SuperDARN observations of storm-time plasma dynamics:
Ionospheric backscatter occurrence and convection response to Storm Sudden Commencement

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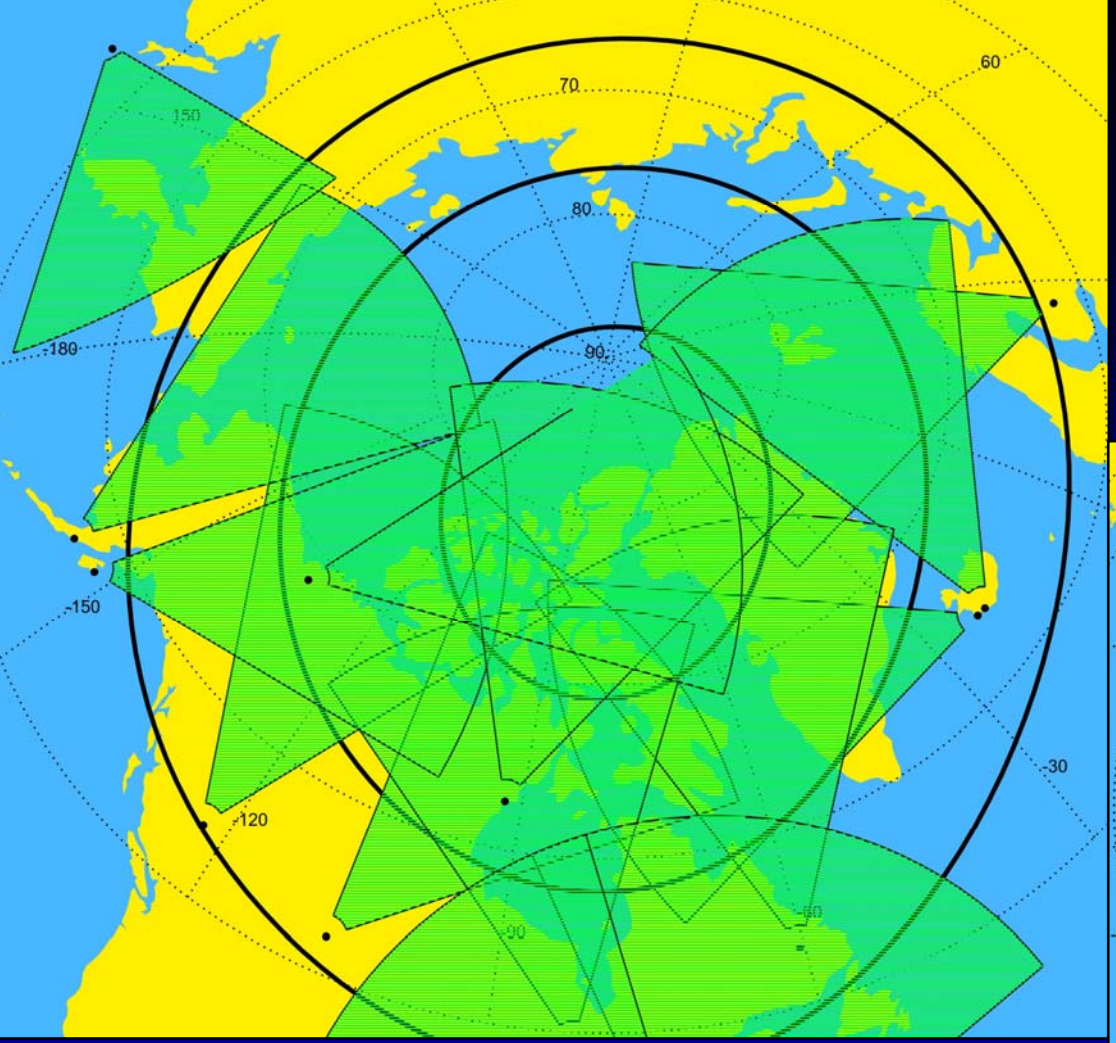
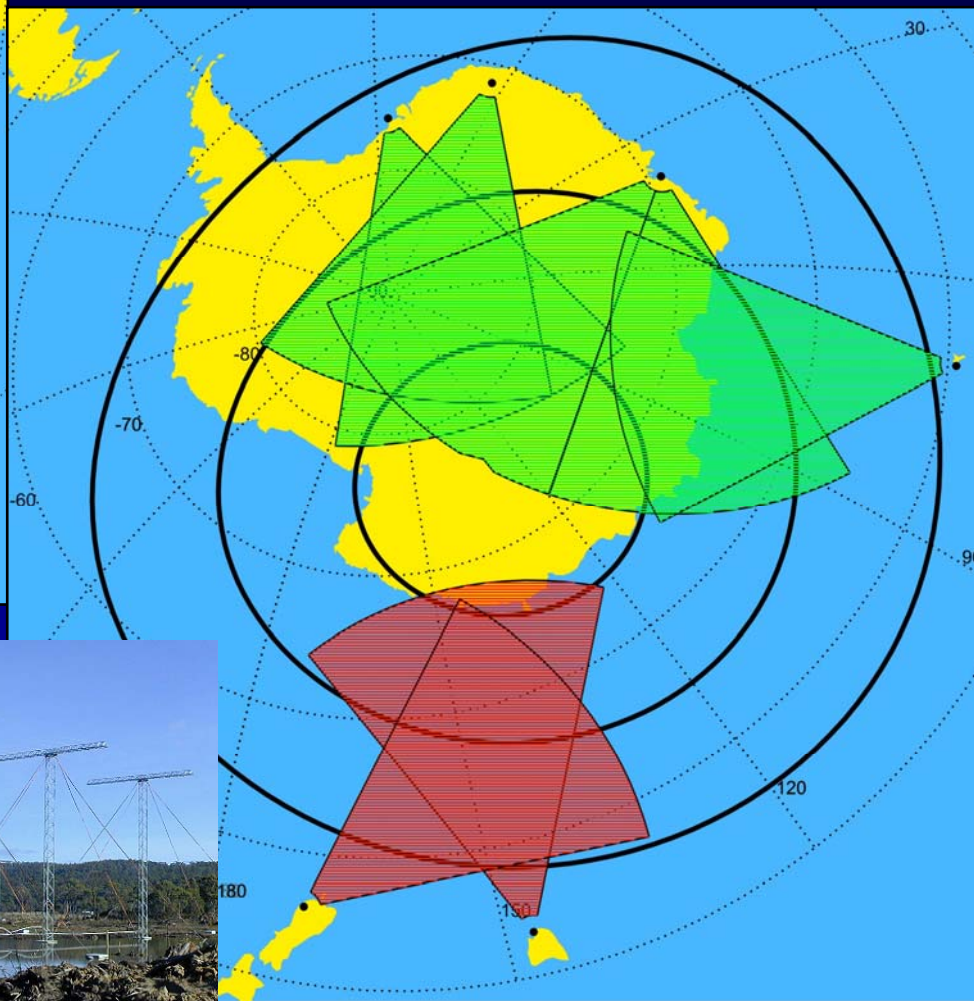
Abstract

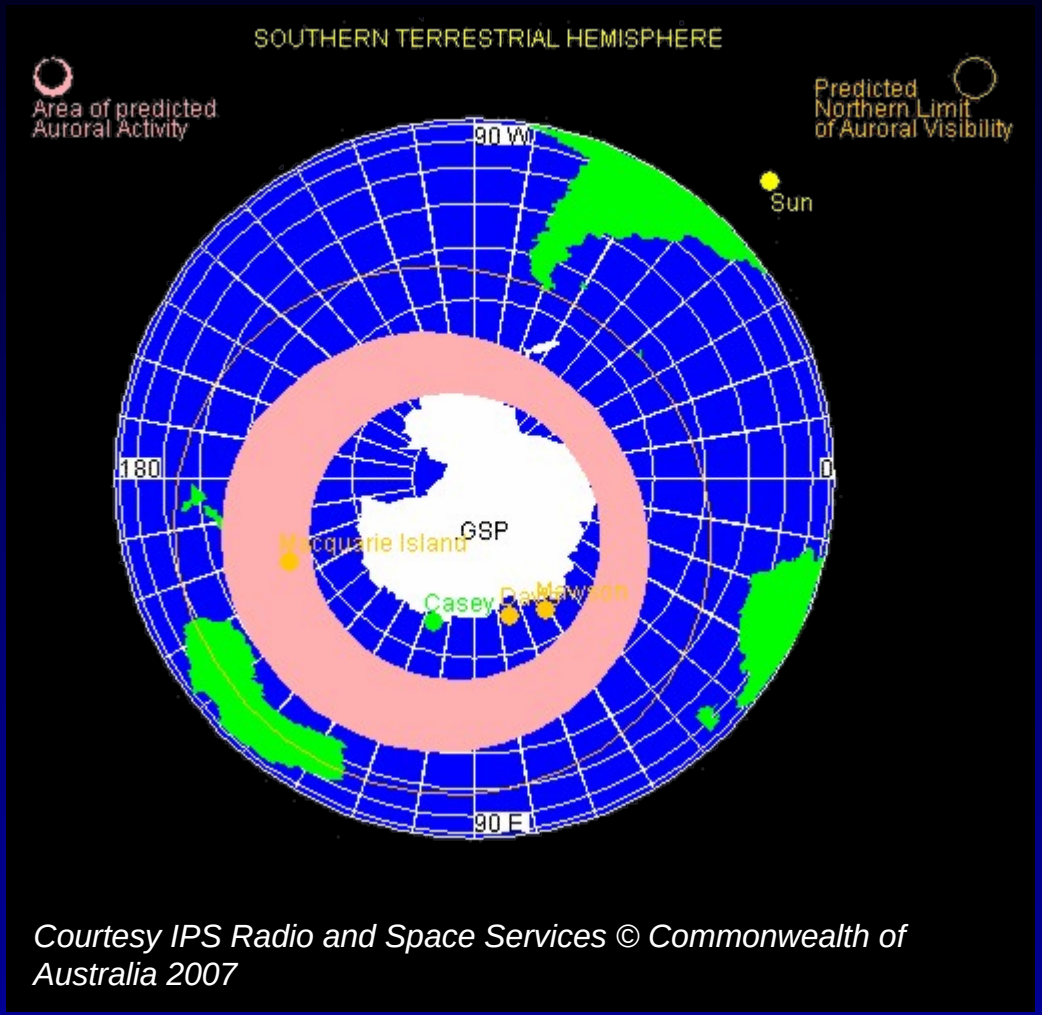
We present observations of the ionospheric echo occurrence and Doppler velocities during the periods of significant geomagnetic disturbances (Kp ≥ 7) in 2002-2006. The total numbers of ionospheric echoes are compared for all SuperDARN radars from which data were available. The comparisons are conducted for the occurrences throughout an entire storm event as well as for the occurrence time variations in 10-min intervals. It is shown that both exhibit large variability from event to event with the Kodiak, Hankasalmi, and Bruny Island radars performing reasonably well. The time variation of the plasma convection intensity near the Storm Sudden Commencement (SSC) is also investigated. It is demonstrated that the plasma convection intensity often peaks several hours after SSC with the peak occurring near the time when a sharp drop in the Dst index is observed.

TIGER and SuperDARN





Motivation and Objectives



Courtesy IPS Radio and Space Services © Commonwealth of Australia 2007

During geomagnetic storms the auroral oval expands equatorward with the HF radar backscatter often moving outside of the radars' viewing area in the F region

Auroral radars also often suffer from enhanced absorption and over-refraction during storms

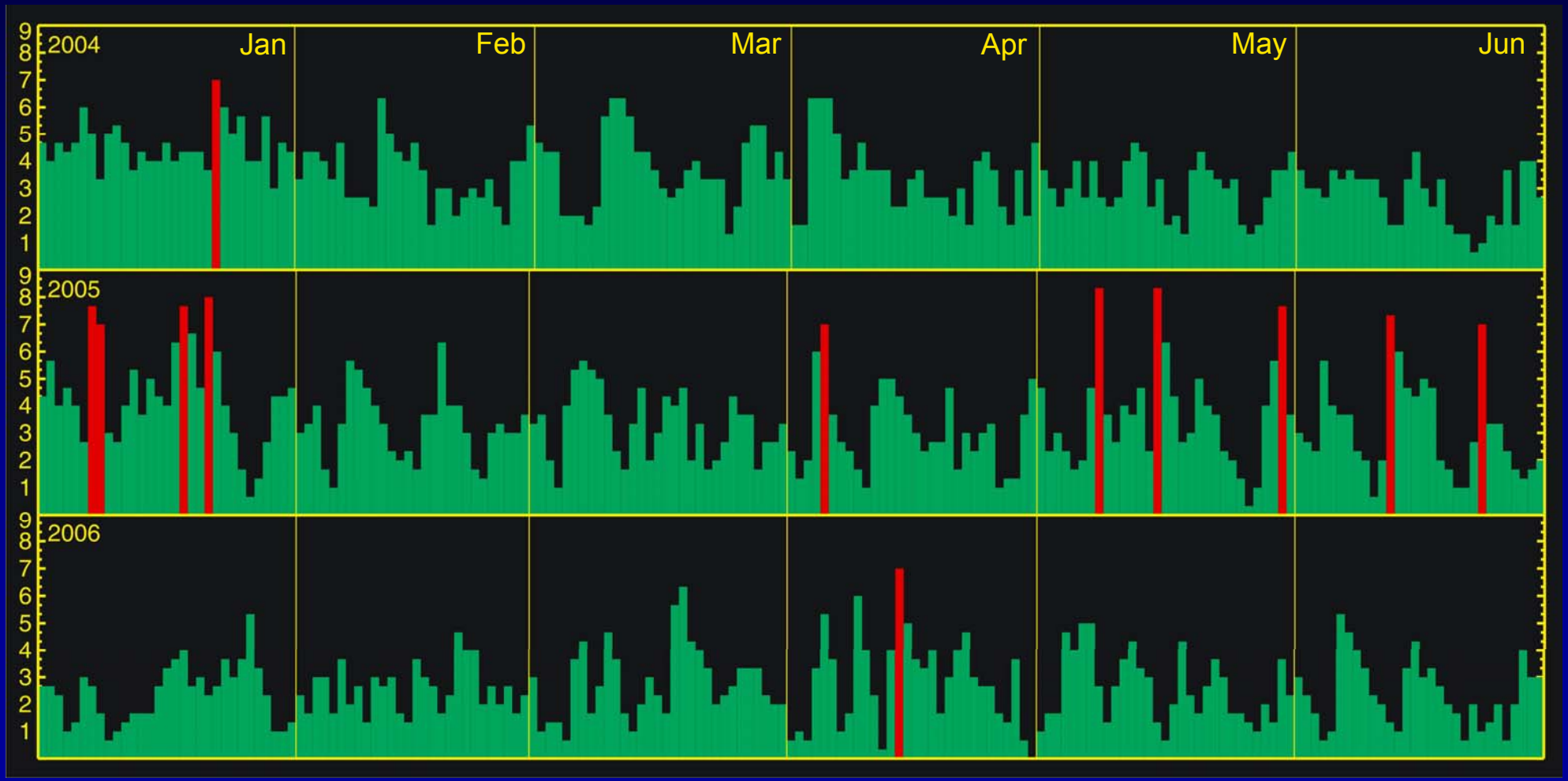
Plasma convection during storm conditions has been traditionally studied near magnetic equator and/or using low-orbit satellites

Aim 1: to analyze performance of the SuperDARN radars during storms

Aim 2: to investigate the plasma convection response to SSC

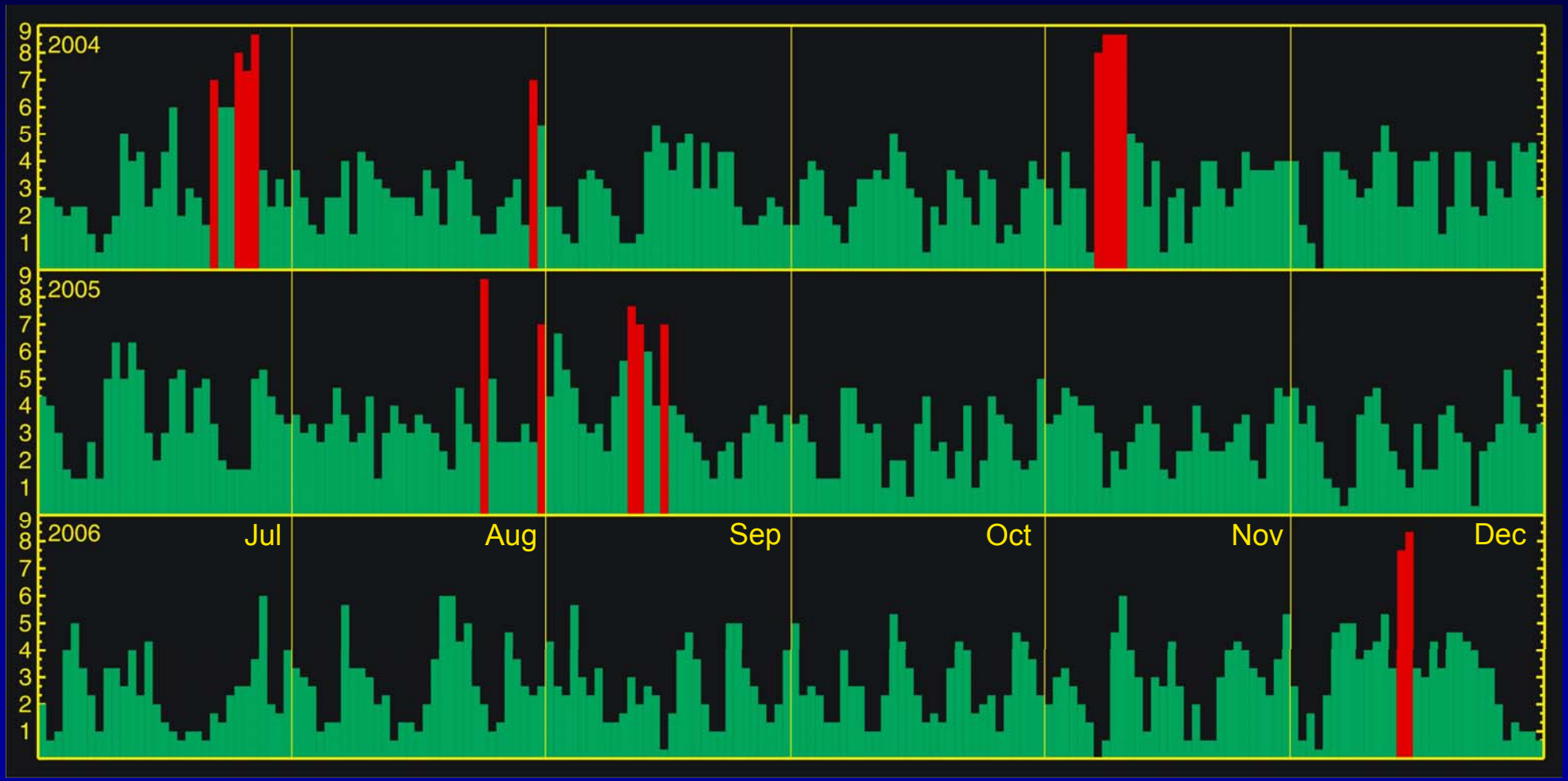
Kp: January – June, 2004-2006

The Kp shown are the maximum values of the Kp index for each day in January – June in 2004-2006. Days which have a maximum Kp ≥ 7 are highlighted in red

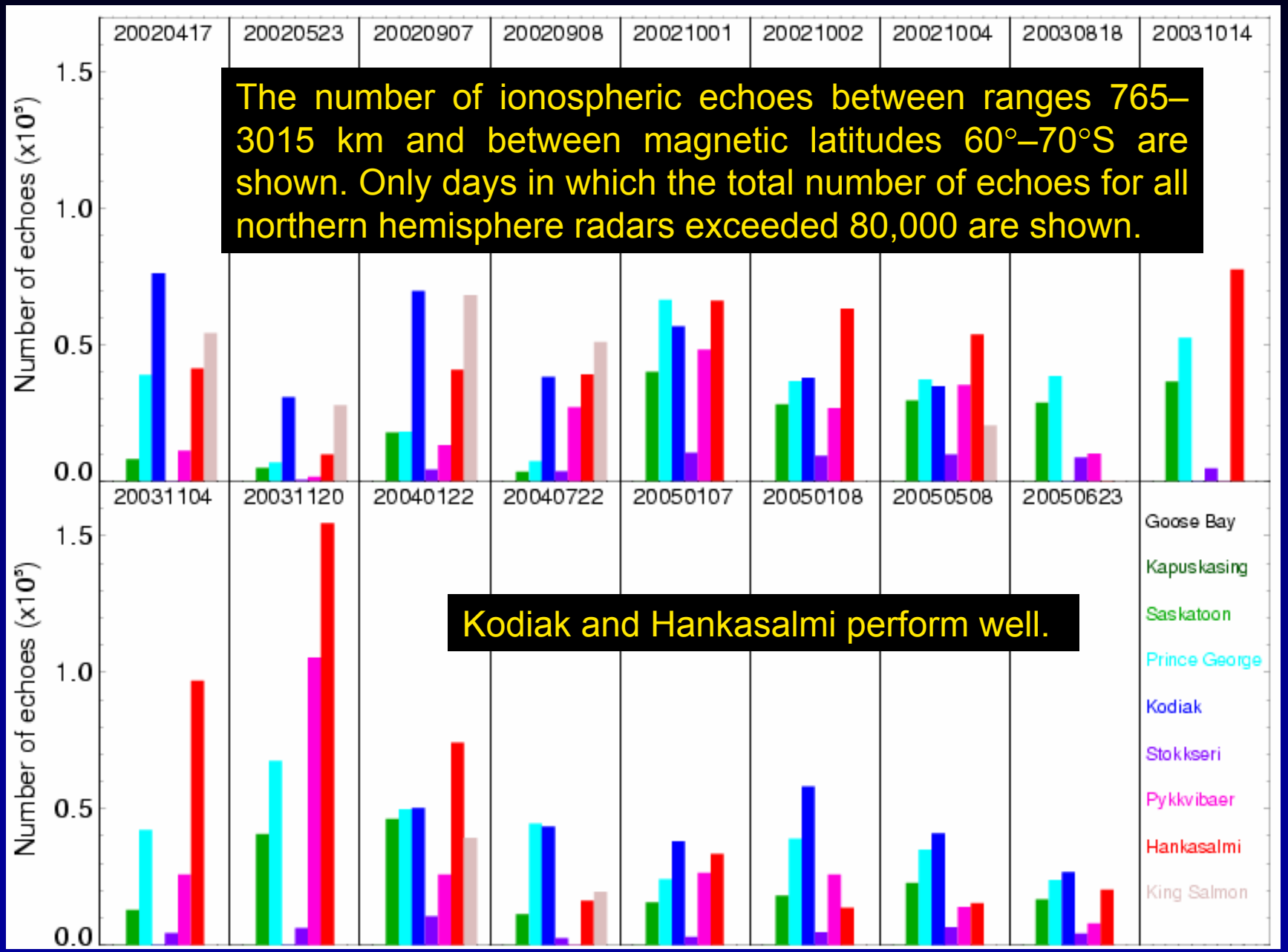


Kp: July – December, 2004-2006

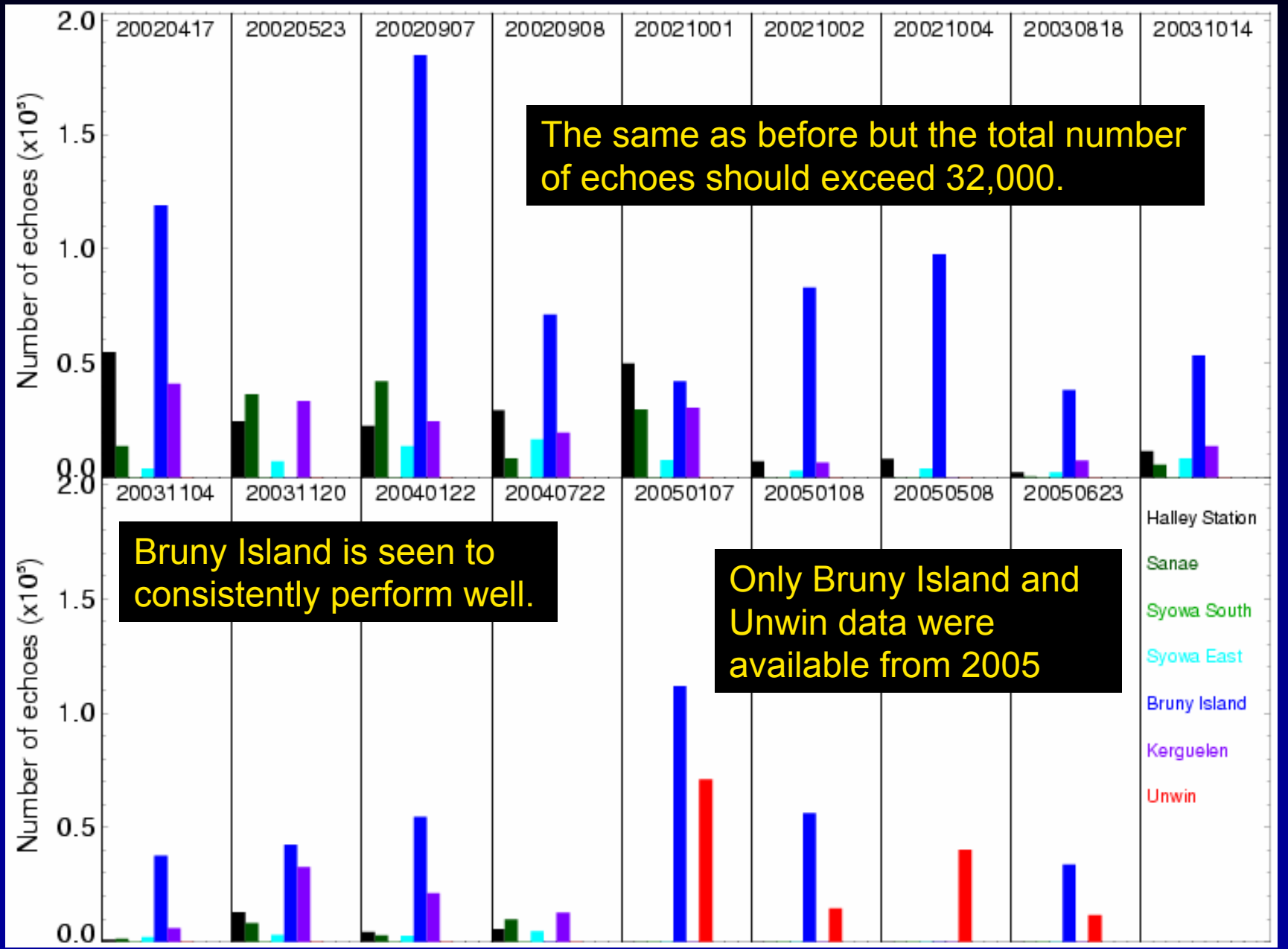
The same as before, but for July – December

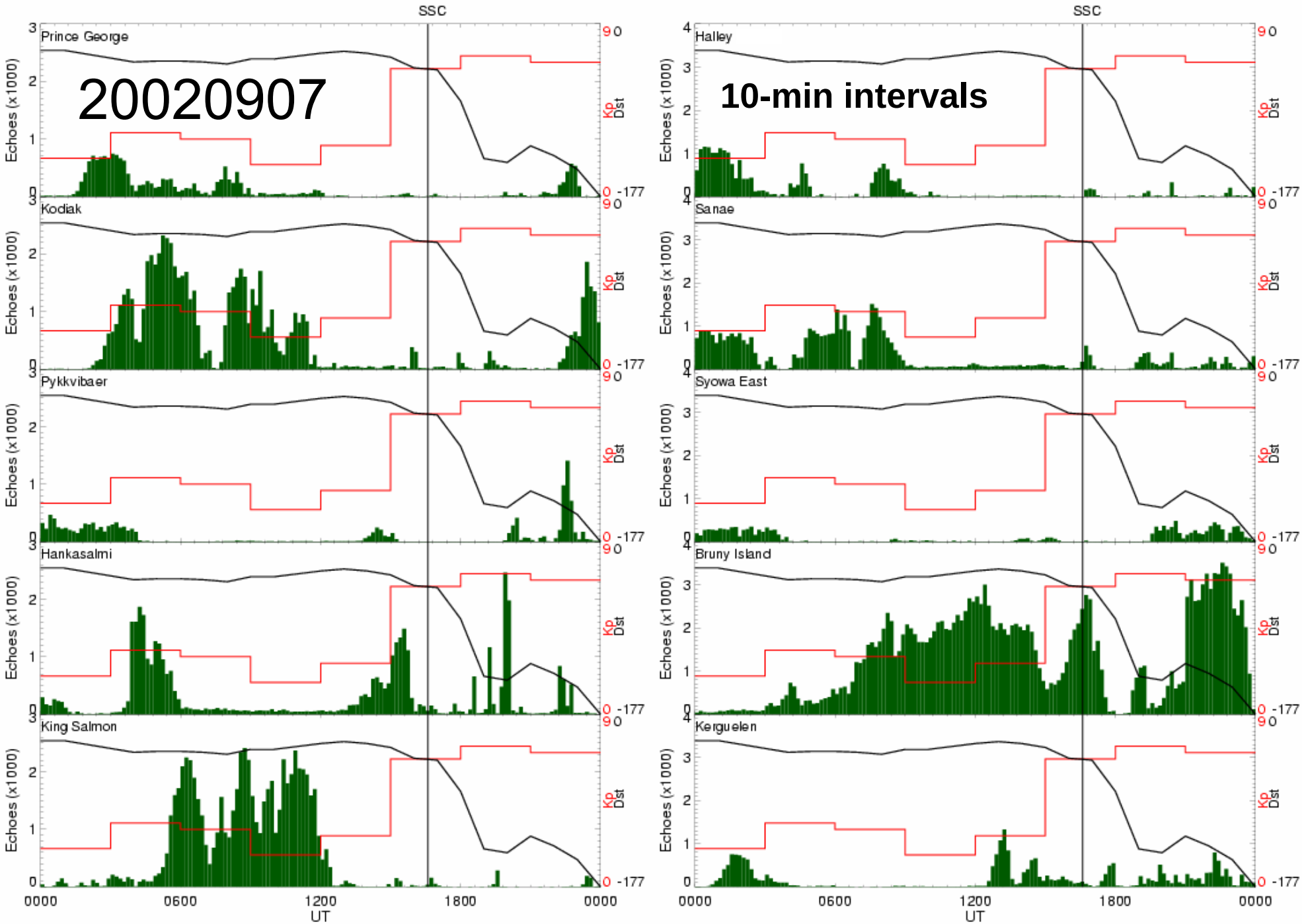


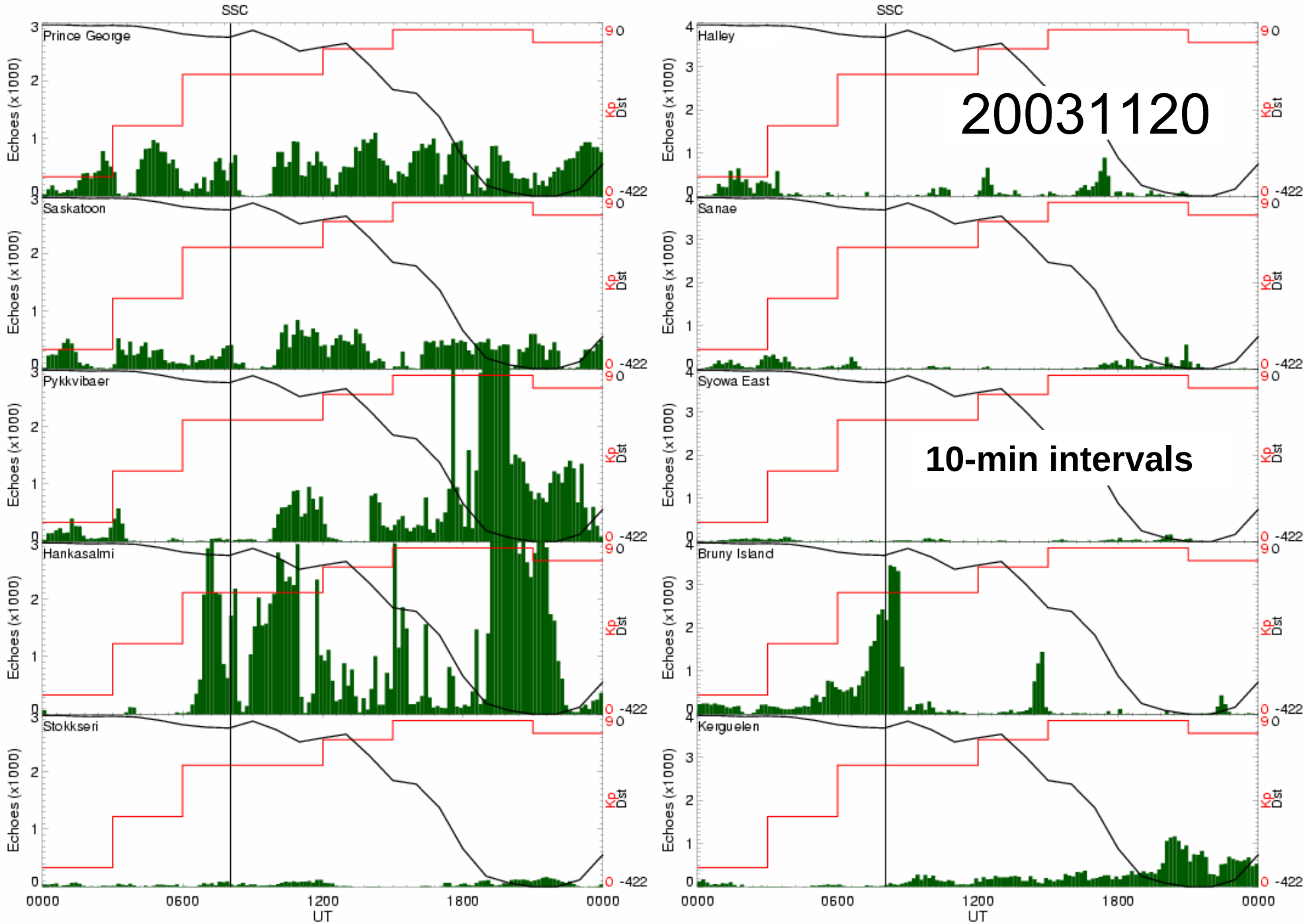
Storm-time echoes: Northern Hemisphere



Storm-time echoes: Southern Hemisphere

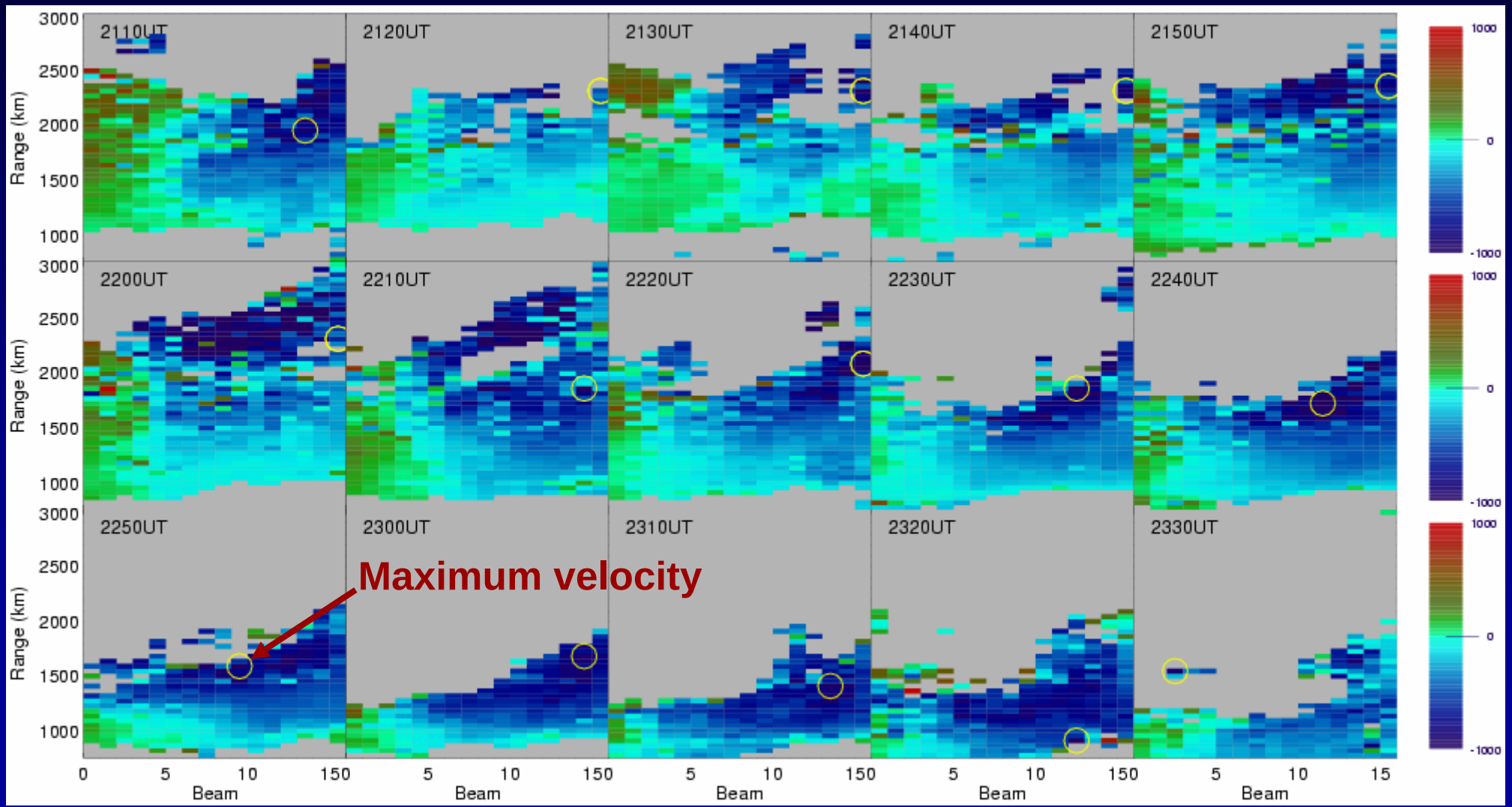



SSC
Prince George
20020907
Kodiak
Pykkvibaer
Hankasalmi
King Salmon
SSC
Halley
10-min intervals
Sanae
Syowa East
Bruny Island
Kerguelen
Echoes (x1000)
Kp
Dst
90
0
-177
0000
0600
1200
1800
UT


SSC
Prince George
Saskatoon
Pykkvibaer
Hankasalmi
Stokkseri
Halley
Sanae
Syowa East
Bruny Island
Kerguelen
Echoes (x1000)
Kp
Dst
0
-422
0000
0600
1200
1800
UT
20031120
10-min intervals

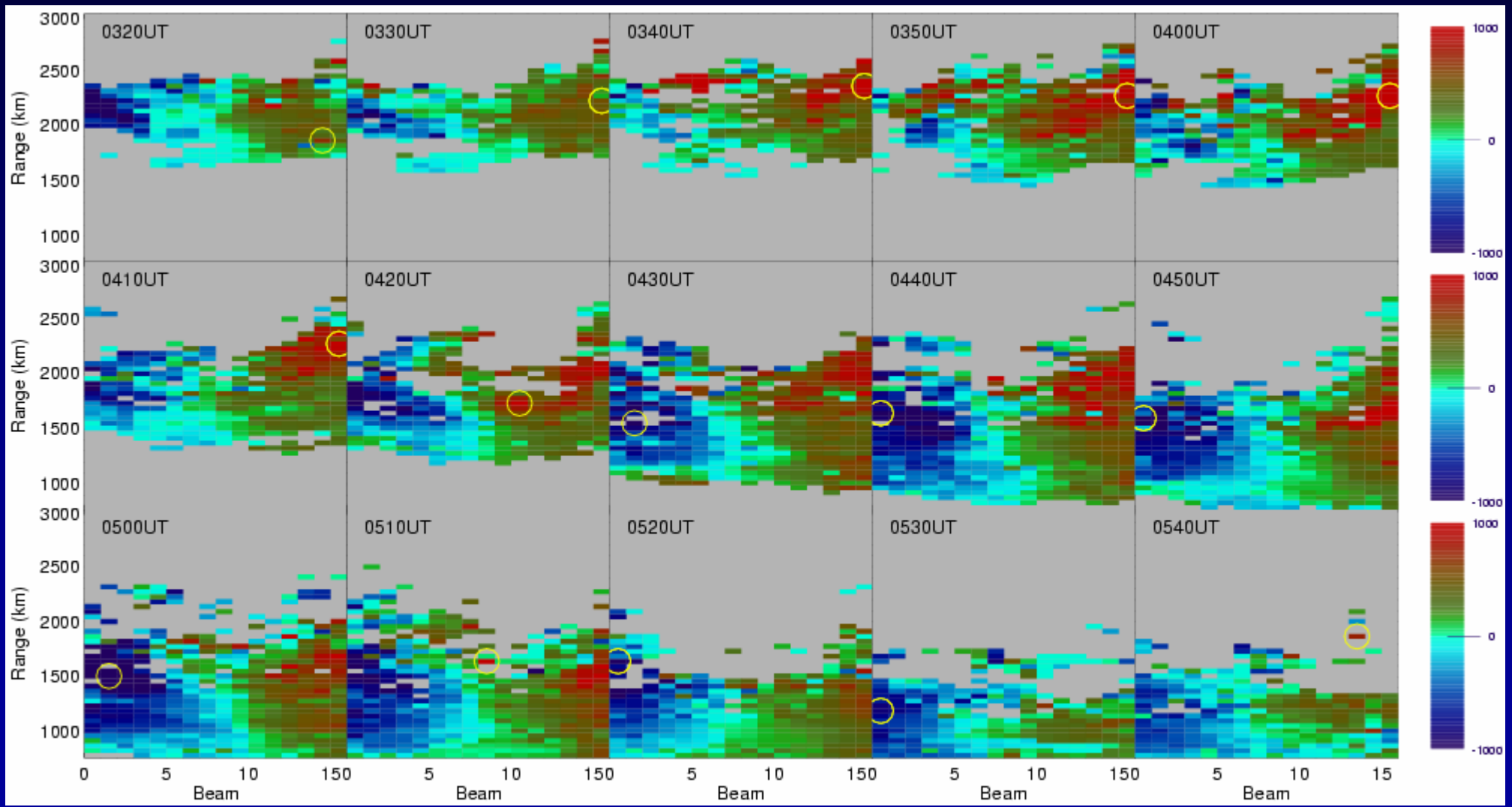
Bruny Island Velocities on 20020907

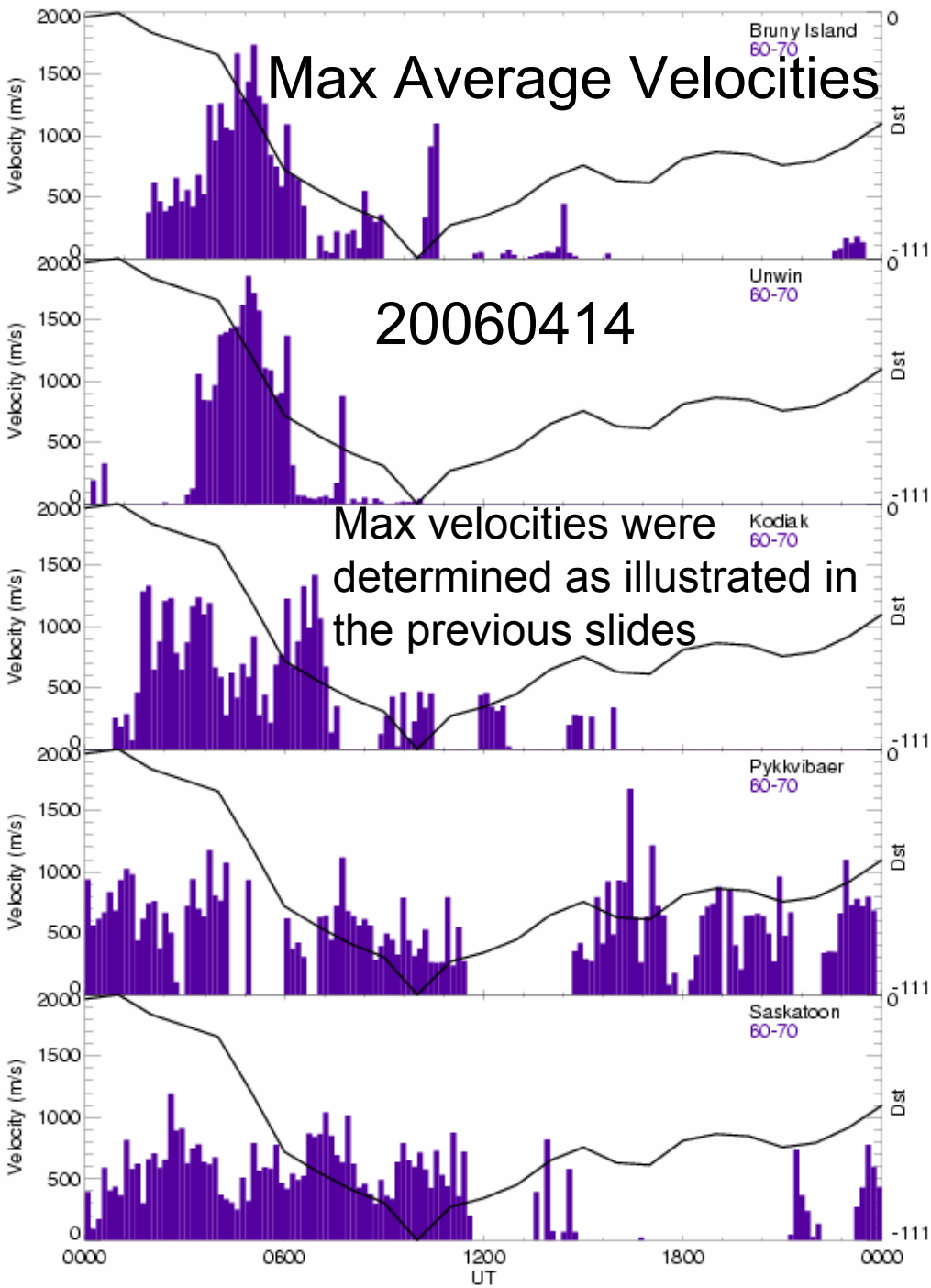
Shown are the 10-min range-beam plots colour-coded in average velocity. Values V > 2000 m/s were excluded from the averaging. Each cell required to contain 2 echoes and the neighbouring cells in range and beam required one echo.

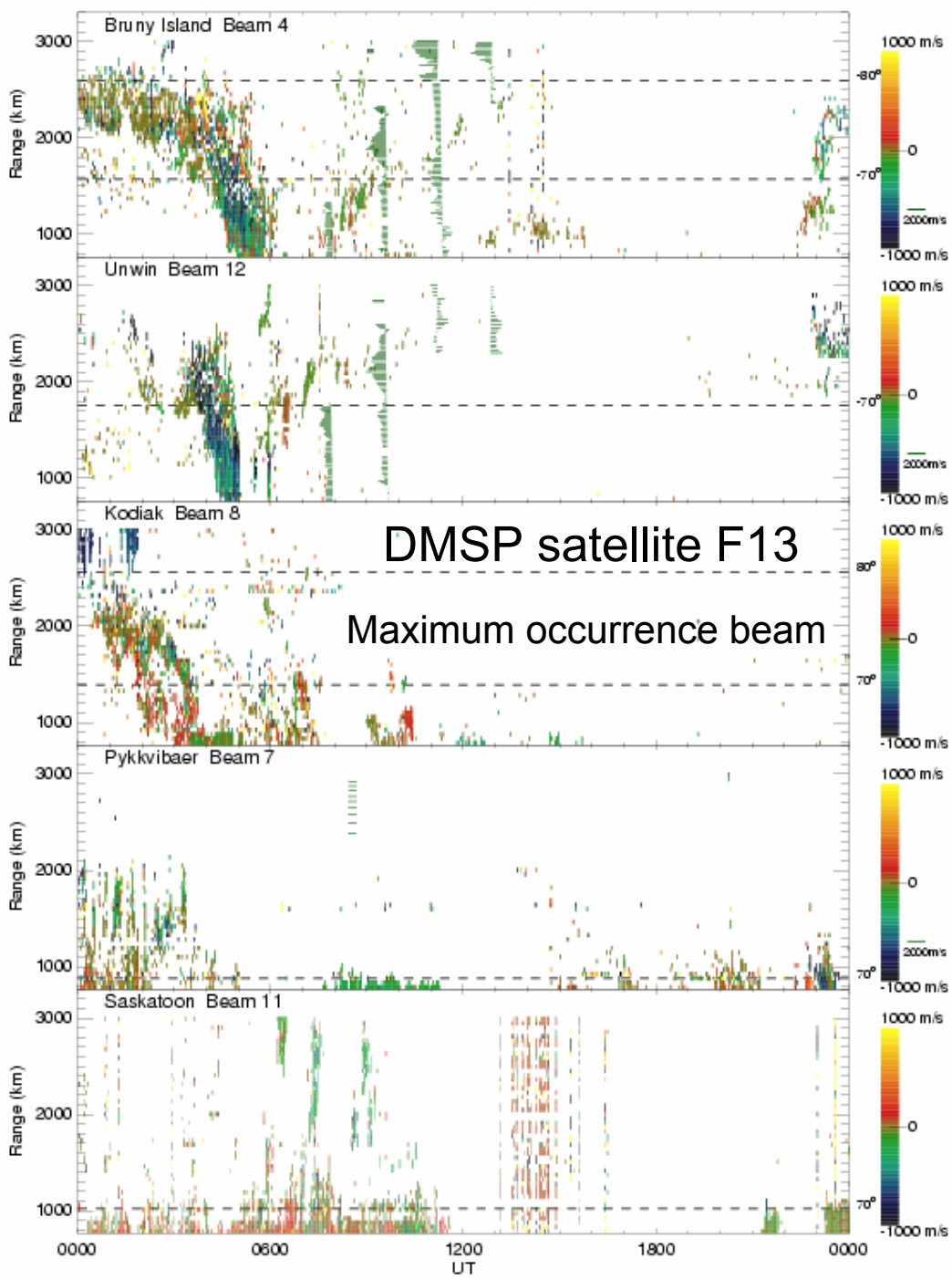


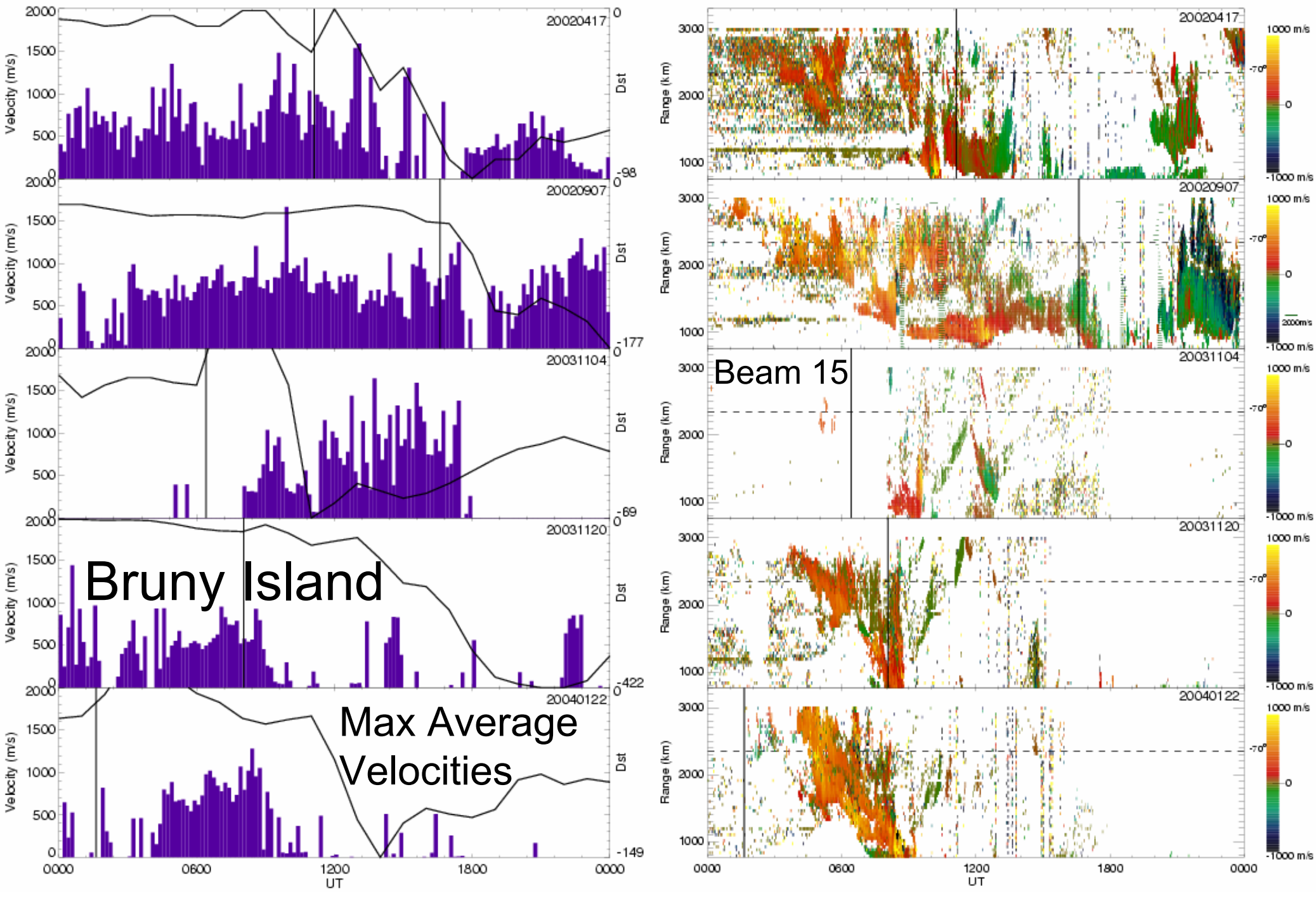
Bruny Island Velocities on 20060414

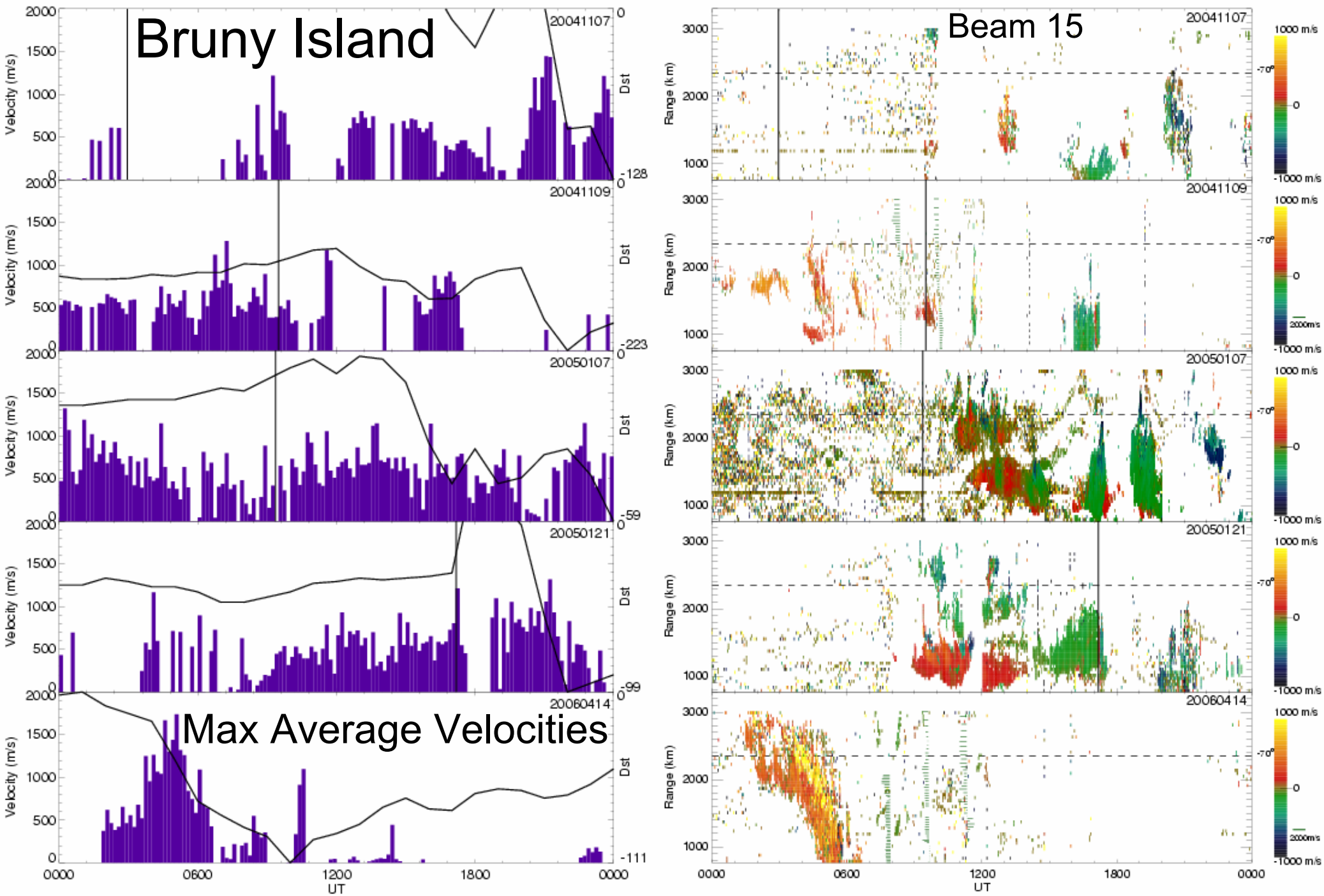
As before, but for 20060414




Max Average Velocities
20060414
Max velocities were determined as illustrated in the previous slides
Bruny Island
60-70
Unwin
60-70
Kodiak
60-70
Pykkvibaer
60-70
Saskatoon
60-70
Velocity (m/s)
Dst
UT
0000
0600
1200
1800
0000


DMSP satellite F13
Maximum occurrence beam
Bruny Island Beam 4
Unwin Beam 12
Kodiak Beam 8
Pykkvibaer Beam 7
Saskatoon Beam 11
Range (km)
1000 m/s
-1000 m/s
UT
0000
0600
1200
1800
0000


Bruny Island
Max Average Velocities
Beam 15
20020417
20020907
20031104
20031120
20040122
Velocity (m/s)
Range (km)
Dst
-98
-177
-69
-422
-149
UT
0000
0600
1200
1800
0000
1000 m/s
-1000 m/s


Bruny Island
Beam 15
Max Average Velocities
20041107
20041109
20050107
20050121
20060414
Velocity (m/s)
Range (km)
Dst
UT
0000
0600
1200
1800
0000
1000 m/s
-1000 m/s
-70°
0
2000m/s

Summary and Conclusions

- The total numbers of echoes were compared for several storms events. Kodiak, Hankasalmi, and Bruny Island radars were seen to generally perform well
- Analysis of occurrence variation near SSC at 10-min resolution showed that occurrence often droped significantly before SSC when Kp index starts to increase. For some radars, it was also seen to recover a few hours after SSC around the time when Dst index was at minimum. The Bruny Island radar appeared to perform well during storms
- The convection velocity was estimated from the maximum velocity in the field-of-view
- Some intensification in convection was seen several hours after SSC near a sharp drop in Dst