Statistics of dusk echoes including ULF waves

夕方側に見られるULF 波動を含むレーダーエコーの統計解析

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2: ISEE, Nagoya University
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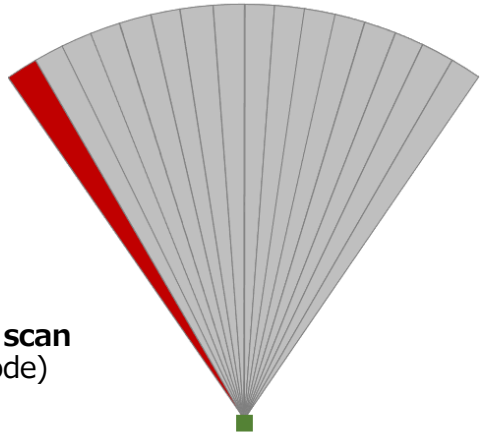
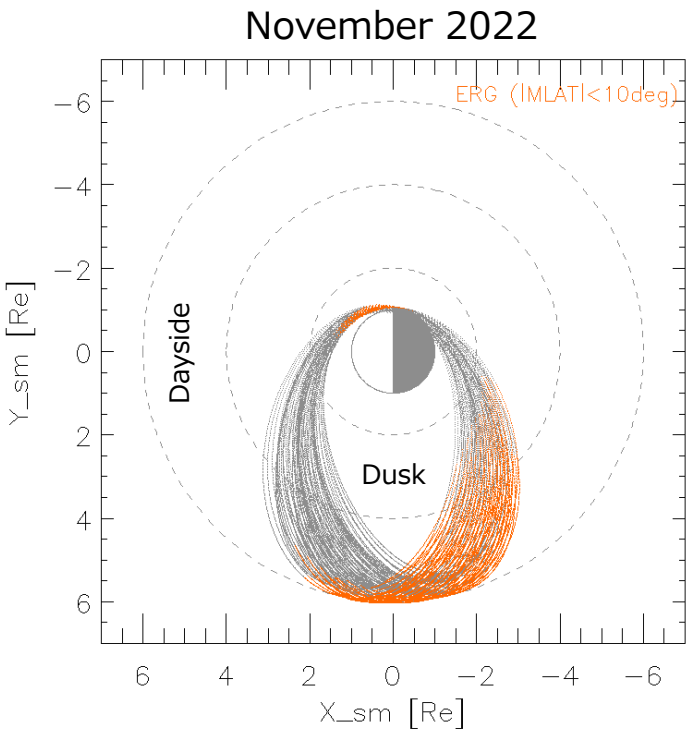
4: Kyushu Institute of Technology
5: Univ. of Saskatchewan
6: National Institute of Polar Research

Conjunctions of SD with Arase in 2022/2023

- Arase covered the auroral/subauroral region on the dusk side which is a hot spot of irregularities (= source of radar echoes)
- Submitted special time requests for running interleaved_normalscan in support of Arase in autumn months of 2022 and 2023
- Requests were approved for ~5 days/month
- May be able to track variations faster than the normal beam steering



Interleaved normal scan
(so-called Arase mode)

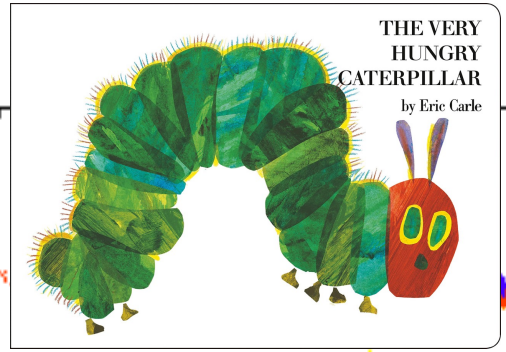


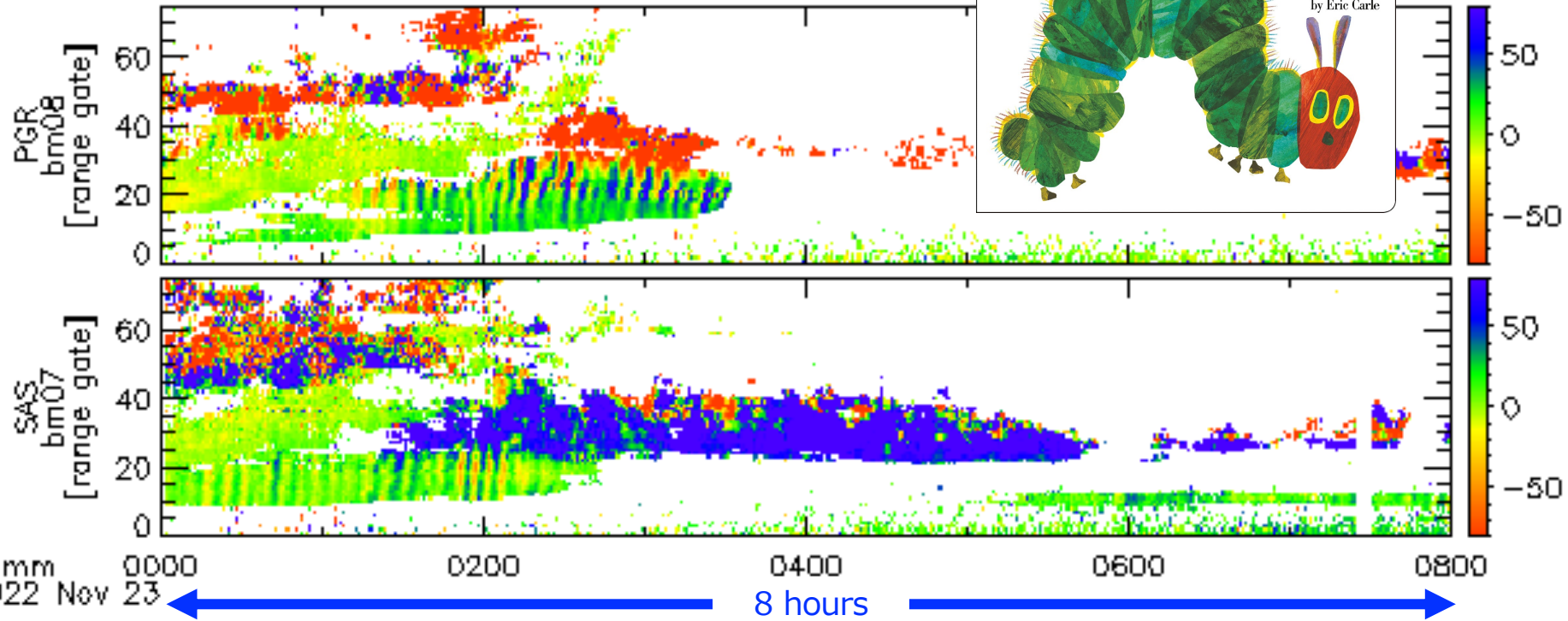
Caterpillar-like ULF signatures on Nov 23, 2022

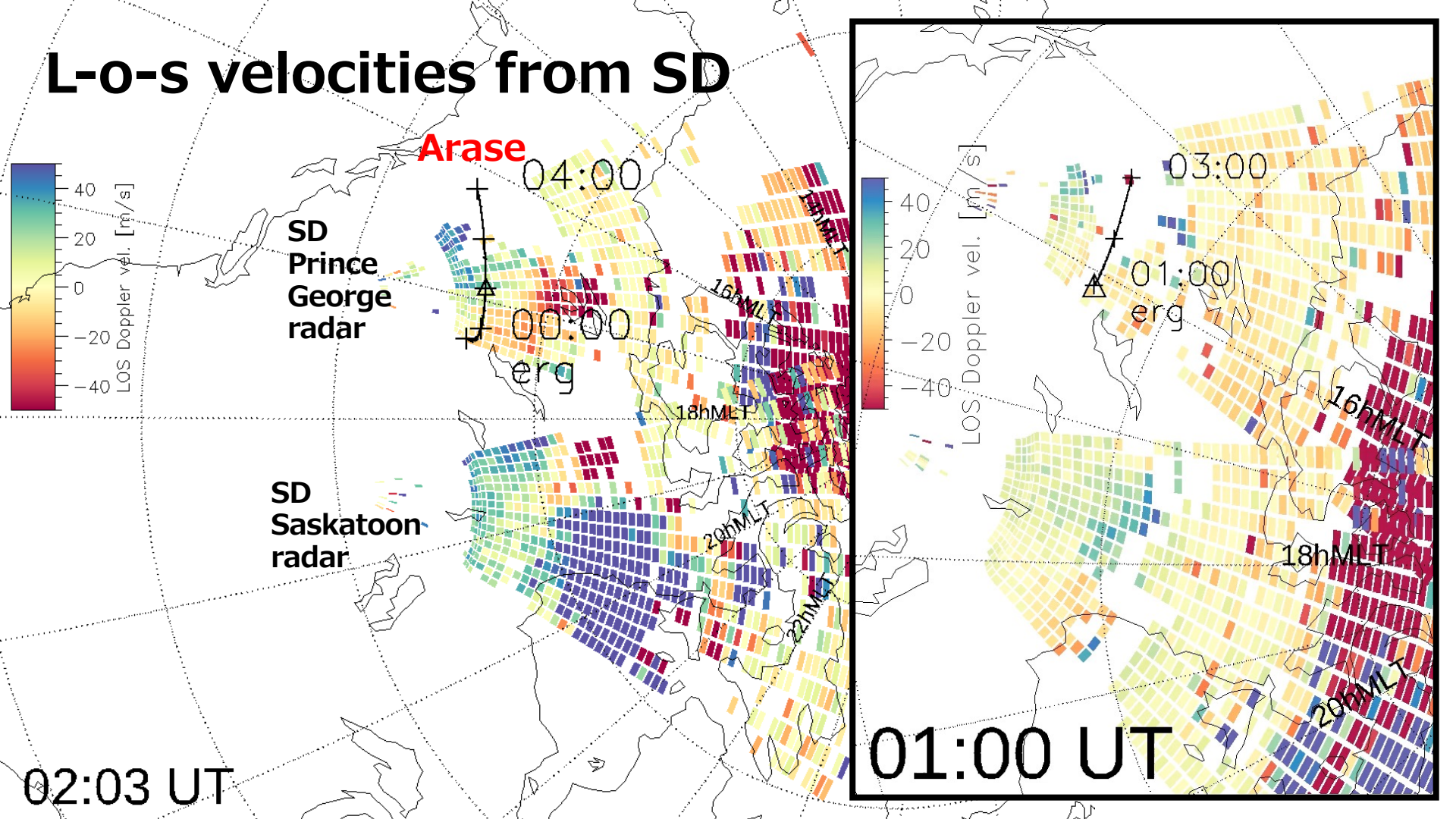
Kp 0 super quiet interval

November 23, 2022

Very hungry caterpillar by Eric Carle






L-o-s velocities from SD
Arase
SD
Prince
George
radar
SD
Saskatoon
radar
LOS Doppler vel. [m/s]
40
20
0
−20
−40
04:00
00:00
erg
16hMLT
18hMLT
20hMLT
22hMLT
02:03 UT
03:00
01:00
01:00 UT

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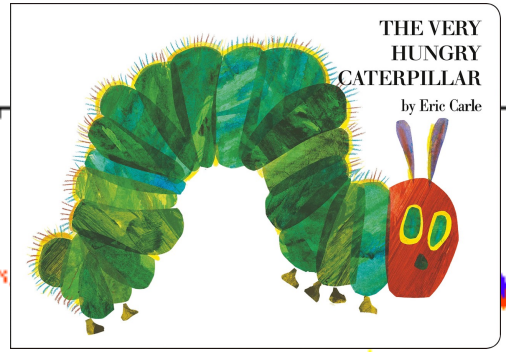
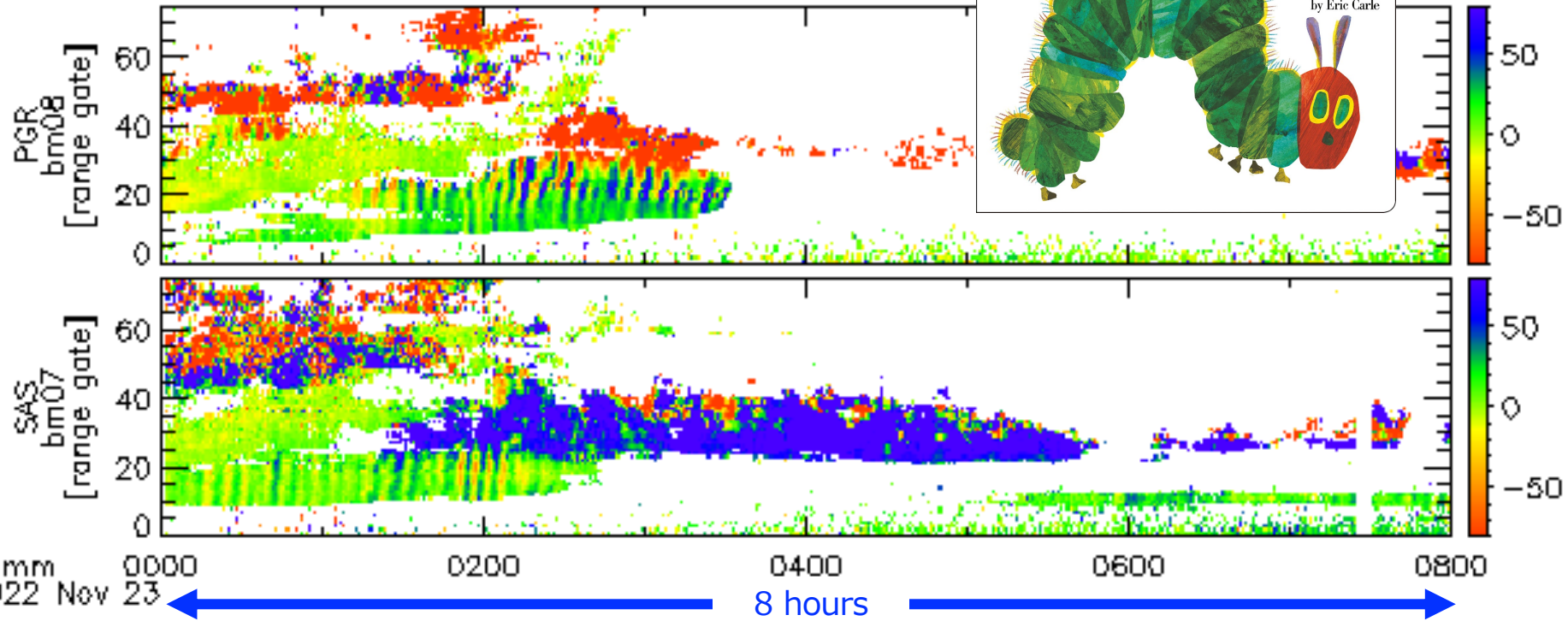
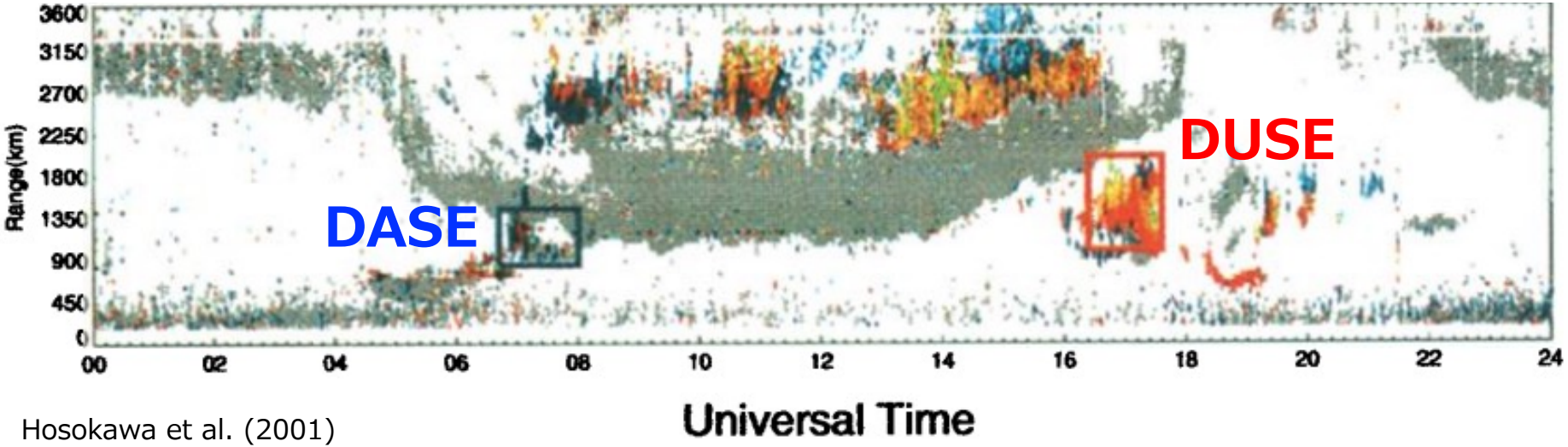




Dusk/Dawn Scatter Echoes (DUSE/DASE)

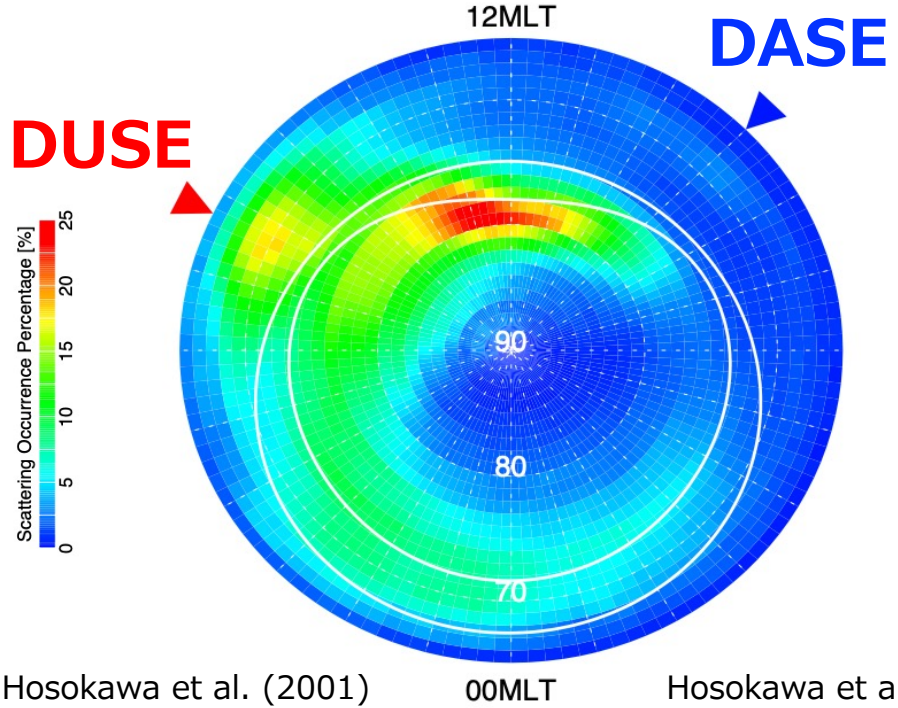
- SuperDARN radars often detect backscatter echoes in the subauroral region immediately after sunset, which are known as DUSE (Ruohoniemi et al., 1988; Hosokawa et al., 2021; 2022)
- Similar echoes are observed before sunrise (DASE) although the occurrence rate is relatively low



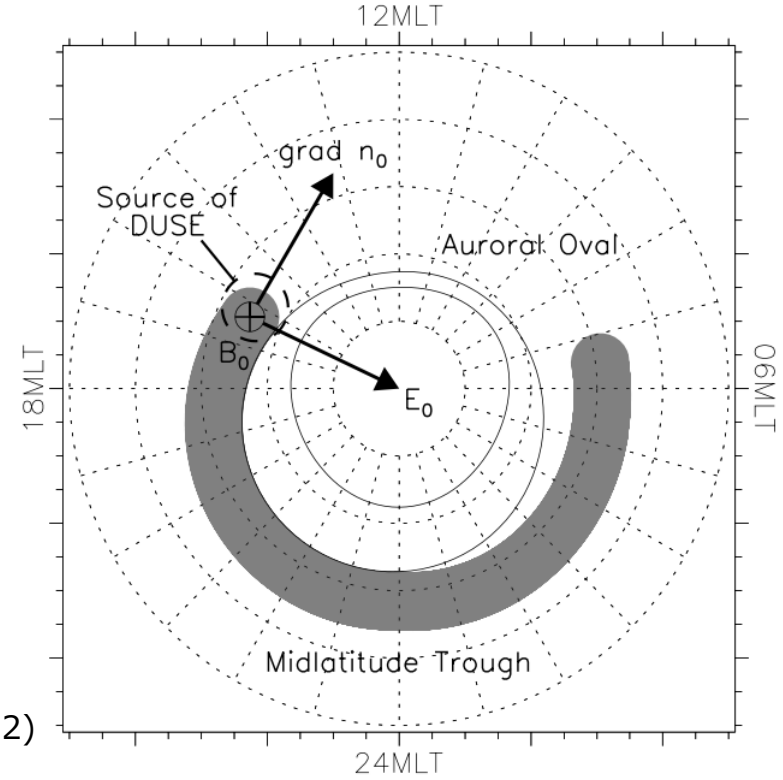
Hosokawa et al. (2001)

Generation mechanism of DUSE/DASE

- Generation of DUSE/DASE can be explained by the gradient-drift instability driven by the density gradient at the sunward edge of the trough



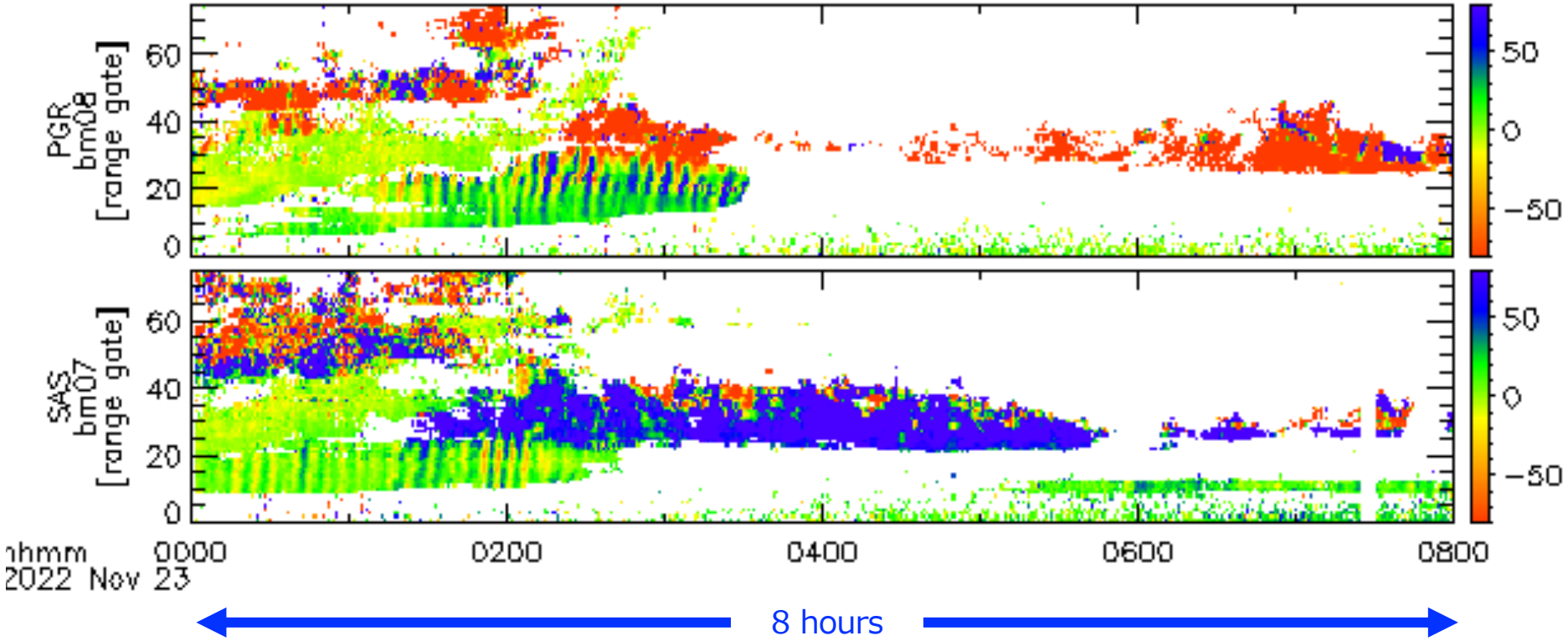
Hosokawa et al. (2001)



Hosokawa et al. (2002)

Caterpillar-like ULF signatures on Nov 23, 2022

- Caterpillar-like ULF was embedded within DUSE after sunset



Questions to be answered and what we did

- How often do DUSE/DASE contain caterpillar-like ULF signatures?
- If yes, is there any specific reason for the co-existence of DUSE and caterpillar-like ULF wave?
- To answer these questions, we performed a small statistics using data from the campaign observations (27 days) in autumn 2023
- The radars used for statistics are:
  Auroral region: Kodiak, Prince George, Saskatoon
  Mid-latitude region: Christmas Valley East/West, Fort Heys East/West

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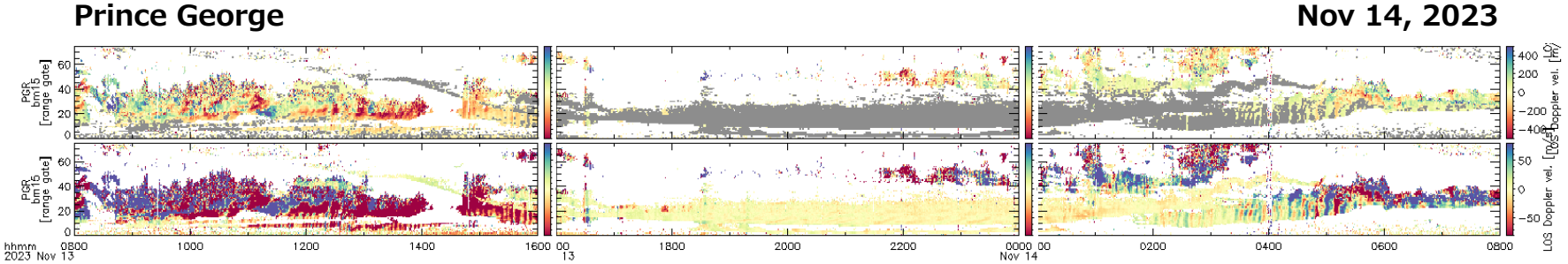

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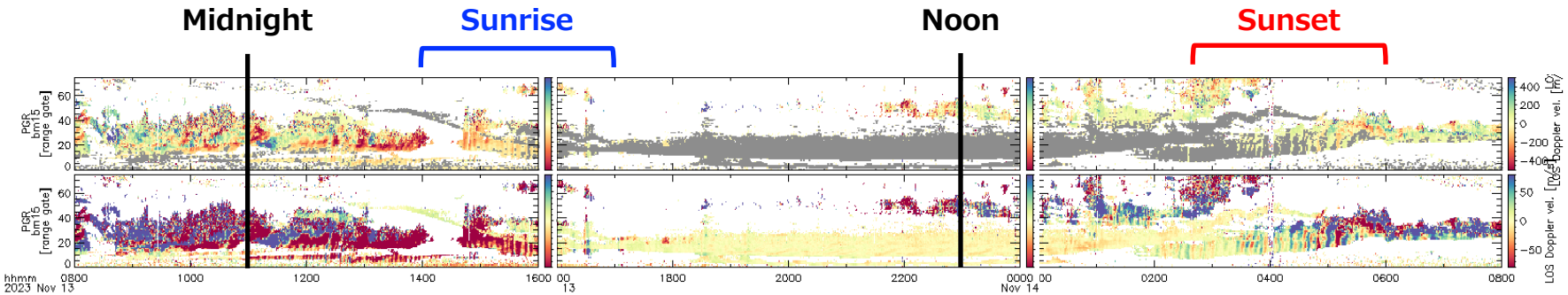
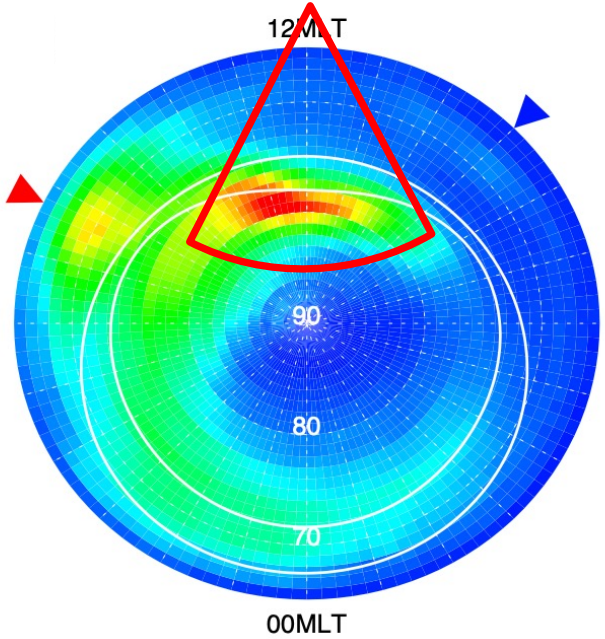
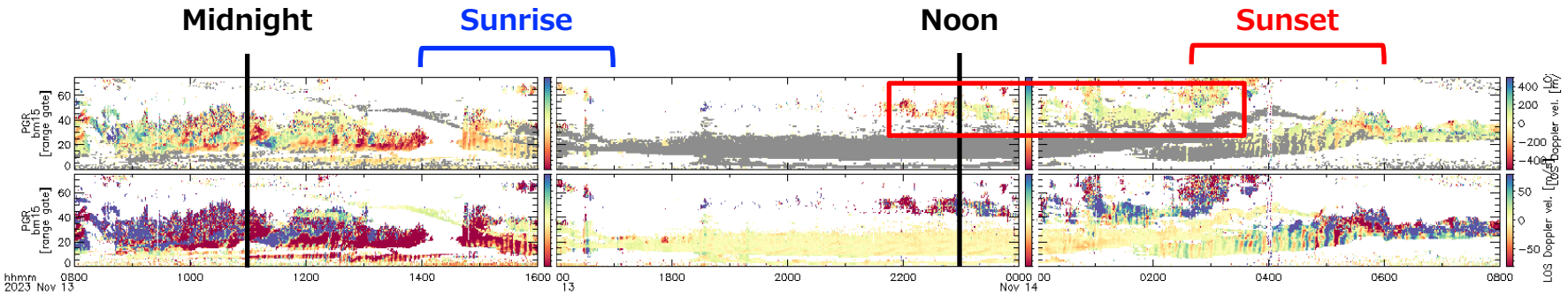


Source of echoes

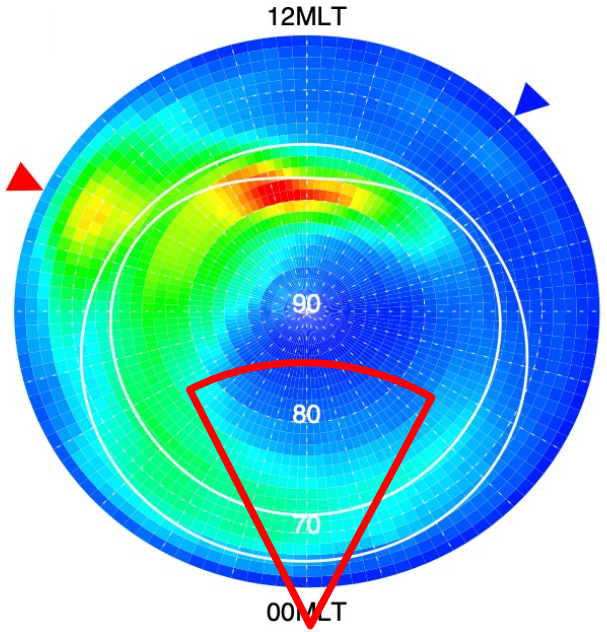
- Cusp echo on the dayside

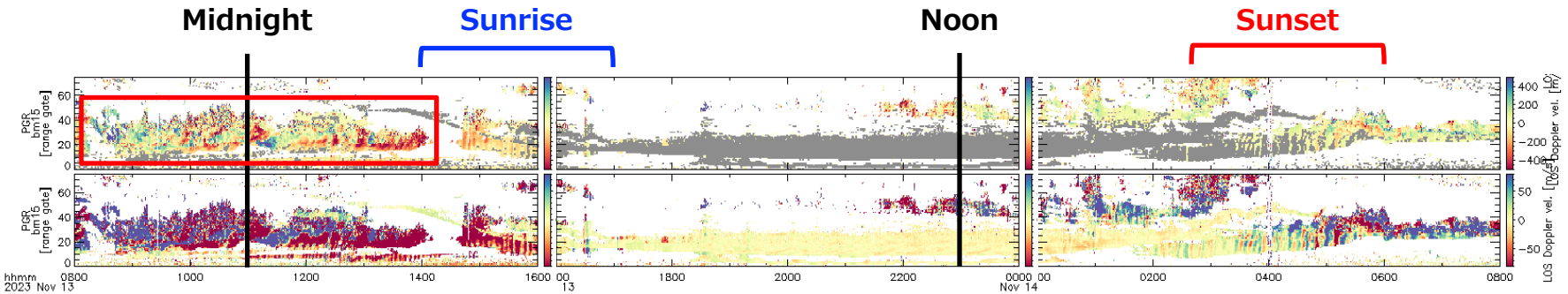




Source of echoes

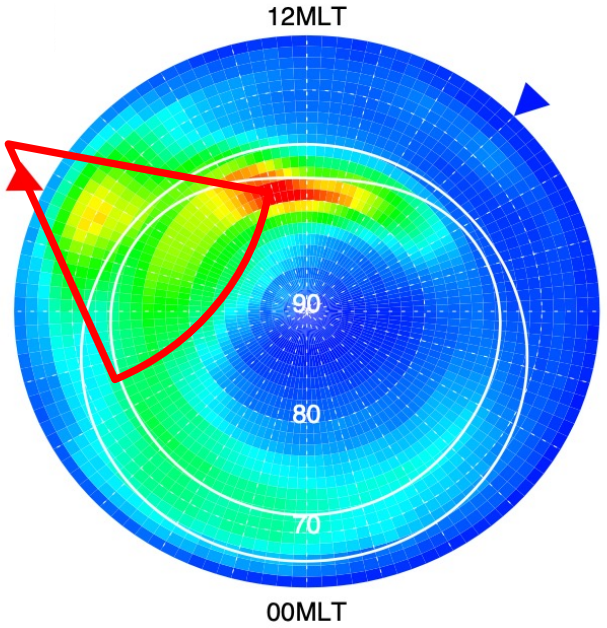
- Cusp echo on the dayside
- Auroral echo on the nightside

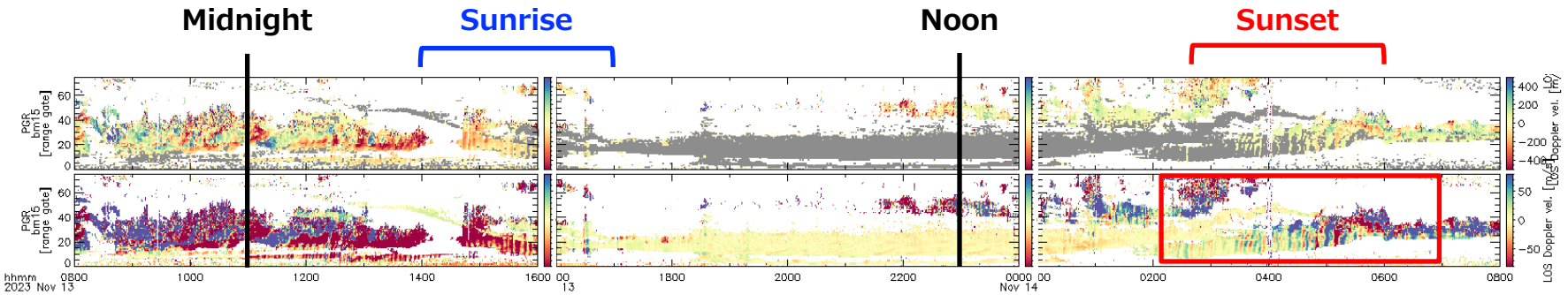




Source of echoes

- Cusp echo on the dayside
- Auroral echo on the nightside
- Dusk scatter echoes (DUSE)





Source of echoes

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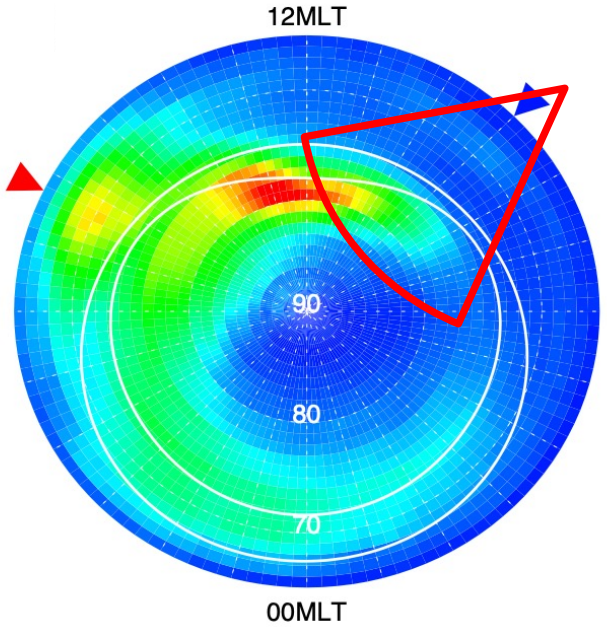
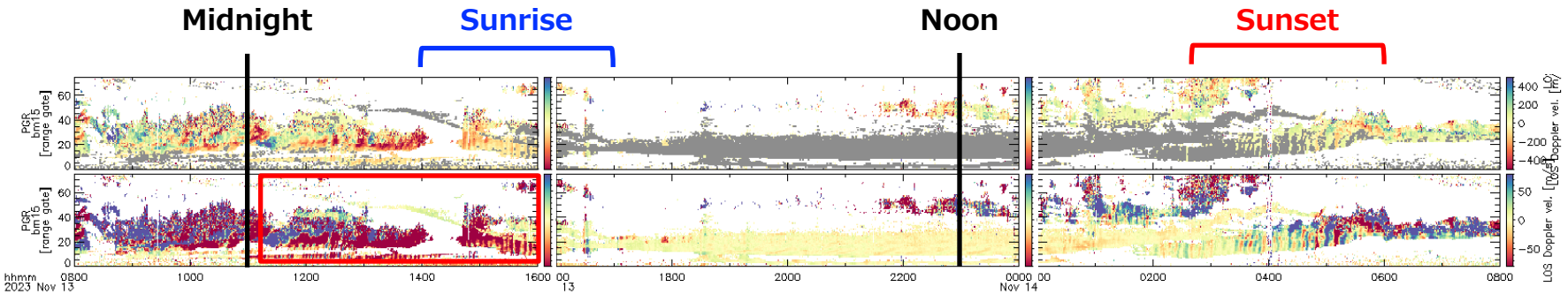
- Auroral echo on the nightside
- Dusk scatter echoes (DUSE)
- Dawn scatter echoes (DASE)





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- Auroral echo on the nightside
- Dusk scatter echoes (DUSE)
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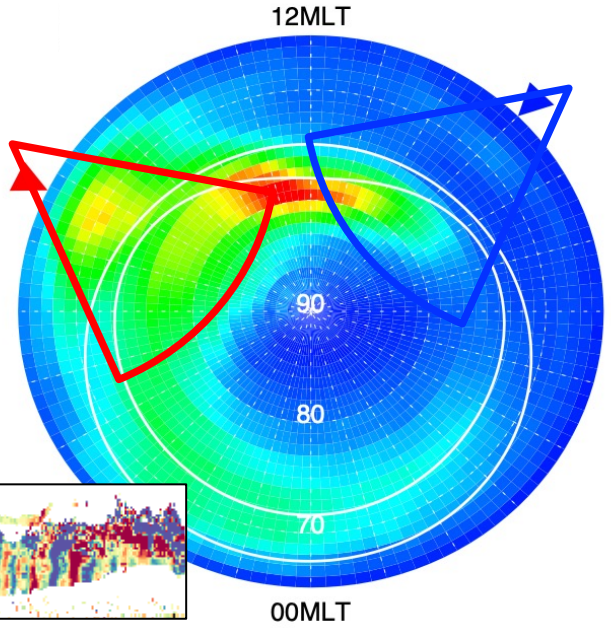
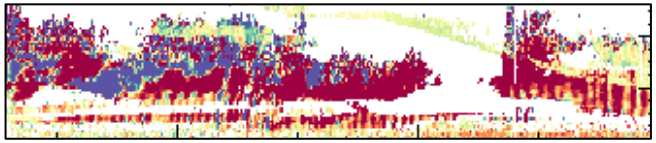
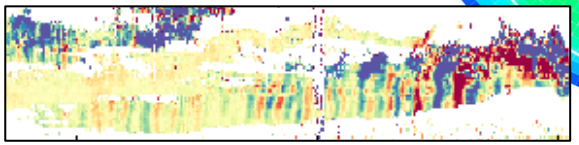
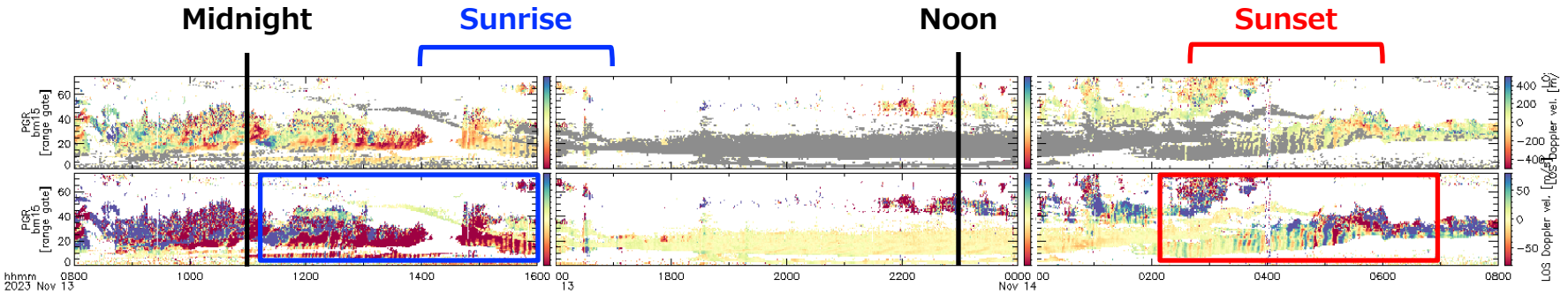


DASE

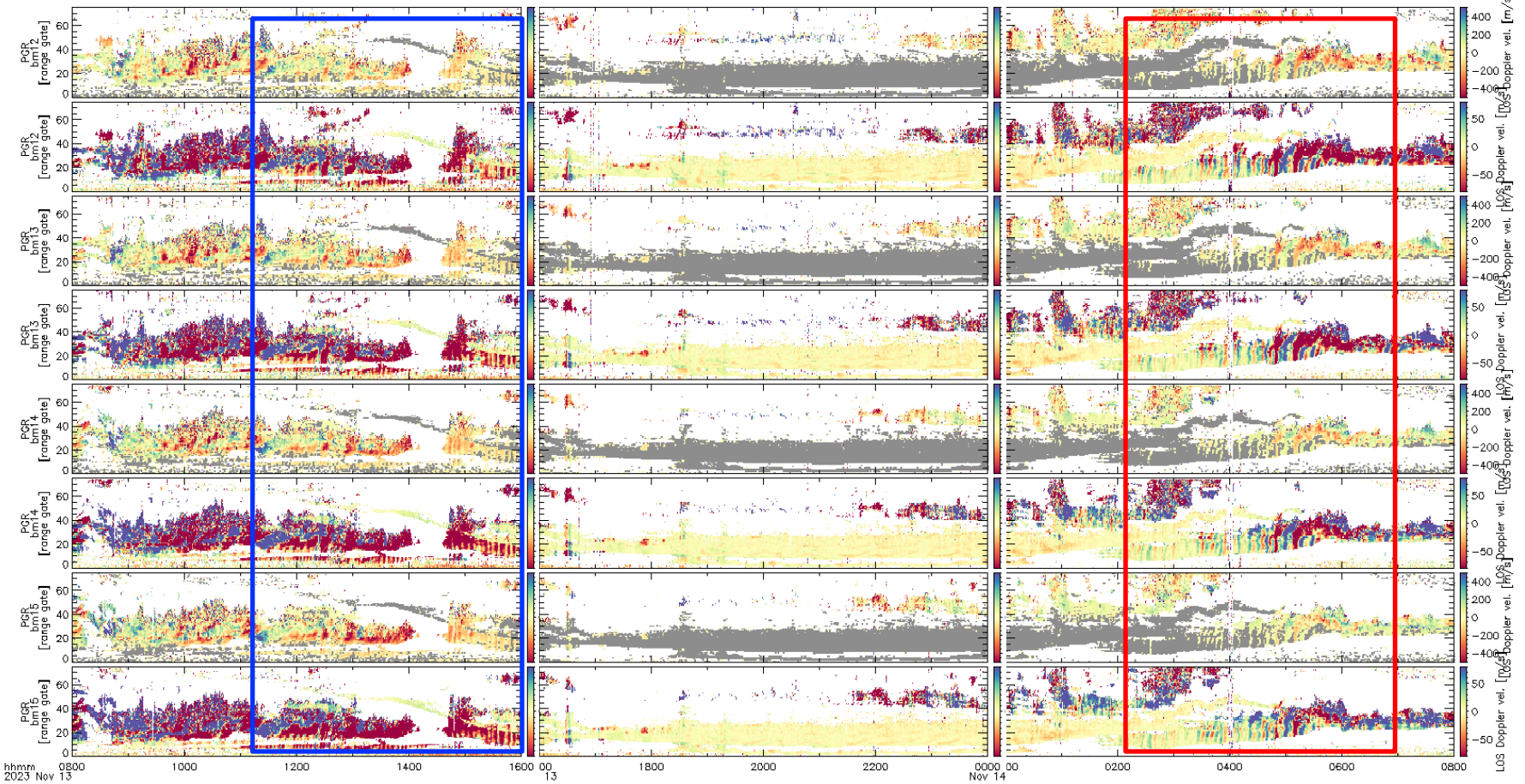


DUSE

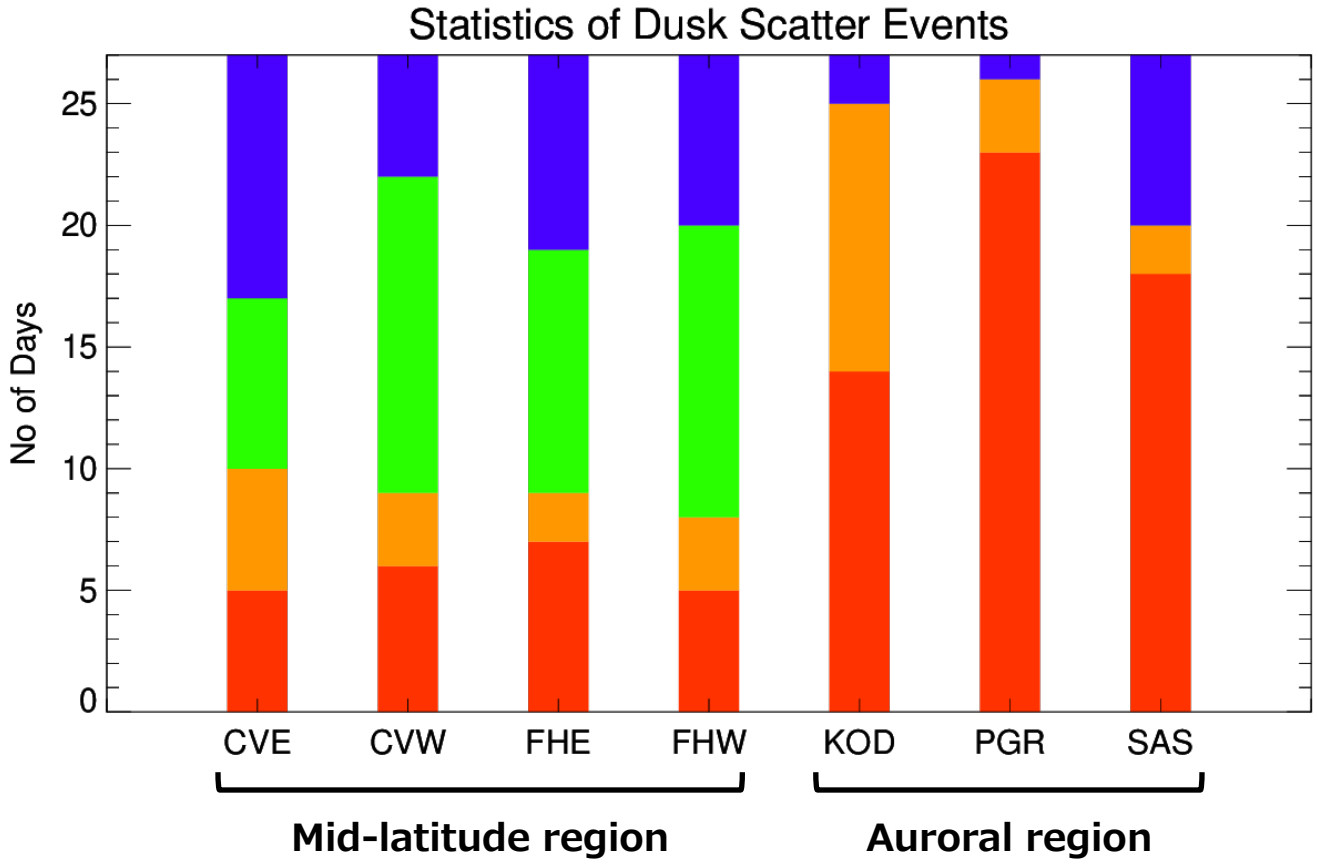




Have looked at 16 beams, 7 radars, 27 days



Small statistics with 27 days observations



DUSE with Caterpillar

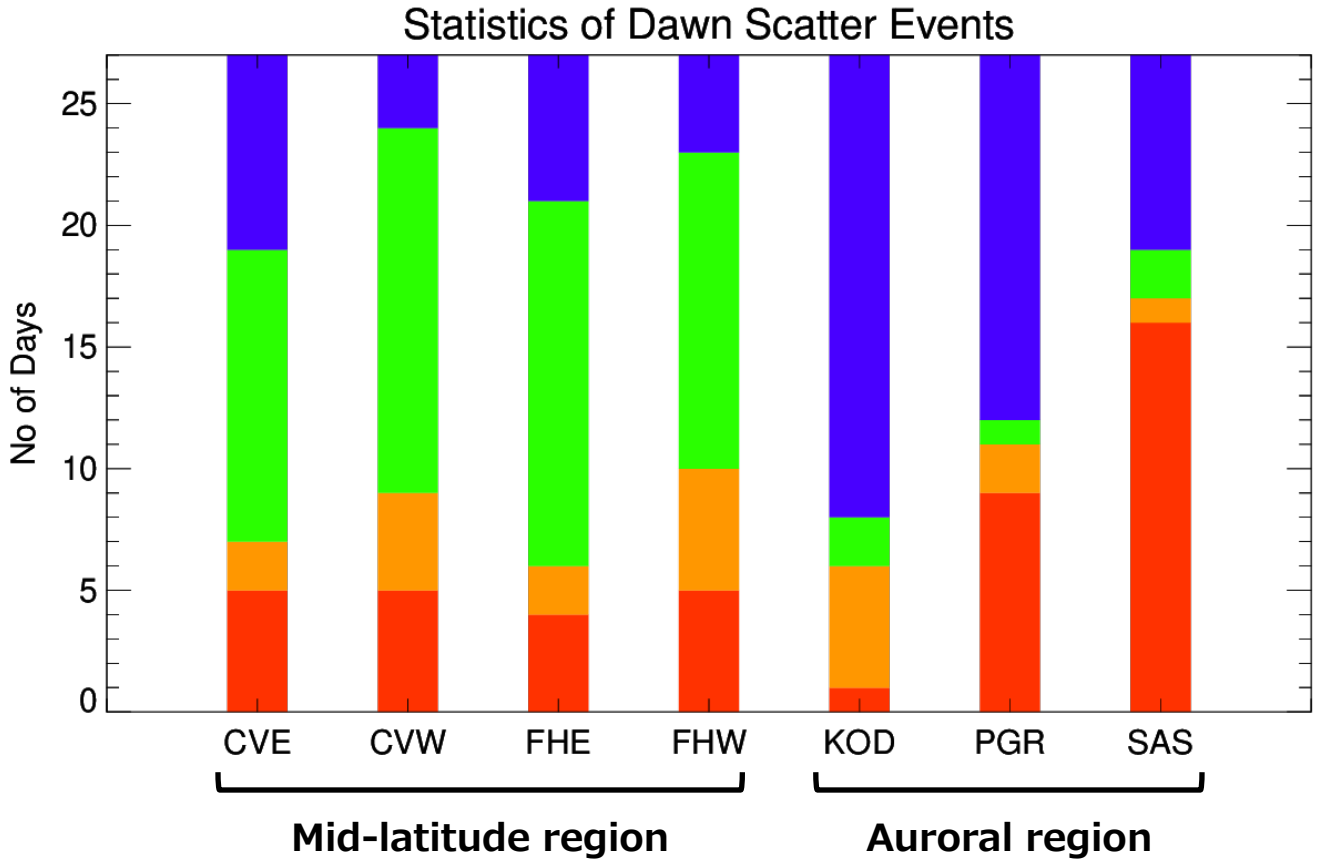
DUSE without Caterpillar

Other echoes

No echo

DUSE

Small statistics with 27 days observations



DASE with Caterpillar

DASE without Caterpillar

Other echoes

No echo

DASE

Answer to the question (and by-product)

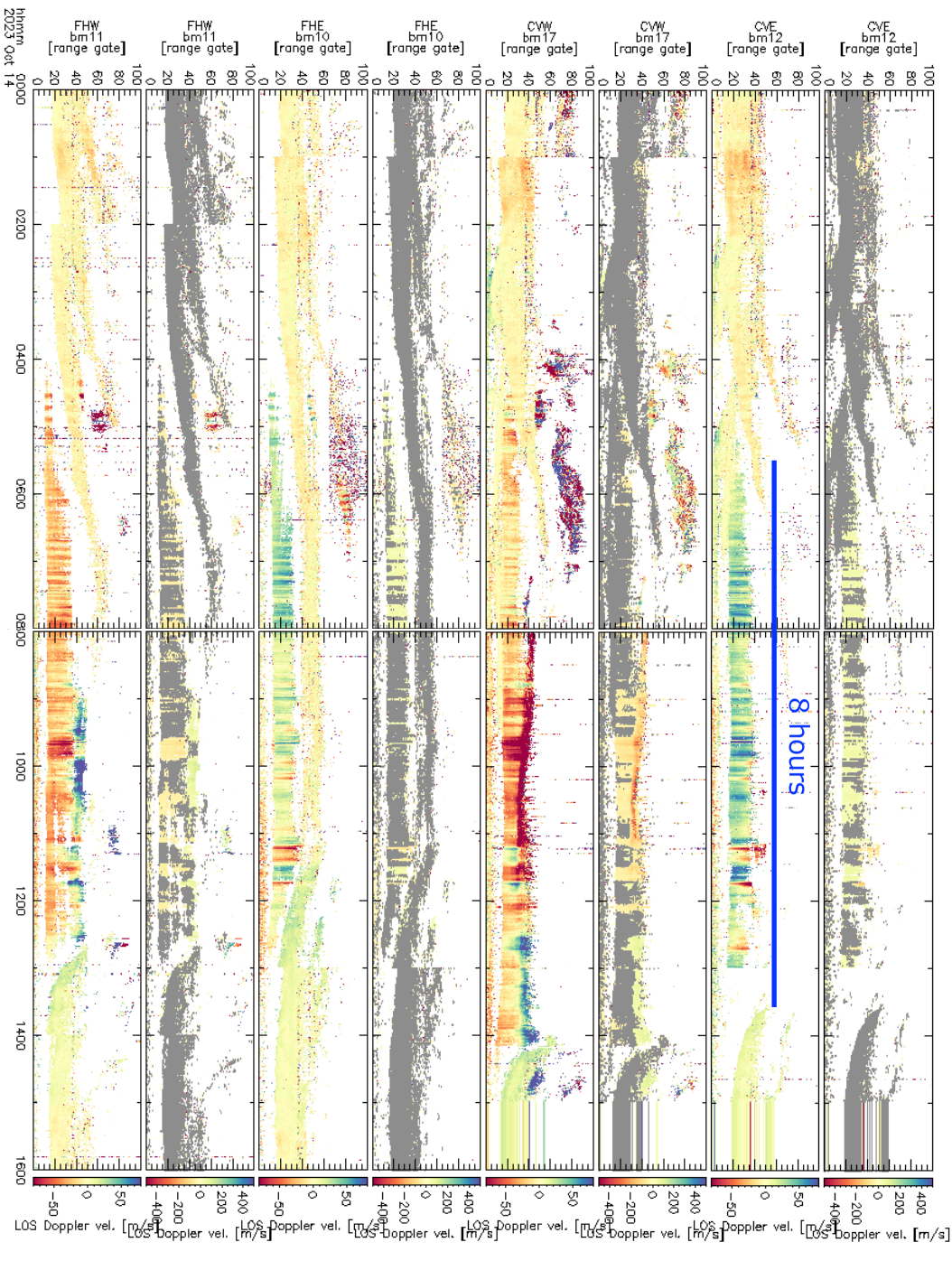
- How often do DUSE/DASE contain caterpillar-like ULF signatures?
  → Quite often, but not always (unfortunately)
- If yes, is there any specific reason for the co-existence of DUSE and caterpillar-like ULF wave?
  → There is no such a trick to produce ULF waves in such specific location
  Sunward edge of the trough is not always a source of ULF waves
- Not only during DUSE/DASE, ULF waves are often observed on the nightside especially by the mid-latitude radars

連続的な ULF を含むエコー

Oct 14, 2023 at mid-latitudes

Fort Heys | **Christmas Valley**

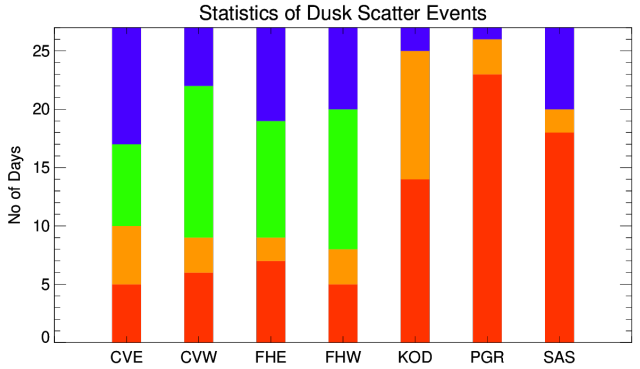
West | **East** | **West** | **East**



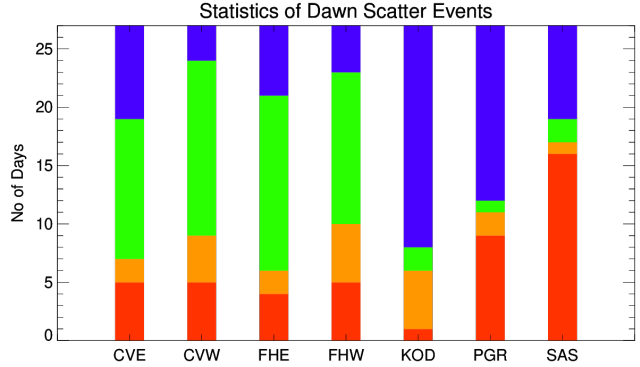
Summary

- Dusk/dawn scatter echoes (DUSE/DASE) contain ULF wave signature quite often, but not 100%
- DUSE/DASE with ULF signatures are more common at the auroral latitudes
- At mid-latitudes, other long-lasting radar echoes showing ULF signatures are seen during quite periods

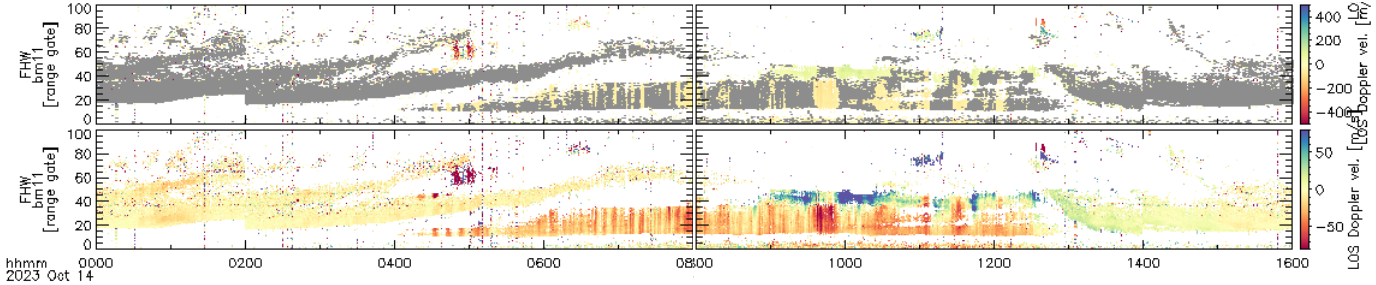
DUSE



DASE

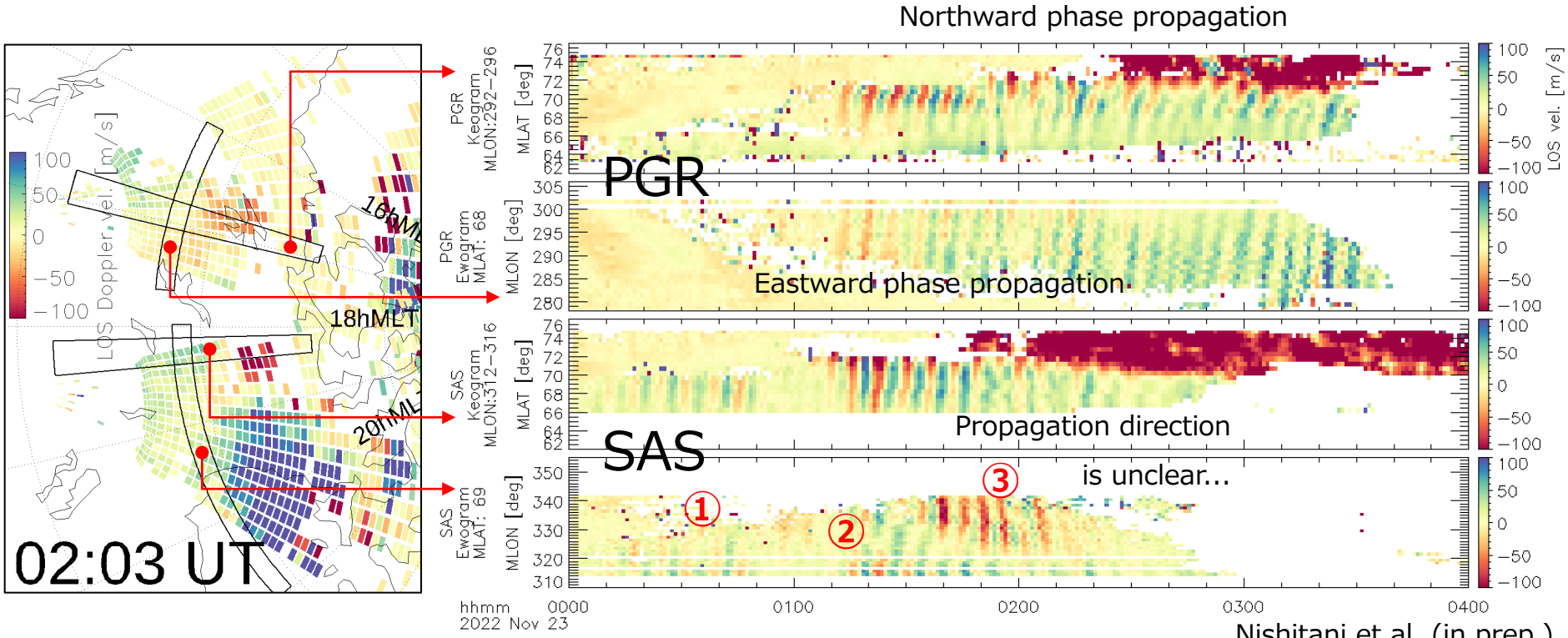


Long-lasting echo with ULF at mid-latitudes



Propagation characteristics in keo/ewograms

- Anti-sunward propagation is obvious in the data from PGR



Nishitani et al. (in prep.)