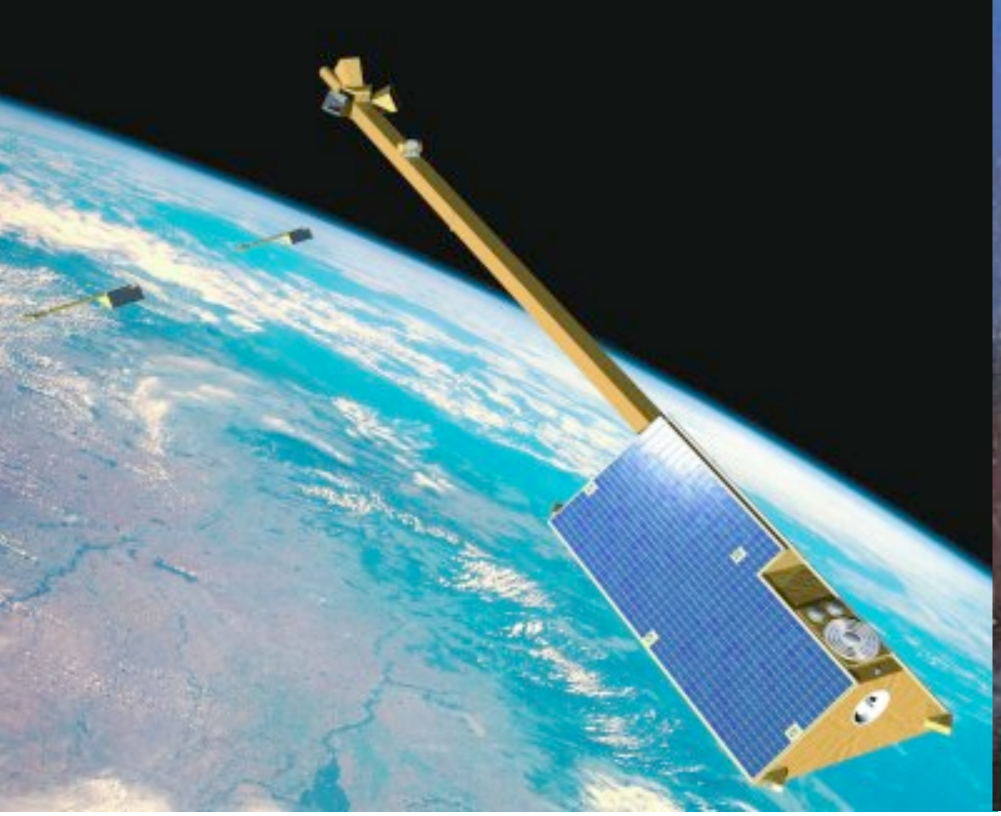

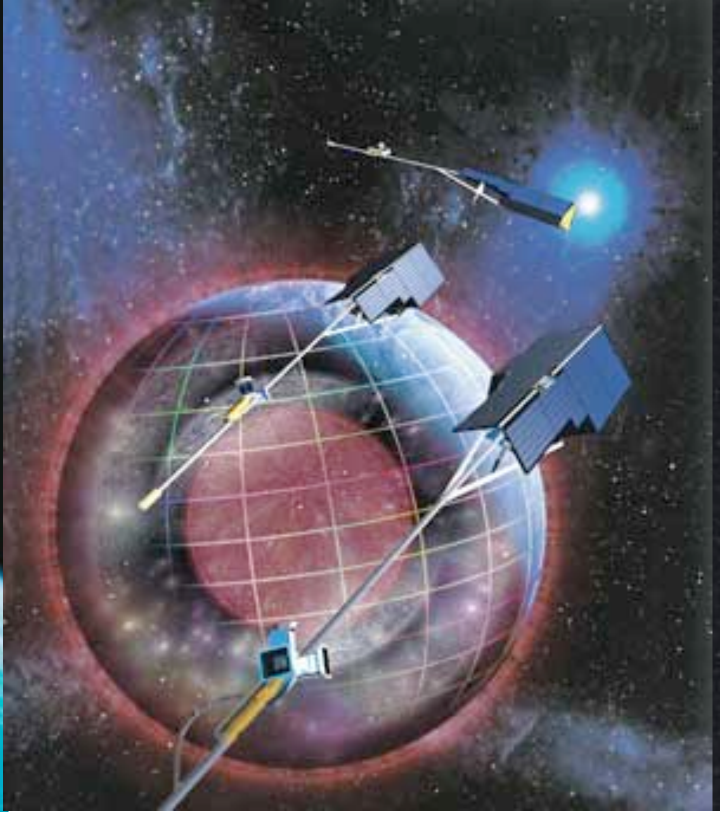

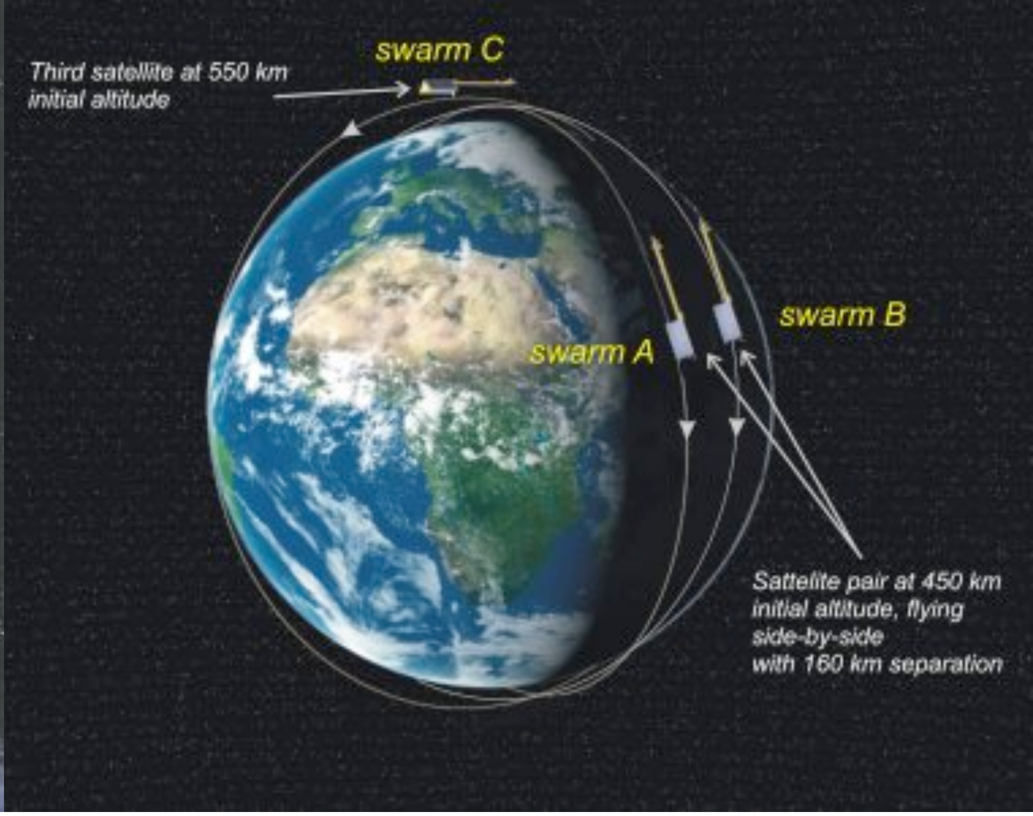

Opportunities for the joint analysis of Swarm and SuperDARN measurements of ionospheric electric fields

A. Grocott [1], M.P. Freeman [2], M. Lester [1], S.E. Milan [1], T.K. Yeoman [1]

[1] Radio & Space Plasma Physics Group, University of Leicester, [2] British Antarctic Survey, Cambridge

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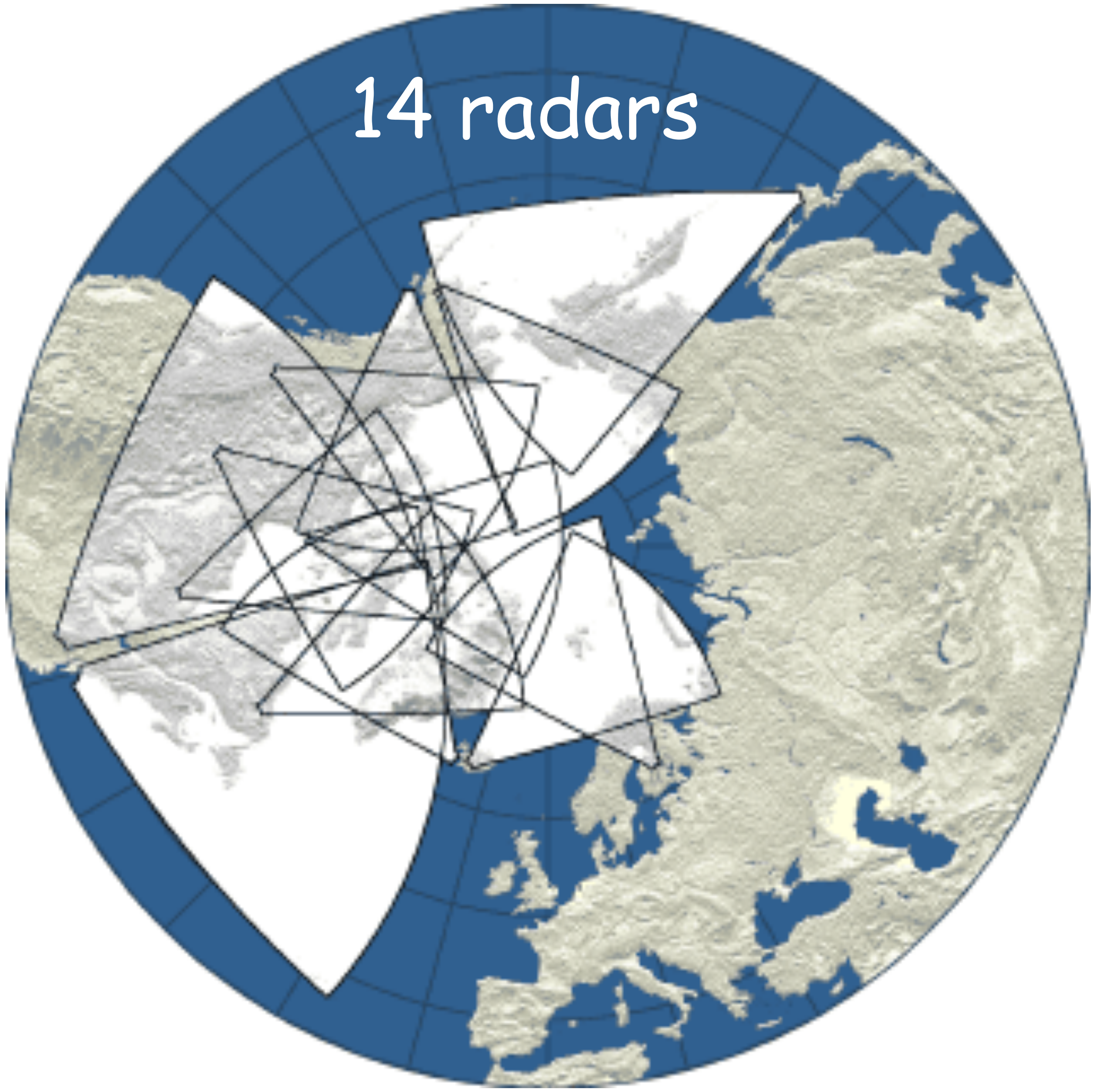

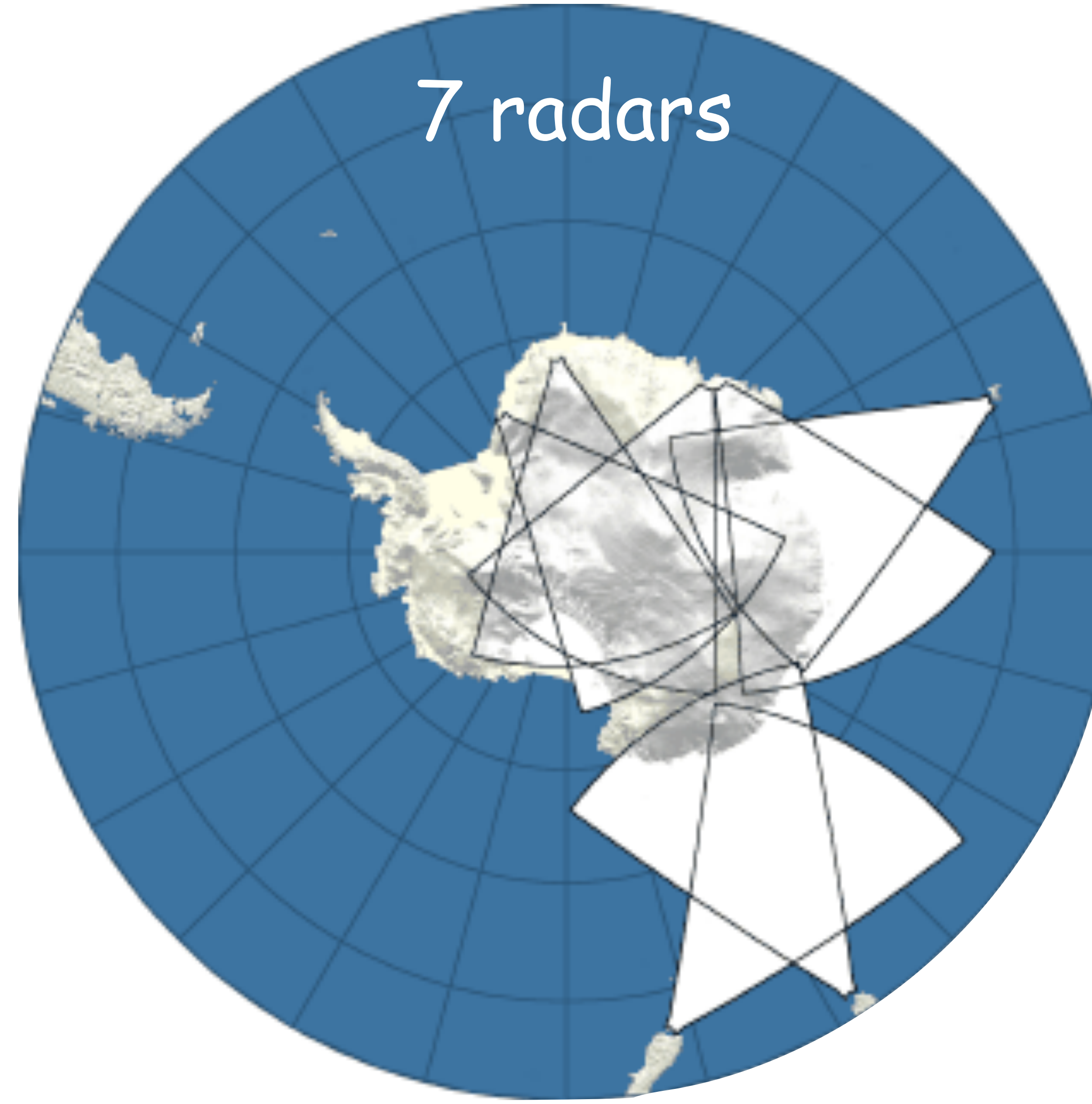

SuperDARN: Super Dual Auroral Radar Network

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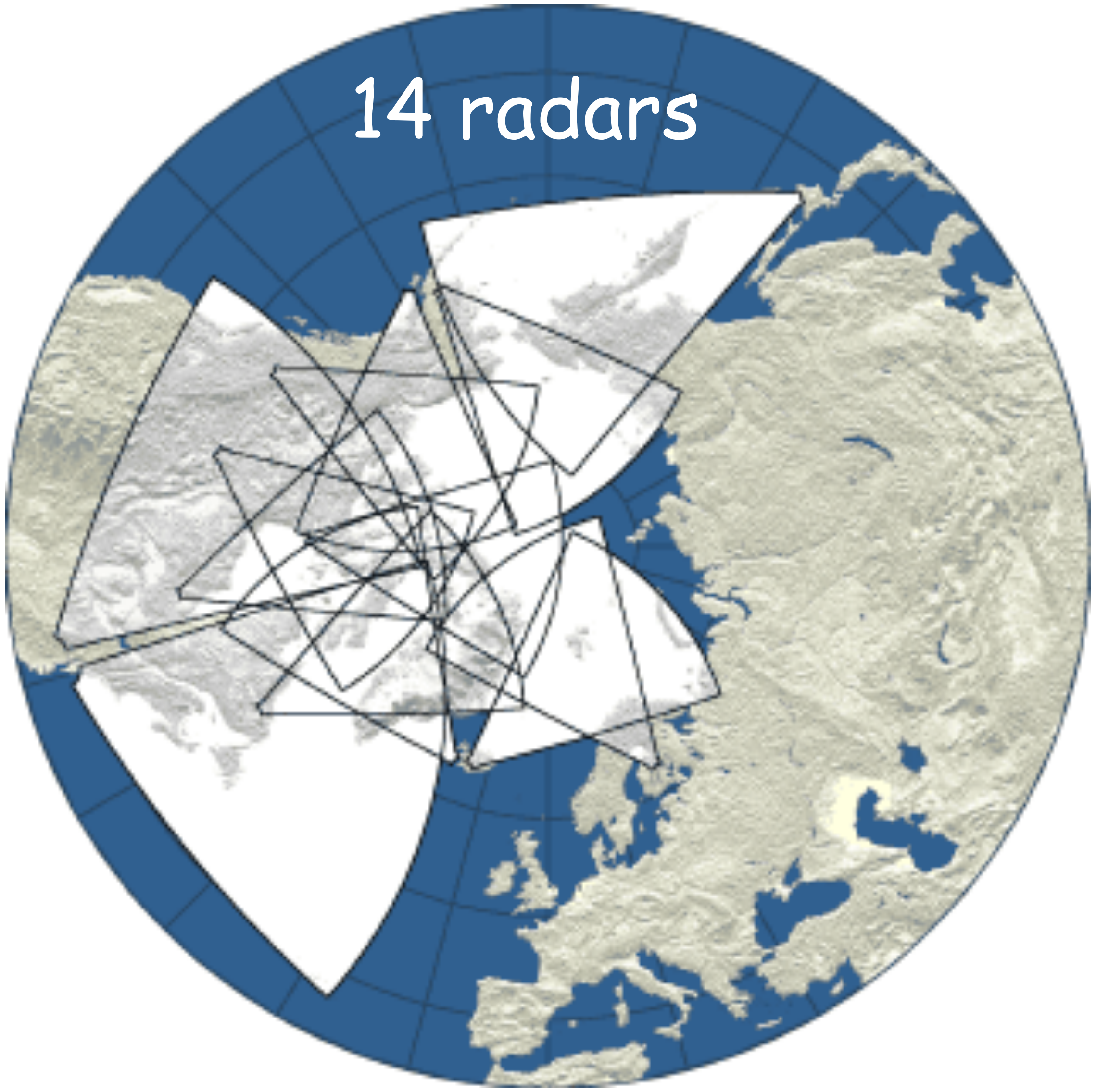

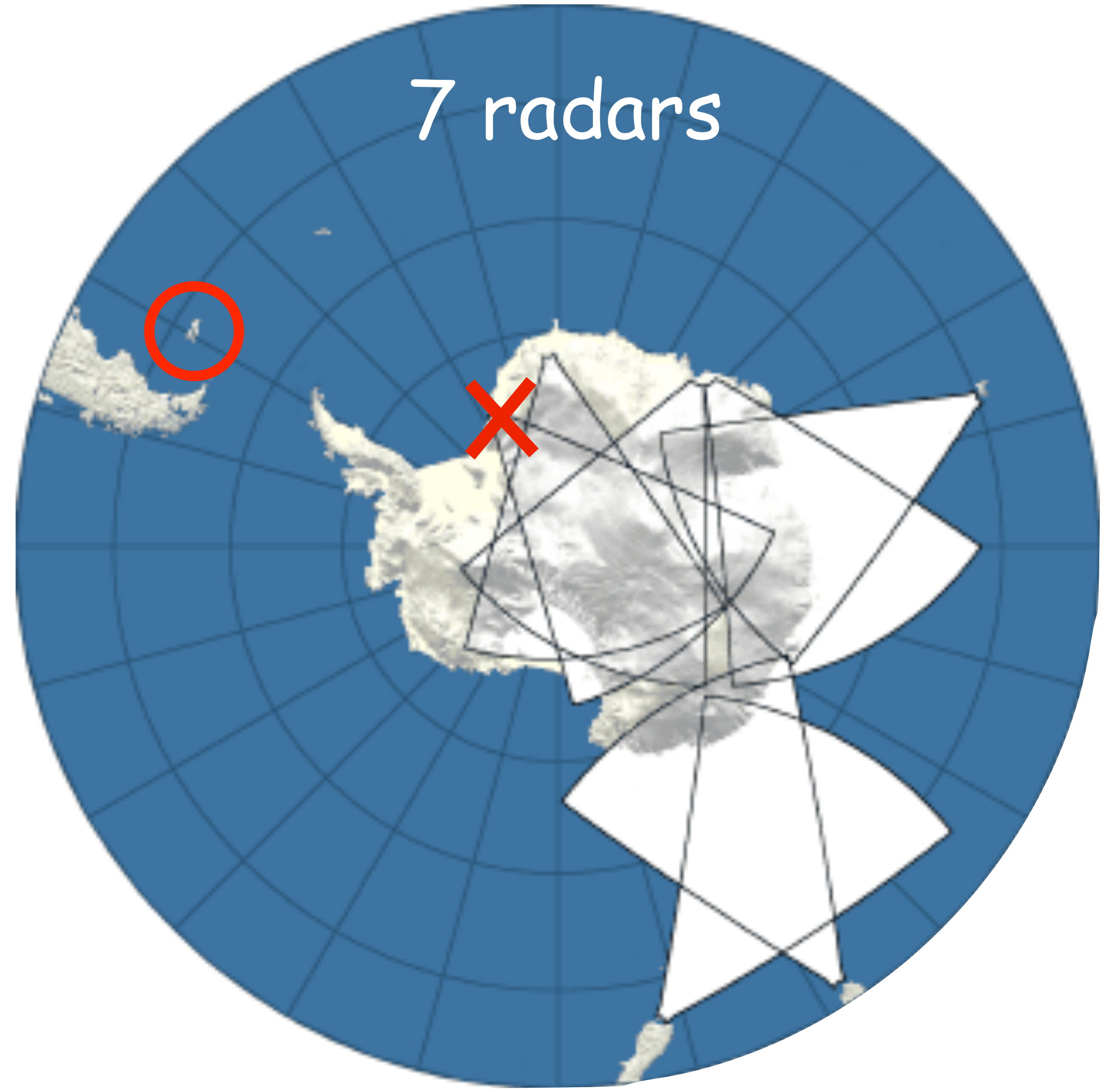

SuperDARN: New NERC funded radar in the Falklands

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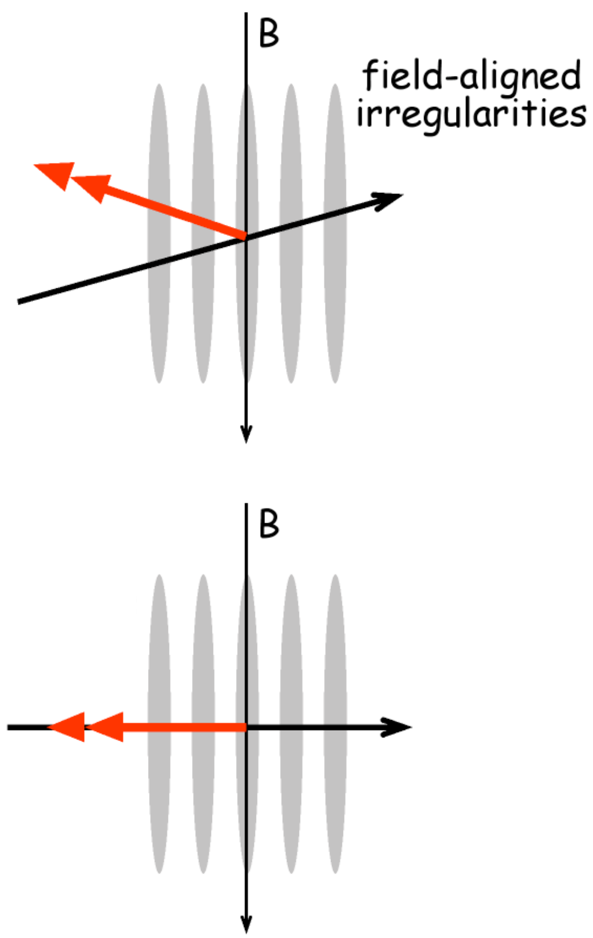
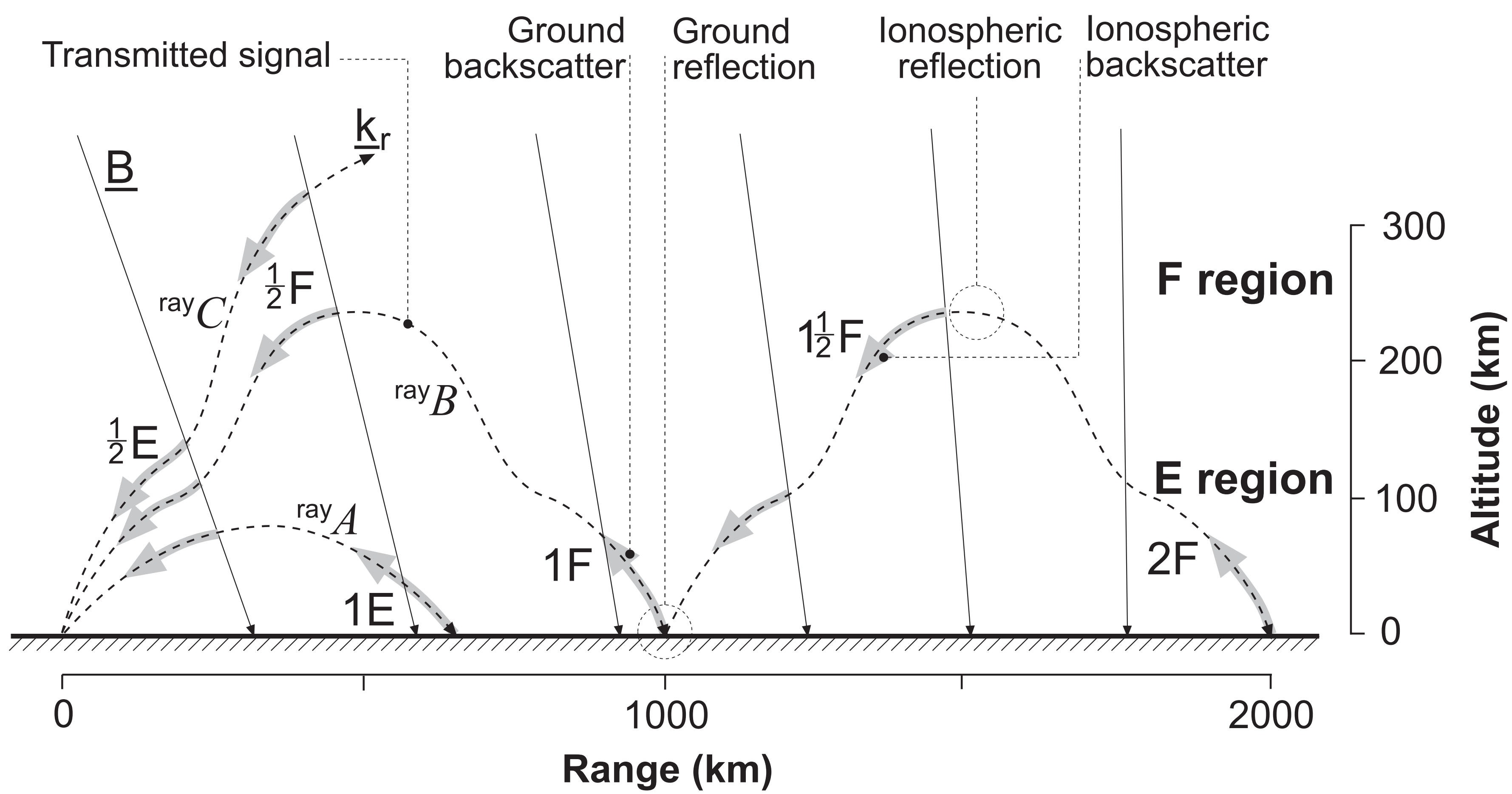
HF propagation modes and backscatter regions





- Coherent scatter (**Bragg** scatter) from field-aligned irregularities
- Radar wave vector must be orthogonal to the magnetic field
- HF rays refract in the ionosphere and thus achieve orthogonality at F-region heights even at high latitudes

- Backscatter can be received:
  - from both the E and F regions
  - from the ground, via oblique reflection from the ionosphere (groundscatter)
  - from far ranges, via multiple hop paths (ionosphere-ground-ionosphere)

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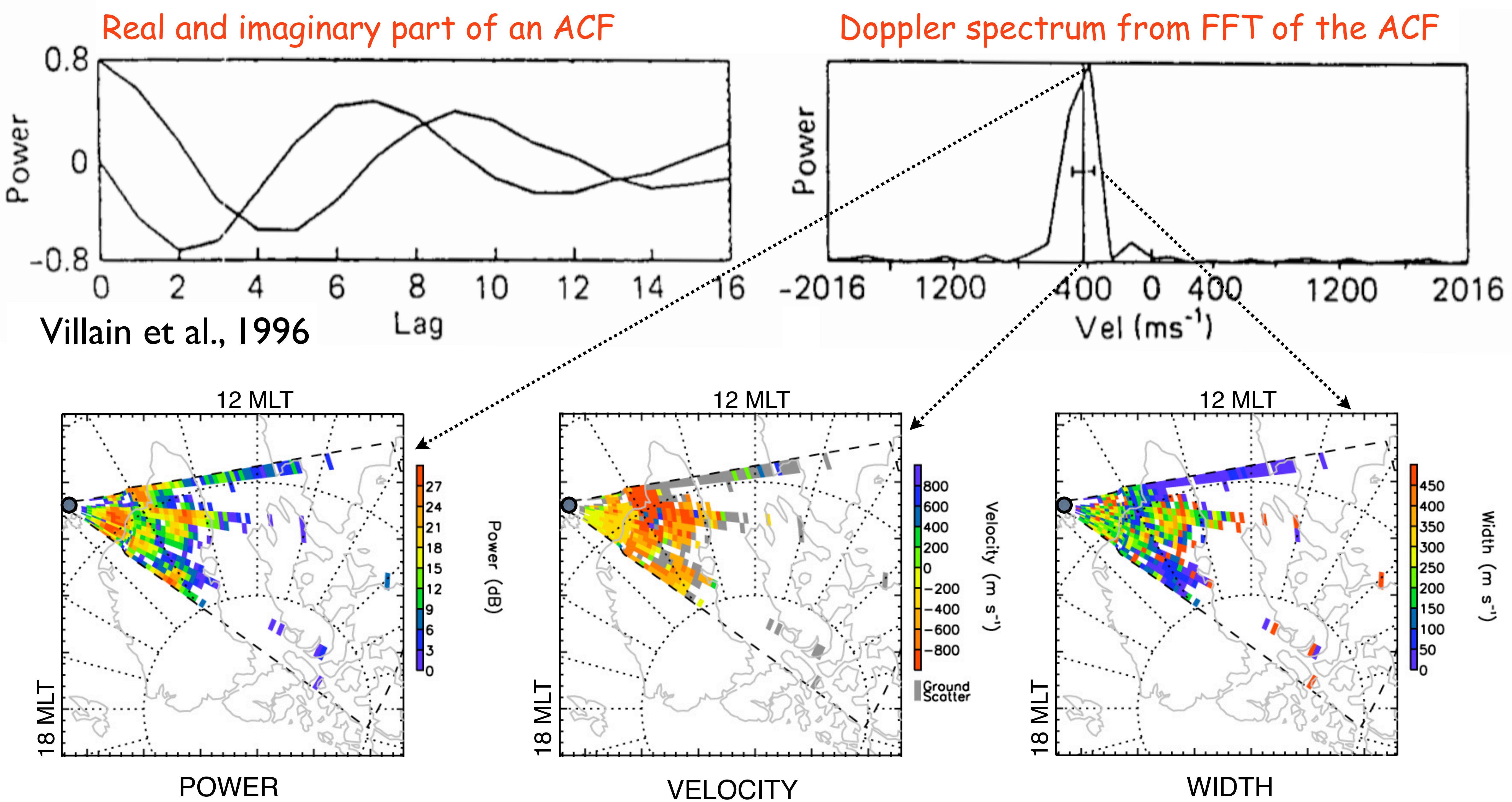
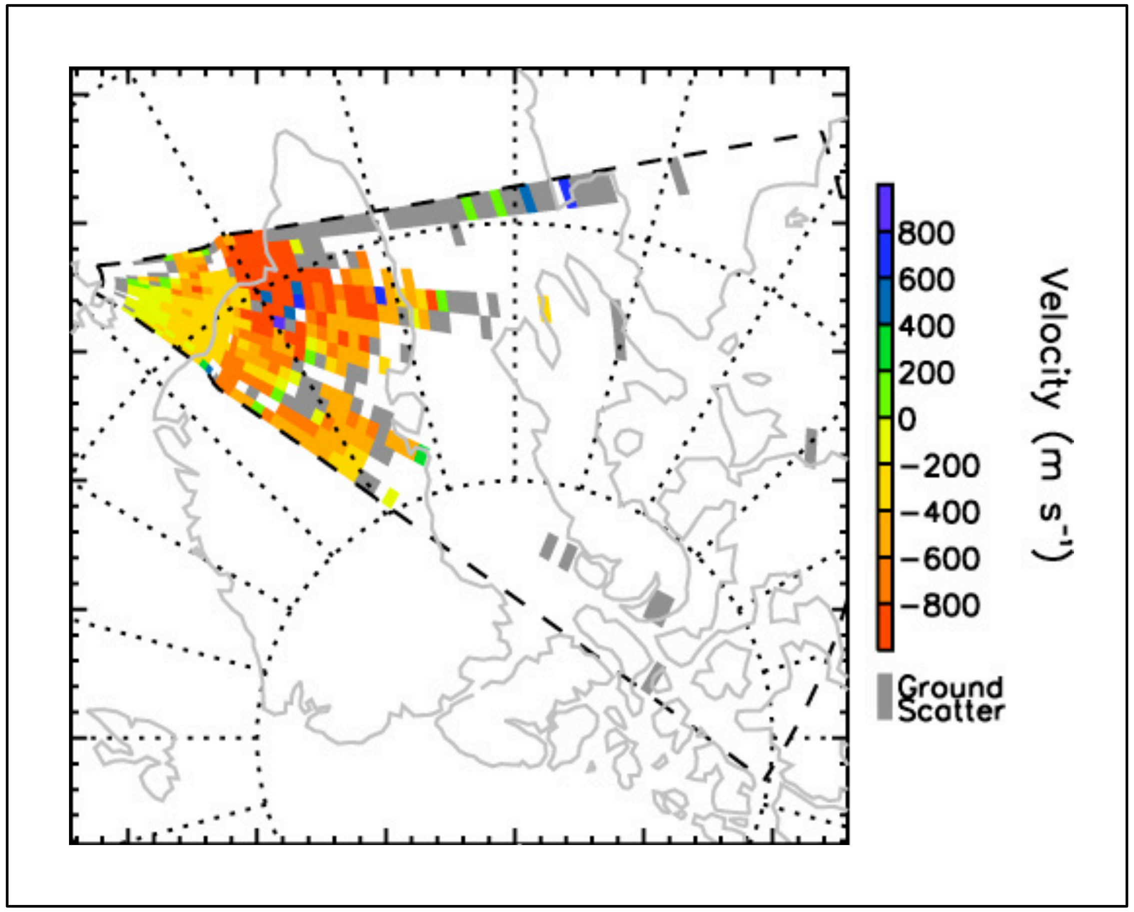
SuperDARN measured parameters

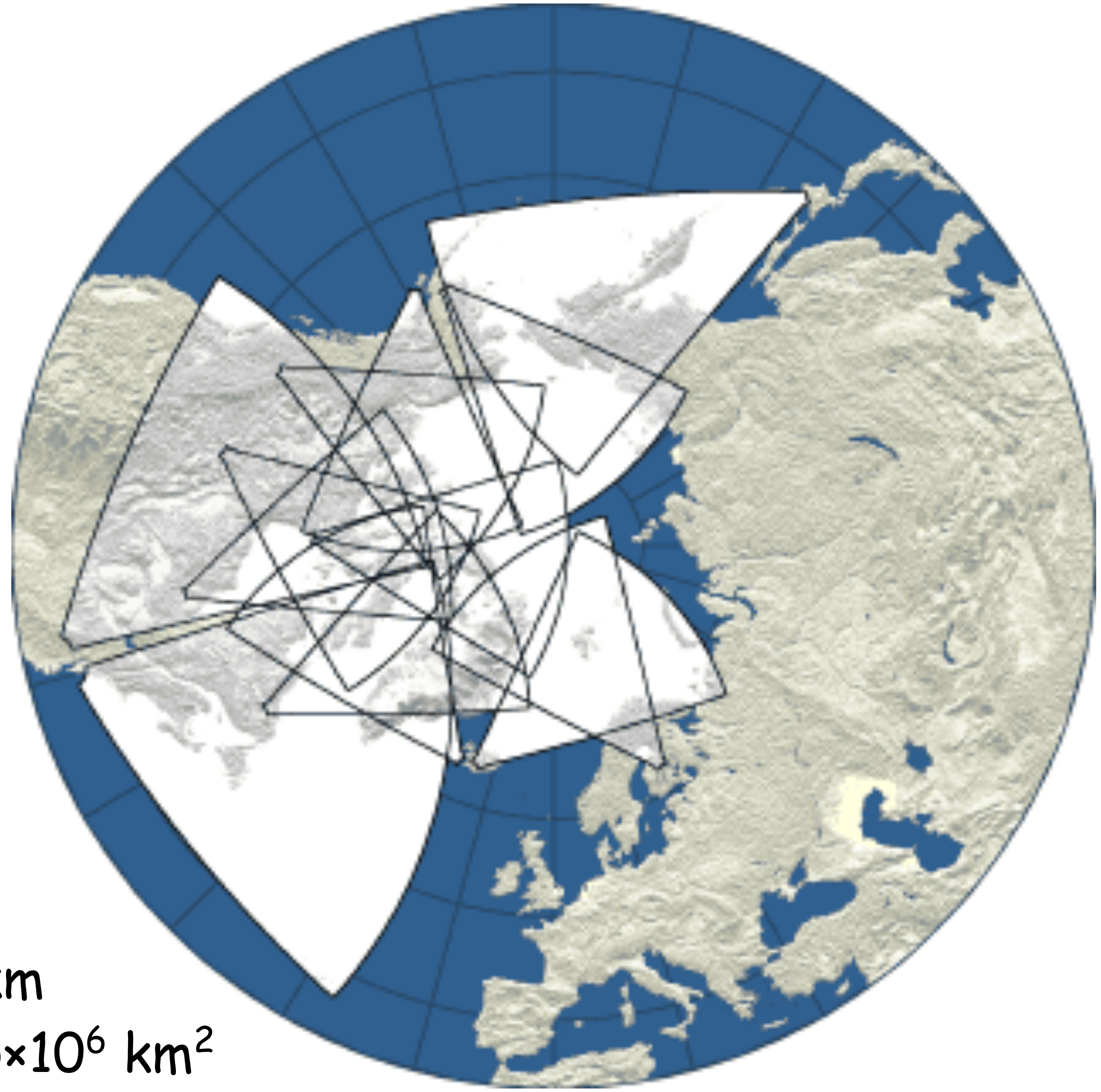
The radar transmits a seven pulse multipulse sequence from which a 17 lag complex autocorrelation function (ACF) of the returned signal is obtained.

The FFT of the ACF gives the Doppler spectrum



SuperDARN measured parameters





Field-of-view

16 beams of 75 - 120 range gates, 15 - 45 km gate length, max. range ~ 3500 km, area ~5×10^6 km^2

~3 - 7 s beam scan time giving 1 - 2 min full scan time

Advantages

Large area covered; high time resolution

Disadvantages

Line-of-sight velocity only; backscatter not ubiquitous

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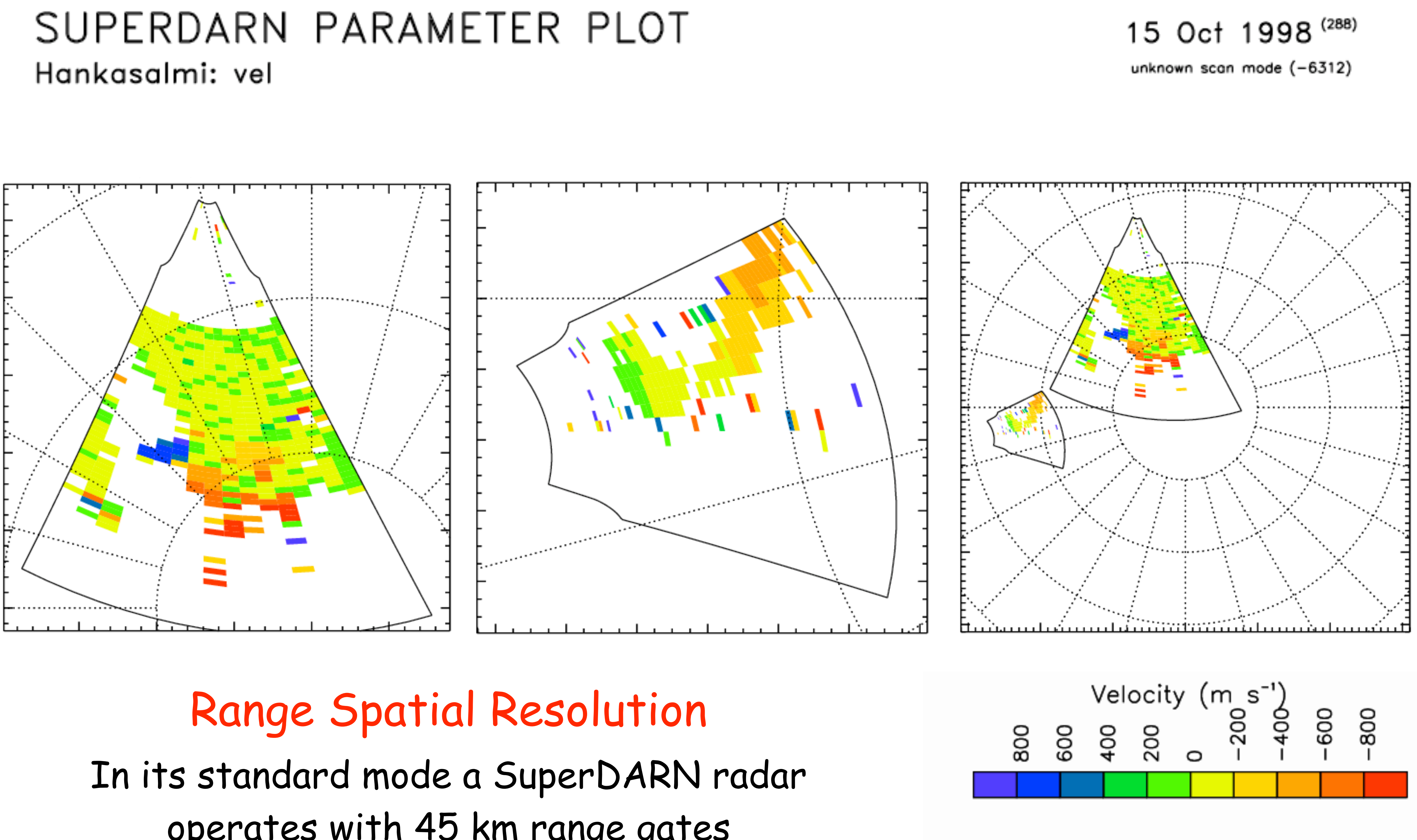

Range Spatial Resolution

In its standard mode a SuperDARN radar operates with 45 km range gates

In myopic mode it operates with 15 km range gates giving a smaller overall field-of-view but higher spatial resolution

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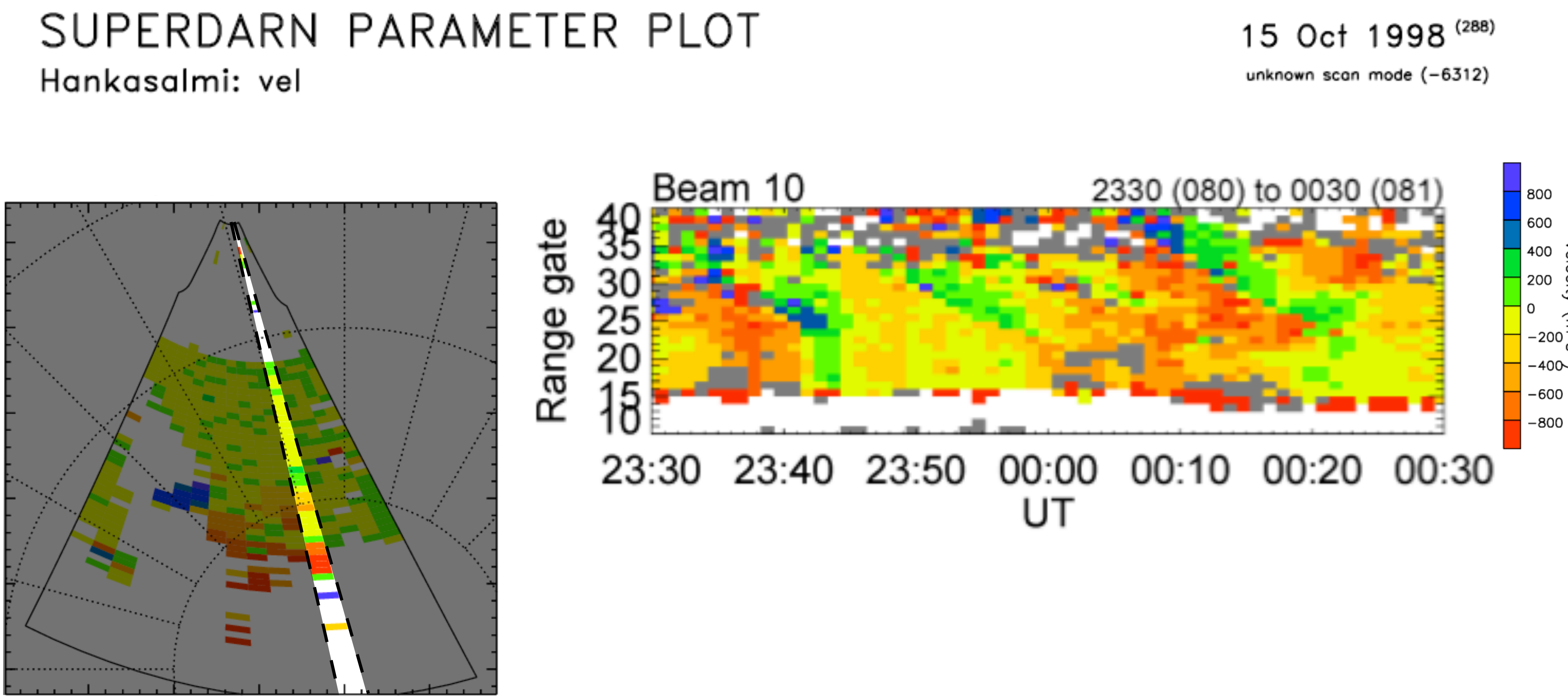

Time series analysis

Range Time Velocity: The time variability of velocity measurements within a single beam can be inspected

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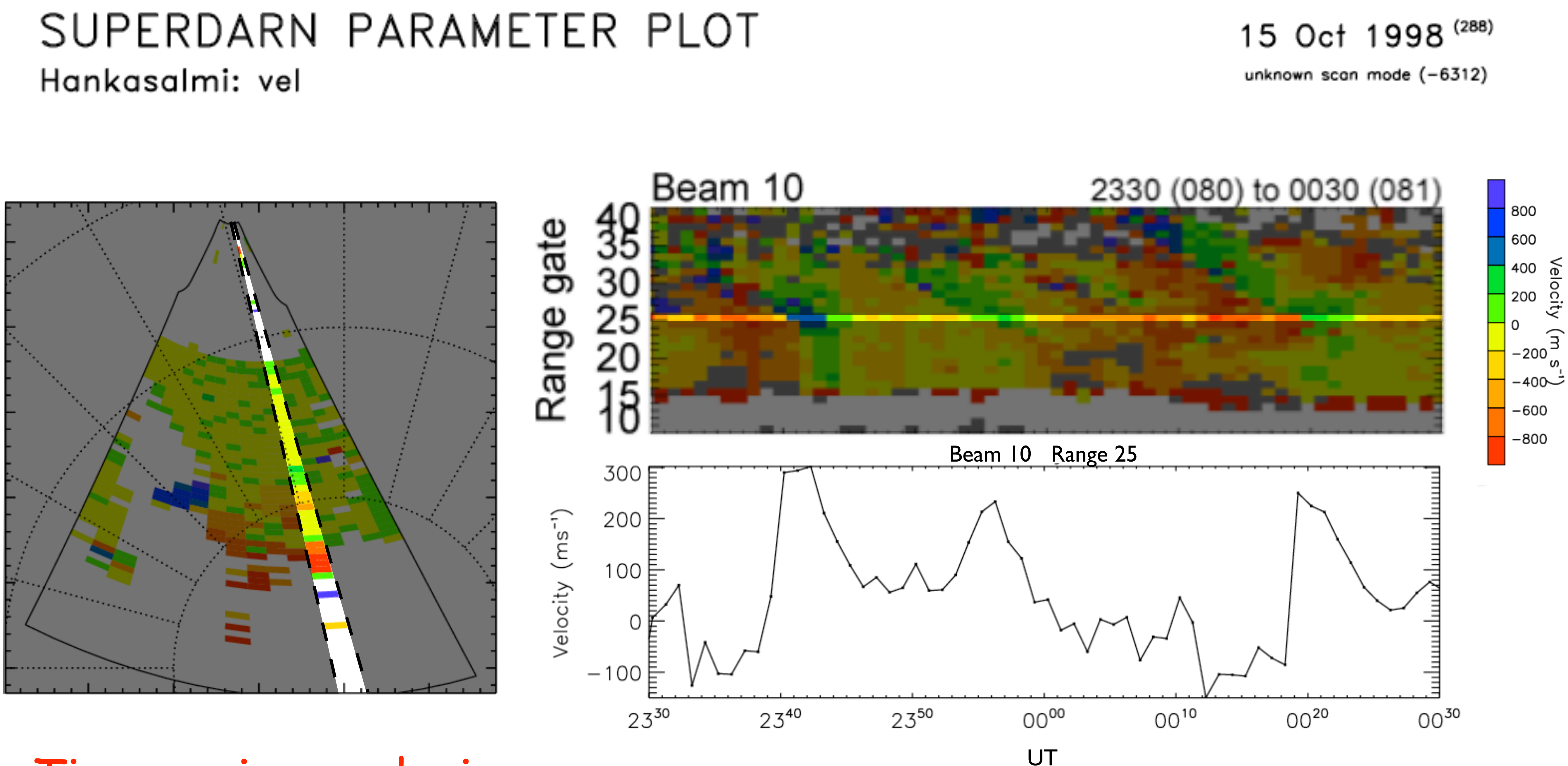

Time series analysis

Range Time Velocity: The time variability of velocity measurements within a single beam can be inspected

Range gate velocity profile: A time series of the velocity measured at a single location can also be extracted

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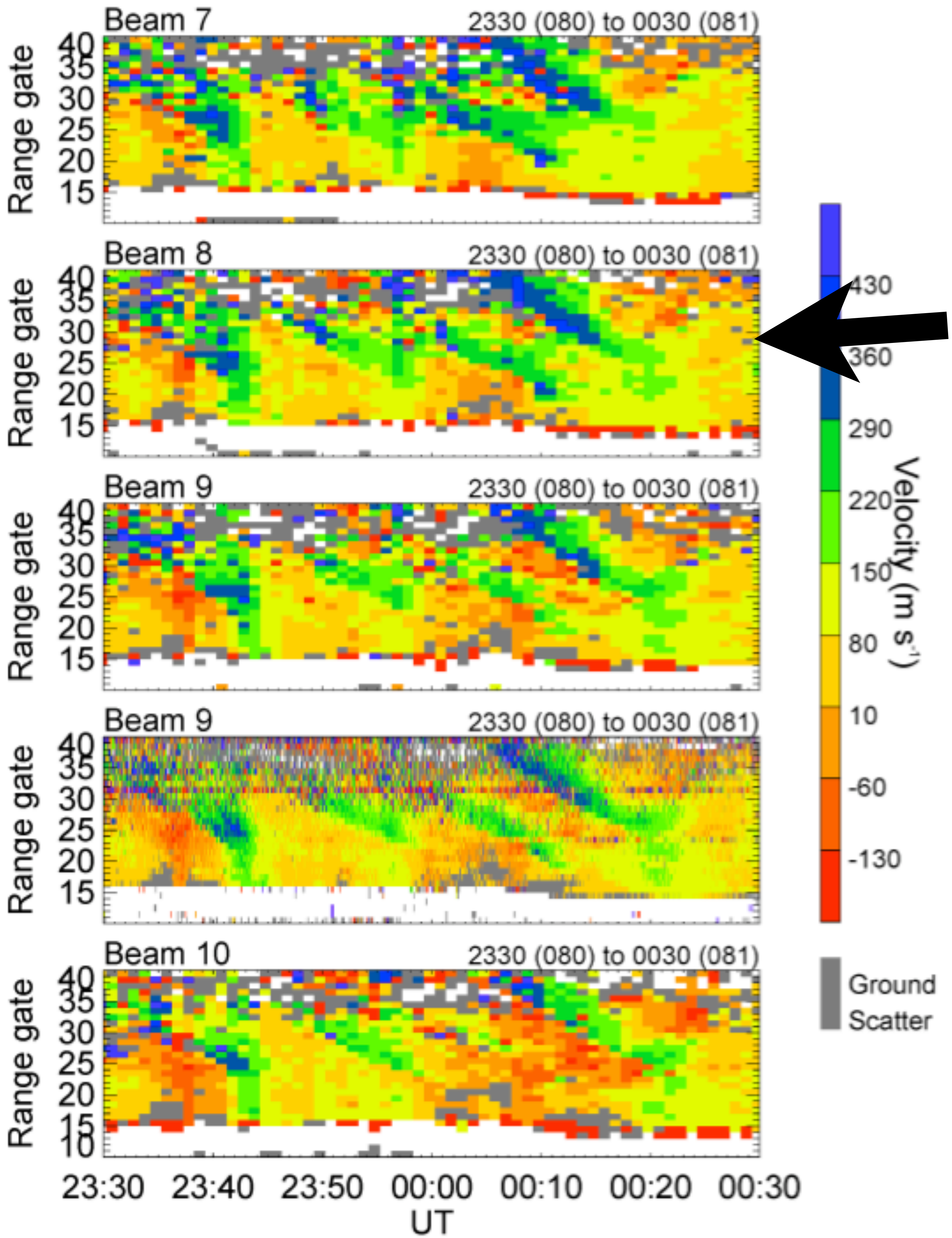
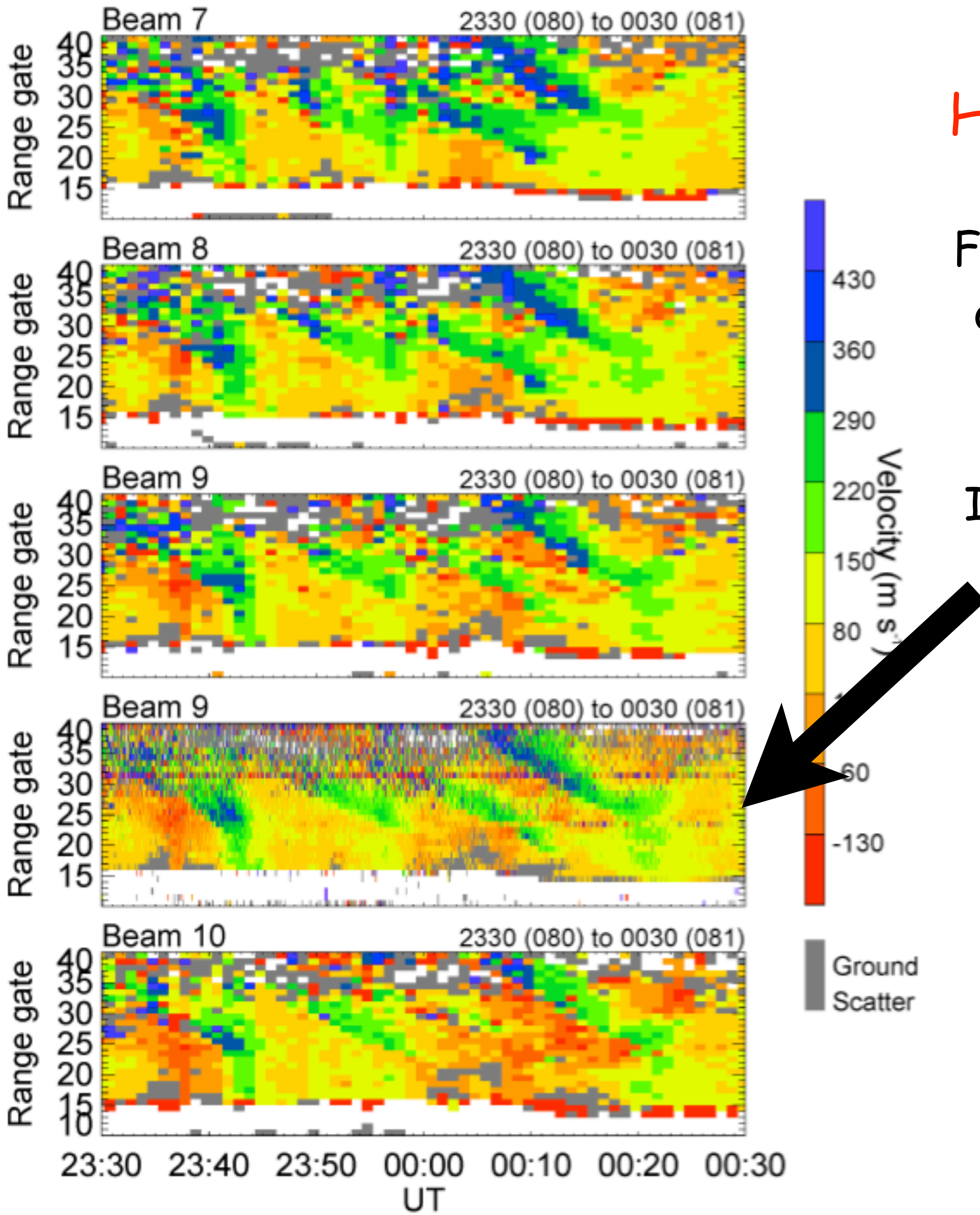
High Temporal Resolution



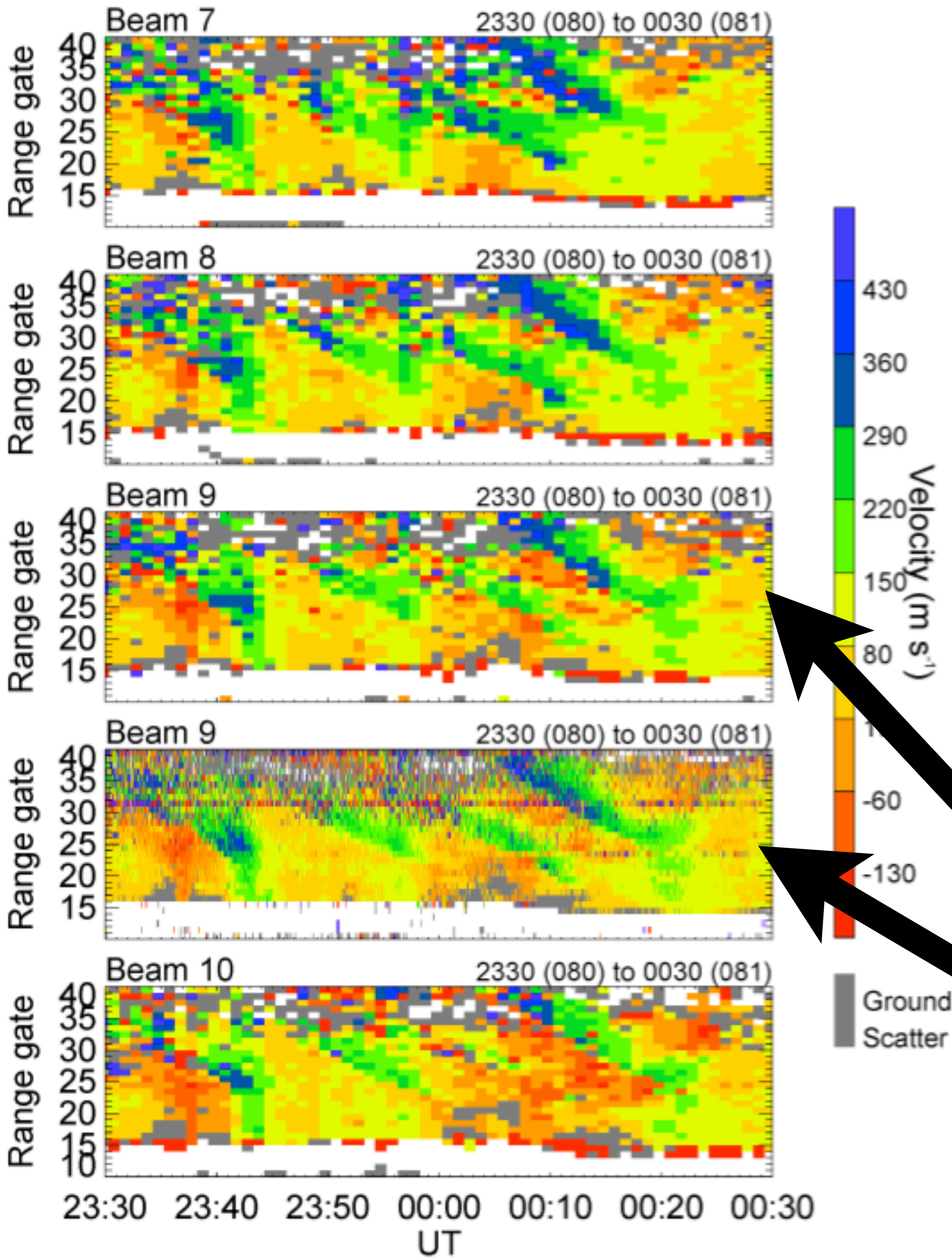
For a standard 1 min scan each of the 16 beams have a dwell time of 3 s



High Temporal Resolution

For a standard 1 min scan each of the 16 beams have a dwell time of 3 s

If a single beam is fixed then the temporal resolution of that beam will be 3 s



High Temporal Resolution

For a standard 1 min scan each of the 16 beams have a dwell time of 3 s

If a single beam is fixed then the temporal resolution of that beam will be 3 s

If the radar is 'stereo' then one channel can camp on a single beam whilst the other performs a full scan, resulting in data such as this

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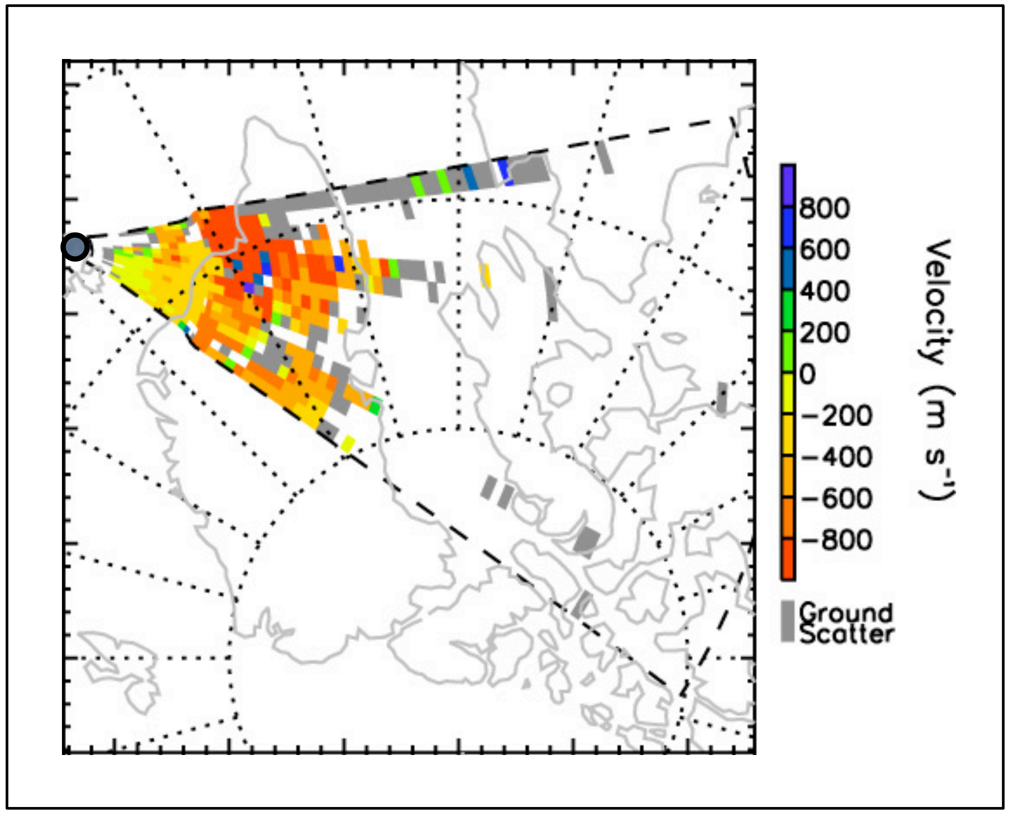
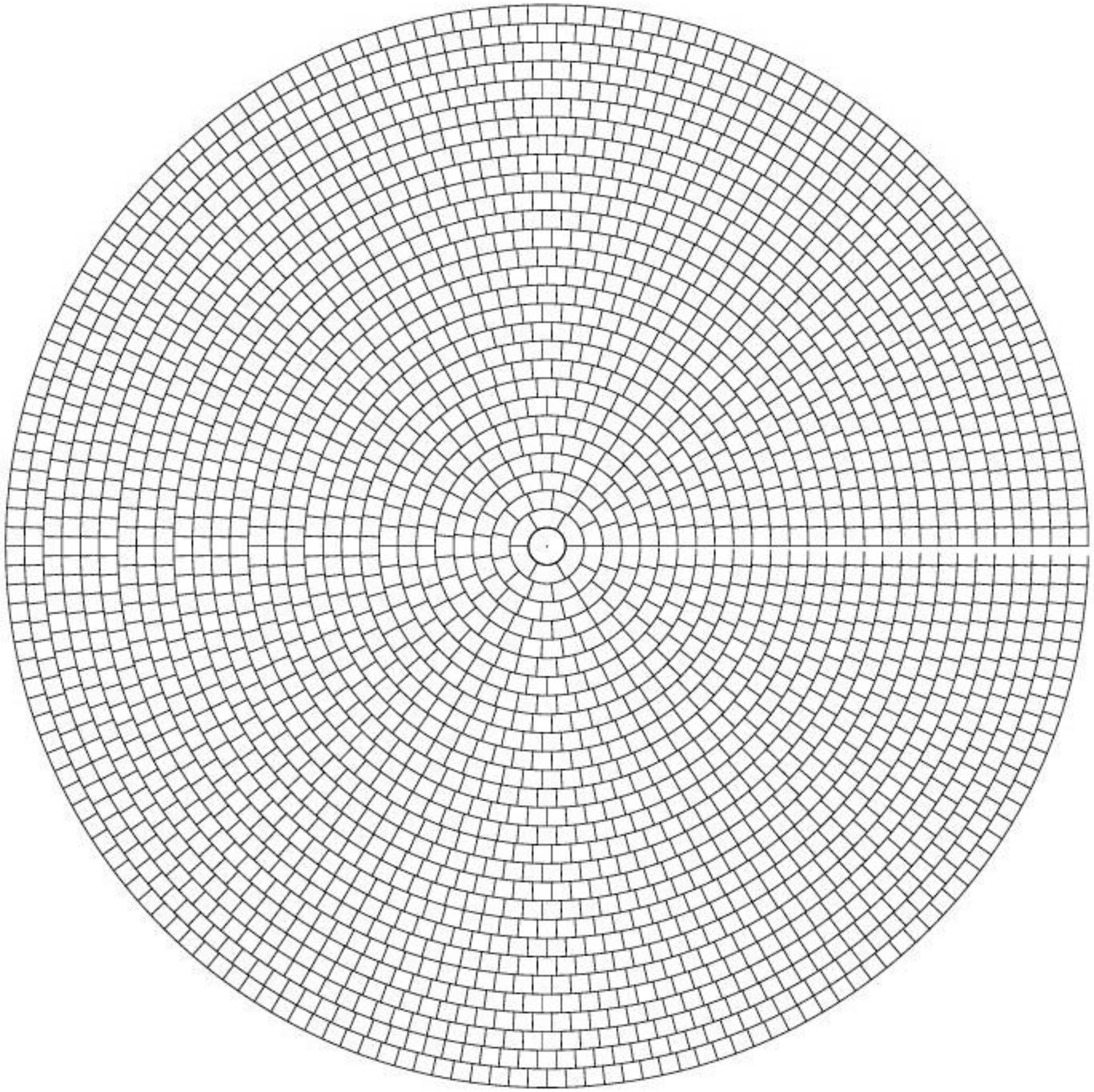
The SuperDARN "map-potential" technique
(Ruohoniemi and Baker, 1998)

Developed by APL

Combine sparse l-o-s velocities to give estimate of instantaneous, global potential pattern





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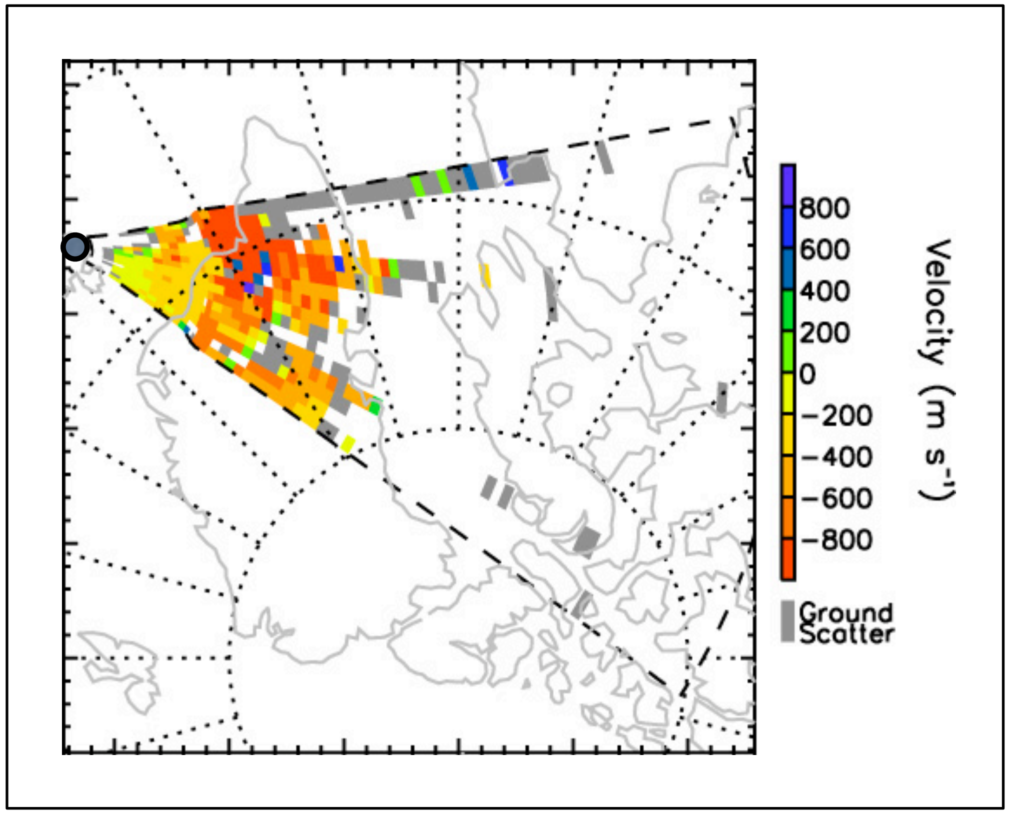

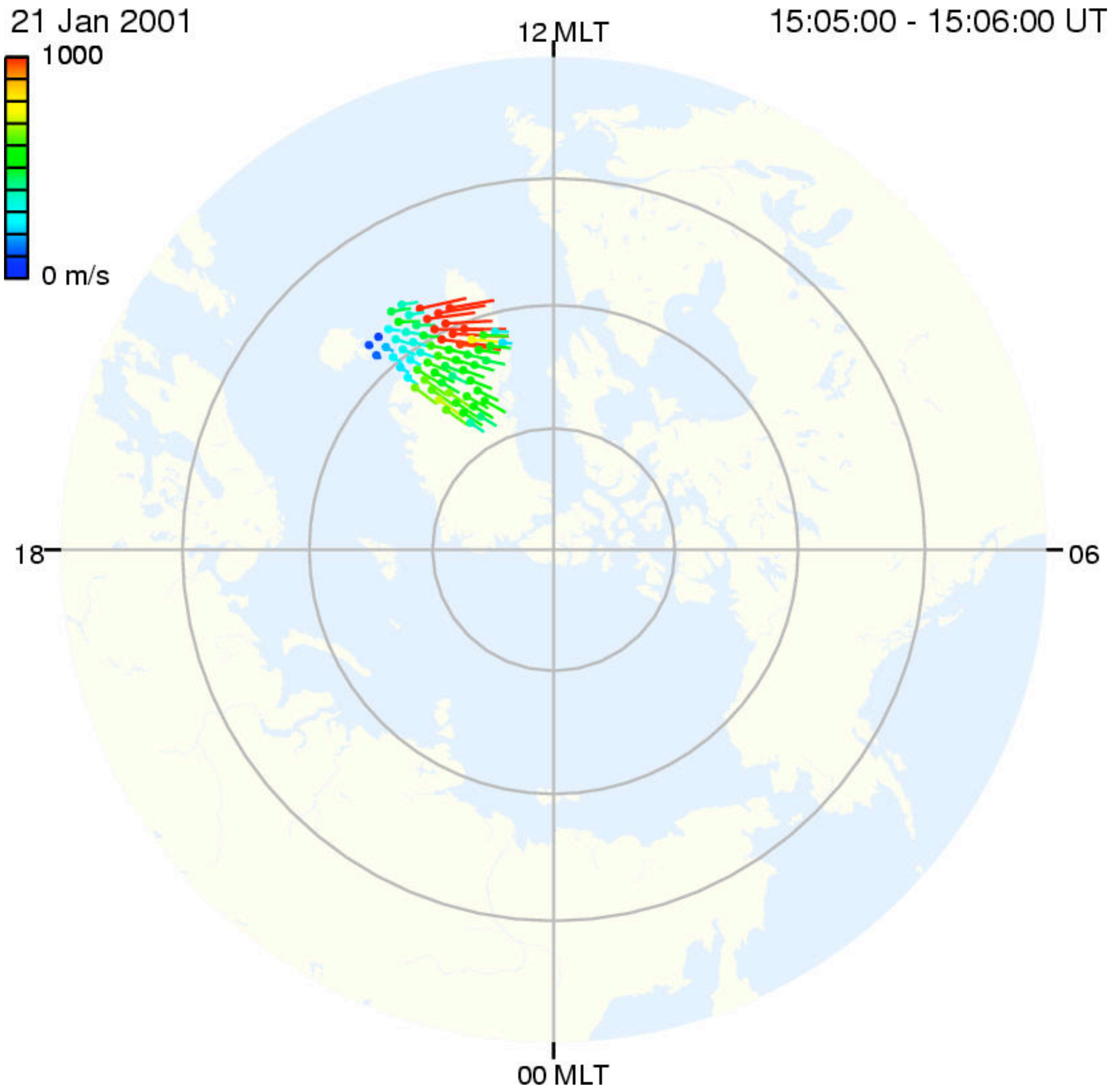

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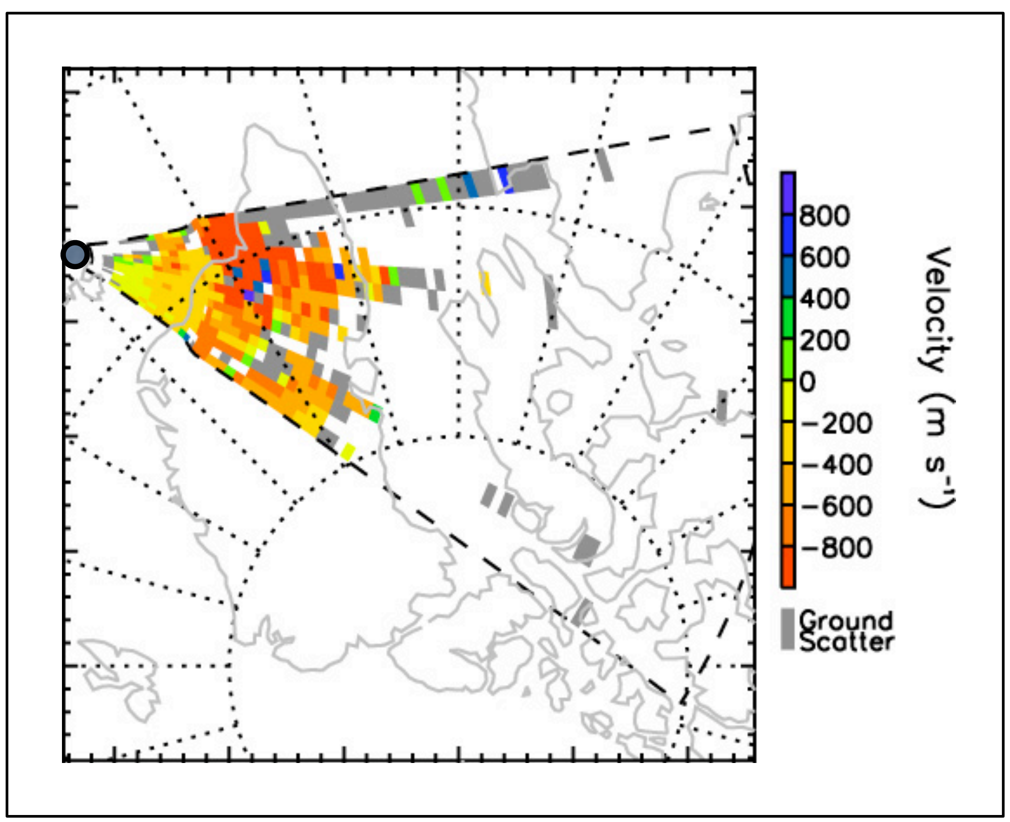

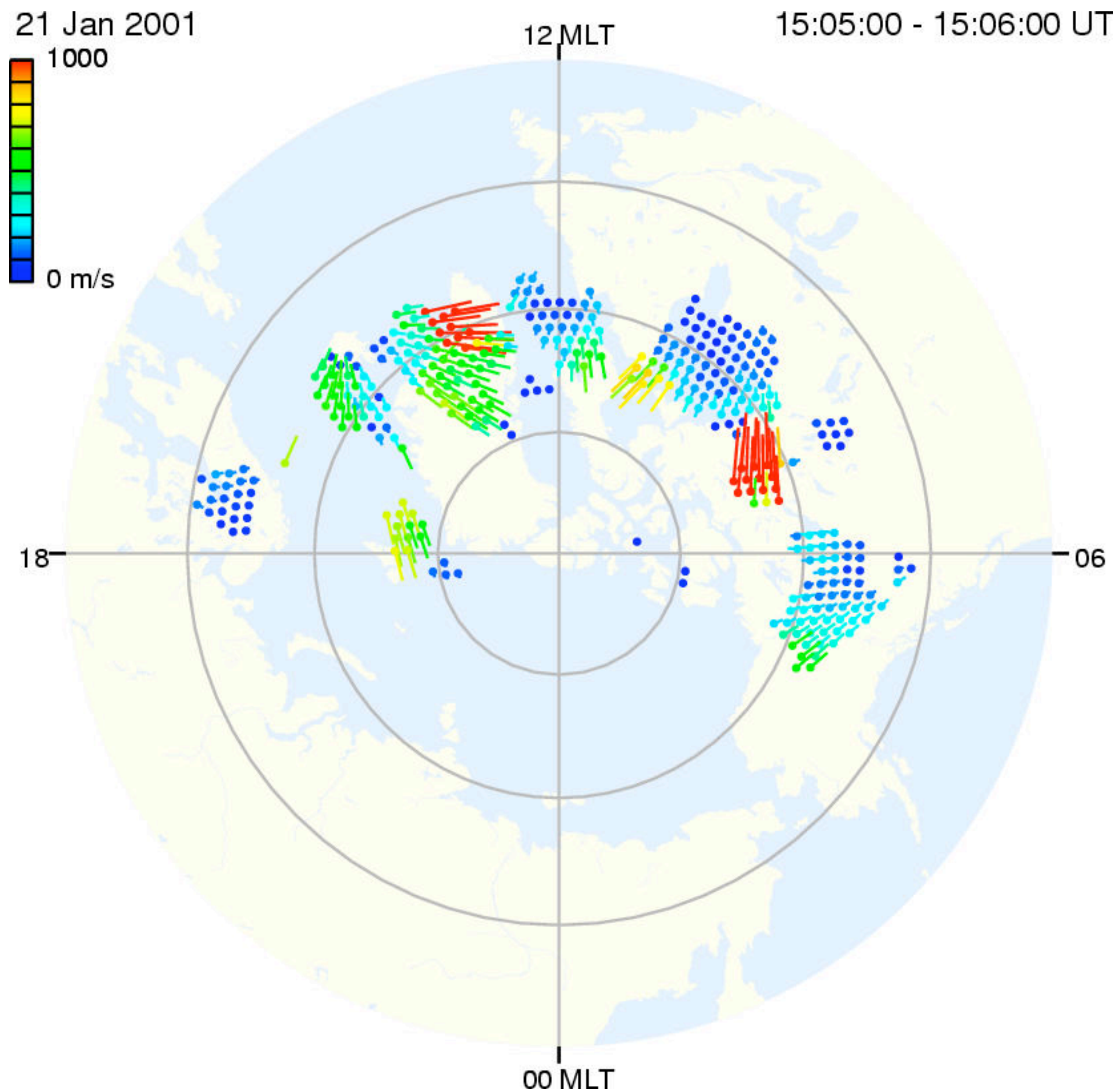

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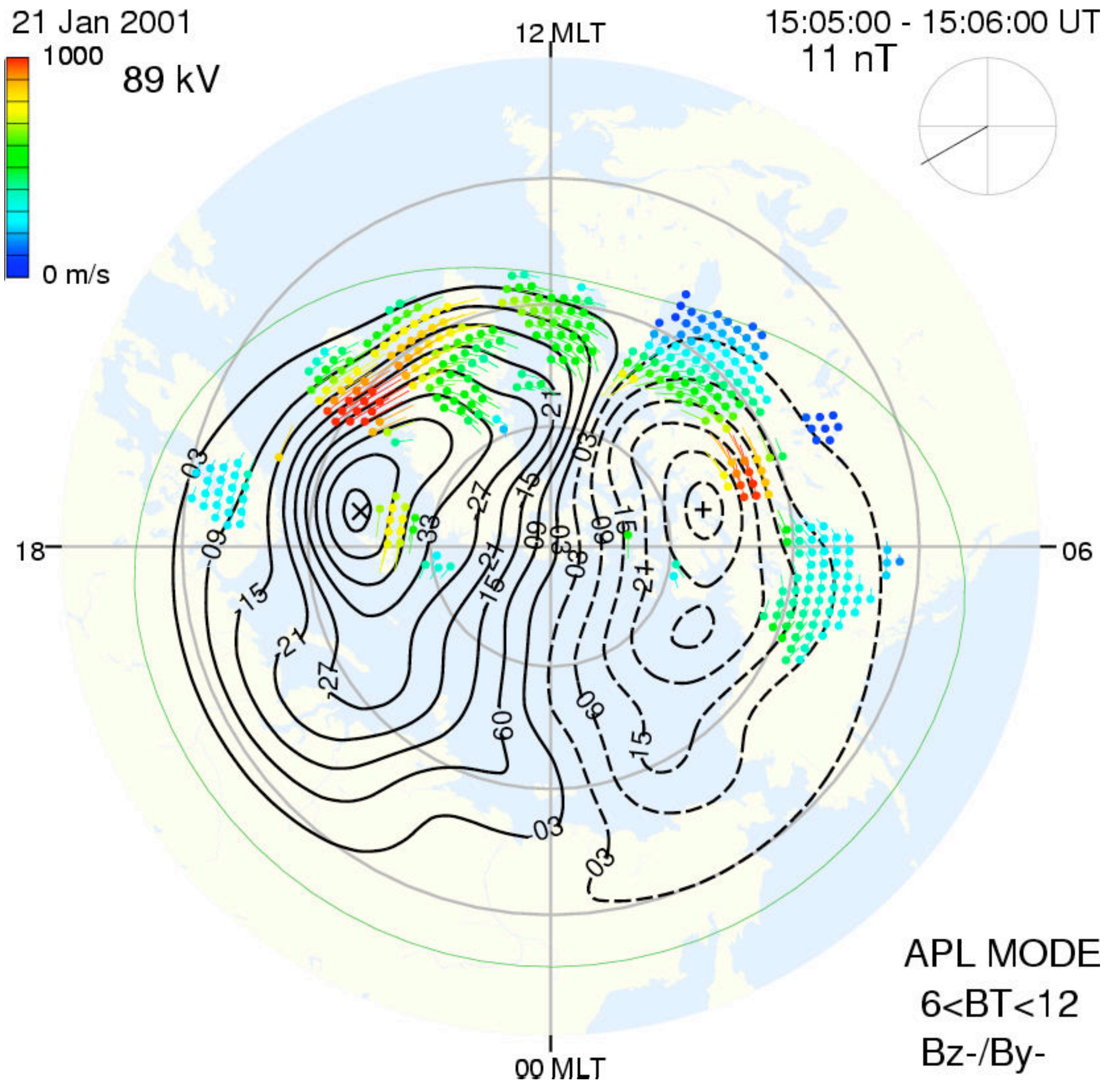

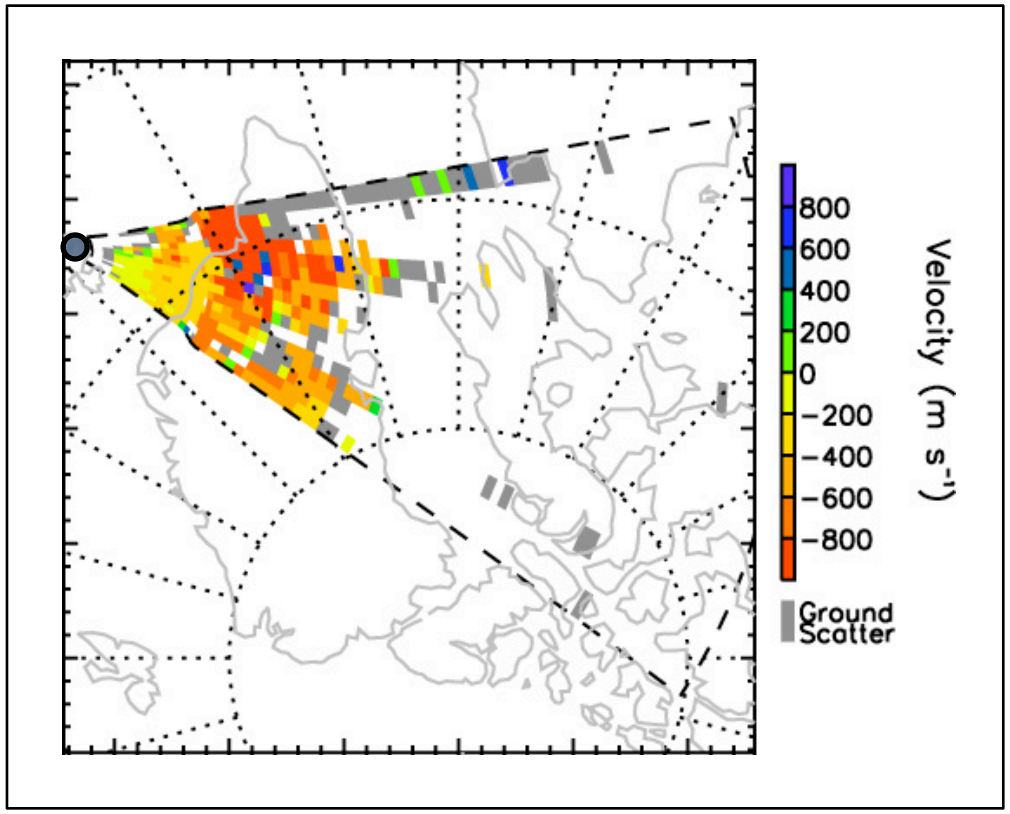

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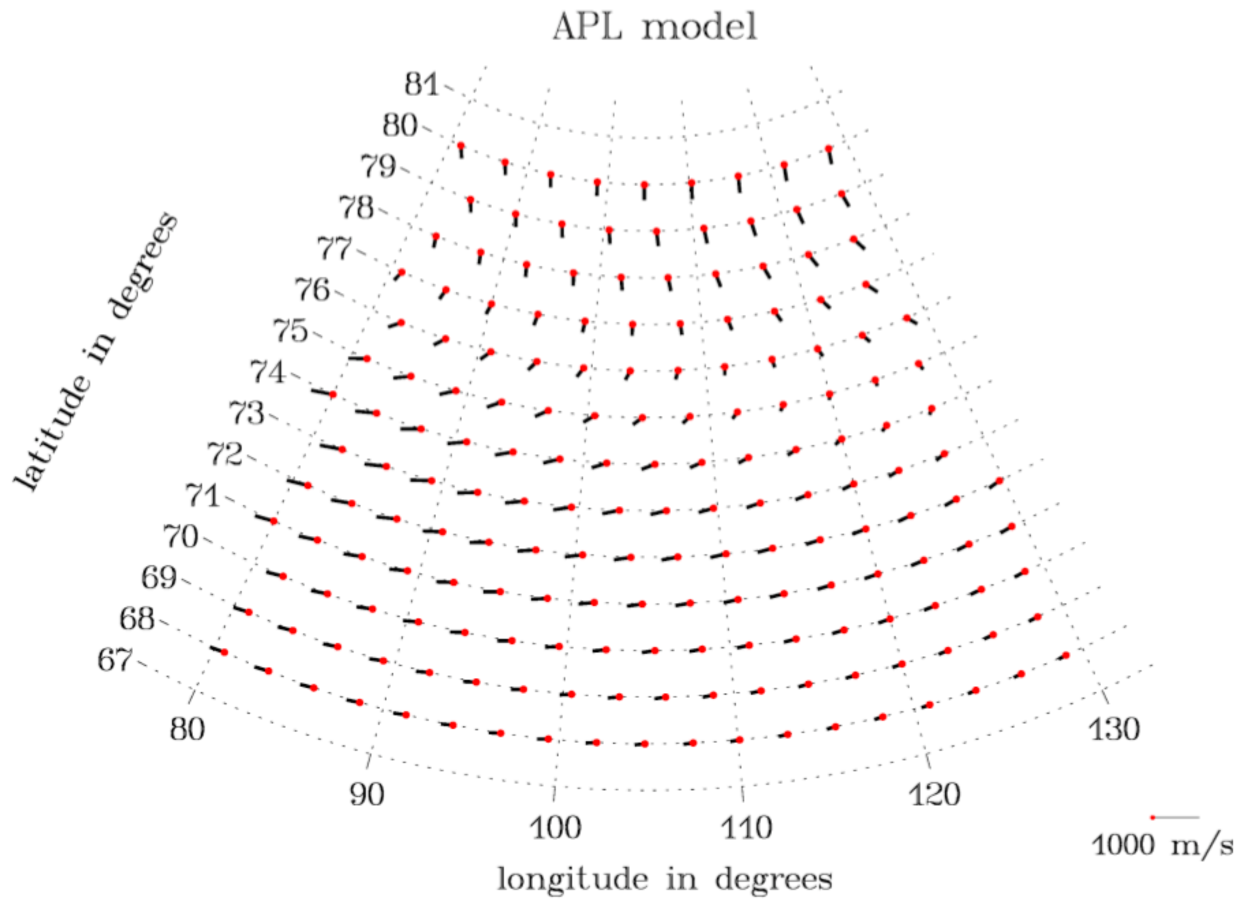
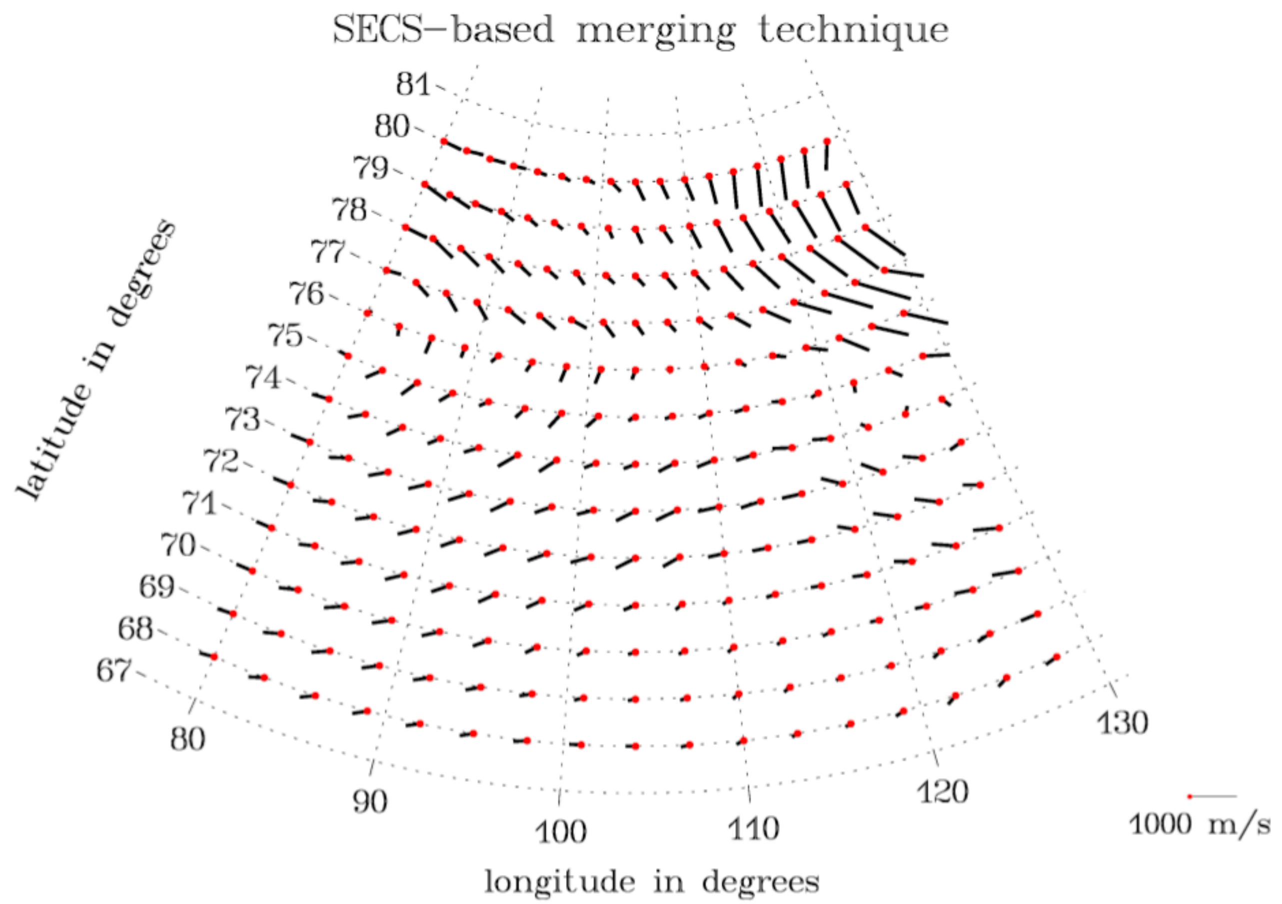
Spherical Elementary Current Systems (SECS) (Amm et al., 2009)

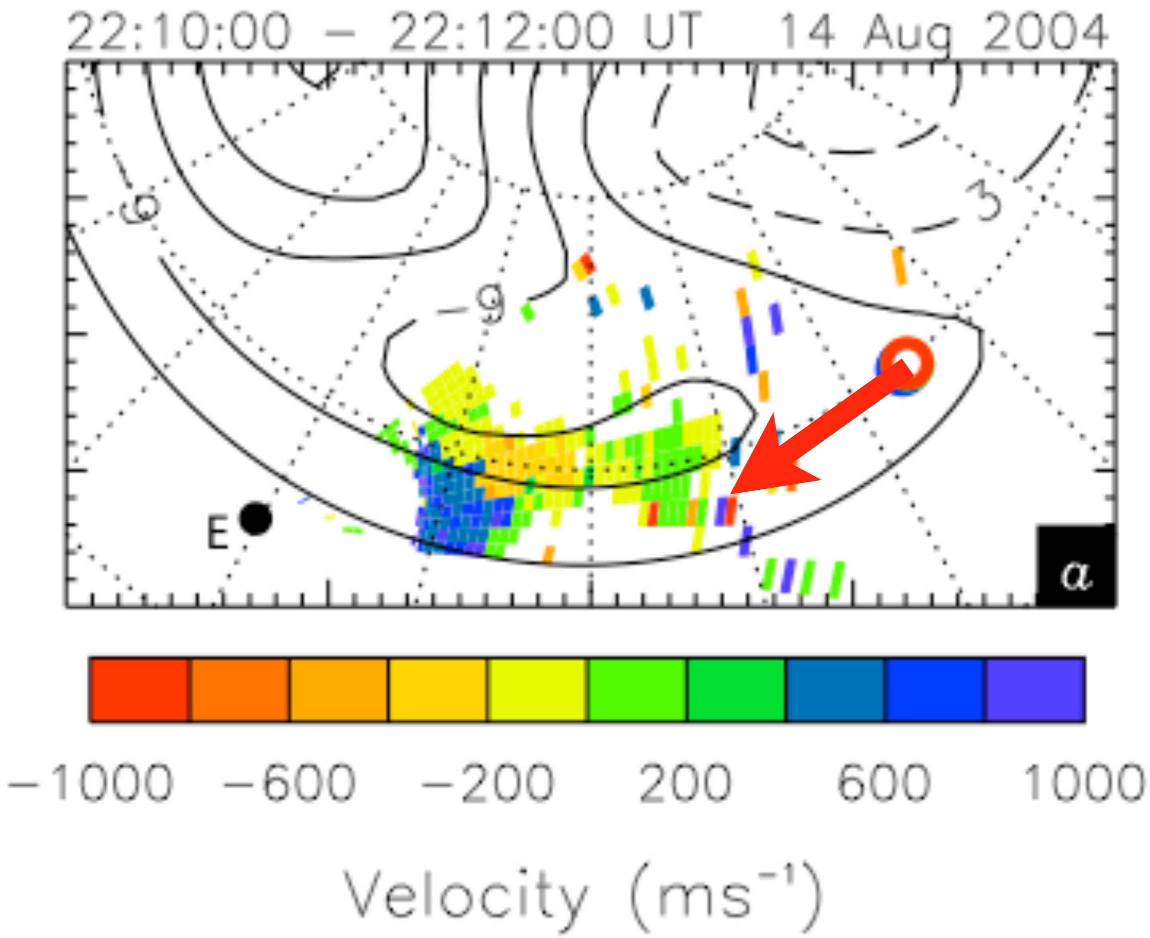


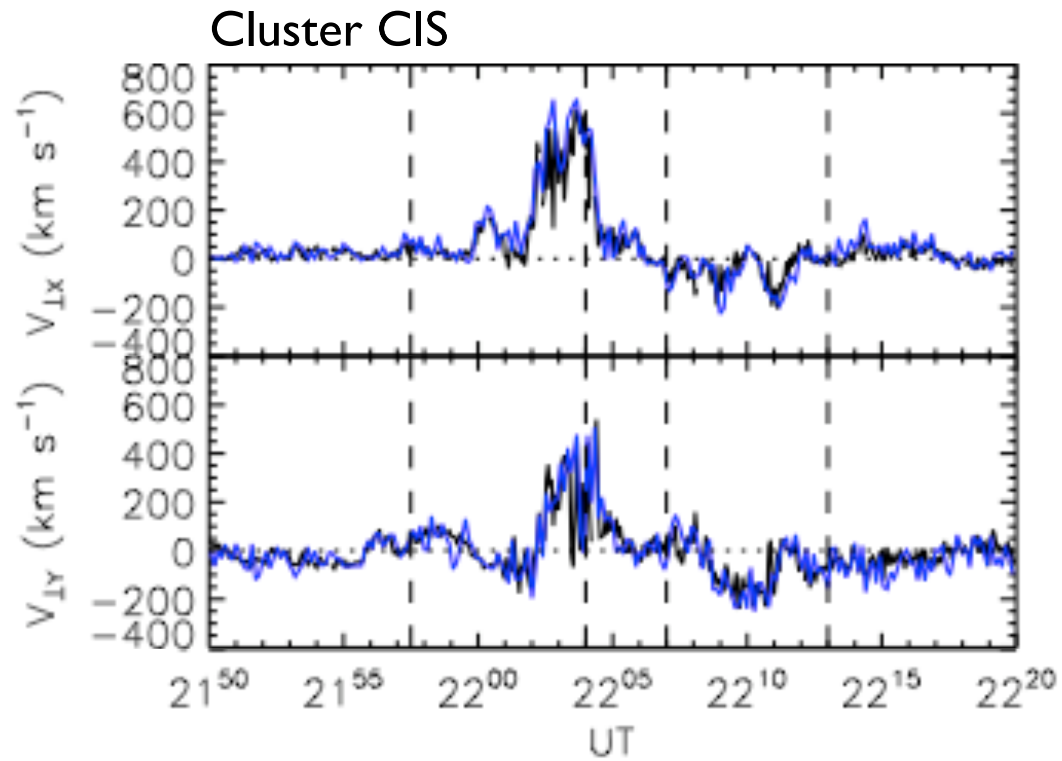


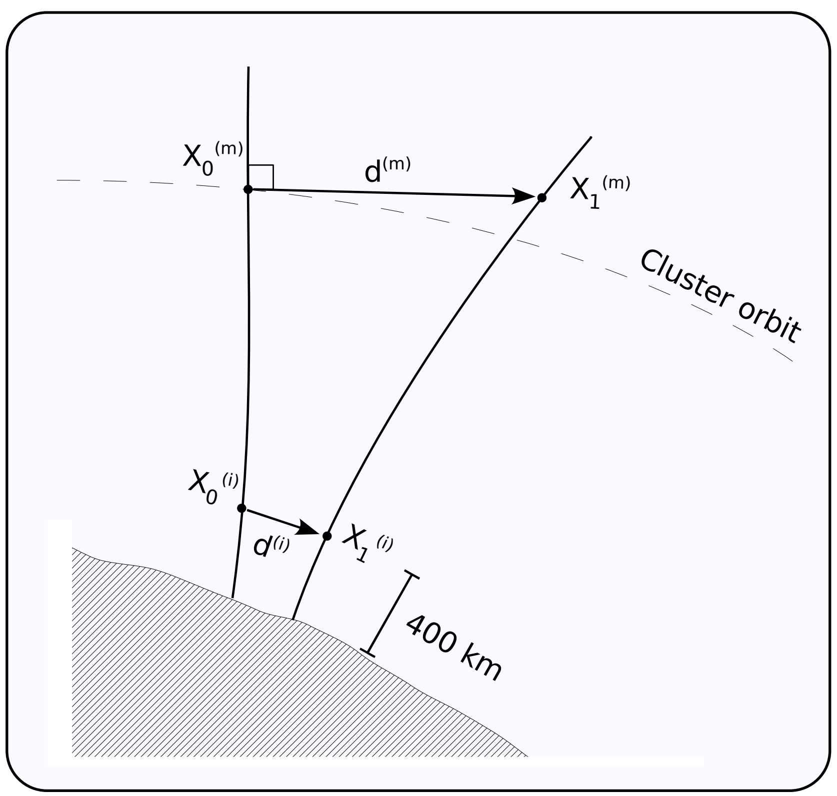
Based on a technique used to determine ionospheric equivalent currents from ground magnetometer data (Amm and Viljanen, 1999)

Involves fitting to a series of local 'poles', the locations of which can be placed freely such that they are most suitable with respect to the density of the measurements

Results in more local detail as well as better preserving the l-o-s velocity magnitudes than the global fitting technique





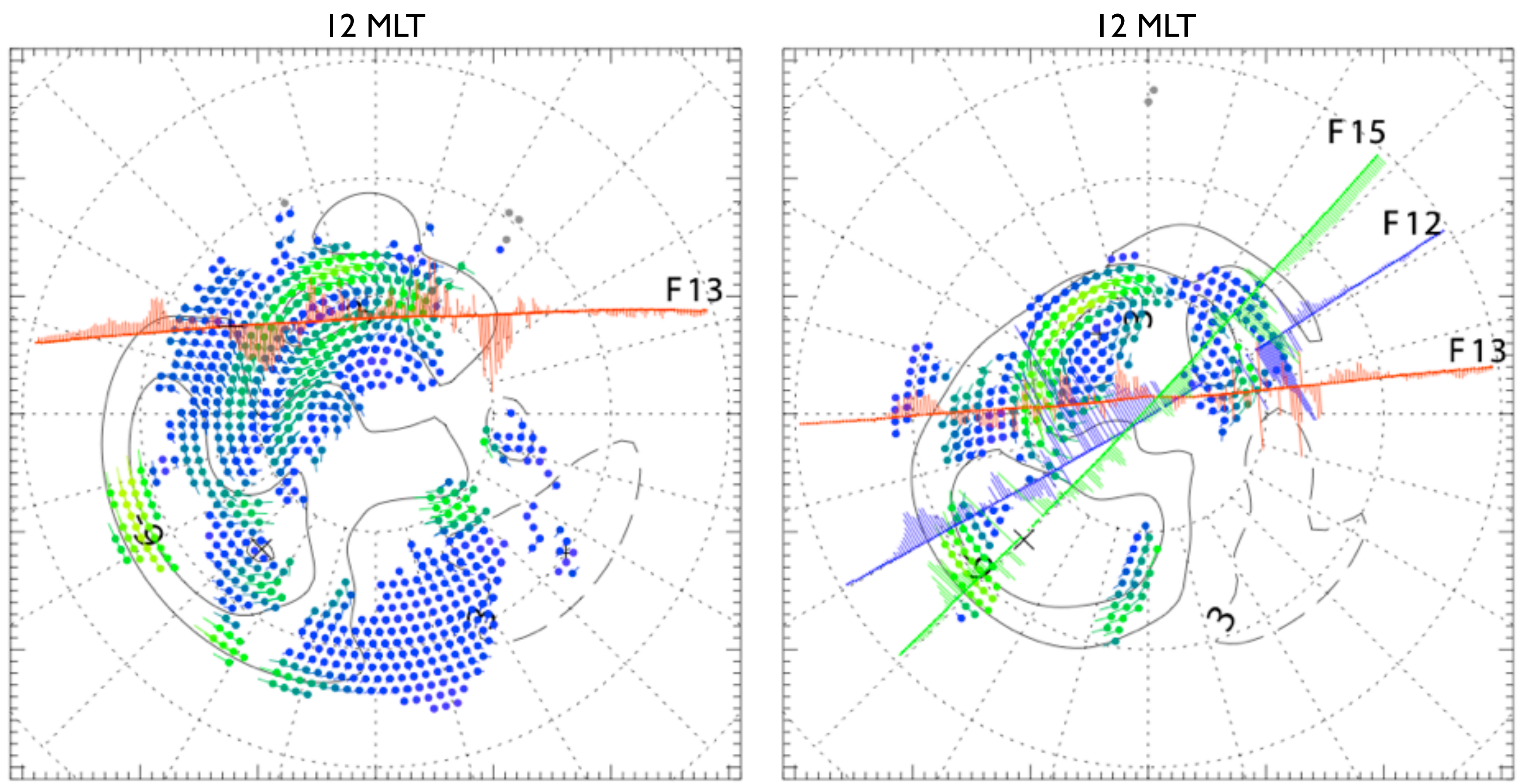


Joint space- and ground-based studies

SuperDARN velocity data can be used to relate in-situ magnetospheric observations to the macro-scale and global-scale convection

By mapping down the magnetic field magnetospheric observations can be directly compared with ionospheric observations

SuperDARN comparison with DMSP drift vector measurements



Imber, 2008

SuperDARN Map Potential convection patterns with DMSP overpasses showing the cross track ion drift overlaid

DMSP reveals flow structure on smaller spatial scales than SuperDARN, but the radars provides the global context not evident in the spacecraft data

SuperDARN map is 2 min snapshot, DMSP track covers ~20 mins

DMSP altitude is ~900 km vs. ~250 km for SuperDARN scatter

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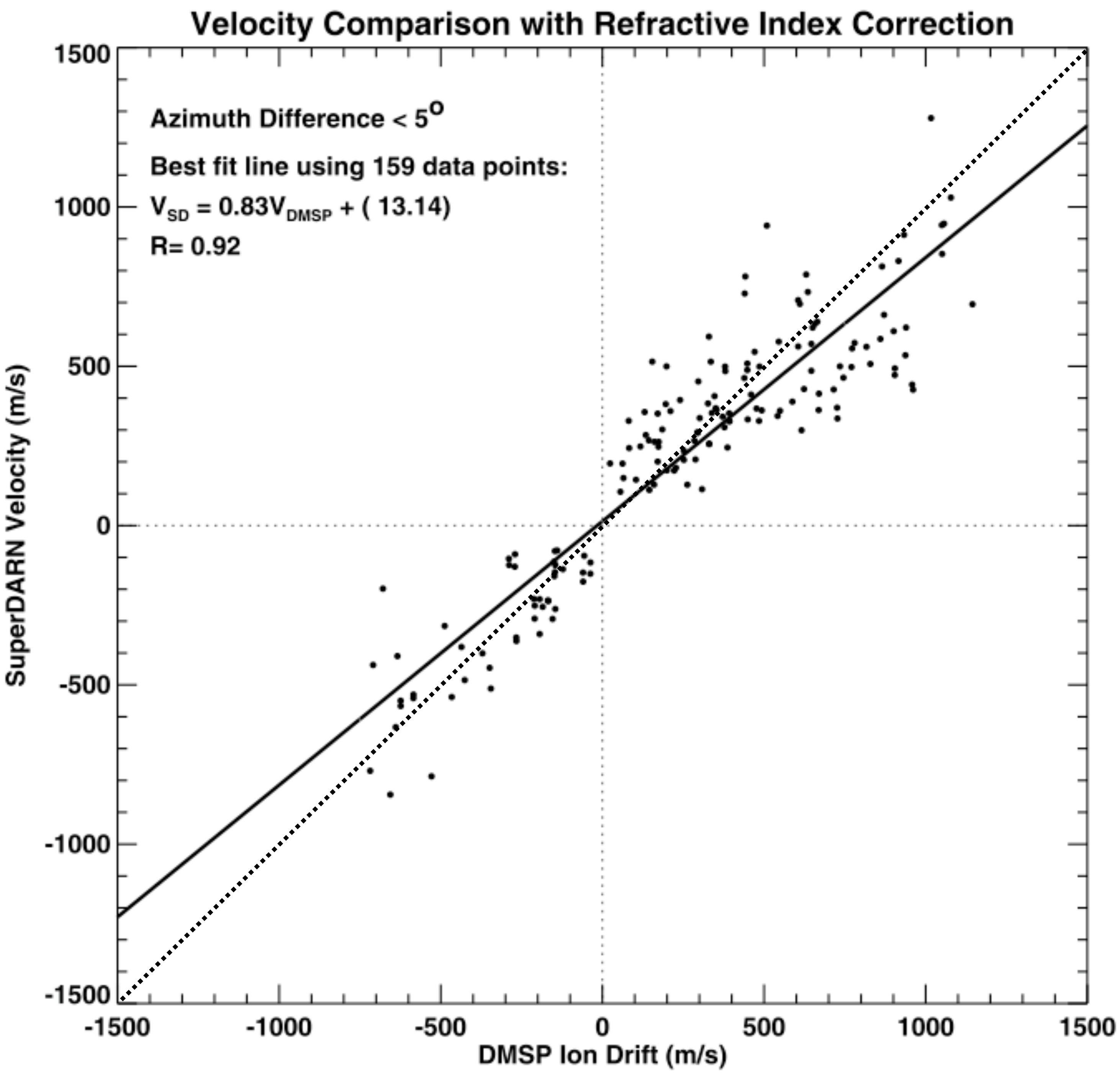
SuperDARN comparison with DMSP drift vector measurements



SuperDARN l-o-s velocity versus DMSP cross-track ion drift

Best fit suggests that DMSP measures slightly higher velocities

Overall correlation is very good (R=0.92)

Discrepancies my be caused by differences in the spatial / temporal ambiguity in measurements made by moving spacecraft - Swarm may overcome this

Gillies et al., 2009

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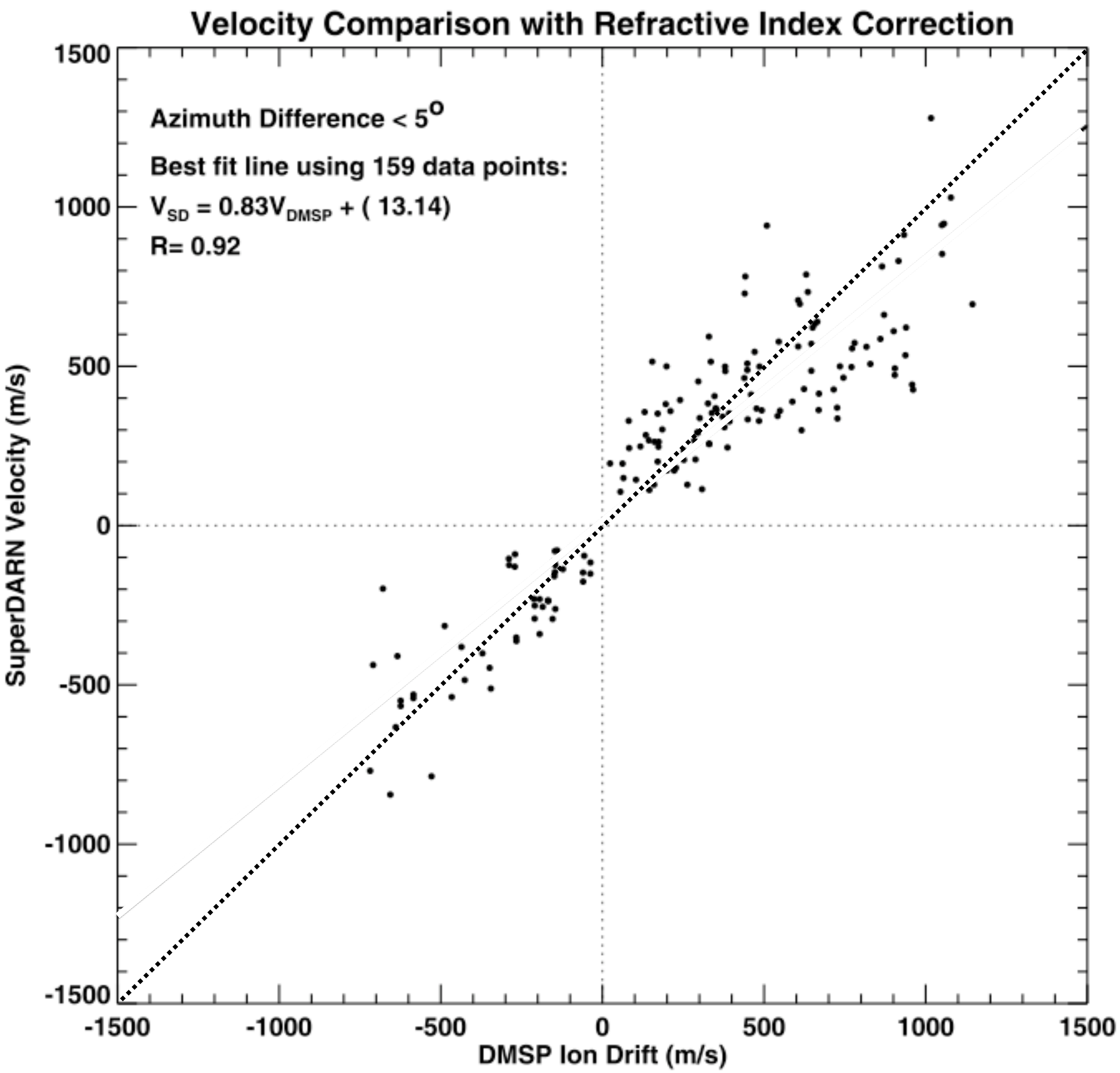

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SuperDARN gives us:

- The ability to image the global convection pattern allowing remote sensing of the state and dynamics of the magnetosphere and magnetotail, in real time

- A means to validate electric field variations over the lower part of the spatial and temporal frequency spectrum, including on the spacecraft separation scale of 150 km

- The ability to distinguish between spatial variations in the field at a give time, and temporal variations at a given location

For a more comprehensive review of SuperDARN results and capabilities see the recent review paper by Chisham et al. in Surveys in Geophysics (2007).

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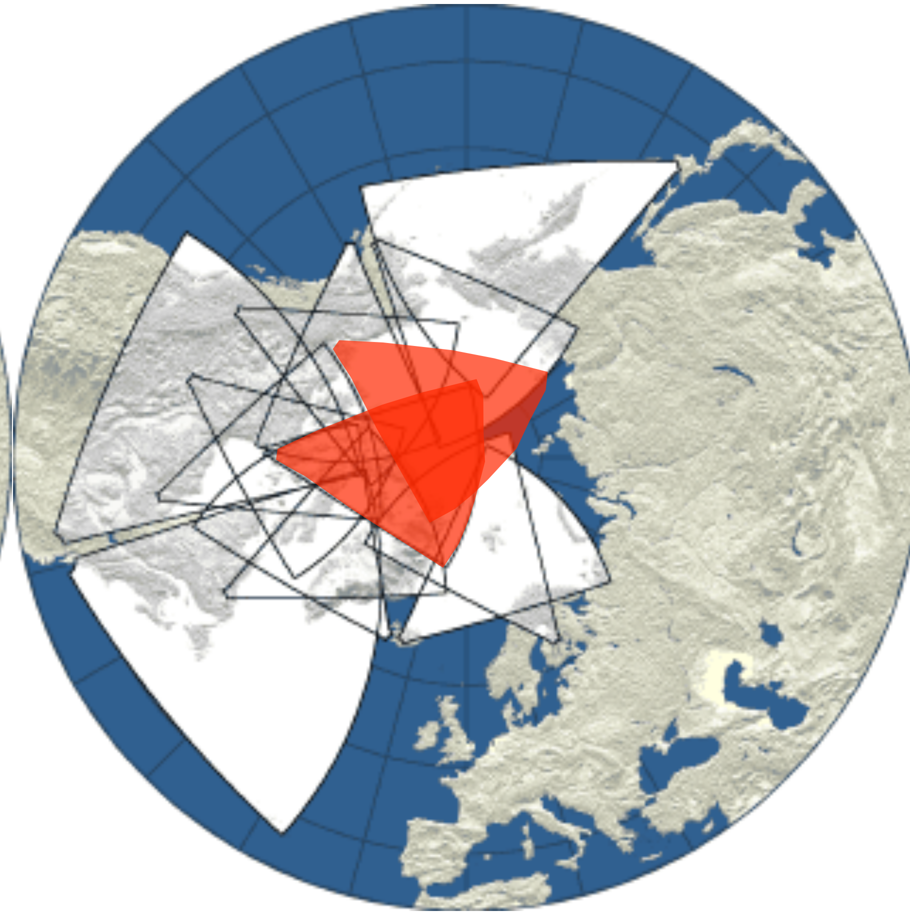
The Future of SuperDARN

StormDARN

For studying radiation belt physics and active times when the polar cap has expanded to lower latitudes



PolarDARN

Overlooking the geomagnetic pole, filling in a pre-existing gap and enabling the dynamics of the polar cap to be better understood

SiberDARN

Four new radars in Siberia to complete northern hemisphere coverage and provide fully global monitoring

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