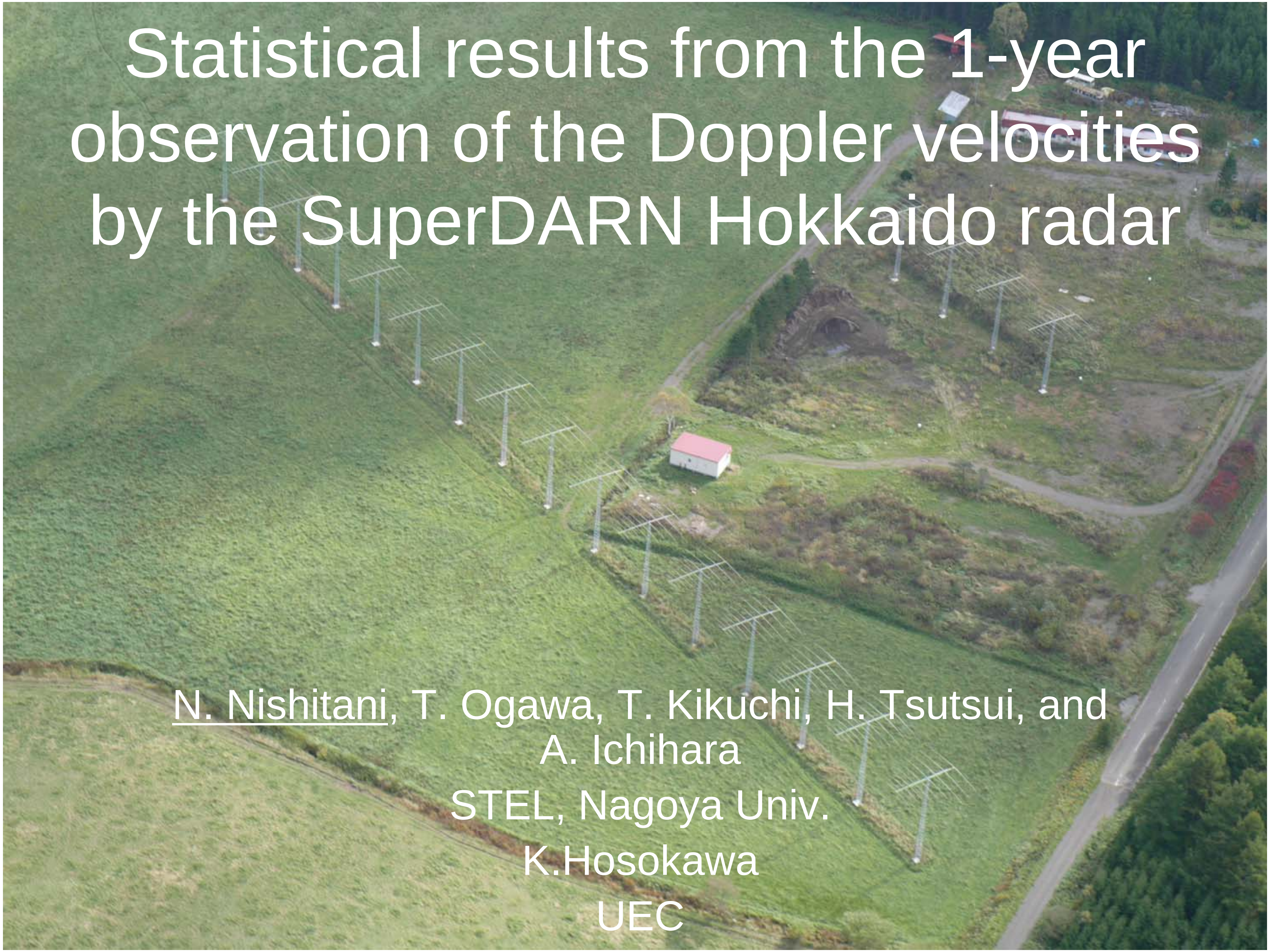
Statistical results from the 1-year observation of the Doppler velocities by the SuperDARN Hokkaido radar



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UEC

Contents:

- Statistical results from the 1-year observation of the Doppler velocities by the SuperDARN Hokkaido radar (Tsutsui et al.)

- Development of new algorithm for distinguishing ionospheric echoes from ground-scatter echoes (Ichihara et al.)

Statistical studies of ionospheric convection distribution by SuperDARN

- Ruohoniemi and Greenwald (J. Geophys. Res., 101, 21,743, 1996)
  - Goose Bay data
- Ruohoniemi and Greenwald (J. Geophys. Res., 110, A09204, doi:10.1029/2004JA010815)
  - SuperDARN data in the polar region
- Baker et al. (J. Geophys. Res., 112, A01303, doi:10.1029/2006JA011982, 2007.)
  - Wallop radar (geomag. lat.: 50 degrees) data

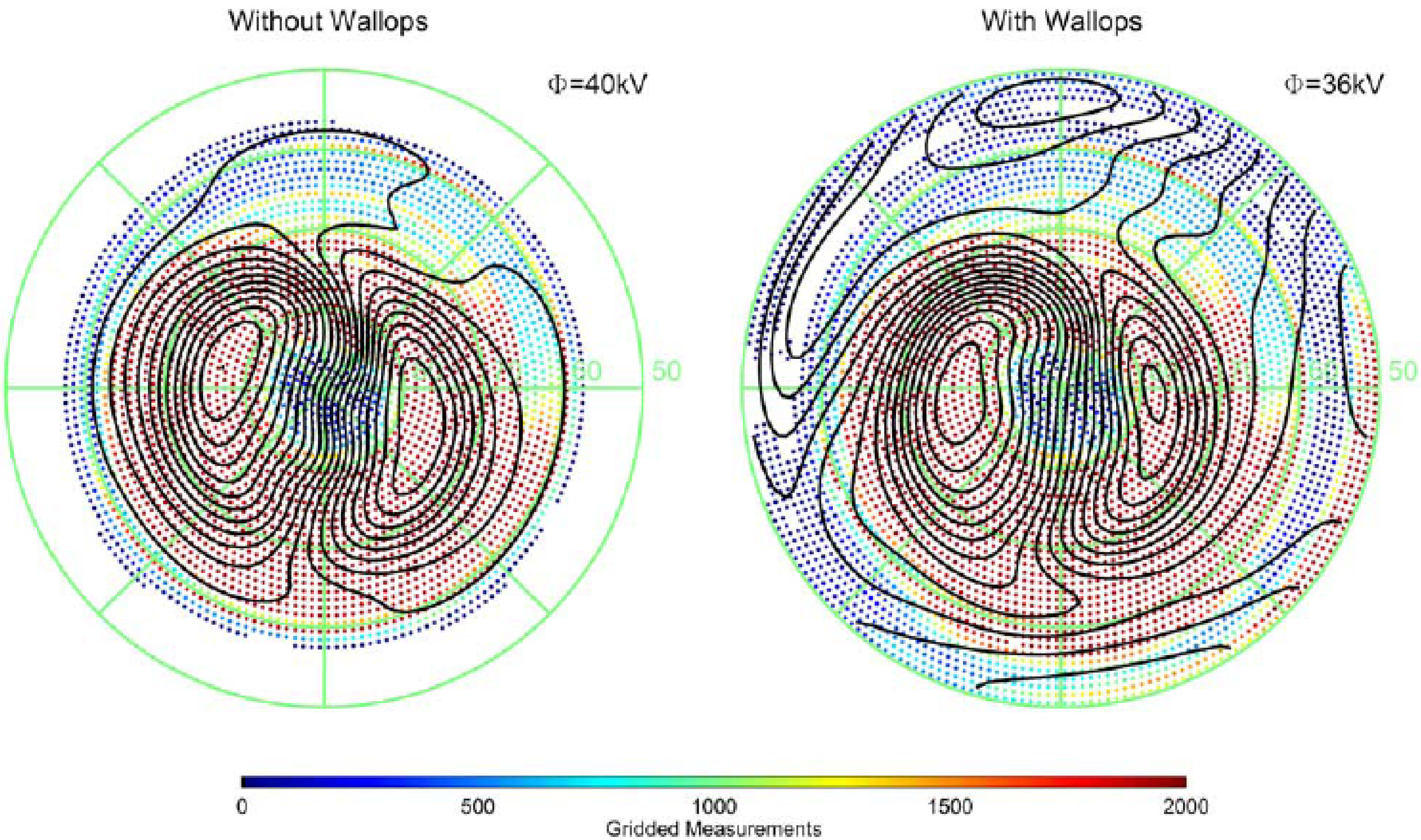


Figure 11. Average patterns of Northern Hemisphere ionospheric convection calculated from SuperDARN data collected during periods of weak geomagnetic activity ($Kp \leq 3$) between June 2005 and April 2006. The panel on the right (left) shows the convection calculated with (without) data from the Wallops radar. The format is the same as used in Figures 4–10; the contour spacing is 2 kV; the cross-polar potential is provided at the upper right. Colored dots show how many gridded Doppler measurements contributed to the patterns at a given location according to the scale provided along the bottom.

Baker et al., J. Geophys. Res., 112, A01303, doi:10.1029/2006JA011982, 2007

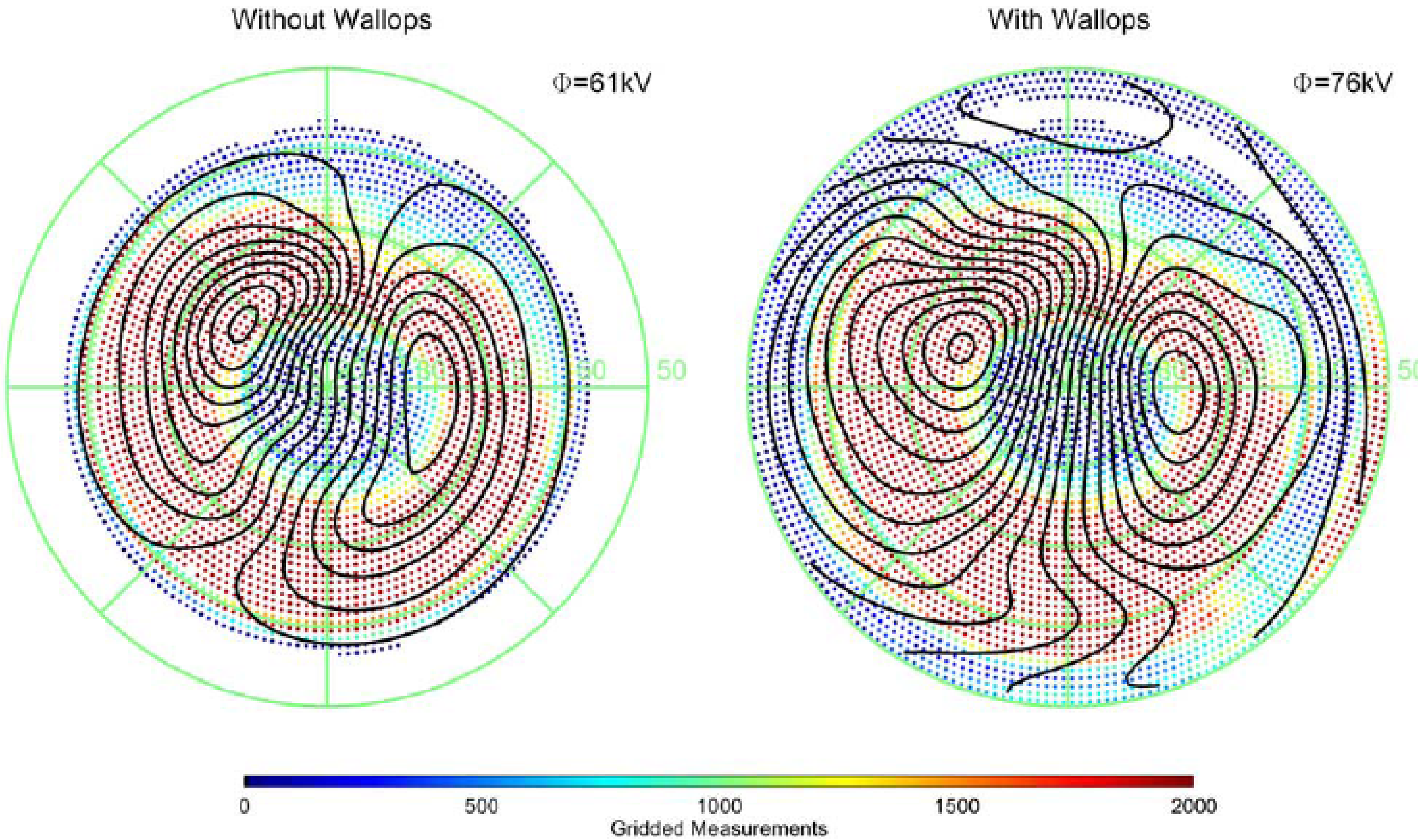
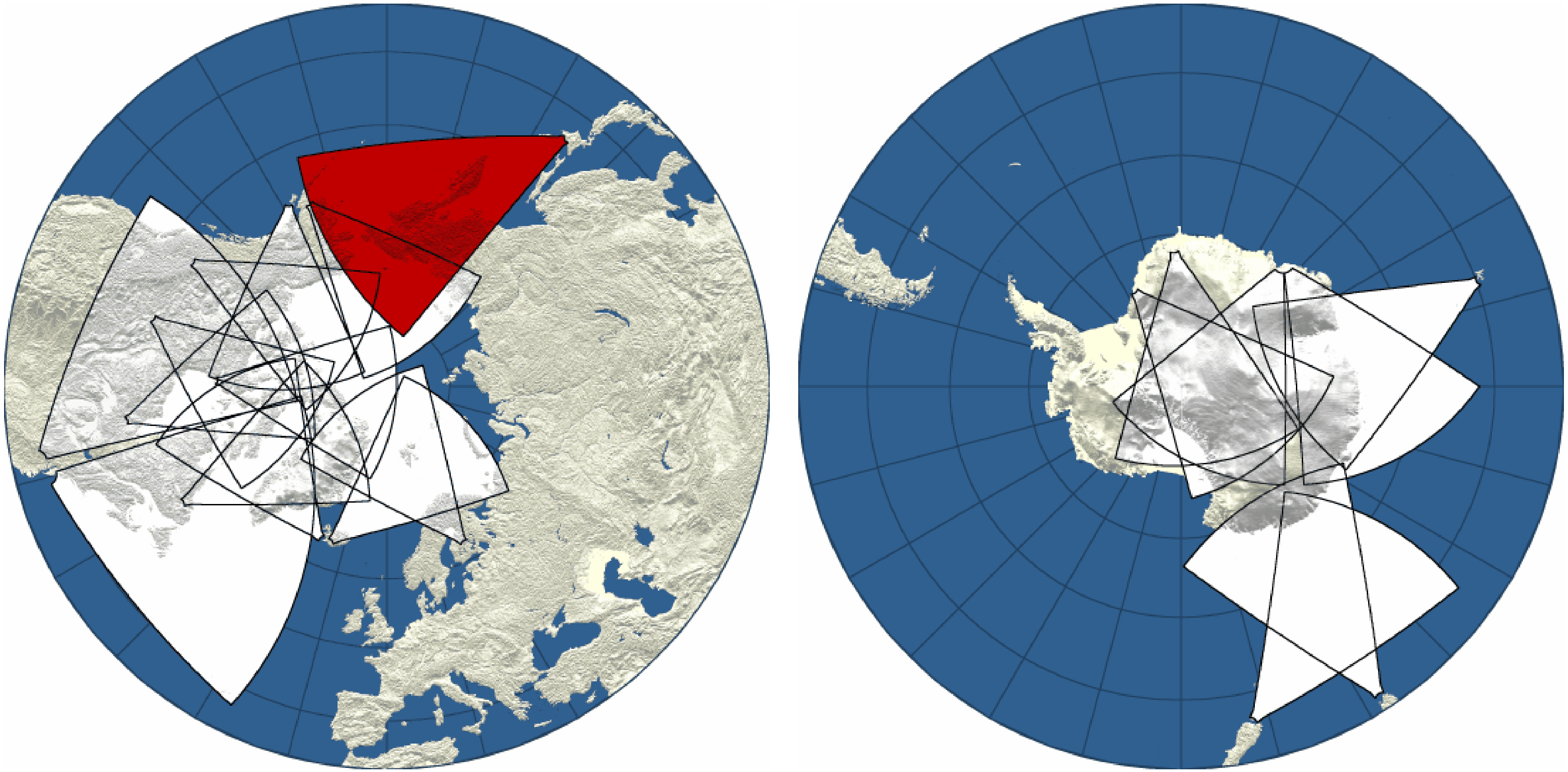


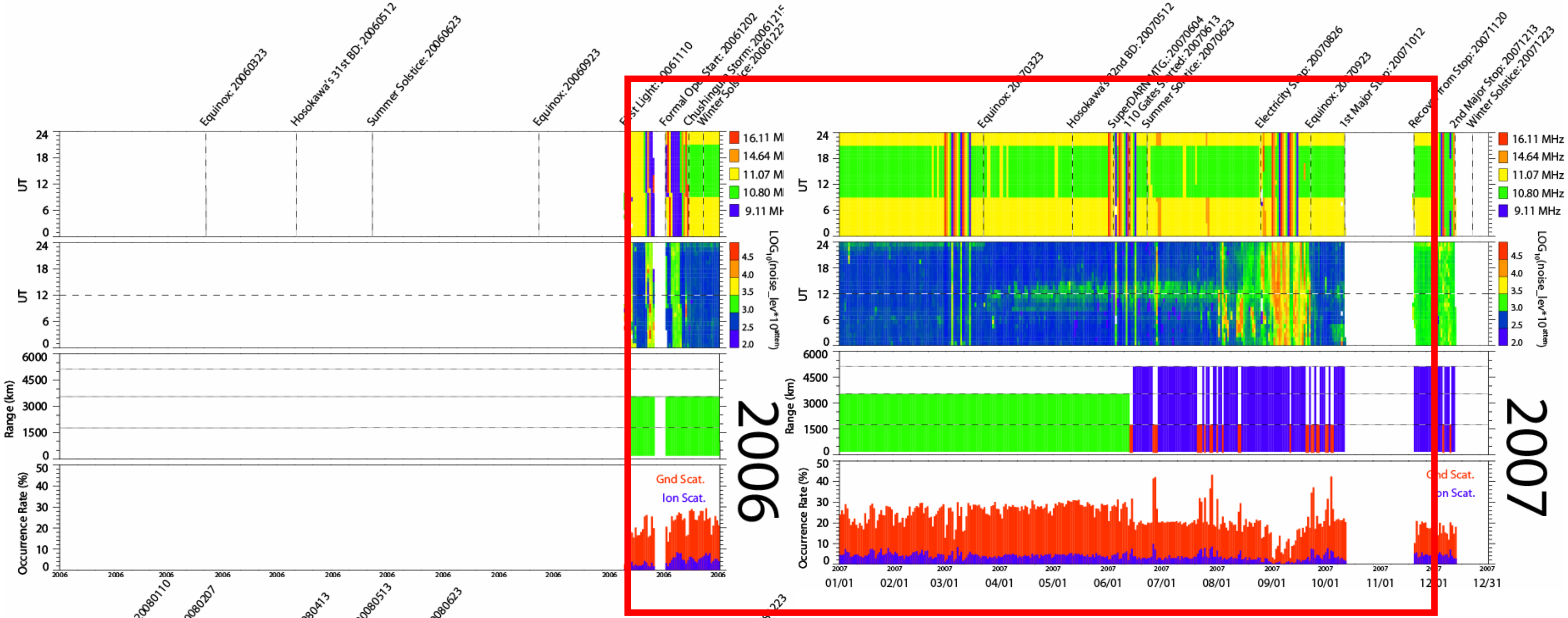
Figure 12. Average patterns of Northern Hemisphere ionospheric convection calculated from SuperDARN data collected during periods of increased geomagnetic activity ($Kp \geq 3$) between June 2005 and April 2006. The format is the same as used in Figure 10, except the contour spacing is 4 kV.

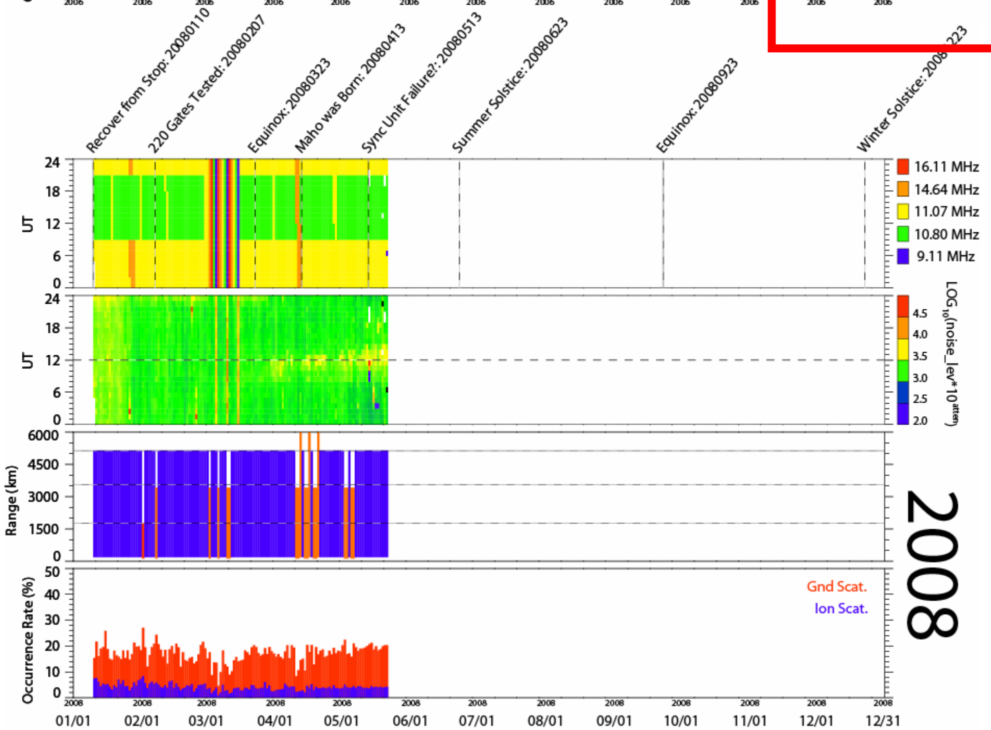
Baker et al., J. Geophys. Res., 112, A01303, doi:10.1029/2006JA011982, 2007

Super Dual Auroral Radar Network (SuperDARN)

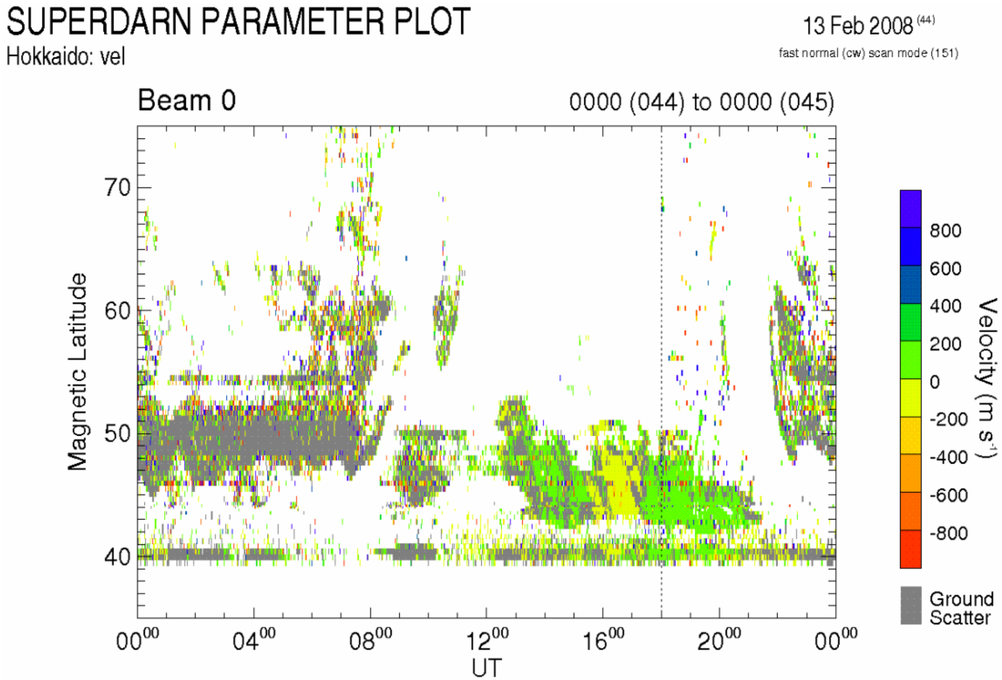


Total: 21 HF radars (14 in the northern and 7 in the southern hemispheres)



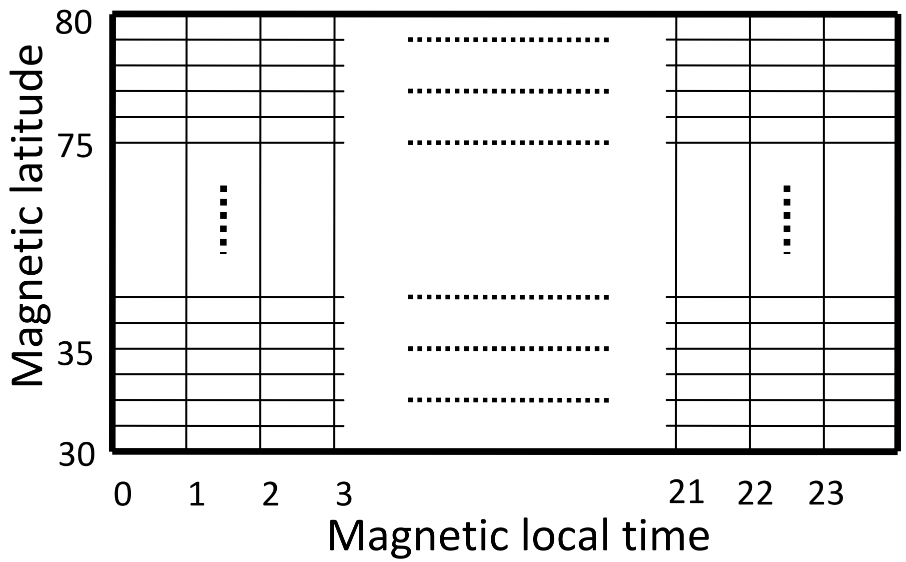


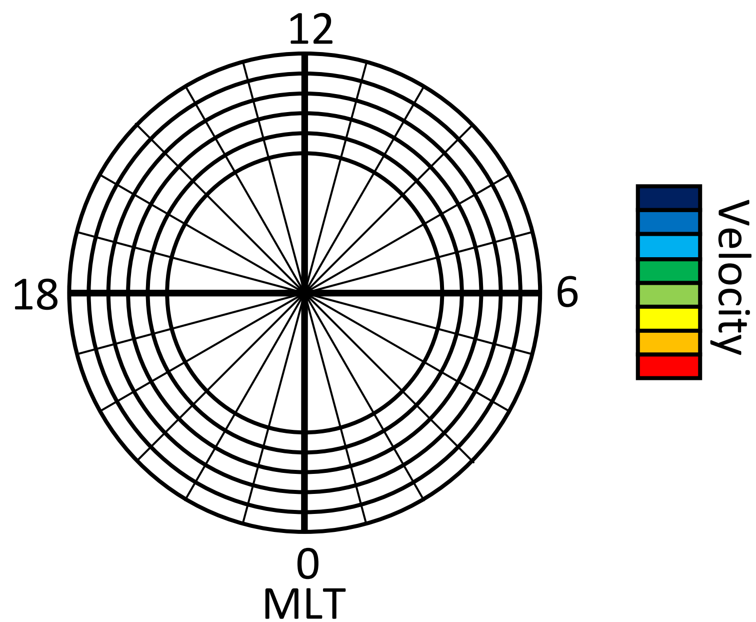
Hokkaido radar performance since Nov. 2006



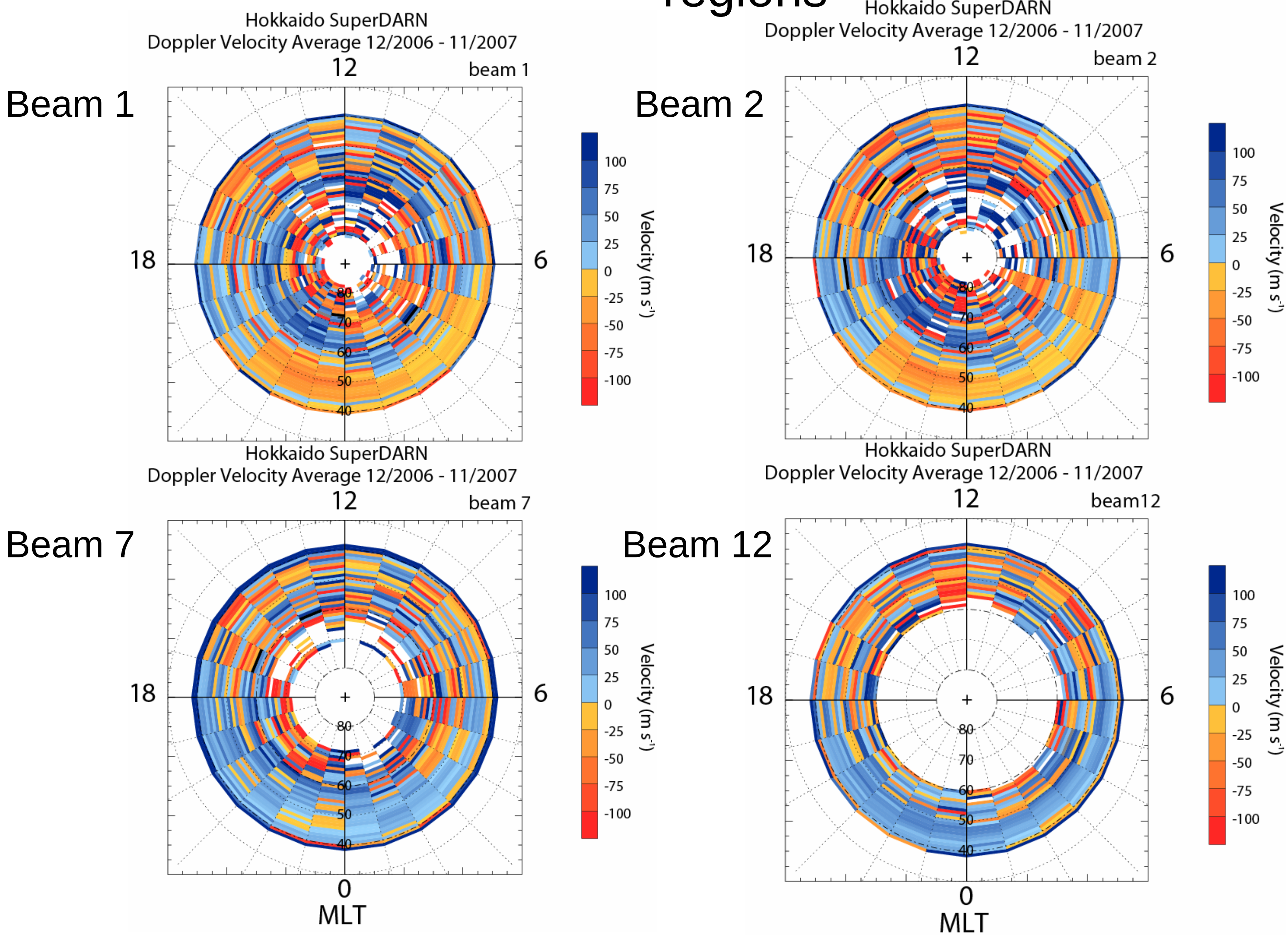
Data classification

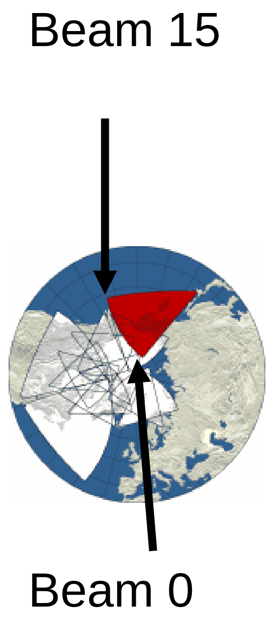
- Conversion of Universal Time to Magnetic Local Time
- 1 bin : 1 hour MLT / 1 deg. Geomag. Latitude
- Make a plot for each beam



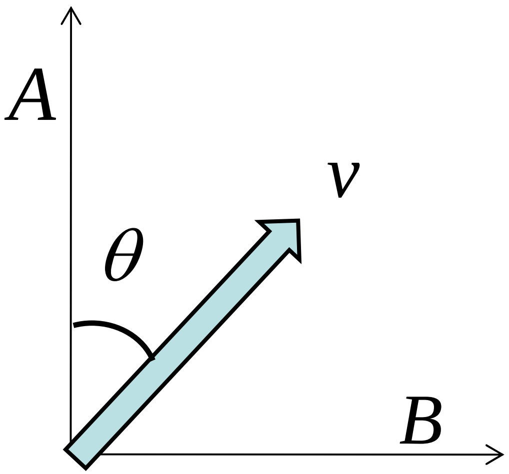


Statistical distribution of los velocities for each beam: fewer samples for high-latitude (> 50 geomag. Lat.) or dayside regions





Applying least-square method for extracting horizontal vector

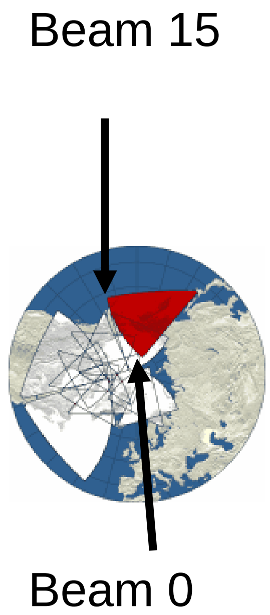


$$v_1 = A\cos\theta_1 + B\sin\theta_1$$

$$v_2 = A\cos\theta_2 + B\sin\theta_2$$

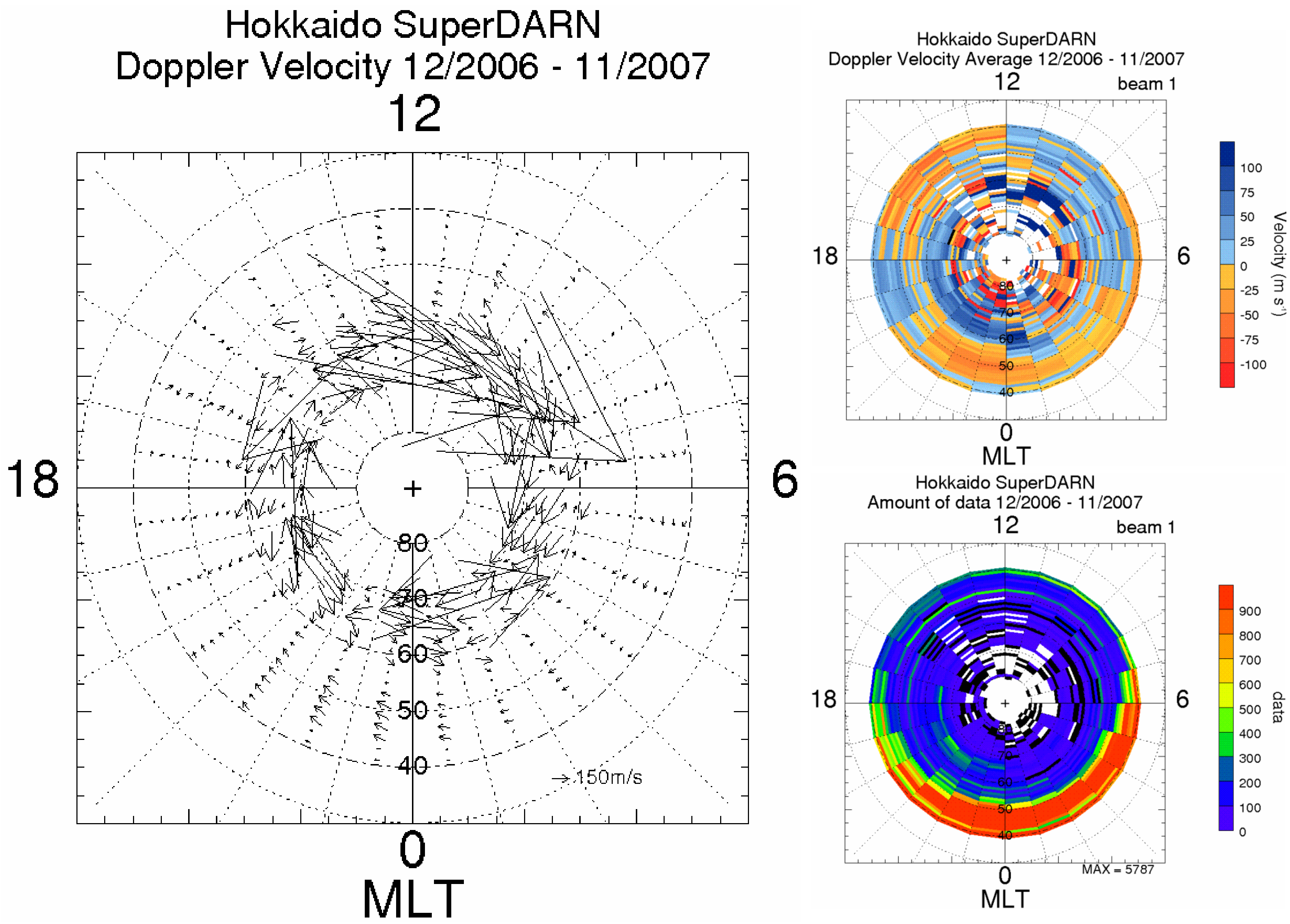
$$\cdots$$

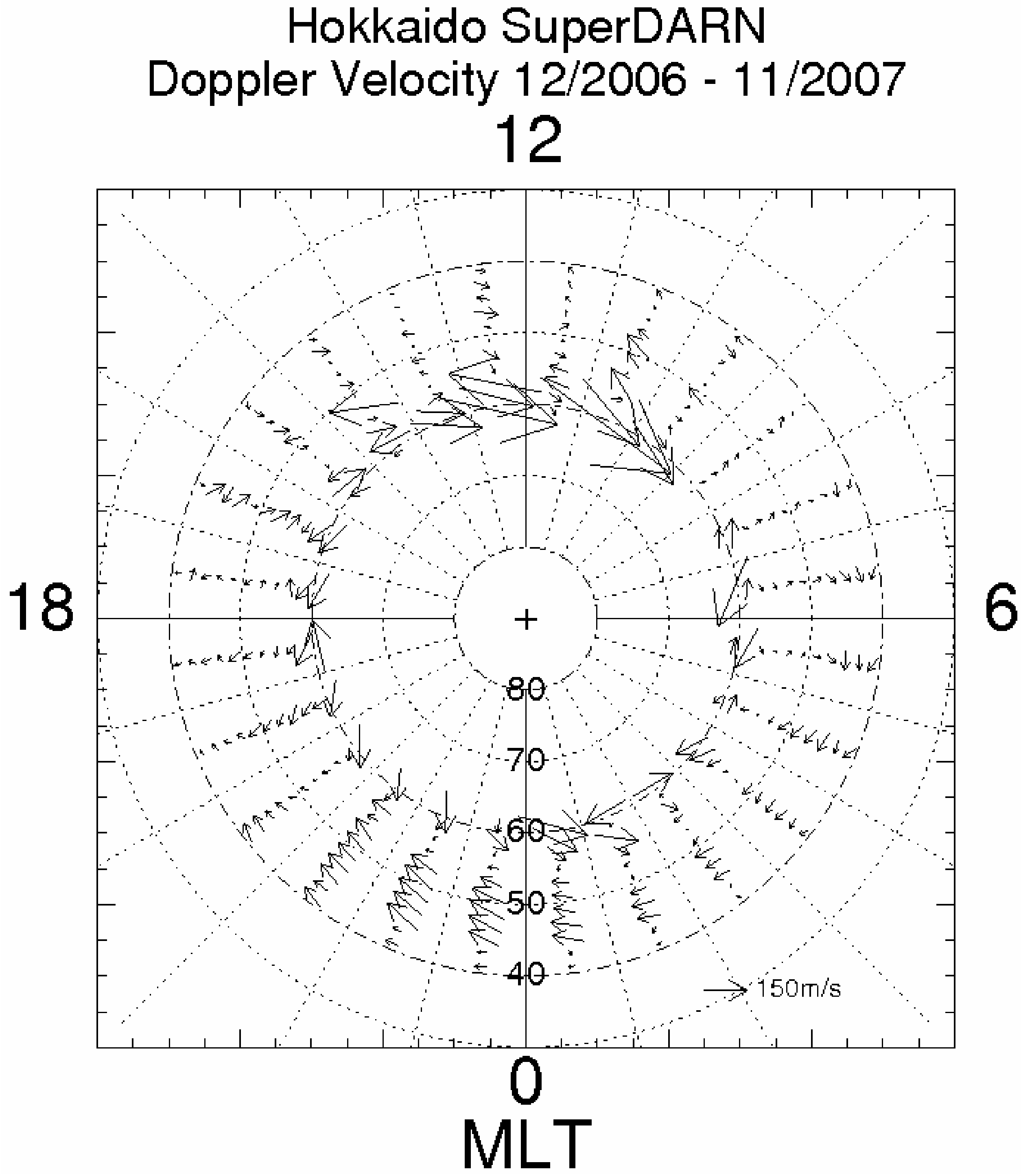
$$v_{14} = A\cos\theta_{14} + B\sin\theta_{14}$$



$$S = \Sigma(v_i - A\cos\theta_i - B\sin\theta_i)^2$$ →minimize

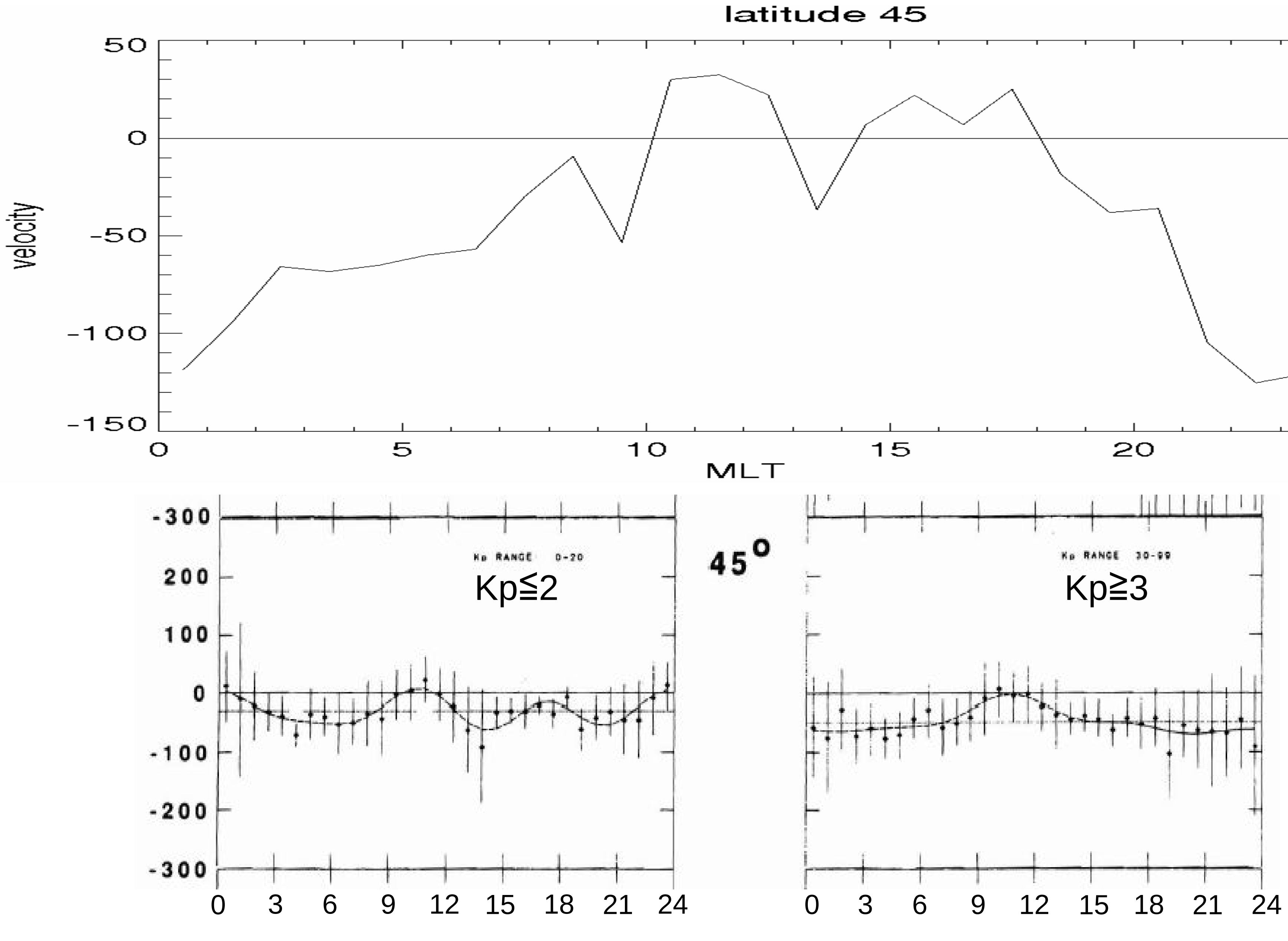
$$\frac{\partial S}{\partial A} = 0 \qquad \frac{\partial S}{\partial B} = 0$$ →obtain A and B


Hokkaido SuperDARN
Doppler Velocity 12/2006 - 11/2007
12
18
6
0
MLT
80
70
60
50
40
150m/s
Hokkaido SuperDARN
Doppler Velocity Average 12/2006 - 11/2007
beam 1
Velocity (m s⁻¹)
100
75
50
25
0
-25
-50
-75
-100
Hokkaido SuperDARN
Amount of data 12/2006 - 11/2007
beam 1
data
900
800
700
600
500
400
300
200
100
0
MAX = 5787

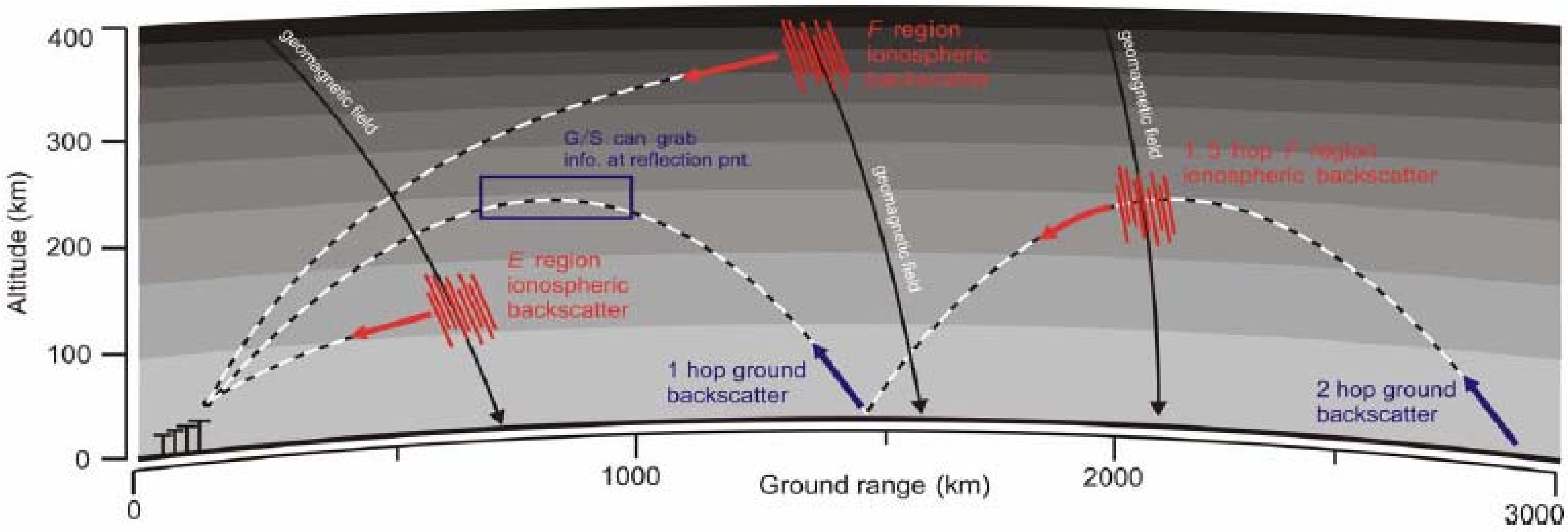


Hokkaido SuperDARN
Doppler Velocity 12/2006 - 11/2007
12
18
6
0
MLT
80
70
60
50
40
150m/s

Comparison between our result (upper panel) and that by Heelis et al. (1992) using DE-2 ion driftmeter (lower panel)



Next topic: distinguishing ionospheric echoes and ground / sea scatter echoes



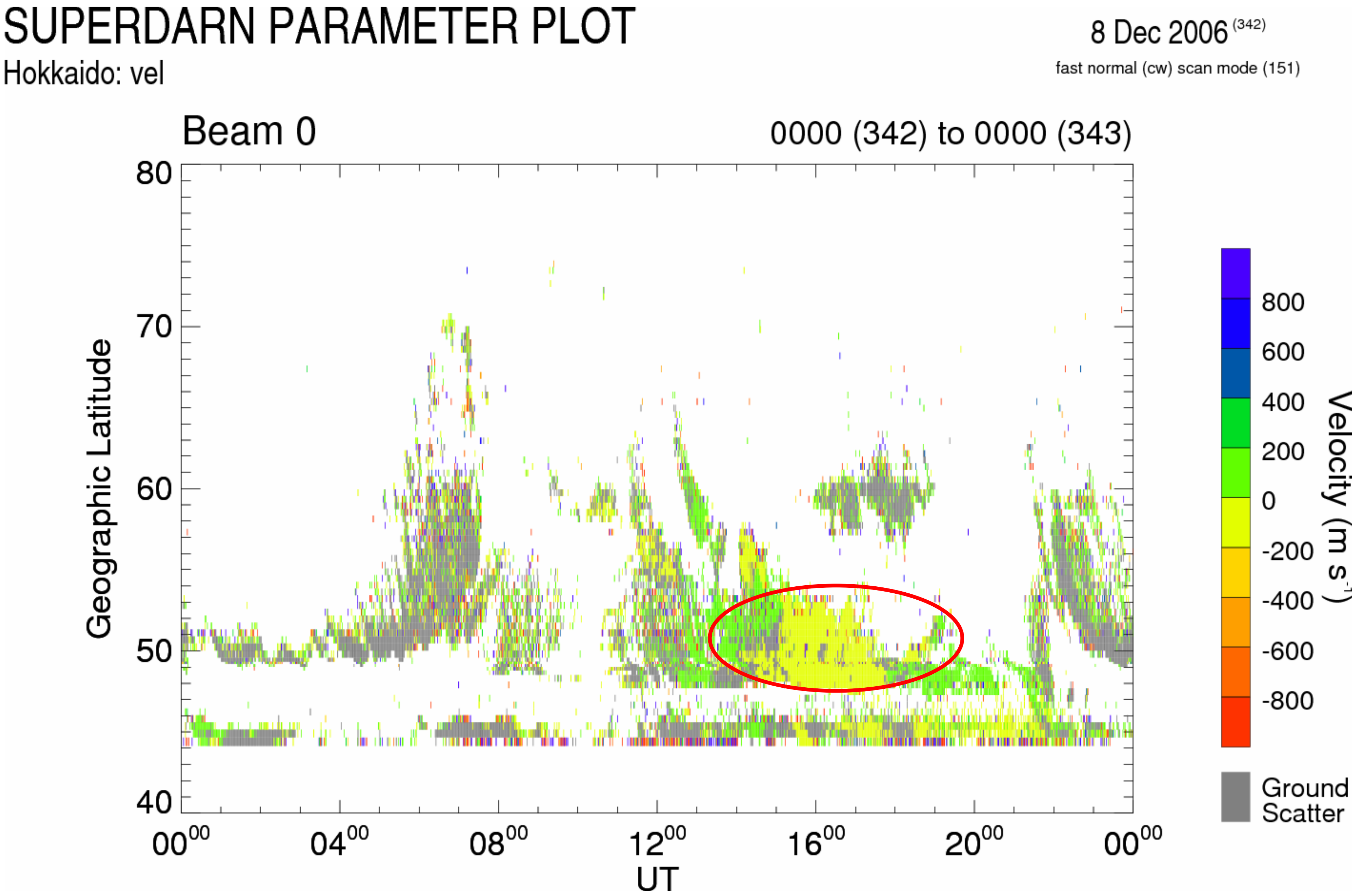
Current criterion

- Identify as ground scatter echoes if

  $|(\text{Doppler velocity})| \leqq 30 - 1/3 \times (\text{Spectral width})$

- We need more methods to confirm that the identification is right.

Example 1: Dec 08, 2006



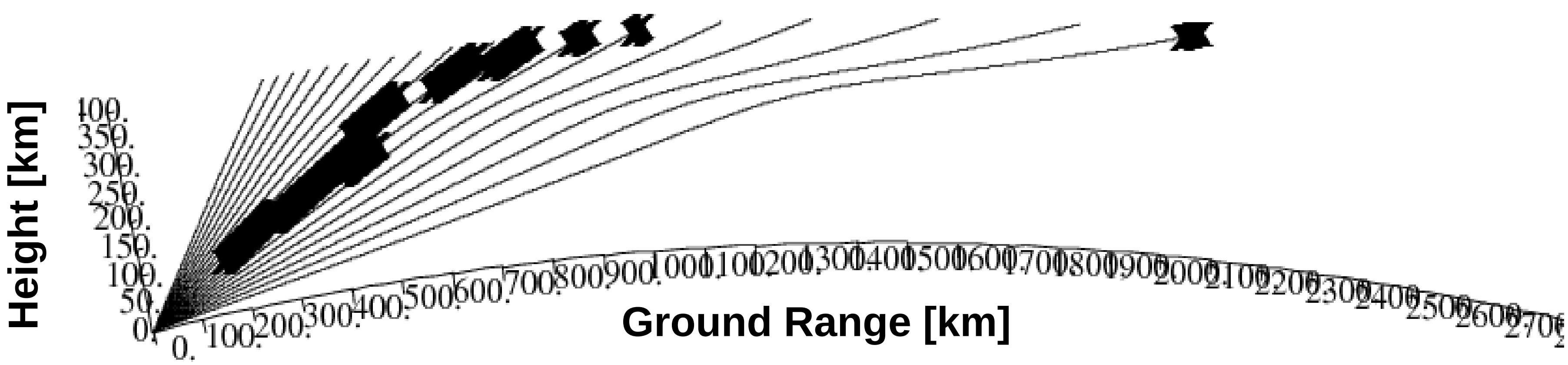
Ray path tracing calculation

Ionosphere model

Electron dencity	IRI-2001 (2006/12/08 16:00(UT))
B	IGRF
Coll freq.	Exponential

Radar wave

Radar loc.	N43.6、E143.6[deg]
Freq.	9.12[MHz]
Elev.	5-50[deg]
Azim.	5.7[deg]



X: radar ray path vector is perpendicular to ambient B (89 to 91 degs.)

Comparison with data

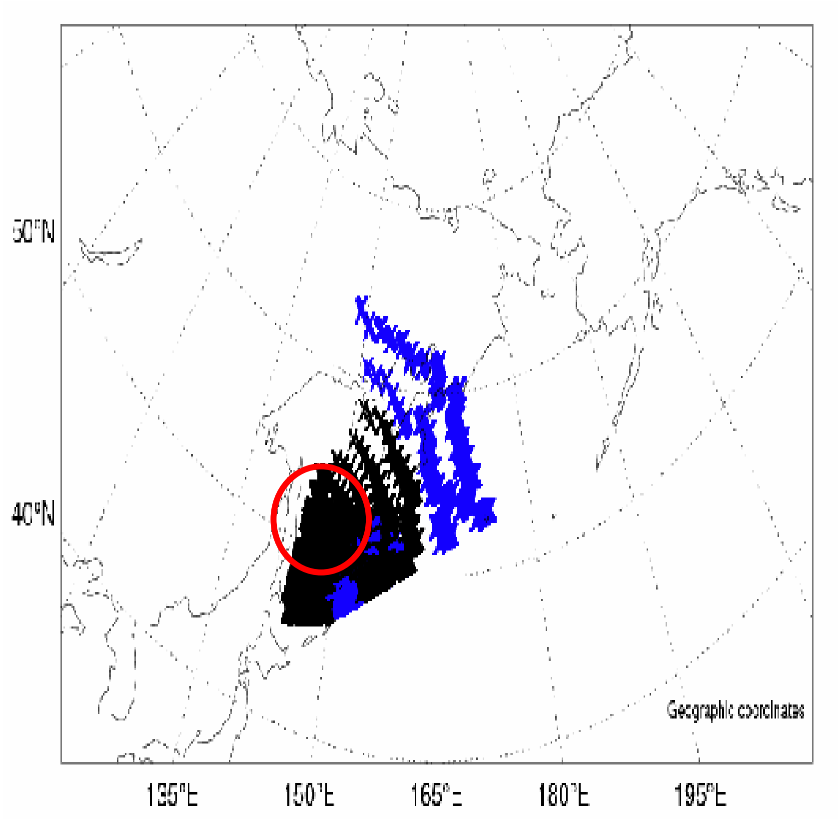


図9:電離圏エコー観測点

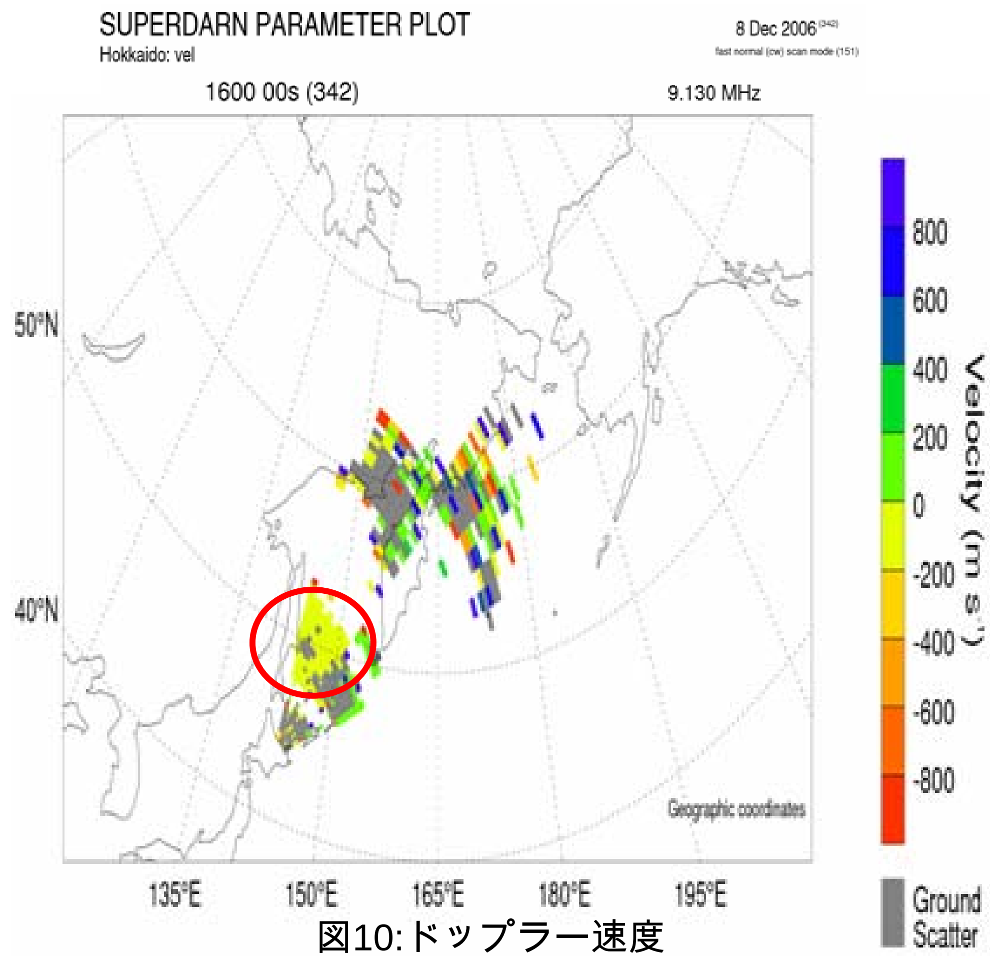
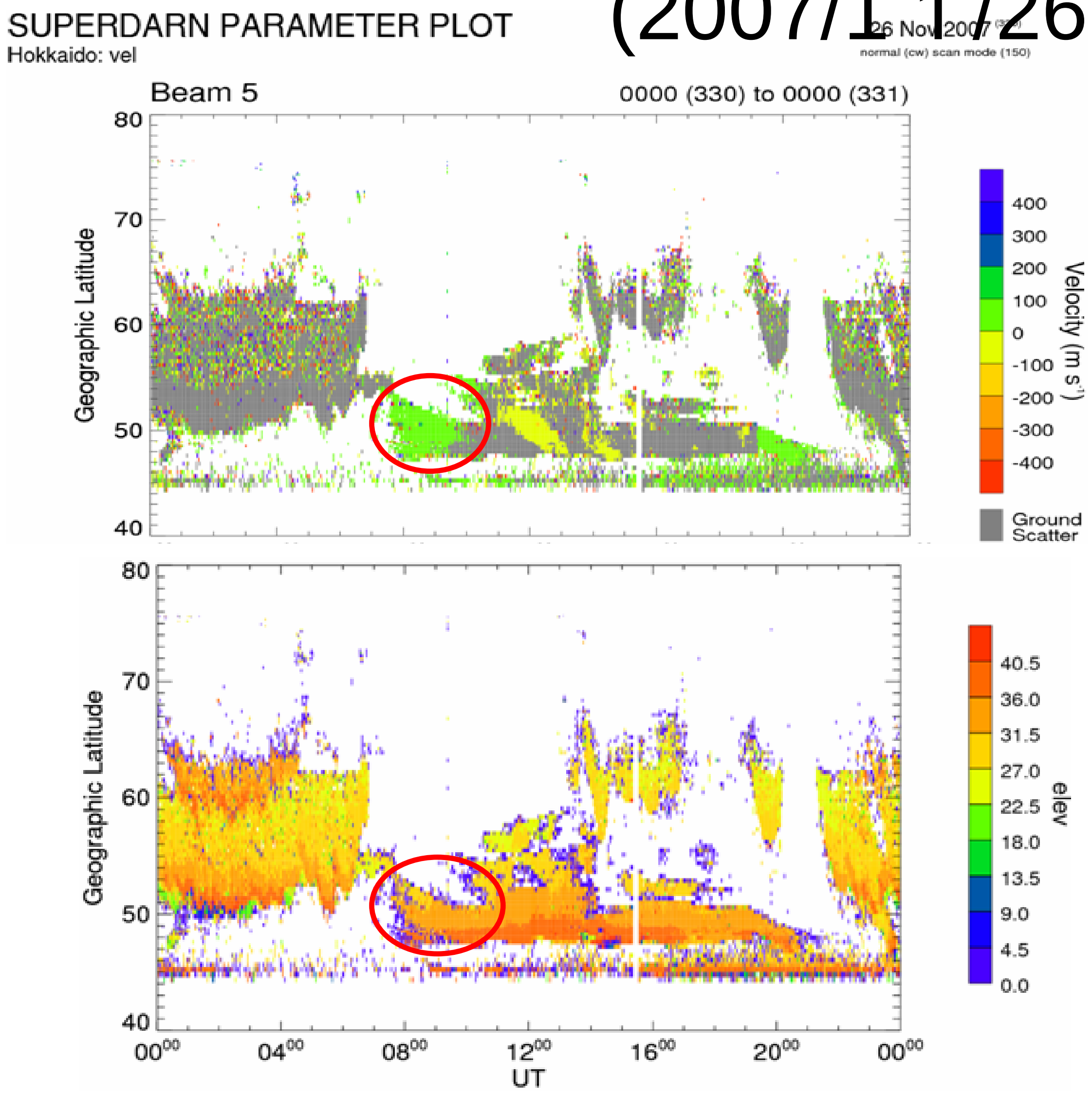


図10:ドップラー速度

•It is highly likely that the red circle region corresponds to ionospheric echo area

More example with elevation angle (2007/11/26, 9UT)



- The elevation angle information is available since November 2007 (until then it could not be used due to the leakage of the main array signal into the interferometer array; it was fixed when Leicester group solved the high noise level receiver problem in November).

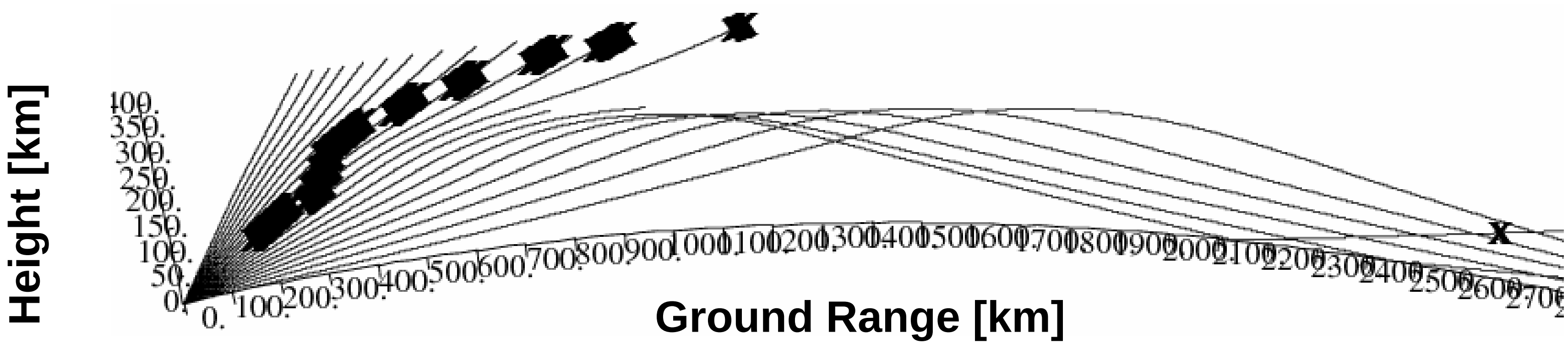
Ray tracing calculation (2)

Model ionosphere

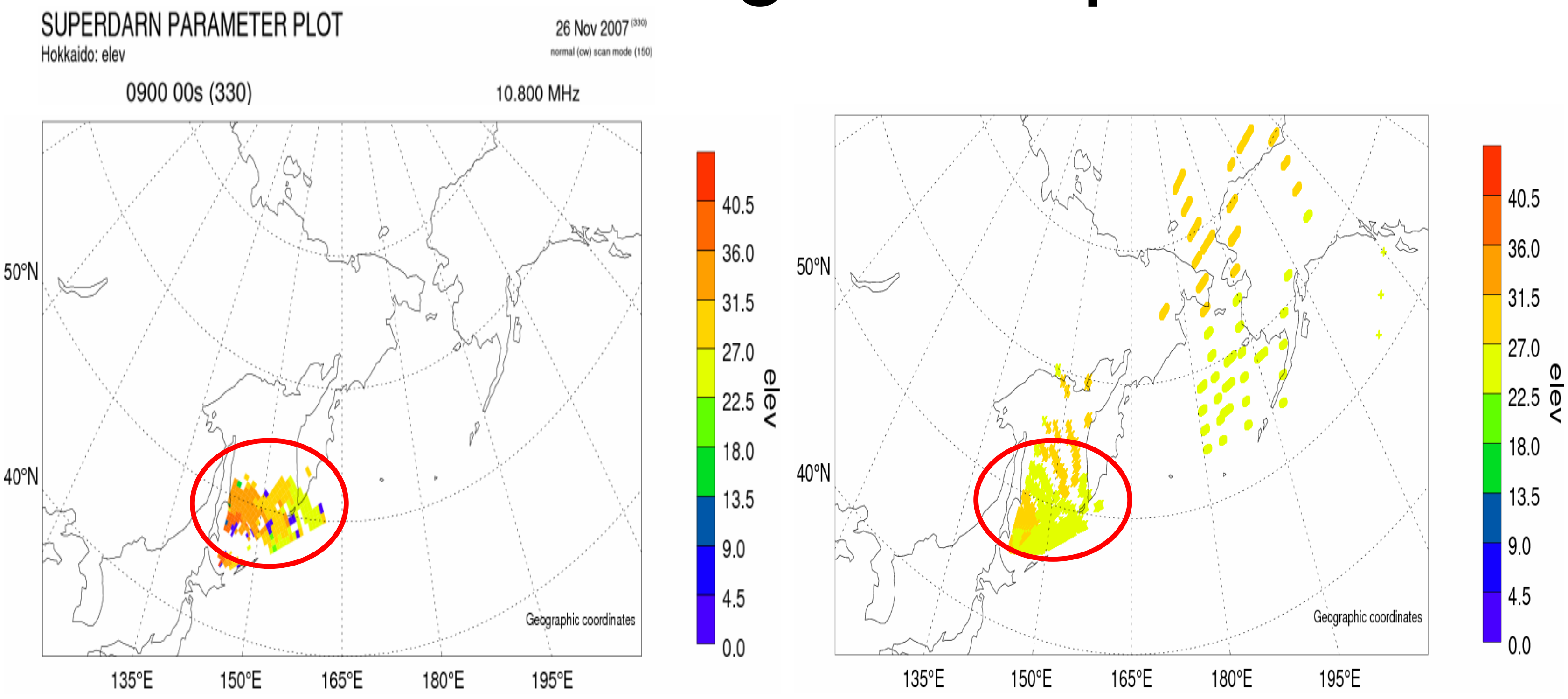
Electron density	IRI-2001 (2007/11/26 9:00(UT))
B	IGRF

Radar wave

Radar loc.	N43.53、E143.61[deg]
Freq.	10.8[MHz]
Elev.	5-50[deg]
Azim.	5.7-53.4[deg]



Elevation angle comparison



- Both the observation (left) and model calculation (right) are consistent with each other.
- Therefore it is highly likely that these are ionospheirc backscatter echoes.

Summary

- We obtained initial results for the statistical distribution of the velocity vectors of ionospheric irregularities measured by the Hokkaido radar.
- For 45 geomagnetic latitude, the east-west components of the velocities by Hokkaido radar are consistent with those obtained by DE-2 ion drift data (Heelis et al., 1992).

- We developed a new algorithm to distinguishing ground/sea scatter and ionospheric scatter by using ray tracing calculation.