On sporadic E layer signatures in SuperDARN data

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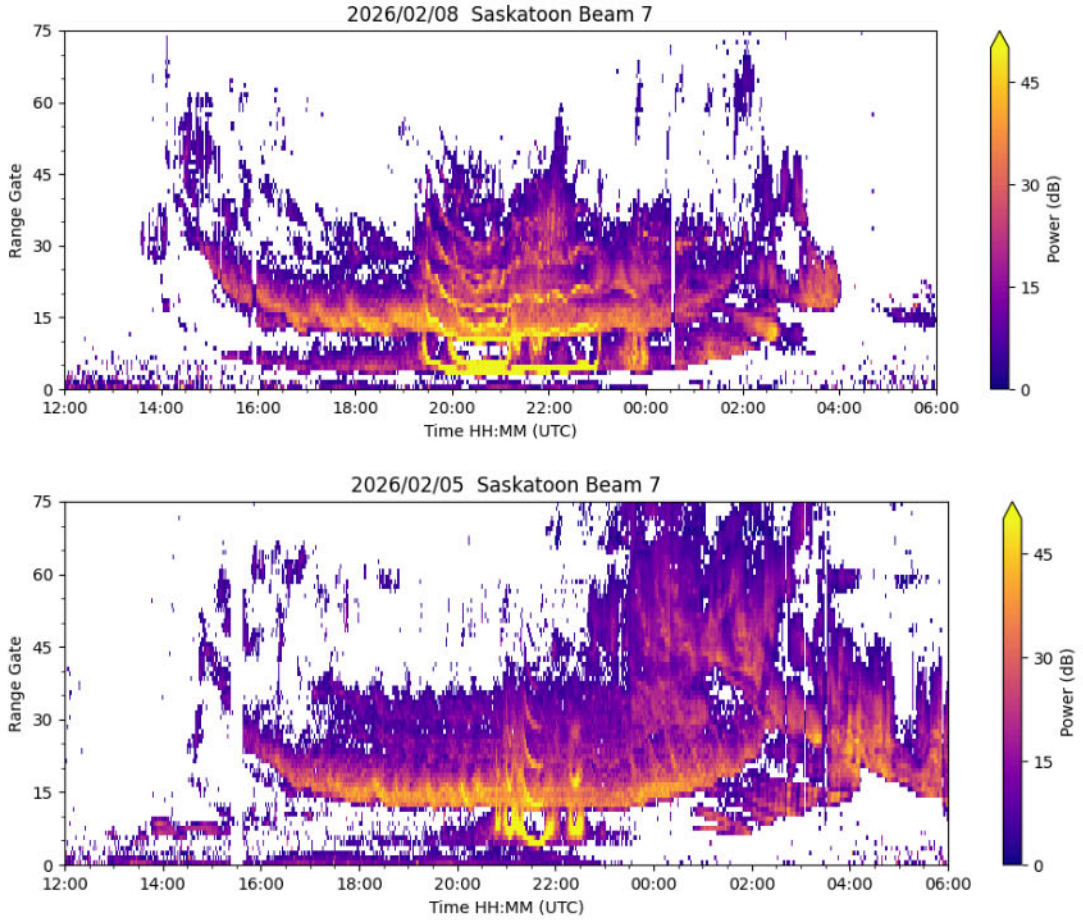
Outline

- Introduction and problem formulation.
- Multi-band "ionosonde" Es echoes?
- Actual Es signatures: identification, characterisation and climatology.
- Summary and conclusions.

Introduction and problem formulation

- E-layer echoes, including those from the sporadic E layer, are commonly treated as interference and excluded from the conventional SuperDARN analysis.
- However, they contain important information on both E-layer parameters and HF propagation conditions.
- While the regular E-layer can be more or less accurately modelled, the Es is essentially unpredictable by its nature. Therefore, to assess HF propagation conditions reliably, it is important to be able to monitor current Es characteristics (altitude, critical frequency, spatial extent, "blanketing" properties etc.).
- SuperDARN radars, through their spatial coverage and continuous operation, present a unique opportunity for addressing this problem at mid to high latitudes.

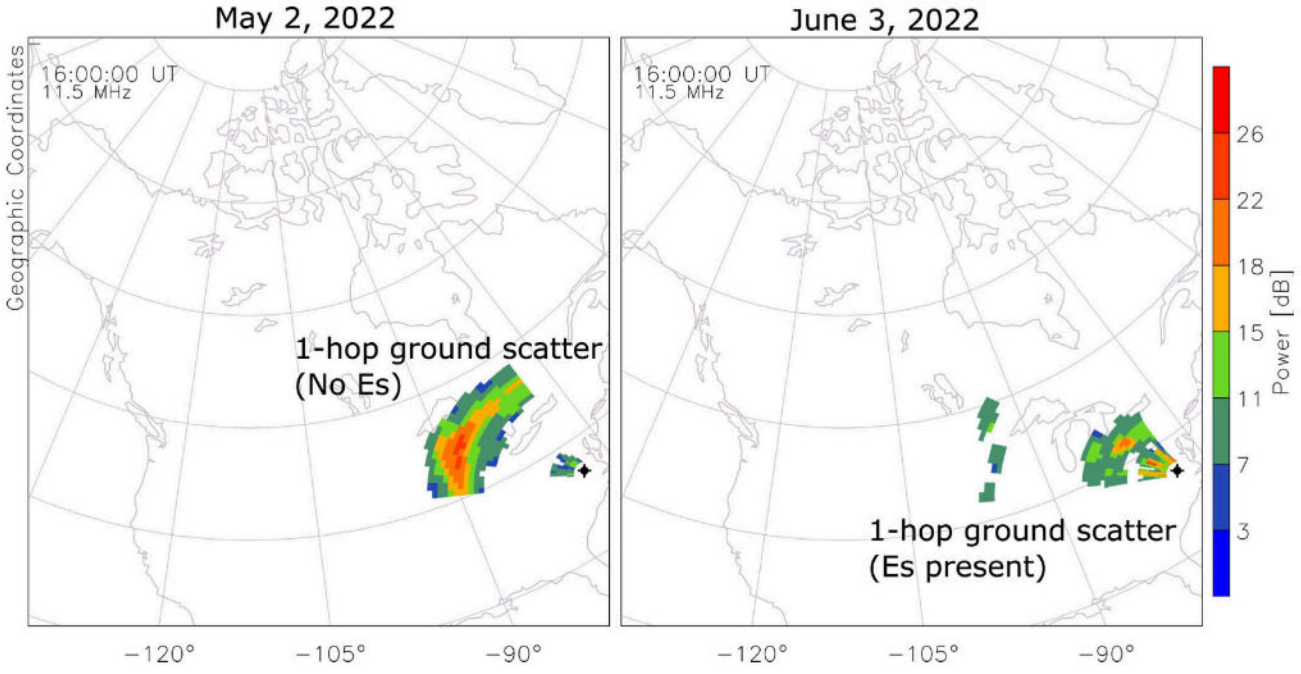
"Hearsay" ionosonde-style Es echoes?



- I have heard from several experienced SuperDARN people that the multi-band echoes from time to time observed in ground scatter represent critical reflections from the Es layer. Indeed, they look "sporadic" enough.

Publications?

- However, I was able to find very few publications (only two?) about the Es signatures in SuperDARN data. Neither of them was concerned with the periodic echo bands but represent case studies describing backscatter patches from near ranges that seems to be capable of "blanketing" regular ground scatter echoes.

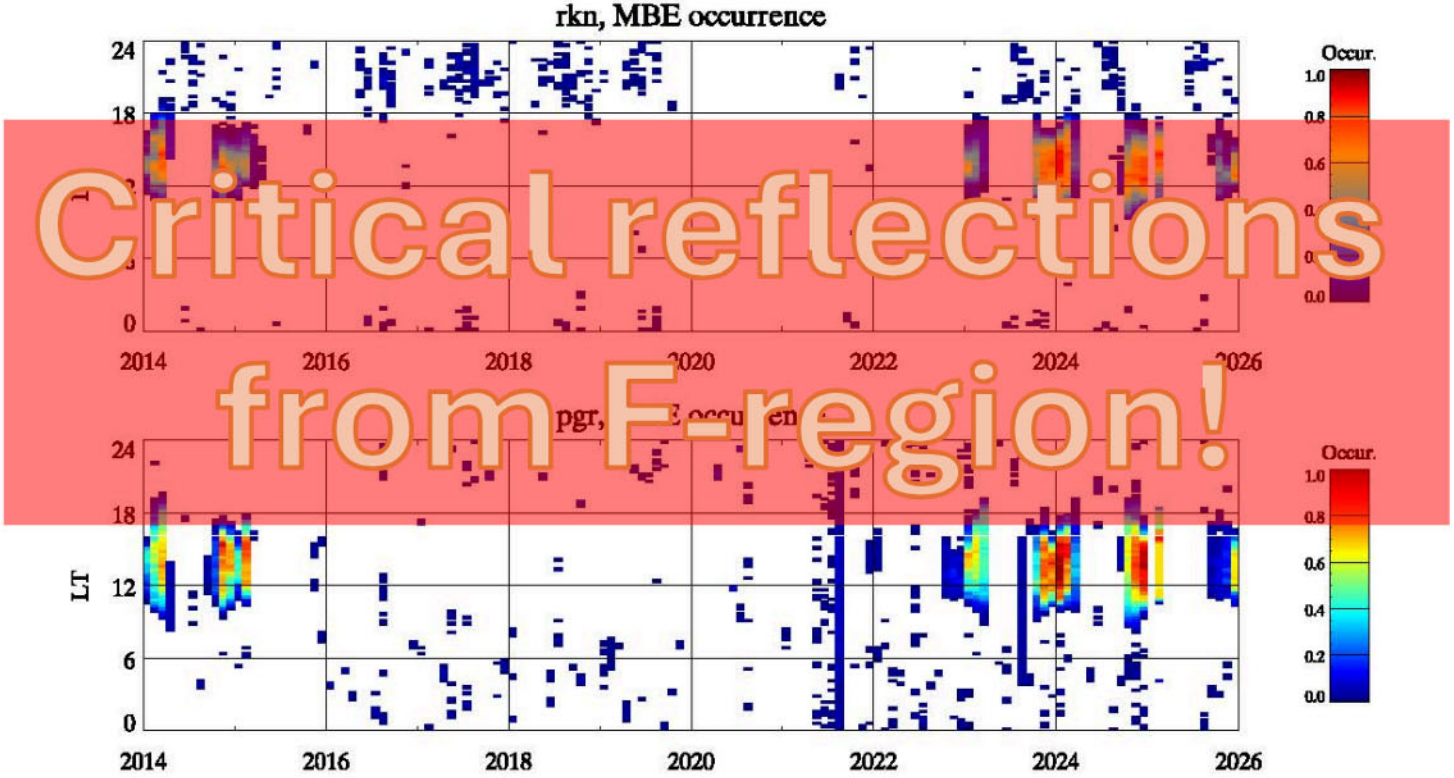


Kunduri et al, 2023
https://doi.org/10.1029/2023JA031455

Closer look at the multi-band echoes

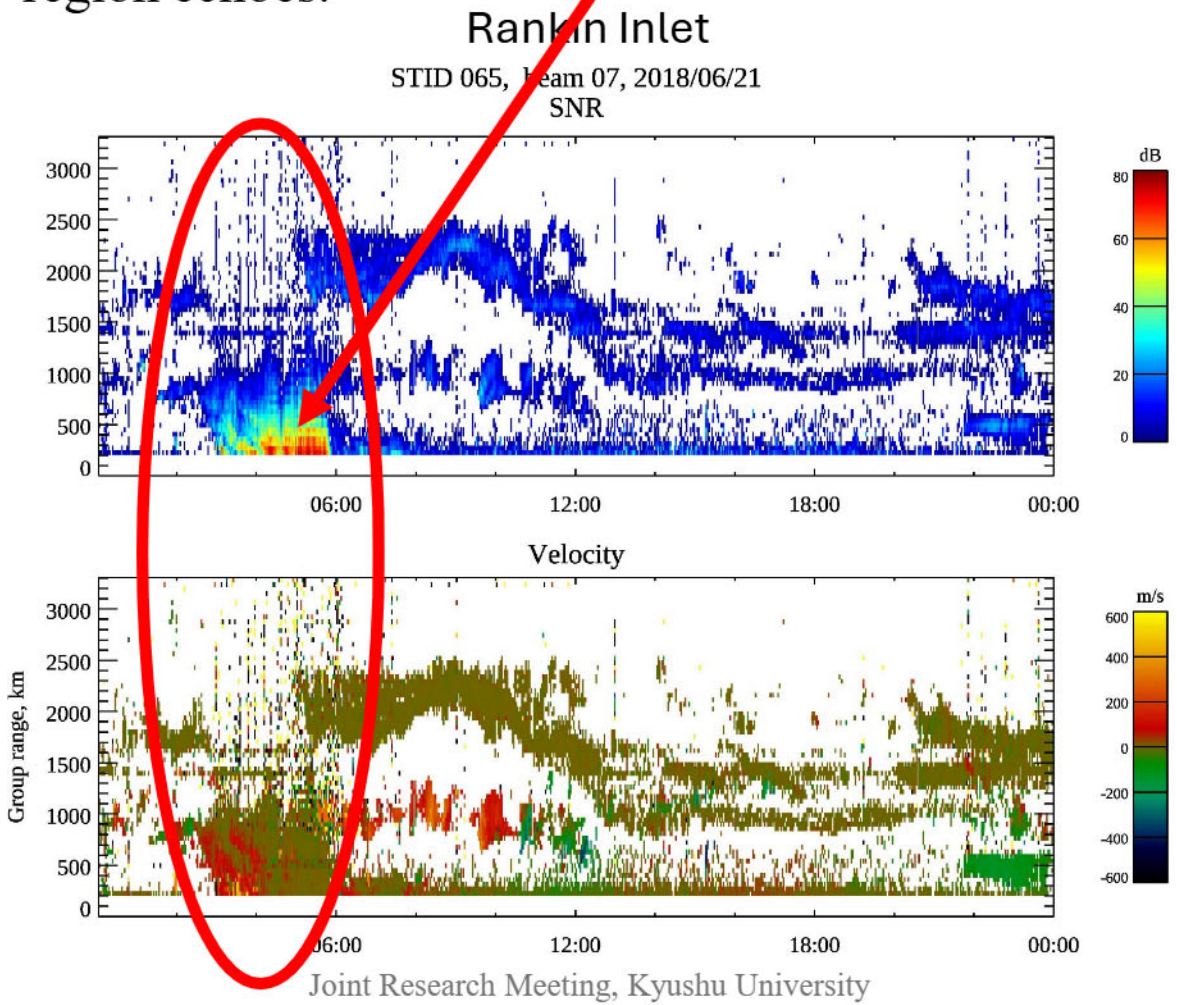
- Problems with their attribution to Es:
  - Effective band separation (altitude) of 300-400 km is too large.

    Is it oblique multi-hop ground scatter?
  - Observed predominantly in winter daytime during solar maximum.



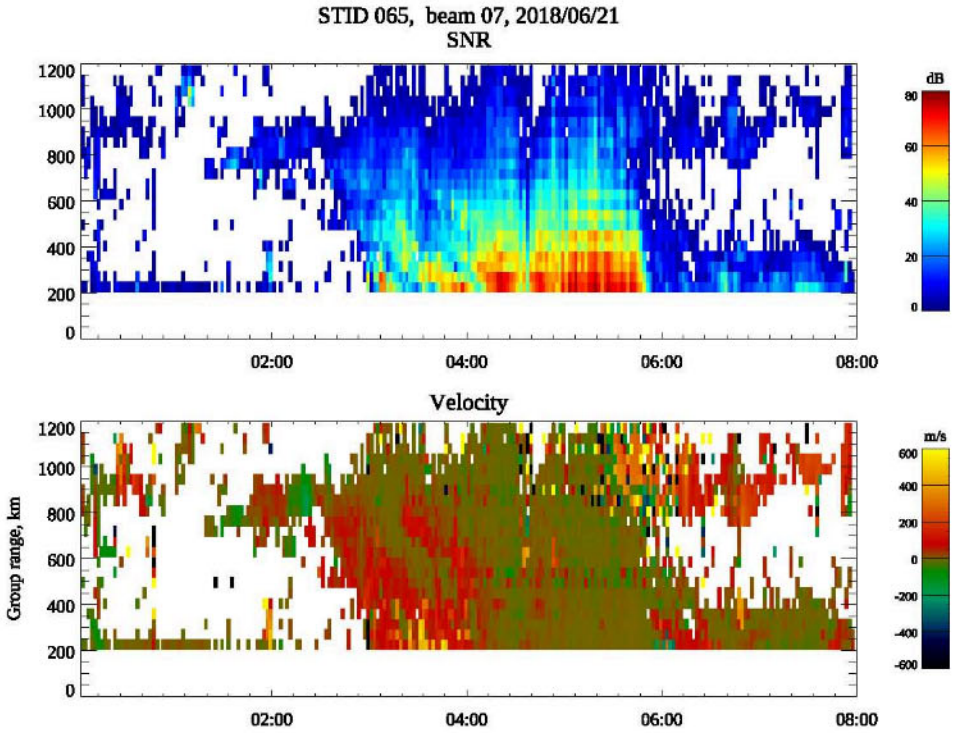
What about "blanketing" close-range echoes?

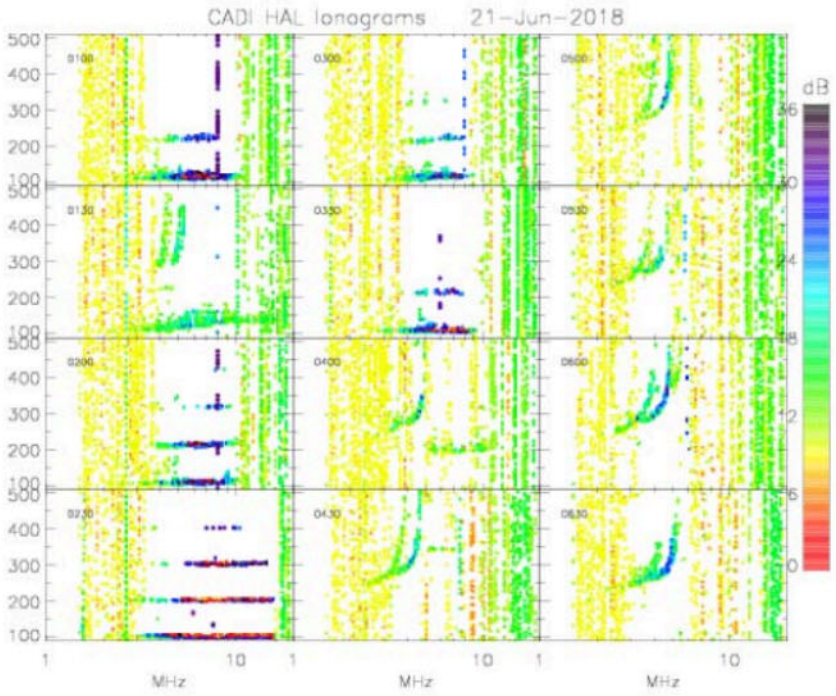
- Indeed, detailed visual analysis showed frequent presence of close-range echoes with very high SNR (up to 60-80 dB) capable of "blanketing" the regular F-region echoes.



Ionosonde data

- These signatures are frequently accompanied by multiple Es traces in nearby ionosonde data.

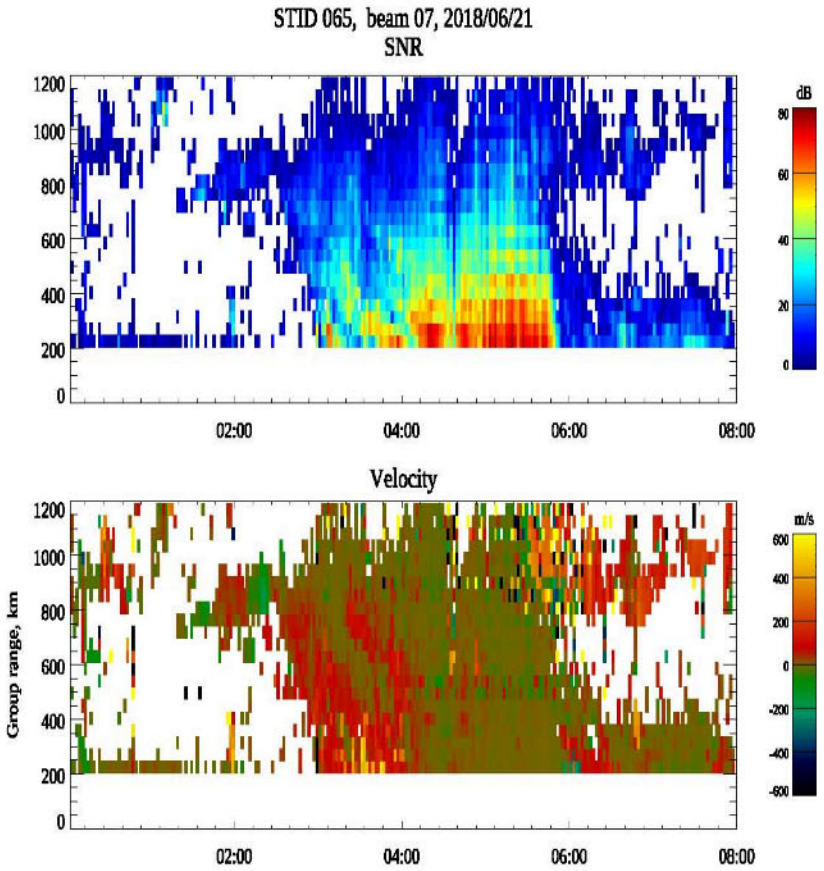


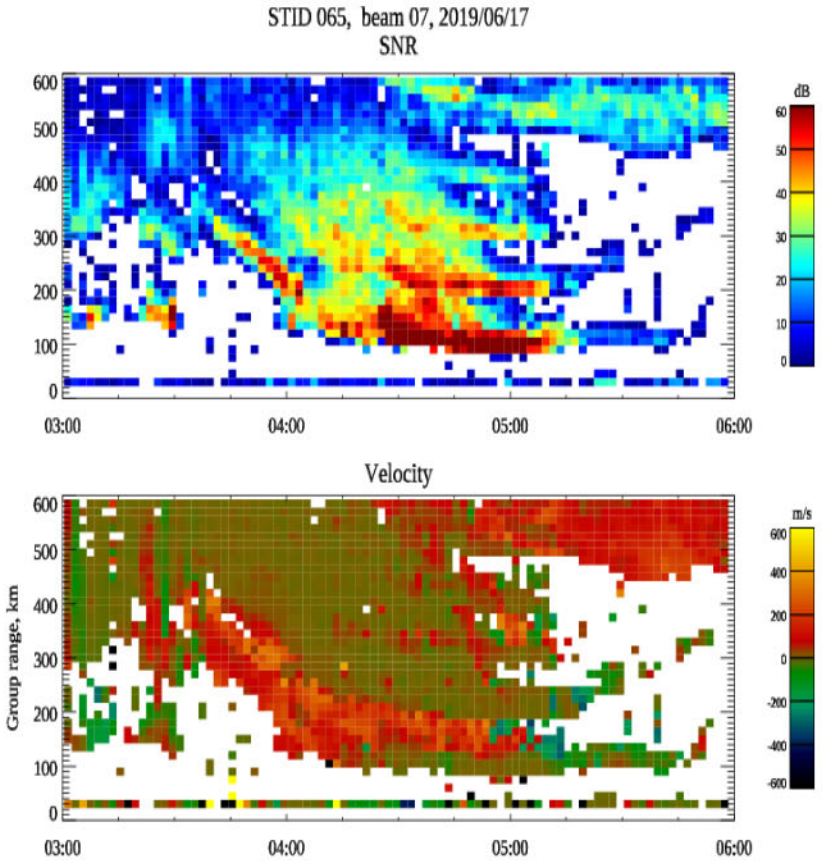


These echoes are also multiband!

Regular resolution:
45 km starting from 180 km

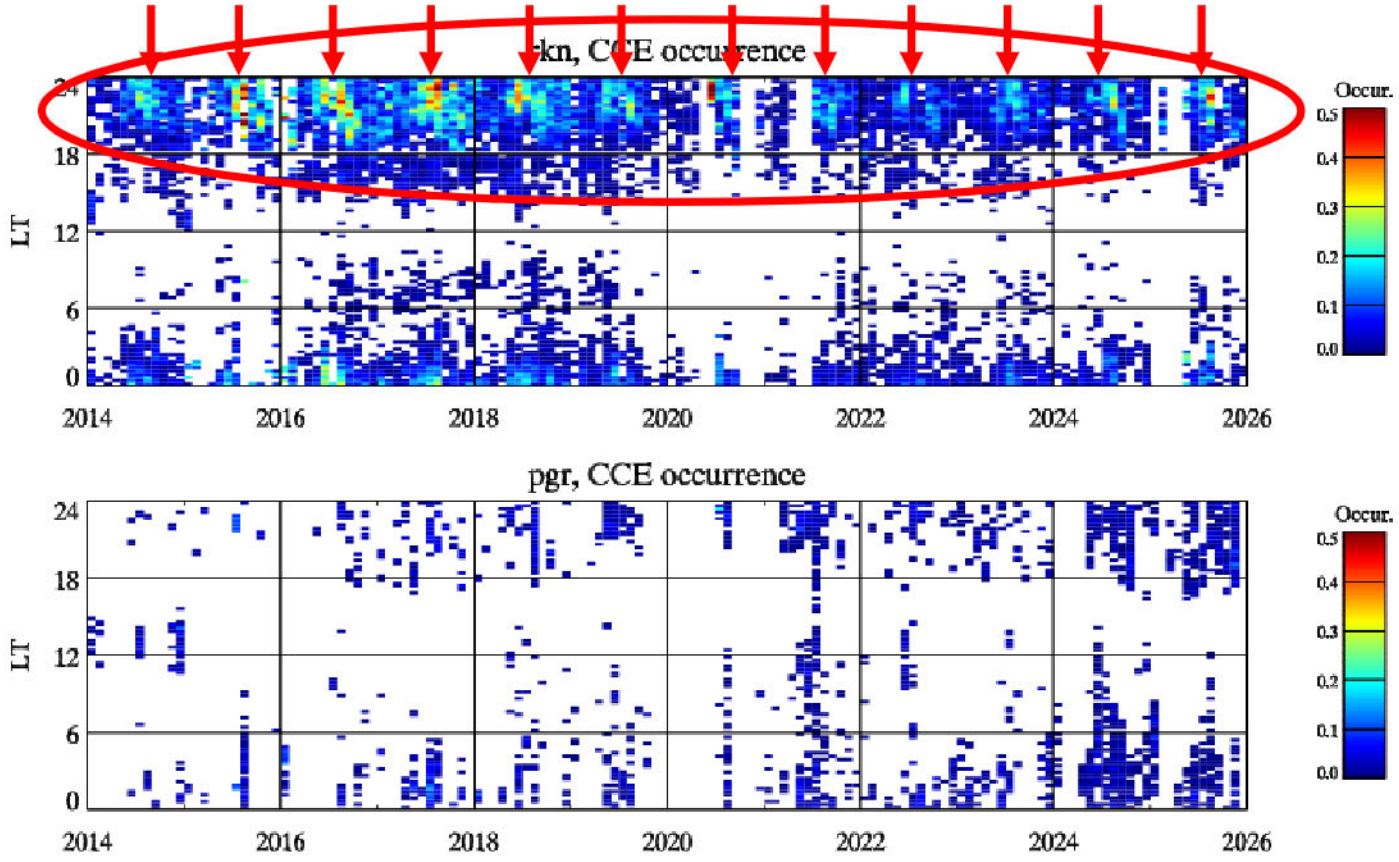
High resolution:
15 km starting from 0 km





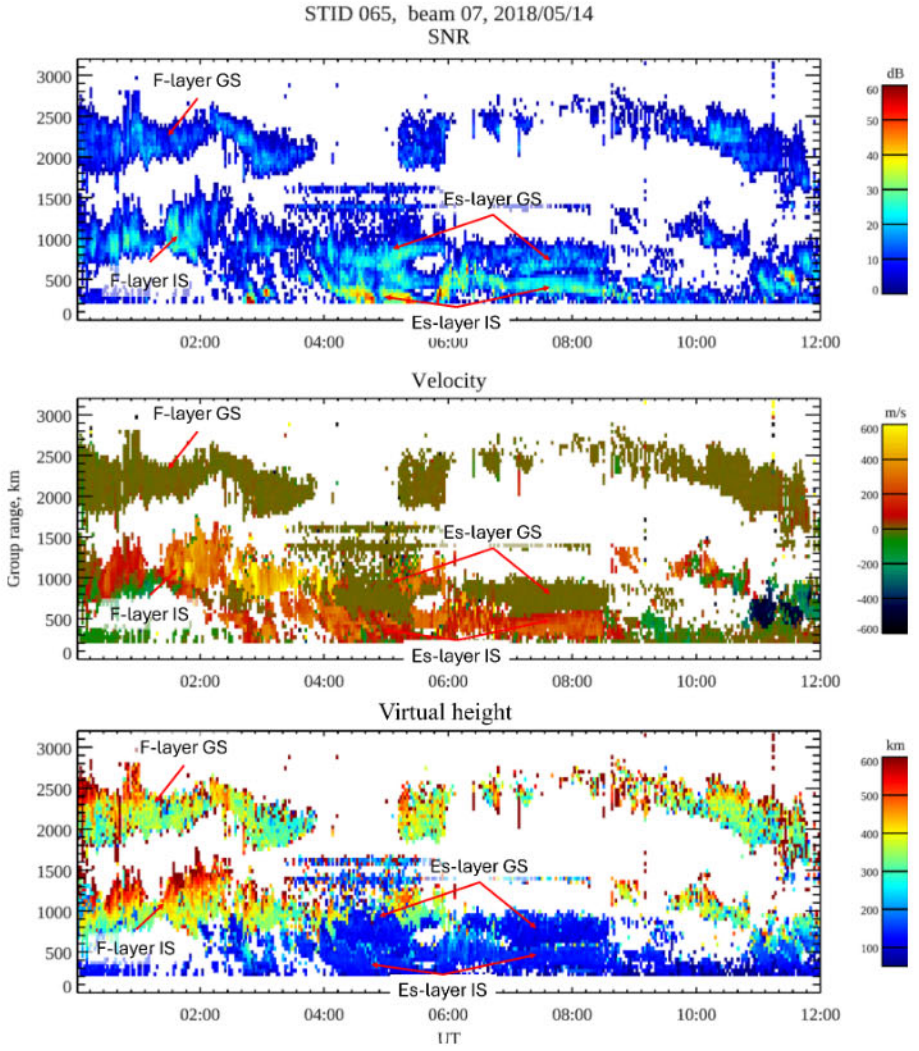
Climatology of high-SNR Es echoes

- The high-SNR Es echoes show preference for high latitudes with occurrence rate maximising in summer months during late-evening/midnight hours.
- This climatology agrees with the known Es properties.



Utilisation of accurate elevation angle

- In recent years accurate calibration of elevation angle became possible, thus, enabling identification of Es echoes based on their virtual height.
- Es echo propagation is barely affected by any refraction so that the virtual height estimates are close to the real heights.
- Virtual height analysis revealed a regular presence of oblique propagation modes, both in ionospheric scatter and ground scatter.



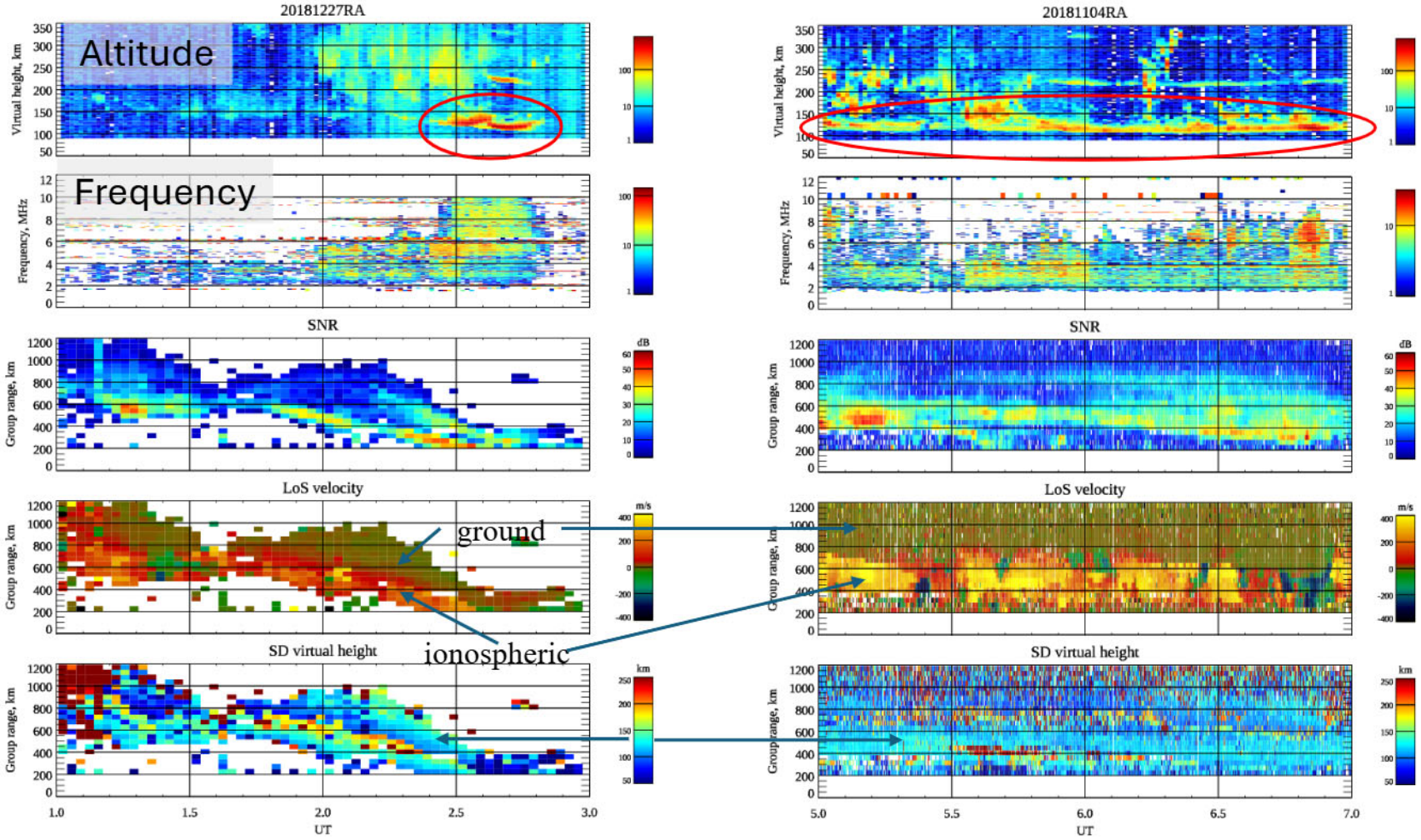
Different scenarios

Limited-size Es "cloud"

Large-scale Es

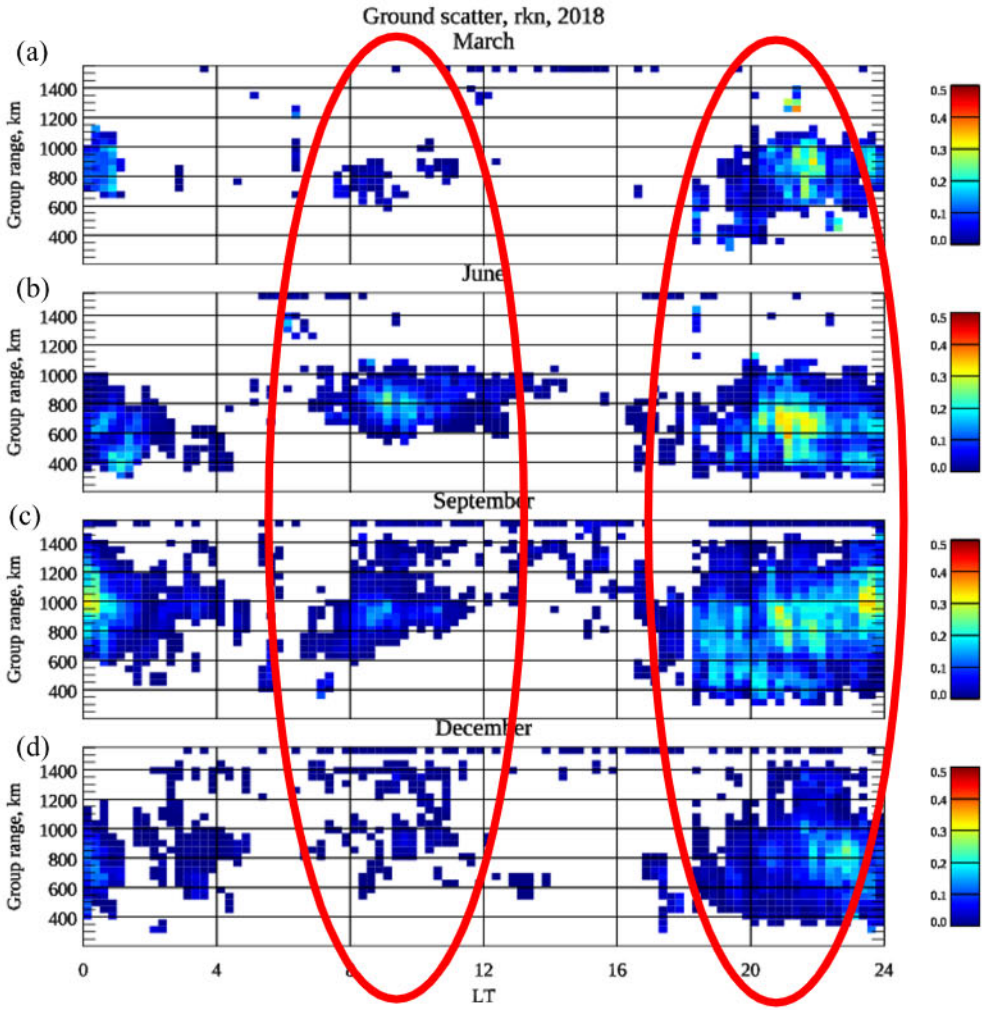
Ionosonde

SuperDARN



Morphology of oblique ground scatter echoes

- The "non-critical" (oblique) echoes show seasonal-diurnal variations similar to the multi-band Es reflections.
- In addition, they exhibit a secondary pre-noon population.
- Both populations seems to agree with the conventional semi-diurnal tide scenario.



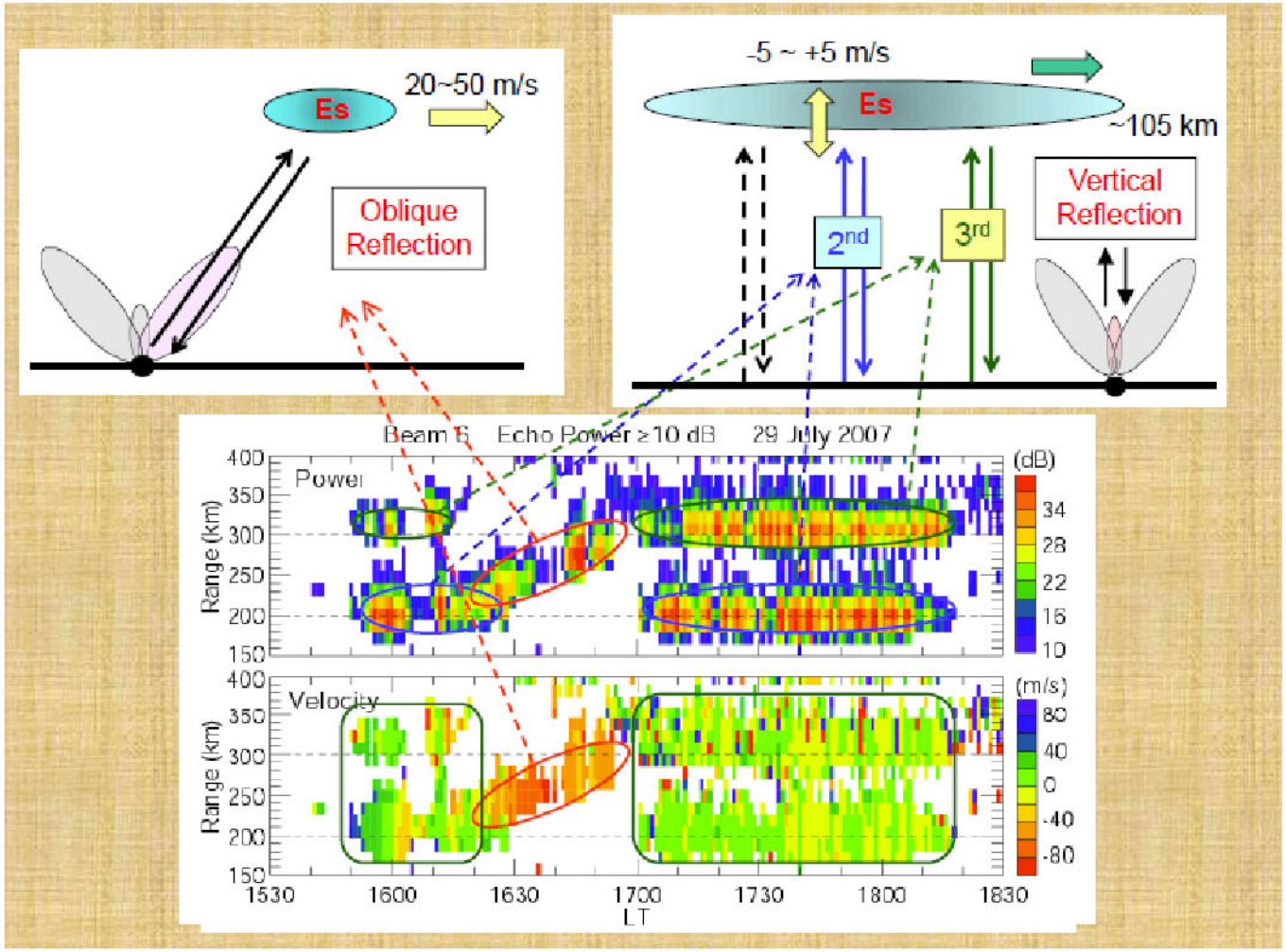
Summary and conclusions

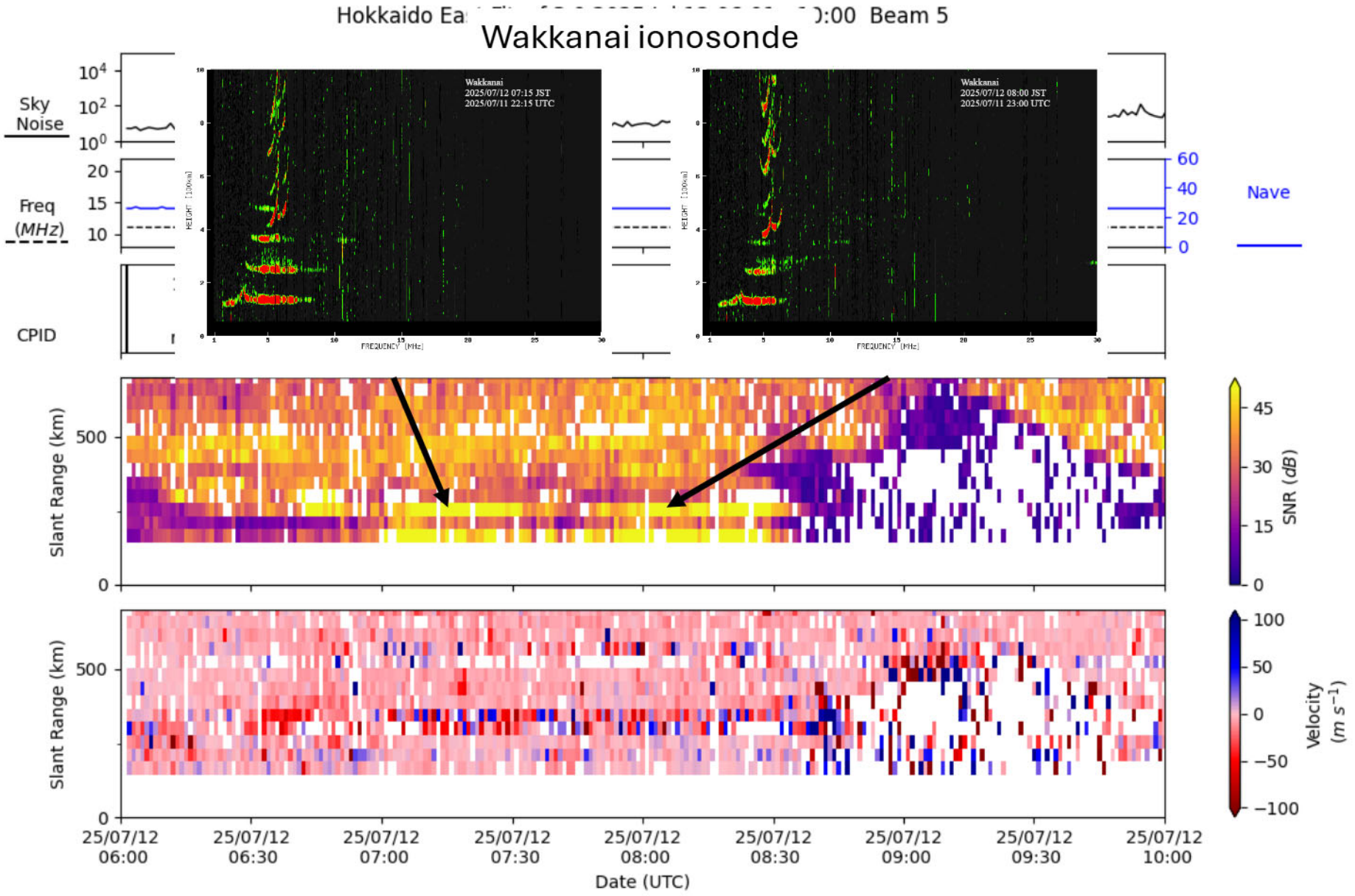
- The muti-band reflections previously attributed to Es occurred to be from the regular F-layer.
- The actual Es signatures in SuperDARN data can be split into three categories (or their combinations):
  - Vertical reflections when f_{mEs} exceeds the radar frequency
  - Obliquely propagating ionospheric scatter
  - Obliquely propagating ground scatter
- Diurnal/seasonal/solar cycle variations of these echoes are in agreement with the conventional interpretation of the Es layer generation in terms of wind shear and electric field convergence.

平成22年度 STEL研究集会「中緯度短波レーダー研究会」 名大 2011.1.31

北海道-陸別 SuperDARN で初観測された 夏季夕方の強い Es 層からの反射エコー

小川忠彦(NICT)、西谷 望(名大STE研)

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Wakkanai ionosonde
Sky Noise
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Wakkanai
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Wakkanai
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FREQUENCY [MHz]
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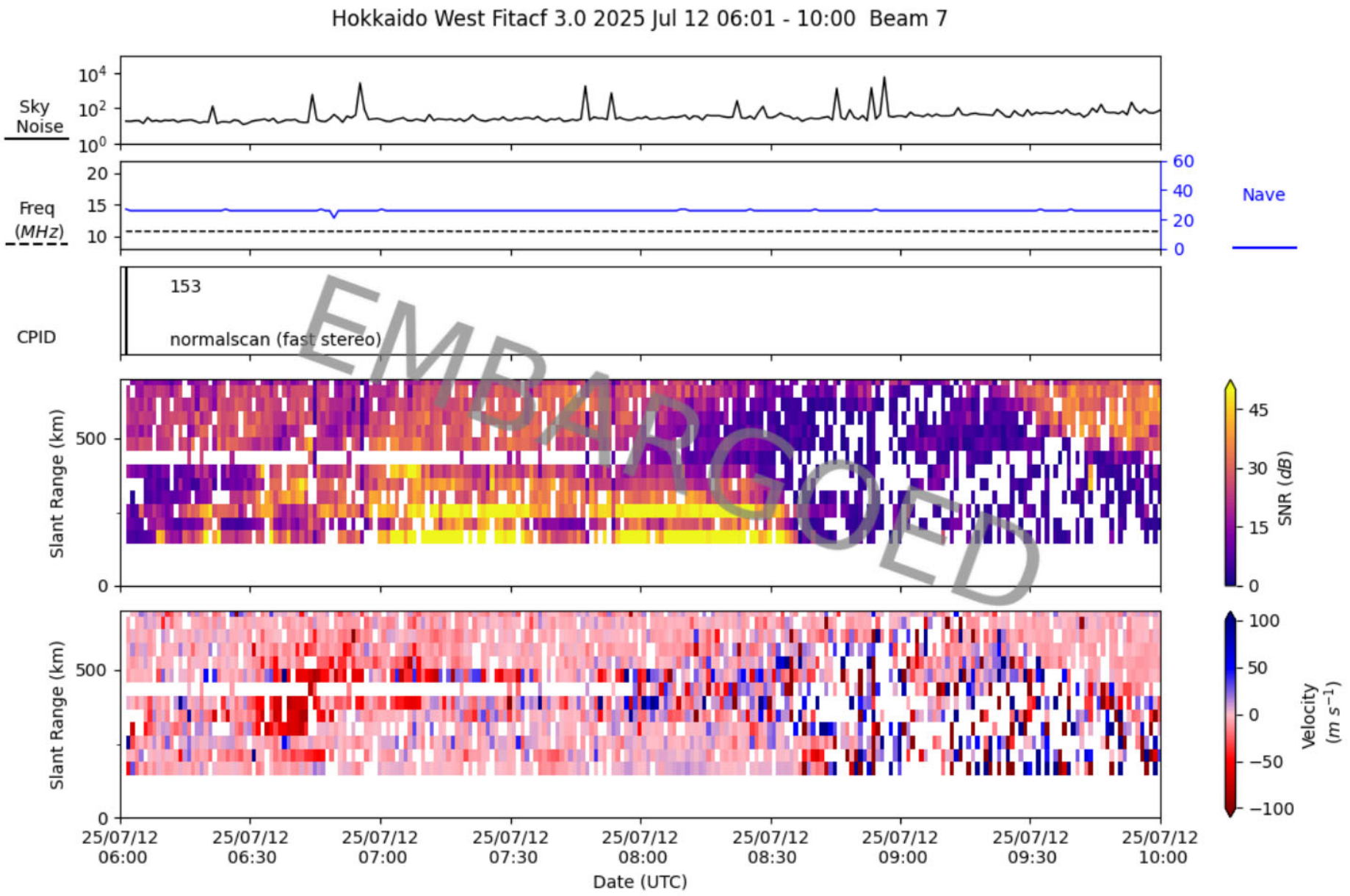
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Sky Noise
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