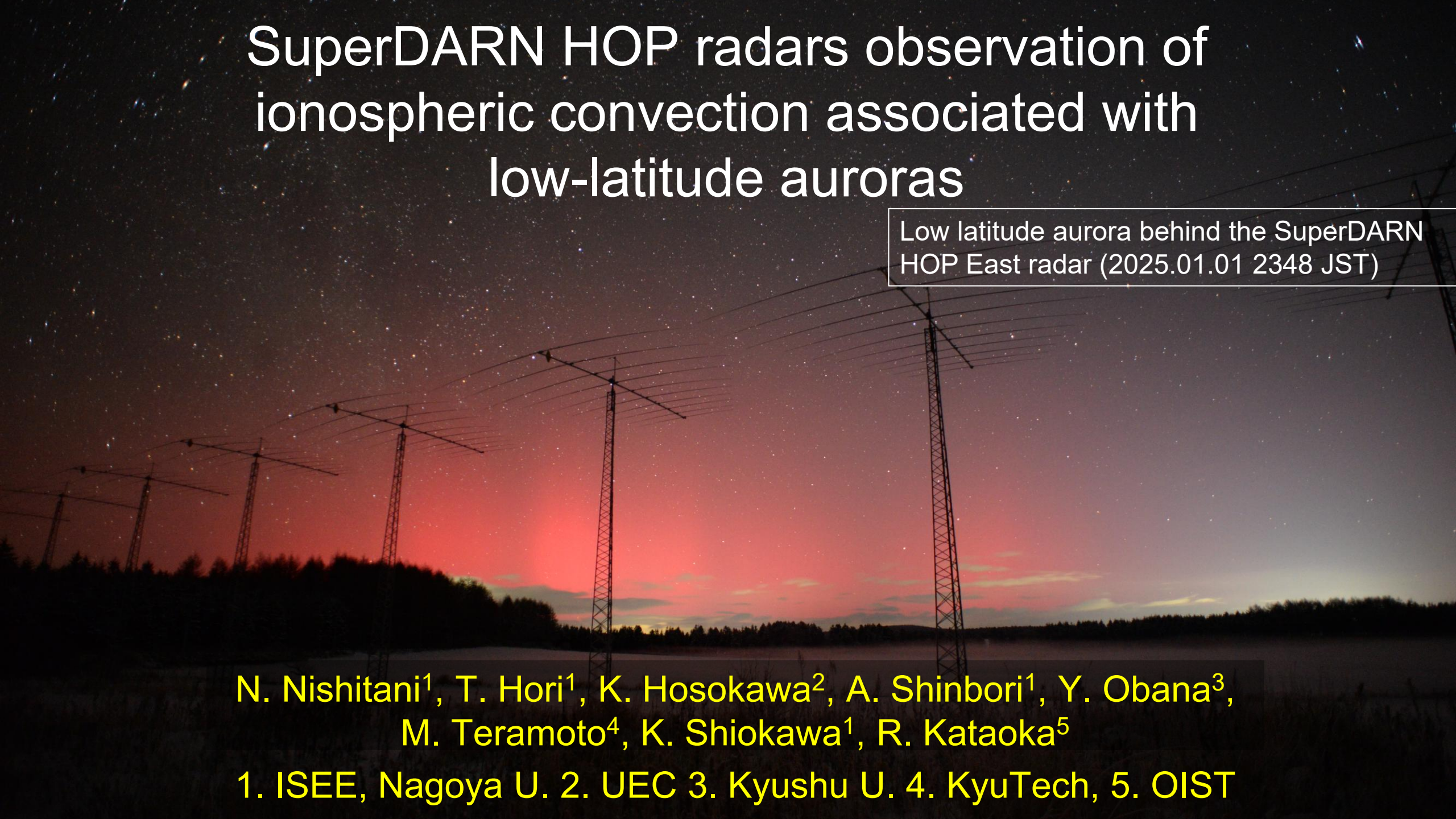
SuperDARN HOP radars observation of ionospheric convection associated with low-latitude auroras



Low latitude aurora behind the SuperDARN HOP East radar (2025.01.01 2348 JST)

N. Nishitani[1], T. Hori[1], K. Hosokawa[2], A. Shinbori[1], Y. Obana[3], M. Teramoto[4], K. Shiokawa[1], R. Kataoka[5]

1. ISEE, Nagoya U. 2. UEC 3. Kyushu U. 4. KyuTech, 5. OIST

Fujii et al. (1994) – high-altitude convection / FAC associated with auroral bulges

Low-latitude auroras are generally considered as SAR arc, as a result of ring current / plasmasphere overlapping (Rees and Roble,1975)

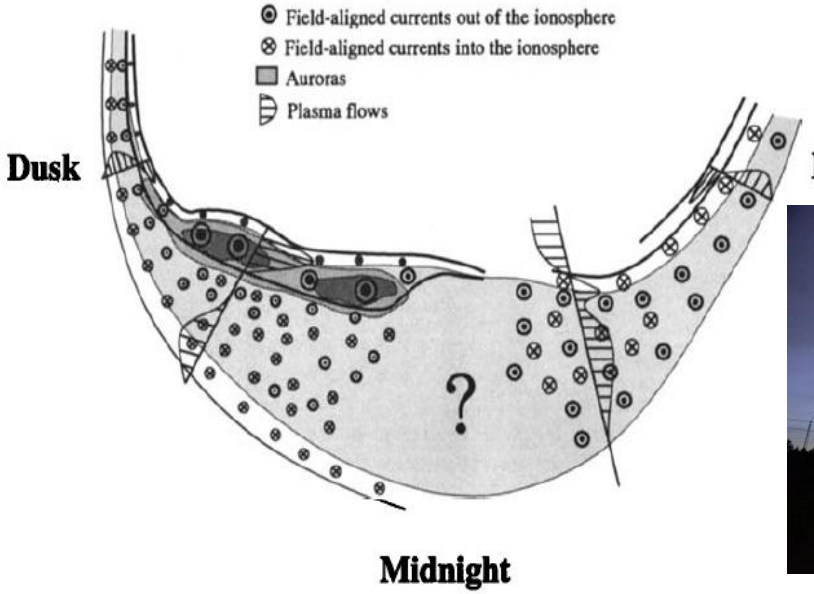


Fig. 11. The distributions of FACs, electric fields (plasma flows), and auroras associated with the generic aurora during a bulge-type substorm. At the poleward boundary of the bulge a pair of upward and downward FACs is observed associated with a narrow eastward and/or antisunward plasma flow.

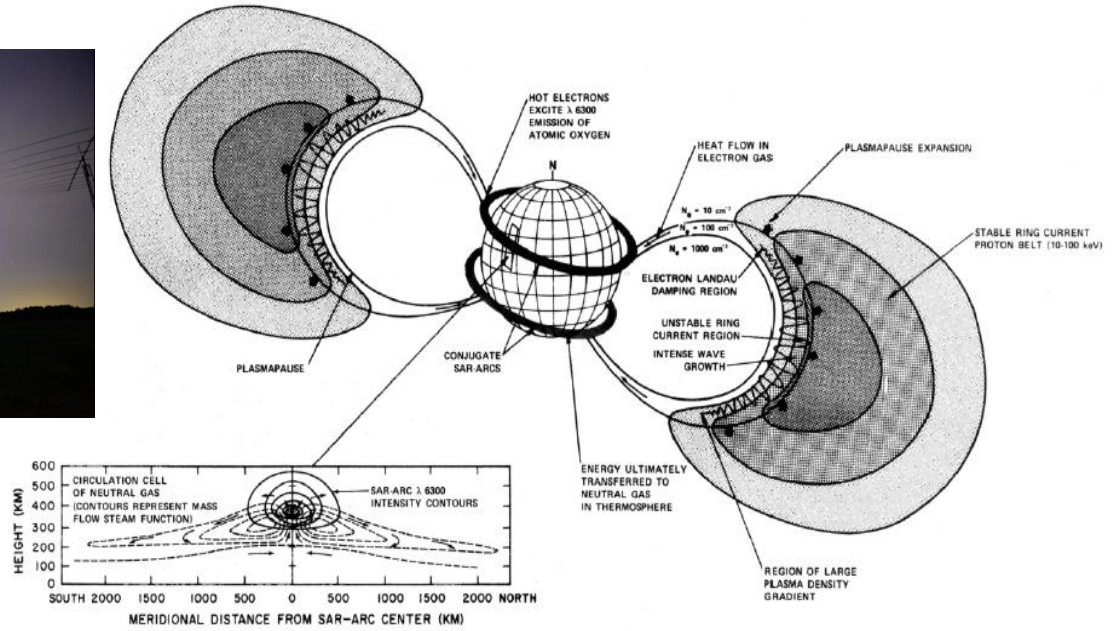


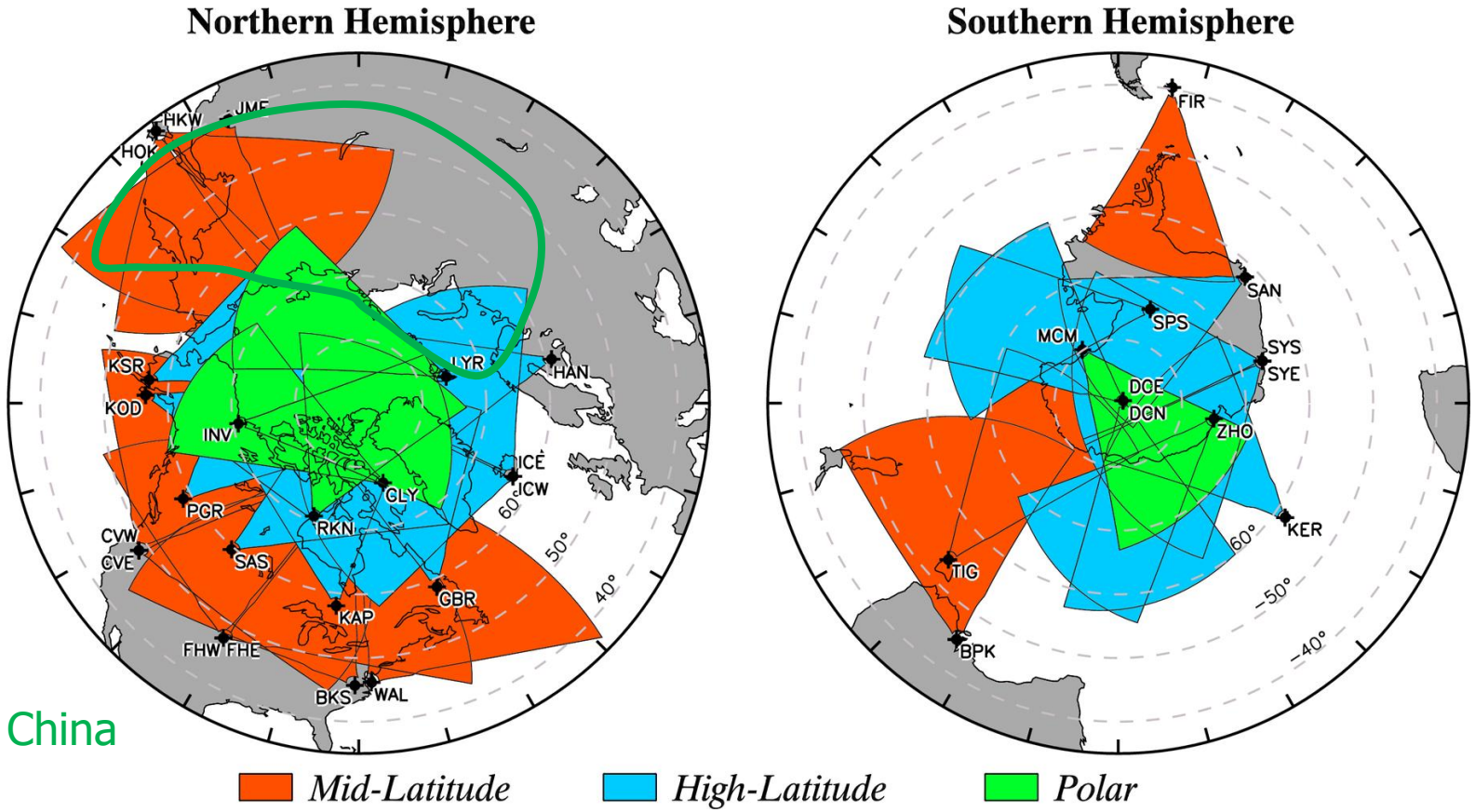
Fig. 43. Schematic diagram of the processes acting within an SAR arc.

REES AND ROBLE: FORMATION OF STABLE AURORAL RED ARCS

How about low-latitude aurora?

Role of the electric field is not described. Some arcs, such as the following cases, do not seem to be “Stable” arcs.

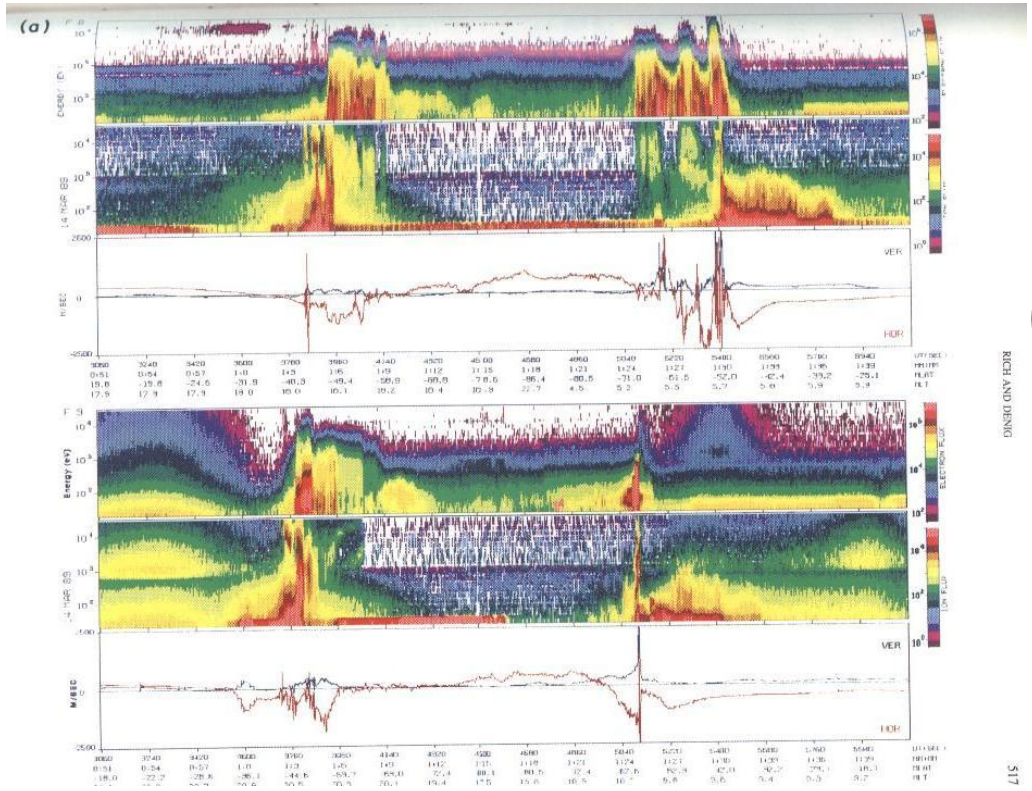
Super Dual Auroral Radar Network (SuperDARN)

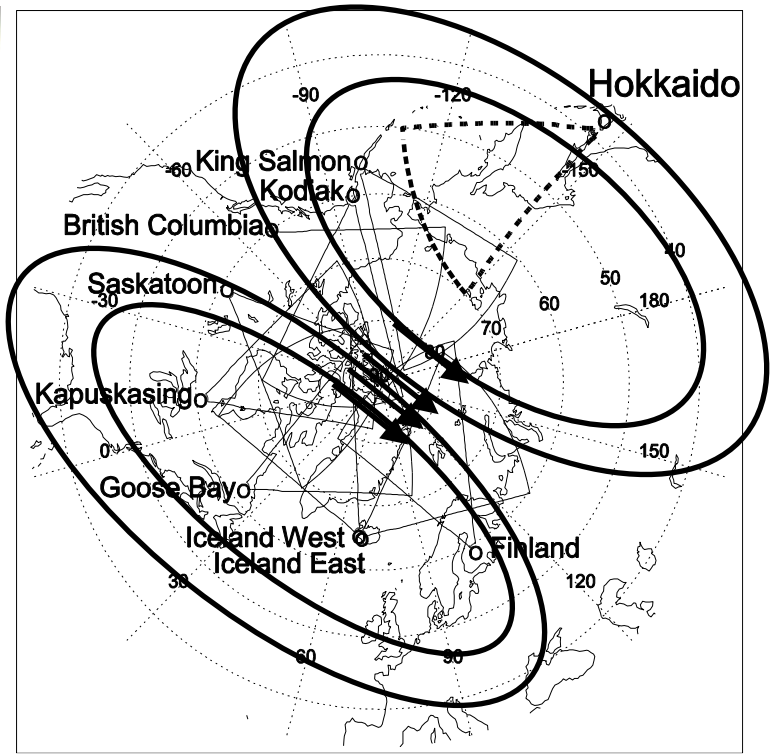


Number of operating HF radars > 35
Standard temporal resolution: 1-2 min
For details, see the mid-latitude SuperDARN review paper by Nishitani et al. (PEPS, 2019)

Convection during a historical geomagnetic storm

March 14, 1989





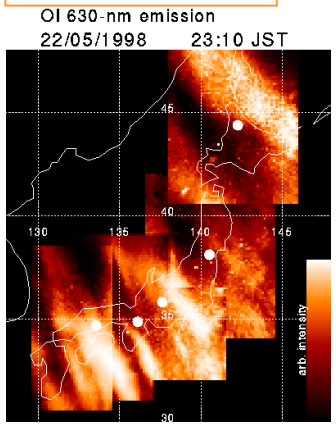
Convection cell expanded up to about 36° geomag. lat.

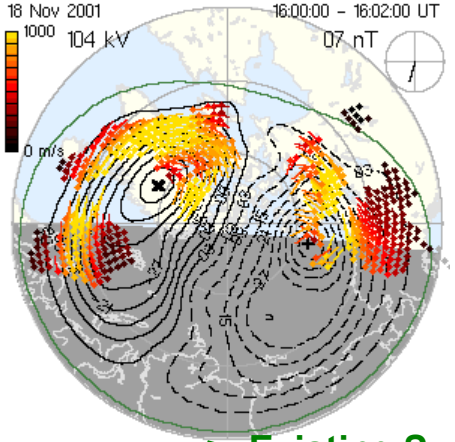
Min. Dst=-589 nT

(Rich and Deng, Can. J. Phys., 1992)

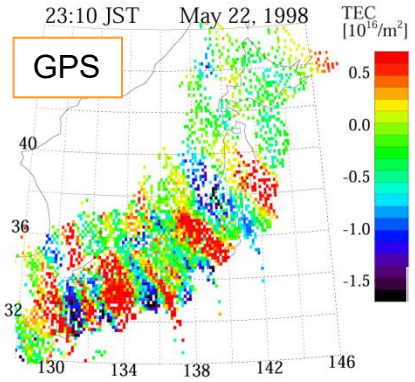
SuperDARN Hokkaido Pair of (HOP) radars (2006.11-)

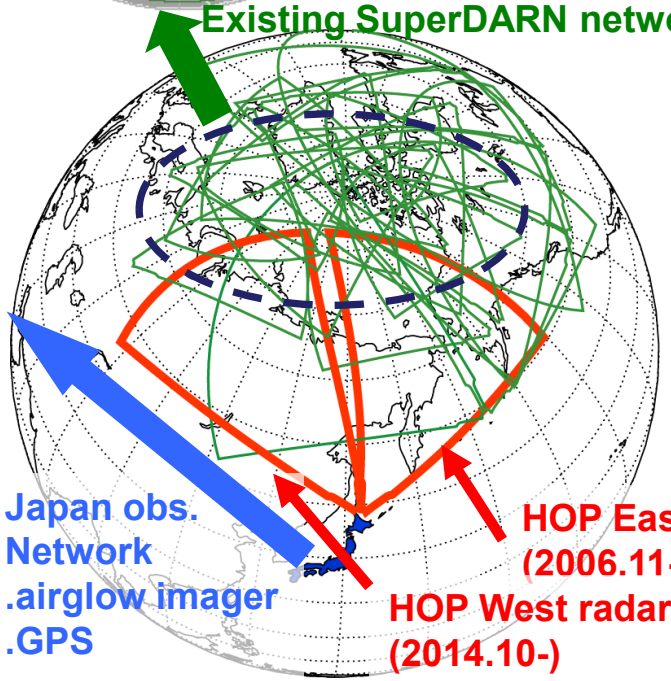
Airglow imagers

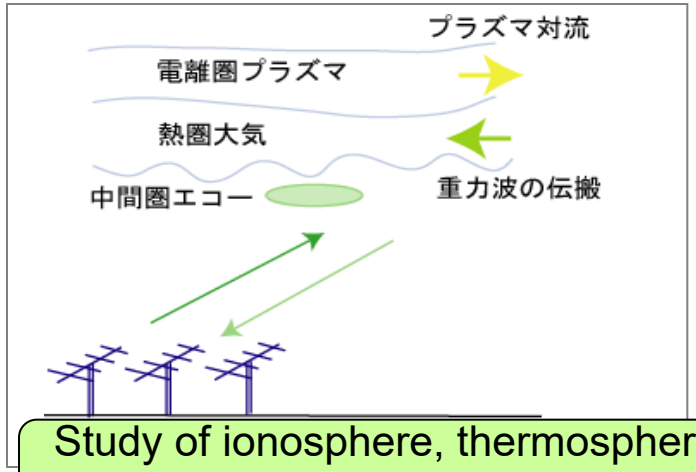




GPS



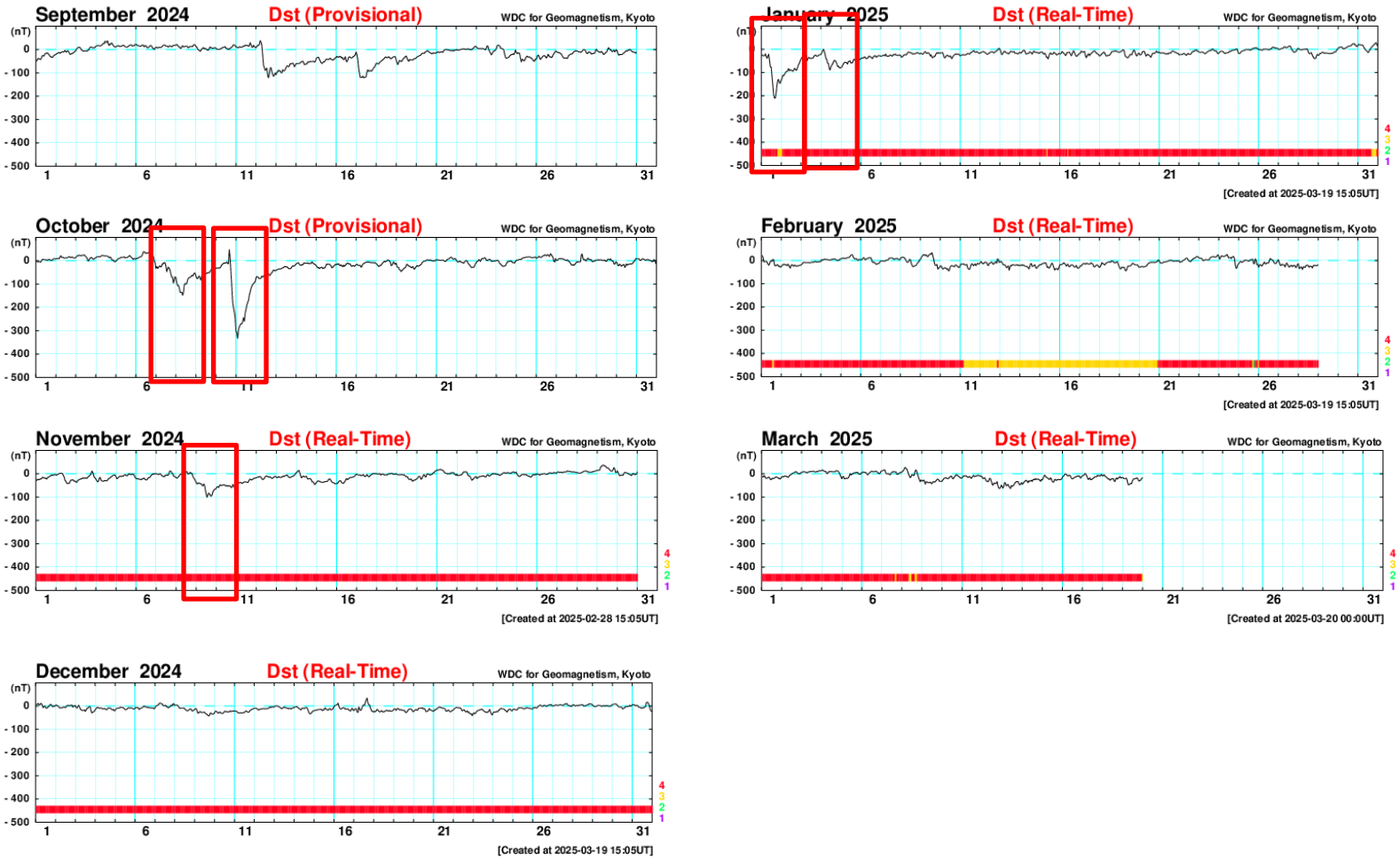




Study of ionosphere, thermosphere and upper mesosphere

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

Dst variations (2024.09-2025.03, provisional/real-time data)



Kyoto Univ WDC

Real-time (Quicklook) Dst Index

https://wdc.kugi.kyoto-u.ac.jp/dst_realtime/202405/index.html

Search

Most Visited | Google | このページを編集する | SuperDARN Worksho... | SuperDARN Worksho... | Midlatitude SuperDAR... | ERG-SuperDARN Conj... | Conclusions | テレワーク実施計画・管... | SuperDARN Data Polic... | Other Bookmarks

Link to Data Center Top Page , Top Page , Last Month , Next Month

[Updated at 2024-07-03 15:05UT]

(The data for this month in the wdc-like format is here.)

Dst index (WDC@Kyoto University

During the storm, most of the SuperDARN radars suffered disappearance of echoes, except for some radars such as in Japan (Hokkaido East/West) and in China.

WDC for Geomagnetism, Kyoto
Hourly Equatorial Dst Values (REAL-TIME)
MAY 2024

unit=nT

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	UT 24
1	-27	-33	-28	-15	-14	-14	-17	-14	-10	-9	-11	-11	-12	-13	-14	-9	-4	1	-2	1	5	1	2	-1
2	-2	-2	6	5	3	2	-4	-4	2	7	5	-4	-9	-19	-21	-54	-78	-74	-85	-93	-96	-77	-56	-63
3	-64	-60	-54	-62	-61	-60	-59	-54	-47	-44	-41	-38	-37	-37	-40	-37	-34	-33	-33	-36	-35	-32	-29	-27
4	-26	-25	-14	-21	-20	-19	-19	-18	-18	-19	-18	-15	-15	-19	-22	-21	-18	-15	-12	-12	-16	-18	-14	-8
5	-4	-5	-3	-8	-14	-17	-17	-9	-1	-2	0	6	12	11	11	12	11	10	11	6	-8	-28	-44	-50
6	-41	-50	-42	-42	-42	-38	-29	-26	-18	-14	-10	-10	-7	-8	-13	-9	-11	-14	-15	-17	-20	-20	-19	-16
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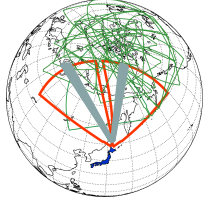
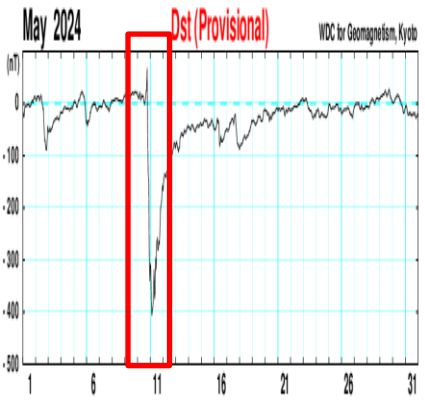
11	-322	-397	-412	-403	-399	-369	-332	-384	-373	-306	-326	-274	-264	-287	-292	-275	-277	-253	-206	-202	-197	-179	-169	-178
12	-159	-149	-141	-145	-148	-154	-144	-142	-140	-122	-111	-114	-114	-112	-112	-106	-103	-98	-89	-86	-83	-86	-98	-92
13	-83	-83	-89	-96	-102	-96	-96	-77	-71	-67	-65	-67	-65	-72	-68	-61	-61	-60	-58	-55	-55	-53	-55	-56
14	-53	-55	-55	-58	-55	-52	-53	-53	-54	-58	-59	-59	-60	-56	-56	-54	-48	-46	-48	-48	-48	-48	-50	-51
15	-50	-48	-46	-47	-42	-40	-45	-45	-42	-41	-44	-50	-52	-52	-52	-50	-46	-42	-35	-36	-43	-52	-56	-59

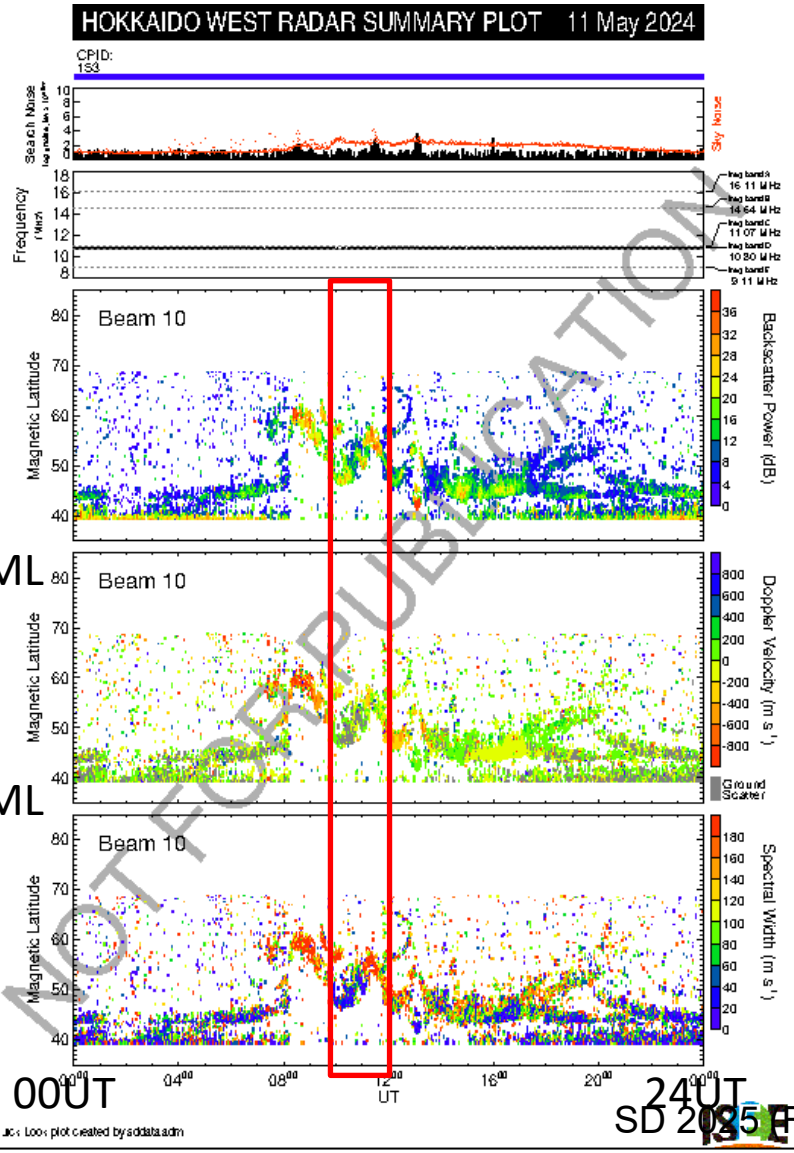
May 11, 2024

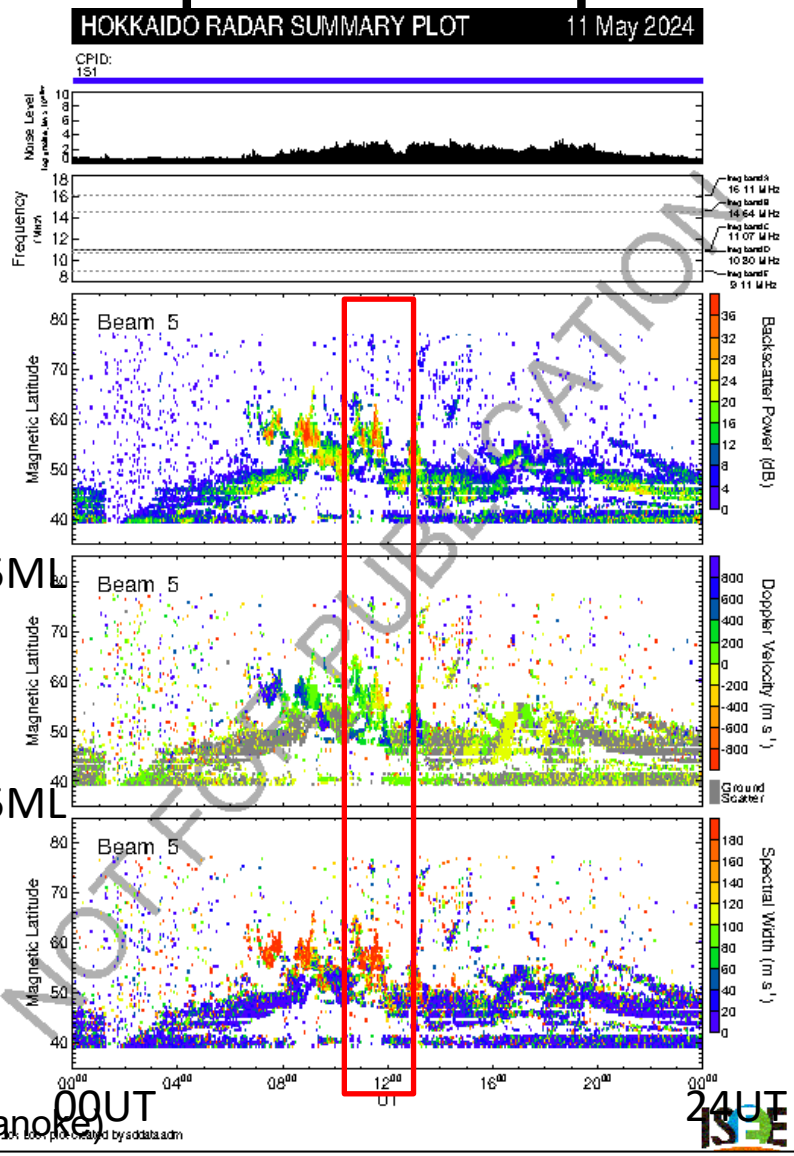
LT=UT+9 hrs

Hokkaido West / East quicklook plots

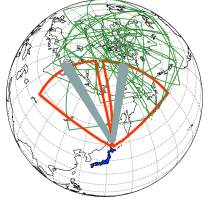








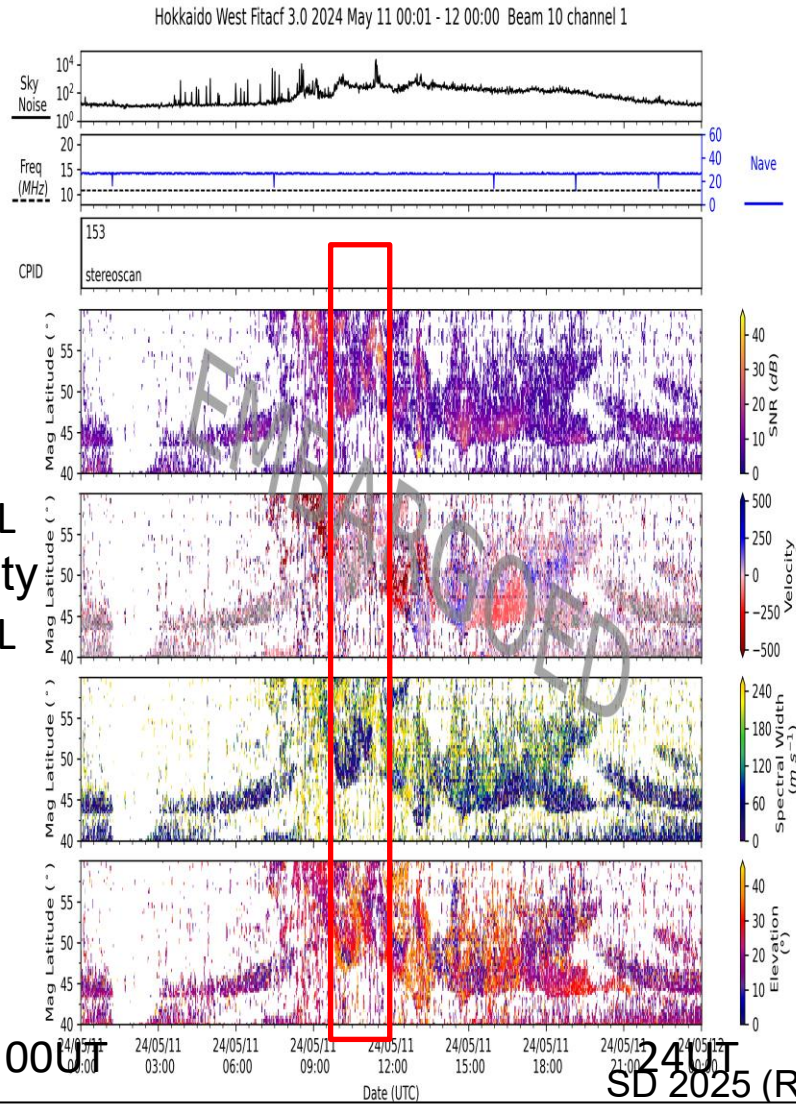
SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

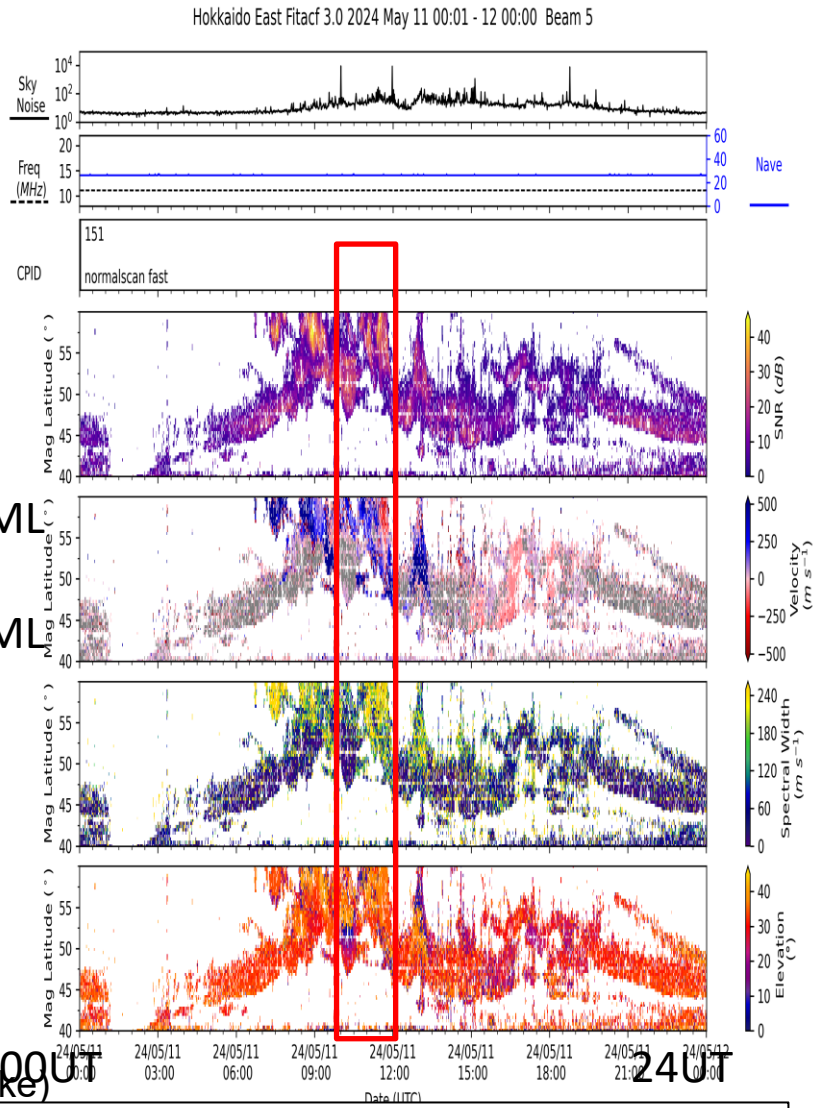


May 11, 2024

LT=UT+9 hrs

Hokkaido West / East quicklook plots





60 ML
LOS velocity
40 ML

60 ML
40 ML

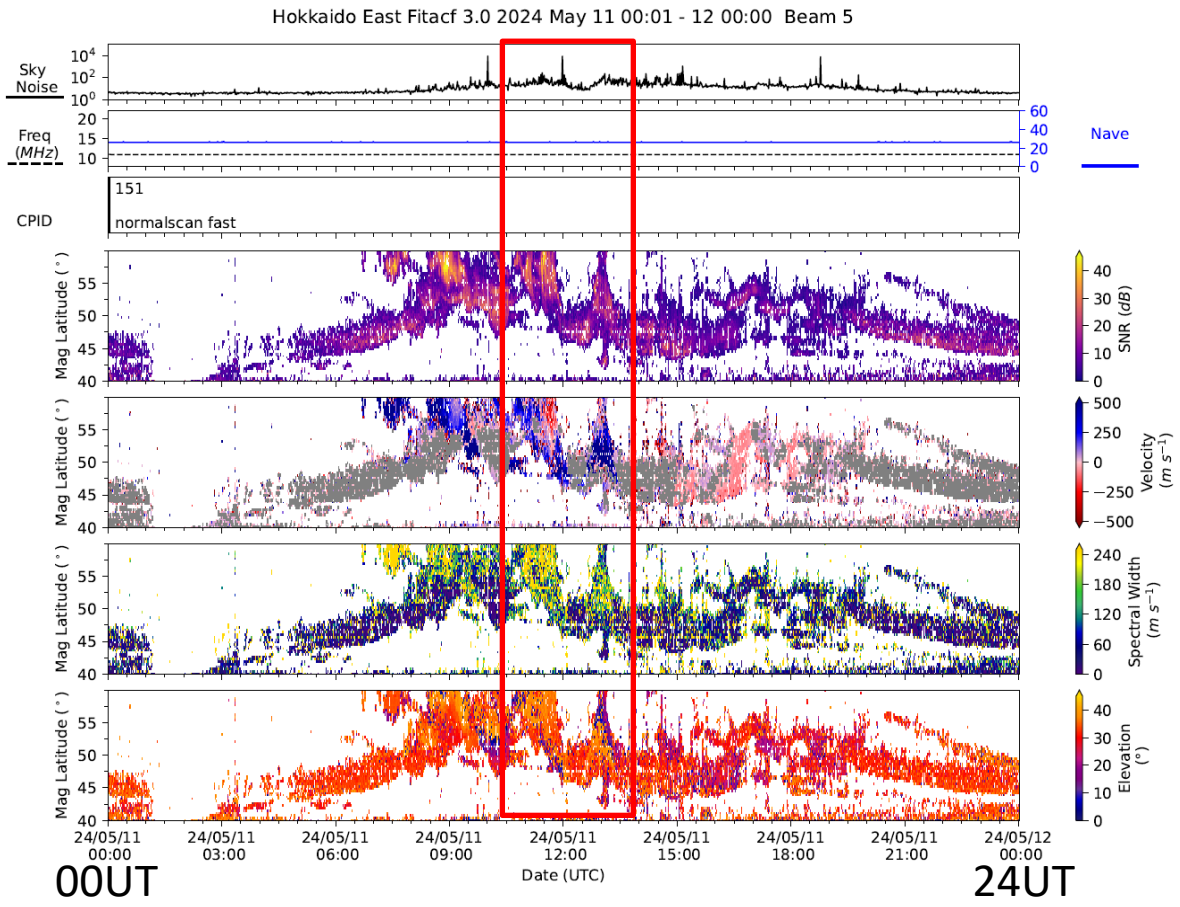
LOS velocity

00UT 24UT

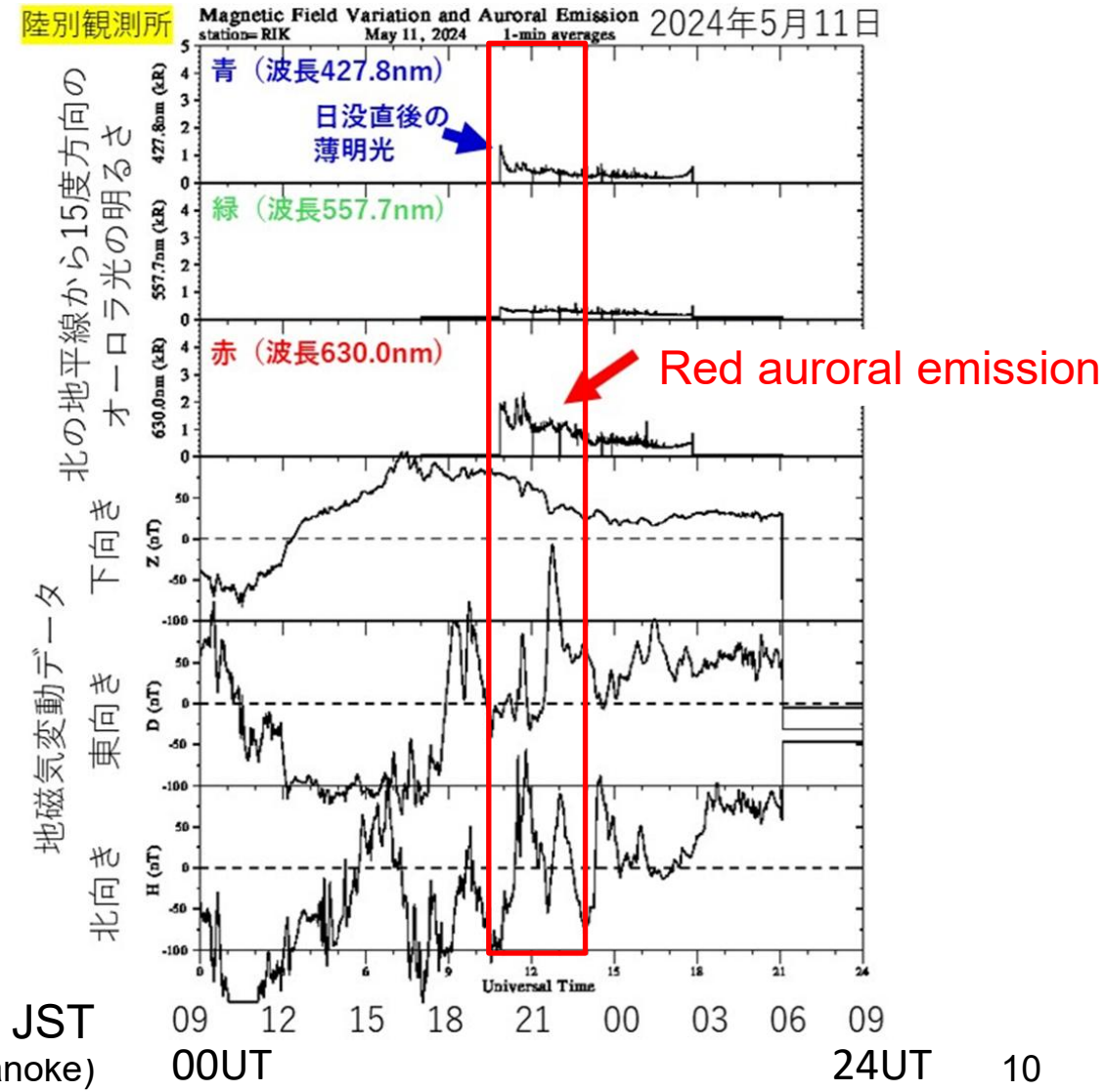
00UT 24UT

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

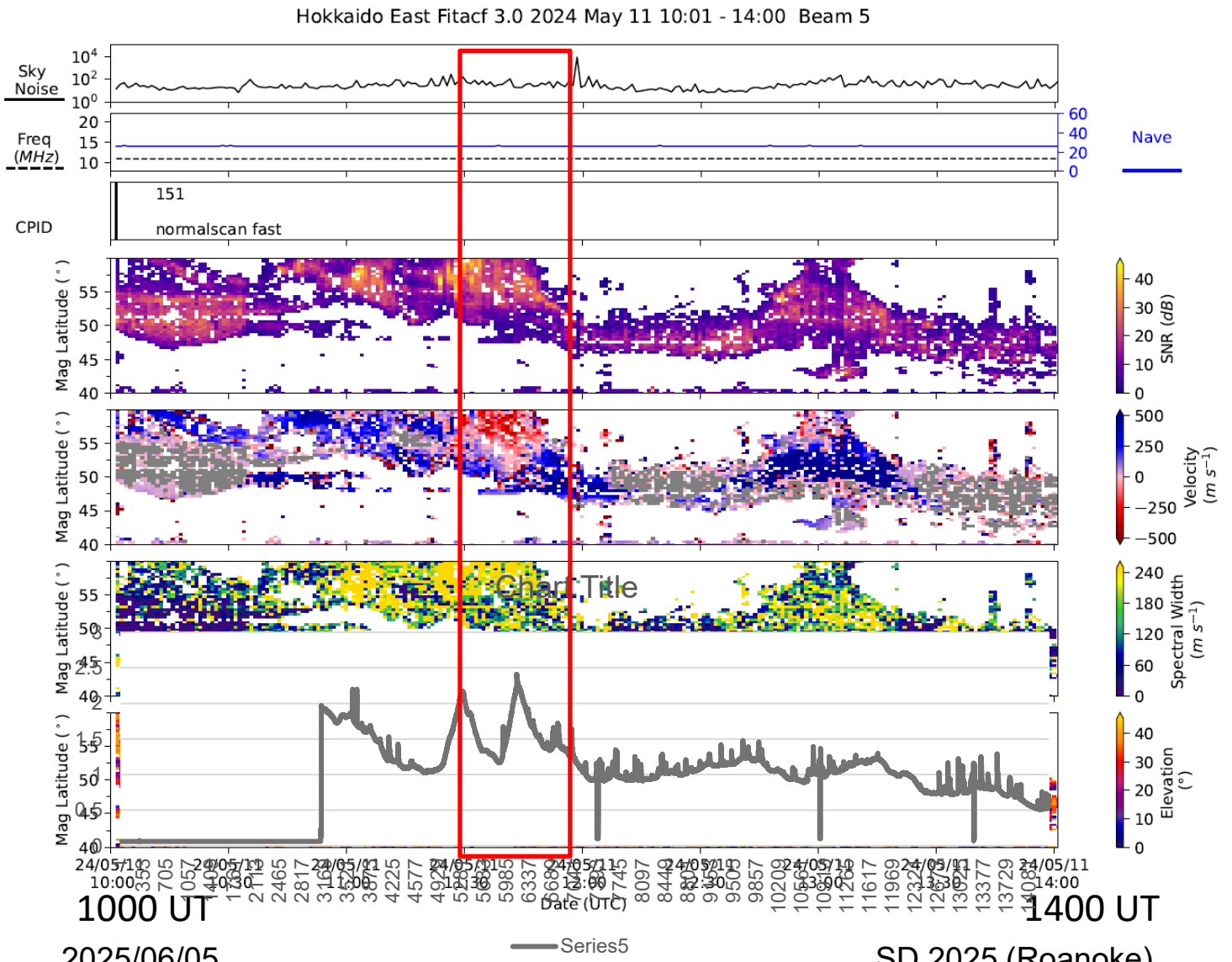
SuperDARN HOK summary plot / auroral emission observed by the Rikubetsu fixed photometer

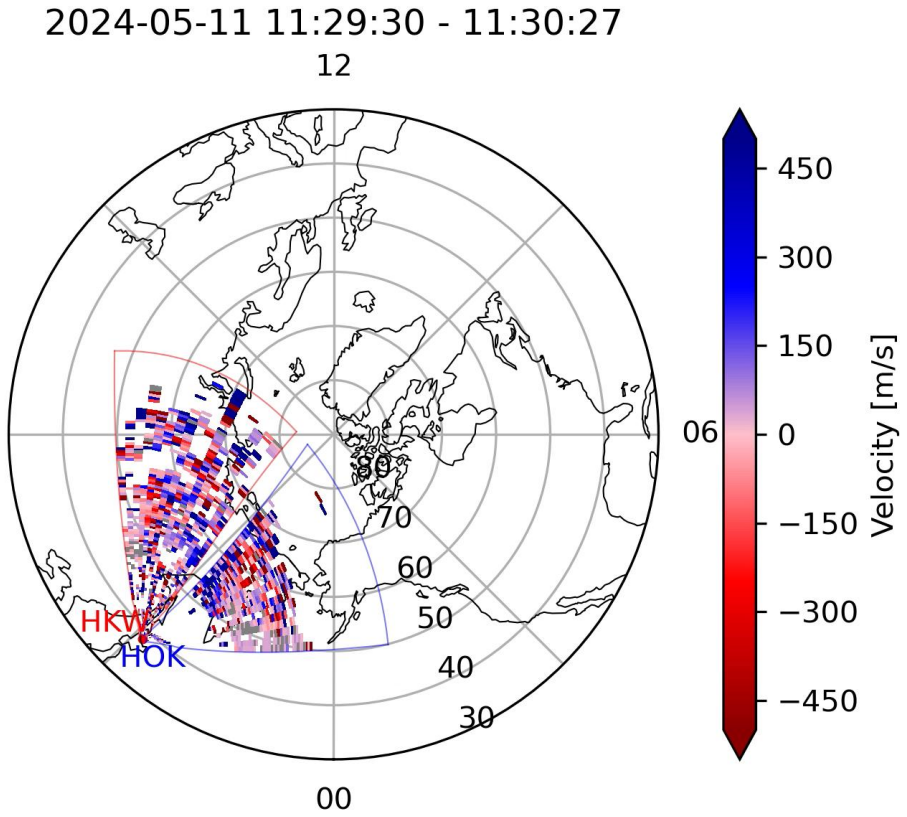


00UT 24UT



HOK summary plot for 10-14 UT, 11 May

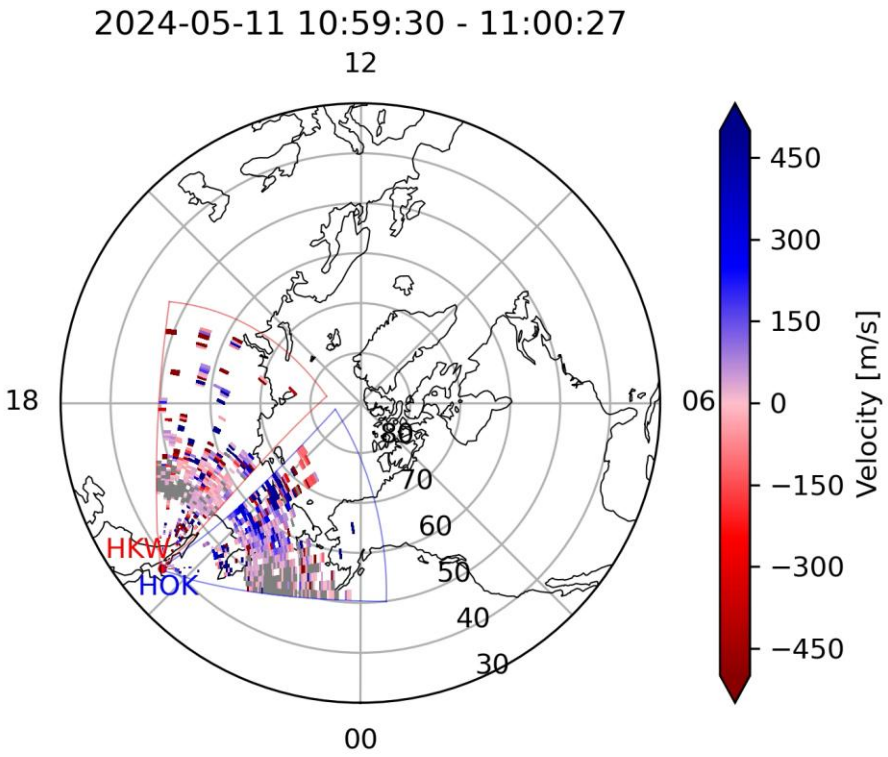




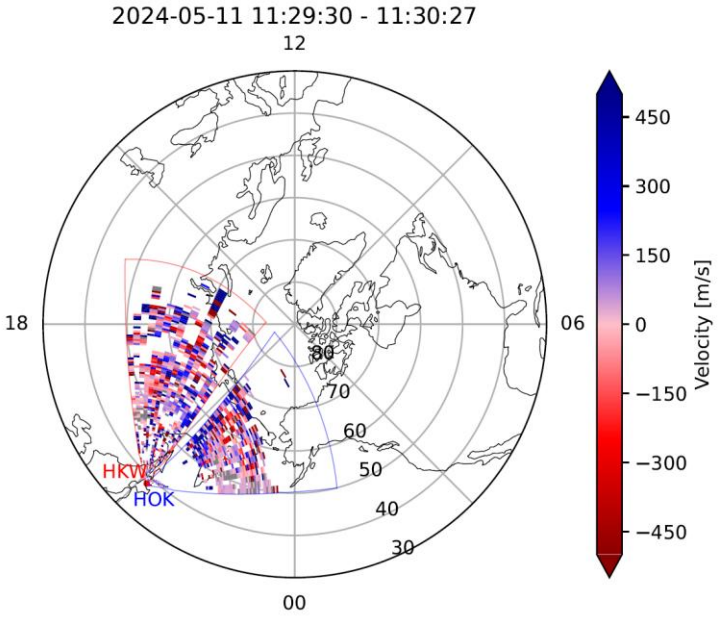
1000 UT

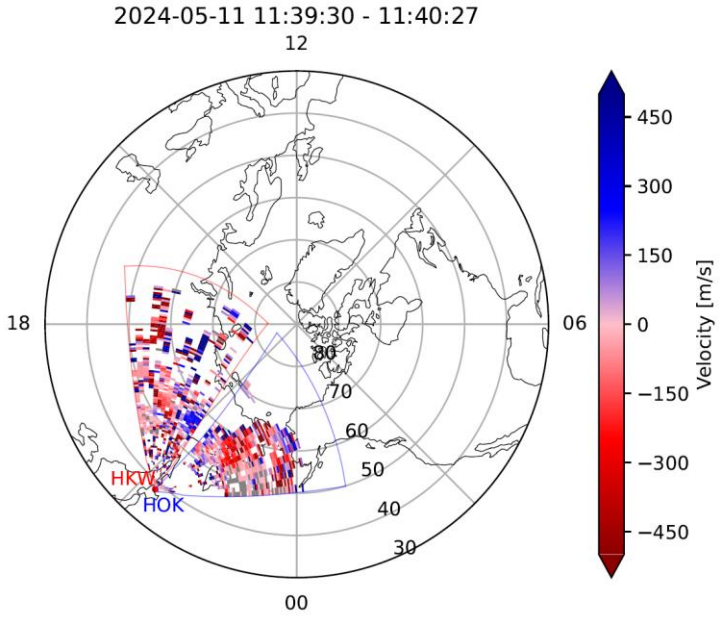
1400 UT

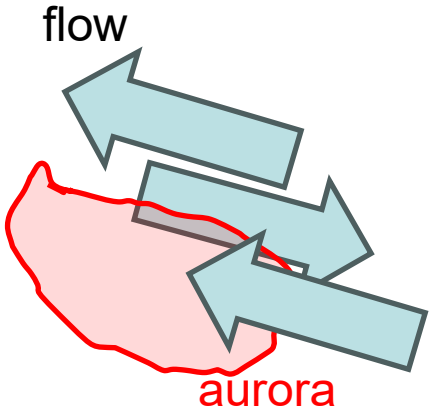
May 2024 storm: camera vs SuperDARN



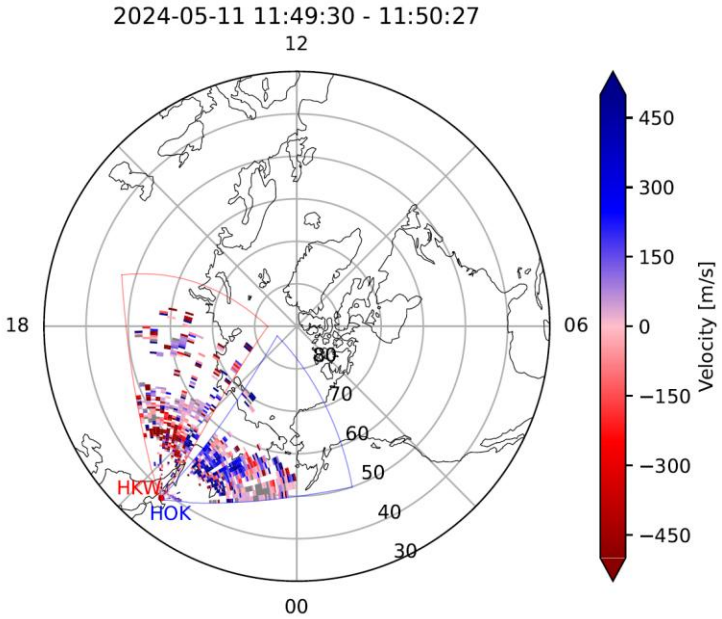
2-D LOS v plots during 1130-1200 UT

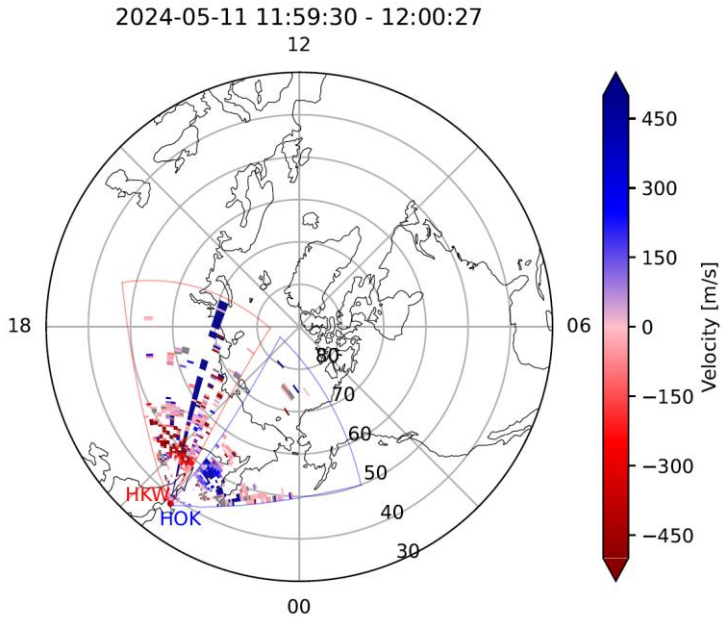






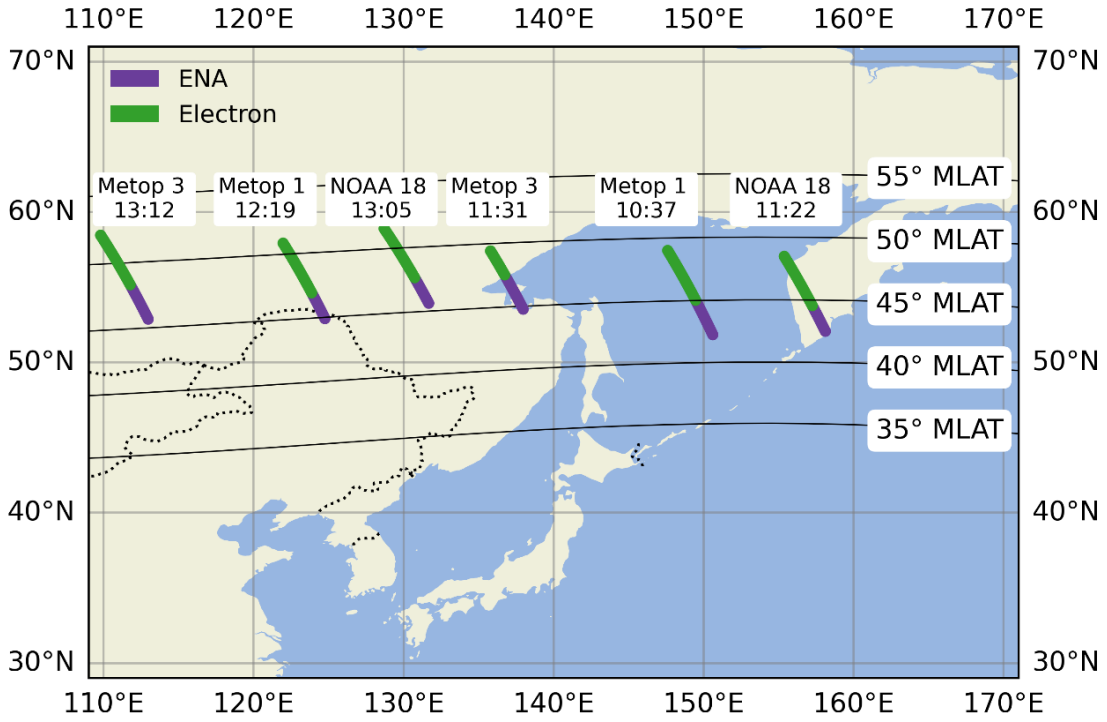
20.5- 21.0 LT





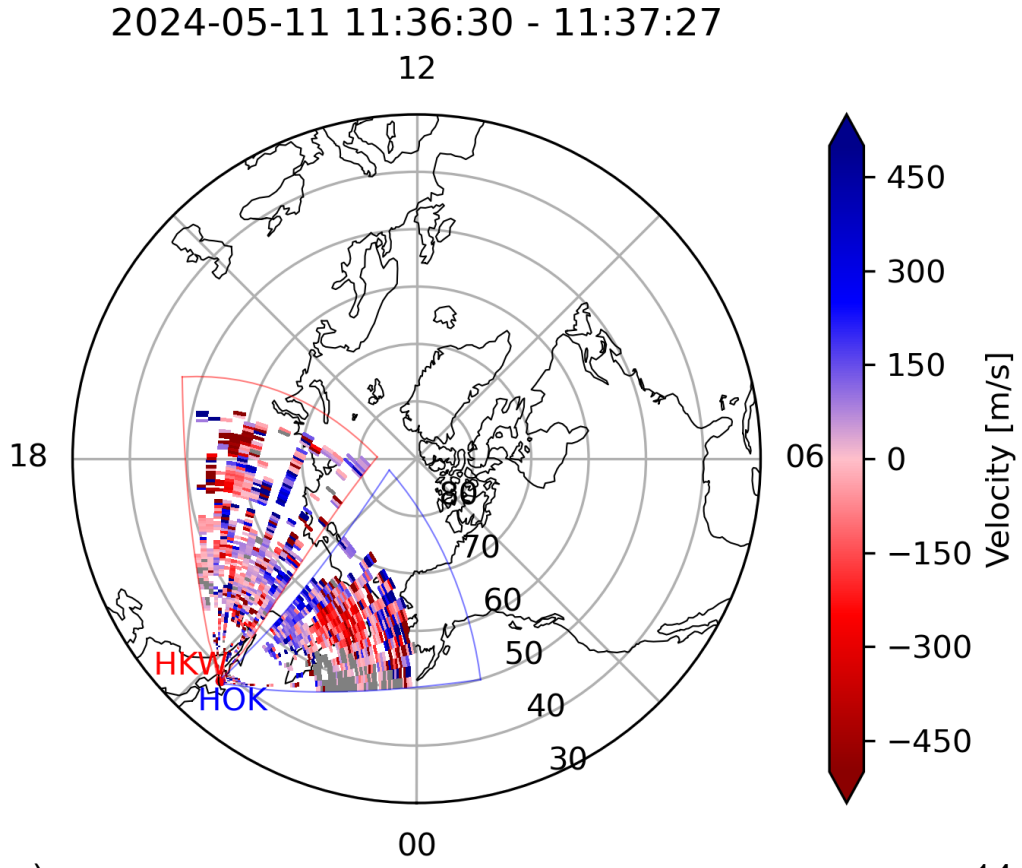
Comparison with NOAA/Metop data

Kataoka et al. (Sci. Rep., 2024)



MLAT using CGM

Electron boundaries converted to AACGM-v2 coords.



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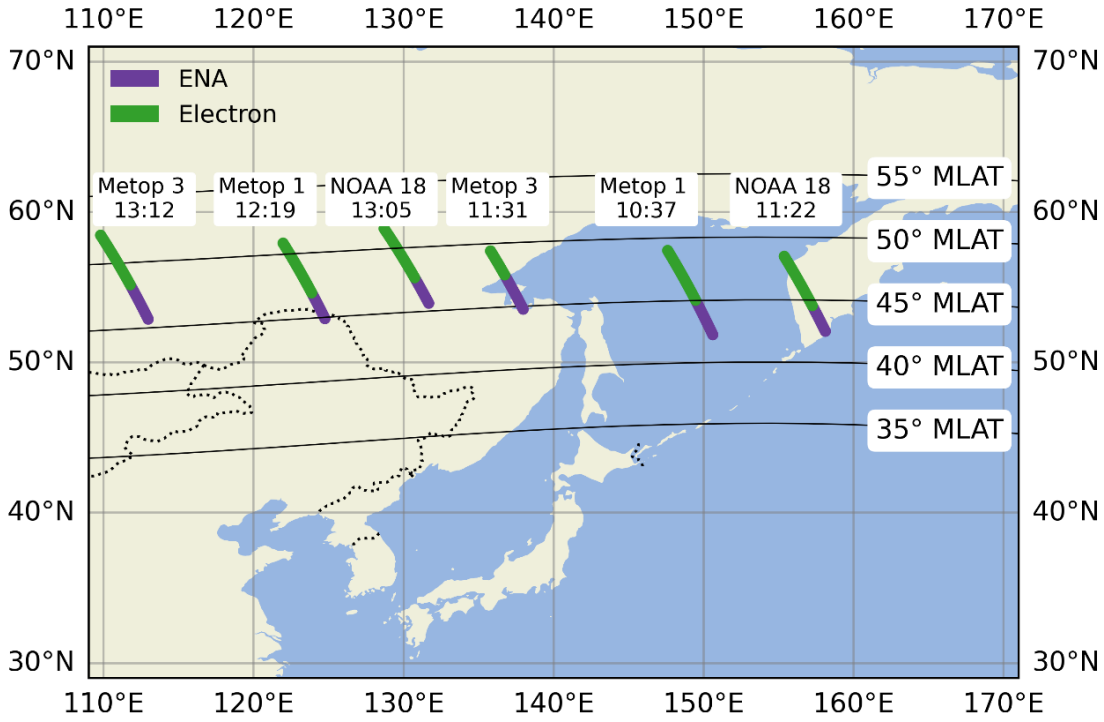
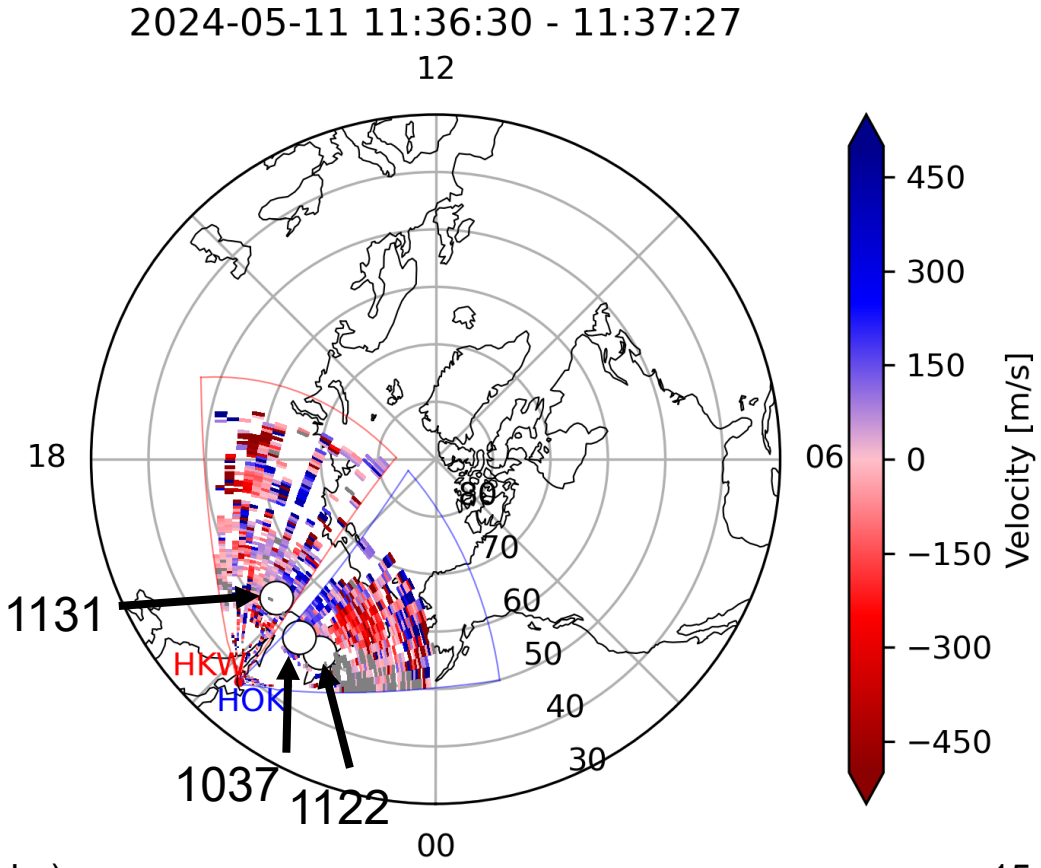
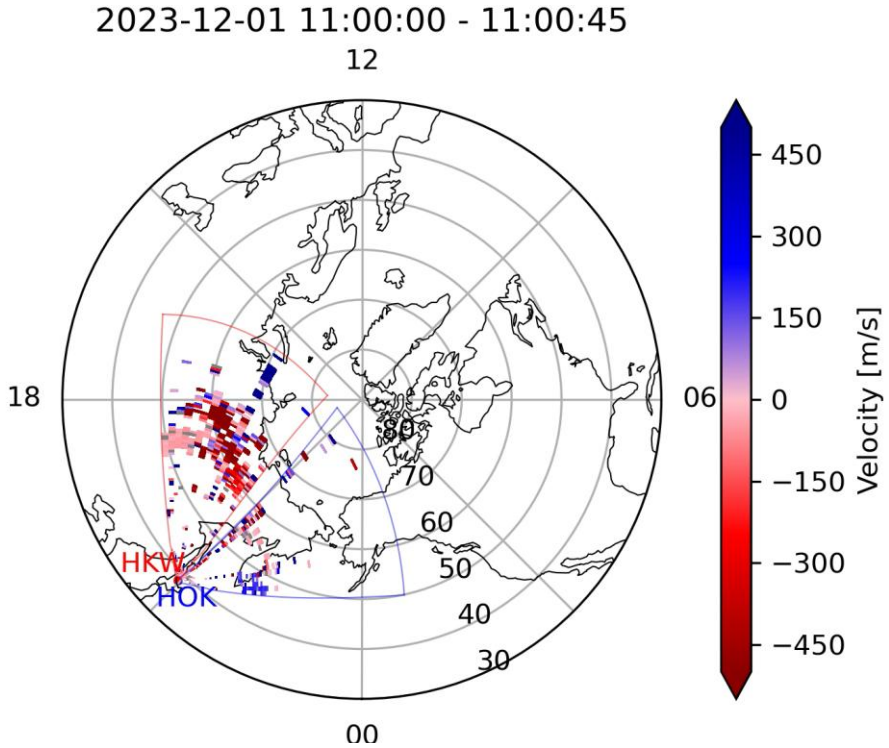


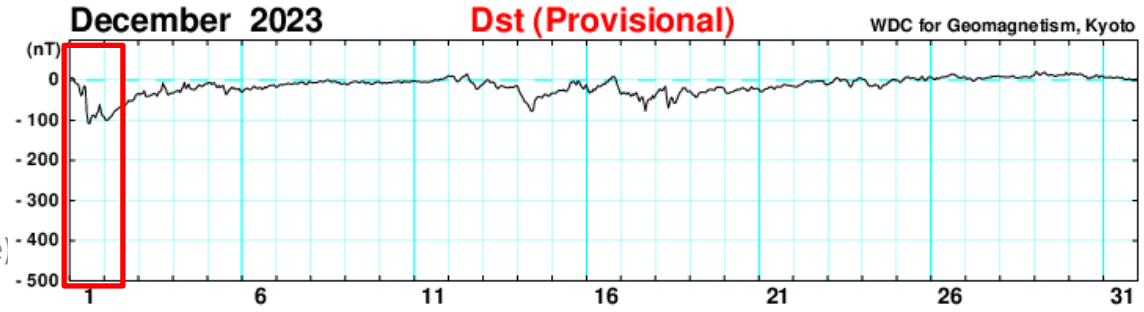
MLAT using CGM

Electron boundaries converted to AACGM-v2 coords.



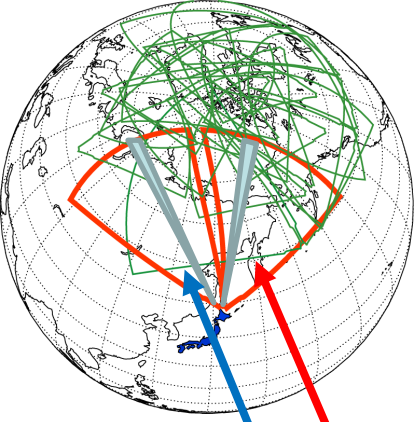
Dec 2023 storm: camera vs SuperDARN

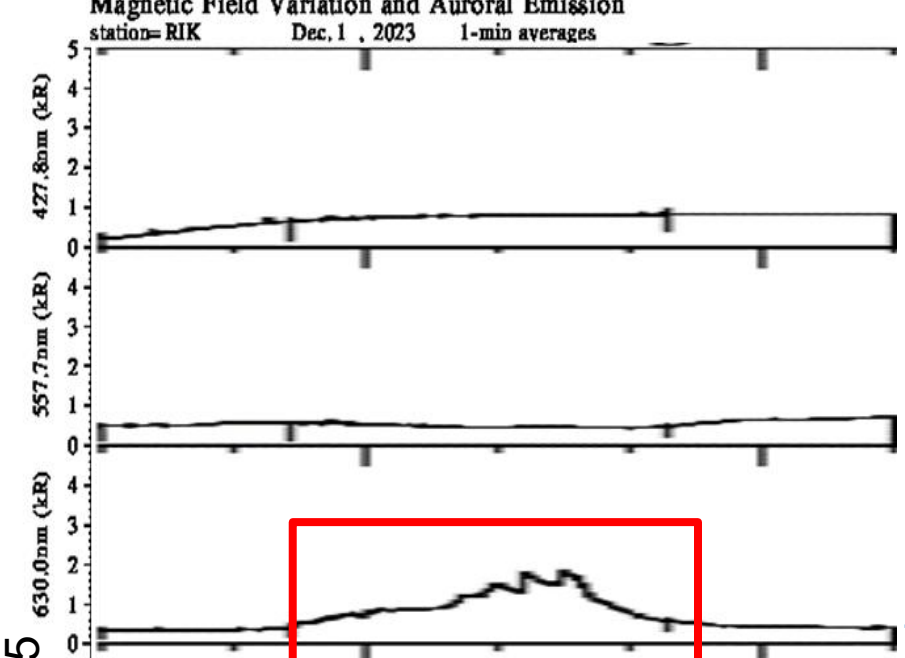


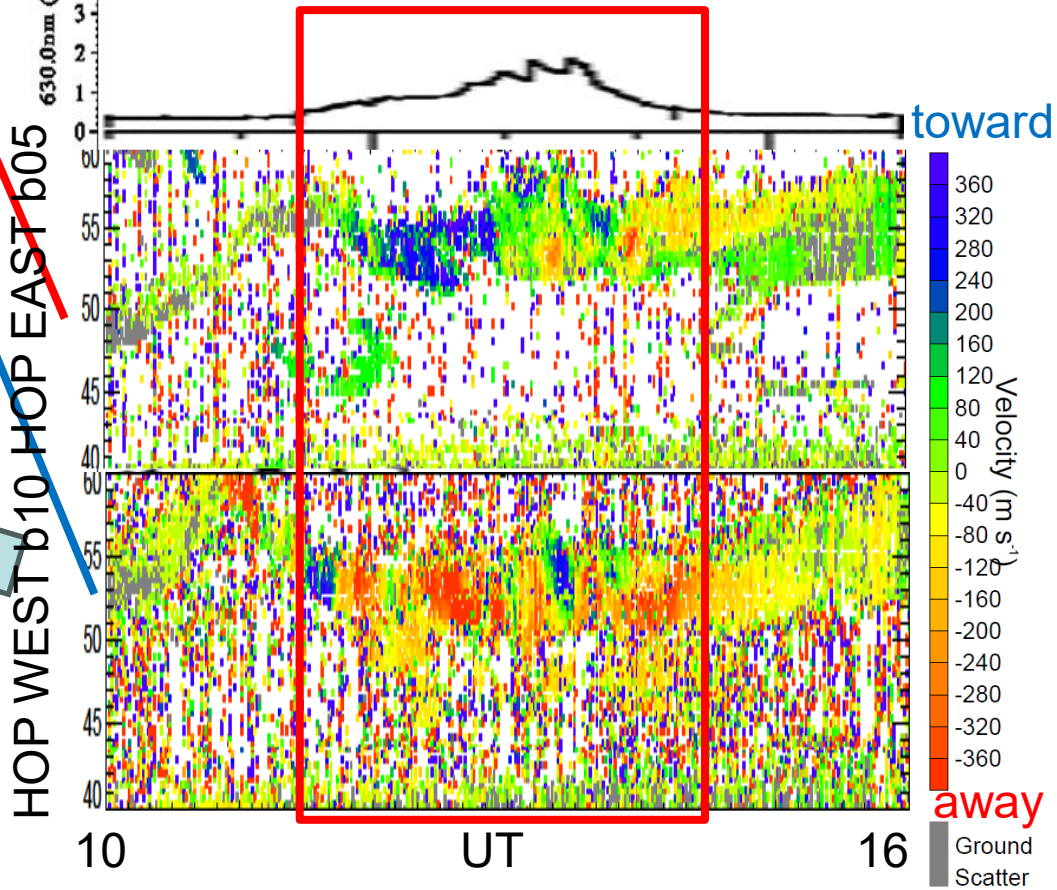


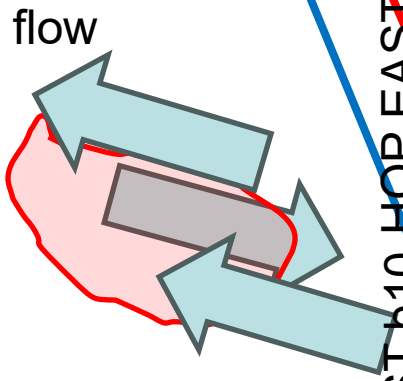
Photometer data@Rikubetsu & SuperDARN Hokkaido East (b05) / West(b10) LOS data

01-02 Dec 2023
10-16 UT (19-25 LT)





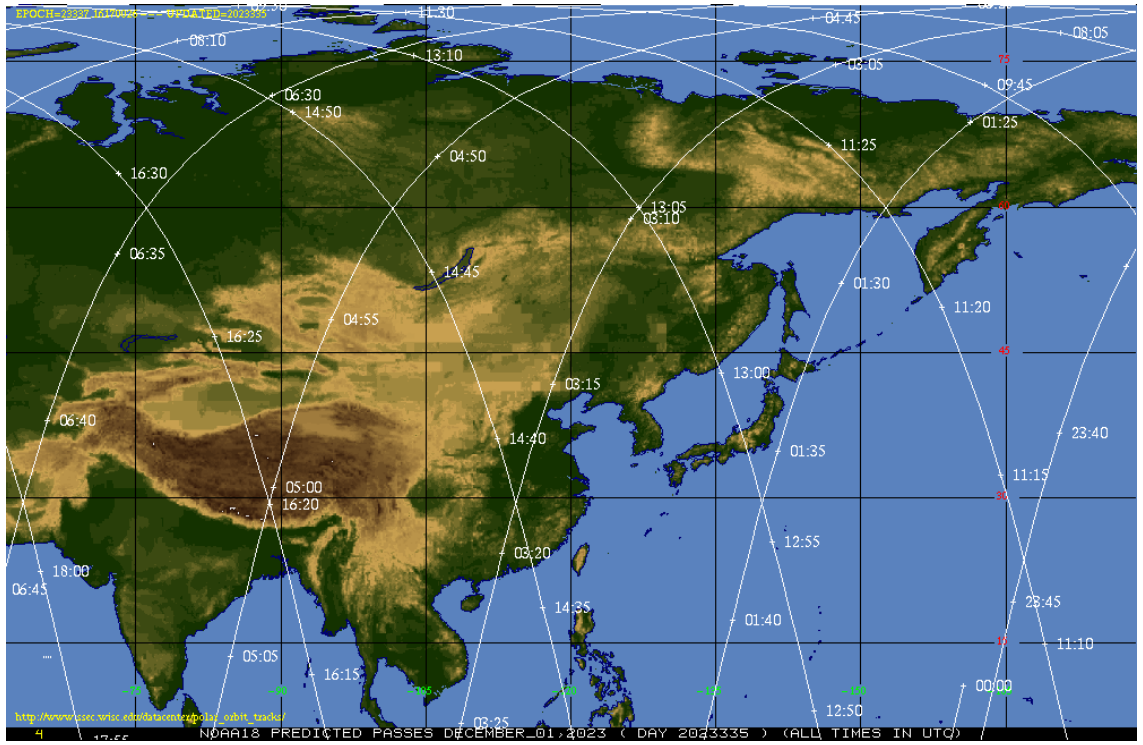




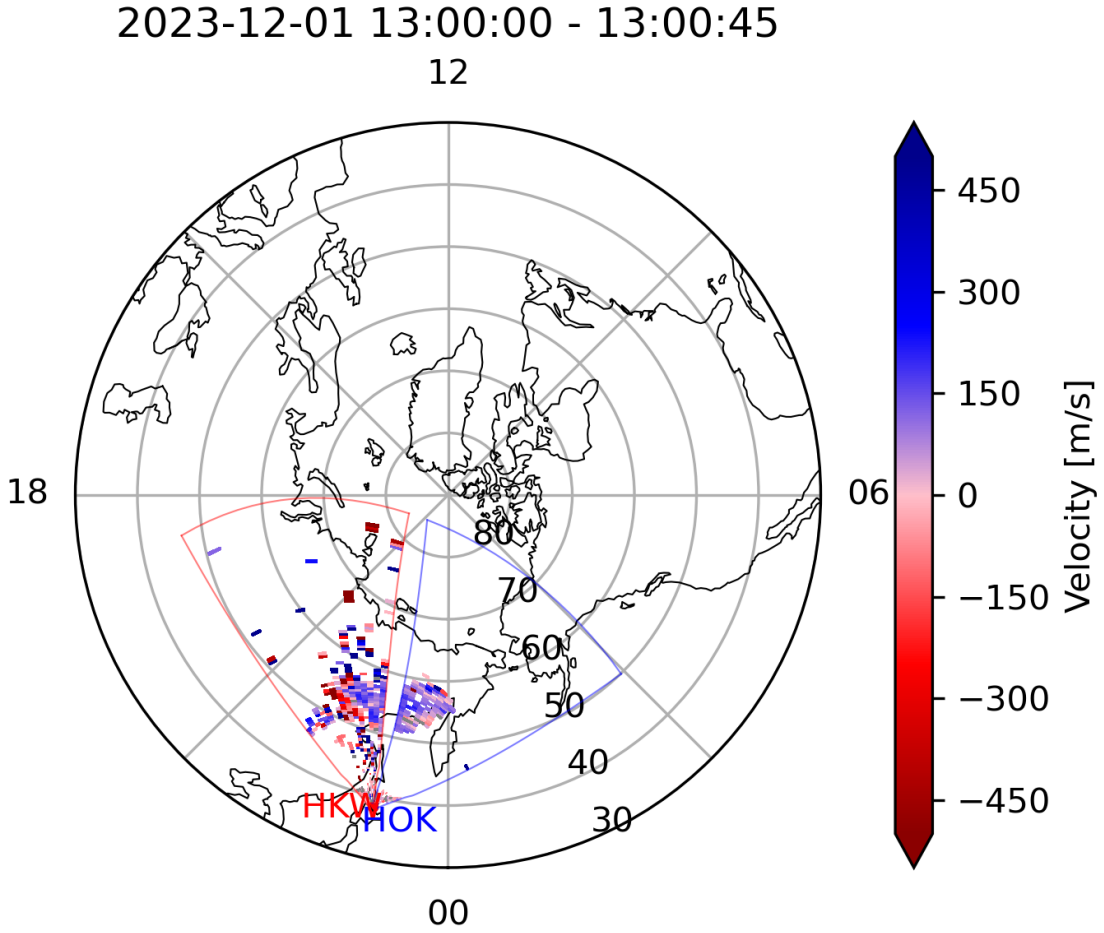
20.5-23.5 LT

Comparison with NOAA/Metop data

NOAA 18 orbit



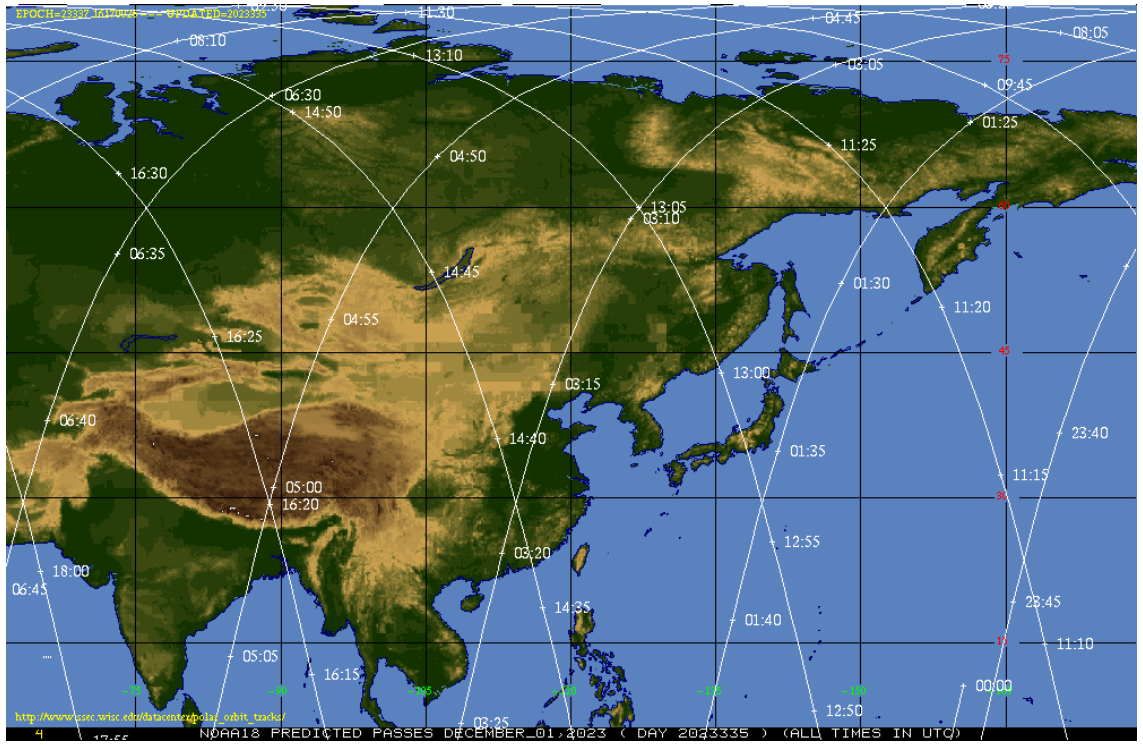
Electron boundaries converted to AACGM-v2 coords.



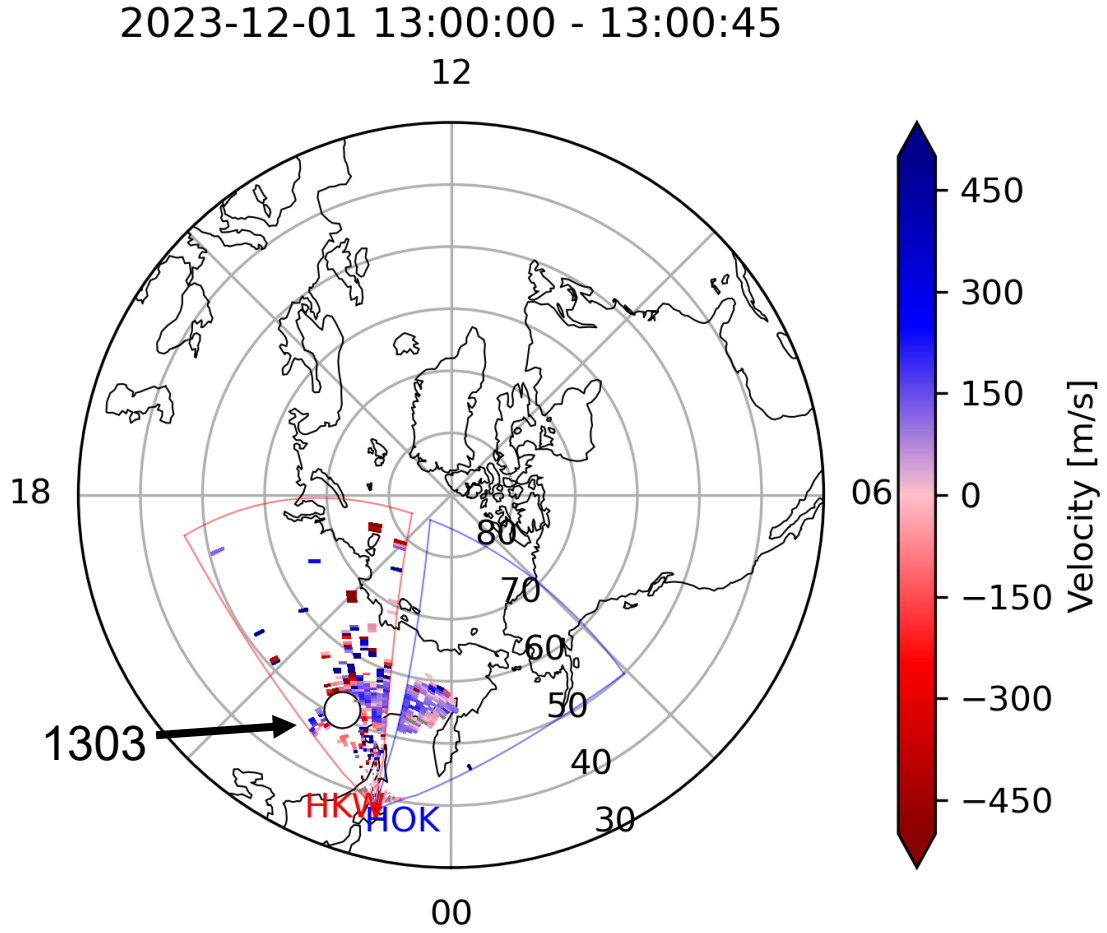
2025/06/05

Comparison with NOAA/Metop data

NOAA 18 orbit



Electron boundaries converted to AACGM-v2 coords.

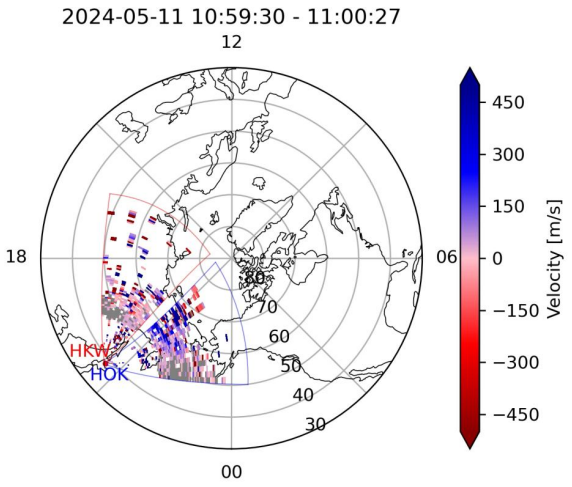


2025/06/05

Summary of major events

Date	Local time	Flow characteristics	Phase relation
01-02 Dec 2023 Dstmin=-108 nT @13-14 UT	20.5-23.5 LT	Enhancement of sheared flows	Obviously related, although complicated
05-06 Nov 2023 Dstmin=-172 nT @19-20 UT	2.0-4.0 LT	Enhancement of sheared flows	In phase between the convection / auroral luminosity enhancements
17-18 Mar 2015 Dstmin=-234 nT @22-23 UT	0.0-2.0 LT	Enhancement of sheared flows	Some phase difference although the characteristic period is the same
10 May 2024 11 May 2024 Dstmin=-412 nT @02-03 UT	~4.0 LT 20.0-21.0 LT	Enhancement of sheared flows	Obviously related, although complicated

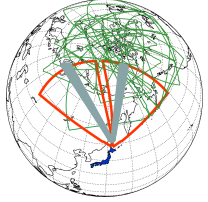
Summary



- During the May 2024 storm event, we detected a shear of flows strongly correlated with the low-latitude auroral emission on 10-12 May 2024. This is consistent with other previous huge geomagnetic storm events (e.g., Dec 1, 2023).
- There is a certain relationship between the auroral emission and the convective flow variations, indicating the important role of electric field structure (and electric current system), which was not seriously considered in the past literature.

  The flow regions were located both poleward and equatorward of the electron precipitation boundary.

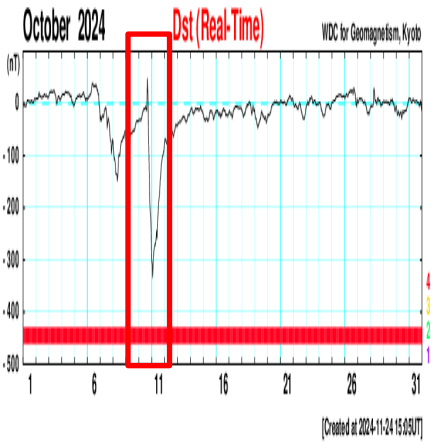
  The flow region expanded up to about 47 degs ML. This is not so low for minimum Dst (~-400 nT). It is probably because the HOP (HOK/HKW) radars were located in the dayside sector during the peak of the storm (2-5 UT or 11-14 LT on 11 May).
- More events (e.g., Oct 2024, Nov 2024, Jan 2025, March 2025) to come!

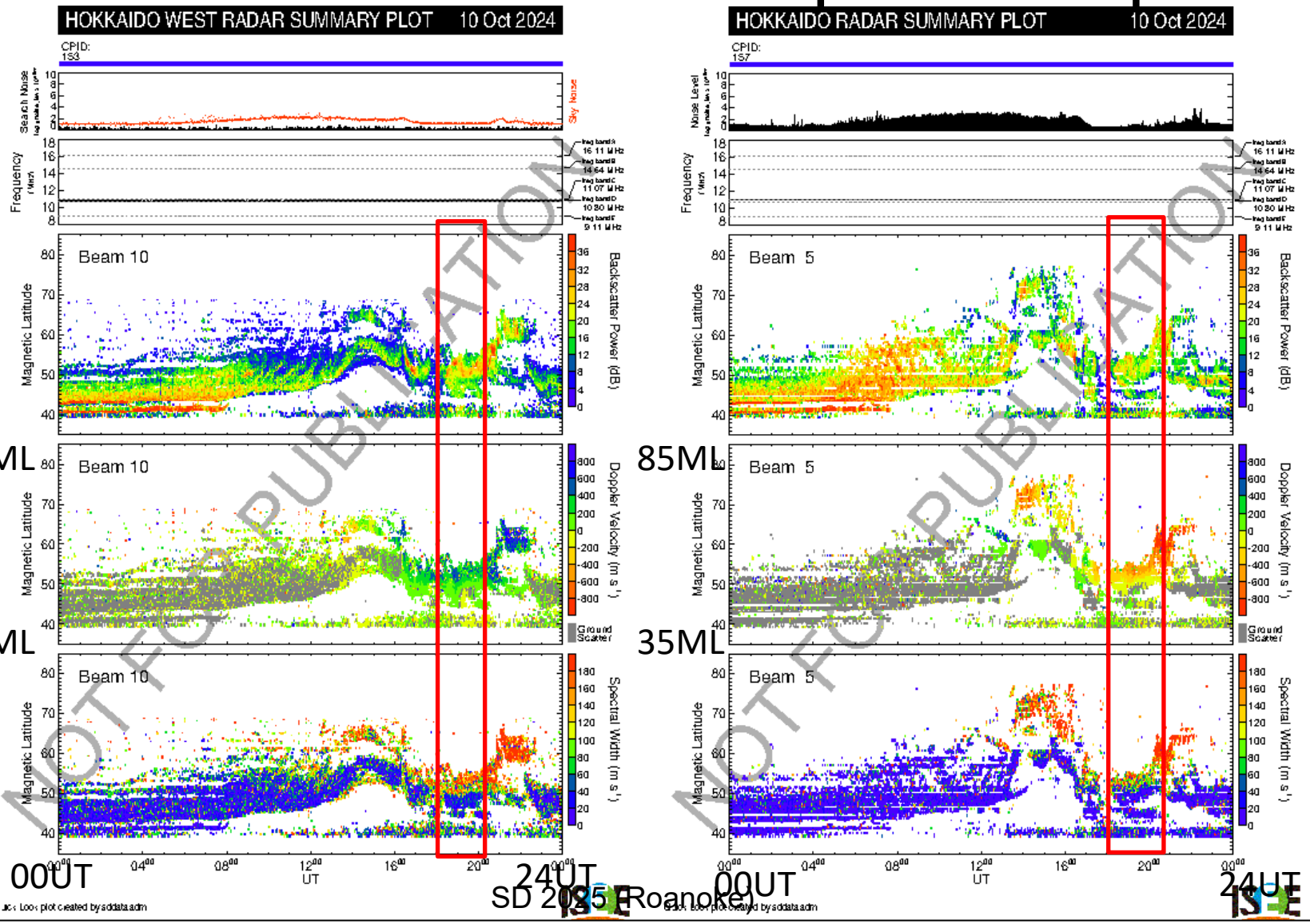


Oct 10, 2024

LT=UT+9 hrs

Hokkaido West / East quicklook plots



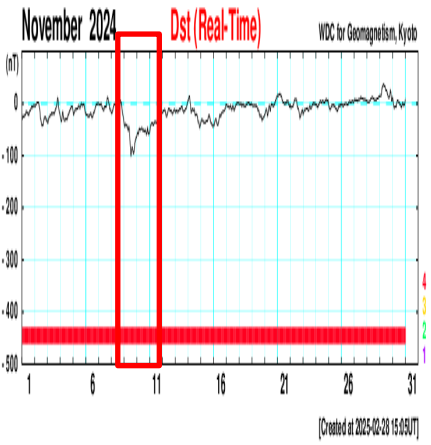


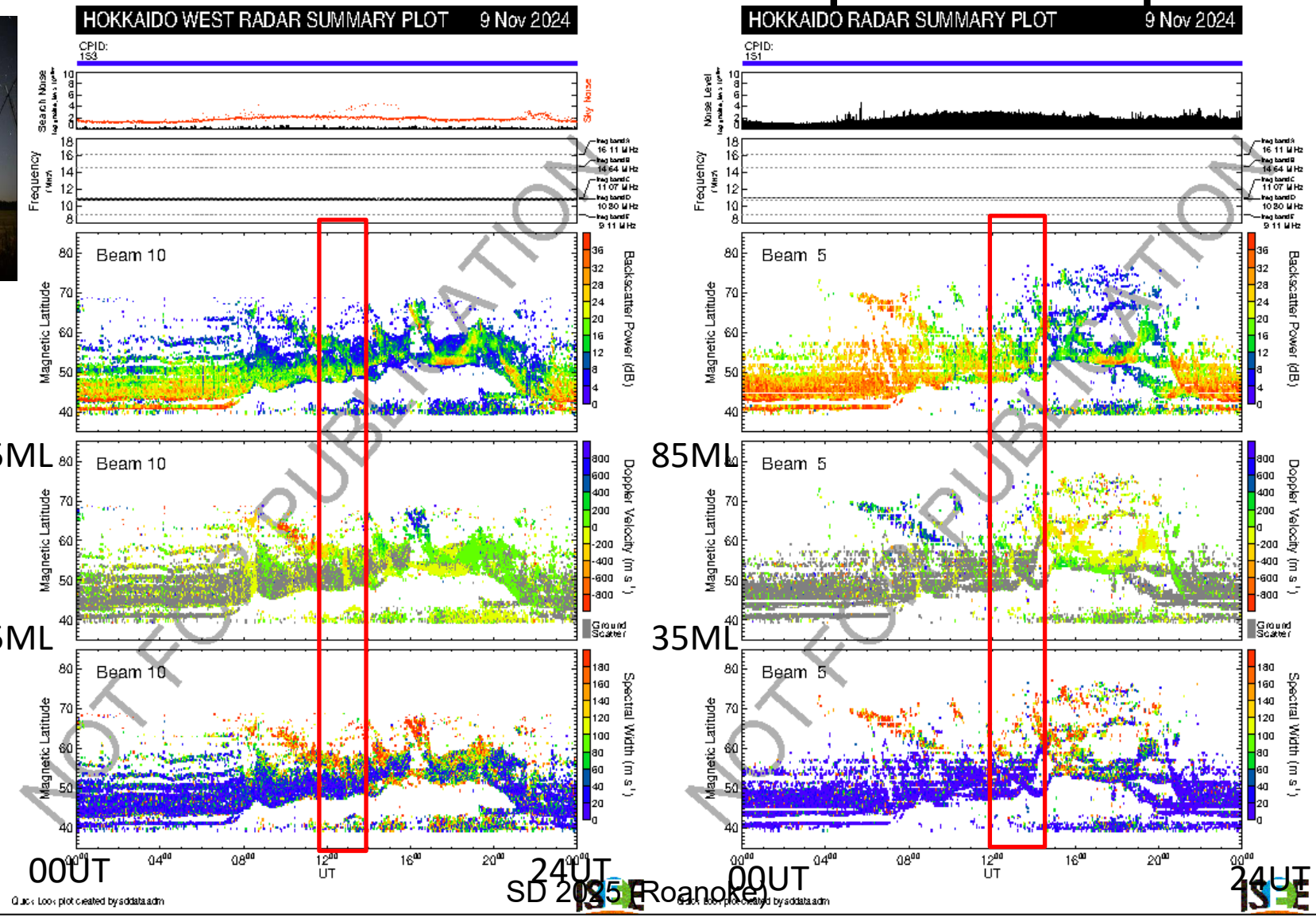
SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

Nov 09, 2024

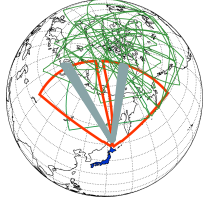
LT=UT+9 hrs

Hokkaido West / East quicklook plots





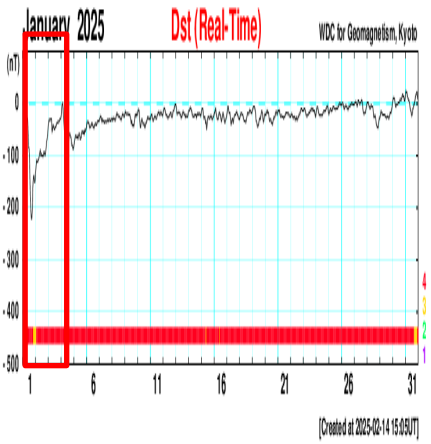
SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

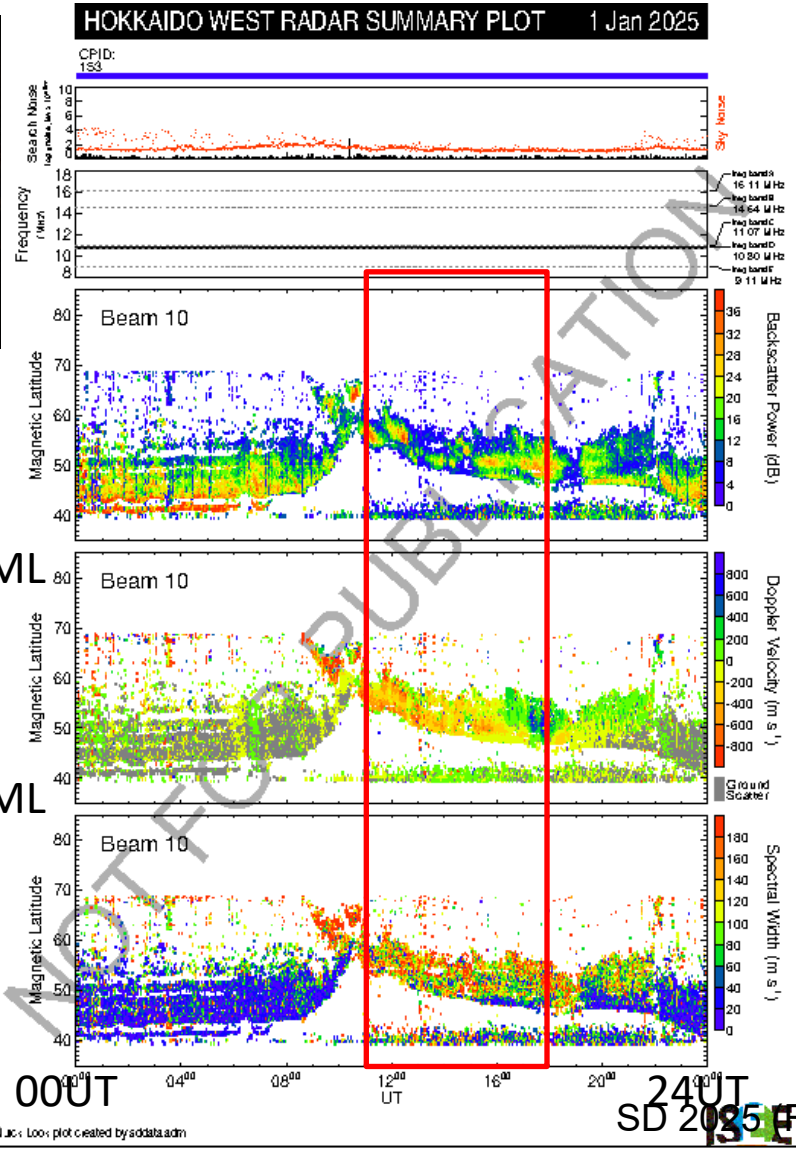


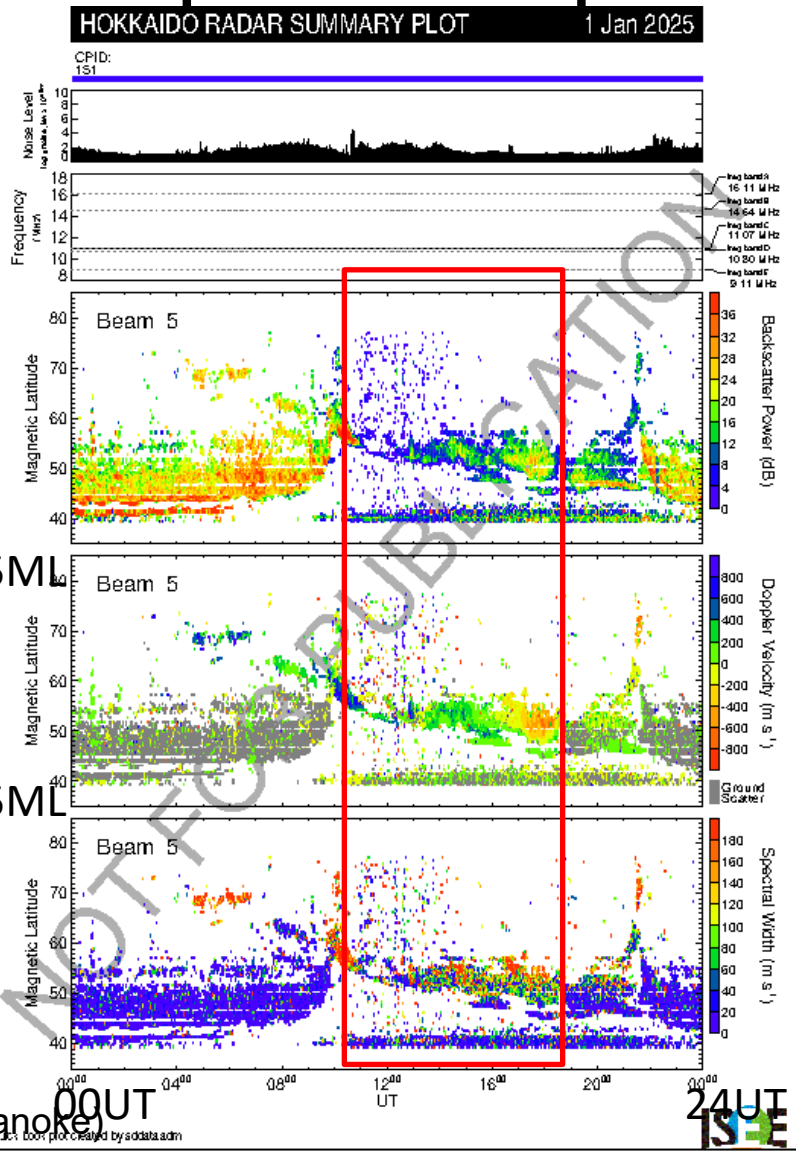
Jan 01, 2025

LT=UT+9 hrs

Hokkaido West / East quicklook plots





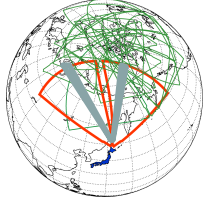


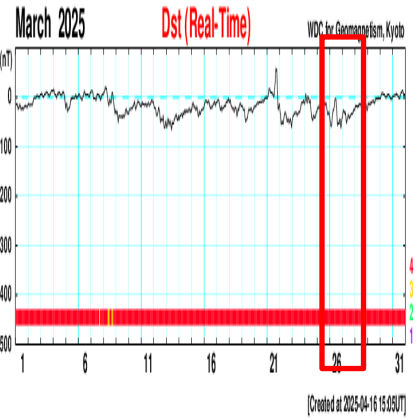
SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

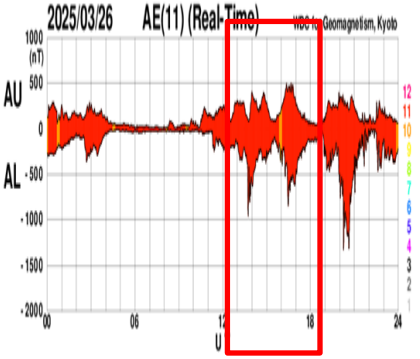
Mar 26, 2025

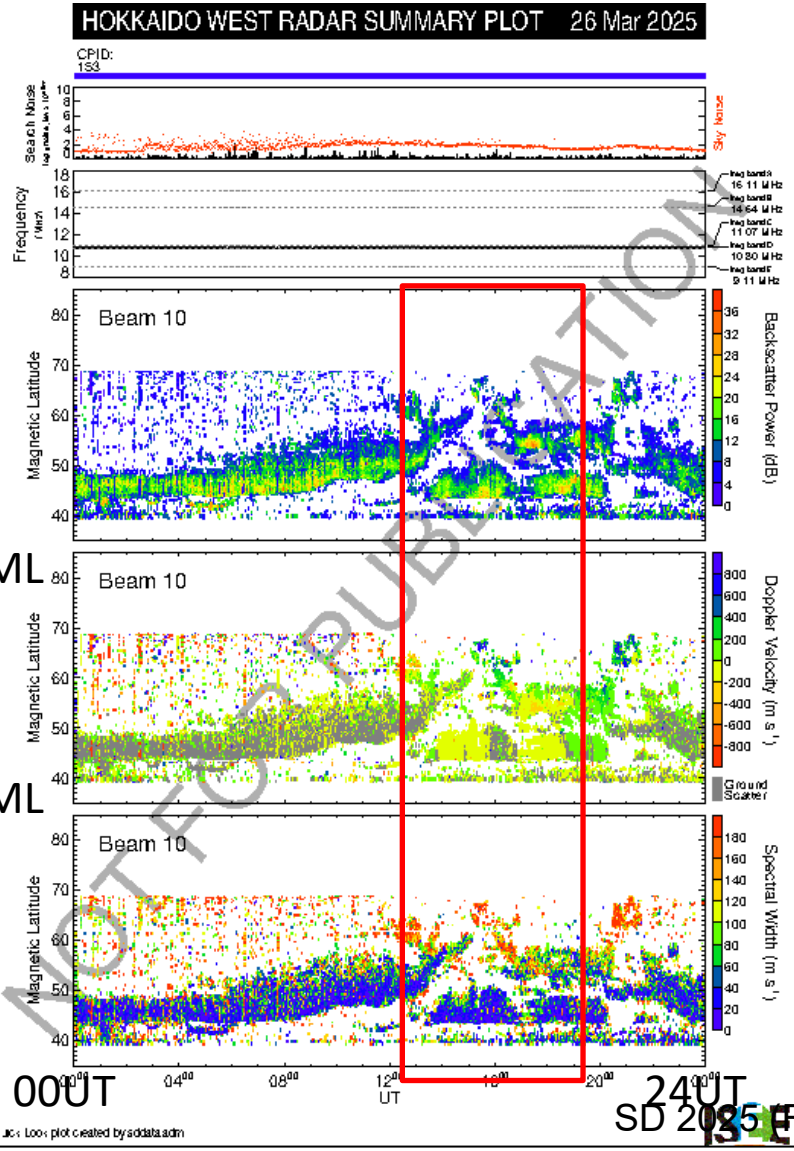
LT=UT+9 hrs

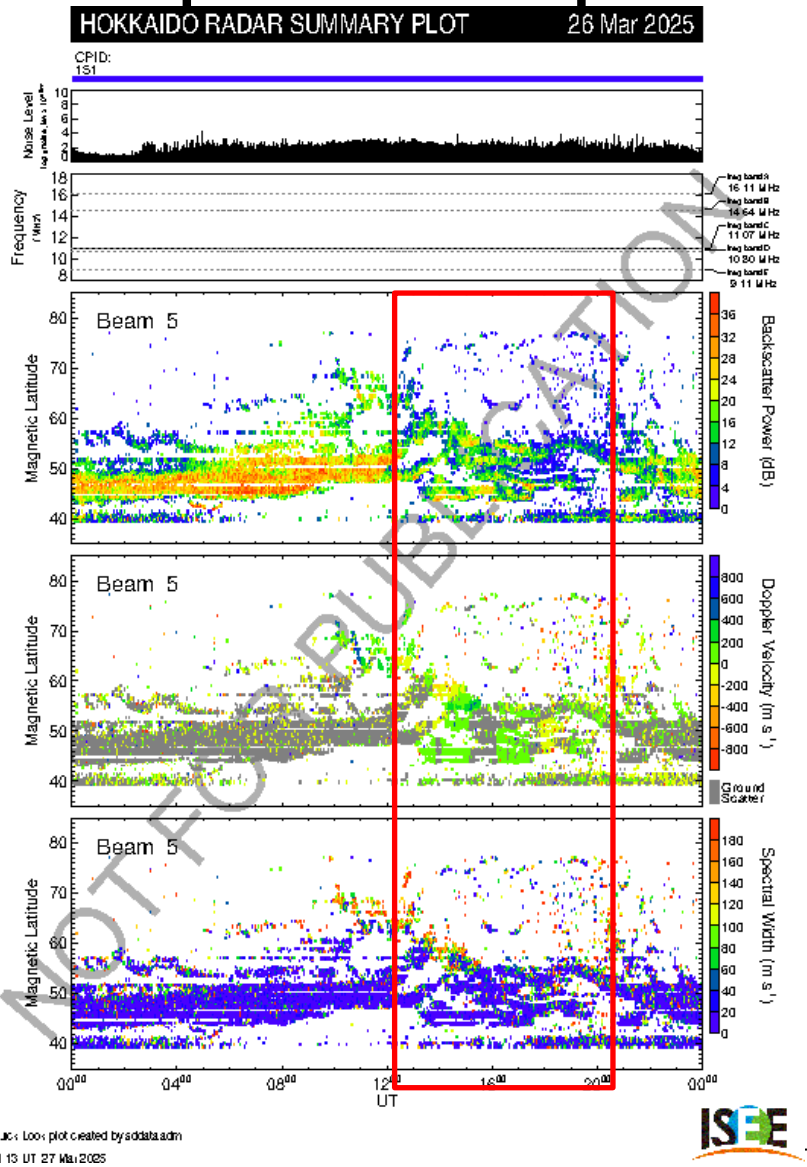
Hokkaido West / East quicklook plots











85ML

35ML

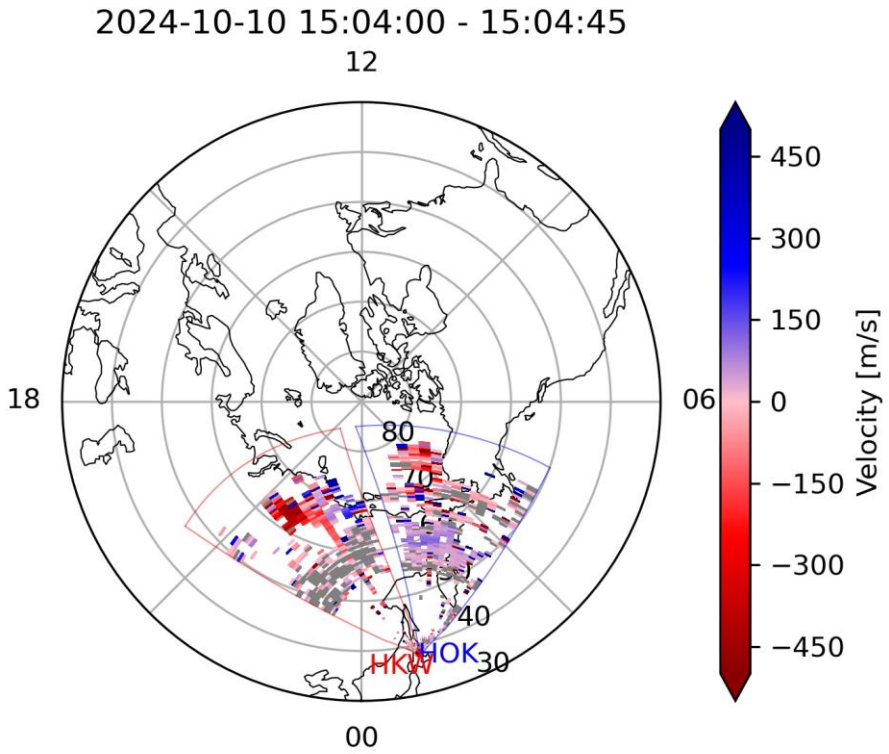
00UT

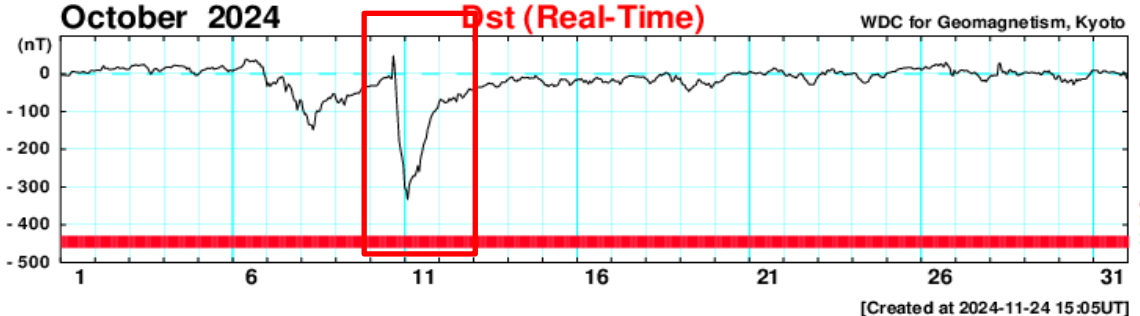
24UT

SD 2025 Ro

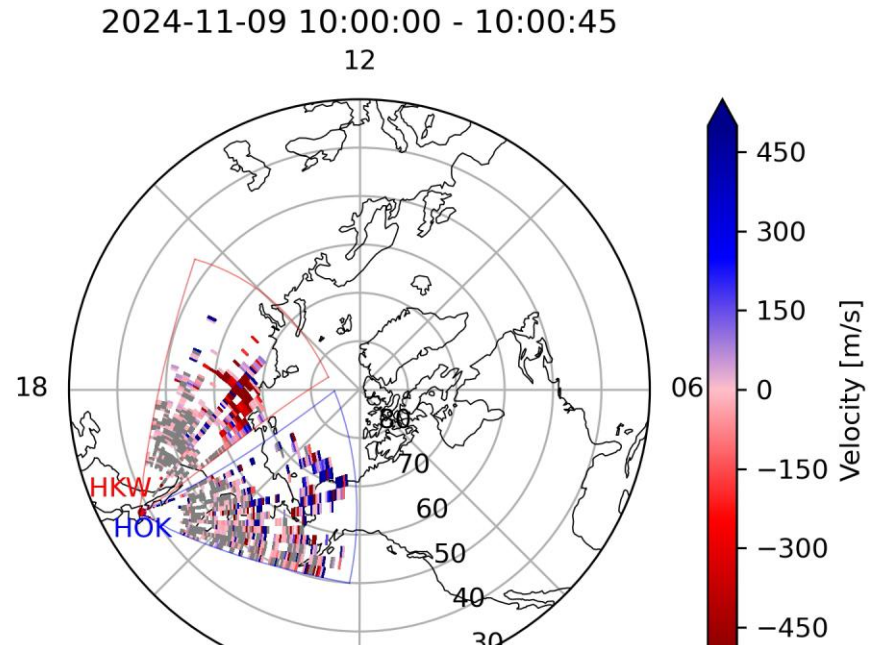
SuperDARN Quicklook plots at: http://cicr.isee.nagoya-u.ac.jp/hokkaido/

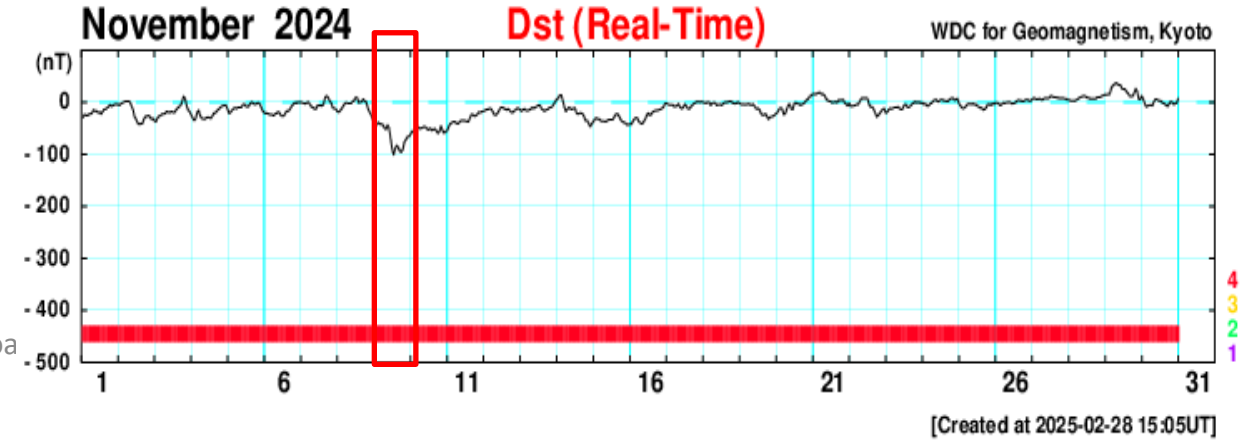
Oct 2024 storm: camera vs SuperDARN



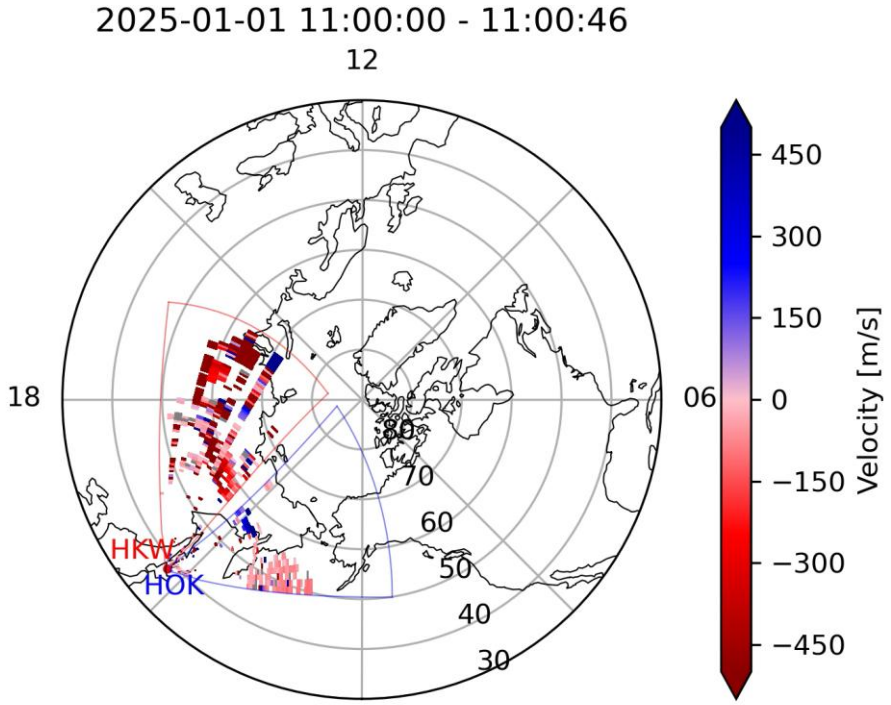


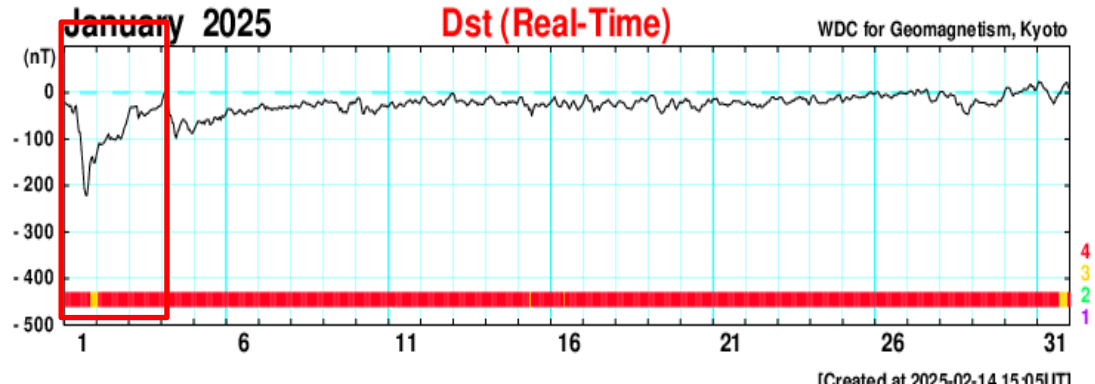
Nov 2024 storm: camera vs SuperDARN



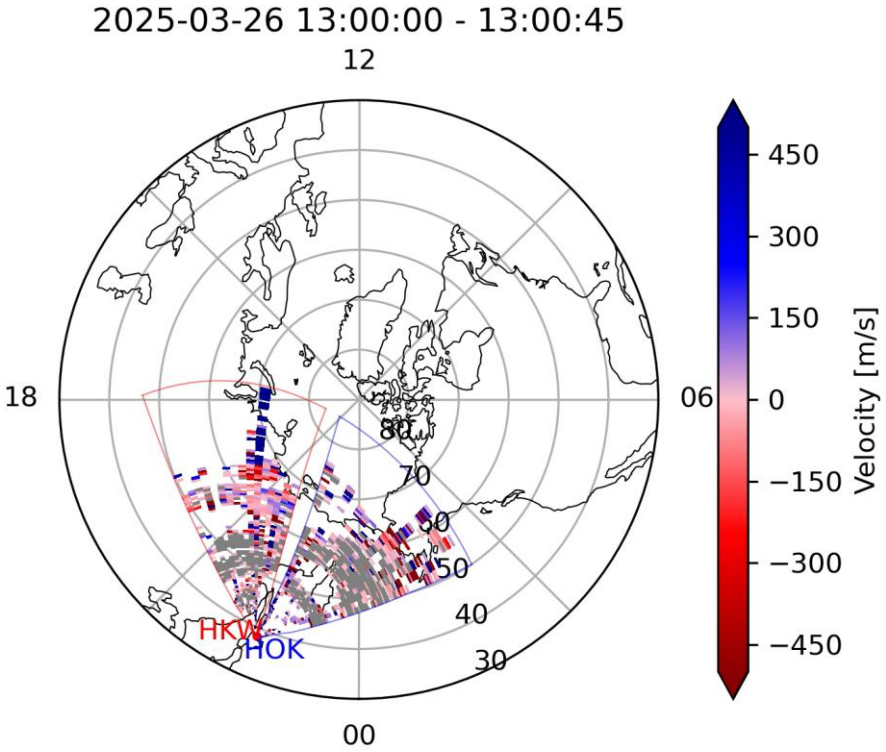


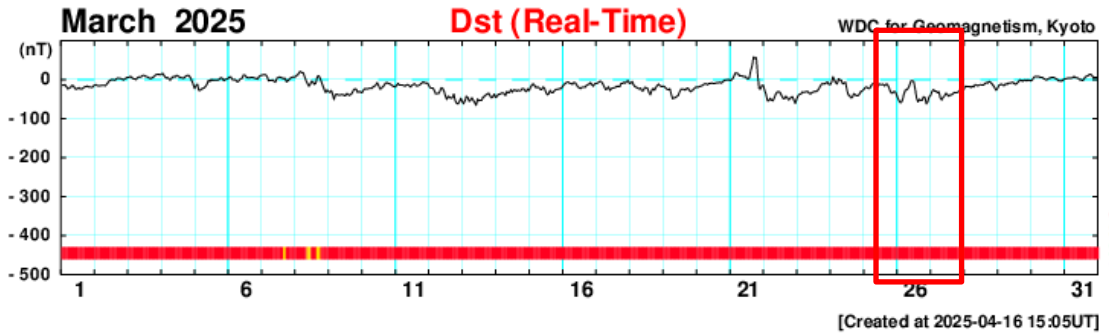
Jan 2025 storm: camera vs SuperDARN





March 2025 storm: camera vs SuperDARN





The Dst change was very small, but still we observed low-latitude auroras – it is a mystery! It is also strange that the convection flows seem to be related to auroral activity.

Apr 2025 storm: cloudy unfortunately, but good SuperDARN data