# Statistics of dusk echoes including ULF waves

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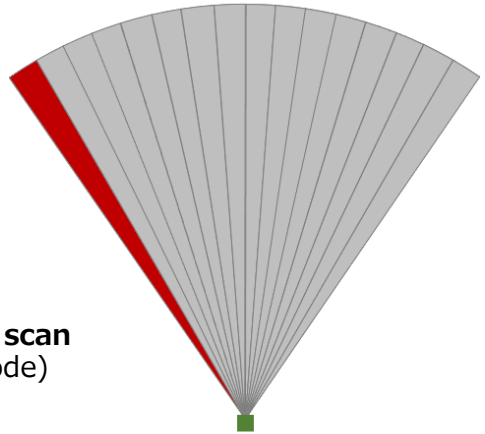
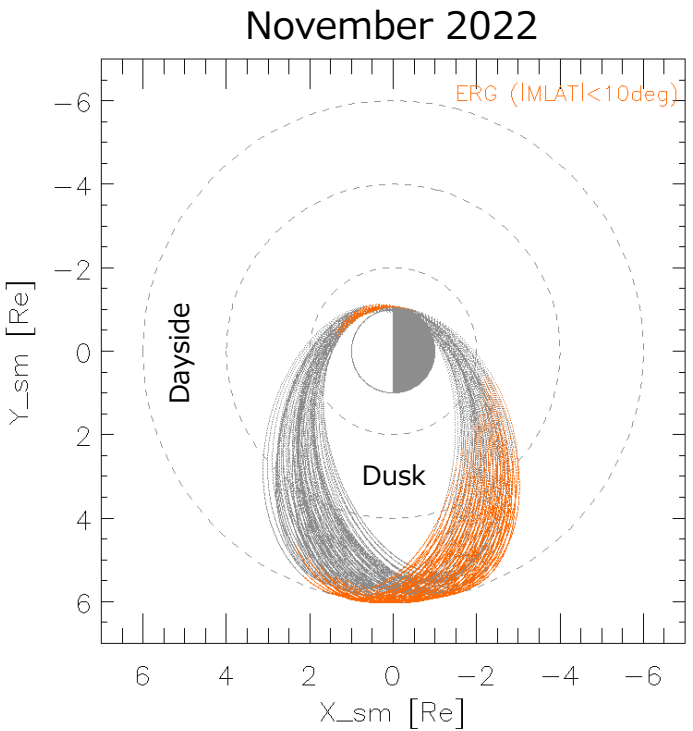
# Conjunctions of SD with Arase in 2022/2023

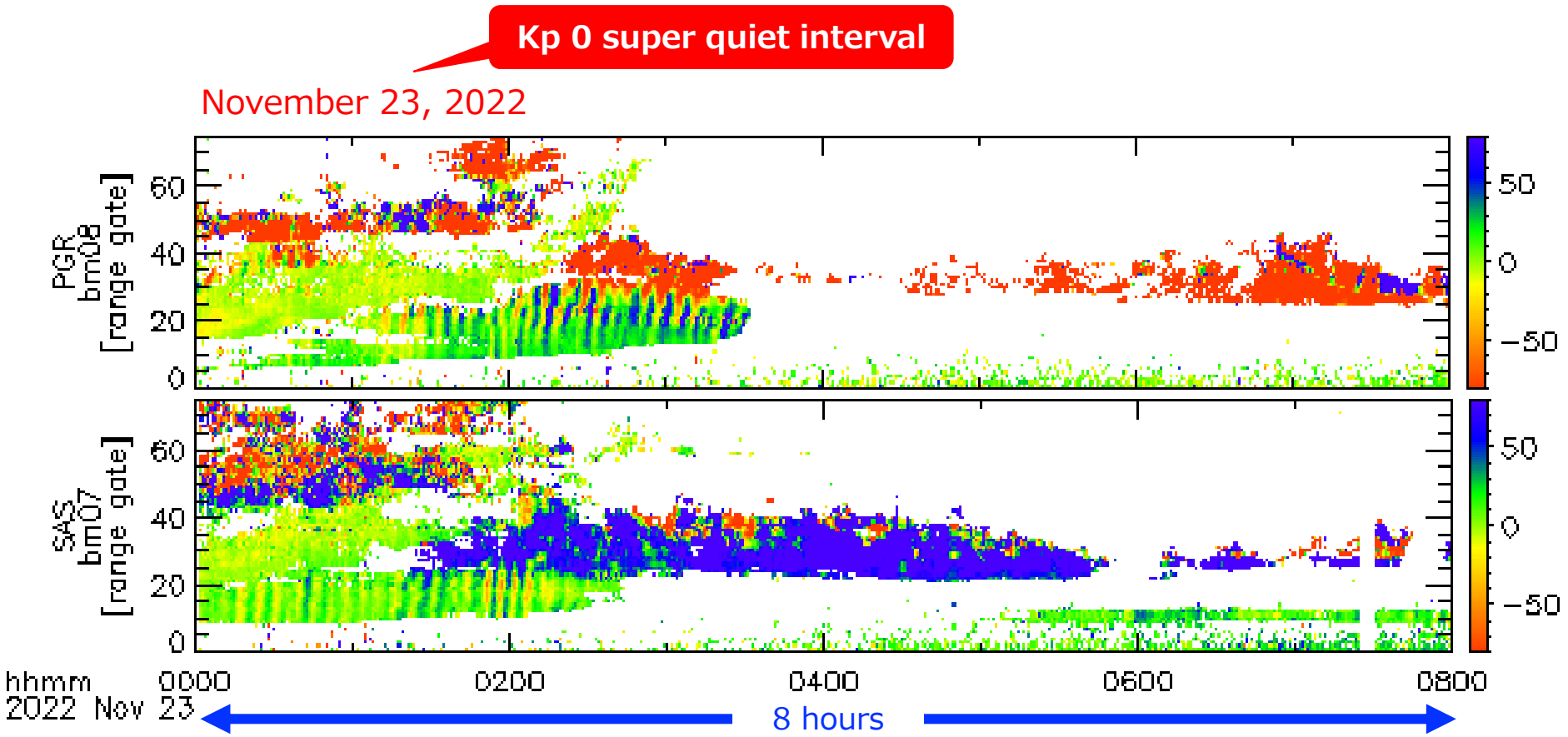
- Arase covered the auroral/subauroral region on the dusk side which is a hot spot of irregularities (= source of radar echoes)
- Submitted special time requests for running interleaved_normalscan in support of Arase in autumn months of 2022 and 2023
- Requests were approved for ~5 days/month
- May be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

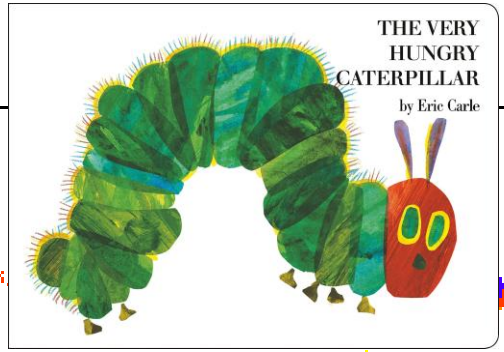


# Caterpillar-like ULF signatures on Nov 23, 2022

Kp 0 super quiet interval

November 23, 2022

Very hungry caterpillar by Eric Carle




PGR bm08 [range gate]

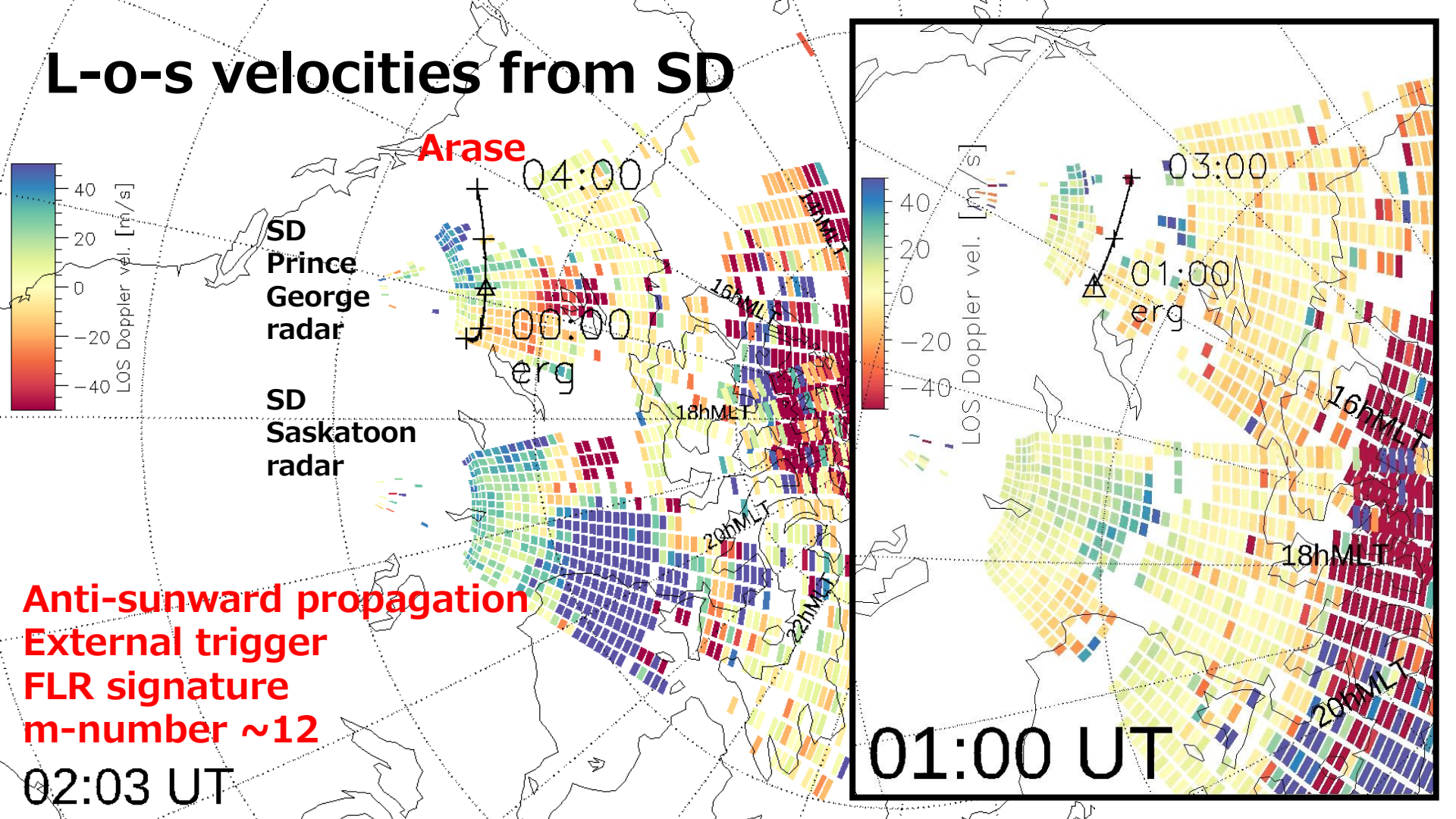
SAS bm07 [range gate]

hhmm
2022 Nov 23

0000 0200 0400 0600 0800

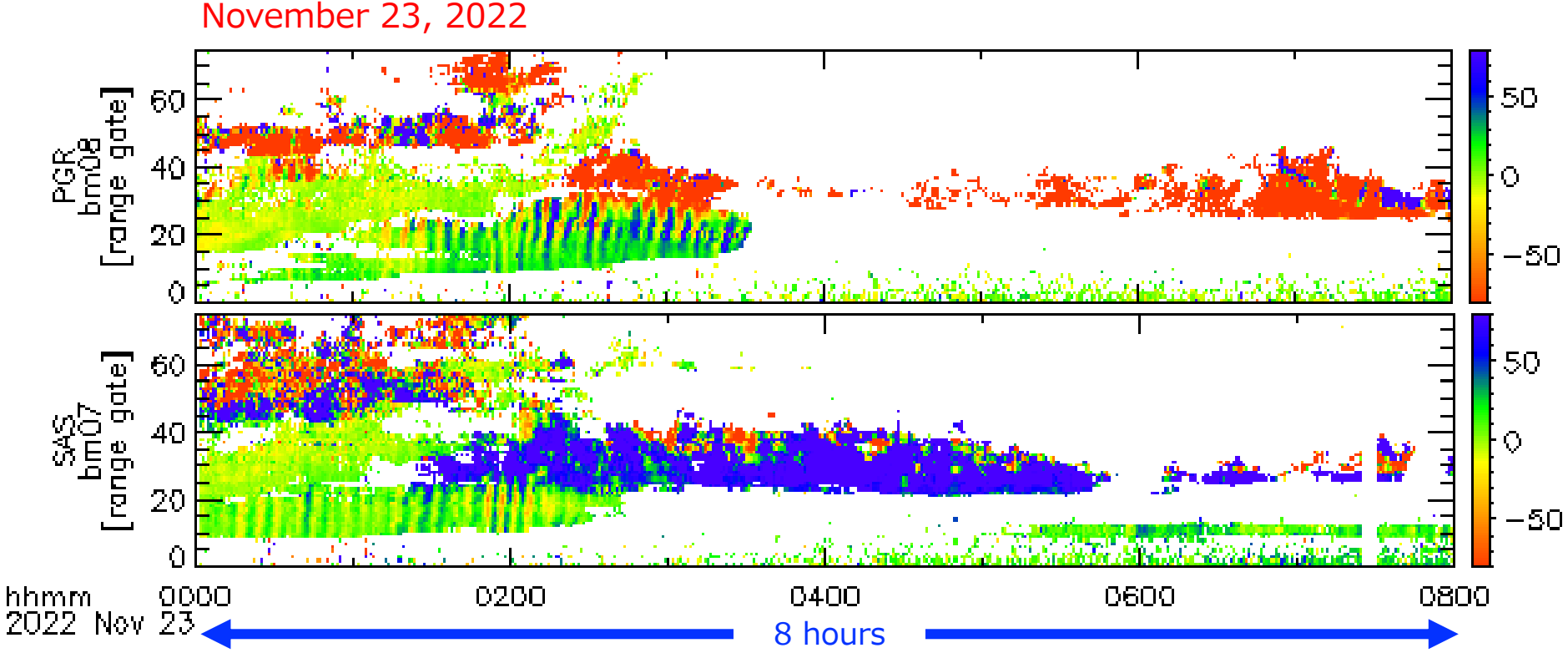
8 hours

# L-o-s velocities from SD



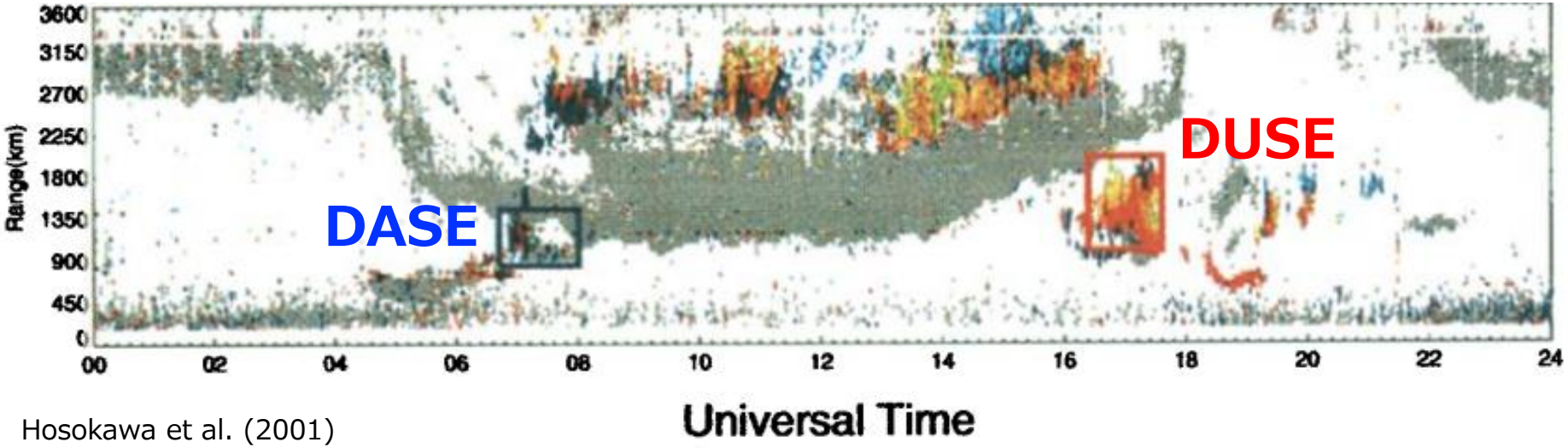
# Caterpillar-like ULF signatures on Nov 23, 2022

- Why was the caterpillar-like ULF observed during super quiet period?



# Dusk/Dawn Scatter Echoes (DUSE/DASE)

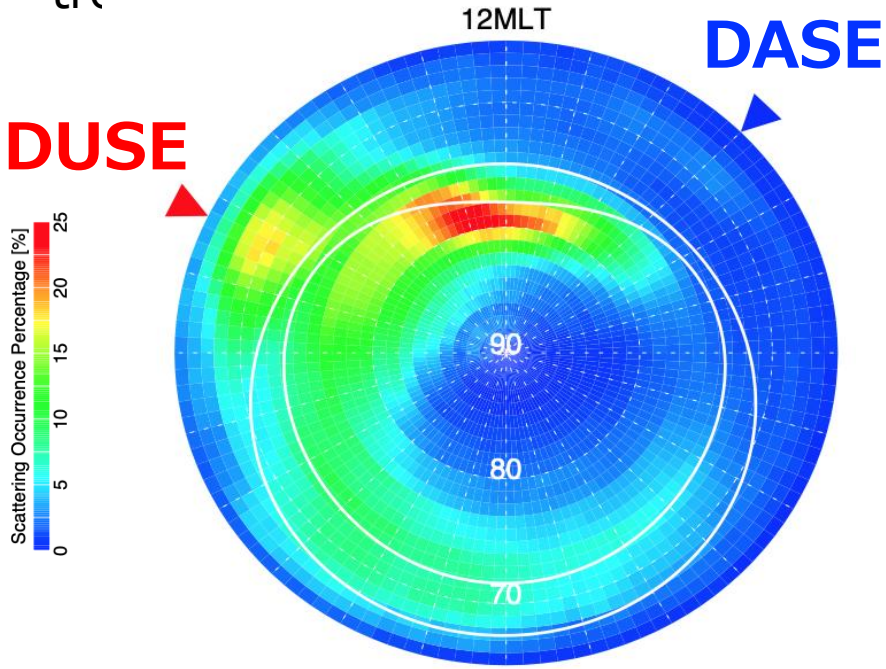
- SuperDARN radars often detect backscatter echoes in the subauroral region immediately after sunset, which are known as DUSE (Ruohoniemi et al., 1988; Hosokawa et al., 2001; 2002)
- Similar echoes are observed before sunrise (DASE) although the occurrence rate is relatively low (Hosokawa et al., 2001)



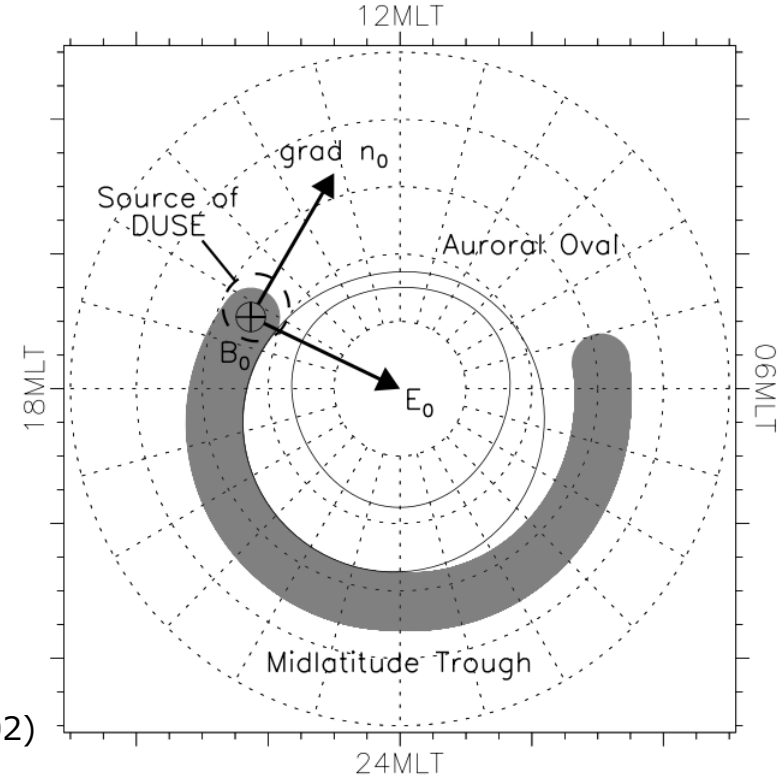

Hosokawa et al. (2001)

# 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



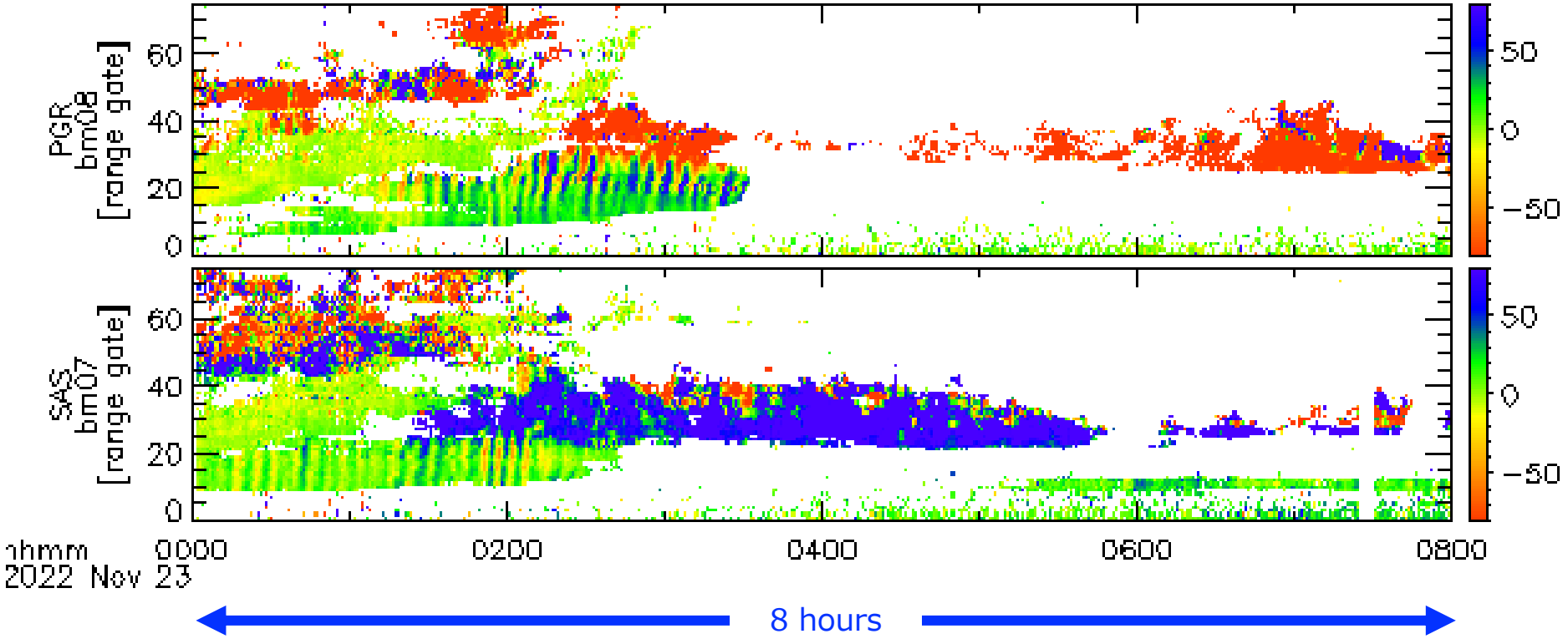

Hosokawa et al. (2001)




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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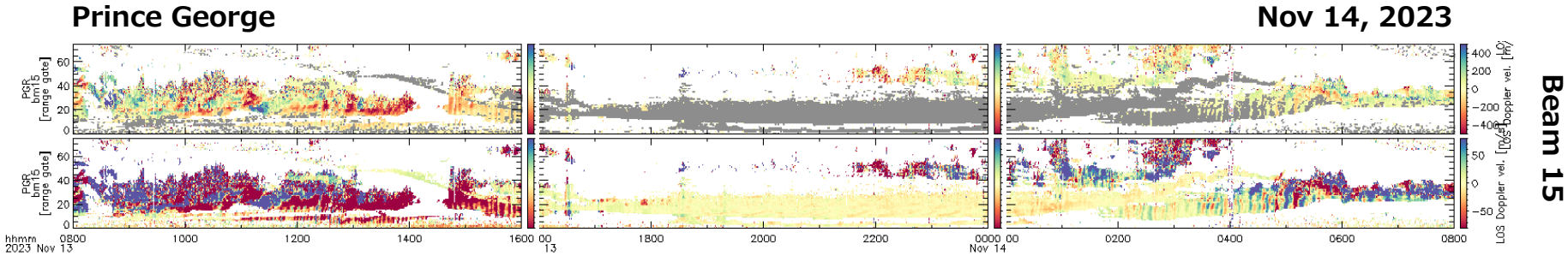

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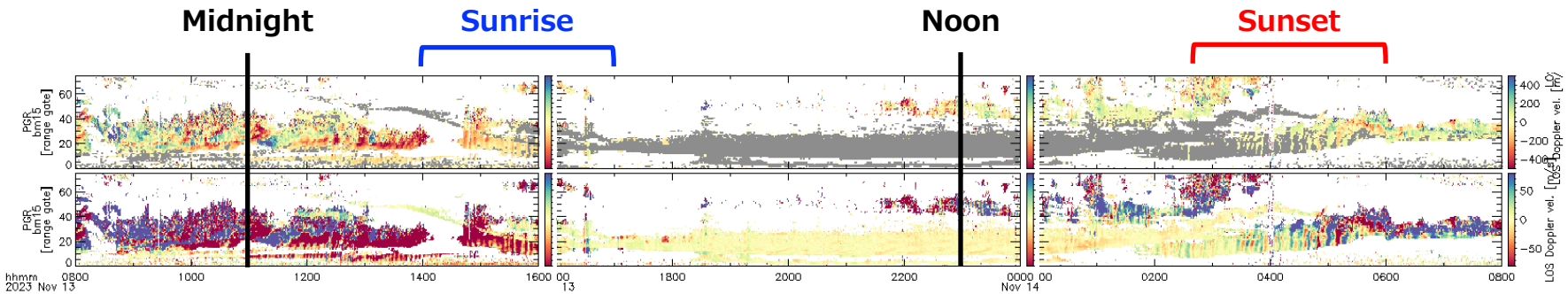
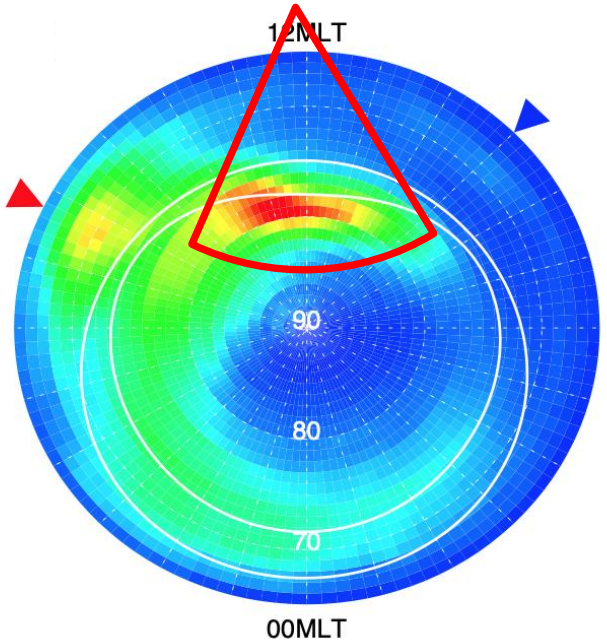
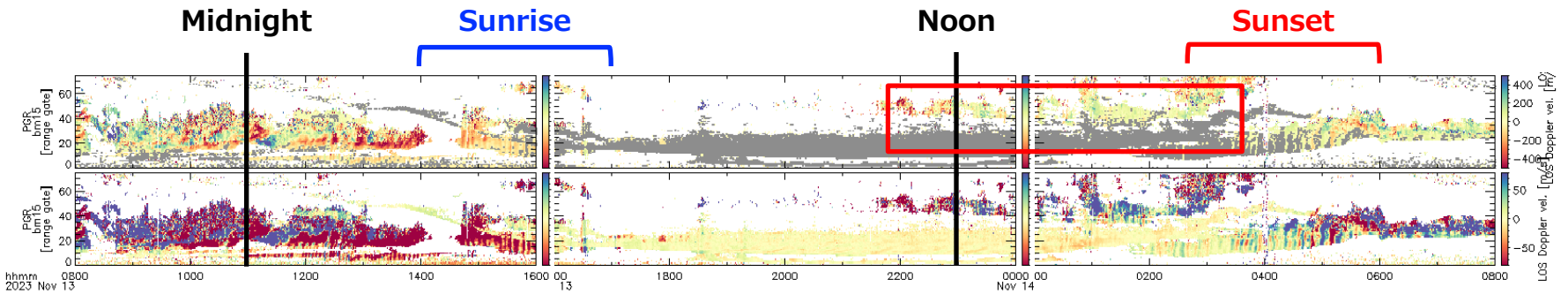


# Source of echoes

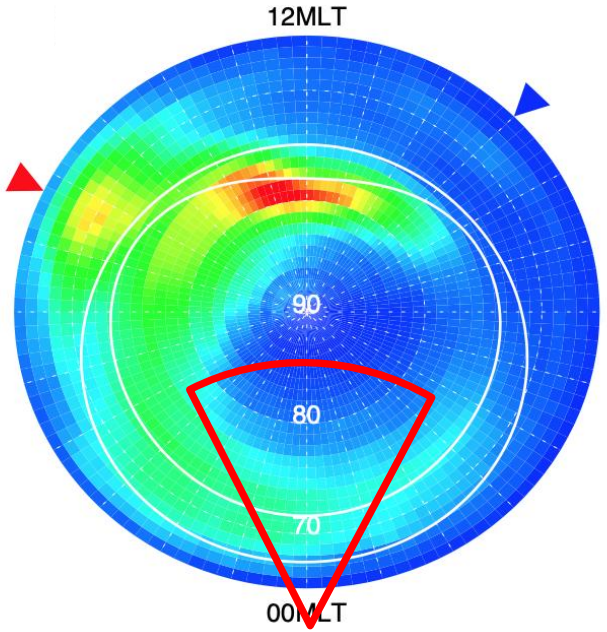
- Cusp echo on the dayside

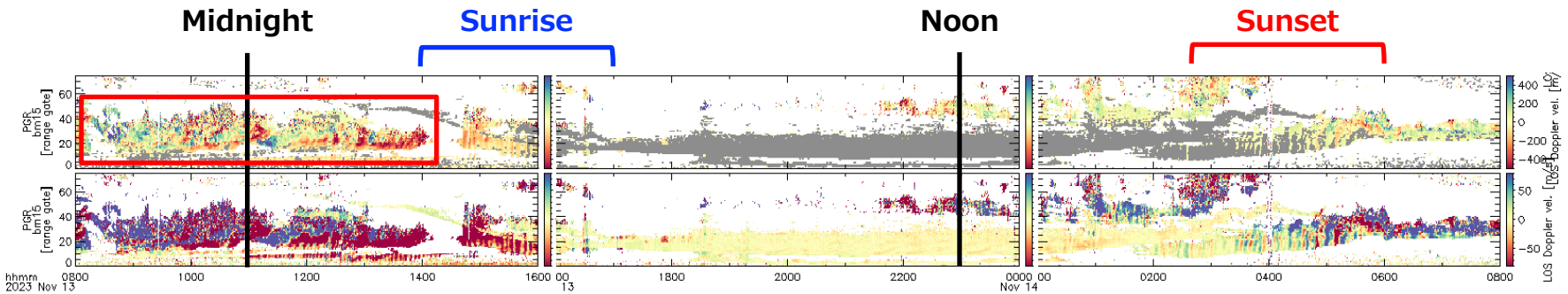


# Source of echoes

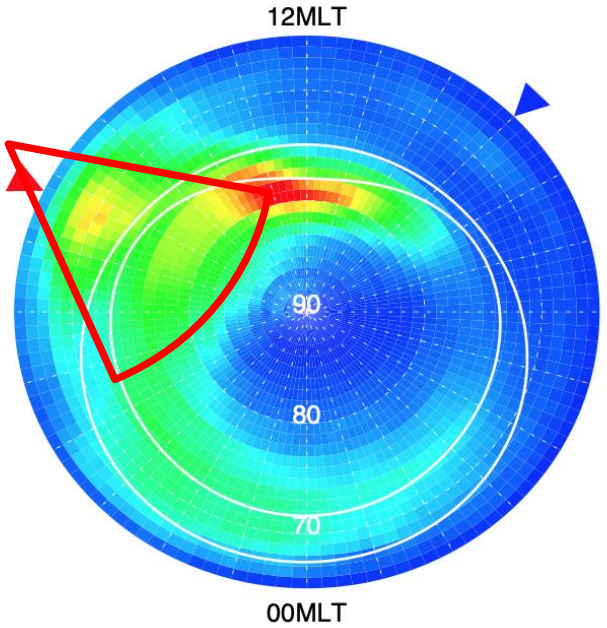
- Cusp echo on the dayside
- Auroral echo on the nightside

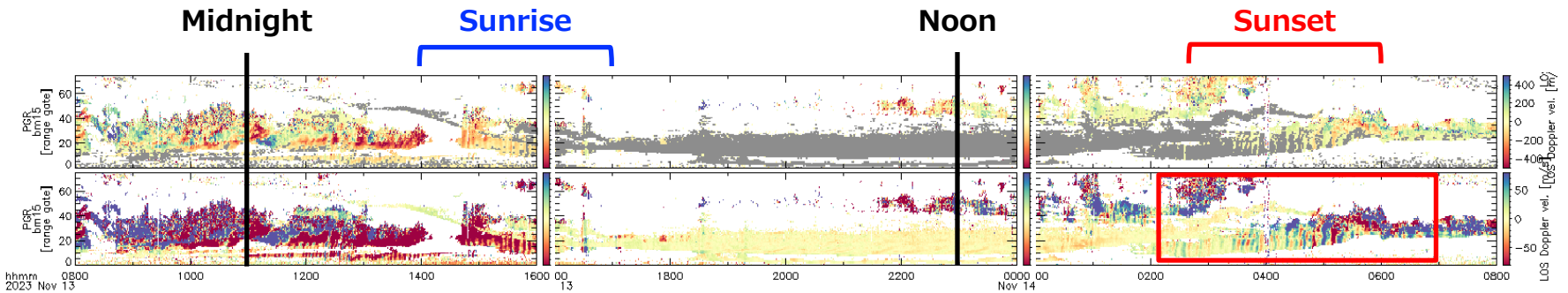


# Source of echoes

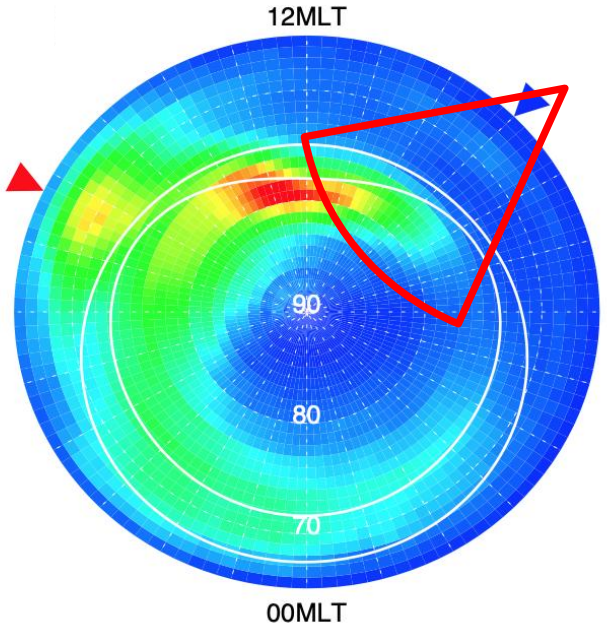
- Cusp echo on the dayside
- Auroral echo on the nightside
- Dusk scatter echoes (DUSE)

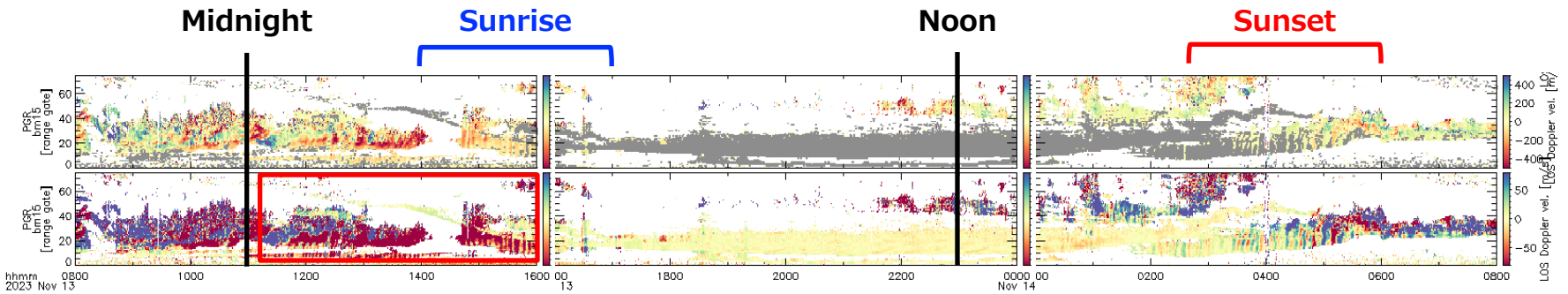


# Source of echoes

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



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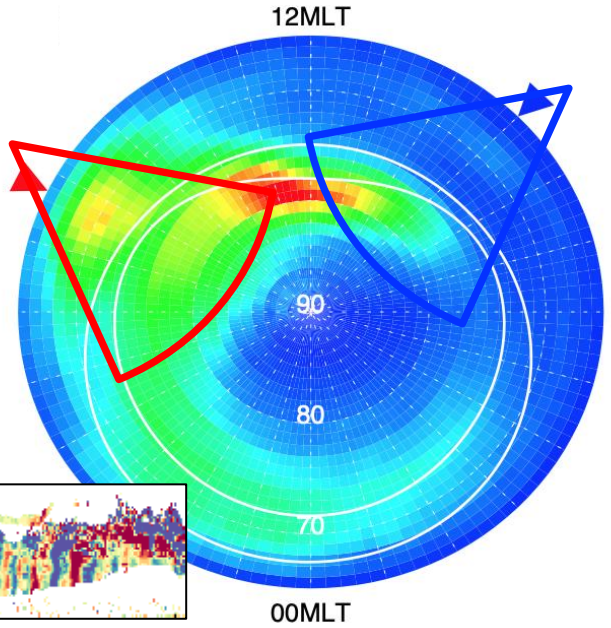
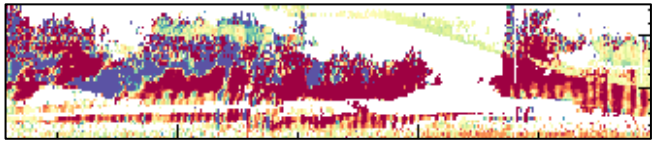
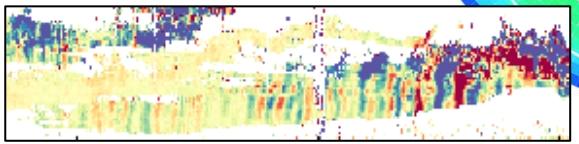
- Auroral echo on the nightside
- Dusk scatter echoes (DUSE)
- Dawn scatter echoes (DASE)

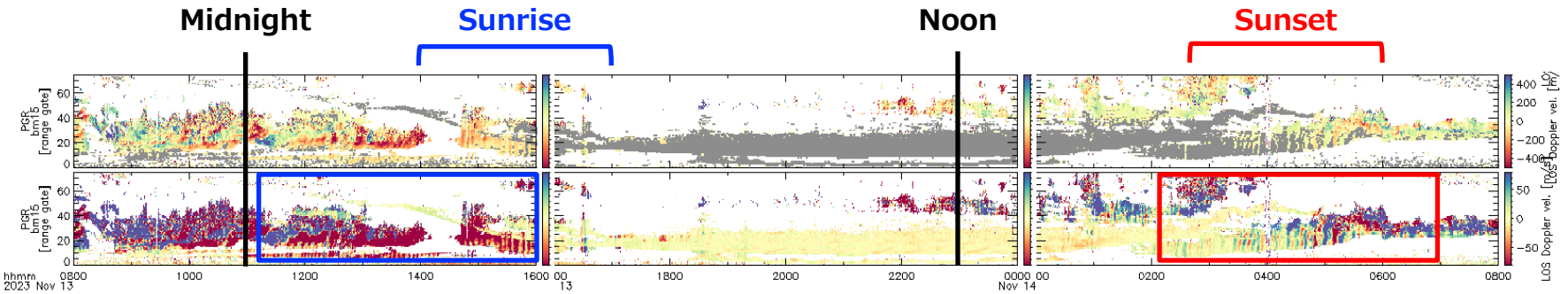



**DASE**

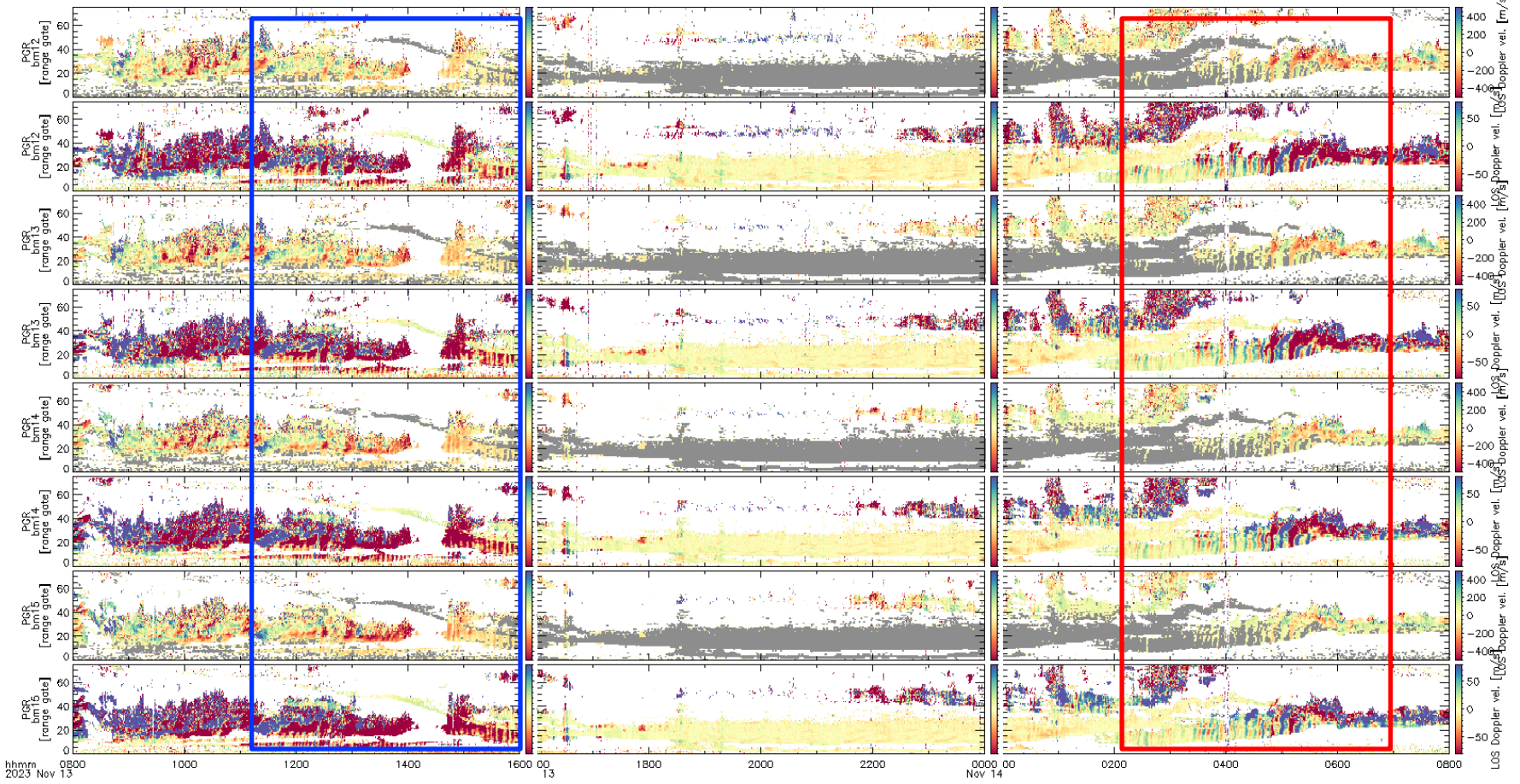


**DUSE**

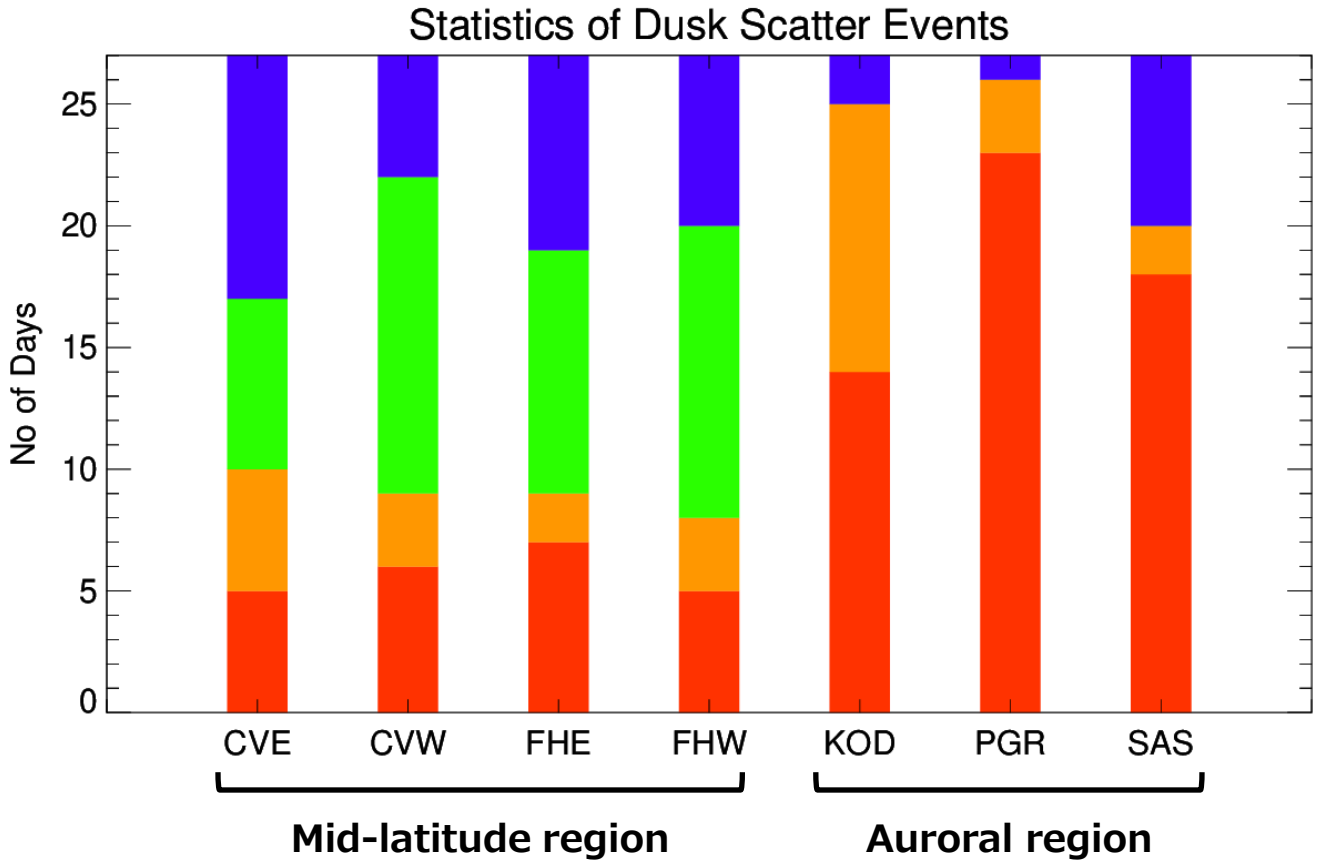




# Have looked at 16 beams, 7 radars, 27 days



# Small statistics with 27 days observations




DUSE with Caterpillar

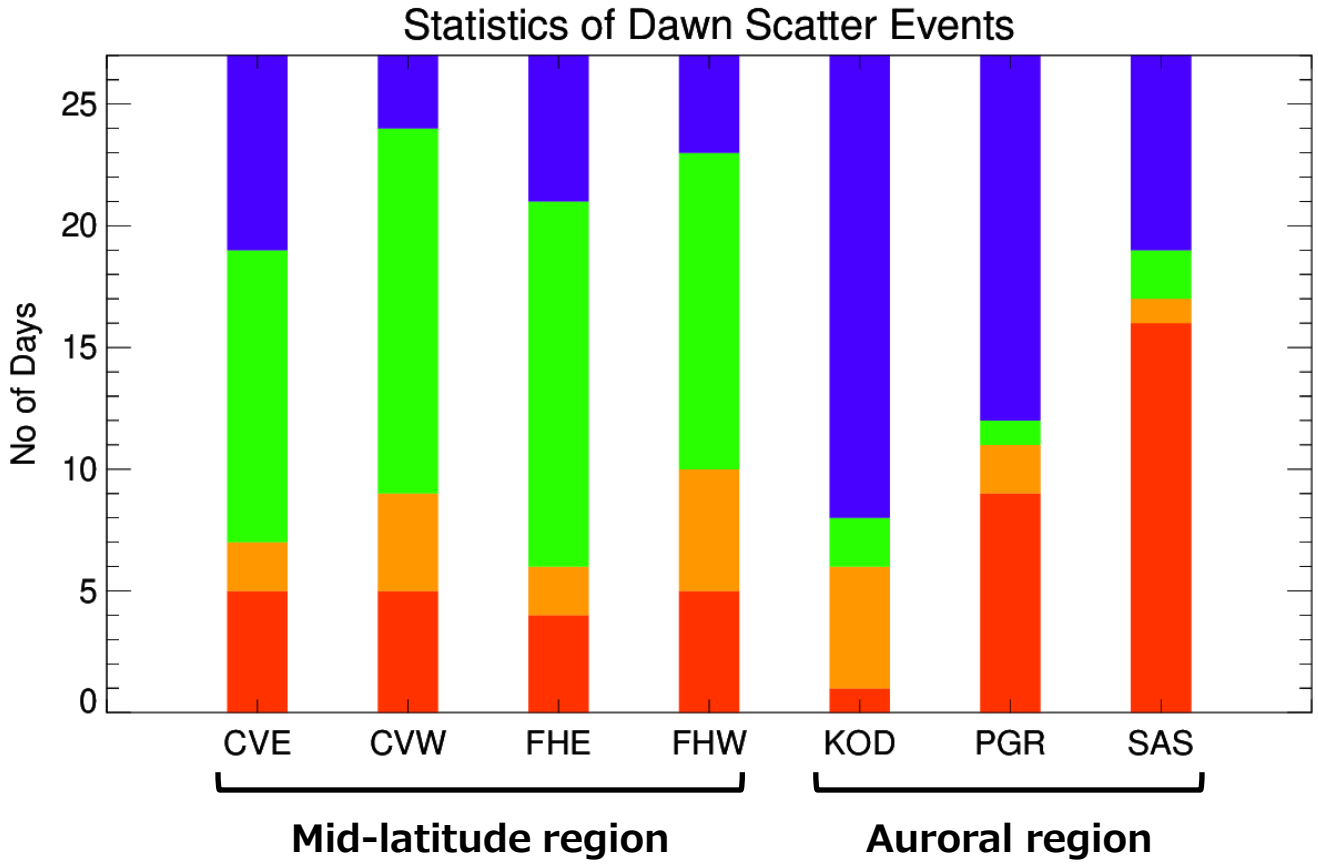
DUSE without Caterpillar

Other echoes

No echo

**DUSE**

# Small statistics with 27 days observations




DASE with Caterpillar

DASE without Caterpillar

Other echoes

No echo

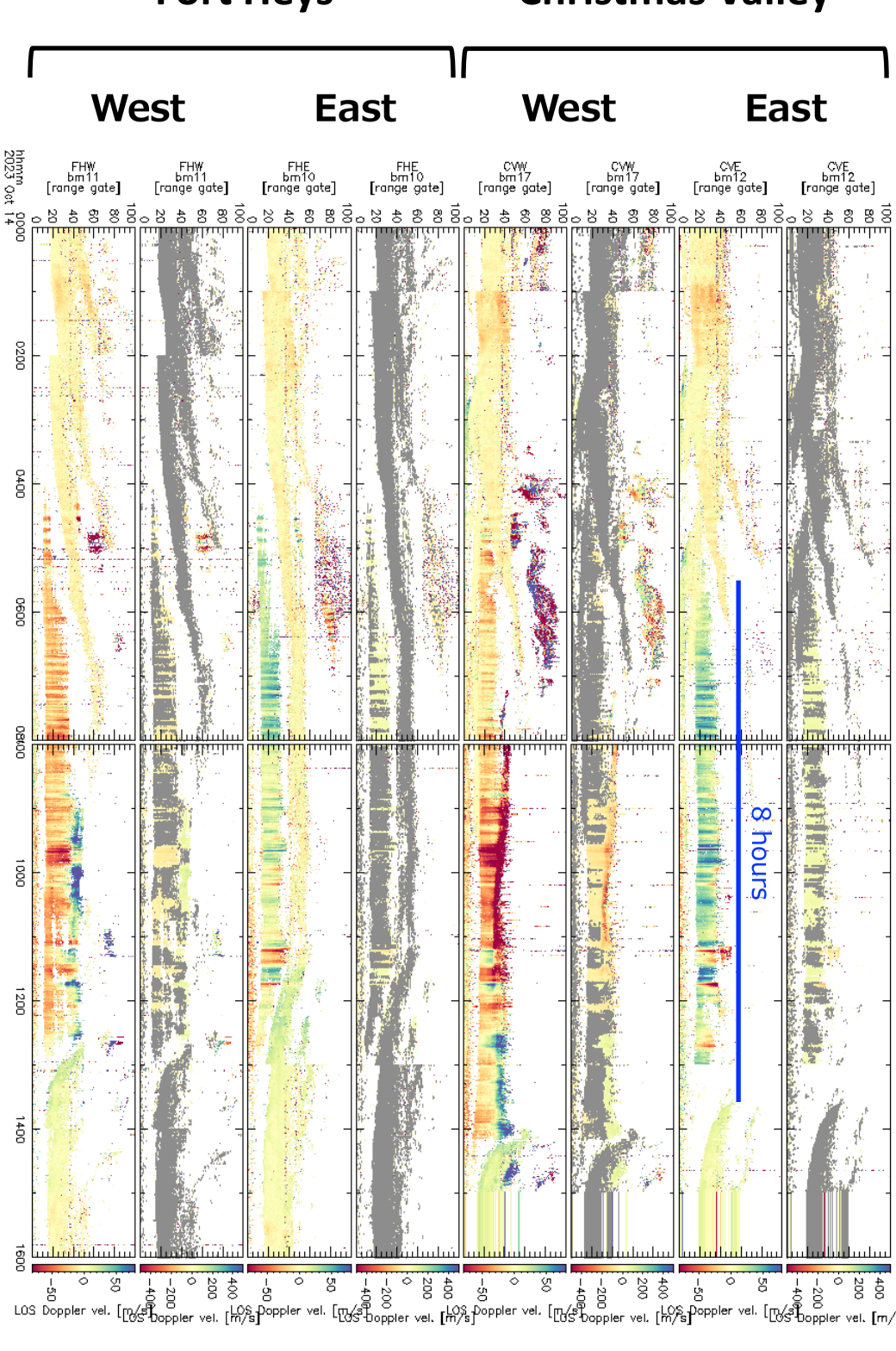
**DASE**

# 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?
  → Such a trick does not exist to produce ULF waves in a 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

# Continuous echoes including ULF

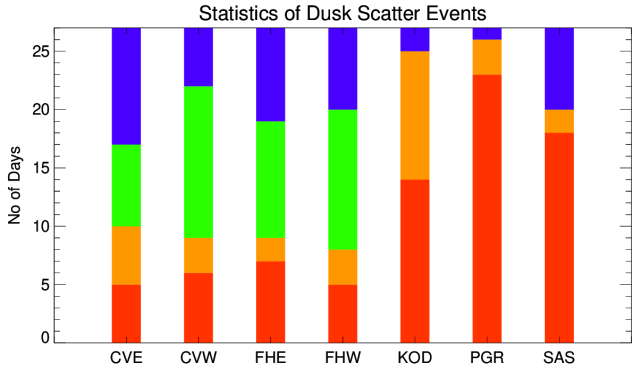
## Oct 14, 2023 at mid-latitudes



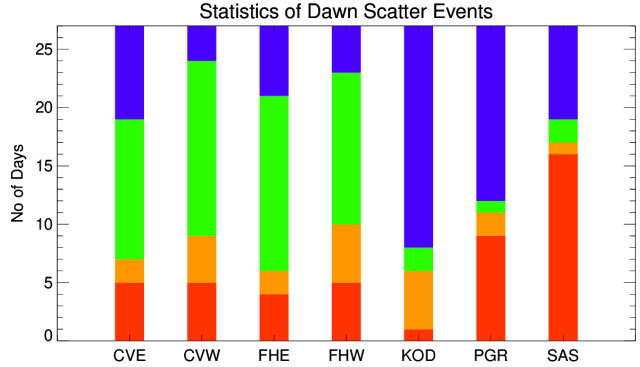
# Summary

- 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 quiet periods

DUSE




DASE




**Long-lasting echo with ULF at mid-latitudes**