Introduction to the Resolute Bay Incoherent Scatter Radars (RISR)

RISR Quick Facts

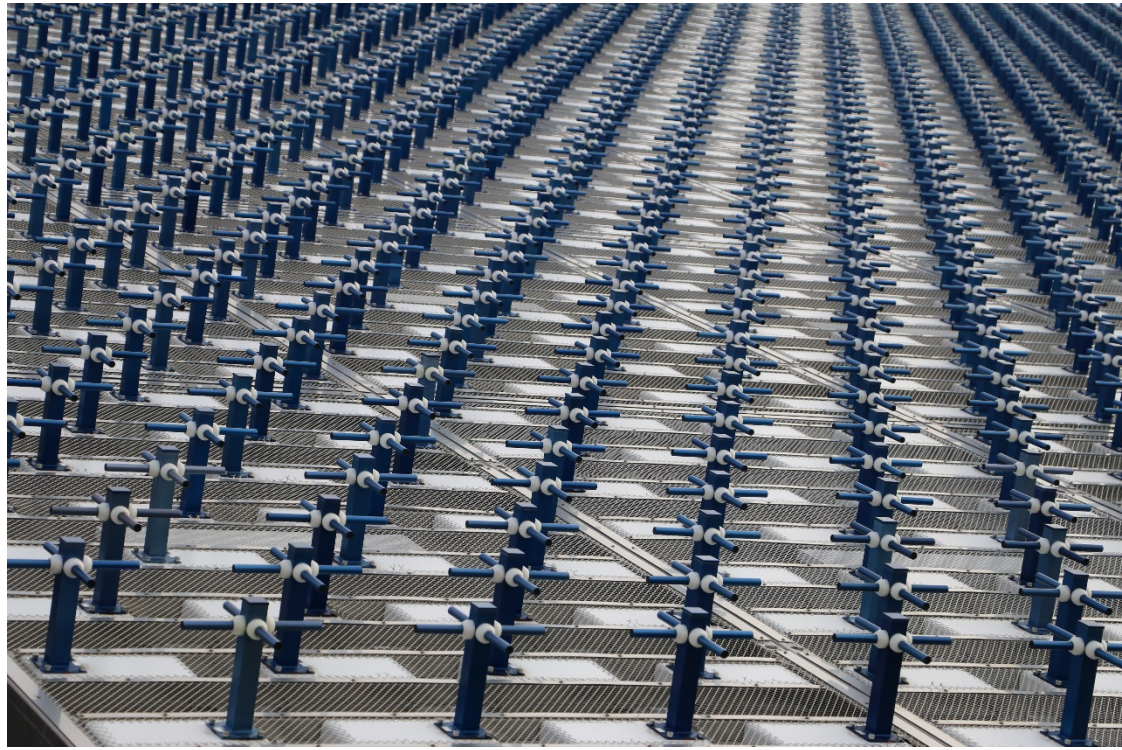
Location	
Geographic	74.72955°, -94.90576°, 145 m Altitude
Corrected Geomagnetic	82.43° N, -34.34°
Solar Local Time	SLT = UT - 6
Magnetic Local Time	MLT = UT - 7

Important Look Directions	RISR-N	RISR-C
Boresight	26.0° az, 55.0° el	-157.0° az, 55.0° el
Most Sensitive Beam	26.0° az, 67.0° el	-157.0° az, 67.0° el
Lowest Elevation	16°	16°
Highest Elevation	90° (vertical)	90° (vertical)
Up-B	N/A	169.09° az, 86.41° el
Common Volume	90° (vertical)	90° (vertical)

Hardware	RISR-N	RISR-C
Panels	121	121
Antenna Element Units	3872	3872
Usual Transmit Frequencies	441.9-443.9 MHz	441.9-443.9 MHz
Number of Receive Channels	4	4

AMISR background:

- An Incoherent Scatter Radar (ISR) measures ionospheric parameters at several ranges along a given beam direction:
  - Electron density N_e
  - Ion temperature T_i
  - Electron temperature T_e
  - Line-of-sight velocity V_{los}
- An Advanced Modular Incoherent Scatter Radar (AMISR), such as RISR-N and RISR-C (Resolute ISR-North/Canada), uses a phased array of many antenna element units (AEUs) to transmit and receive along multiple beam directions nearly simultaneously



AEUs on RISR-C face

AEUs:

- Antenna Element Unit
- Basic transmitter/receiver
- Can produce 500 W
- Beam table is programmed into each AEU
- Both transmit and receive signals are phase shifted based on input beam code (at AEU level)
- Beam forming occurs on a pulse-to-pulse basis
- RISR-N and RISR-C have 3872 AEUs each

Panels:

- Collection of 32 AEUs
- Smallest unit that can be independently operated
- RISR-N and RISR-C have 121 panels each

Main Generator:

- 1-MW diesel generator
- Supplies power to both RISR-C and RISR-N
- Running both radars at 10% duty cycle causes >90% load on generator and overheating
- Typically, ~6% duty cycle is used when both radars are operating

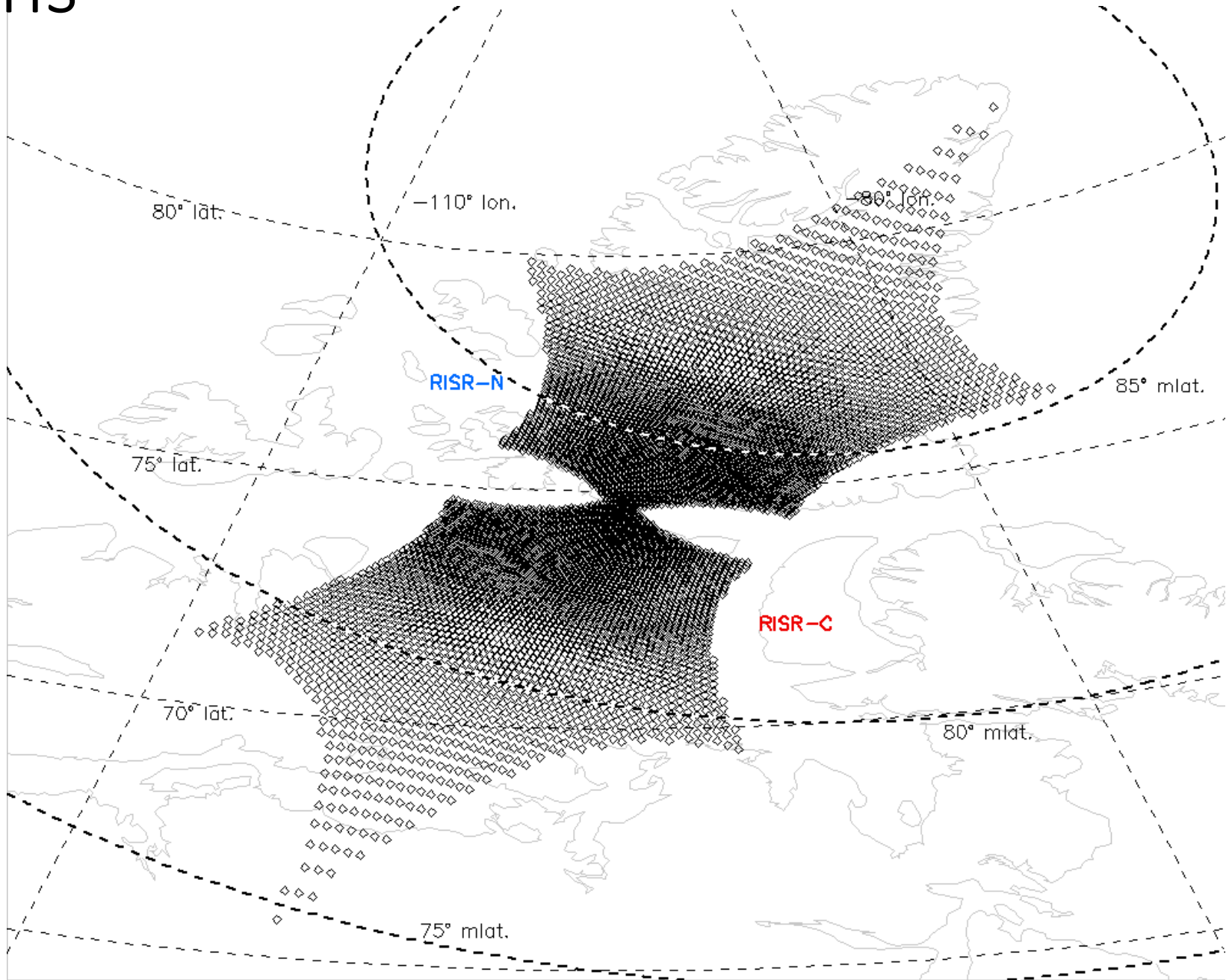
OCC:

- Operations and Command Center
- Building in which controlling computers/instrumentation are housed
- At Resolute, OCC also contains other instruments
- Building has facilities for one person to stay overnight

All beam positions

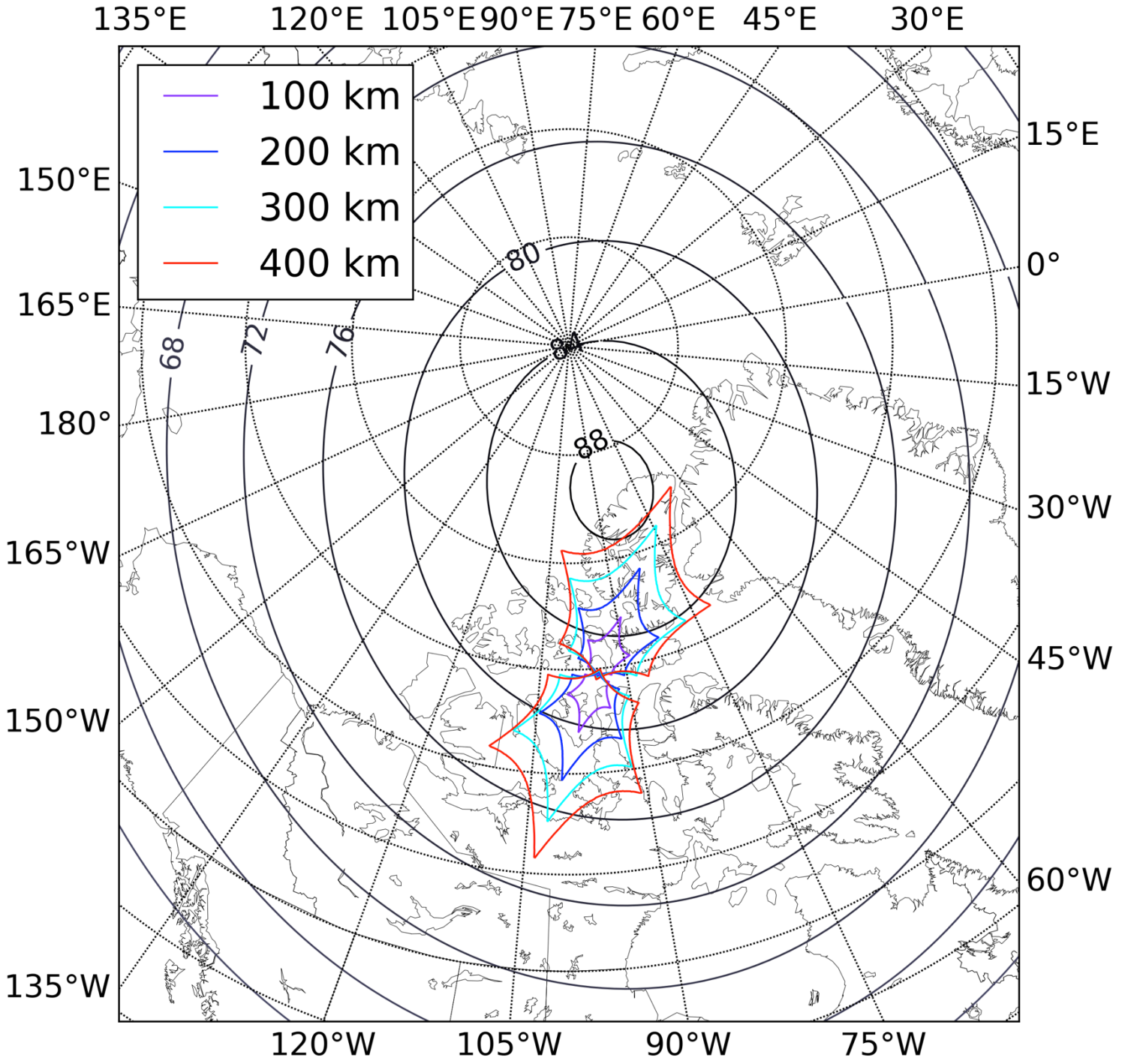
-all possible beams for both radars

-300 km pierce points plotted



Fields of View at Different Altitudes

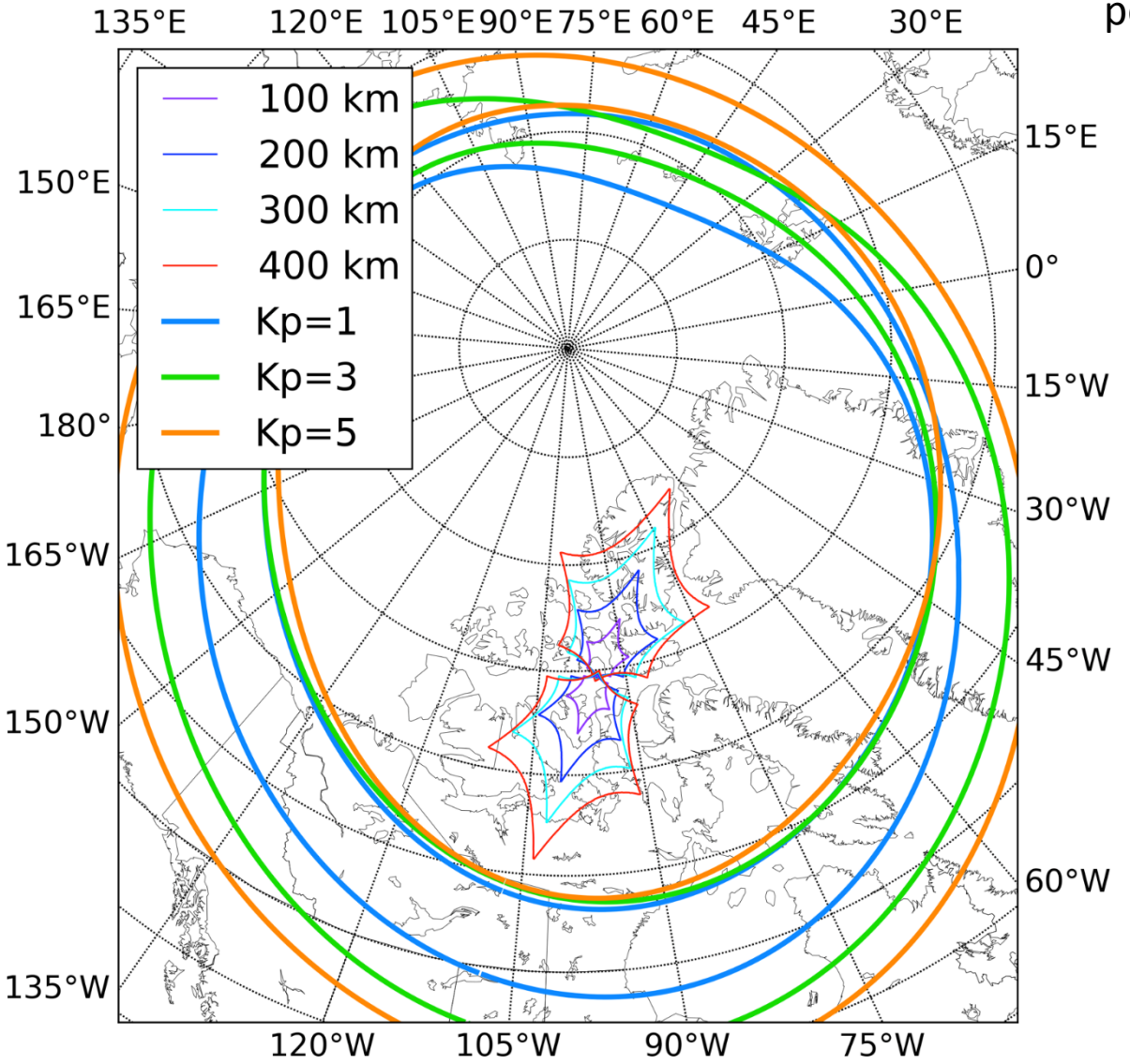
- The solid contours show corrected geomagnetic latitude.
- Resolute Bay is lower in geographic latitude but higher in geomagnetic latitude than Svalbard, making it the highest magnetic latitude ISR station in the world.



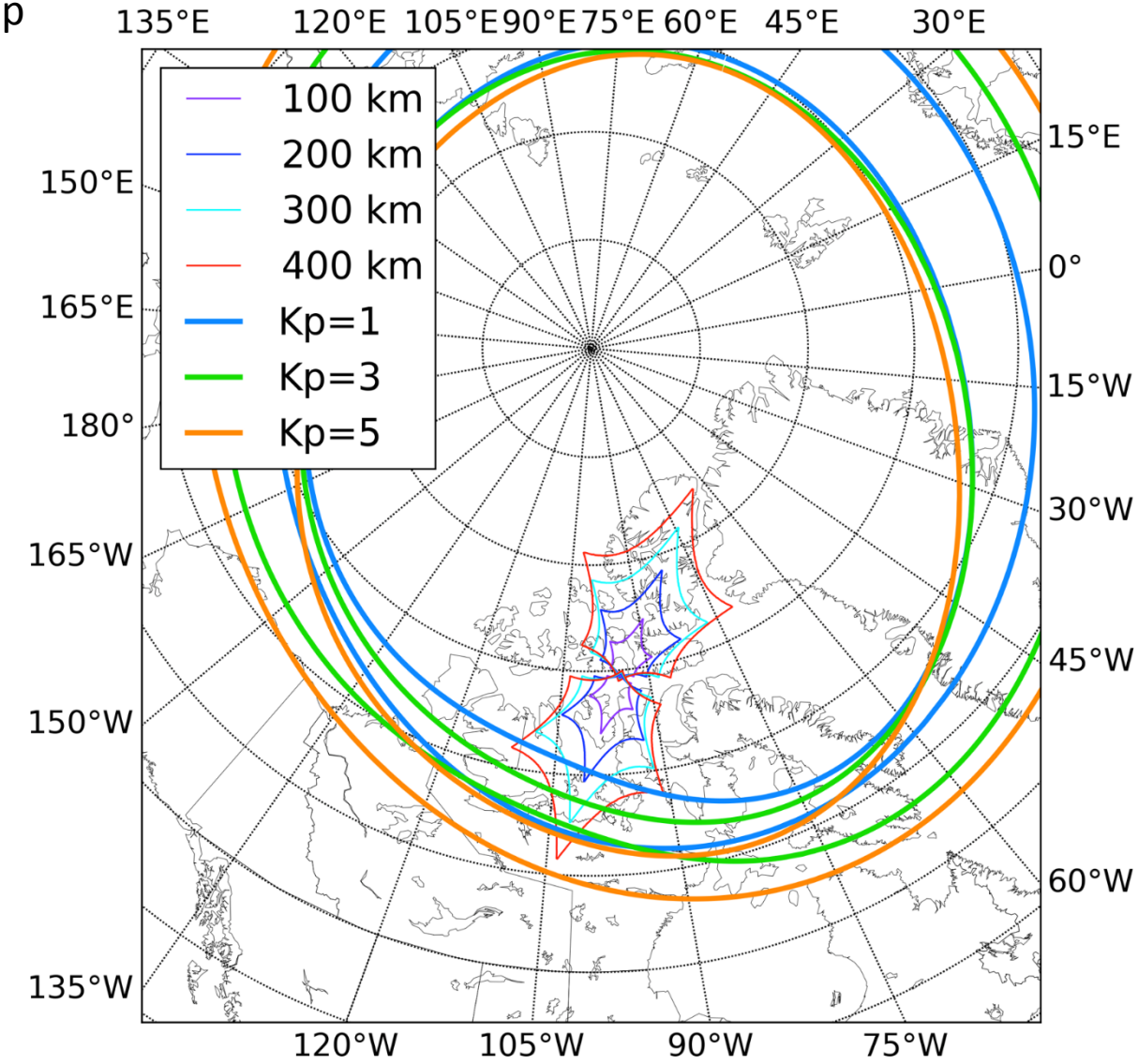
Position Relative to the Feldstein Oval

RISR is usually deep in the polar cap

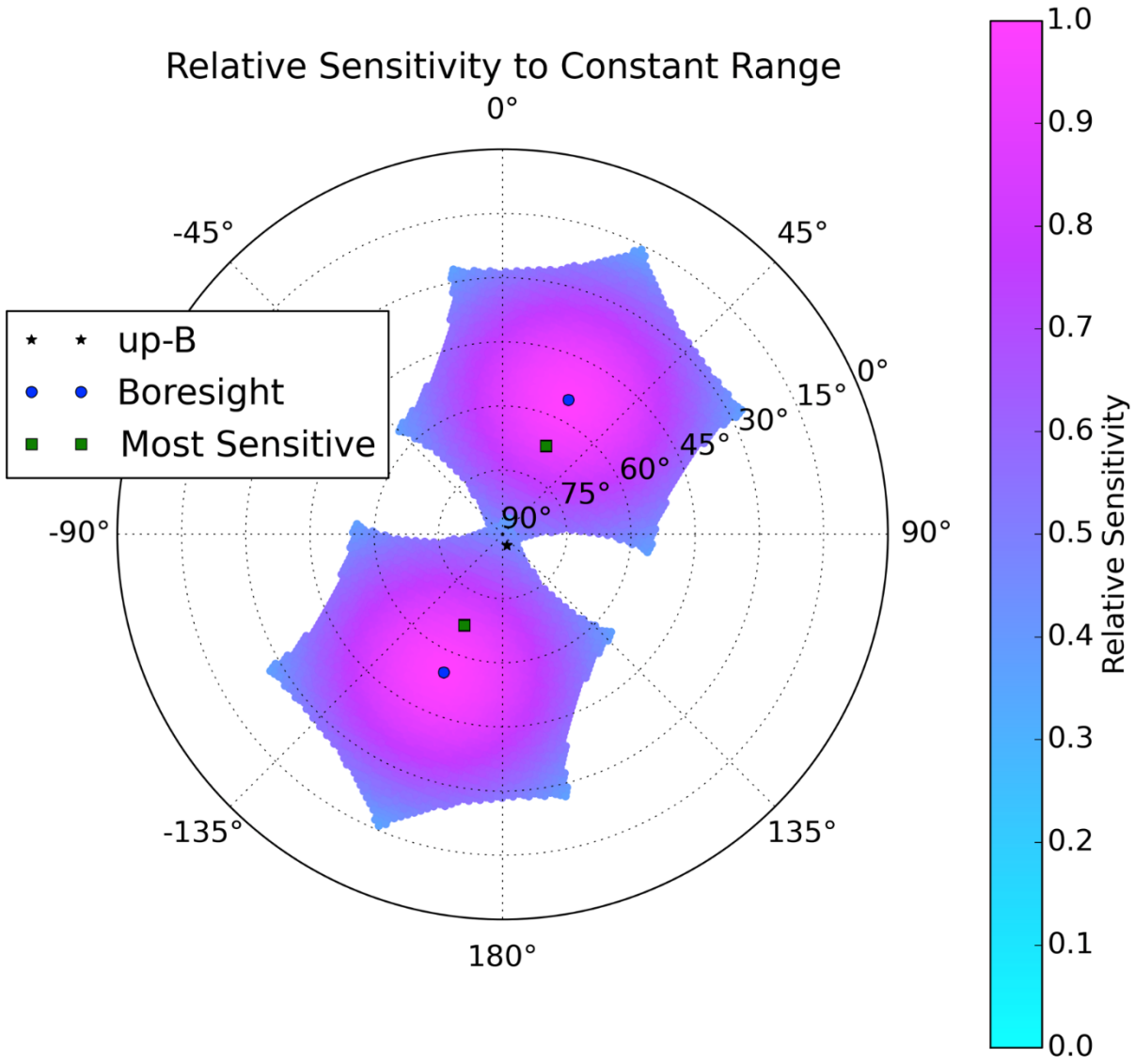
Midnight

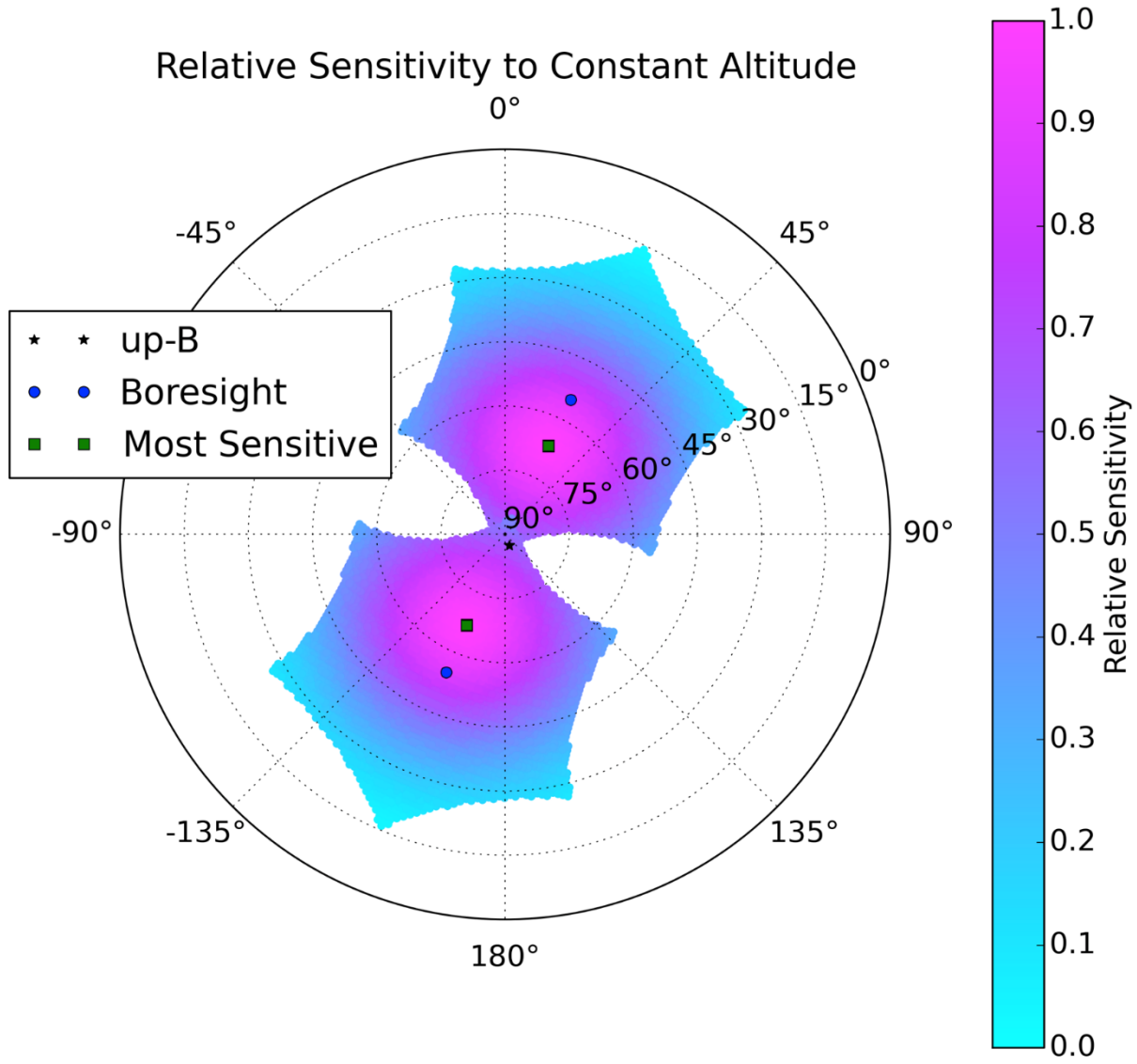


Noon



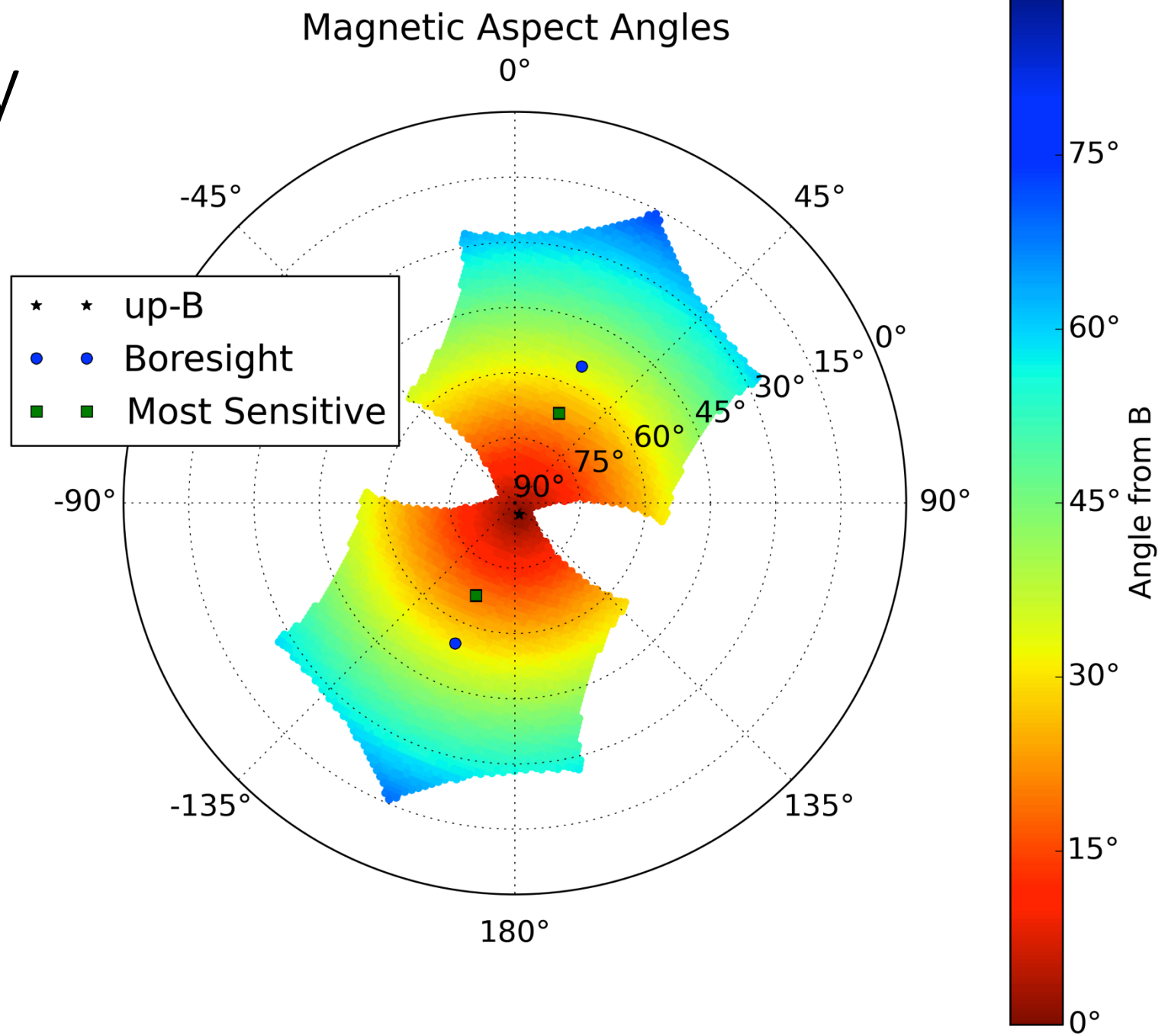
Array Sensitivity as a Function of Beam Position





Magnetic Geometry

- The B field over Resolute is nearly vertical, although not exactly.
- The parallel to B direction (up-B) is slightly SSE of vertical.
- The up-B direction is just outside the RISR-N field of view, but inside the RISR-C field of view.

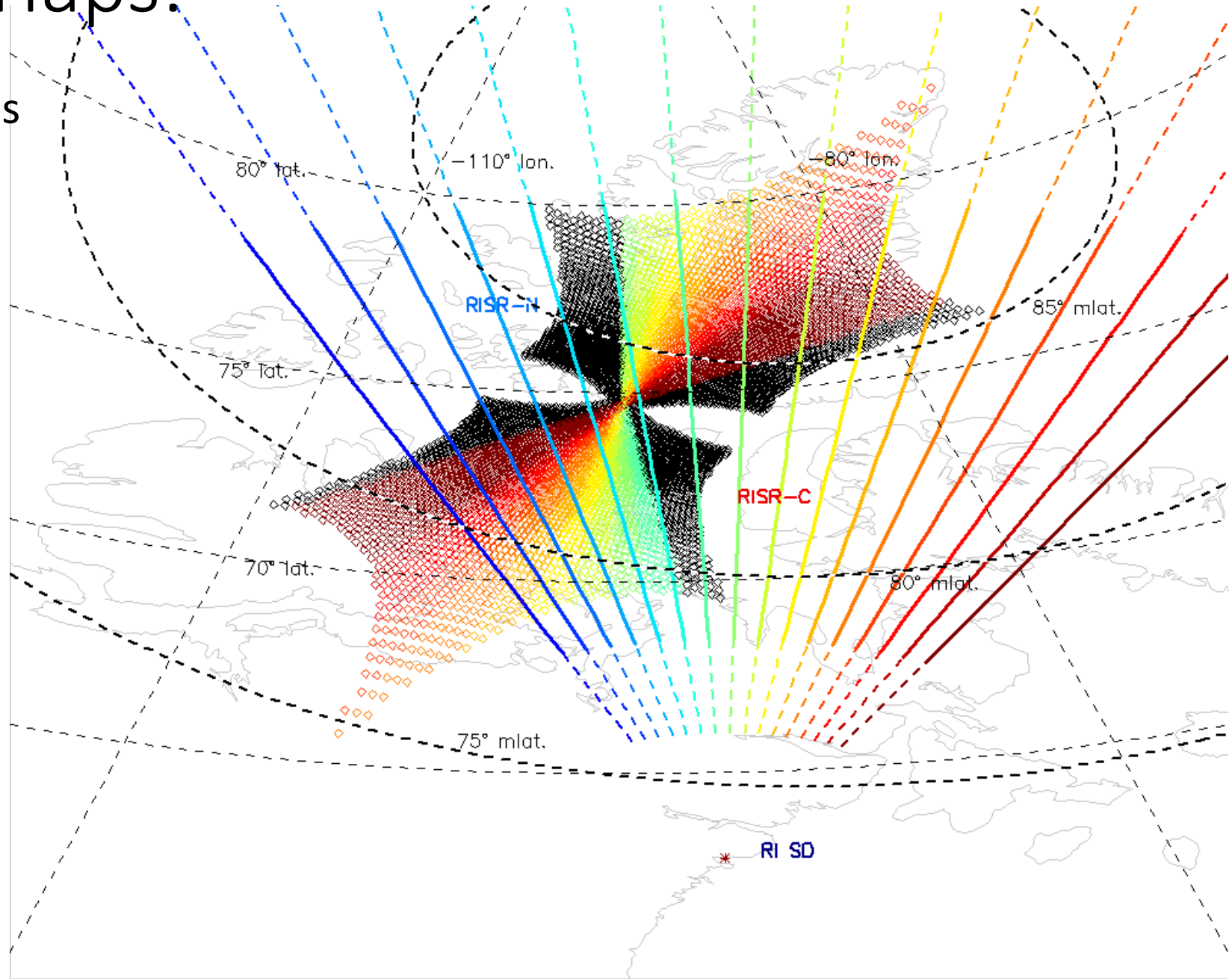


SuperDARN overlaps:

-Rankin Inlet and RISR beams

-Solid portions of beams -- RI range gates 10-40 (630-1980 km)

-colors on RISR beams show azimuth within +/- 10 degrees of RI beam of same color

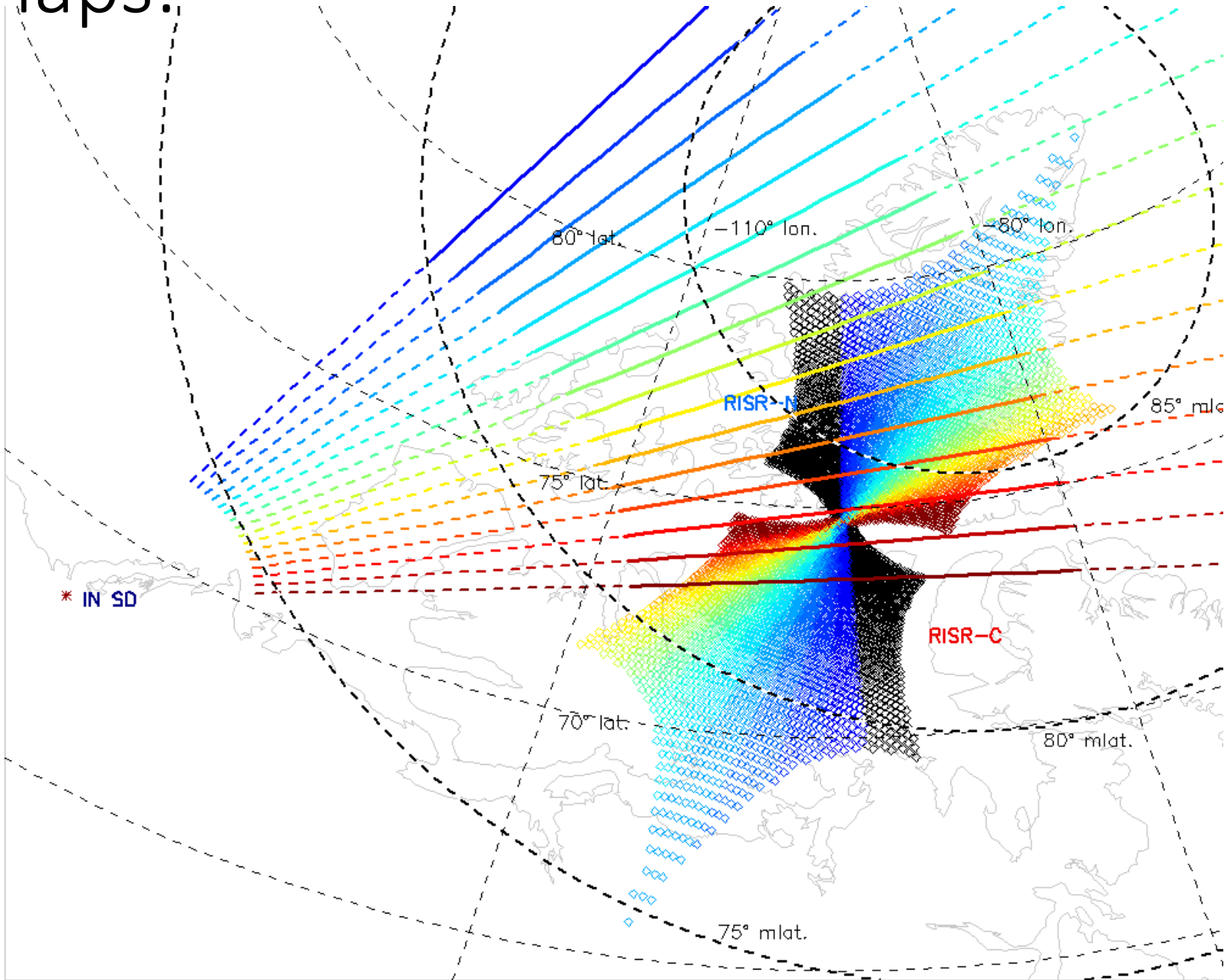


SuperDARN overlaps:

-Inuvik and RISR beams

-Solid portions of beams -- Inuvik ranges 20-40 (1080-1980 km)

-colors on RISR beams show azimuth within +/- 10 degrees of Inuvik beam of same color

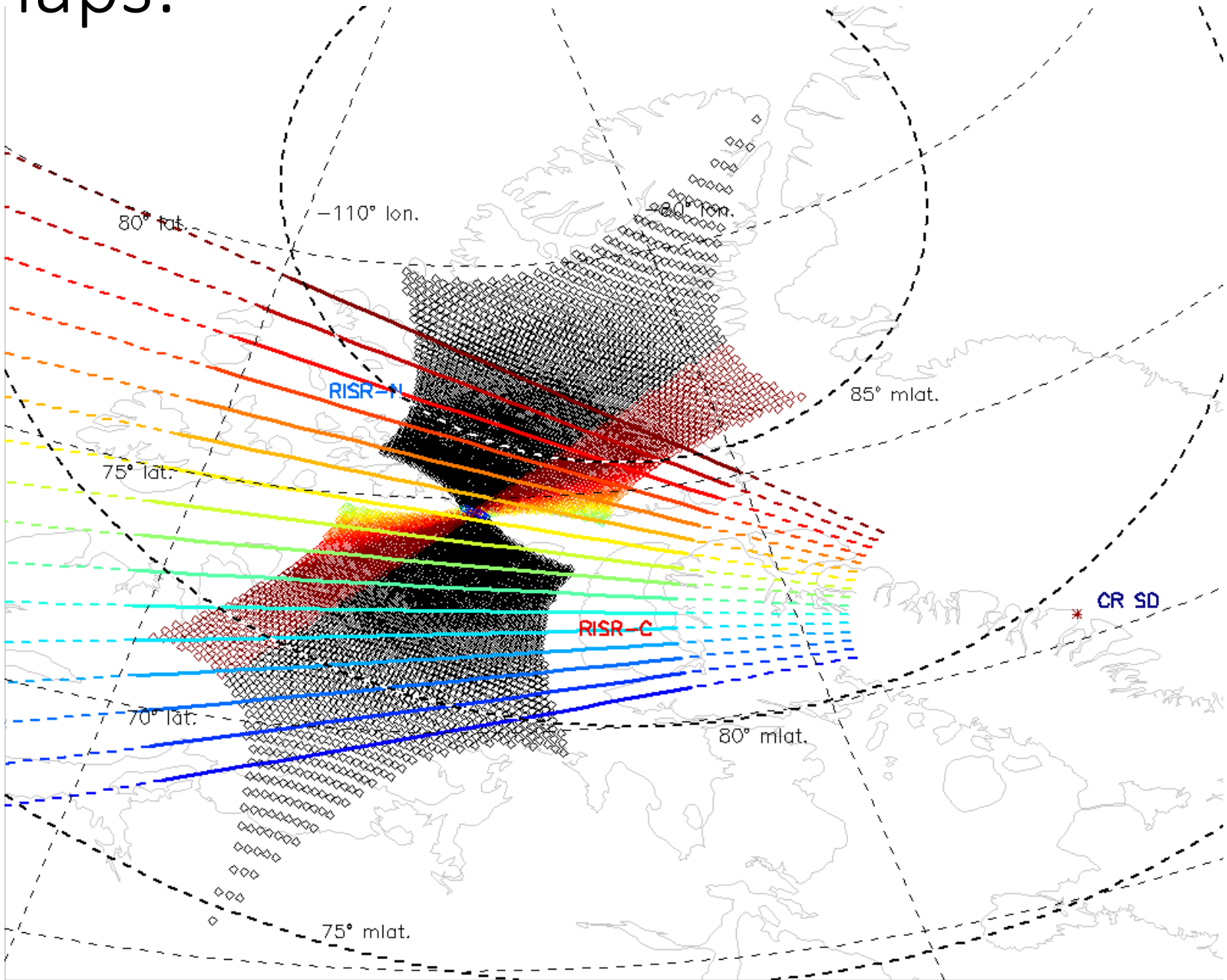


SuperDARN overlaps:

-Clyde River and RISR beams

-Solid portions of beams -- Clyde ranges 10-30 (630-1530 km)

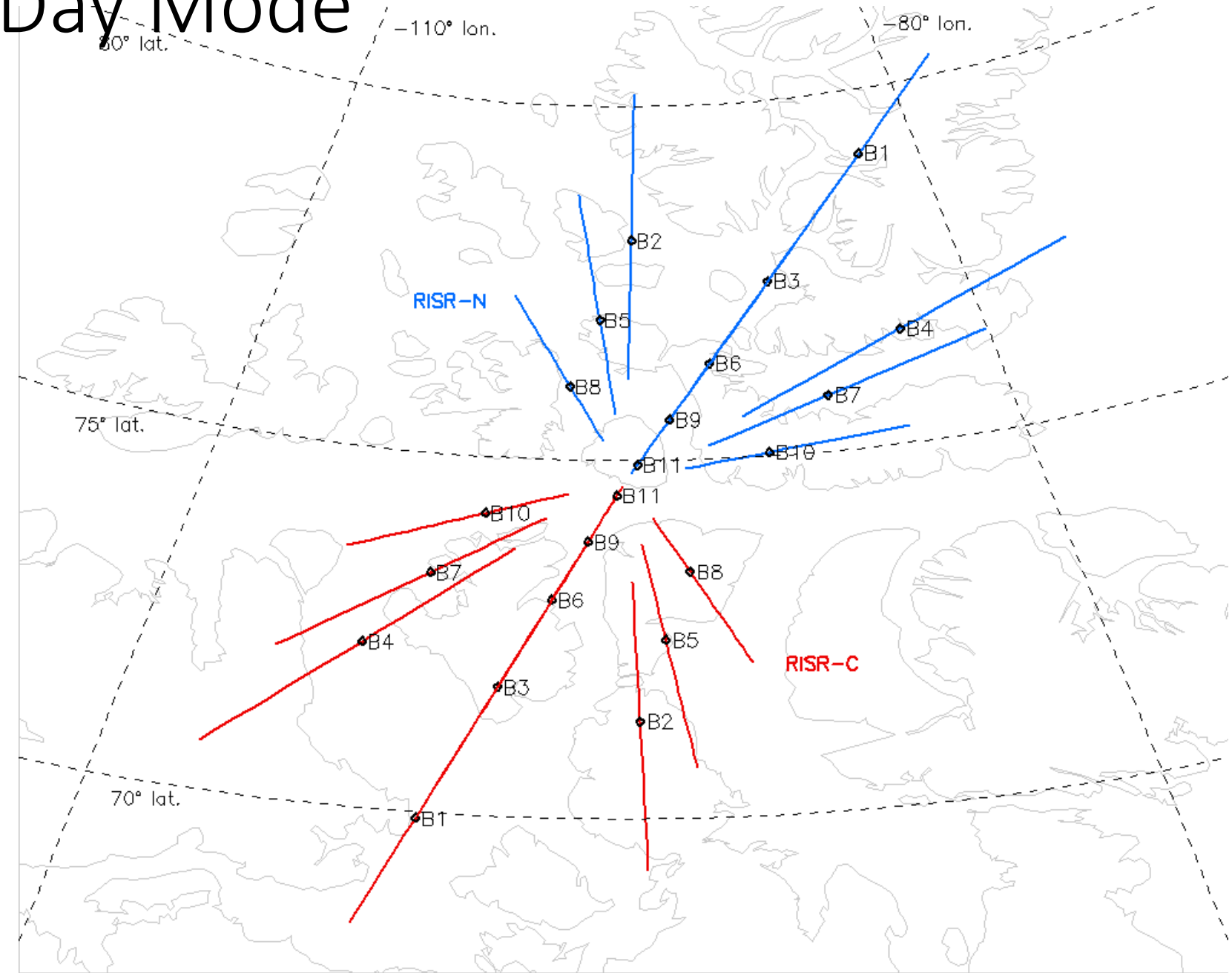
-colors on RISR beams show azimuth within +/- 10 degrees of Clyde beam of same color



Example World Day Mode

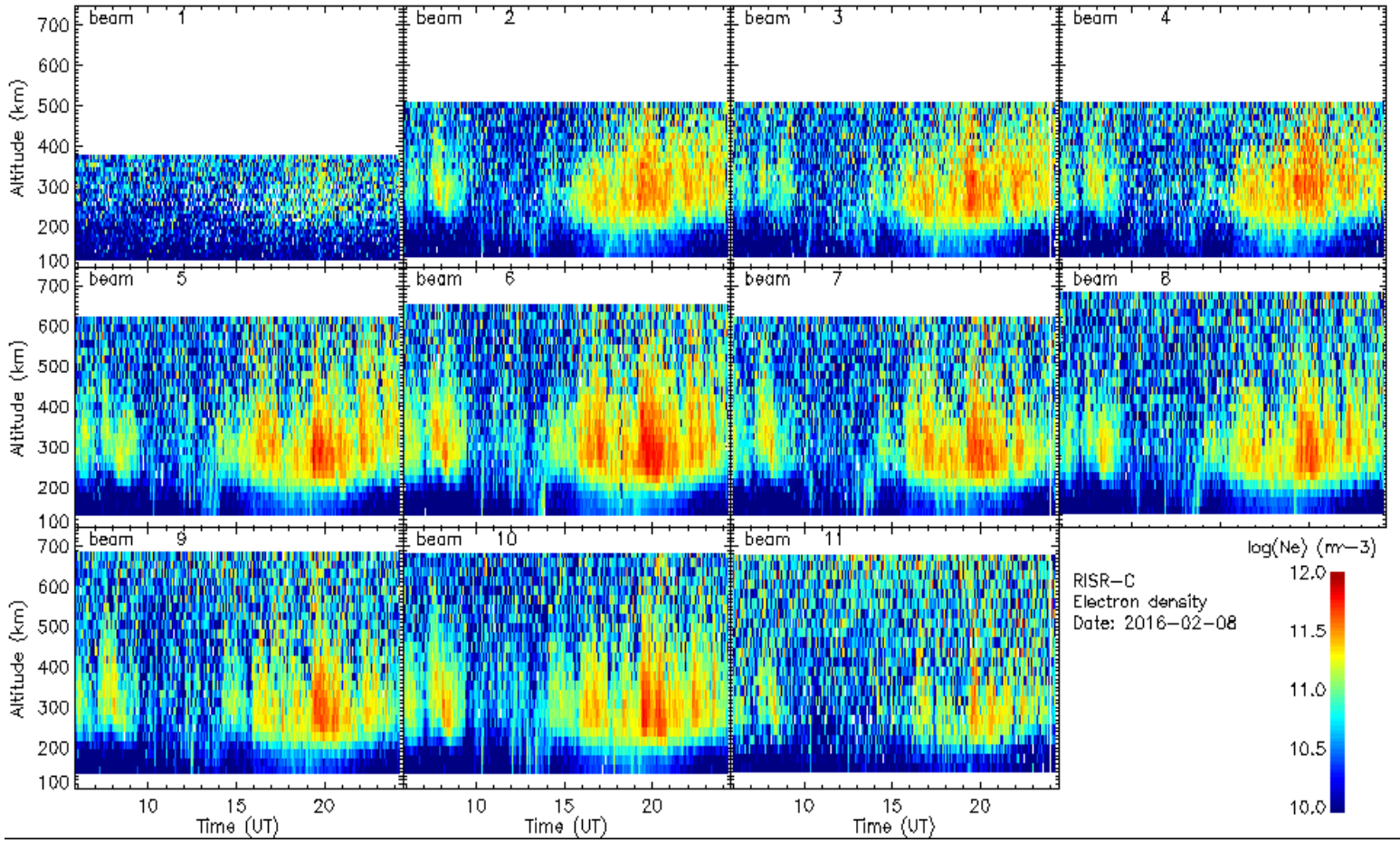
-11 beam positions for each radar in typical world day mode

-diamonds indicate 300 km ionospheric pierce points



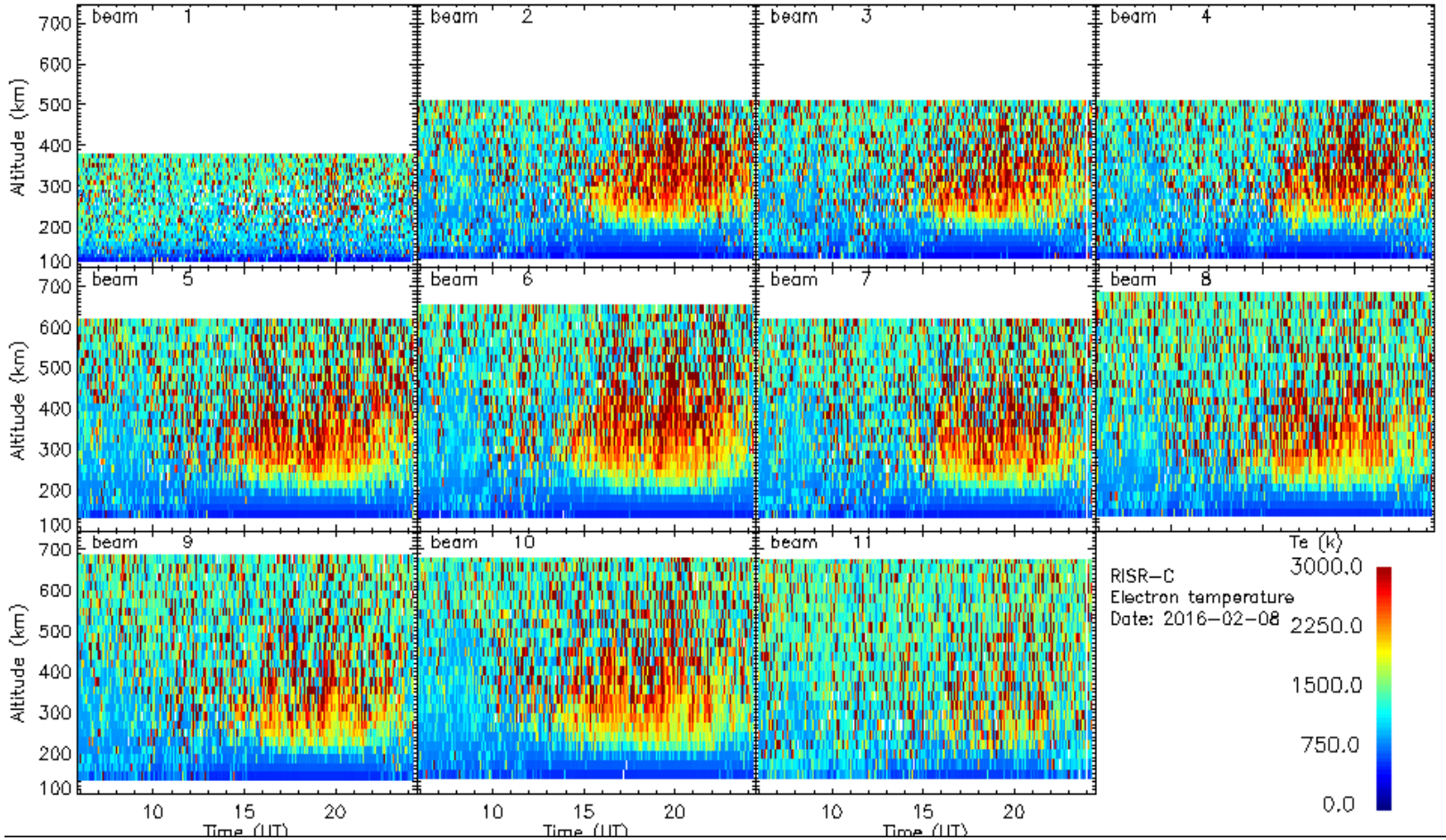
World day data examples – Electron density:

- Electron density in the ionosphere tends to peak ~300 km
- Local time (LT) at Resolute is ~UT-6.3 hours (so 18 UT is near local noon) – peak in density is observed shortly after this



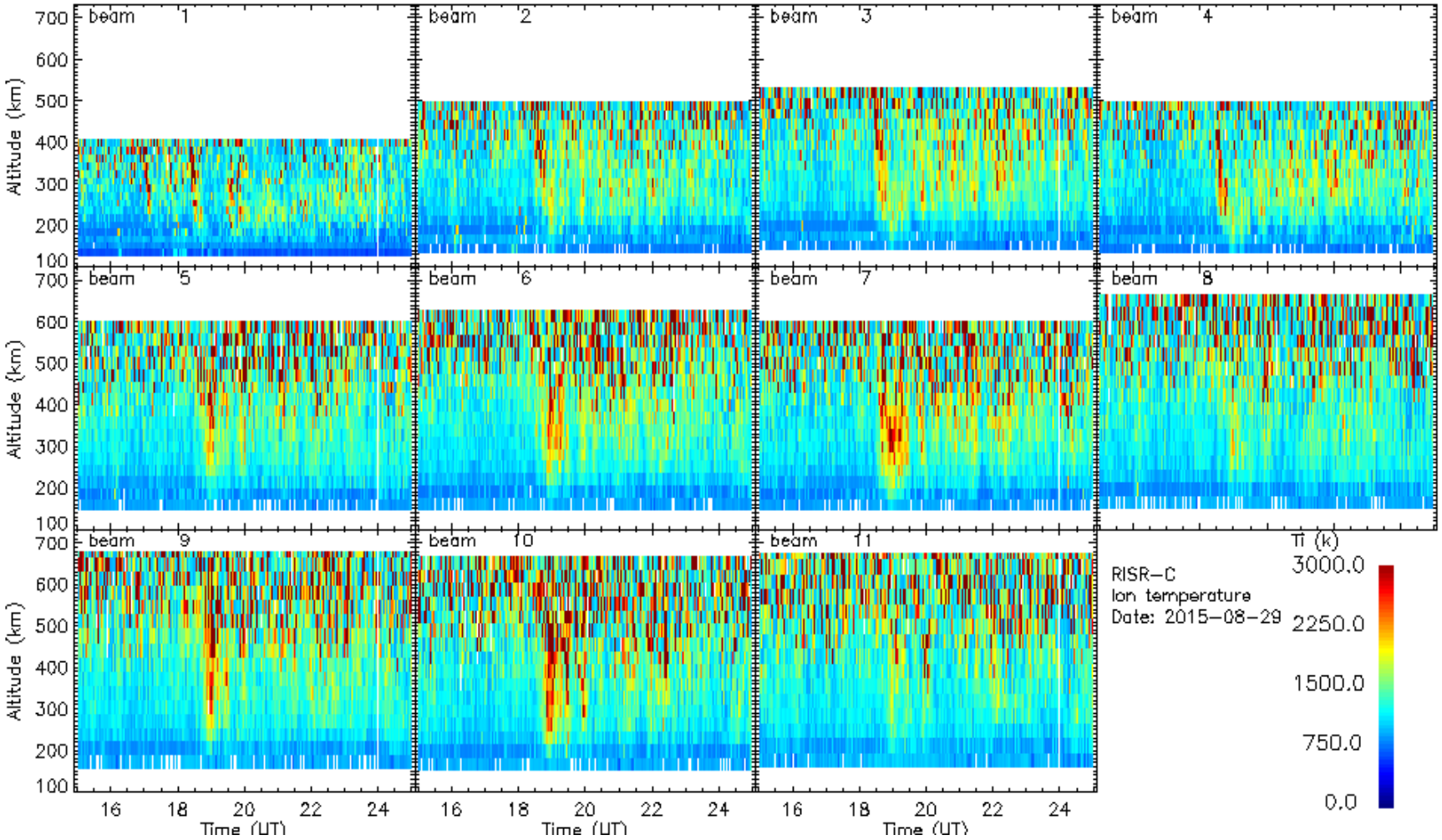
World day data examples – Electron temperature:

- Like density, electron temperature also increases under solar illumination



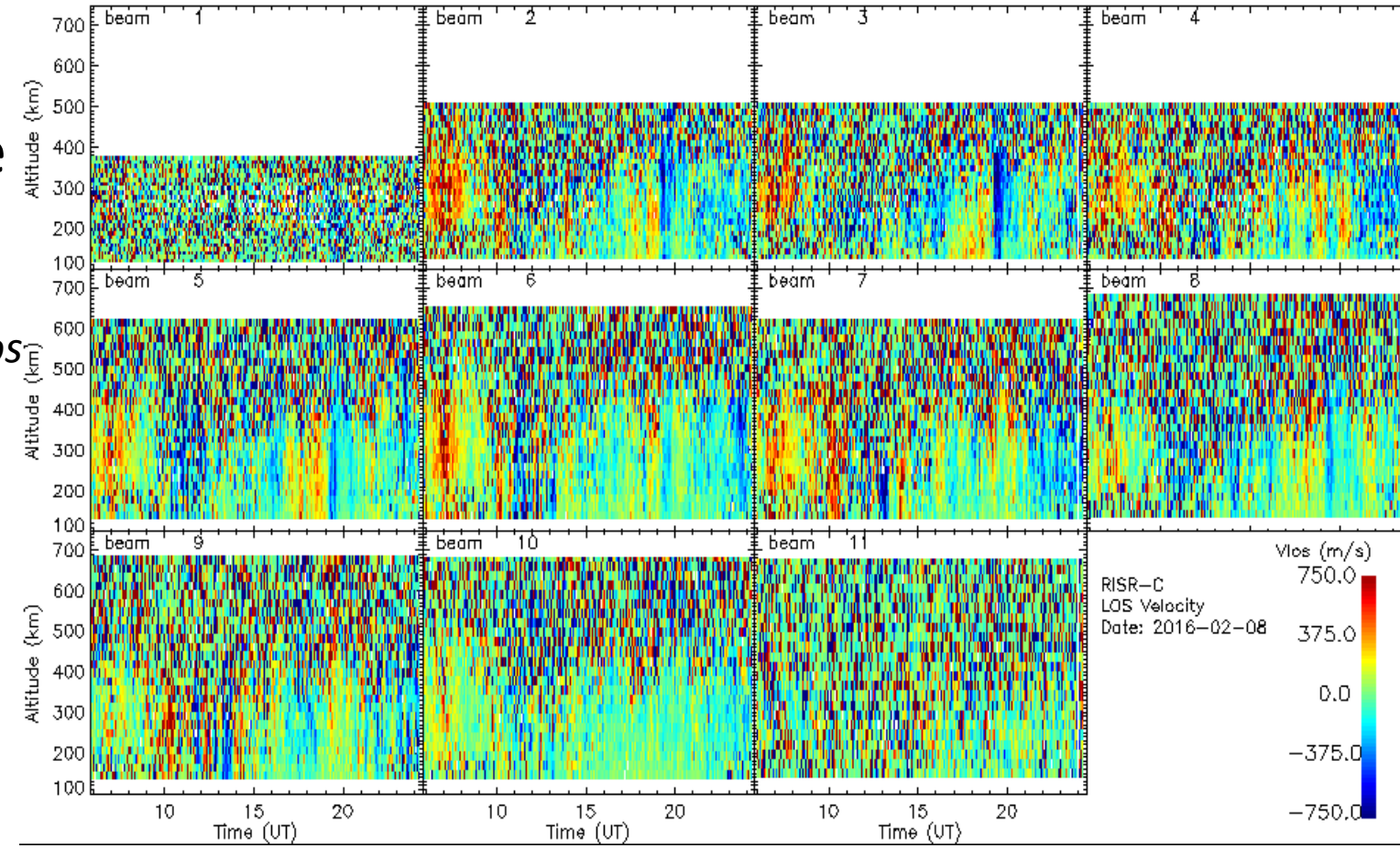
World day data examples – Ion temperature:

- Data taken from August 2015 (first combined full RISR-C and RISR-N run) shows an ion heating event near noon



World day data examples – Line-of-sight velocity:

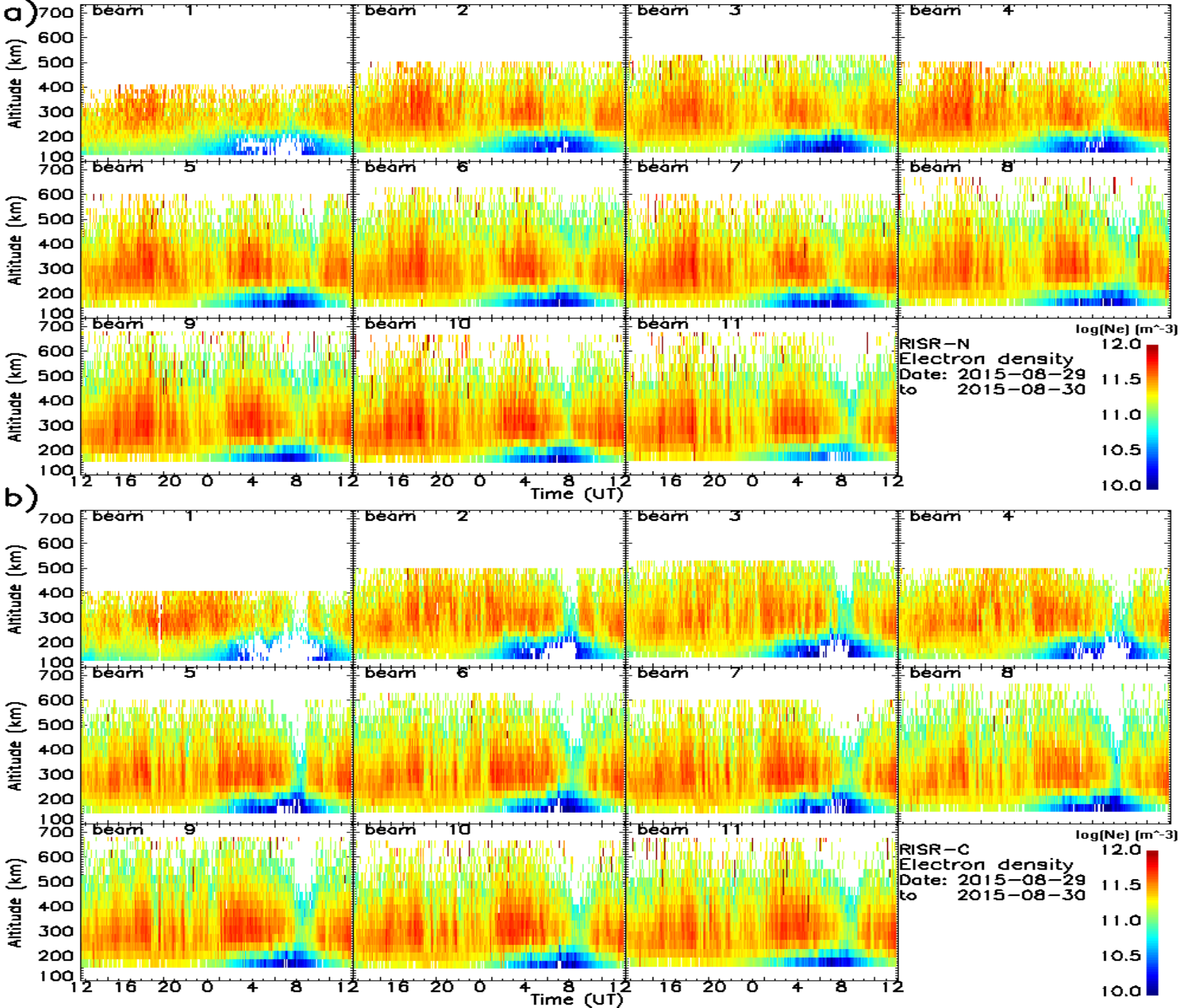
- Red/positive velocities indicate flow away from the radar, while blue/negative velocities indicate movement toward the radar
- Notice that the estimation of V_{los} is quite poor when the electron density is low (compare with previous electron density plots)



Example data from both radars: electron densities

RISR-N

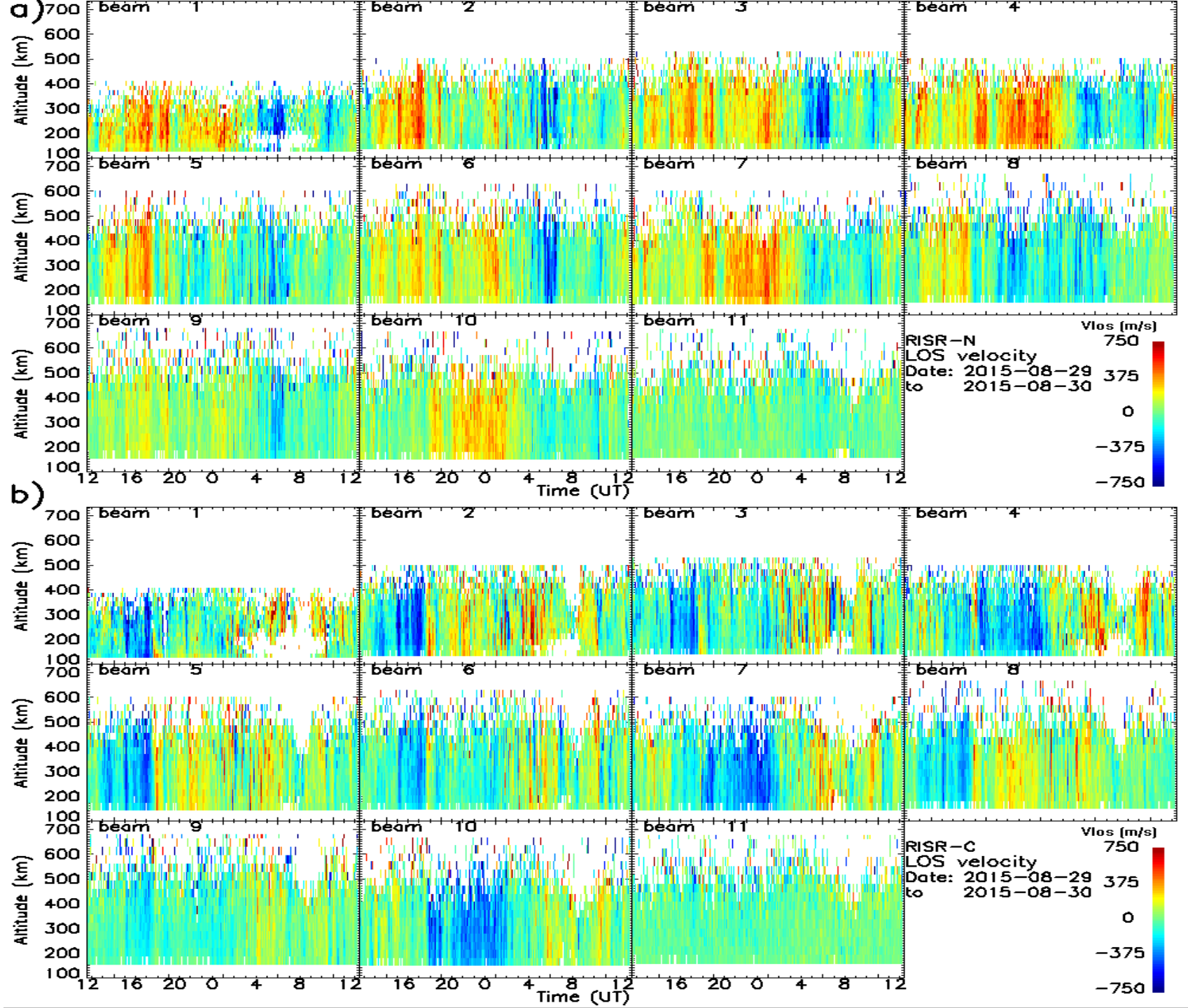
RISR-C



Example data from both radars: LOS velocities

RISR-N

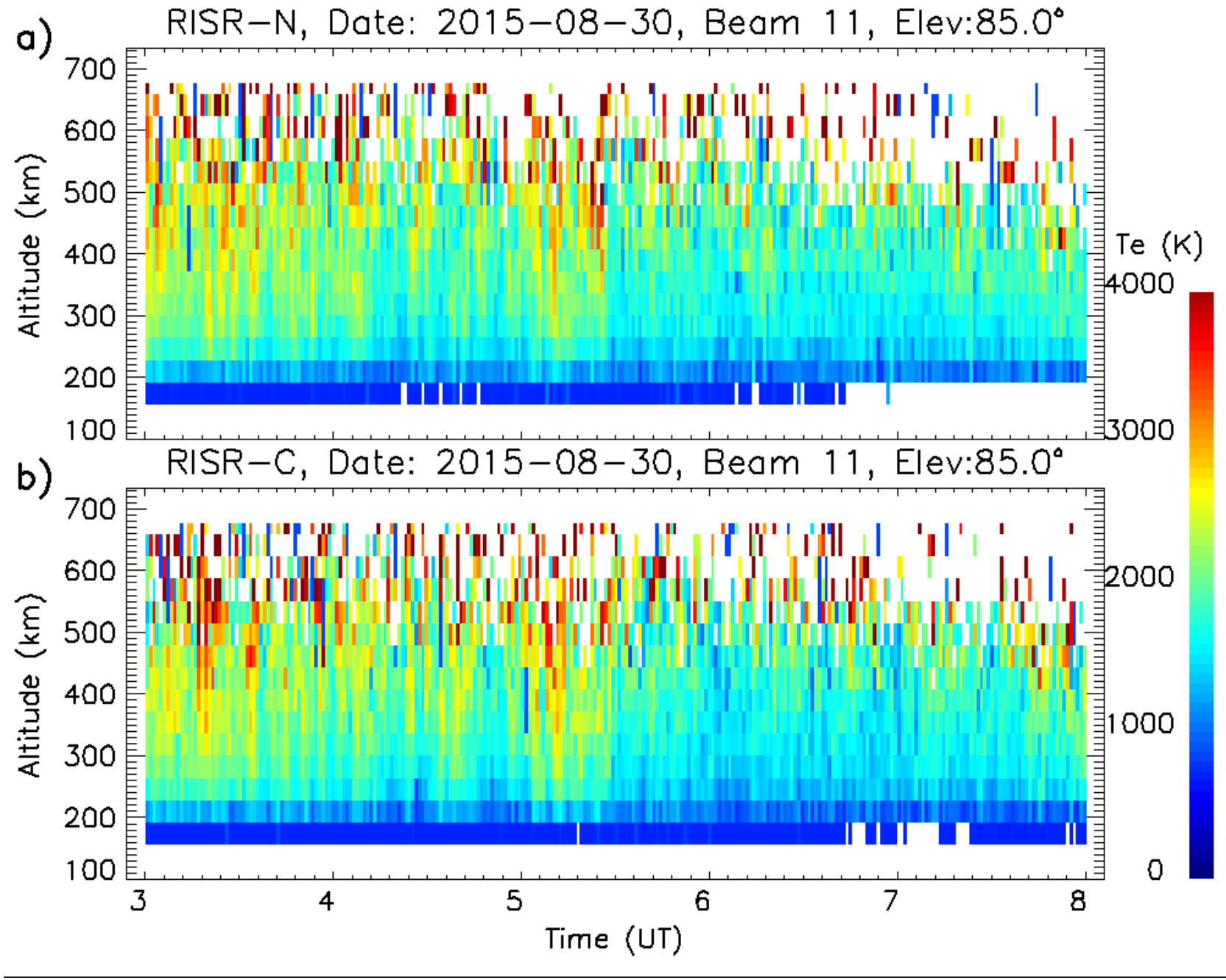
RISR-C



Example data from both radars: electron temperature:

RISR-N

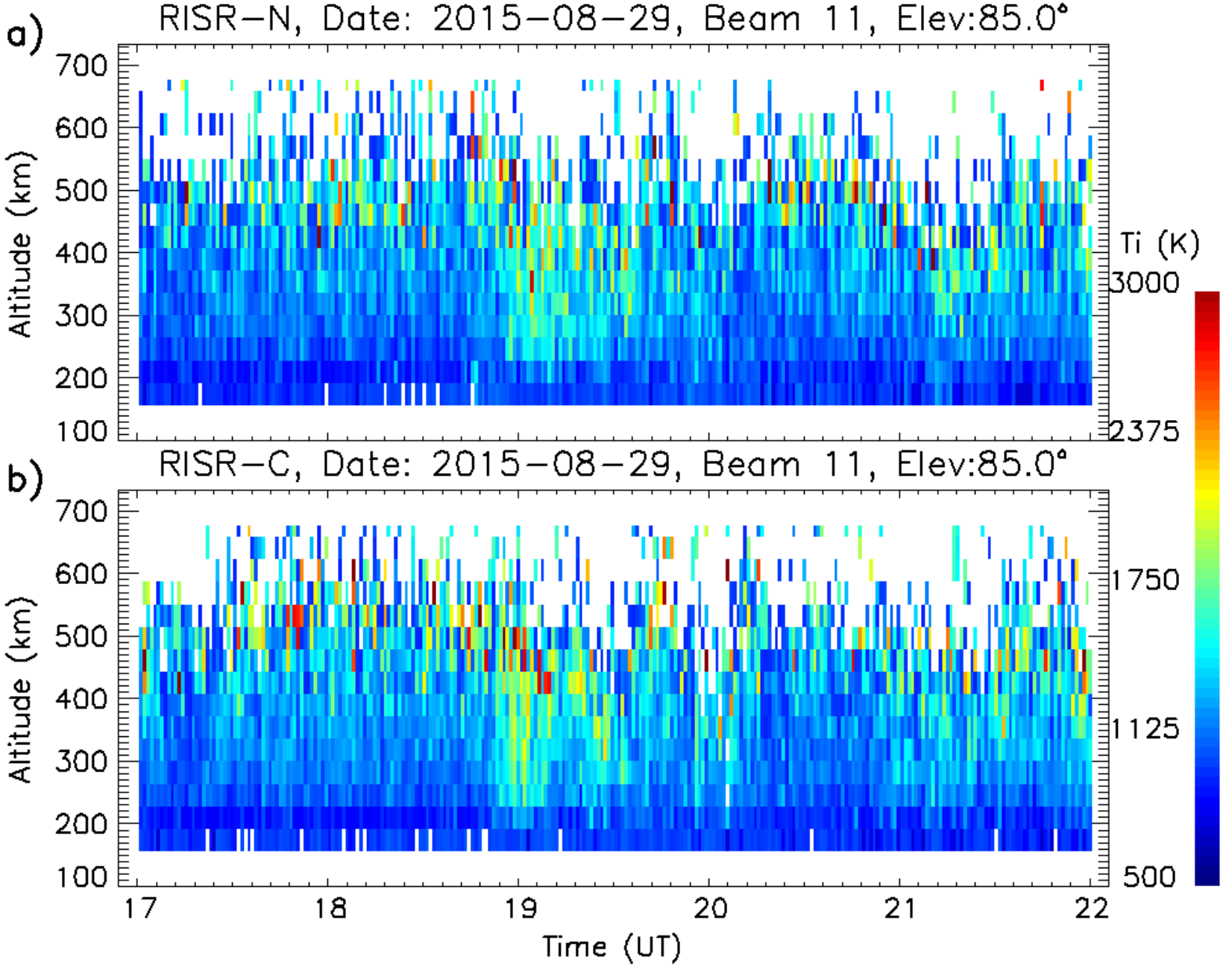
RISR-C



Example data from both radars: ion temperature

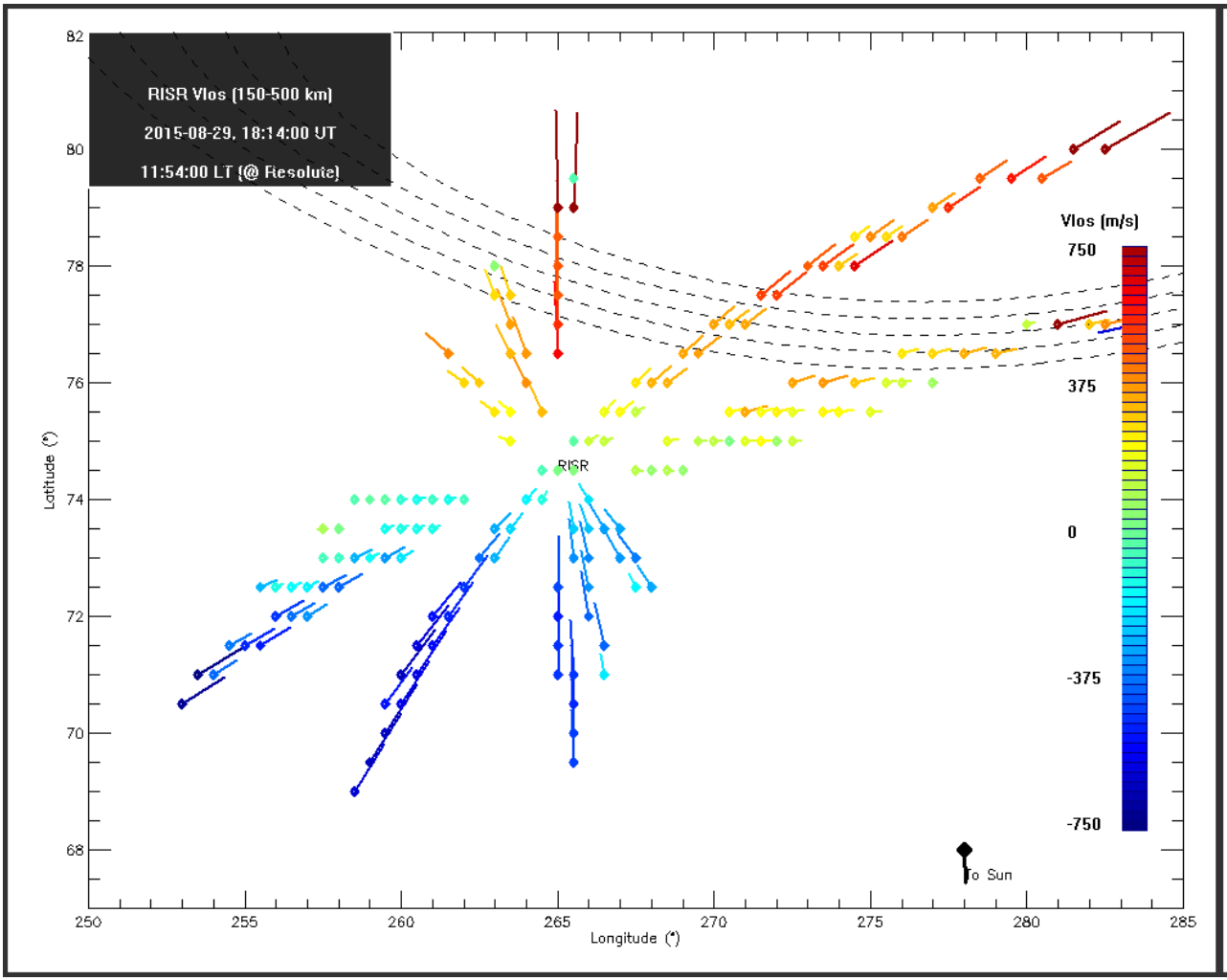
RISR-N

RISR-C

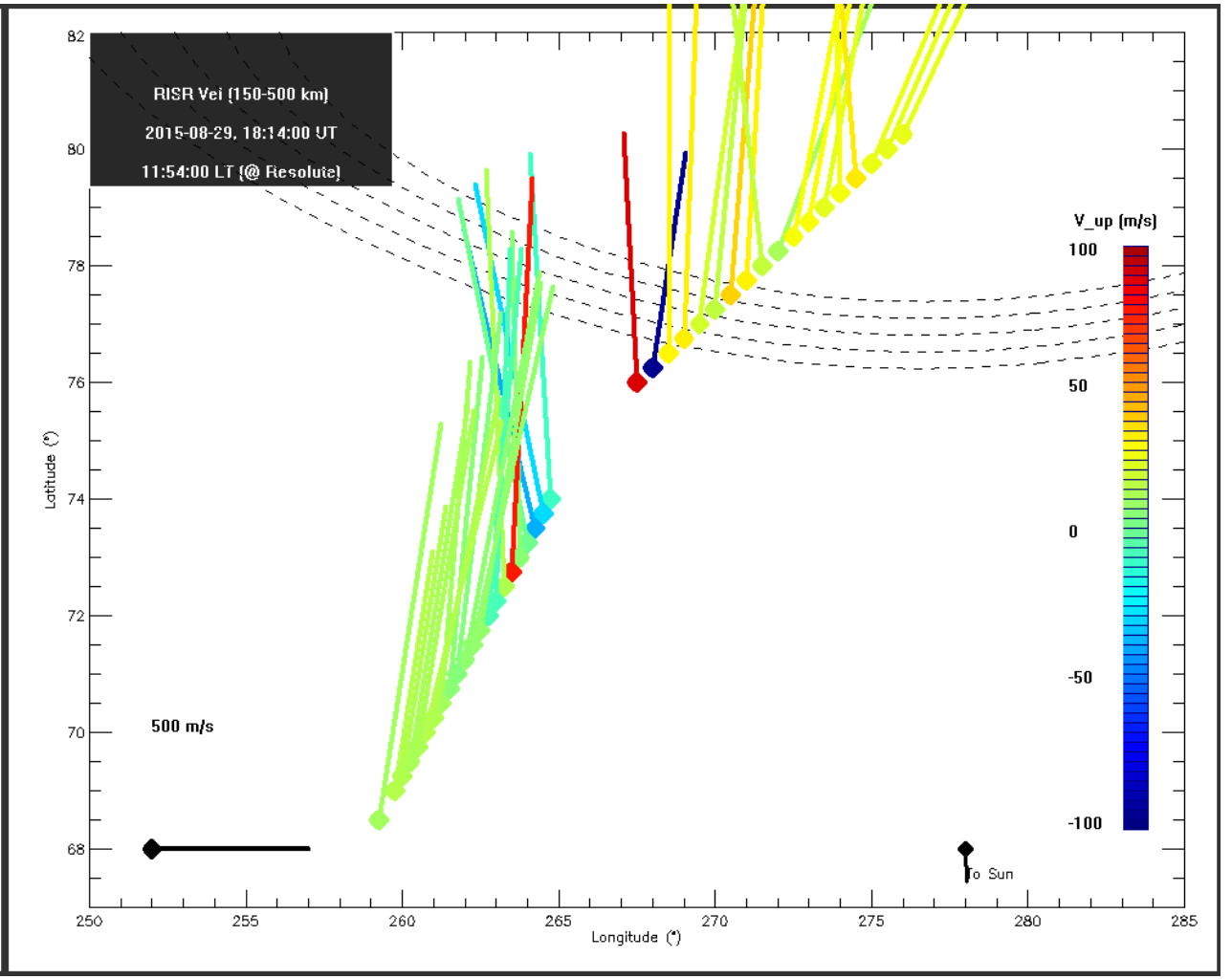


Resolving velocity vectors:

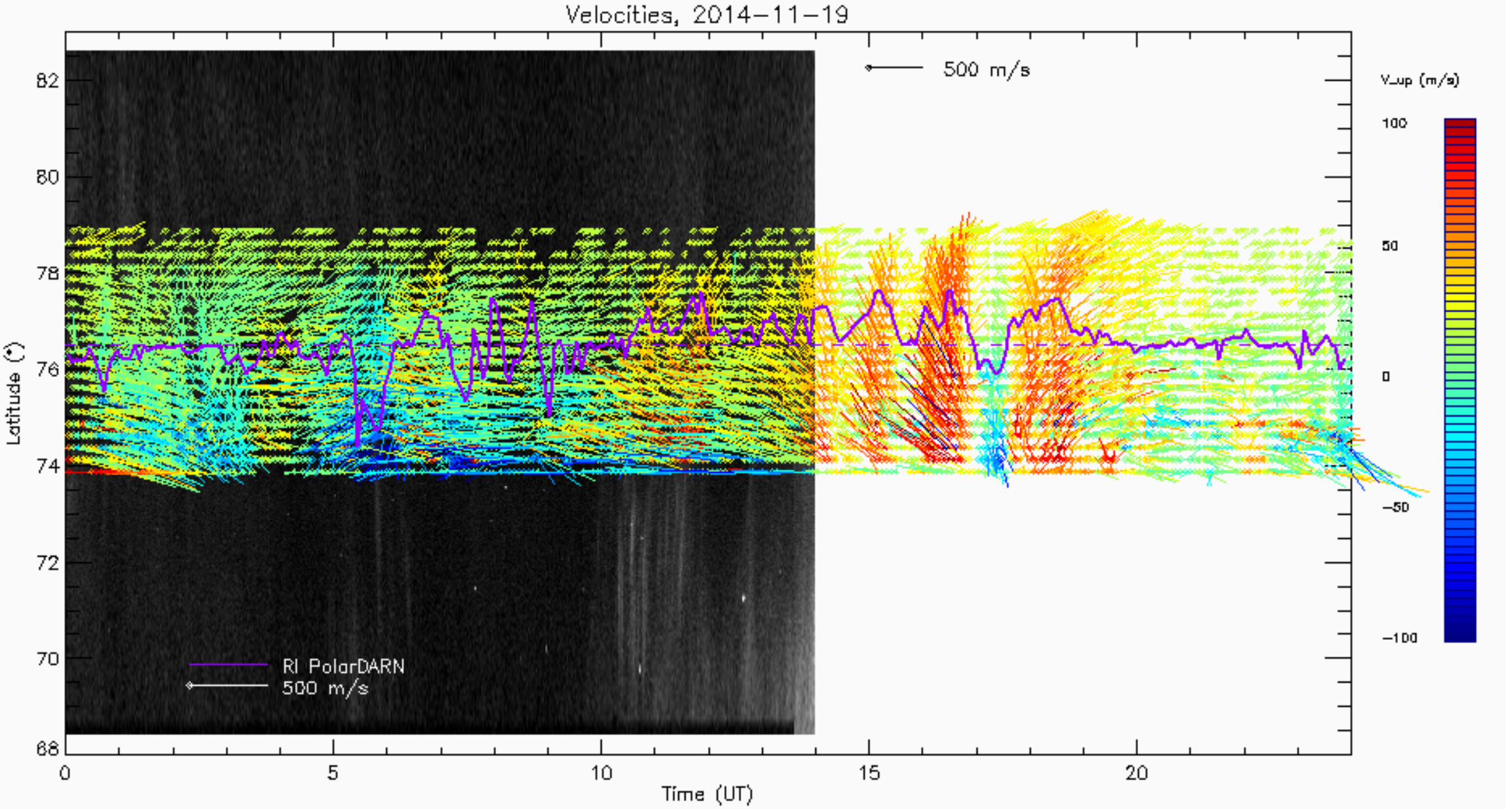
Line-of-sight velocities:



Full vector velocities:



Using a Bayesian inversion technique, full velocity vectors can be estimated using multiple LOS measurements



-REGO keogram, Rankin LOS (N/S), and RISR-N resolved velocity at 24 latitudes

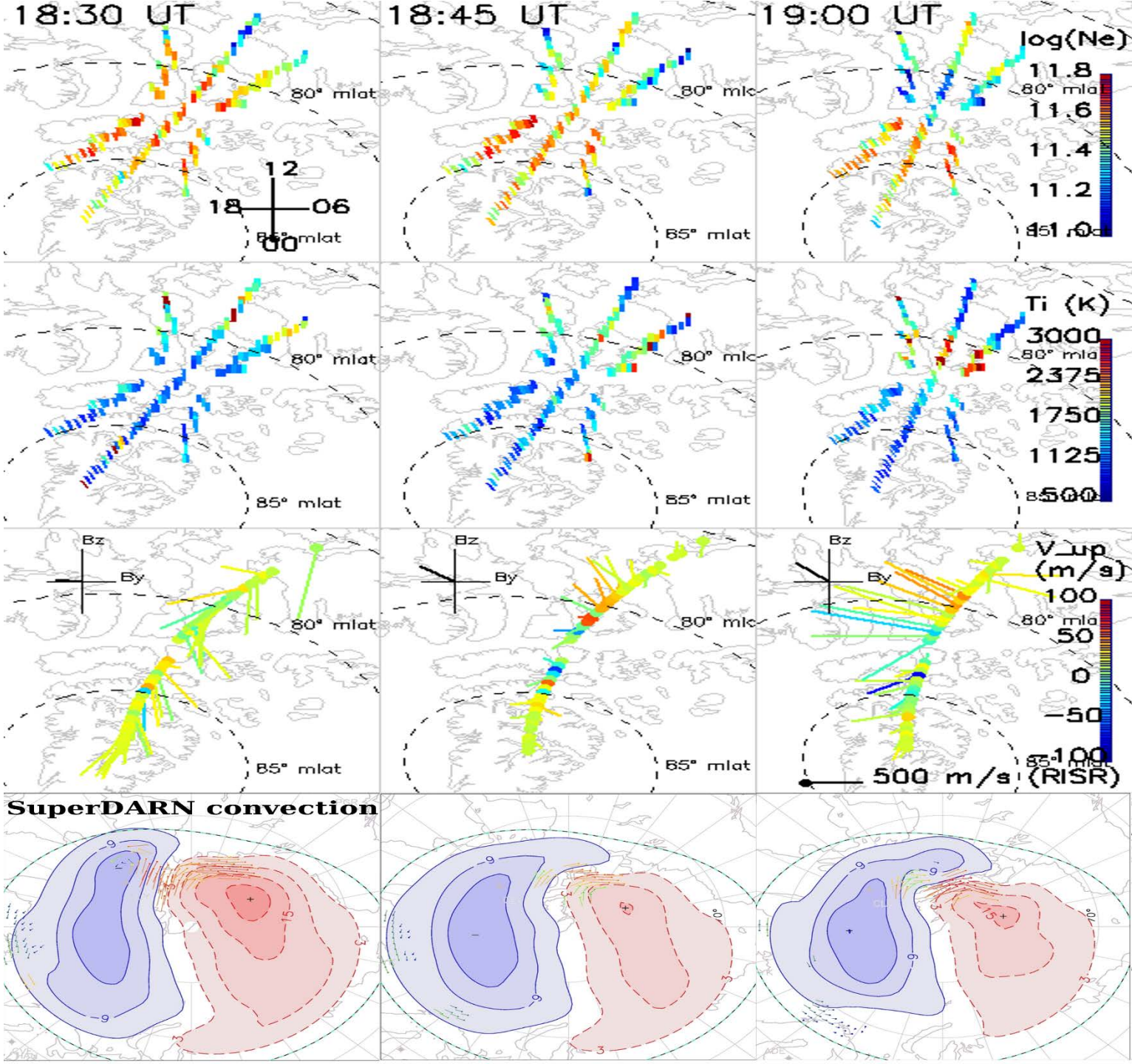
Lat/Lon plots:

Electron density

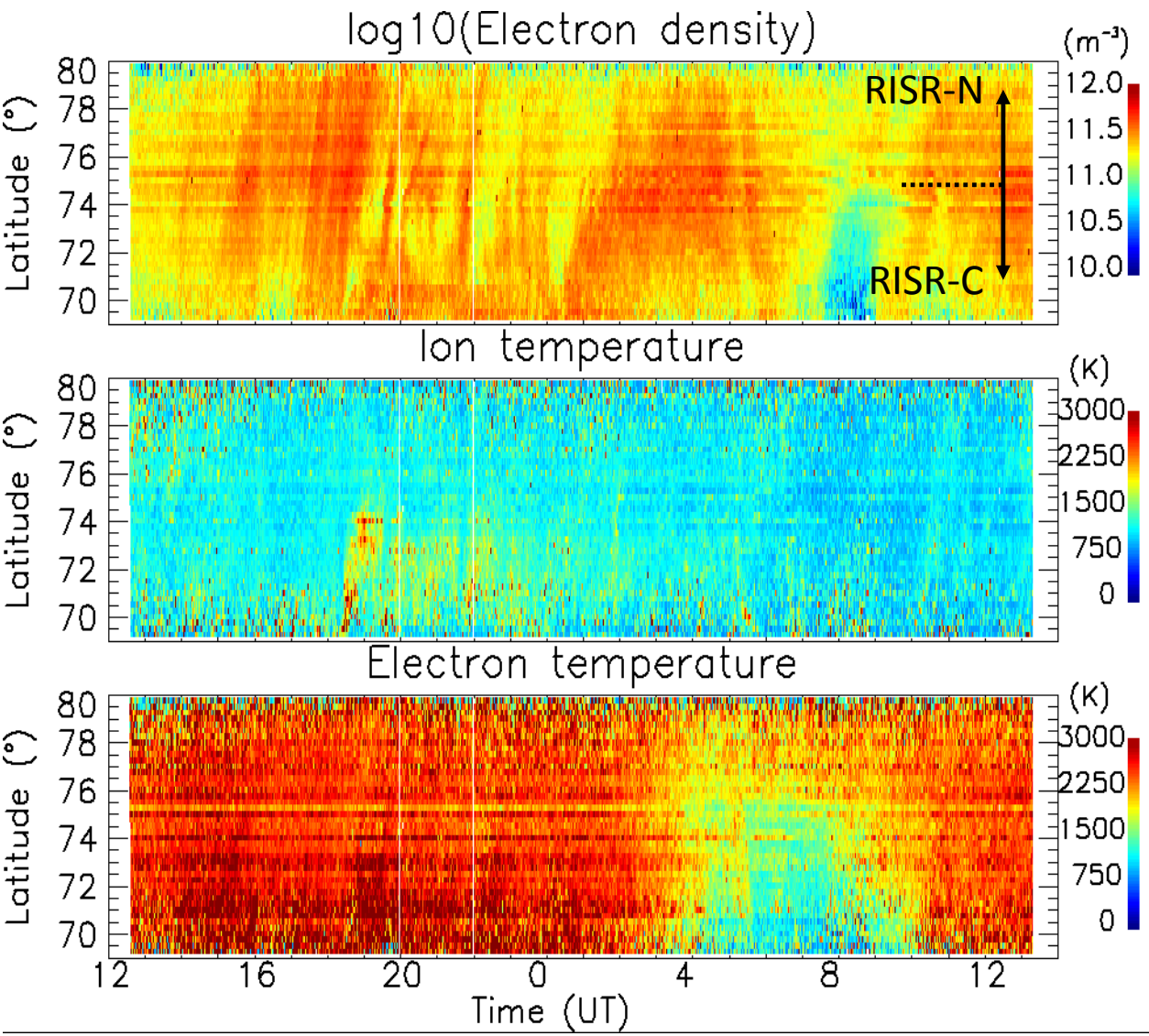
Ion temperature

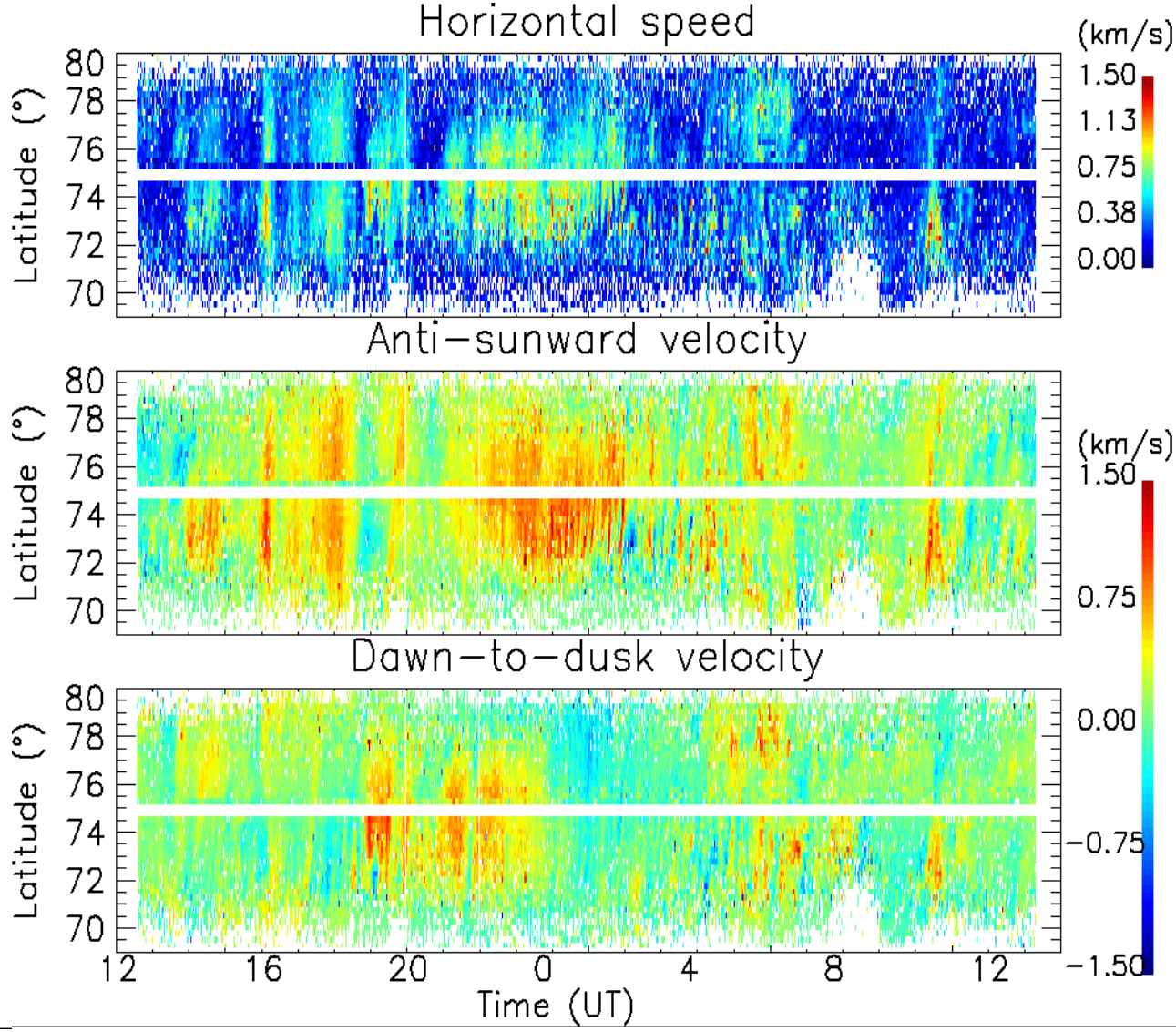
Velocity

SuperDARN



RISR keograms:

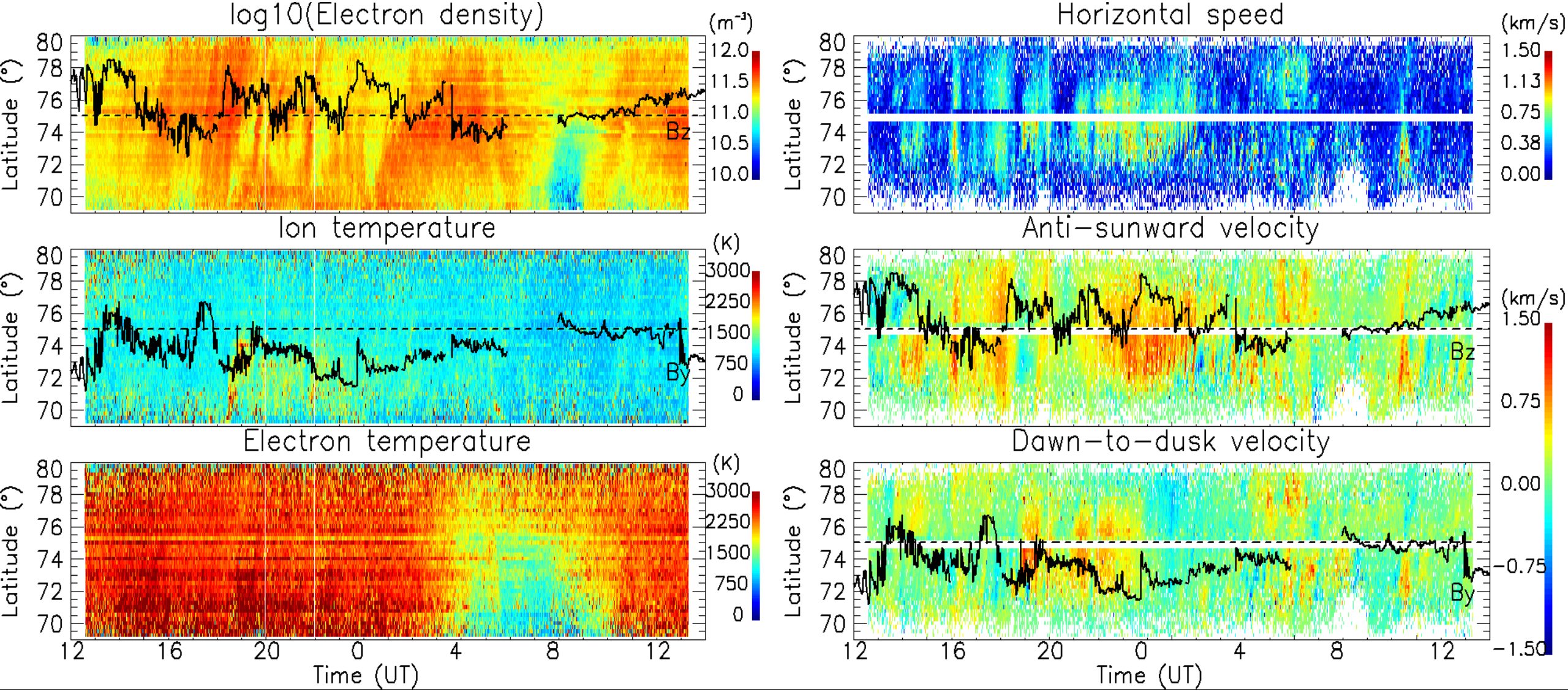




-data from 250-450 km and all longitudes averaged

-effectively, RISR-N above 75^{o} and RISR-C below 75^{o}

RISR keograms:



-OMNI IMF data added (Bz shown in upper left and middle right panels, By shown in middle left and lower right panels)

Summary:

- Both Resolute Bay incoherent scatter radars are now operational
- Requests for experiments for the radars should be sent to:
  - Roger Varney, SRI International, roger.varney@sri.com
  - Robert Gillies, University of Calgary, rgillies@ucalgary.ca
- Important links:
  - SRI AMISR site: http://amisr.com/
  - RISR-N Database: http://amisr.com/database/91/
  - RISR-C Data: http://data.phys.ucalgary.ca/
  - Madrigal Database: http://isr.sri.com/madrigal/