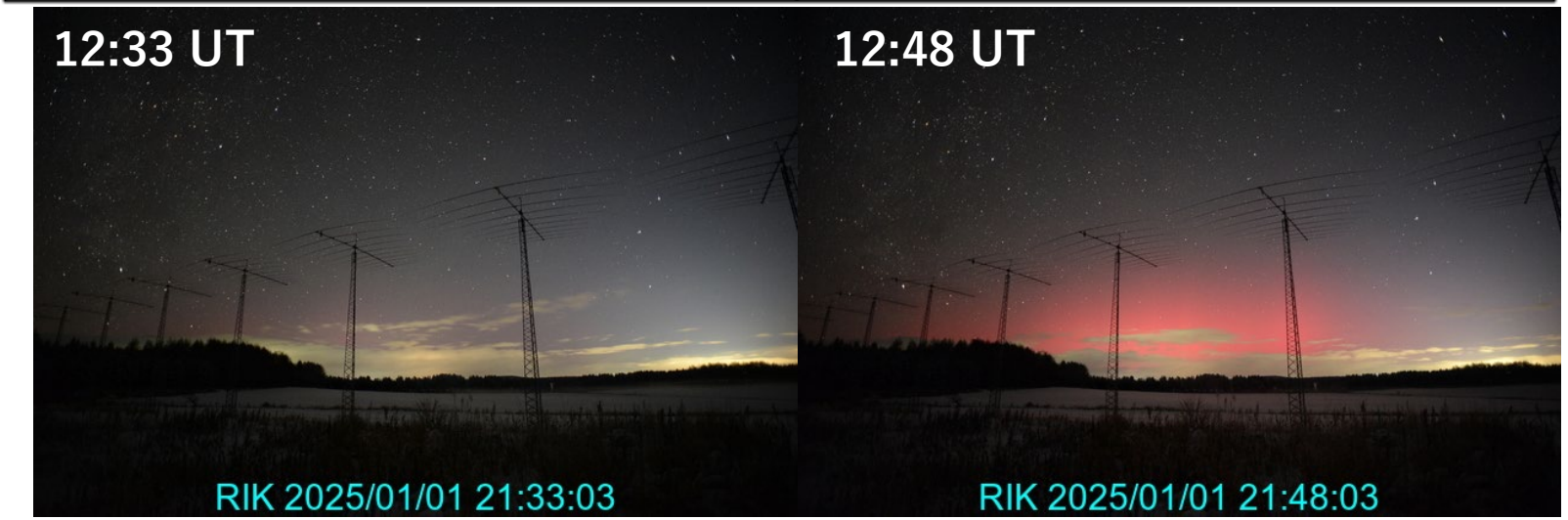
1/1 12:30~21:00 (UT)

[https://stdb2.isee.nagoya-u.ac.jp/member/shiokawa/aurora_250101.html より参考]

⇒Early-stage changes in aurora formation: 12:33~12:48 UT



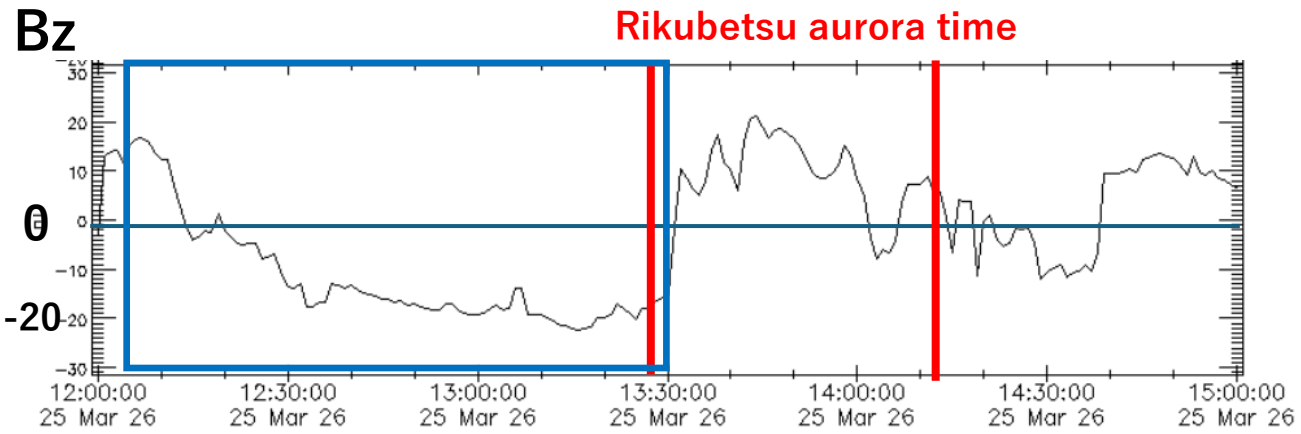



# Discussion

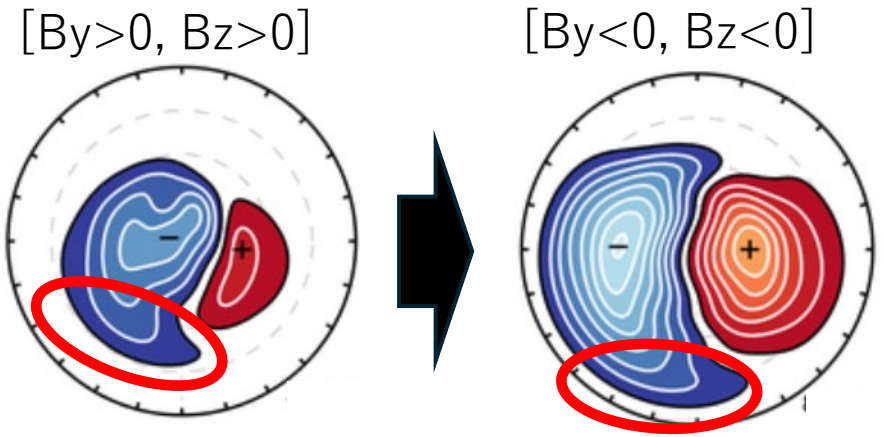
- Ionospheric Convective Variations and Geomagnetic Activity Dependence
- Factors Contributing to Aurora Occurrence in Hokkaido

# Discussion
## - Ionospheric Convective Variations and Geomagnetic Activity Dependence

- **Ionospheric Convective Variations**




・Changes in polar electric field convection patterns due to IMF variations




[ Thomas and Shepherd, https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2018JA025280, 2018]

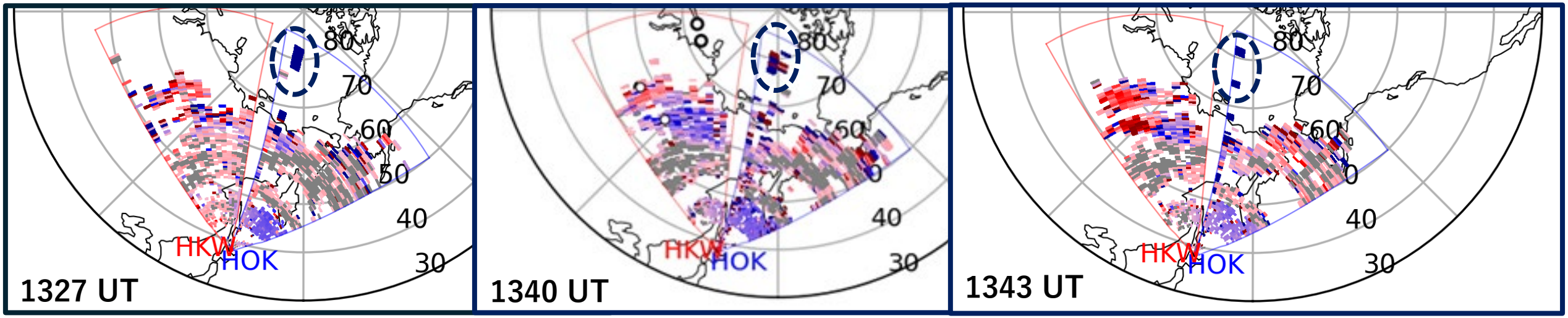
- **Geomagnetic activity dependence**

[2-Event Comparison Chart] ⇒

| Date | Minimum Dst (nT) | Magnetic latitude |
|---|---|---|
| March 26, 2025 | -60 | 約55~58° |
| January 1, 2025 | -212 | 約50° 前後 |

⇒Despite differences in geomagnetic activity levels, a southward shift of the red echo was observed in both events.

# Discussion
## - Factors Contributing to Aurora Occurrence in Hokkaido




**Previous Studies**
- **[Lyons et al.,** https://doi.org/10.3389/fspas.2023.1147531, **2023]**
- **[Lyons et al.,** https://doi.org/10.1029/2011JA016850, **2011]**

Flow channel from polar cap⇒ PBI (Poleward Boundary Intensification)⇒ Streamer⇒ Substorm Onset

**It can be considered that plasma flows originating from polar regions are one cause of aurora formation.**

(Many aspects remain unexplained, and this is merely one hypothesis regarding the causes of low-latitude aurora formation)

# Conclusion

# Conclusion

Why were auroras visible in Rikubetsu despite low geomagnetic activity?

・Because **the change in Bz component was short-lived,** it did not show up strongly in Dst, which takes hourly averages.
・It is possible that auroral emissions caused by **substorms** continued to be visible during the Rikubetsu Aurora Time.

**・Even during a moderate geomagnetic storm (Dst = -60 nT), auroras can be observed in Hokkaido (Rikubetsu) depending on conditions.**
**・ The equatorial auroral oval boundary shifts southward due to the rapid negative swing of the Bz component of the IMF.**

**To understand the mechanism behind aurora occurrences in Hokkaido, we need more detailed research using SuperDARN.**