The SuperDARN Radar network and the RBSP mission – ULF waves

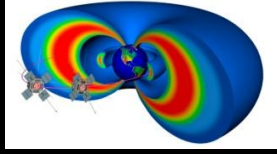
Tim Yeoman

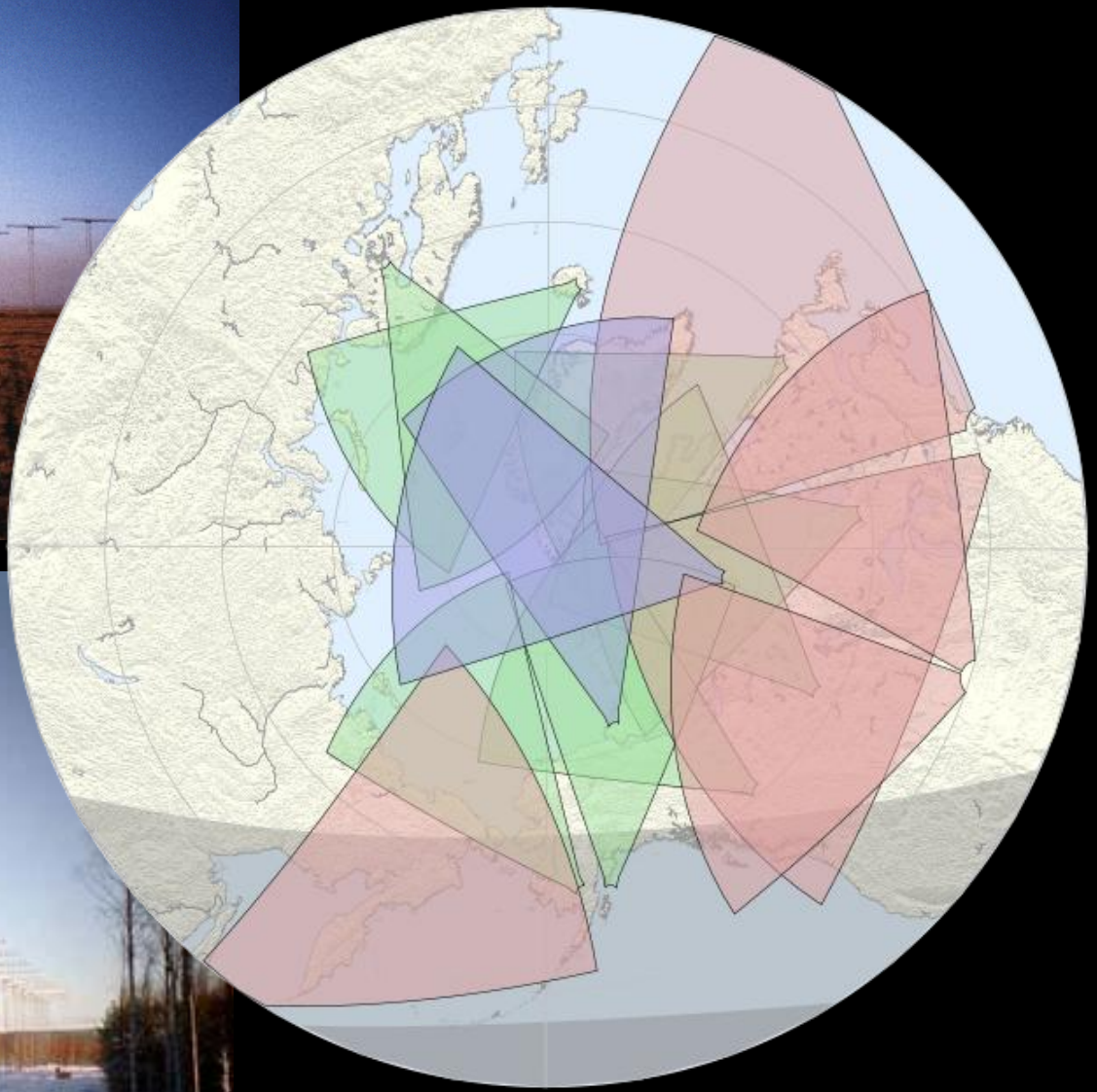
University of Leicester

RBSP meeting, May 2011

The SuperDARN network

Northern hemisphere SuperDARN radars

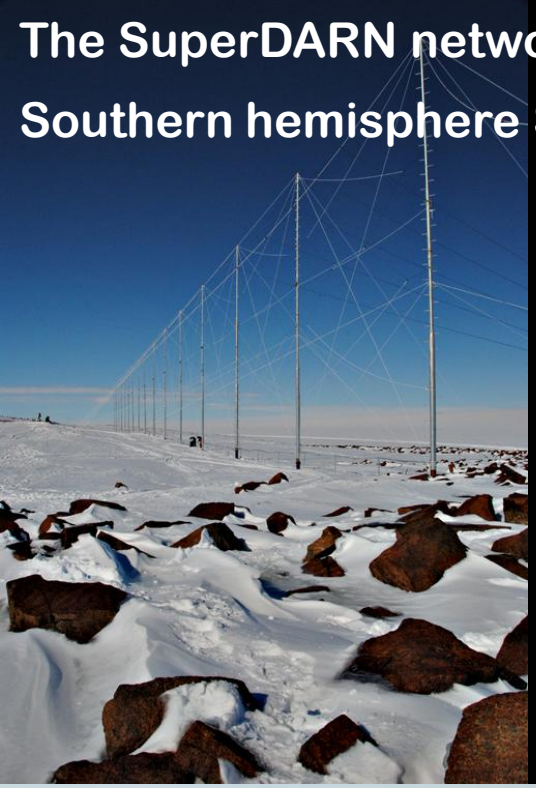


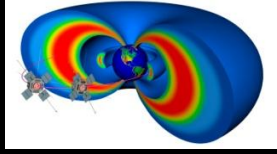


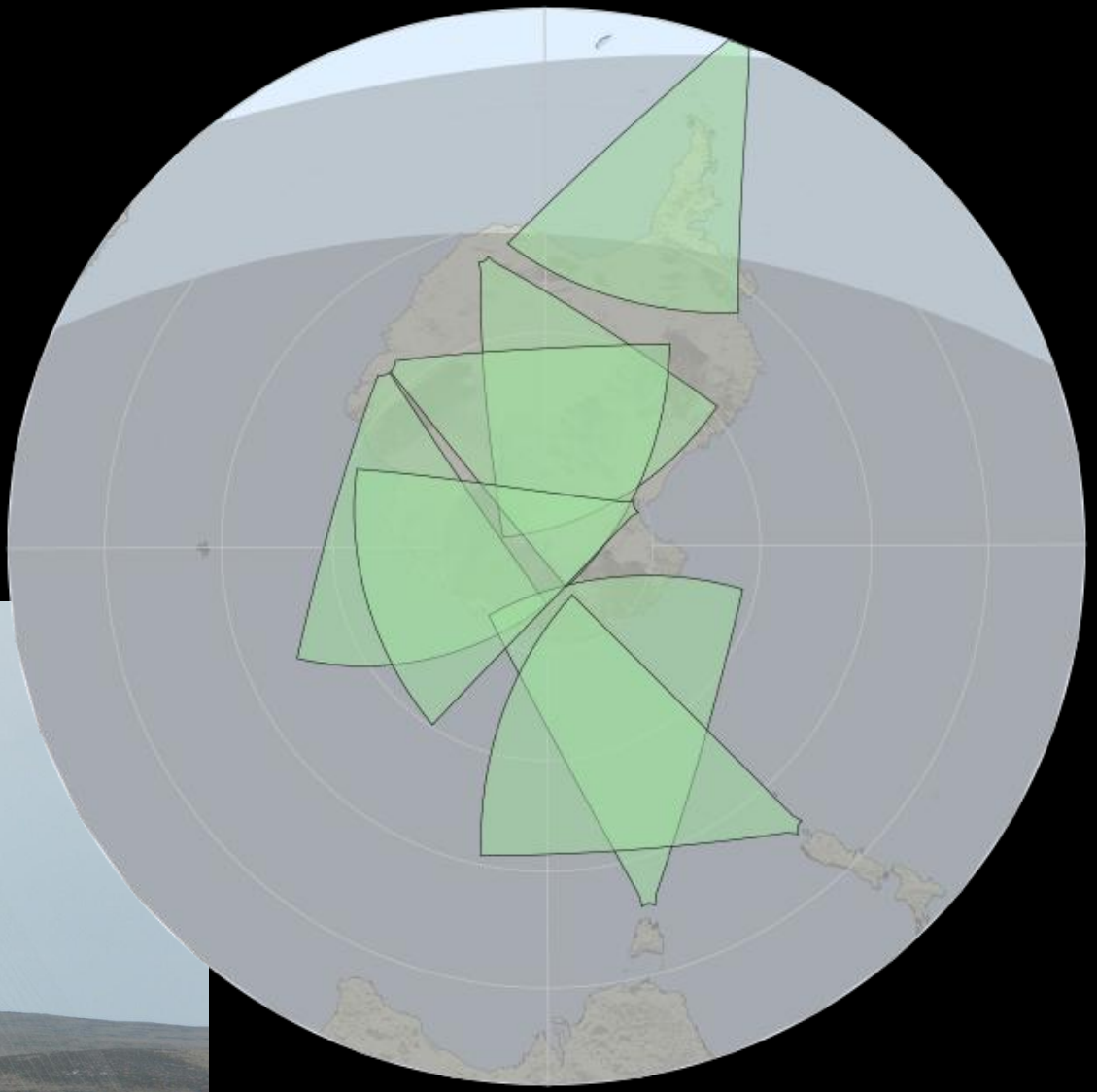
RBSP meeting, May 2011

The SuperDARN network

Southern hemisphere SuperDARN radars

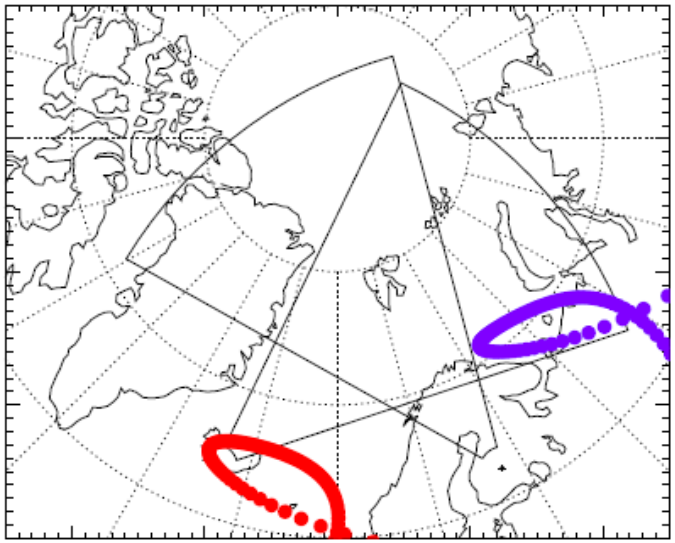






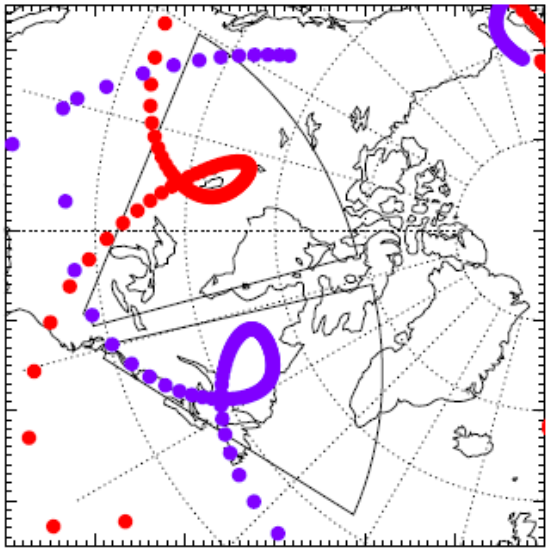
RBSP meeting, May 2011

RBSP passes through CUTLASS FOV

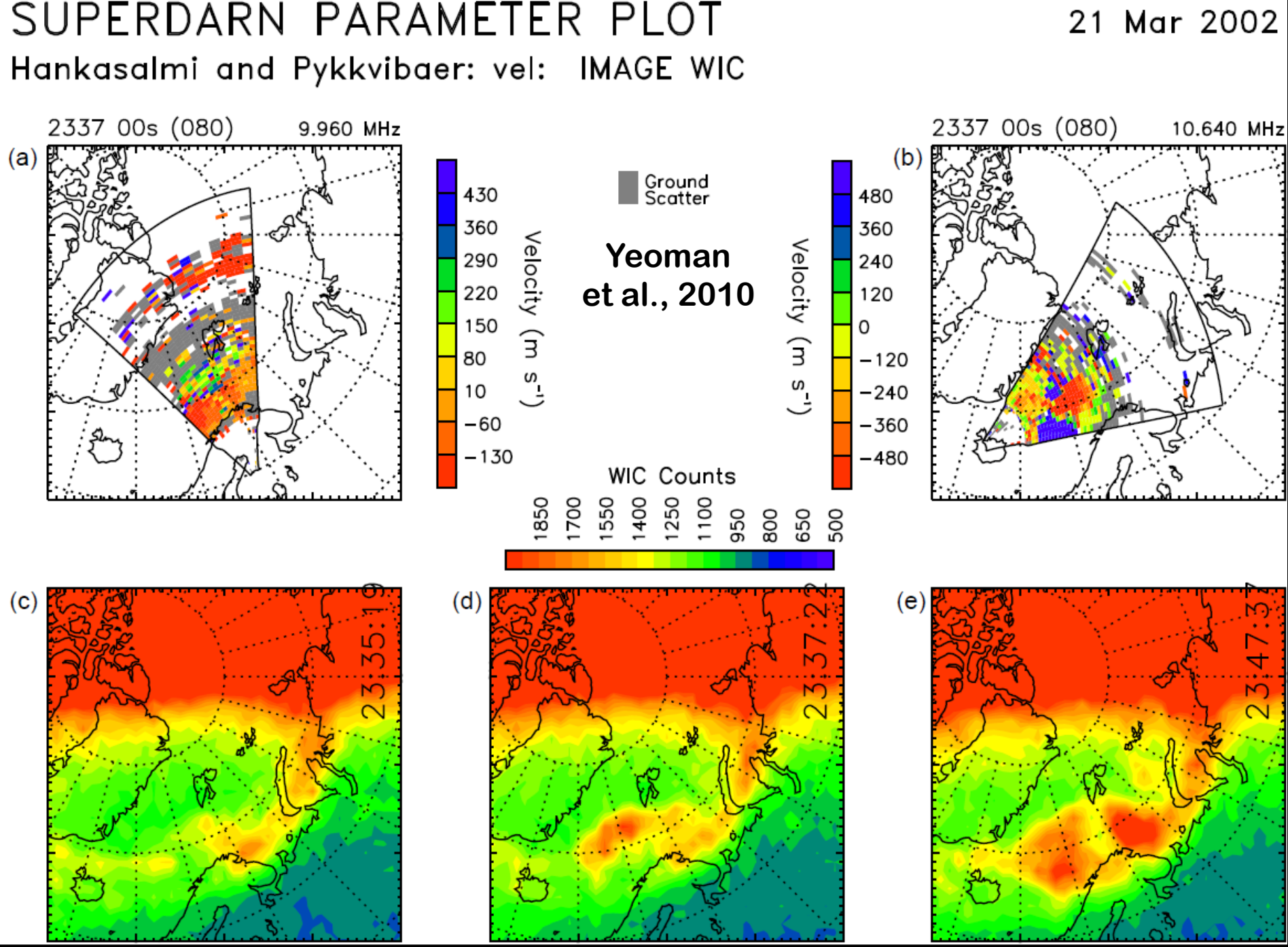


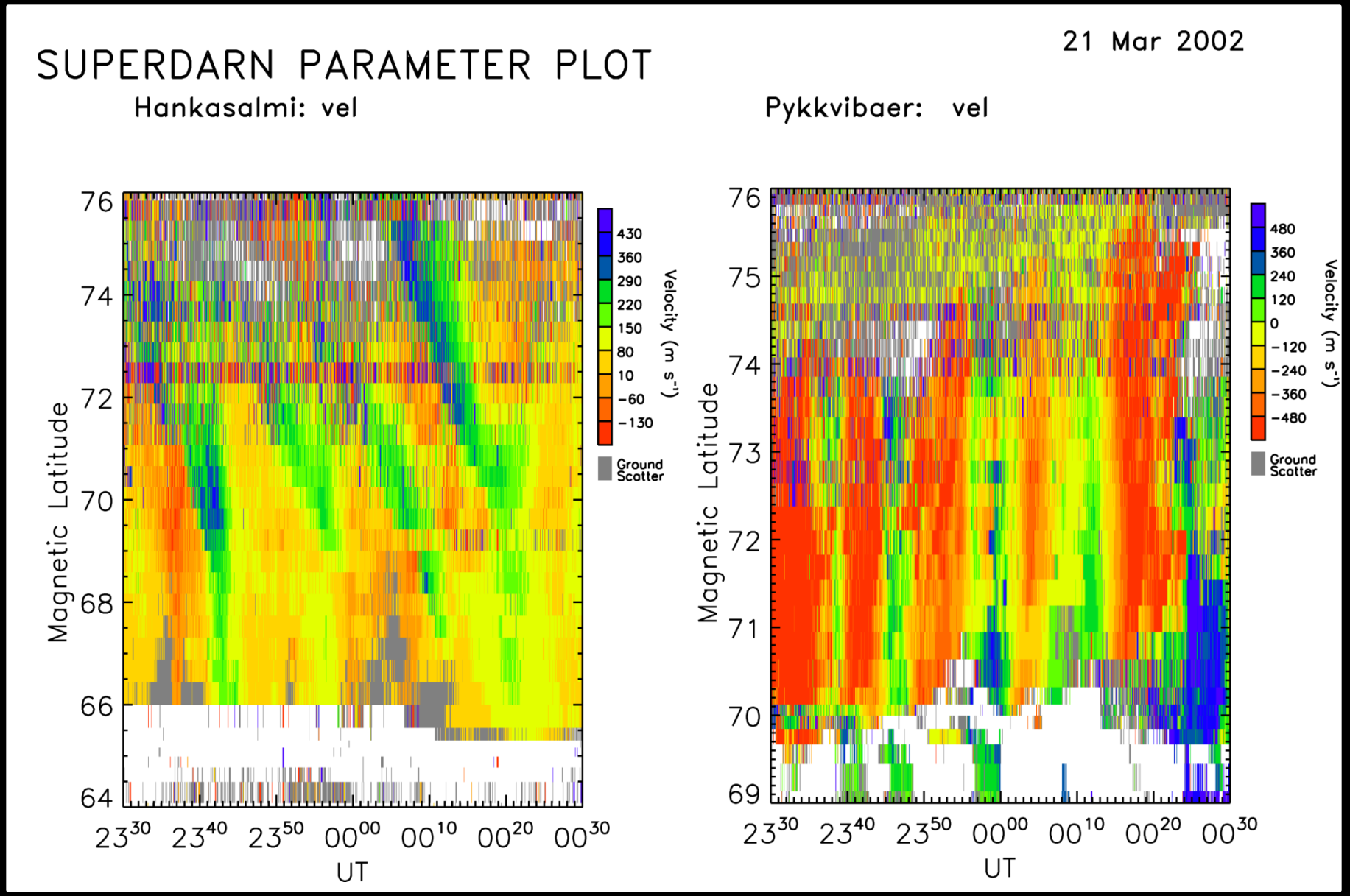
RBSP-A
RBSP-B

RBSP passes through Wallops and Blackstone FOV



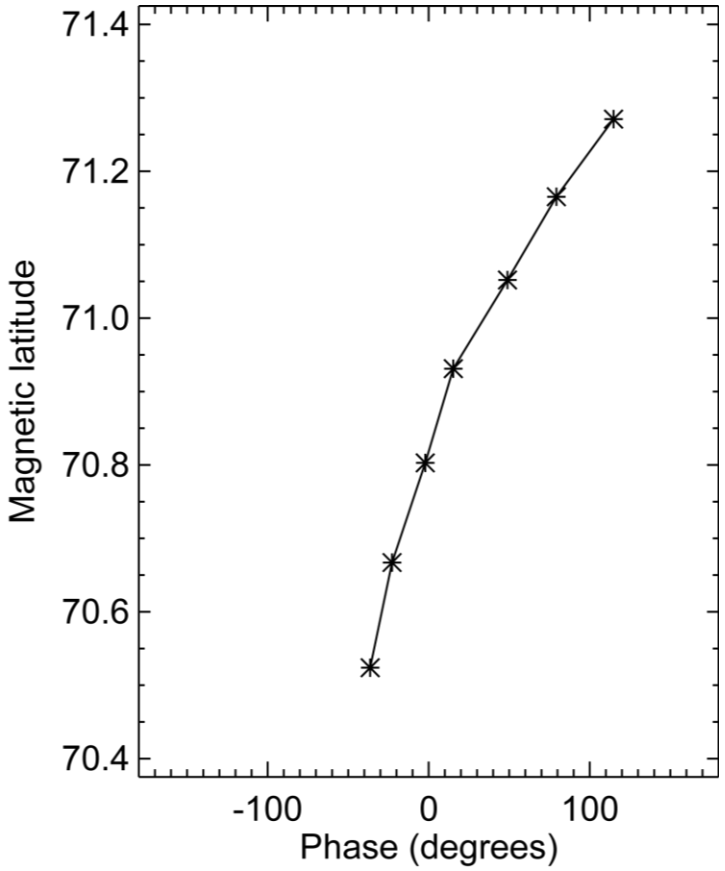
RBSP-A
RBSP-B


SUPERDARN PARAMETER PLOT
21 Mar 2002
Hankasalmi and Pykkvibaer: vel: IMAGE WIC
2337 00s (080)
9.960 MHz
(a)
2337 00s (080)
10.640 MHz
(b)
Ground Scatter
Yeoman et al., 2010
Velocity (m s-1)
430
360
290
220
150
80
10
−60
−130
Velocity (m s-1)
480
360
240
120
0
−120
−240
−360
−480
WIC Counts
1850
1700
1550
1400
1250
1100
950
800
650
500
(c)
23:35:19
(d)
23:37:22
(e)
23:47:37

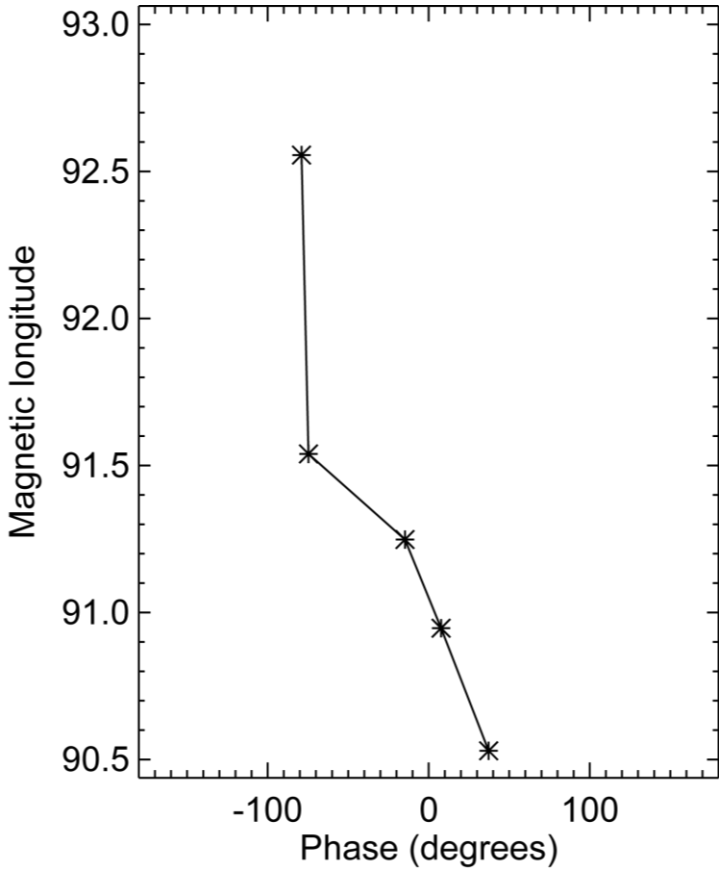


Yeoman et al., 2010

Hankasalmi Beam 9 gates 24-30



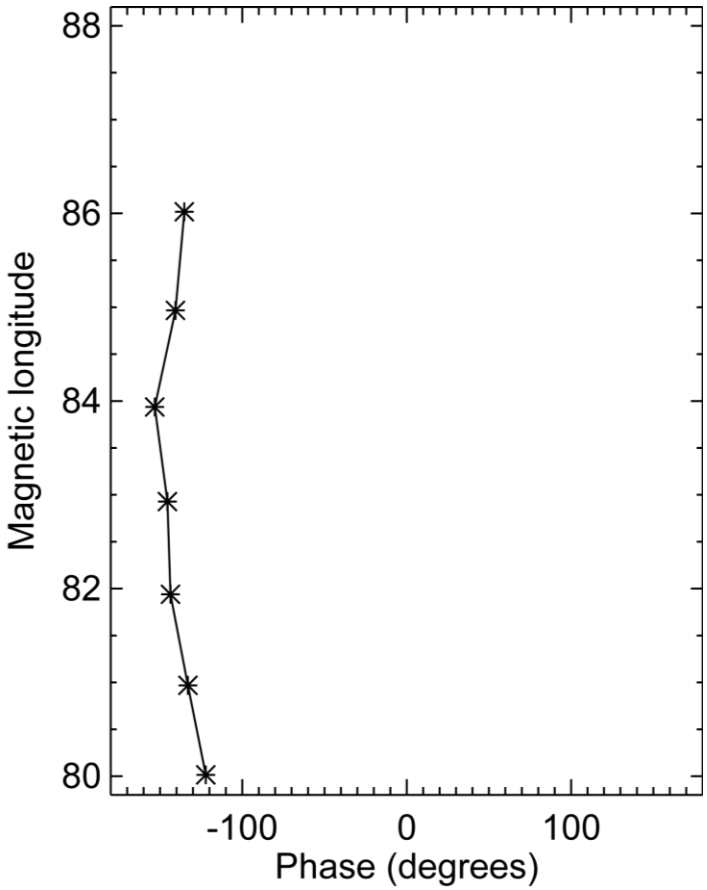
Hankasalmi beams 7 – 12 @ 70° mag.



Phase evolution: ~ 60° per degree latitude, equatorward

Azimuthal wave number , *m* ~13, Eastwards

Þykkvibær Beam 5 gates 16 - 22



Latitudinal and longitudinal phase evolution largely cancel out.

Consistent with Hankasalmi data

Here t = 600 s, m = 13.

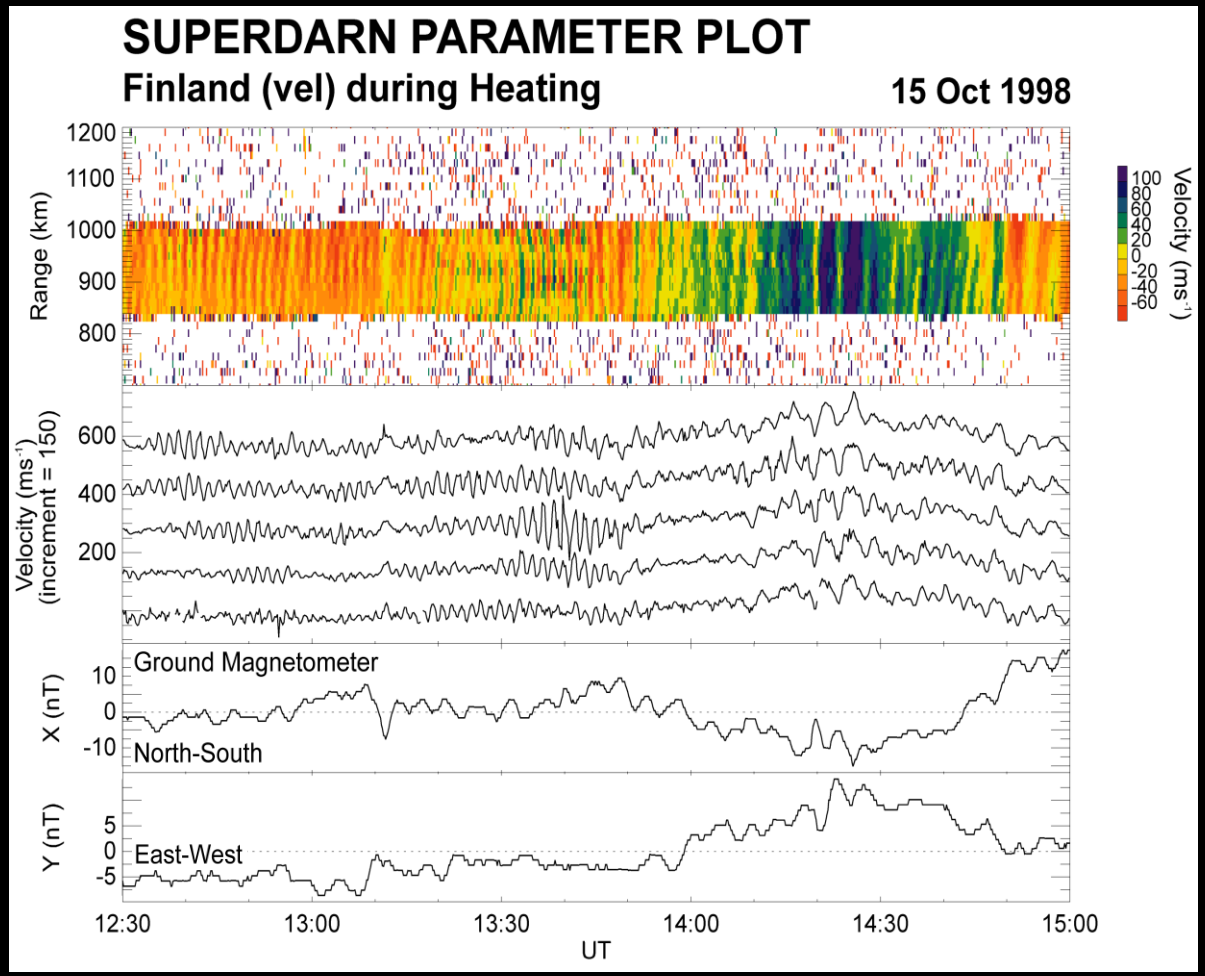
This implies a particle energy of ~60 keV, at L-shells of 7.5 - 15.

Eastward propagation suggests electrons as a source.

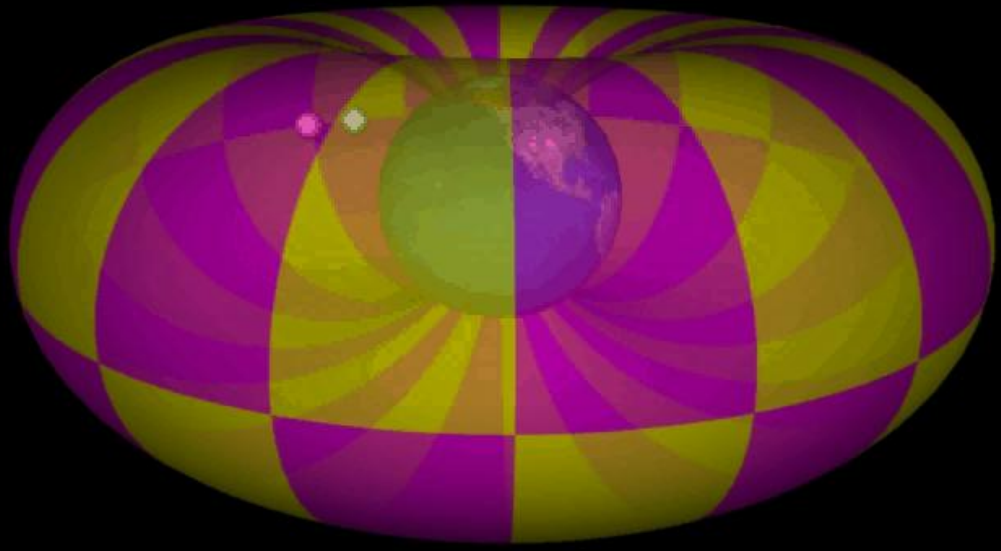
Powerful radio waves from an RF heating facility modify the upper atmosphere.

This creates targets for the SuperDARN radars

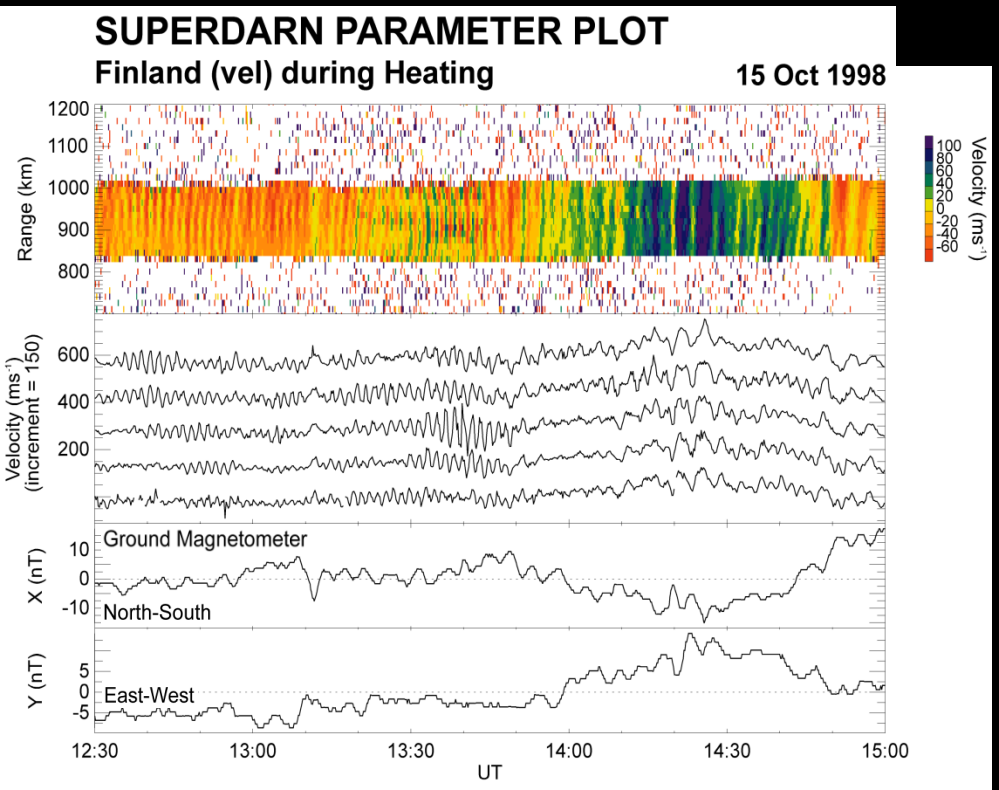
Natural ULF waves from space then become visible

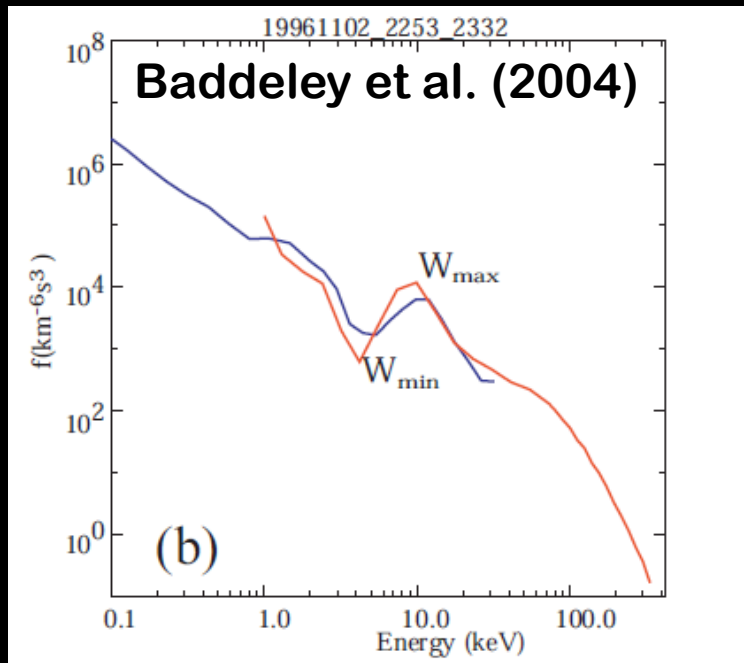


- ULF waves generated by interactions with energetic particles within the Earth's magnetosphere

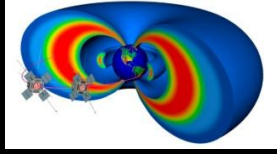


Wright & Yeoman (1999)



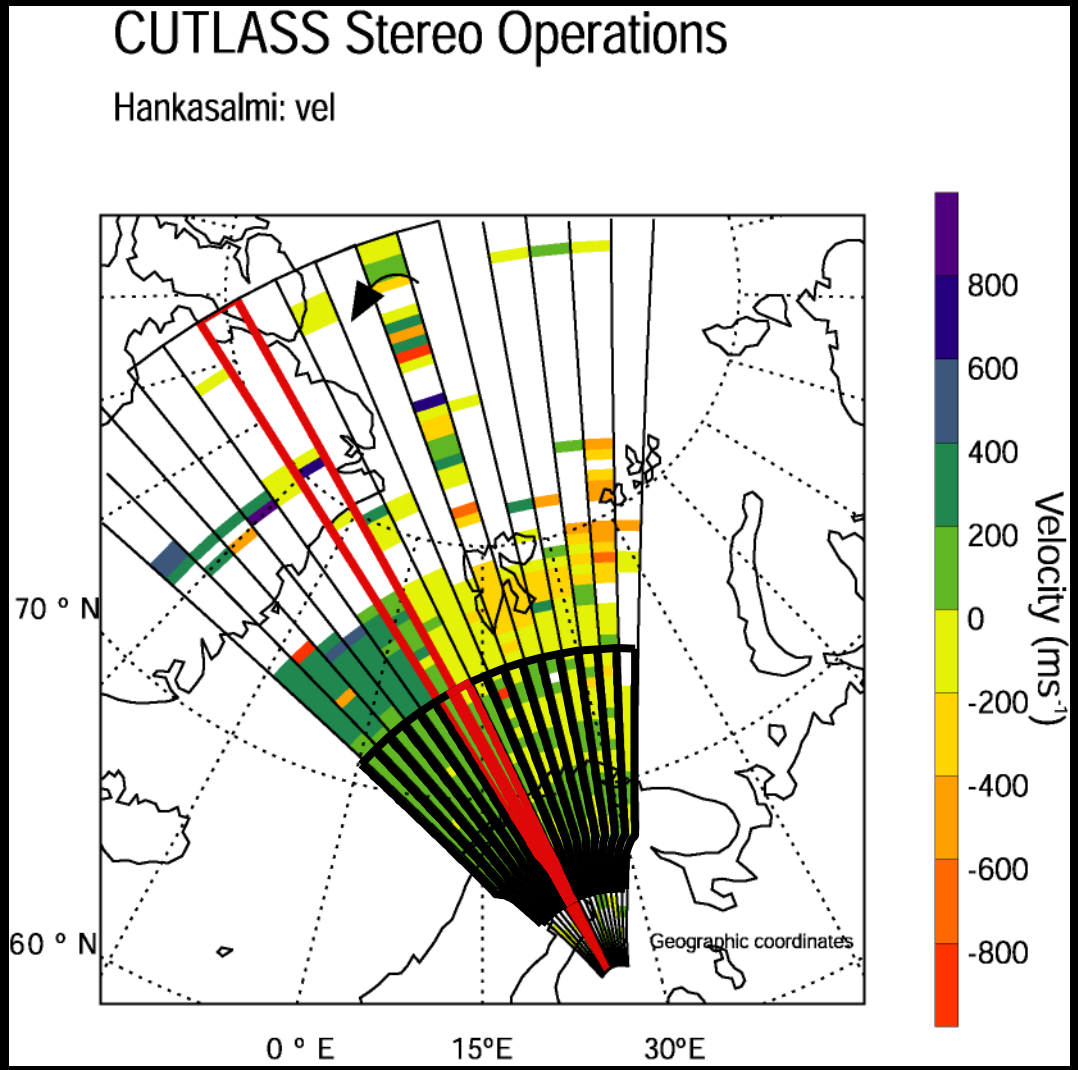


SuperDARN operating modes



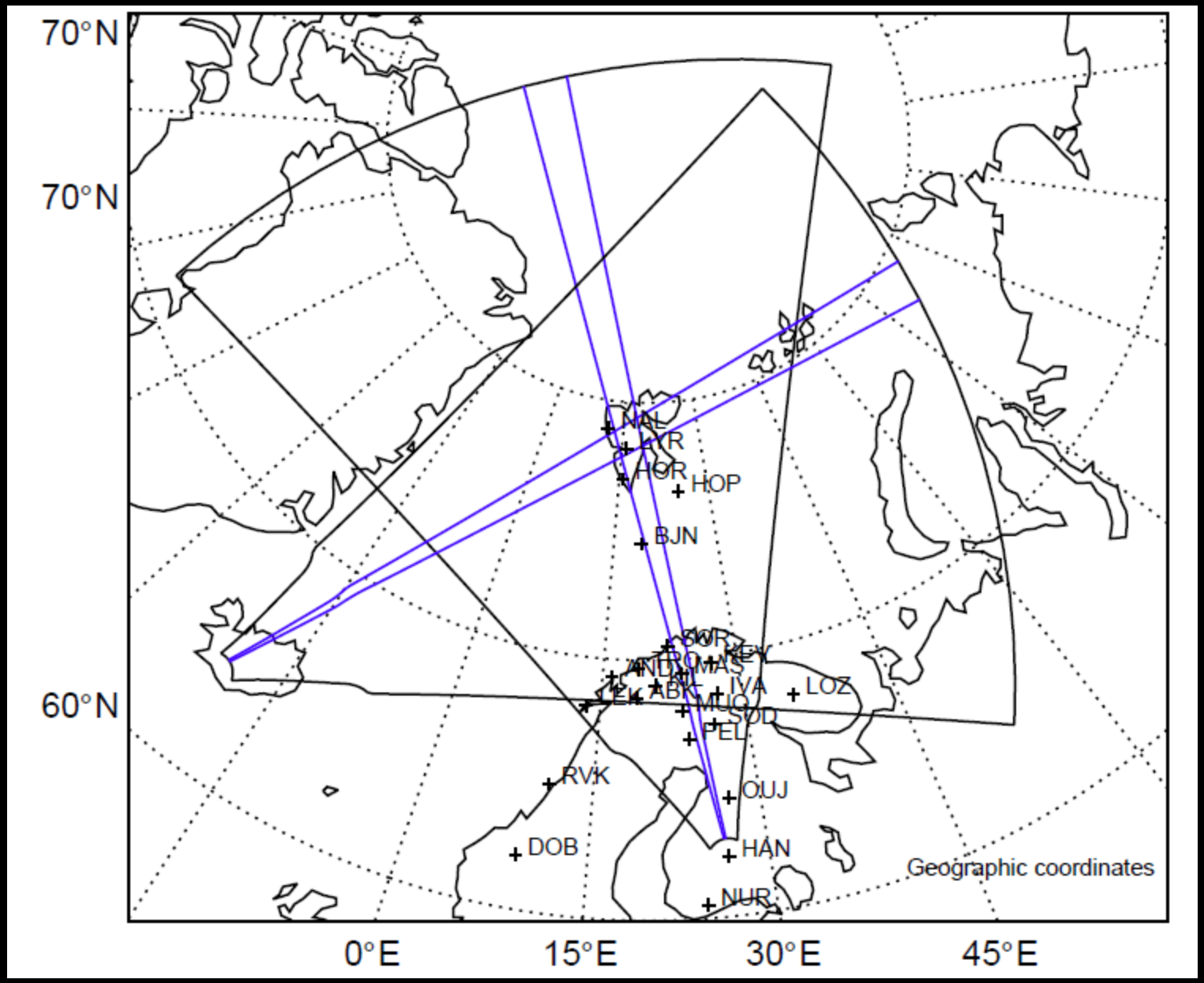
The "stereo" capability allows two modes to be run Simultaneously

Can be interleaved on a mono radar with a loss of time resolution

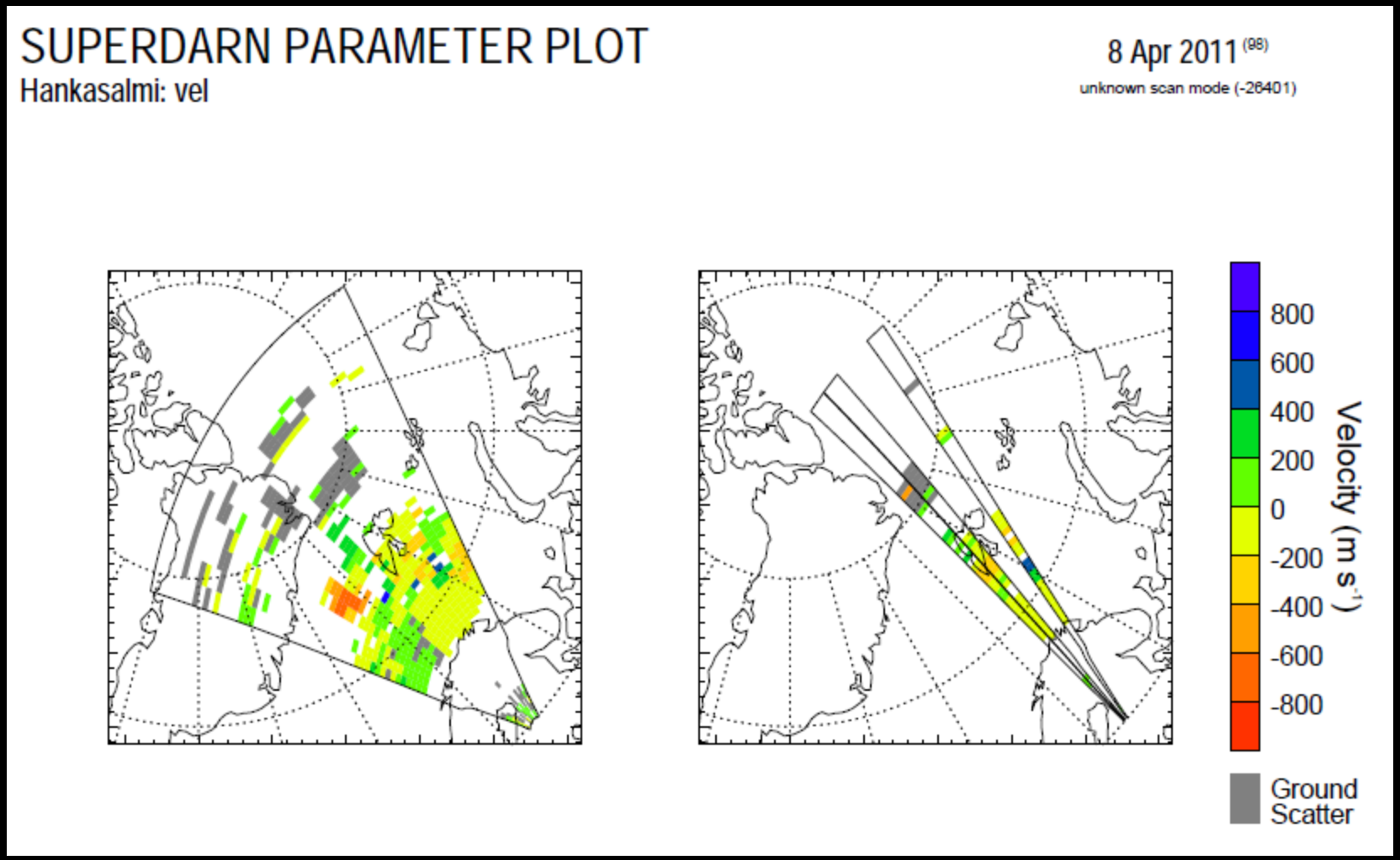


University of Leicester

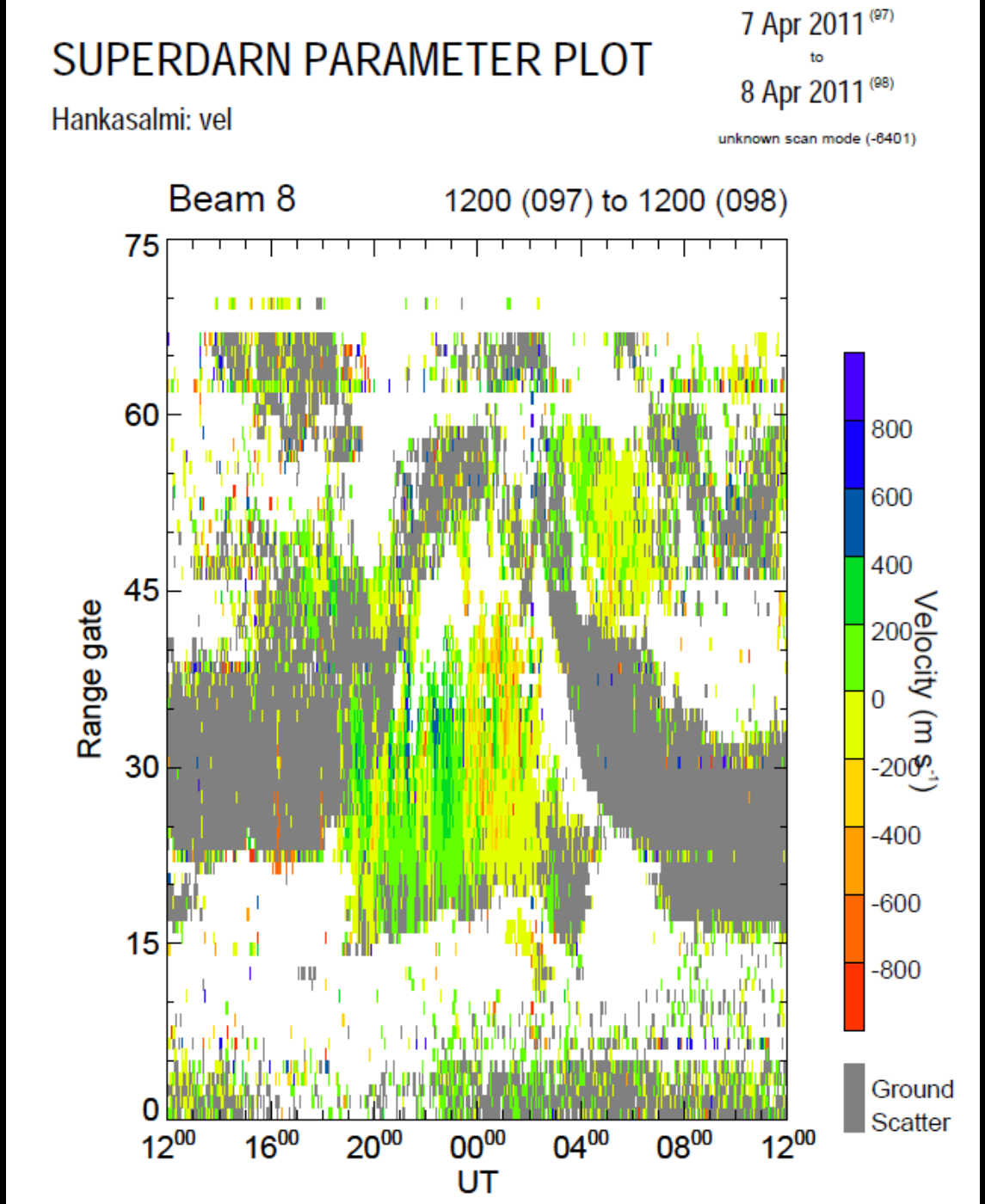
SuperDARN operating modes – standard stereo mode



SuperDARN operating modes – initial RBSP test mode

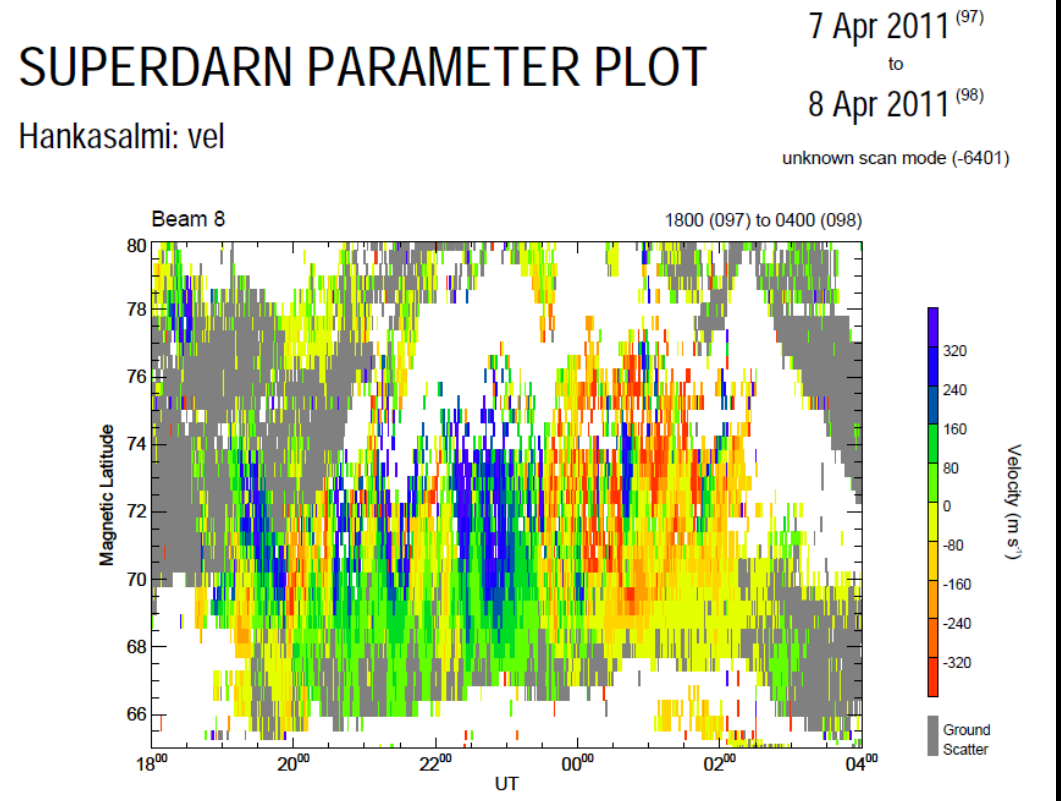


24 h data from Channel A during RBSP test mode



10 h data from beam 8

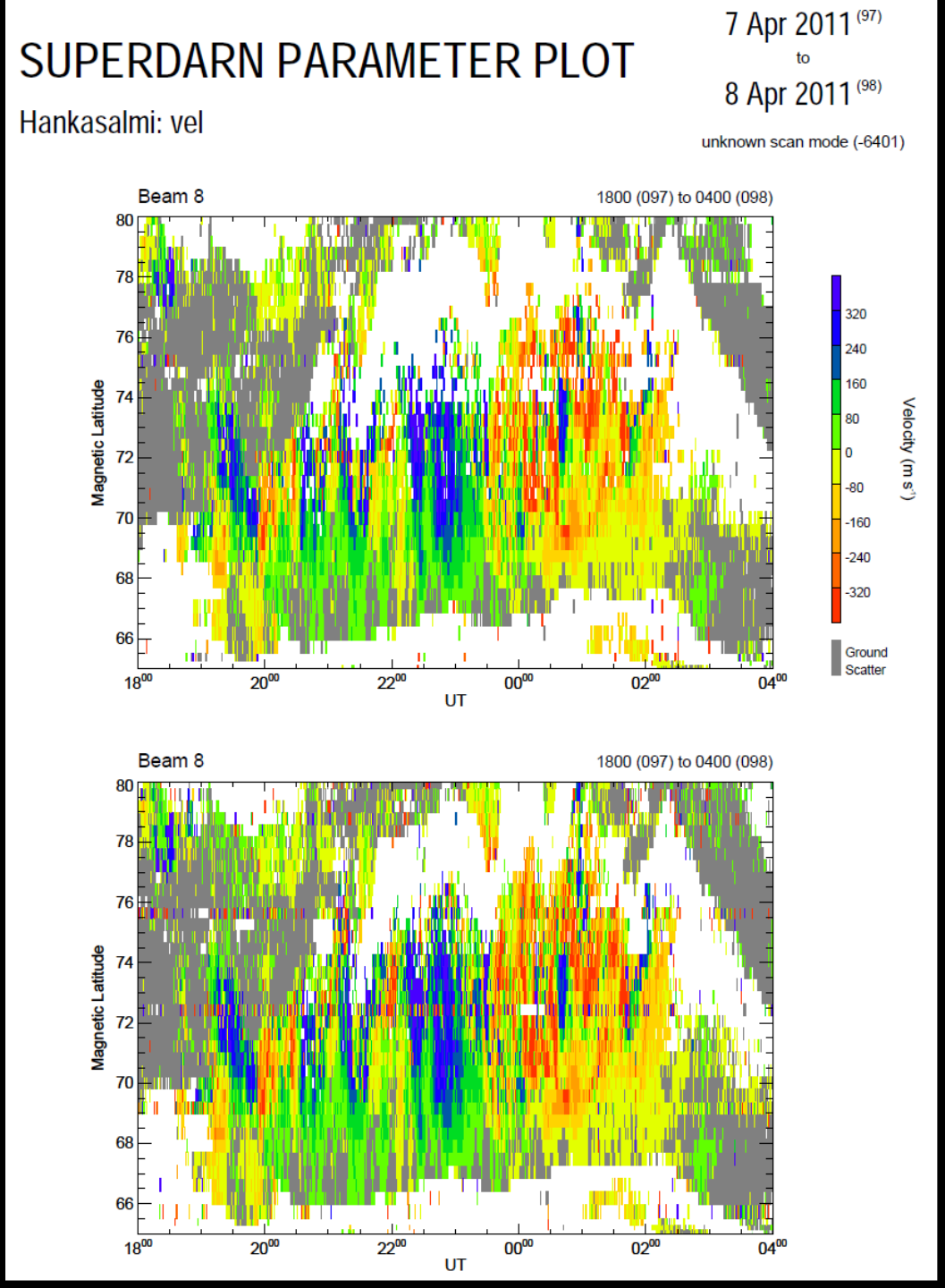
Channel A



10 h data from beam 8

Channel A

Channel B



2 h data

Beam 8A

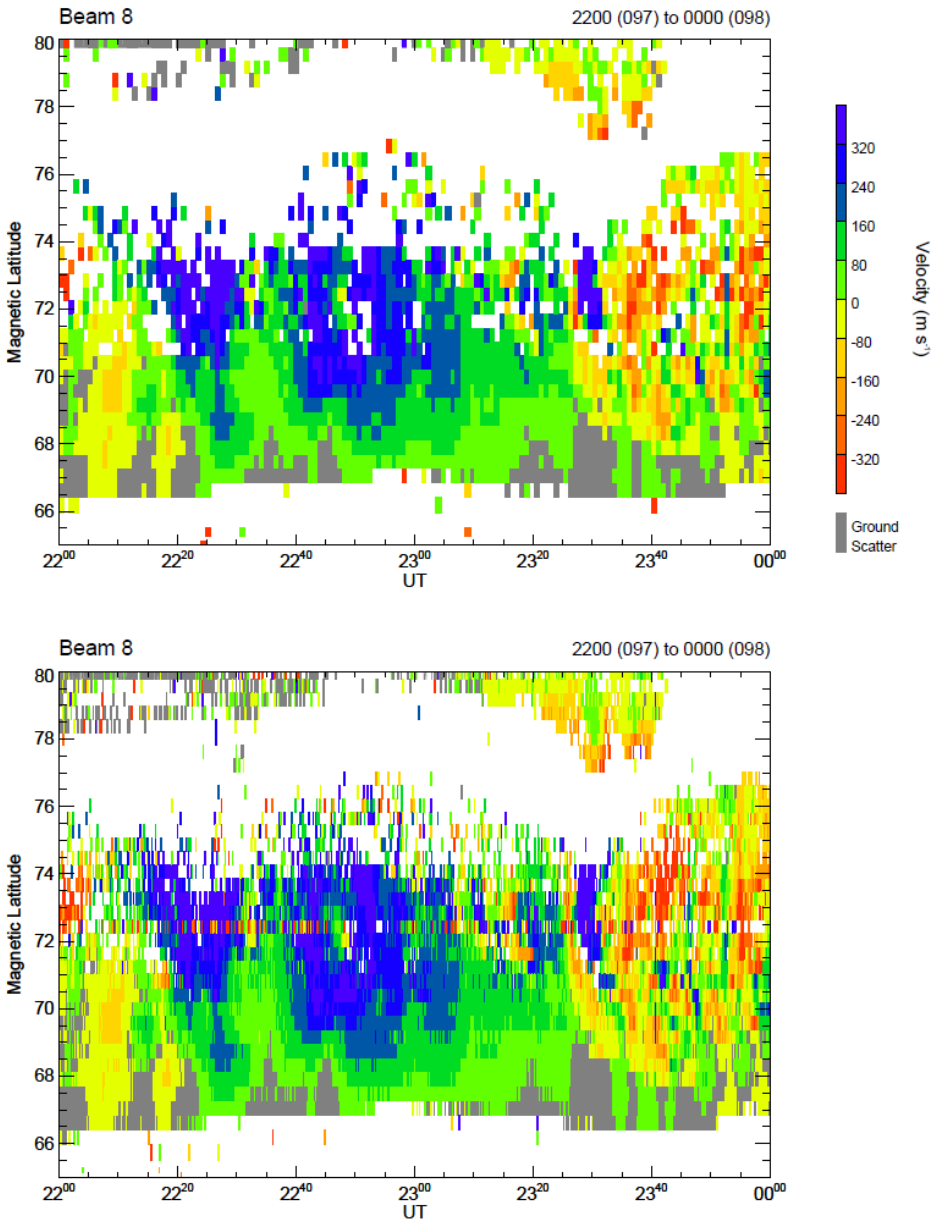
Beam 8B

SUPERDARN PARAMETER PLOT

7 Apr 2011 (97)
to
8 Apr 2011 (98)

Hankasalmi: vel

unknown scan mode (-6401)

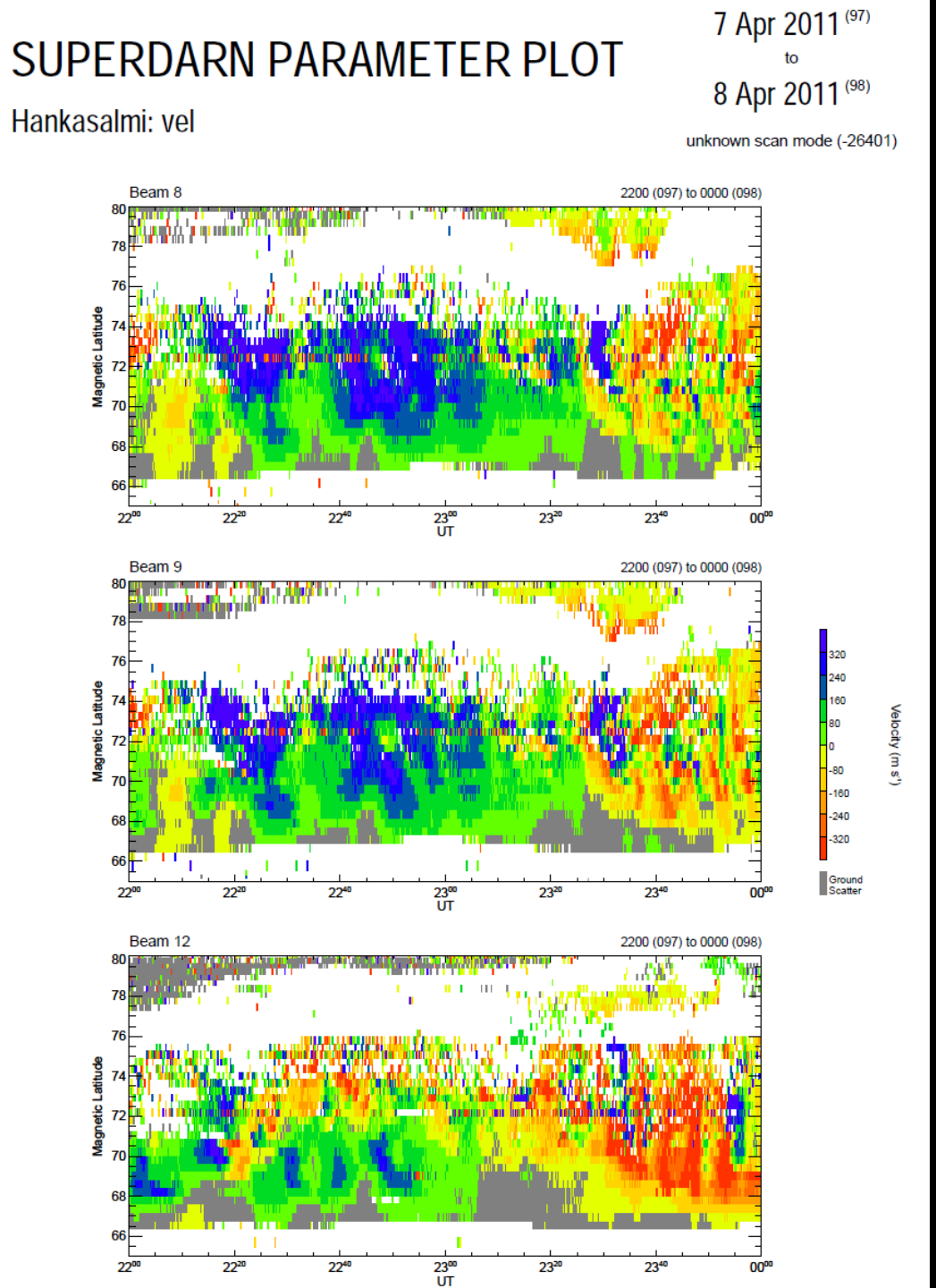


6 h data from the
3 Channel B beams

Beam 8

Beam 9

Beam 12

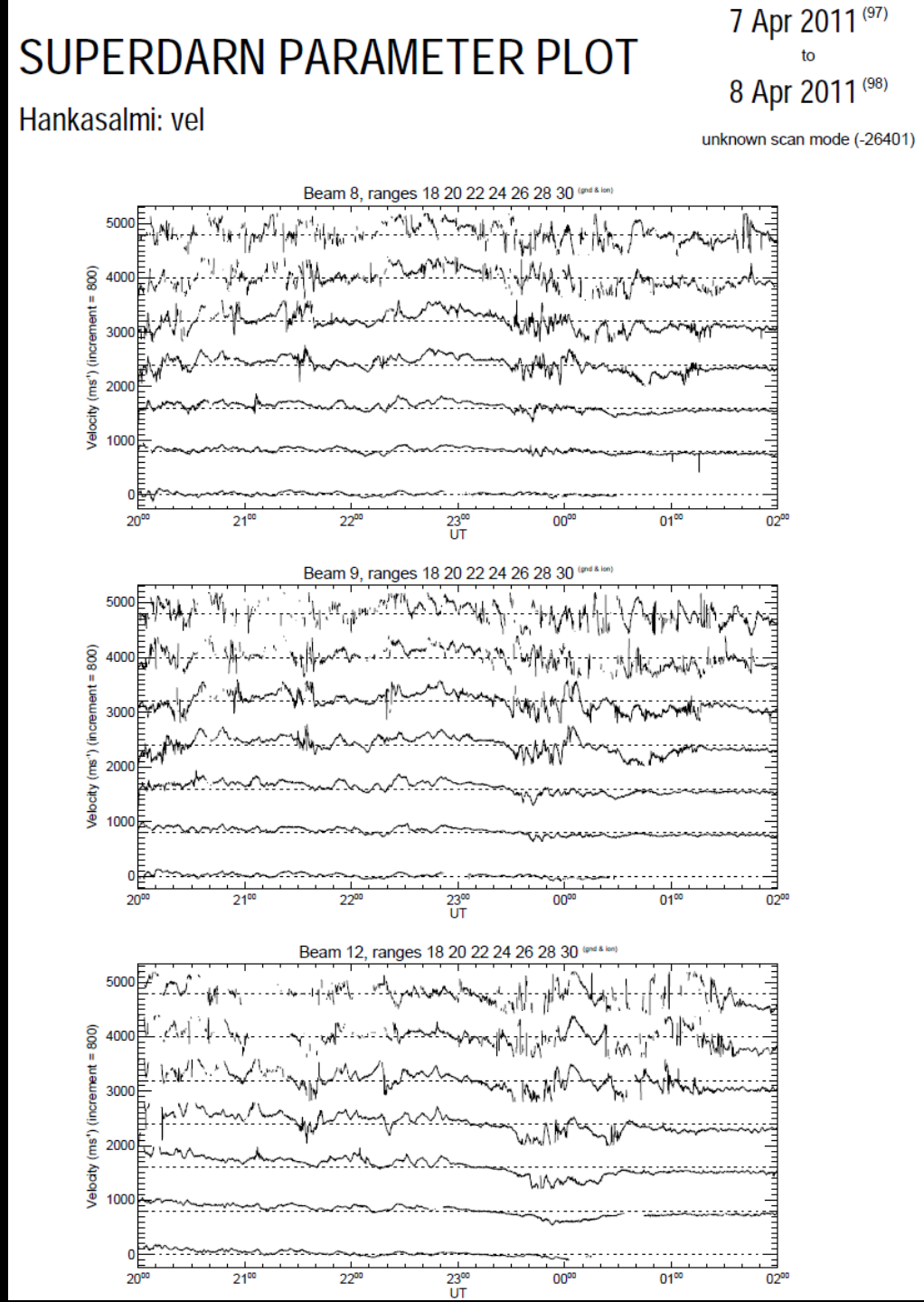


6 h data from the
3 Channel B beams

Beam 8

Beam 9

Beam 12



2 h data from the
3 Channel B beams

Beam 8

Beam 9

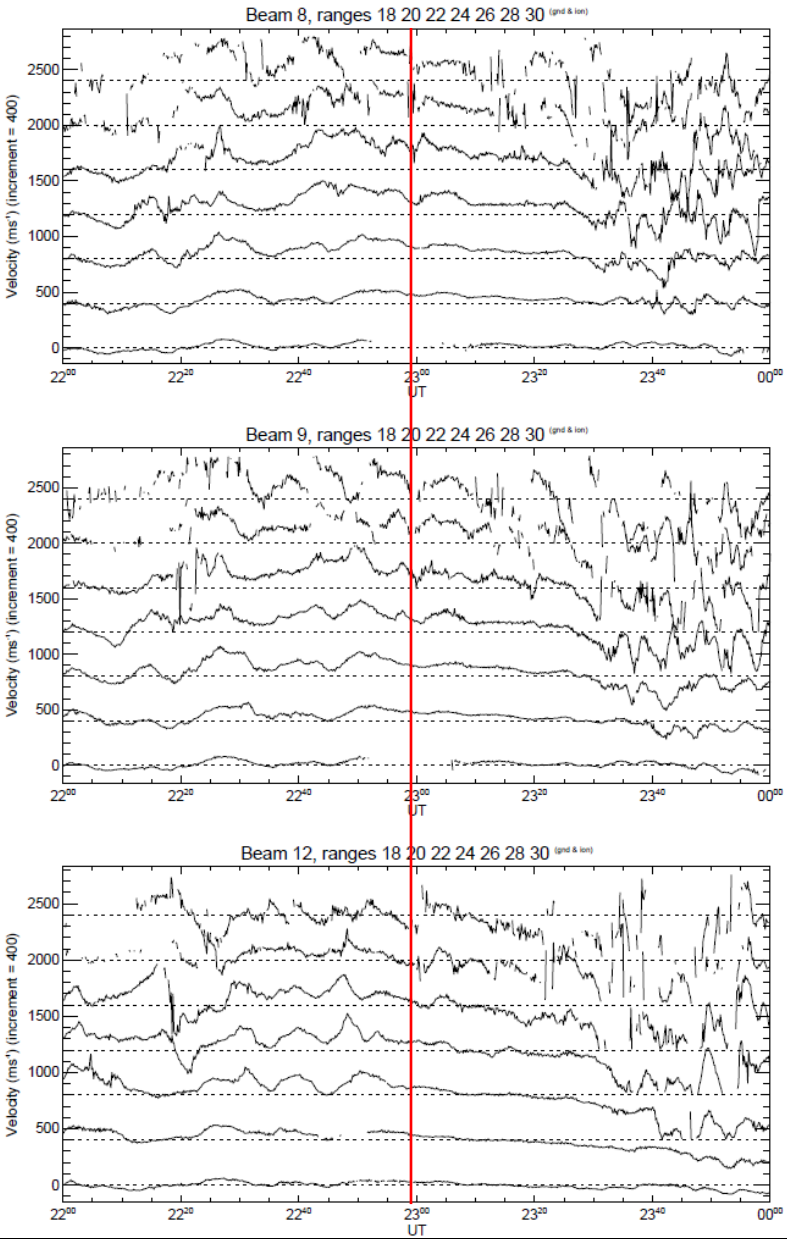
Beam 12

SUPERDARN PARAMETER PLOT

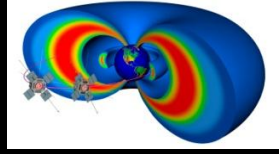
Hankasalmi: vel

7 Apr 2011 (97)
to
8 Apr 2011 (98)

unknown scan mode (-26401)



6. SuperDARN and RBSP



- ULF wave activity and storms.

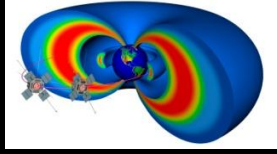
SuperDARN can measure ULF wave fields, frequency, ionospheric electric field, azimuthal structure locally and globally. *m* up to ~100, (attenuation factor of ~50 in ground magnetometer data) whilst RBSP measures energetic particles and chorus waves.

Pc3-5 band (1000 - 10s): Direct measurement on a global scale from all radars. Ionospheric and ground scatter can provide information (direct measurement of electric field and Doppler shifts due to wave modulation of the reflection height). Covered by existing THEMIS mode or similar.

ULF EMIC 10 - 0.2 s: Direct measurement at the lower end of the frequency scale (all radars), Raw data analysis in the middle (partial array coverage), spectral width broadening as a diagnostic at the upper end of frequency scale (all radars).

VLF whistlers 100 Hz- 5 kHz no measurements from SuperDARN

6. SuperDARN and RBSP



What are the key SuperDARN measurements required by the RBSP community for ULF wave radar operations planning?

- Azimuthal structure?
- Integrated wave power in defined frequency bands?
- Global measurement or latitude/MLT distribution?
- Combined data products with ground magnetometer measurements?

- Define an network-wide RBSP mode for storm alert operations
- Define a mode for radar-RBSP apogee conjunctions
- Design a mode for EMIC waves

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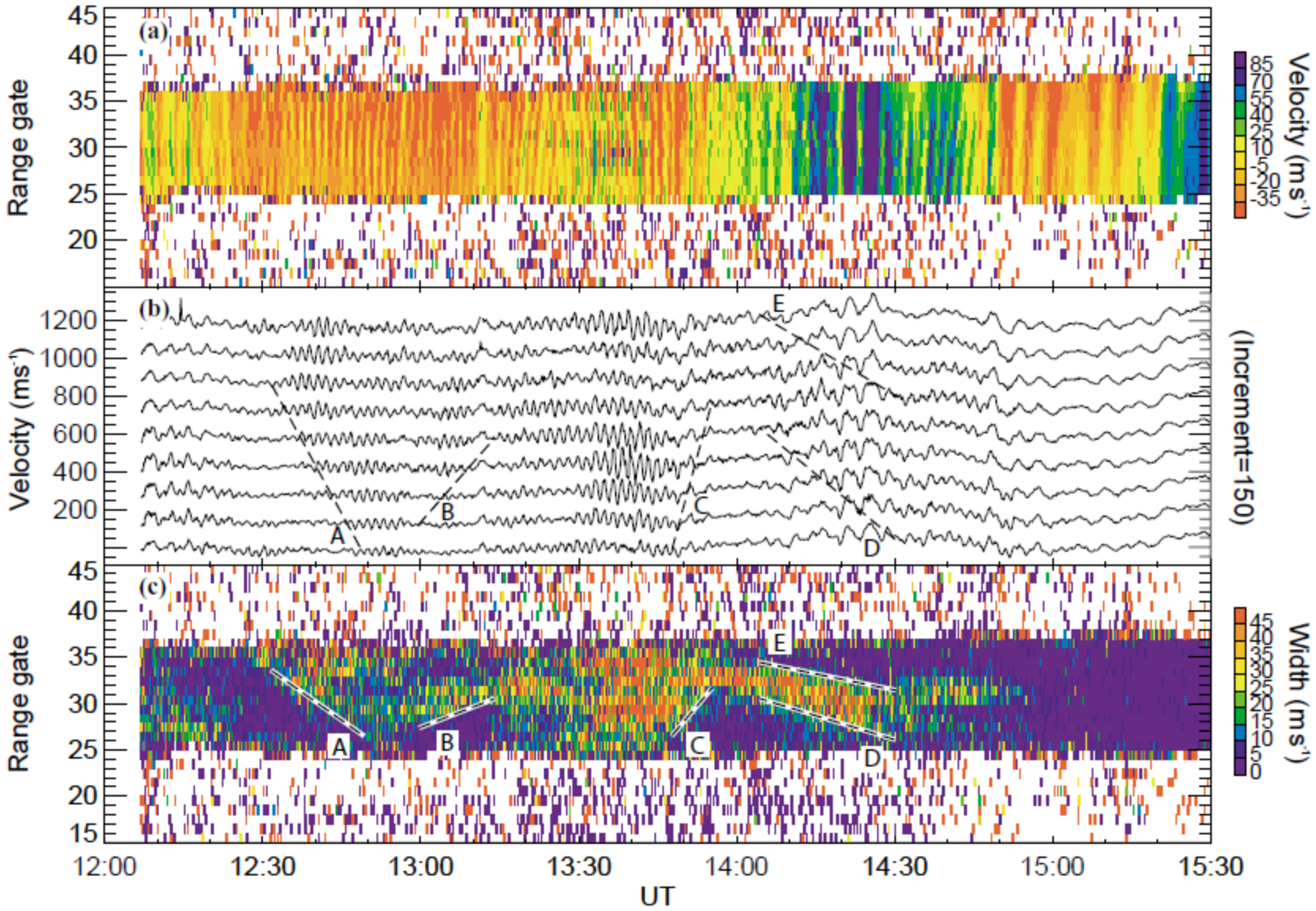
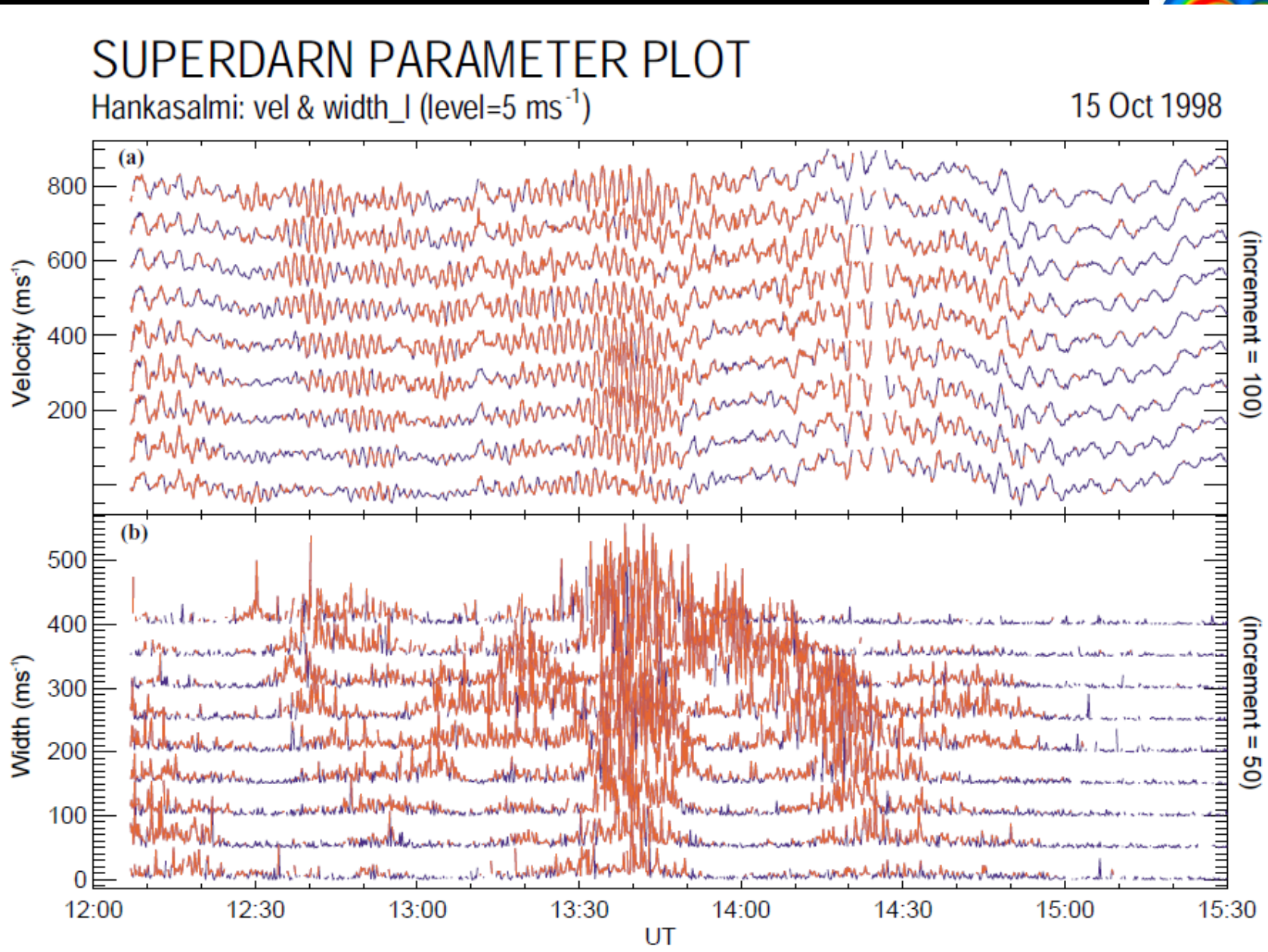
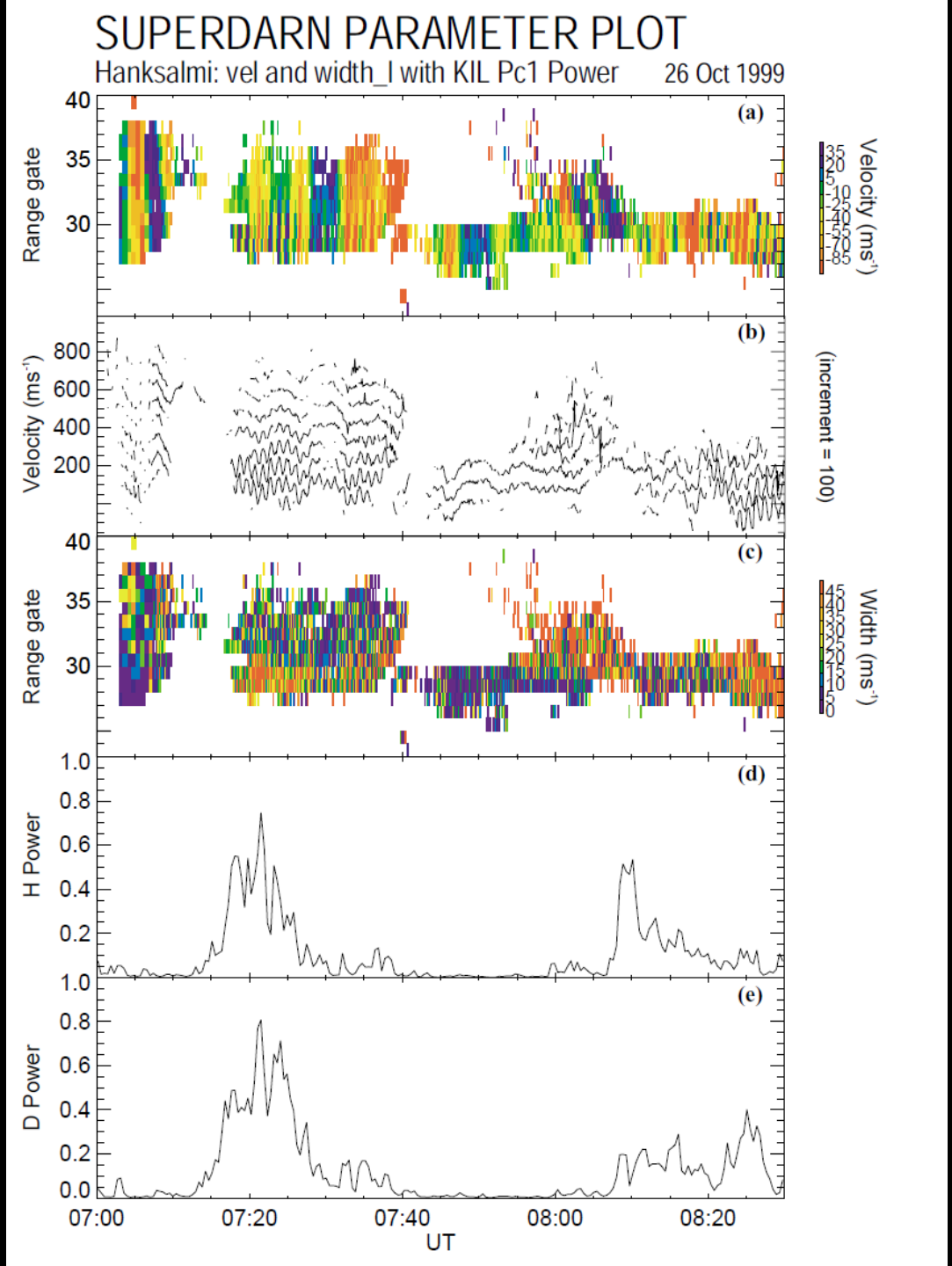
University of Leicester

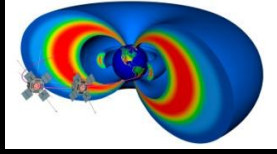
RBSP meeting, May 2011

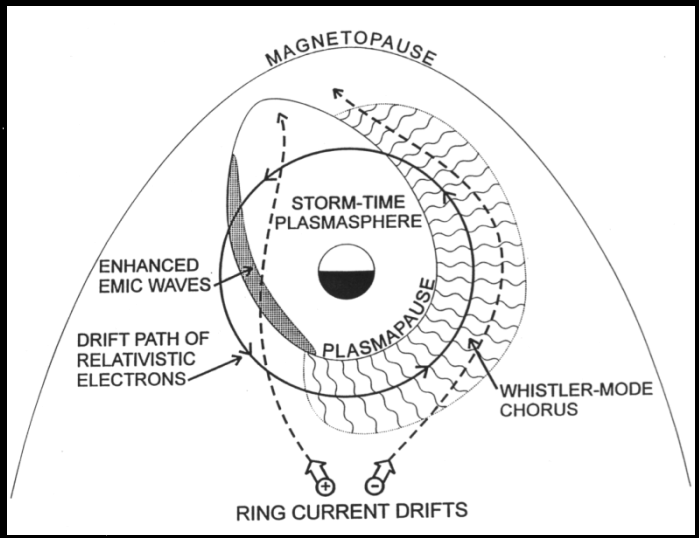
SUPERDARN PARAMETER PLOT




SUPERDARN PARAMETER PLOT
Hankasalmi: vel & width_l (level=5 ms-1)
15 Oct 1998
(a)
Velocity (ms-1)
800
600
400
200
(increment = 100)
(b)
Width (ms-1)
500
400
300
200
100
0
(increment = 50)
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
UT

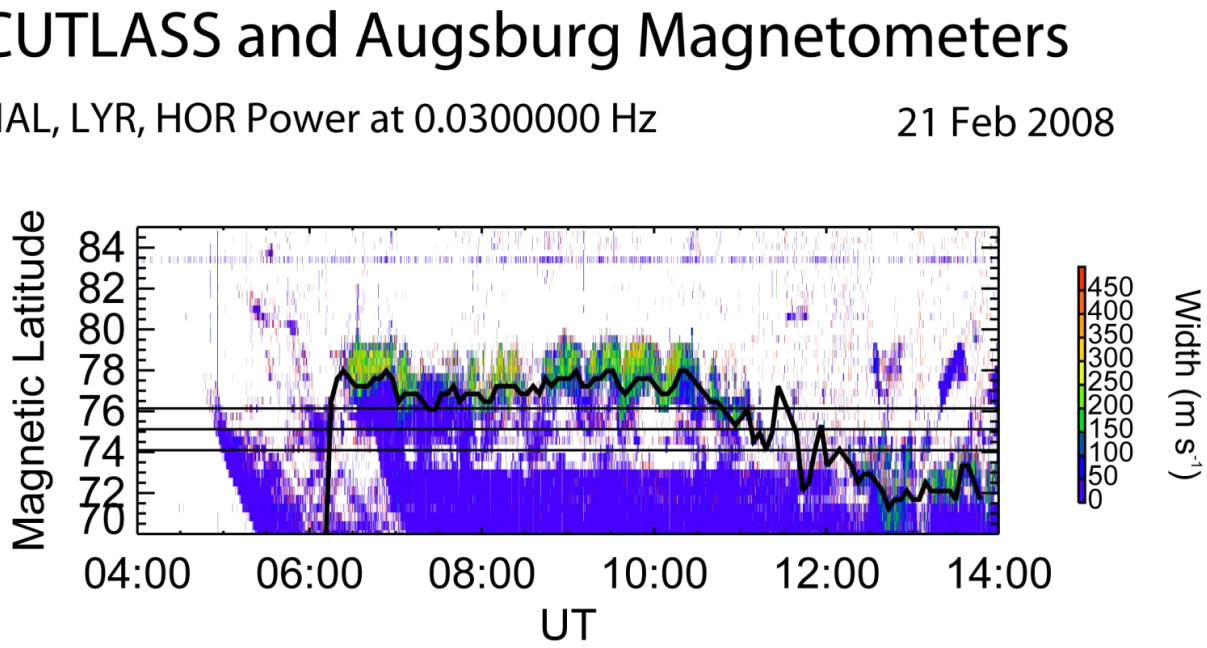

SUPERDARN PARAMETER PLOT
Hanksalmi: vel and width_l with KIL Pc1 Power
26 Oct 1999
(a)
Range gate
Velocity (ms-1)
(b)
Velocity (ms-1)
(increment = 100)
(c)
Range gate
Width (ms-1)
(d)
H Power
(e)
D Power
07:00
07:20
07:40
08:00
08:20
UT

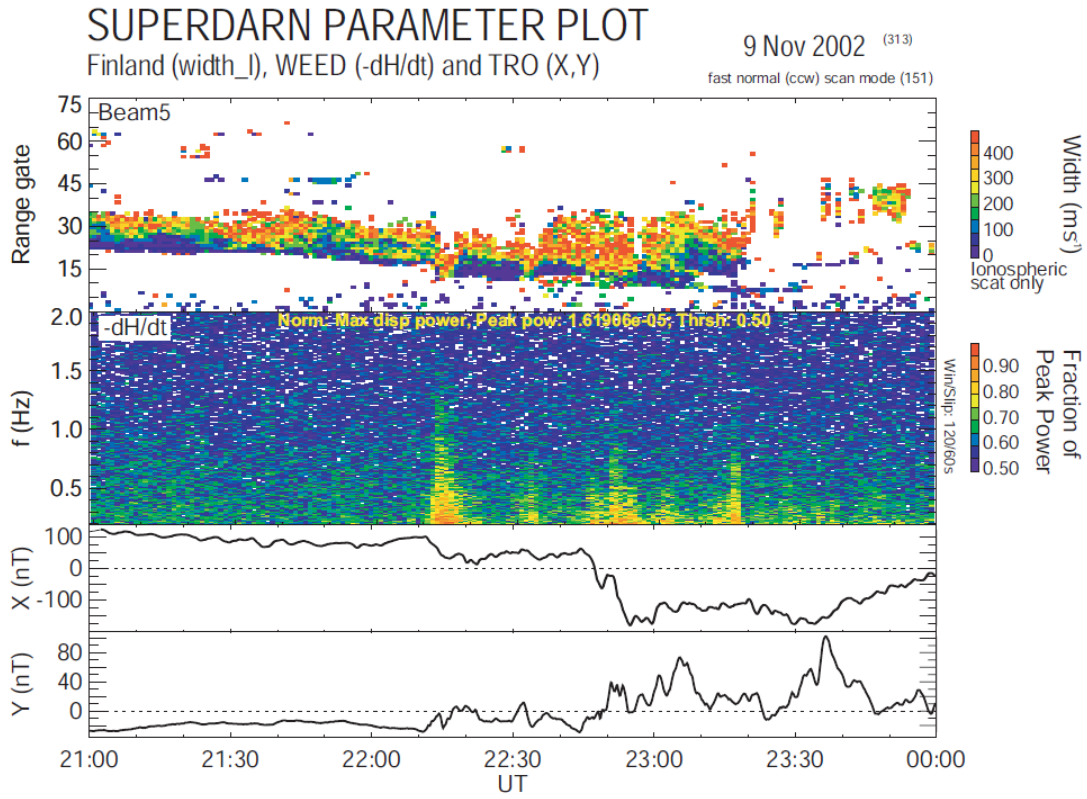



MAGNETOPAUSE
STORM-TIME
PLASMASPHERE
ENHANCED
EMIC WAVES
DRIFT PATH OF
RELATIVISTIC
ELECTRONS
PLASMAPAUSE
WHISTLER-MODE
CHORUS
RING CURRENT DRIFTS

3. SuperDARN data products

Spectral width: a diagnostic of overlying magnetospheric topology and wave activity





Wright et al., 2004