

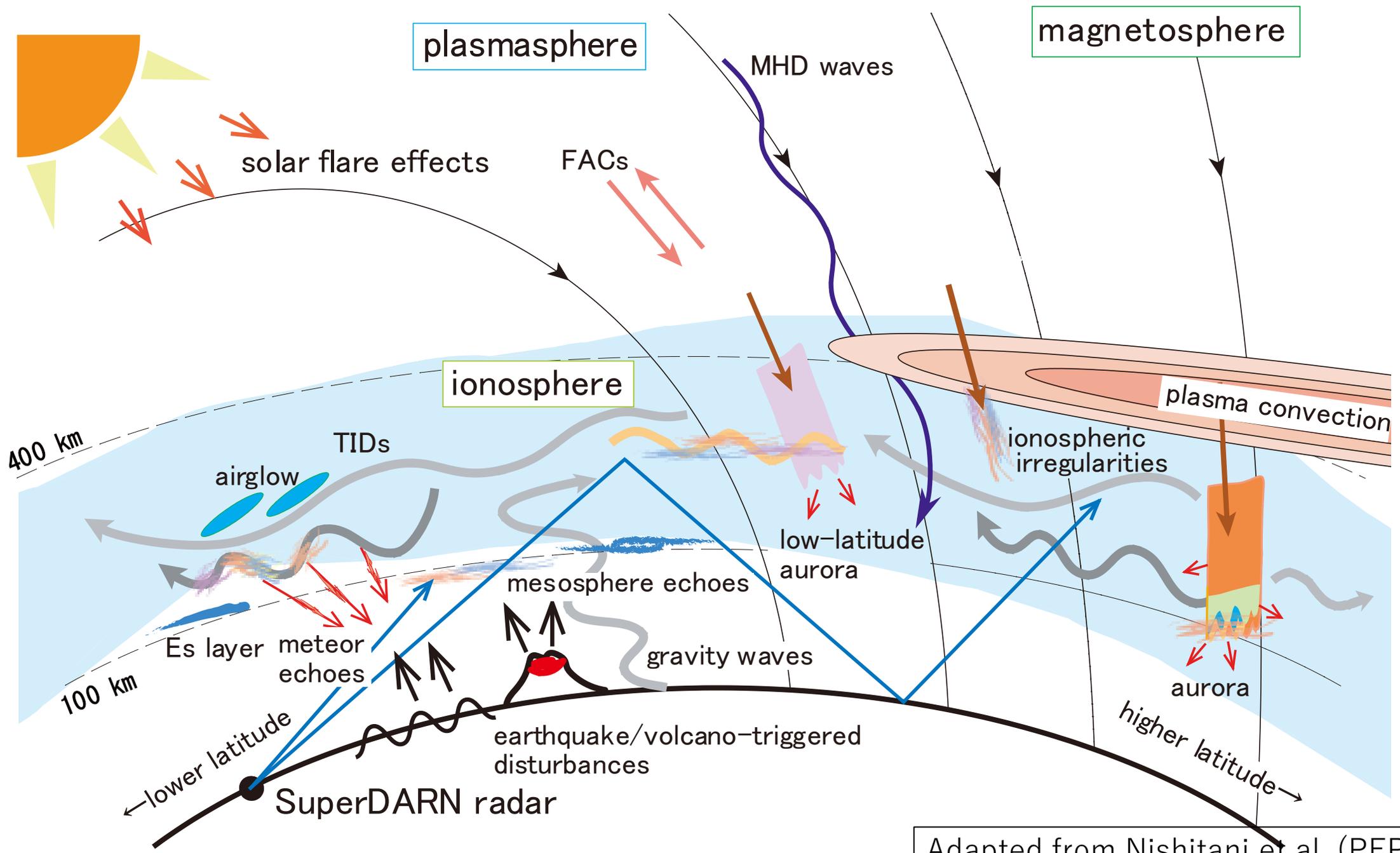
Ionospheric disturbances the SuperDARN HOP radars following the Kamchatka earthquake ($M_w=8.8$) in July 2025: preliminary results

2025年7月Kamchatka Earthquakeに伴い
SuperDARN HOP radarsで
観測された電離圏変動

N. Nishitani, T. Hori, A. Shinbori, and P. Ponomarenko
(ISEE, Nagoya University)

西谷望・堀智昭・新堀淳樹・Pasha Ponomarenko(名大ISEE)

Photo: Supplied / USGS



Adapted from Nishitani et al. (PEPS, 2019)

SuperDARN vs disturbance from below (earthquakes, volcano eruptions)

- Earthquakes

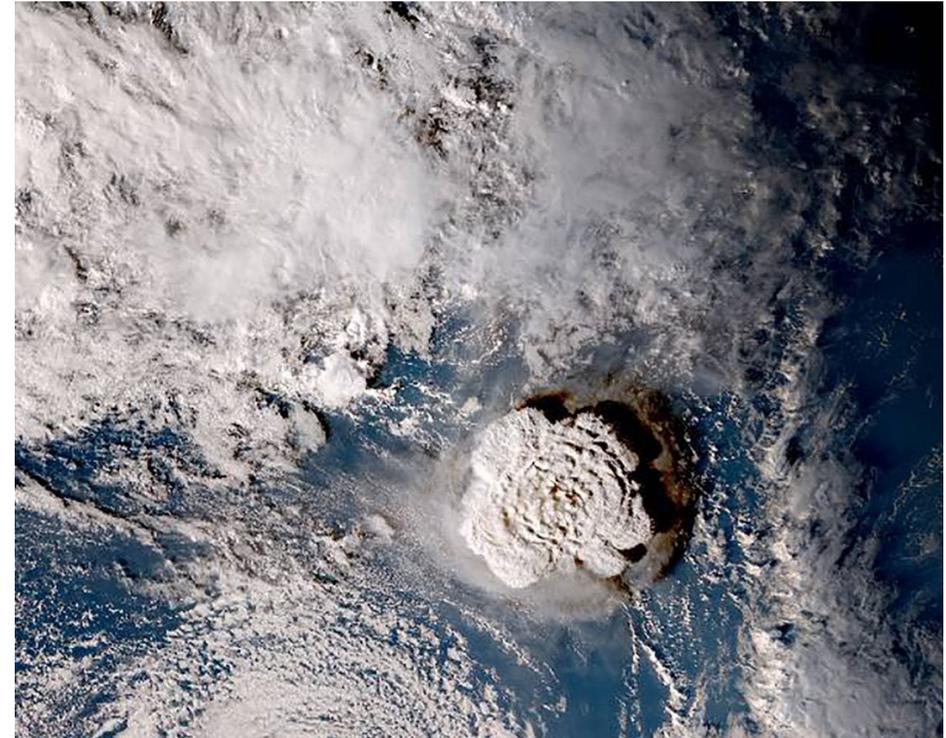
- Nishitani et al., EPS, 2011
- Ogawa et al., EPS, 2012



<https://www.geolsoc.org.uk/science-and-policy/plate-tectonic-stories/tohoku-earthquake/>

- Volcanic eruptions

- Shinbori et al., EPS, 2022

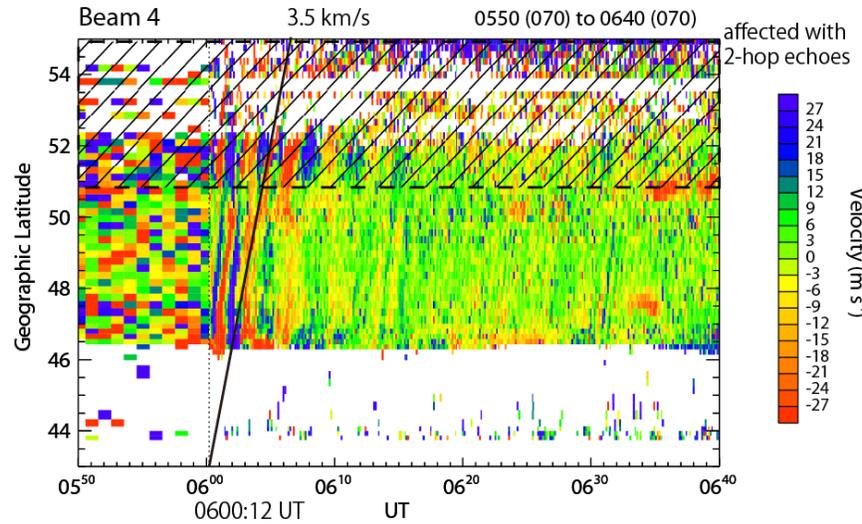


<https://edition.cnn.com/2022/01/17/asia/tonga-volcanic-eruption-tsunami-explainer-intl-hnk>

Coseismic ionospheric disturbances after the 11 Mar 2011 Tohoku Earthquake

SUPERDARN PARAMETER PLOT
Hokkaido: vel

11 Mar 2011

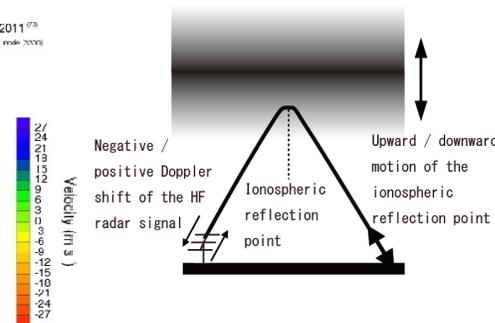
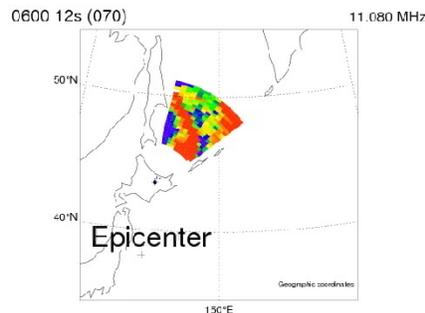


Nishitani et al., EPS, 2011; Ogawa et al., EPS, 2012

- After the earthquake, the radar observed apparent upward-downward motion of the ionosphere with p-p amplitudes up to 200 m/s.
- The disturbance traveled away from the epicenter with velocity range of 6.2 to 3.5 km/s, mostly comparable to that of Rayleigh waves.

SUPERDARN PARAMETER PLOT
Hokkaido: vel

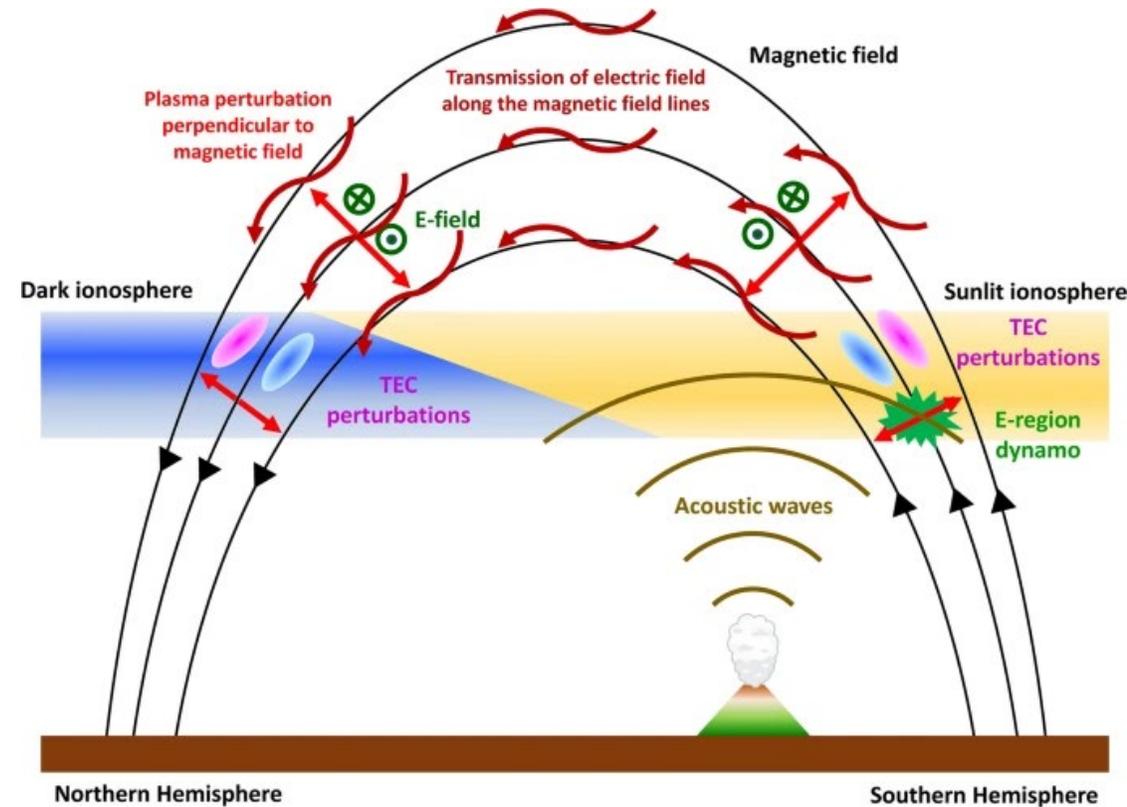
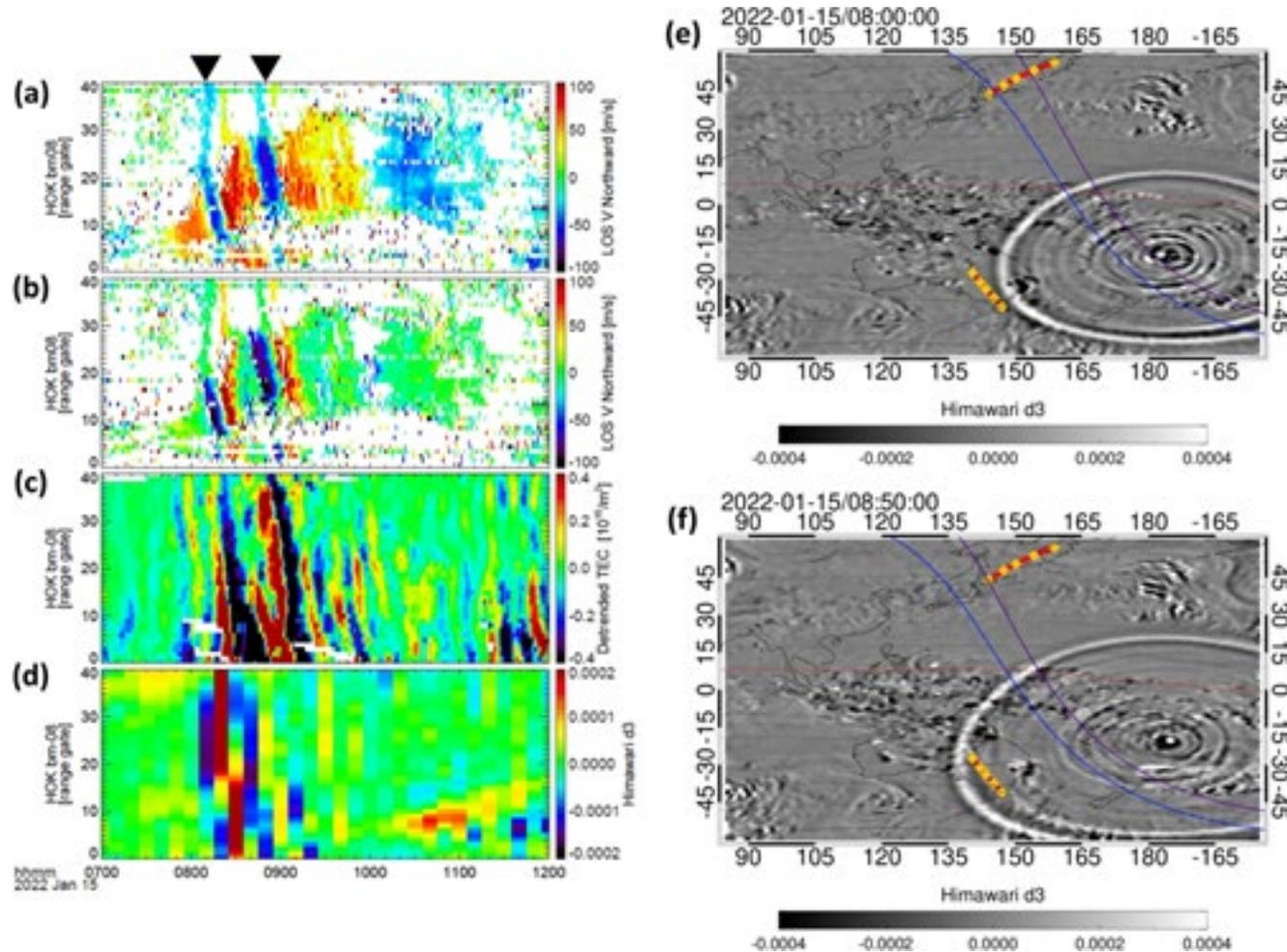
11 Mar 2011 (73)
unknown scan mode (3300)



The propagation has velocity-dispersive characteristics; it the first observation for this propagation velocity range.

Shinbori et al. (2022 EPS):

Ionospheric disturbances magnetically conjugate to the Tonga volcano eruption region – Indicating importance of the electric field mapping effect





Earthquake Hazards Program

In cooperation with: [US](#)

Latest Earthquakes

Overview

Interactive Map

Regional Information

Contributors

Impact

Felt Report - Tell Us!

Did You Feel It?

ShakeMap

PAGER

Ground Failure

Aftershock Forecast

Technical

Origin

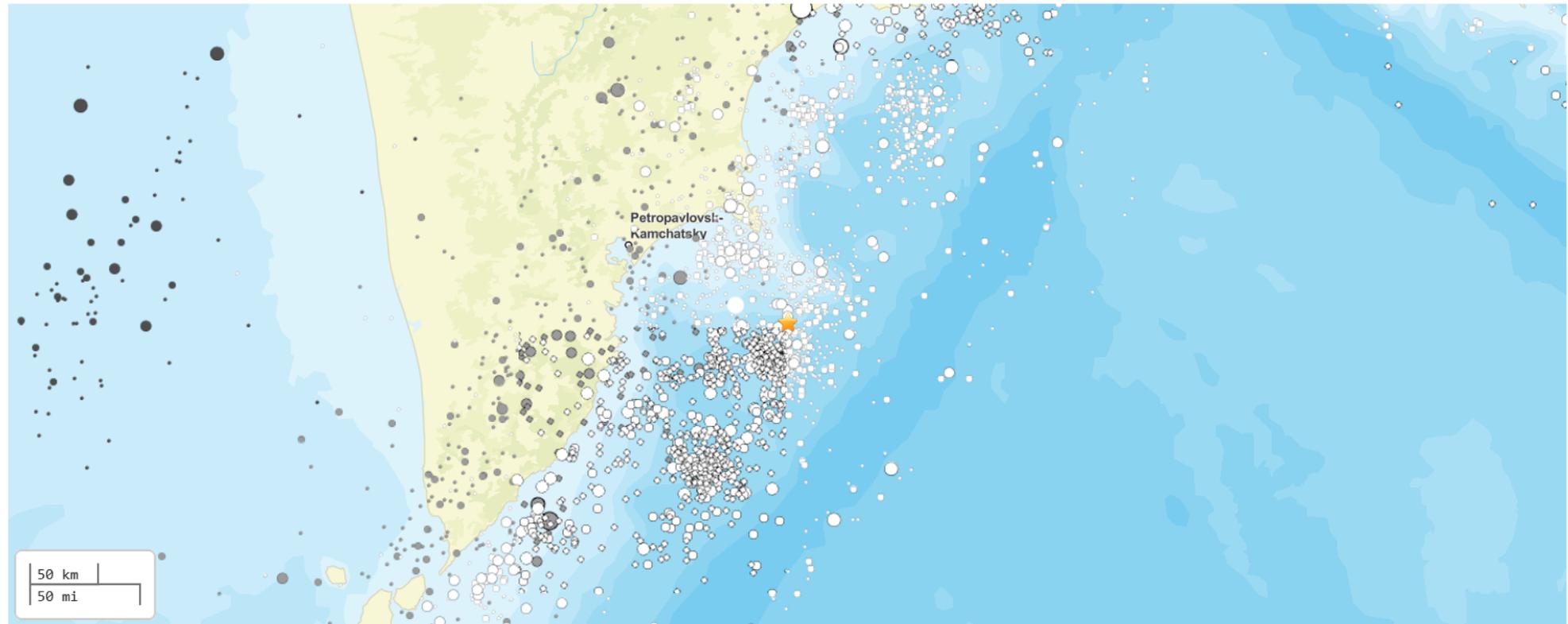
Moment Tensor

Finite Fault

Waveforms

M 8.8 - 2025 Kamchatka Peninsula, Russia Earthquake

2025-07-29 23:24:52 (UTC) | 52.512°N 160.324°E | 35.0 km depth



Nearby Places

SUPERDARN PARAMETER PLOT

Hokkaido East: v01

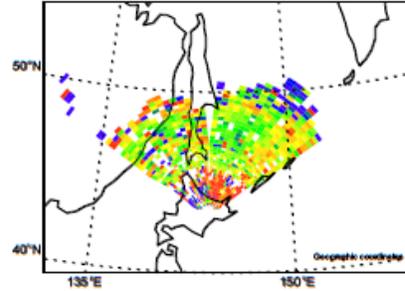
29 Jul 2025⁽²¹⁰⁾

to

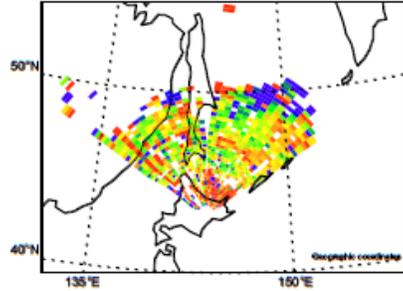
30 Jul 2025⁽²¹¹⁾

fastfssb_normmat(210) (svcasoanodc161)

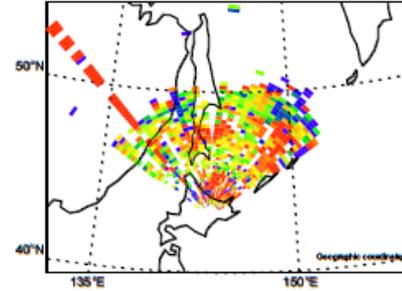
2337 00s (210) 10.790 MHz



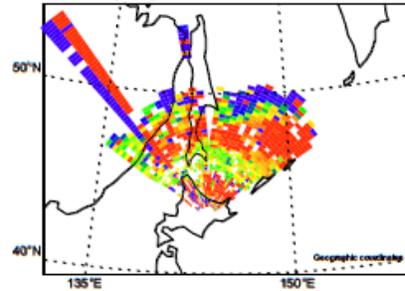
2338 00s (210) 10.790 MHz



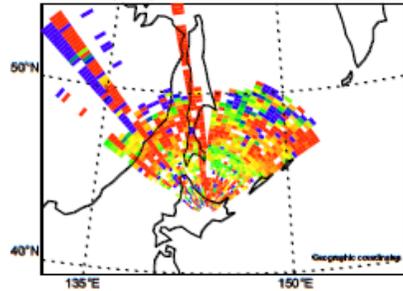
2339 00s (210) 10.790 MHz



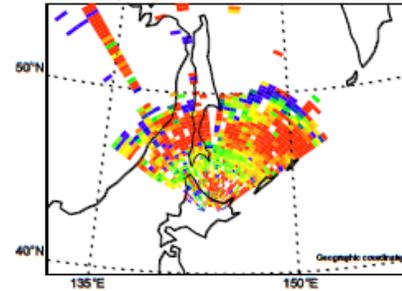
2340 00s (210) 10.788 MHz



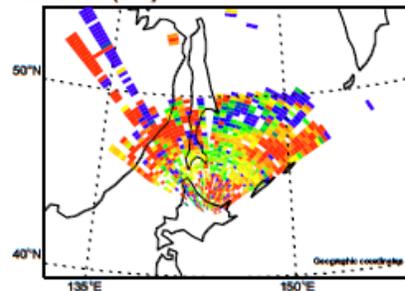
2341 00s (210) 10.788 MHz



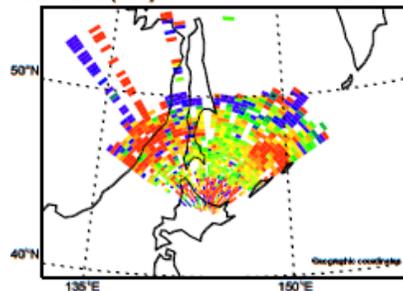
2342 00s (210) 10.785 MHz



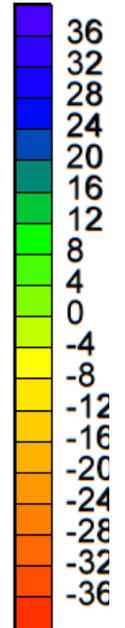
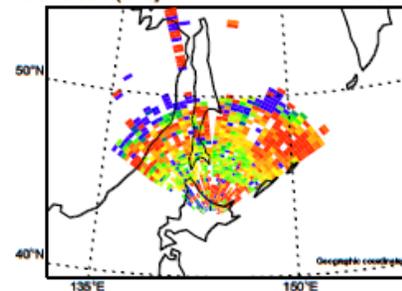
2343 00s (210) 10.783 MHz



2344 00s (210) 10.780 MHz



2345 00s (210) 10.780 MHz



SUPERDARN PARAMETER PLOT

Hokkaido East: vel

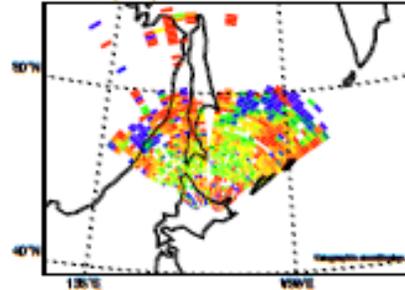
29 Jul 2025⁽²¹⁰⁾

to

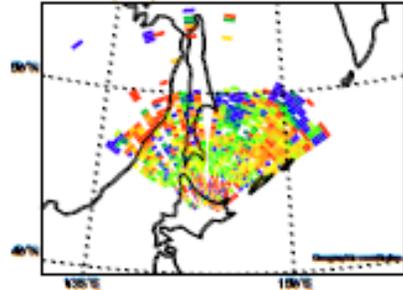
30 Jul 2025⁽²¹¹⁾

f a s i f a b s t n e o m a s t i (o i) / c v c j a c m o d e (d 1 5) (1 5 3)

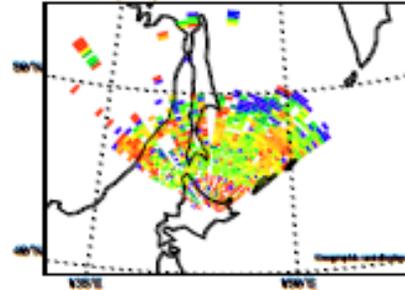
2346 00s (210) 10.780 MHz



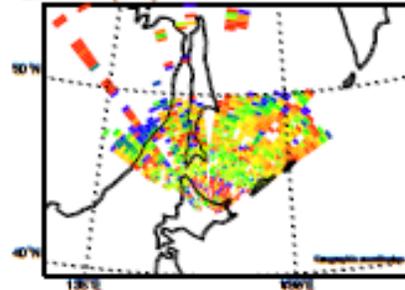
2347 00s (210) 10.780 MHz



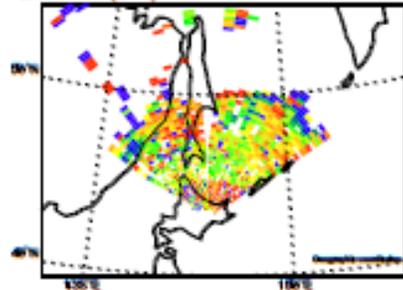
2348 00s (210) 10.782 MHz



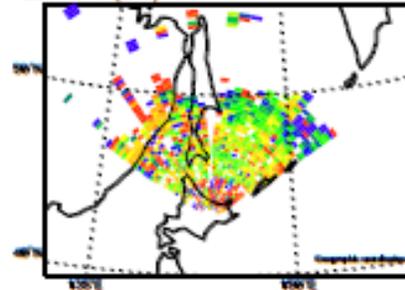
2349 00s (210) 10.780 MHz



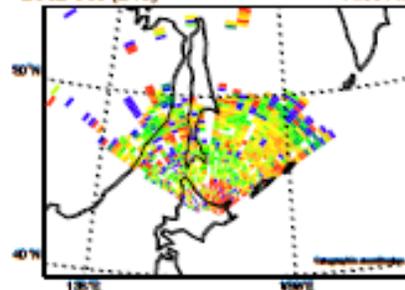
2350 00s (210) 10.792 MHz



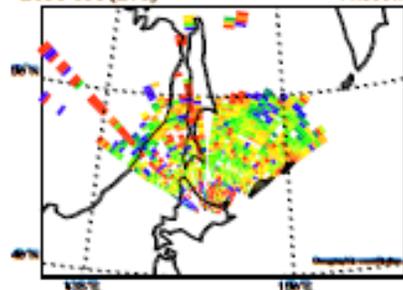
2351 00s (210) 10.792 MHz



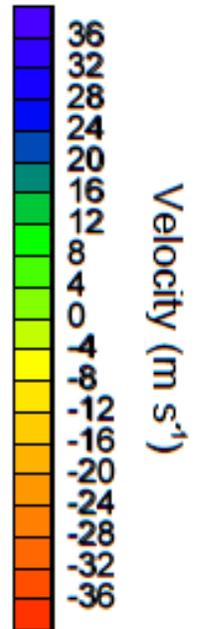
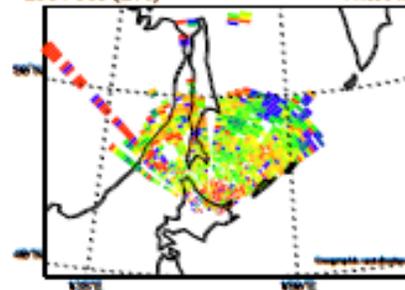
2352 00s (210) 10.780 MHz



2353 00s (210) 10.780 MHz



2354 00s (210) 10.780 MHz



SUPERDARN PARAMETER PLOT

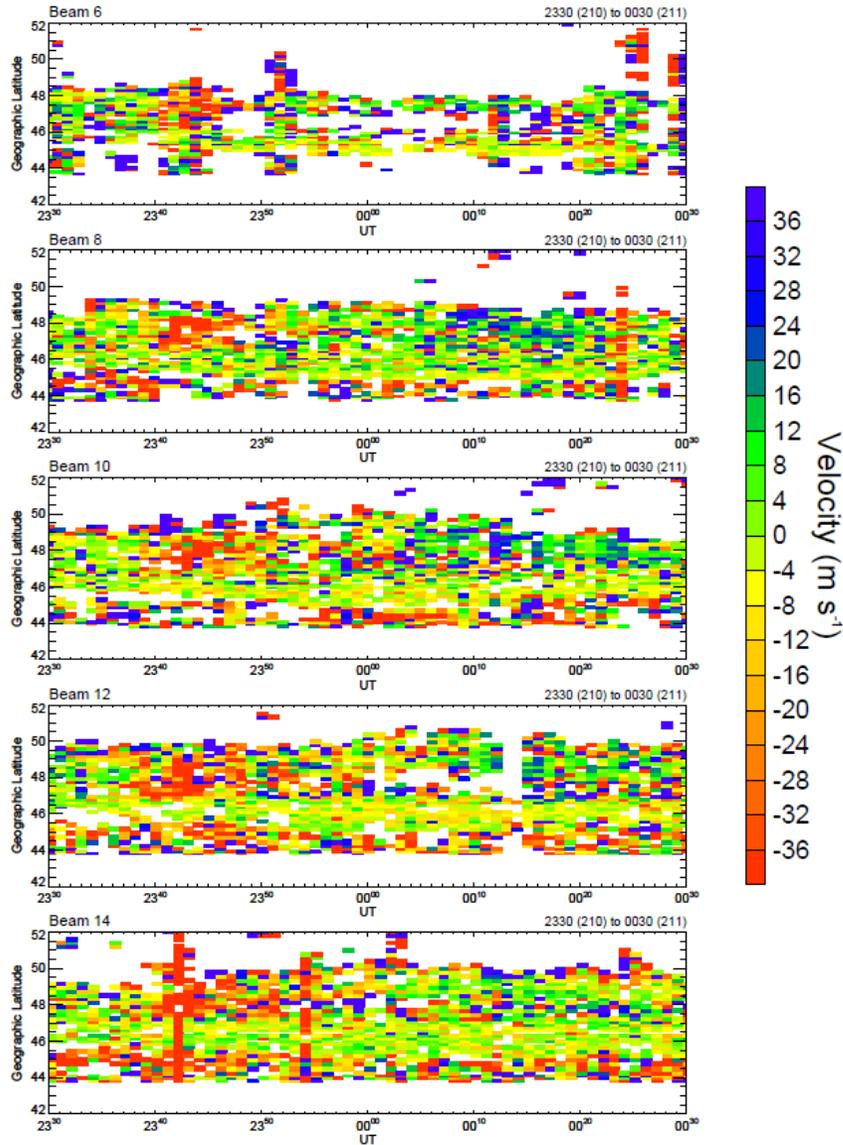
Hokkaido West: vel

29 Jul 2025⁽²¹⁰⁾

to

30 Jul 2025⁽²¹¹⁾

fast stereo normal (cw) scan mode (153)



SUPERDARN PARAMETER PLOT

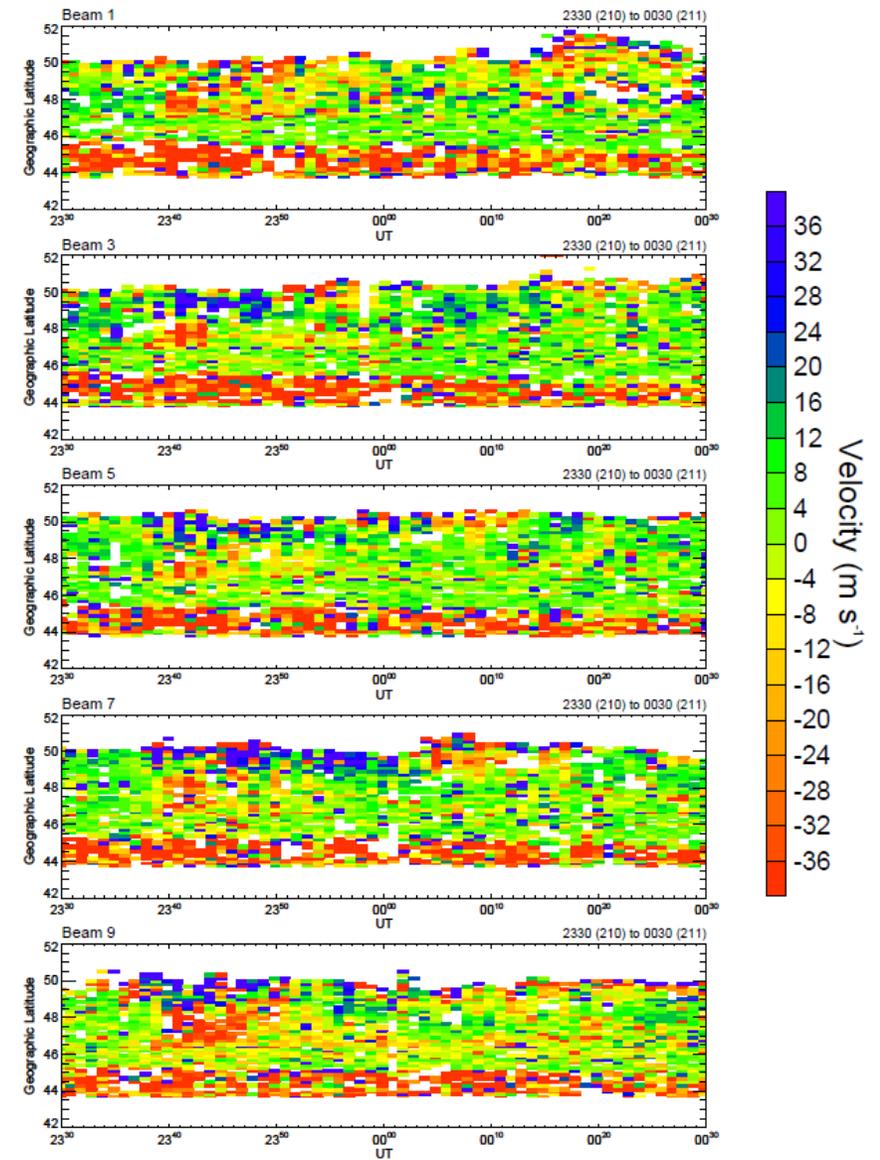
Hokkaido East: vel

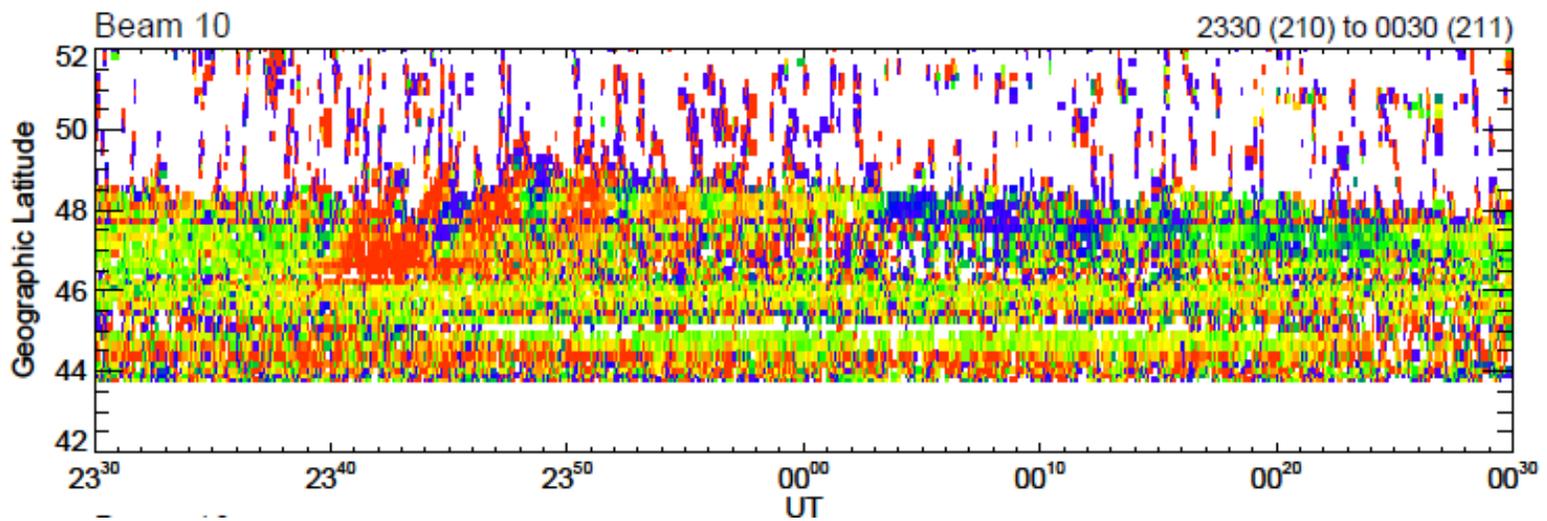
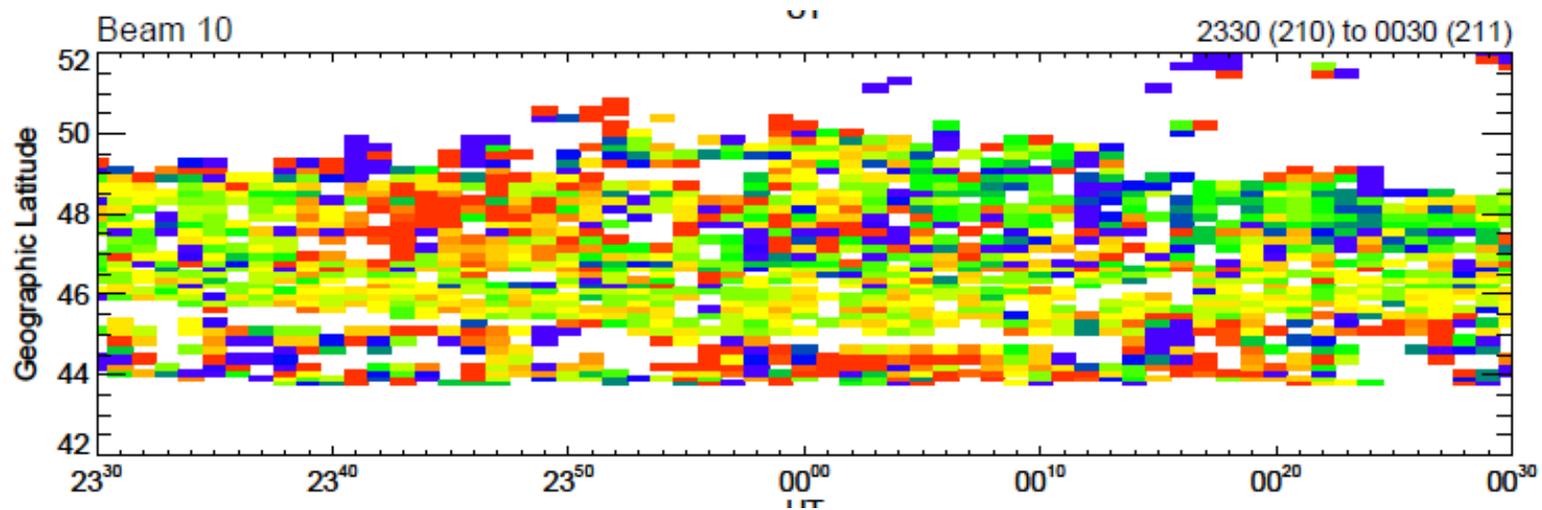
29 Jul 2025⁽²¹⁰⁾

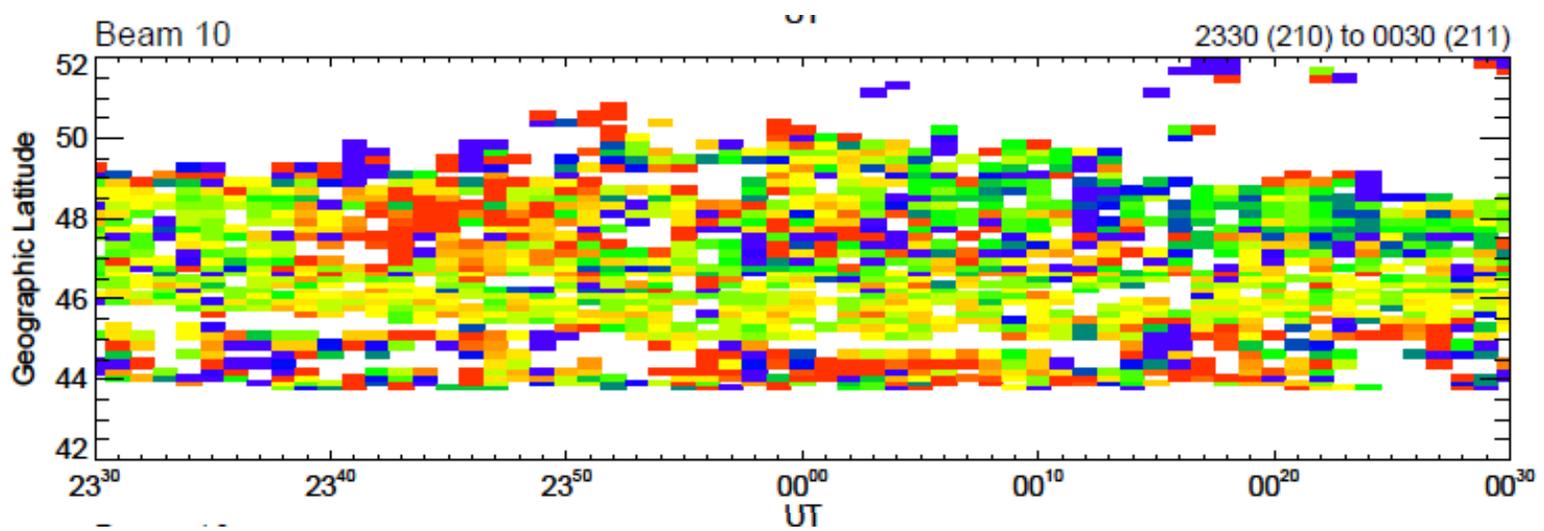
to

30 Jul 2025⁽²¹¹⁾

fast normal (cw) scan mode (151)



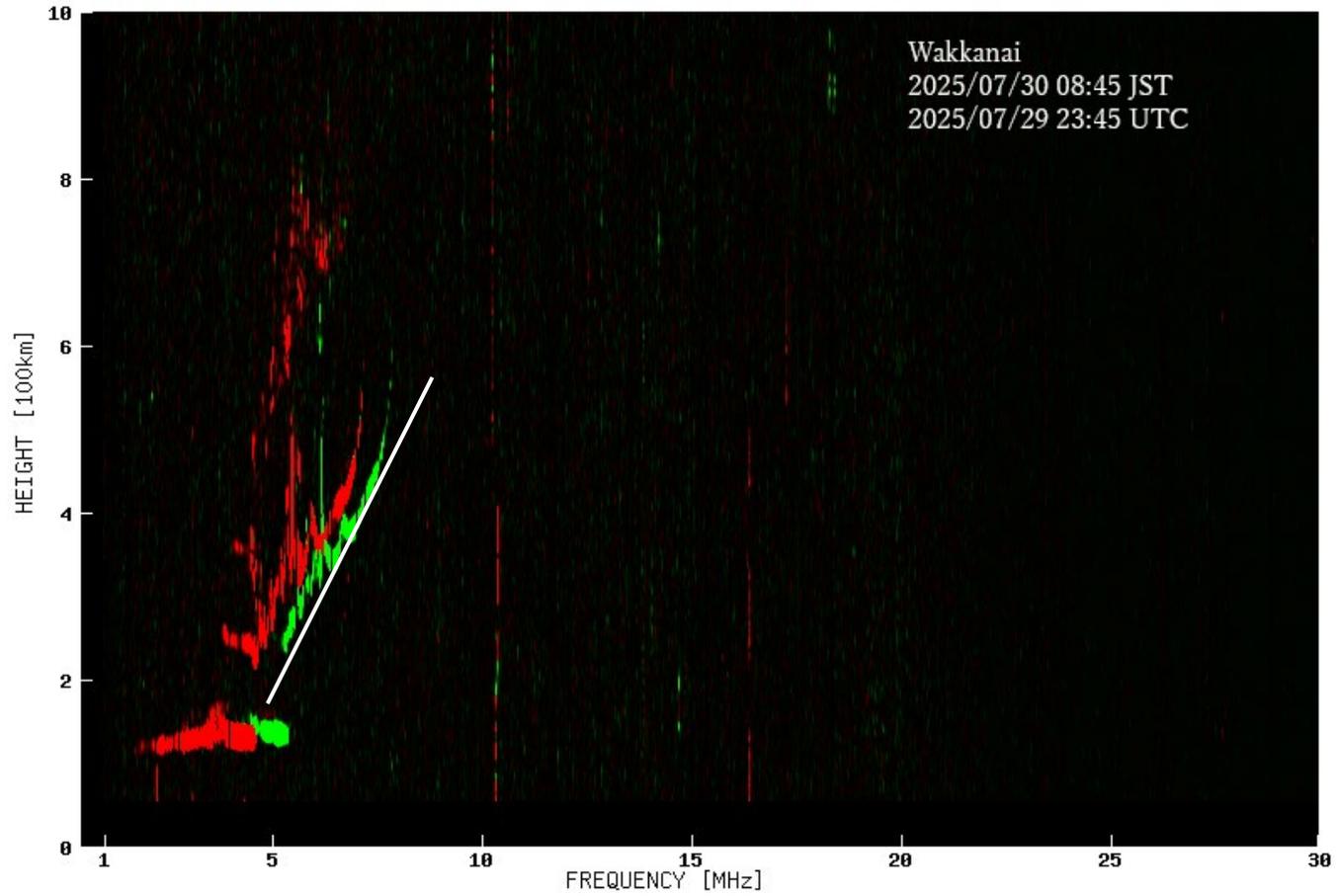




ChA/ChB observation

- ChA (f=10.810 MHz) sudden positive excursion
 - Between beam 10 and 11 : 0624: 21 UT
- ChB (f=9.150 MHz, beam 10) sudden positive excursion
 - @ 0624: 30 UT
- Time difference: 09 seconds
- Altitude difference in reflection point based on the secant law: 86.8 km
- Vertical propagation speed: $86.8/9=9.6$ km/s -> too big!
- Possible factors: spatial difference, improper estimation of the reflection height, etc.

Wakkanai Ionosonde



SuperDARN front lobe/back lobe

N. Nishitani et al.

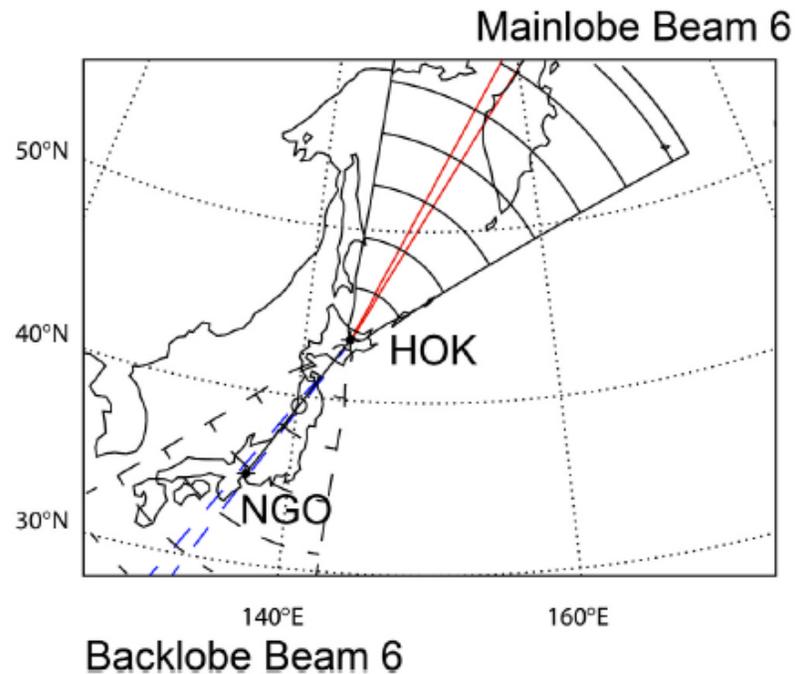
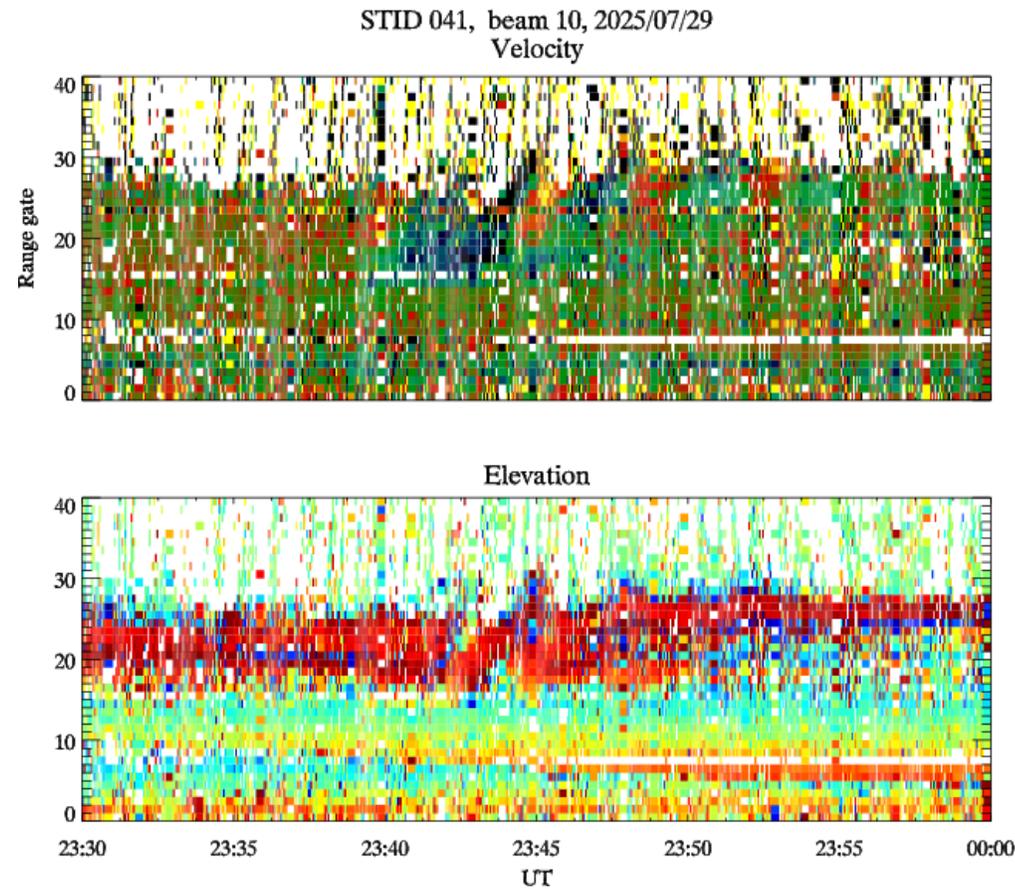


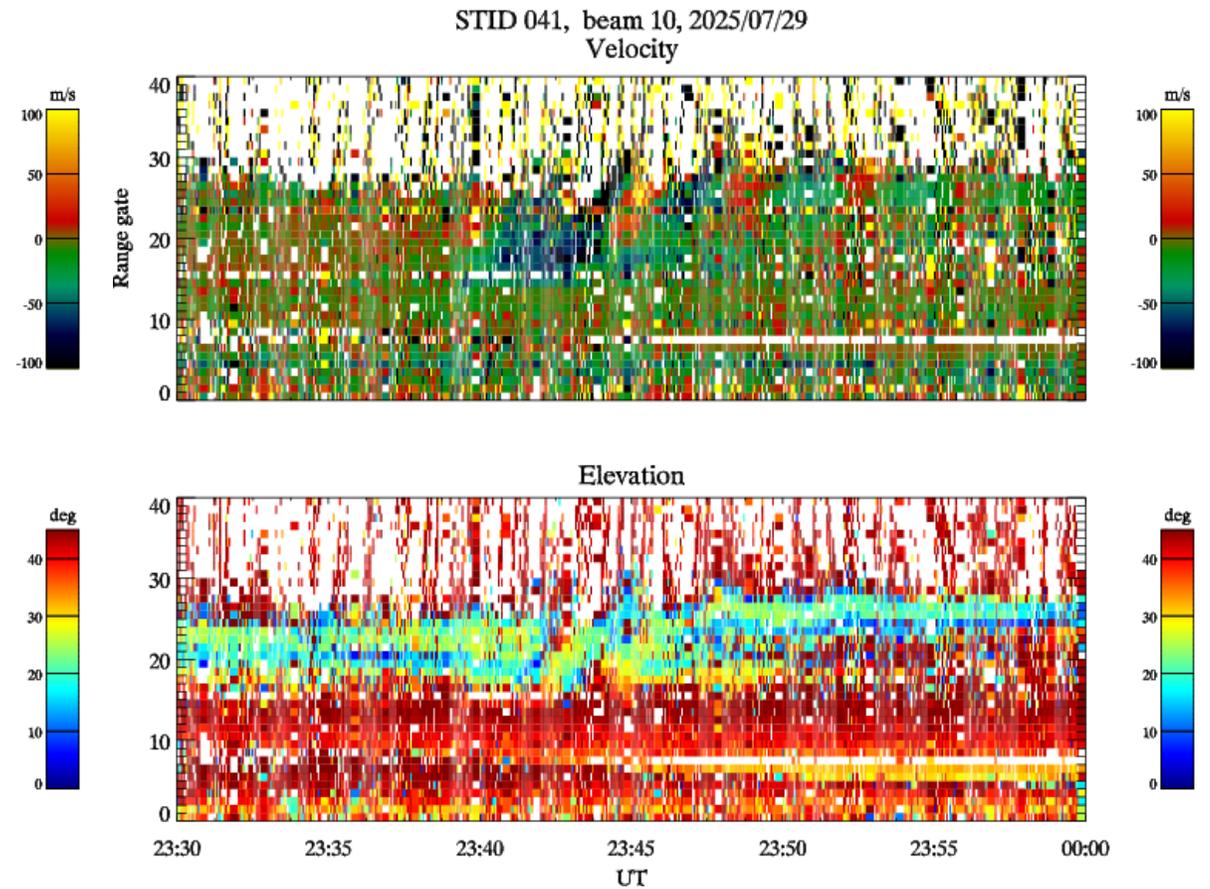
Fig. 1. Map of the SuperDARN Hokkaido East radar site (HOK), its field of view in the mainlobe direction (solid lines), field of view in the backlobe direction (dashed lines) and the location of the remote HF wave receiver in Nagoya (NGO). The mainlobe and backlobe of Beam 6 are also shown. The ionospheric reflection points inside both the mainlobe and backlobe fields of view are shown by arcs (every 5 range gates for the 45 km resolution mode). The middle point between the HOK and NGO are indicated by an open circle. The Rikubetsu receiver (RIK) is only a few tens of meters from the radar antennas, so that it is not shown on the map.

- SuperDARN is supposed to received echoes from the mainlobe beams.
- However, in some cases, the waves can be emitted backward (backlobe beams) where they are backscattered by ground/sea surface irregularities (unlikely to be ionospheric)
- Is there an opportunity that the echoes are backlobe ones?

Front lobe vs Back lobe → front lobe is likely

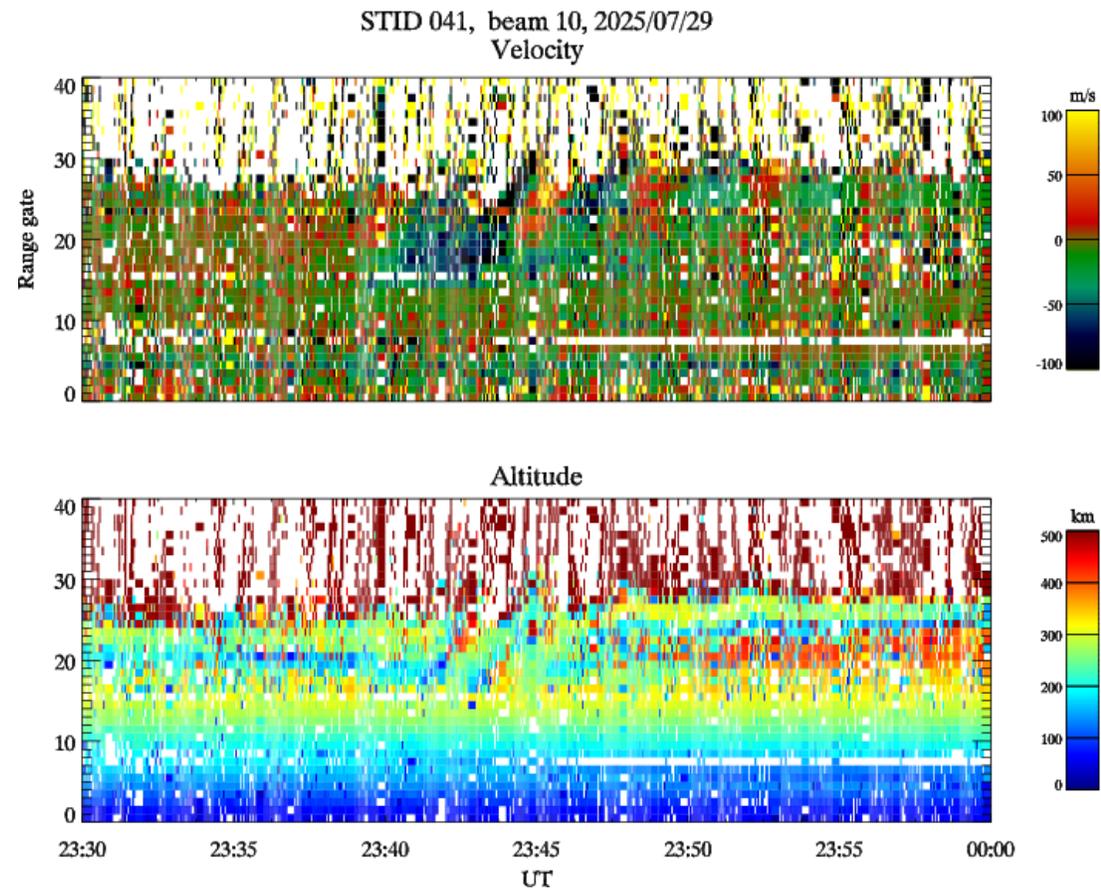


Front lobe



Back lobe

Doppler velocity and virtual height



Summary and conclusions (1/2)

- The SuperDARN HOP radars (HOK/HKW) succeeded in monitoring the ionospheric disturbances triggered by the Kamchatka earthquake ($M_w=8.8$) in July 2025.
- The HKW radar has stereo mode data, scanning the same beam direction simultaneously using two different frequencies, i.e., two different reflection heights.
- In addition, the scanning direction of the channel A (normalscan) is opposite to the propagation direction, enabling the precise identification of the meeting point/time with the accuracy of 3 seconds. Therefore it is possible to identify horizontal/vertical propagation characteristics of the disturbances with 3 second temporal resolution.

Summary and conclusions (2/2)

- Preliminary estimation of the vertical propagation speed is unrealistic (~ 10 km/s). Pasha point out there are several factors for improvements, especially the estimation of reflection heights.
- More to come!