Testing the Equipotential Magnetic Field Line Assumption Using SuperDARN Measurements and the Cluster Electron Drift Instrument (EDI)

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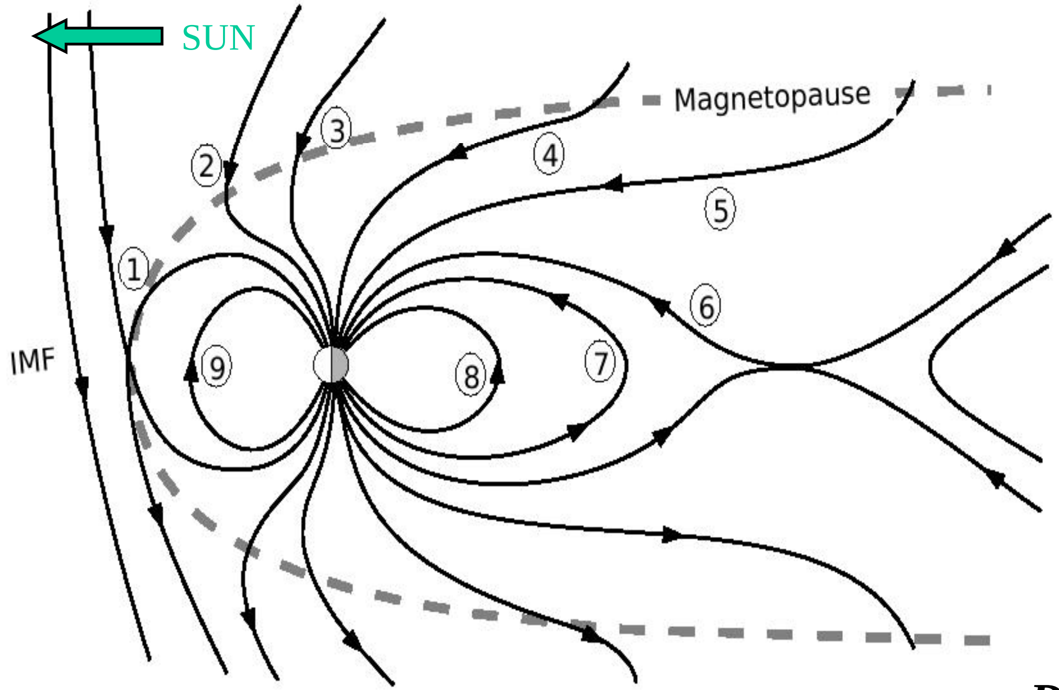
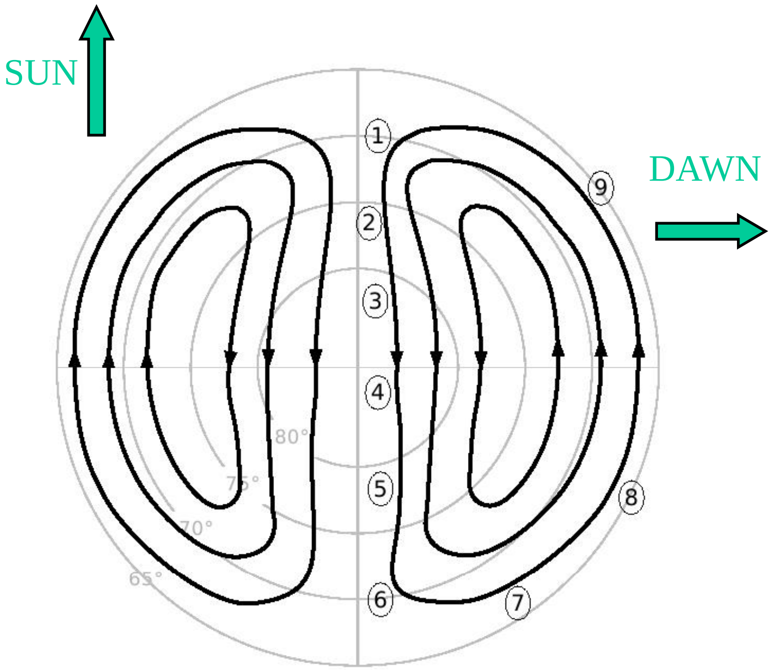
Magnetosphere-Ionosphere Coupling

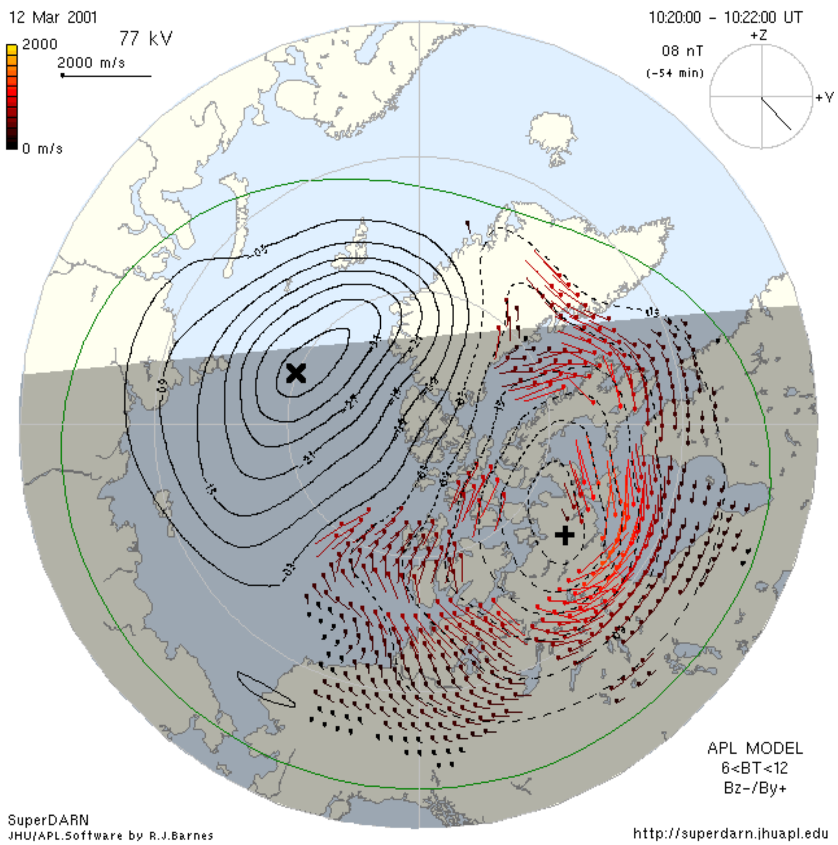


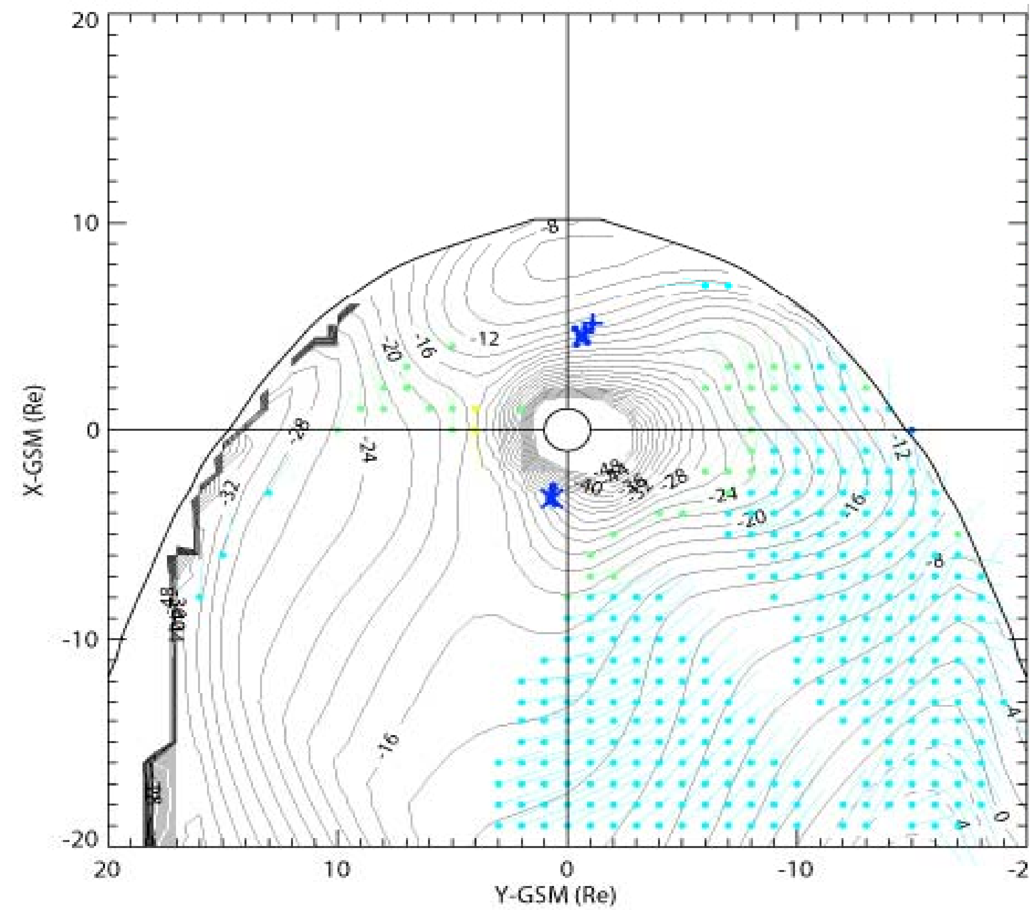


***Dungey*, 1961**

- Plasma convection in the magnetosphere driven by the solar wind and interplanetary magnetic field (IMF) is mirrored in the ionospheric convection at high latitudes.
- **<u>ASSUMPTION:</u>** Magnetic Field lines can be treated as electrostatic equipotentials

Equipotential Magnetic Field Lines?





Is this a believable representation of magnetospheric convection?

The equipotential field-line assumption can be tested using spacecraft measurements.

Testing the Equipotential Magnetic Field Line Assumption

APPROACH:

- Use an empirical magnetic field model (Tsyganenko T01) to identify the magnetic footpoint of the Cluster spacecraft in the ionosphere.
- Check to see if there are simultaneous SuperDARN measurements in the close vicinity of the Cluster ionospheric footpoint.
- Calculate an EDI estimate for what the ionospheric velocity should be at the footpoint location assuming equipotential magnetic field lines.
- Compare the EDI estimate with the SuperDARN measurements.
- Any EDI-SuperDARN inconsistencies should be a result of either:

  1) Inaccuracies in the T01 magnetic field model.

  OR 2) Violation of the equipotential magnetic field line assumption.

EDI-SuperDARN Dataset

448,431 1-minute Cluster-3 EDI values obtained between March 2001 – April 2006.

196,731 "GOOD" Cluster-3 EDI values northward of 55° MLAT.

11,882 "GOOD" EDI values with SuperDARN data within 100km of the T01 footpoint.

8,199 "GOOD" EDI values remain after other selection criteria are satisfied.

e.g. Exclude interplanetary conditions that do not produce nominal T01 performance.

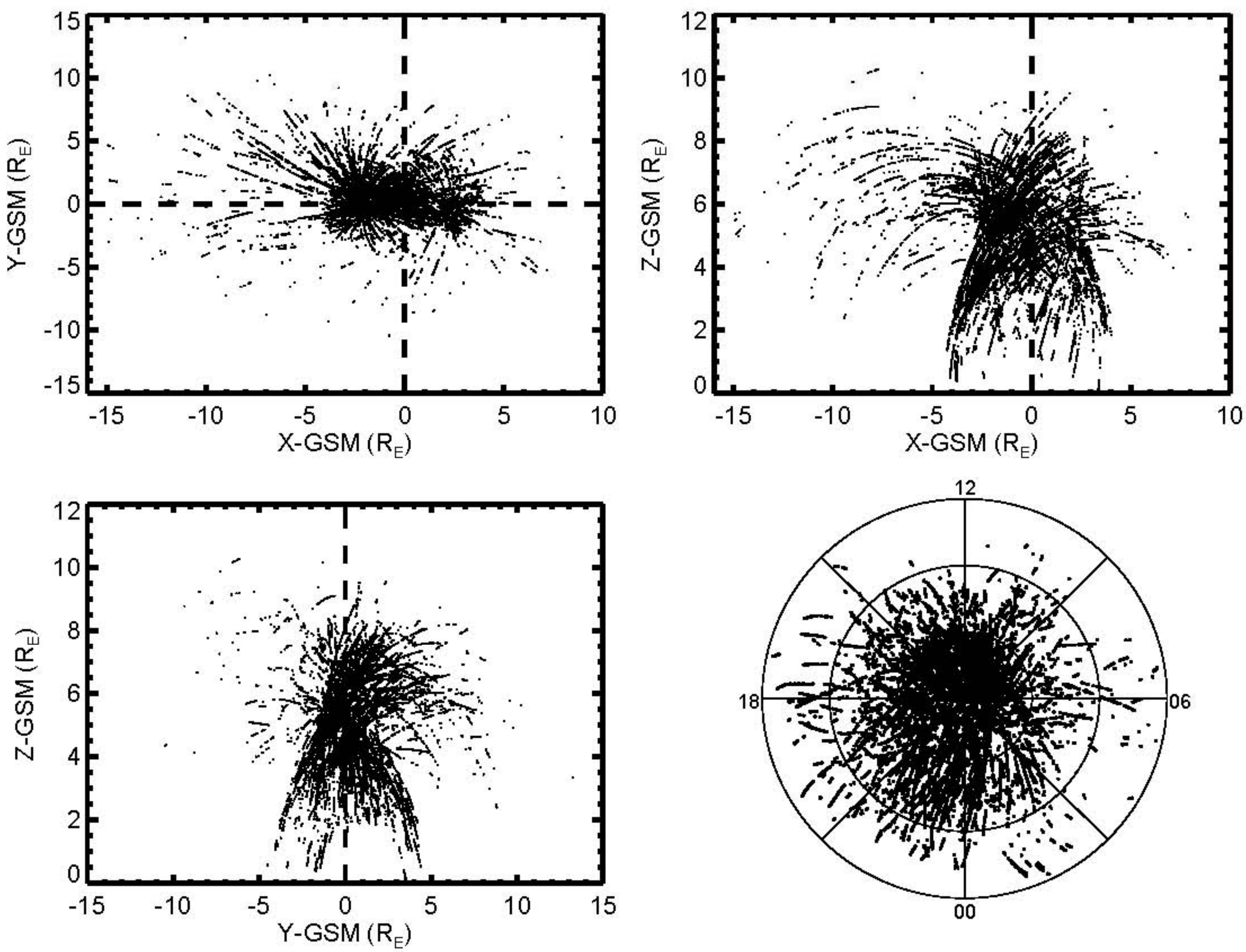
e.g. Exclude periods when the T01 model is inconsistent with Cluster FGM.

15,013 SuperDARN V_{LOS} measurements within 100km of the selected EDI footpoints.

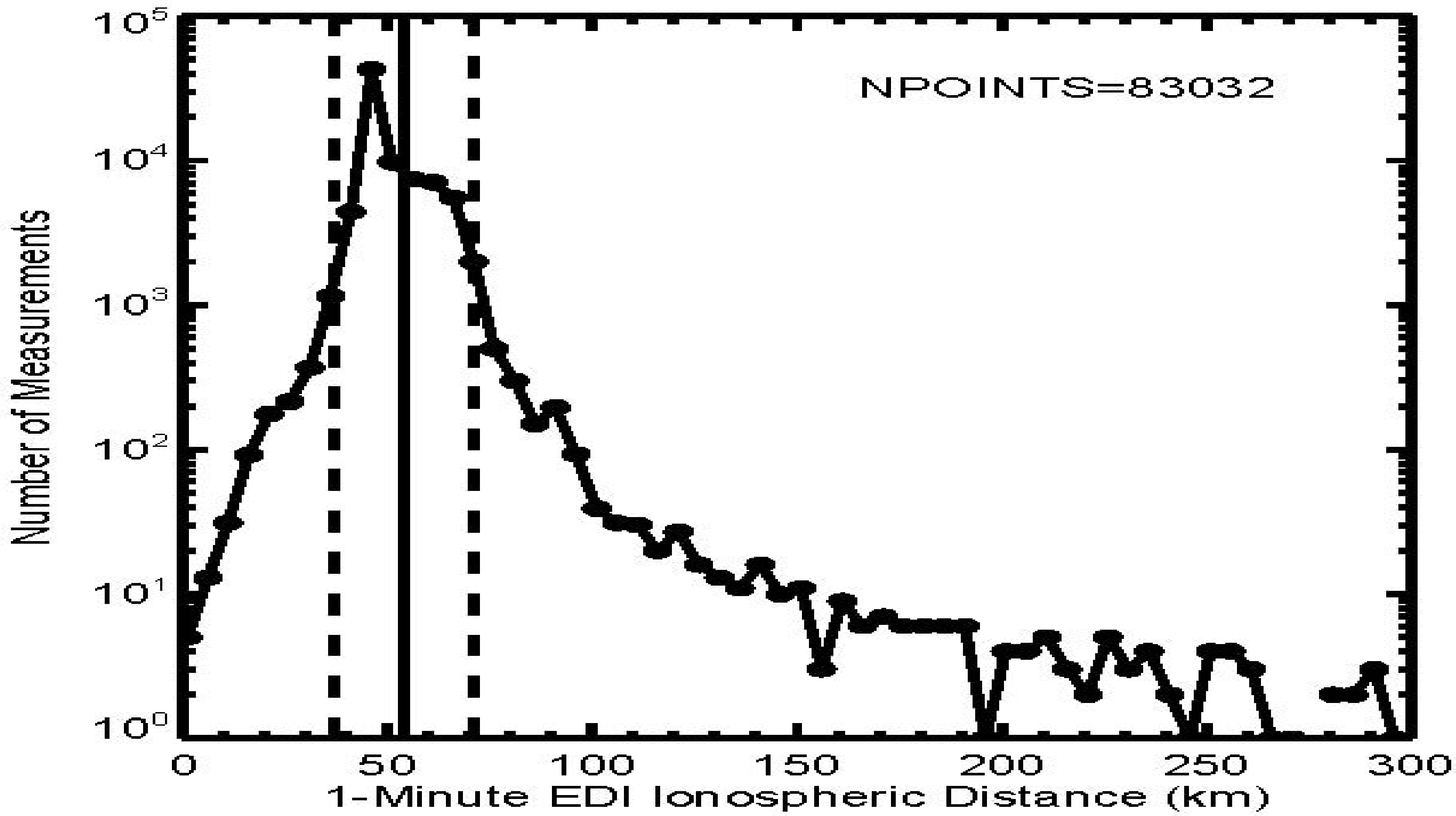
→ 15,072 EDI - SuperDARN data pairs within 100km of each other.

NOTE: Widening the search radius to 250 km and using the same selection criteria yields 97,235 EDI–SuperDARN data pairs.

Conjugate EDI-SuperDARN Locations

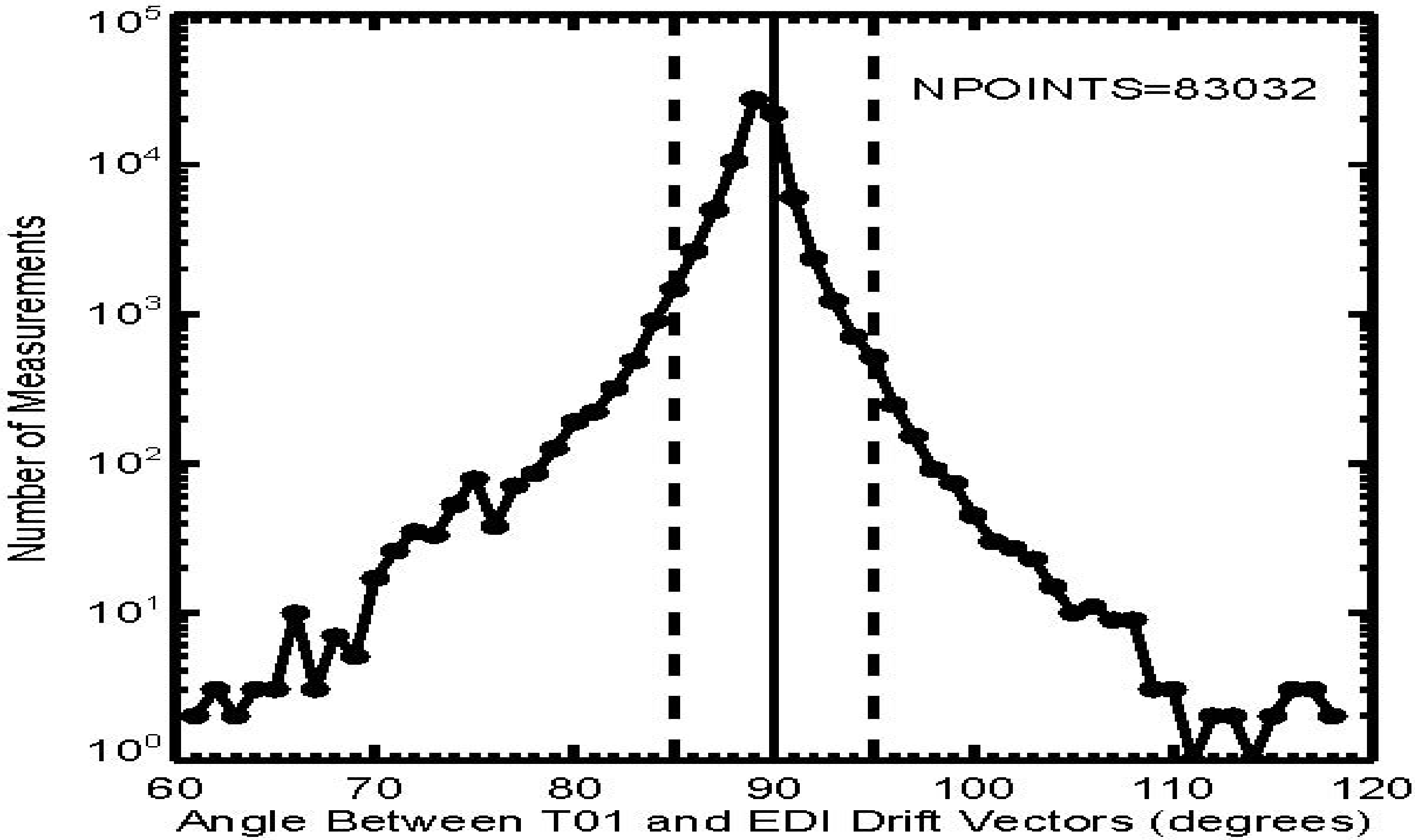


EDI Ground-Track Distance



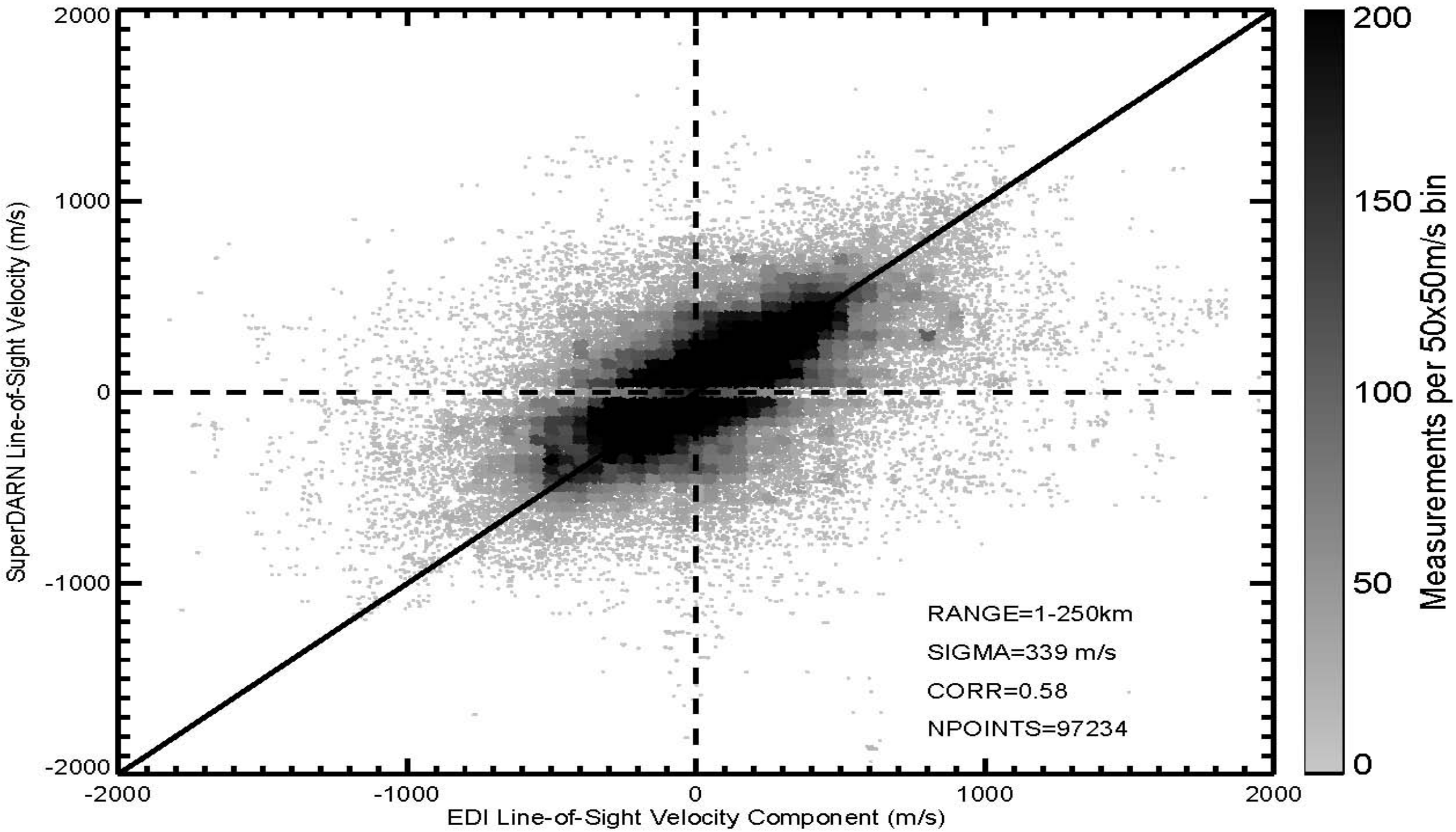
EDI measurements selected for ground distances comparable to a SuperDARN grid-cell

T01 Model Accuracy at Cluster

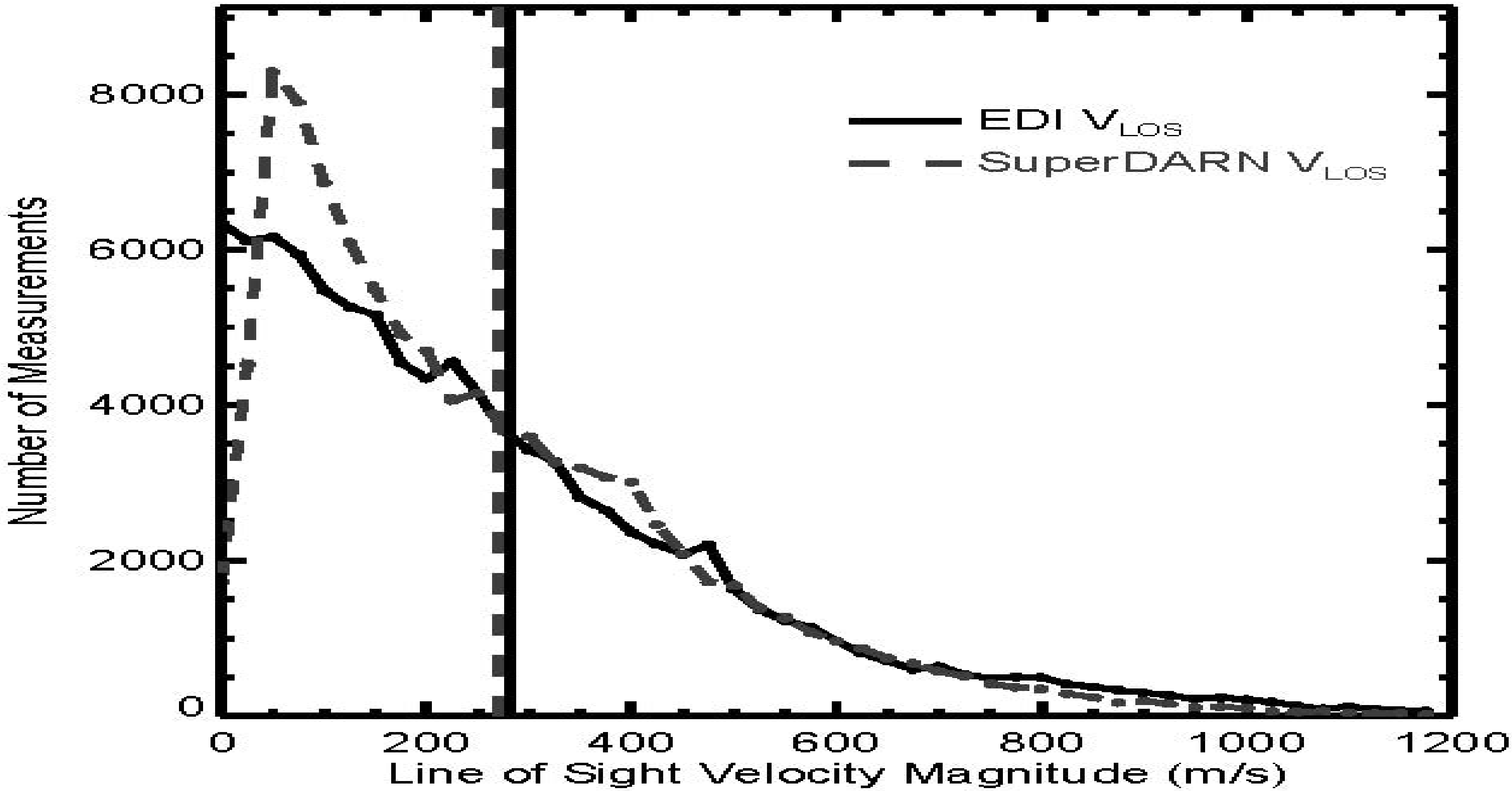


EDI measurements selected for magnetic field comparable to T01 model estimates

VLOS Comparison

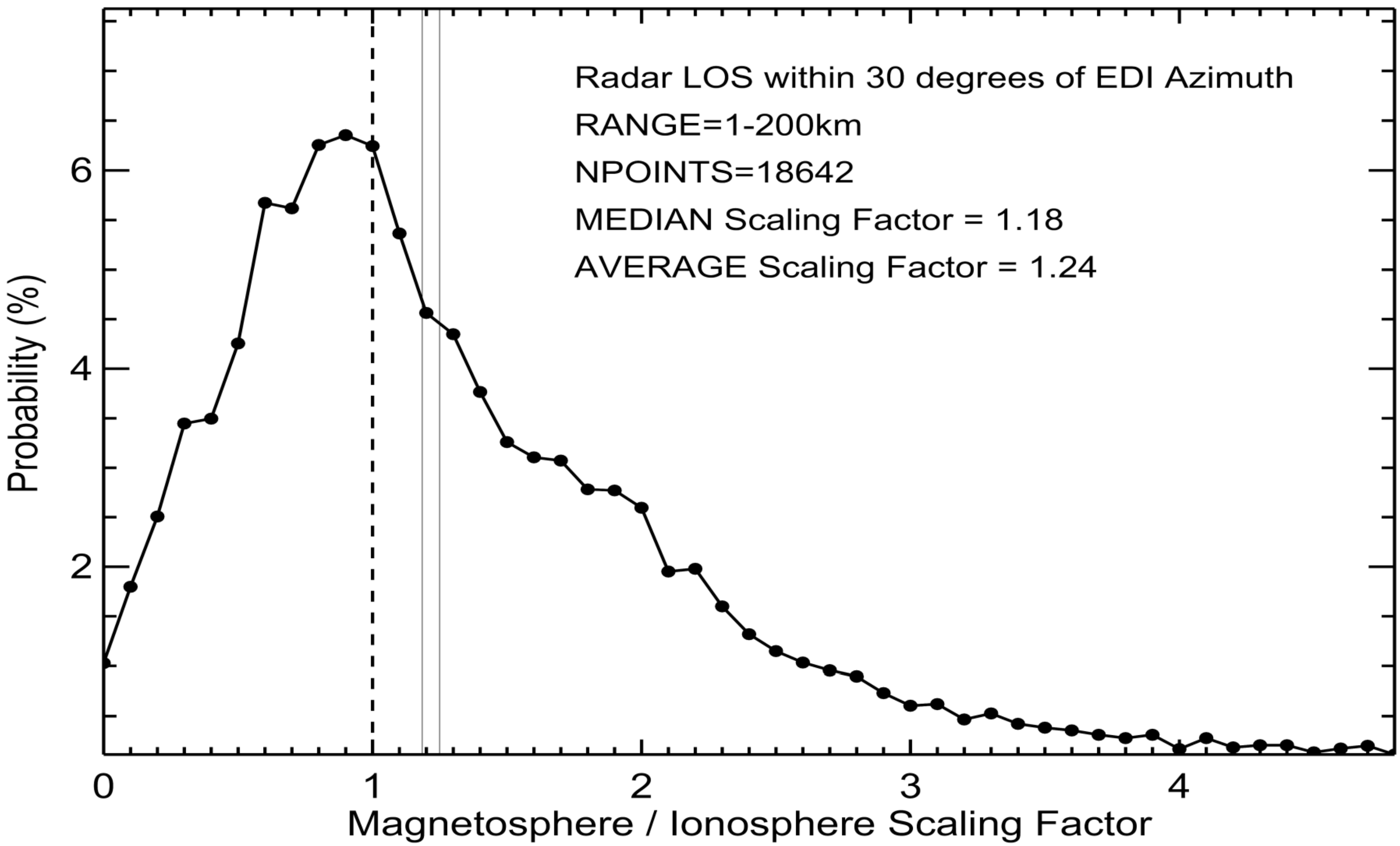


VLOS Distributions



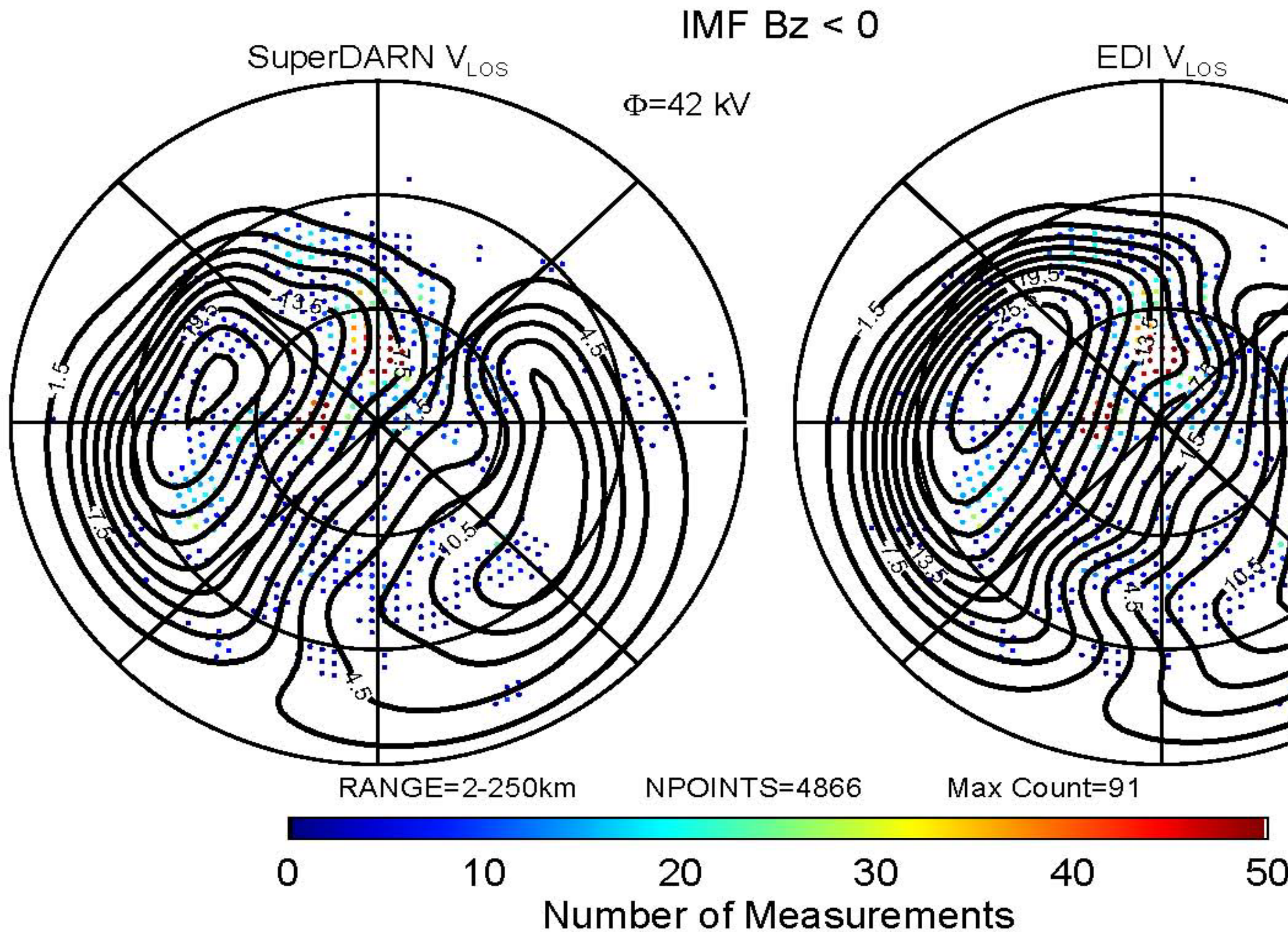
SuperDARN VLOS distribution is truncated because of ground-scatter bias

Magnetosphere-Ionosphere Scaling Factor

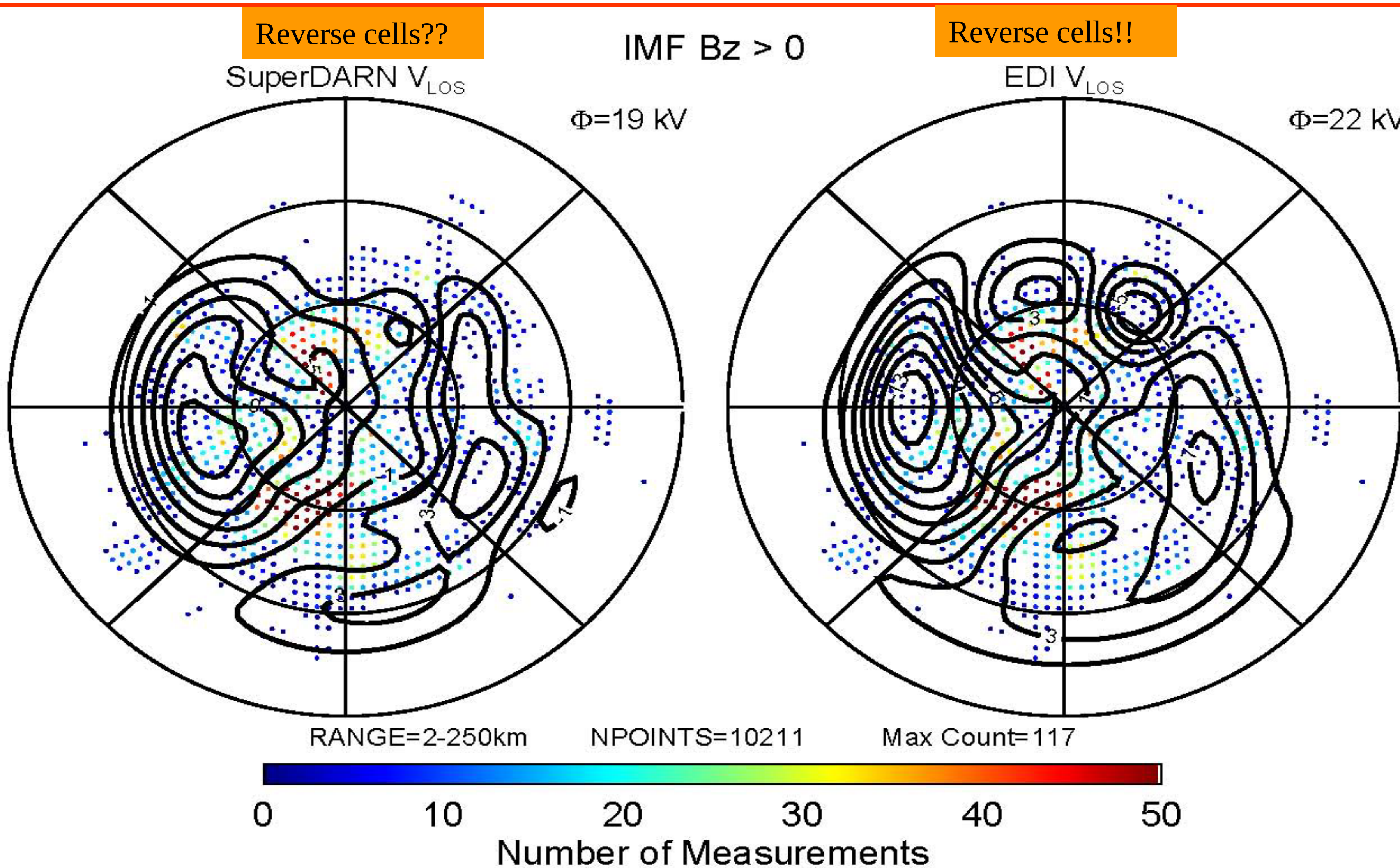


- On average, 24% of convection measured by EDI is not measured in the ionosphere. However, the peak of the distribution is actually slightly less than unity.

Southward IMF



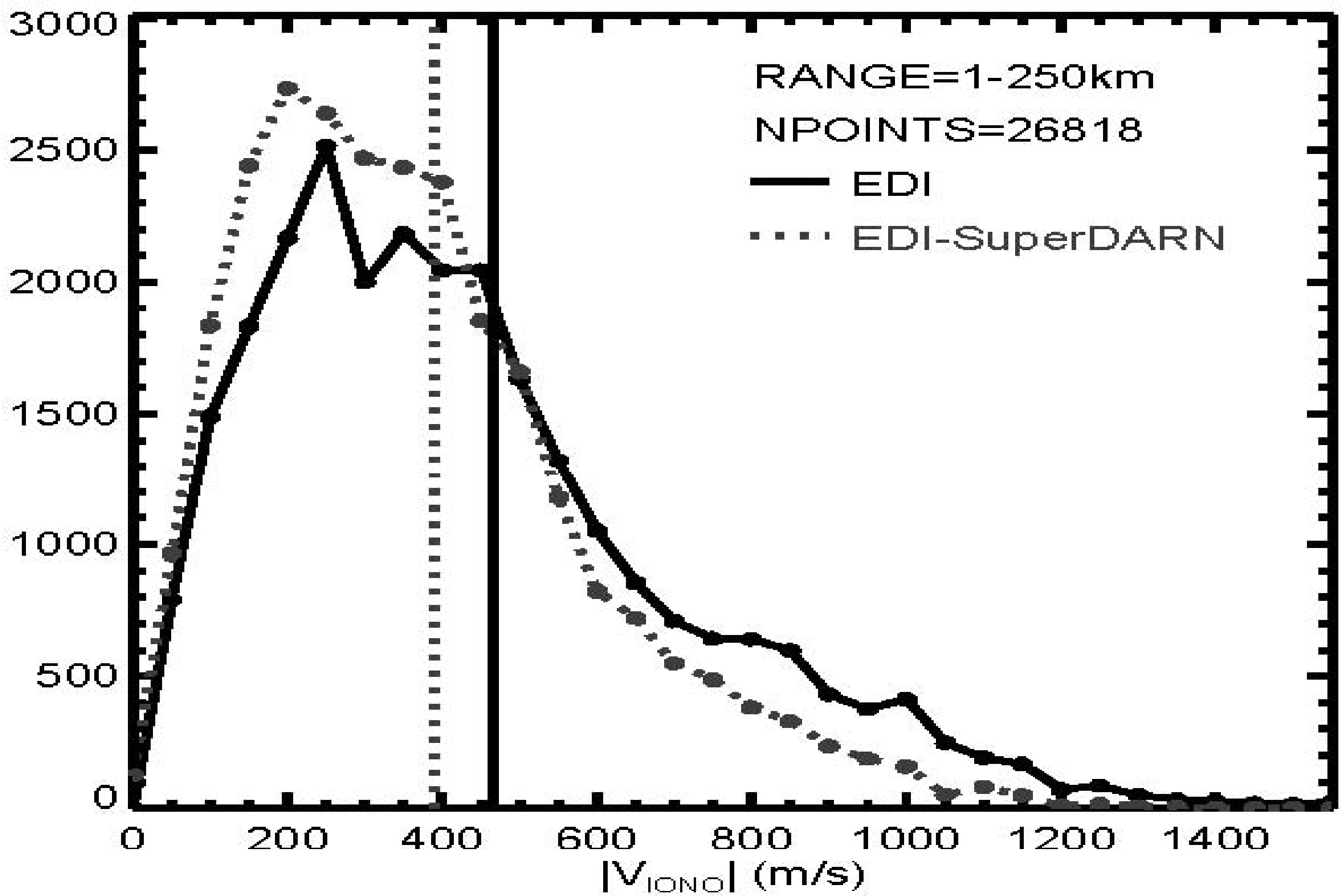
Northward IMF



Summary

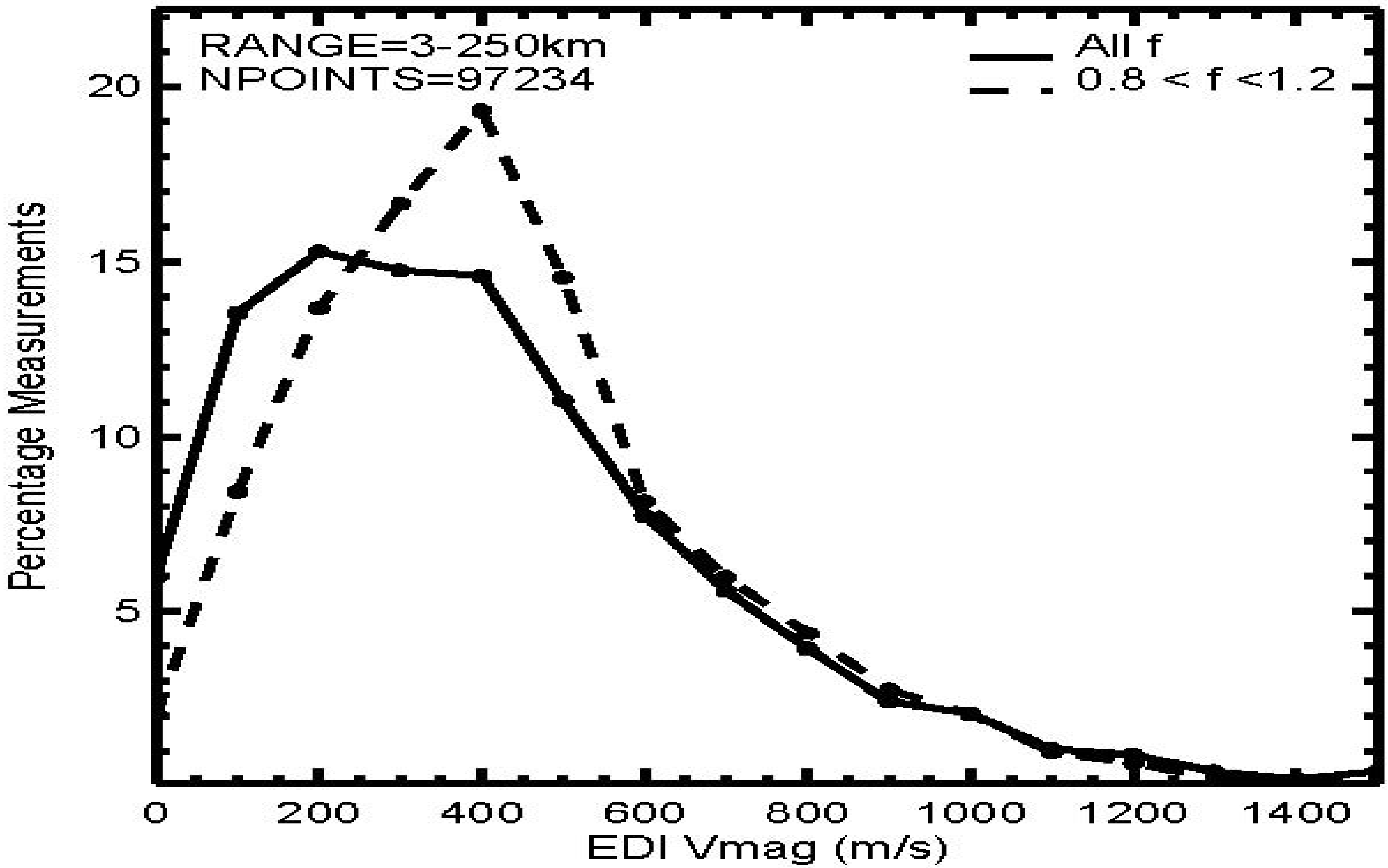
- SuperDARN measurements have been compared with Cluster EDI measurements to test the assumption of equipotential magnetic field lines.
- On average, 24% of the convection measured by Cluster EDI at high altitude is not measured by SuperDARN in the ionosphere.
- However, the distribution of the magnetosphere-ionosphere scaling factor is broad and peaks near unity.
- The best EDI-SuperDARN consistency occurs during periods of moderate magnetosphere-ionosphere coupling and at high latitudes in the polar cap.
- The general consistency between EDI and SuperDARN convection patterns suggests that the majority of inconsistencies operate over small spatial and/or temporal scales.
- During northward IMF the multi-cell convection measured by EDI at high altitude is more pronounced than that measured by SuperDARN.

Drift Vector Magnitude Comparison



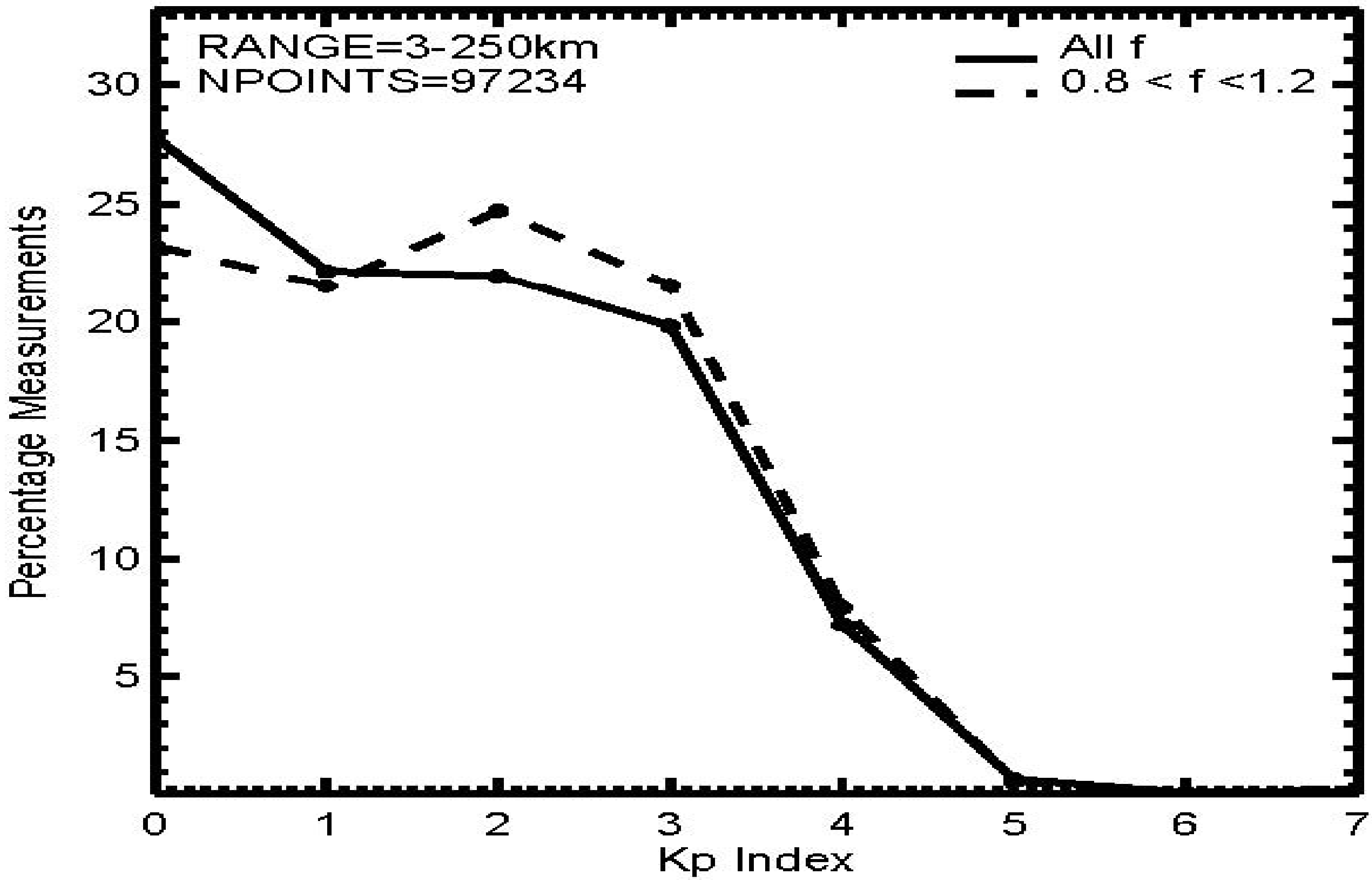
The EDI drift velocity magnitude distribution has a higher tail than SuperDARN

EDI Drift Velocity Magnitude



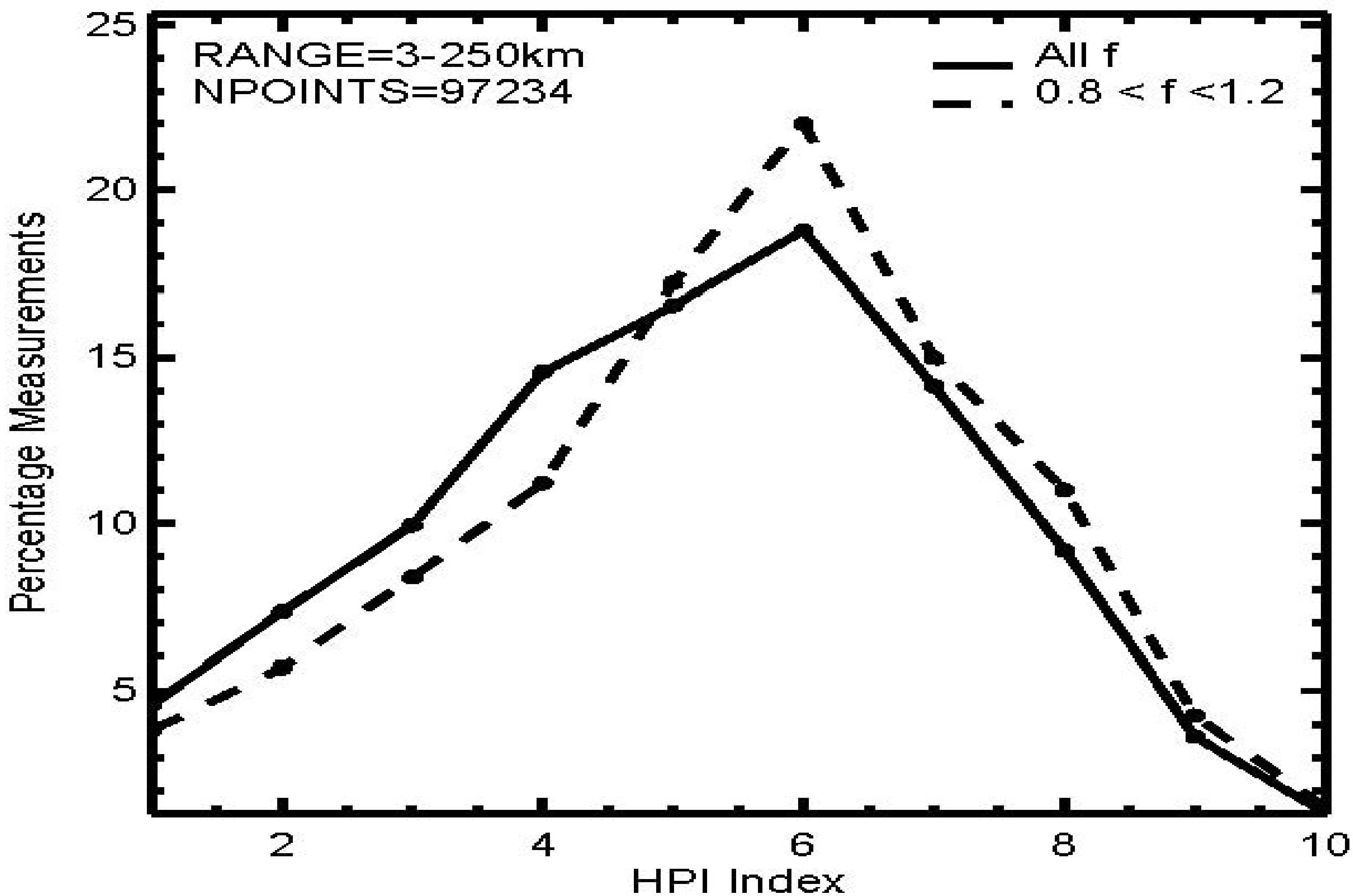
There is better EDI-SuperDARN consistency for moderate EDI drift velocities

Kp Magnetic Index



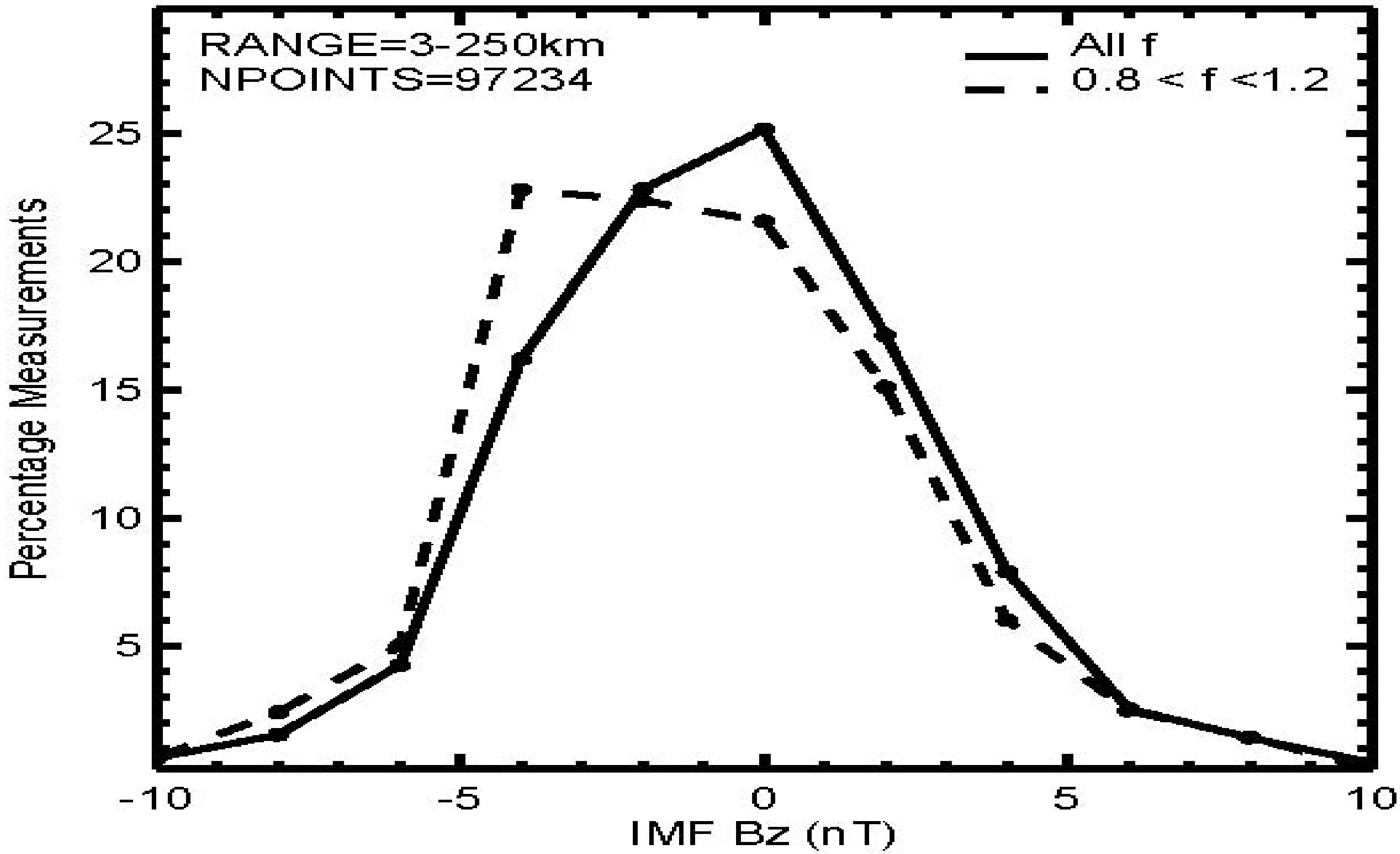
There is better EDI-SuperDARN consistency during moderate magnetic activity

Auroral Hemispheric Power Index



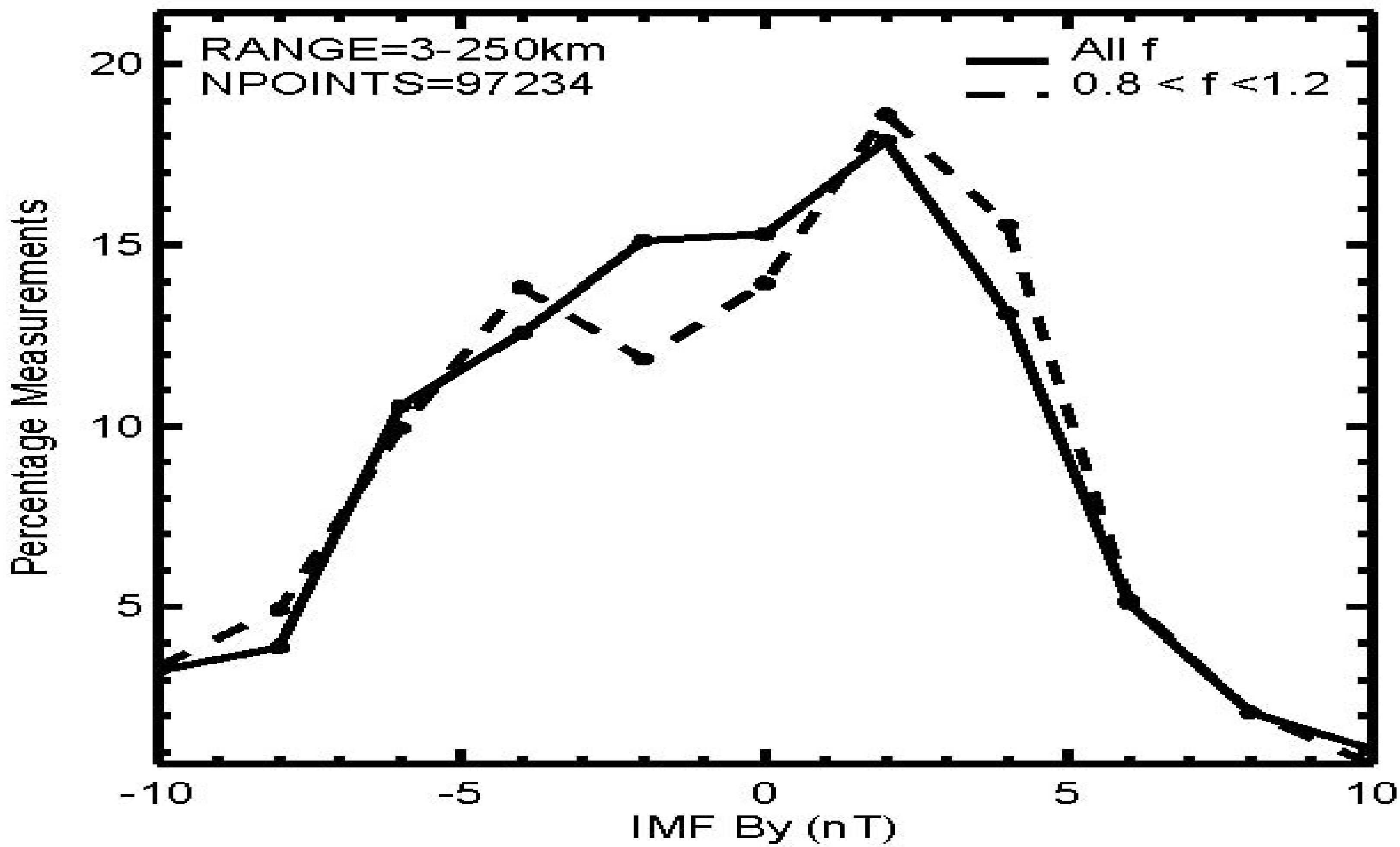
There is better EDI-SuperDARN consistency during moderate auroral activity

IMF Bz Component



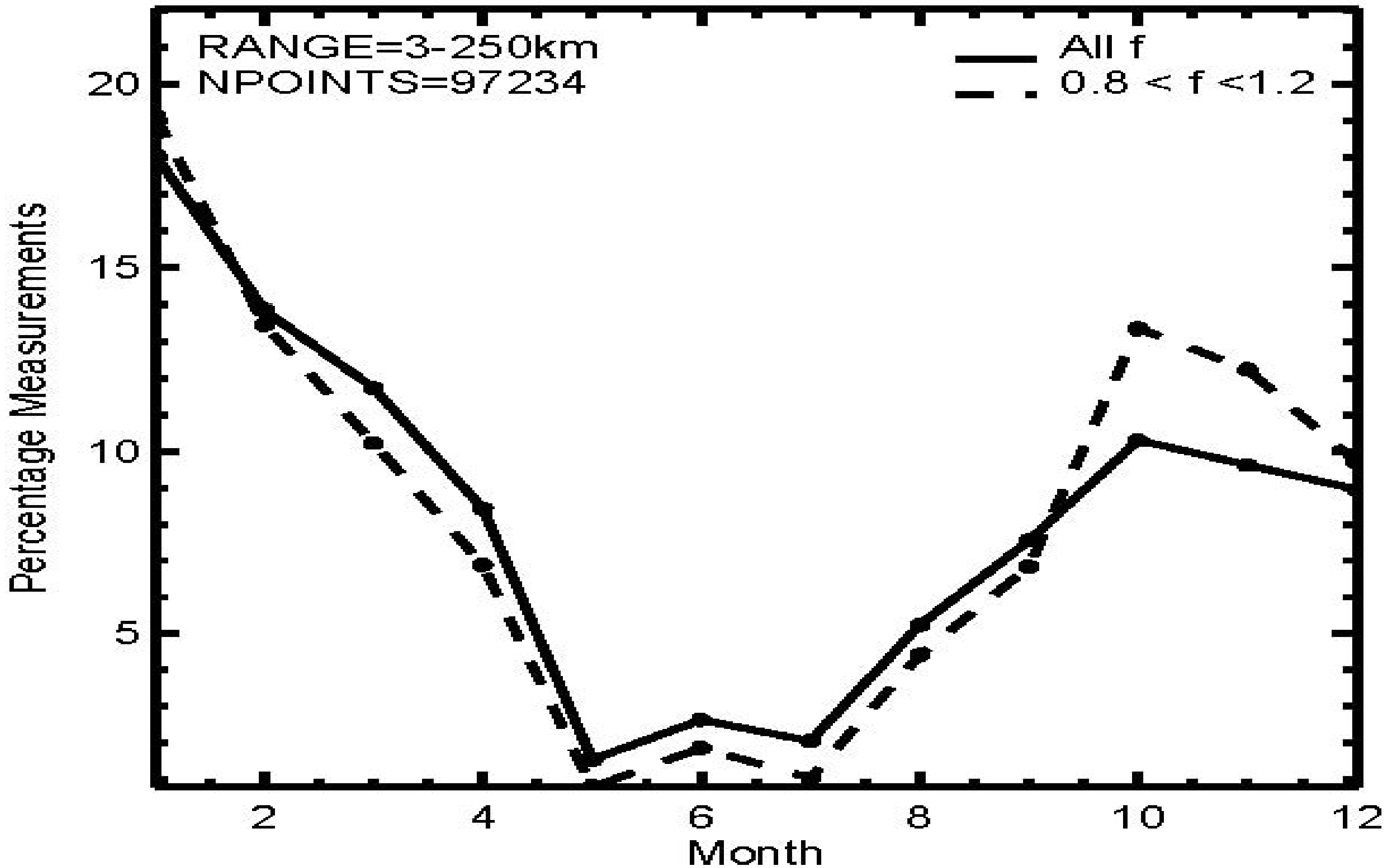
There is better EDI-SuperDARN consistency during southward IMF

IMF By Component



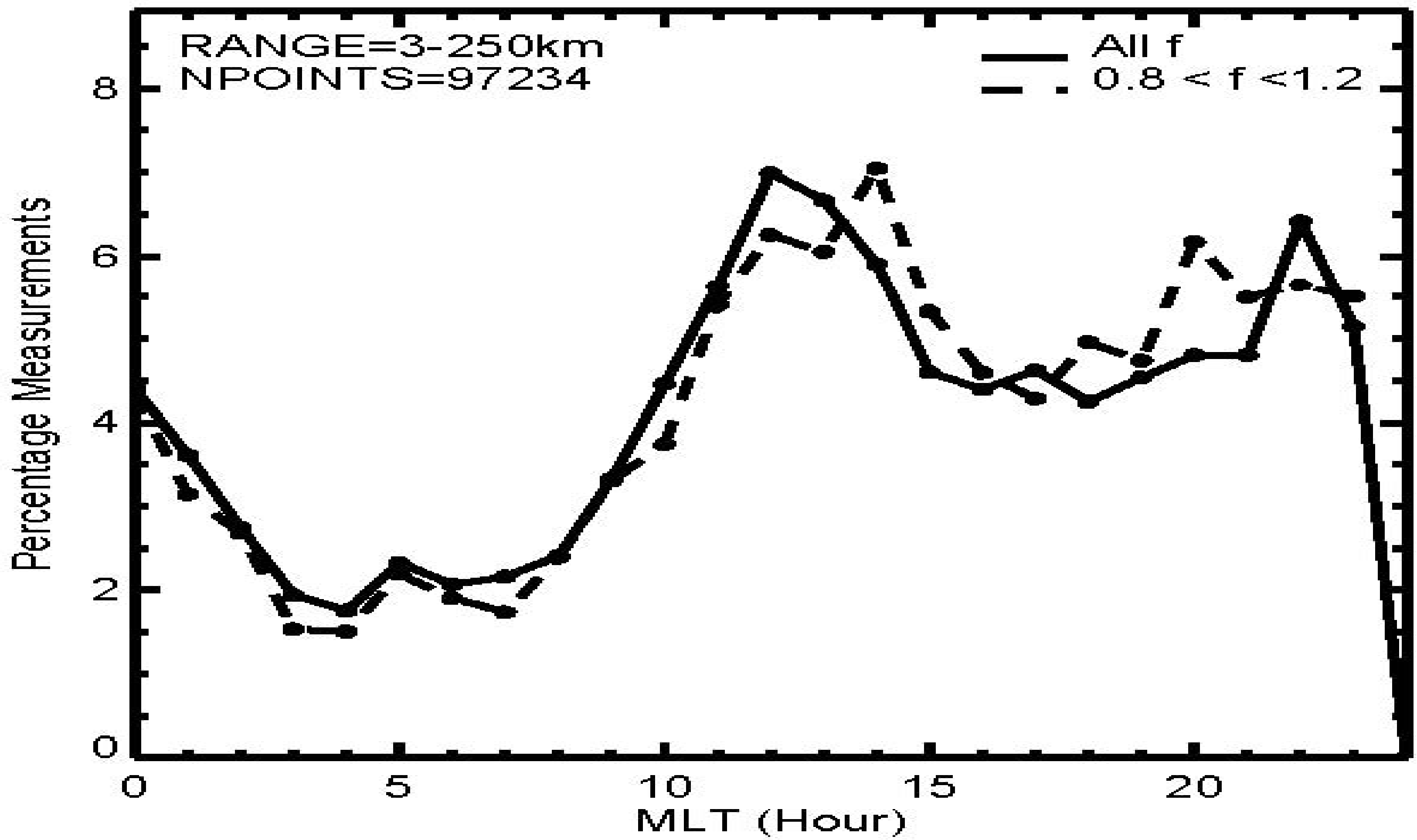
There is better EDI-SuperDARN consistency for positive IMF By component

Month of Year



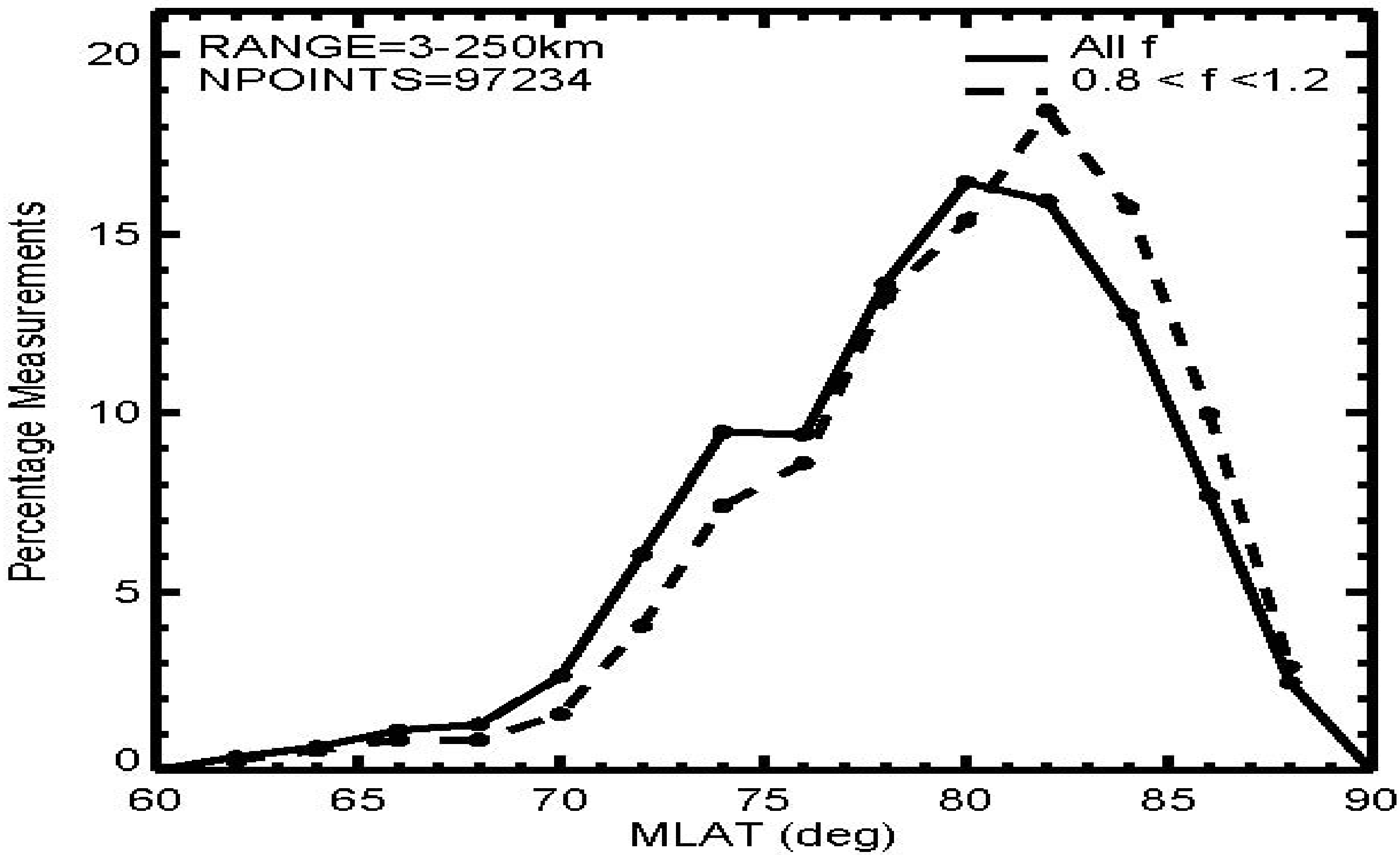
There is better EDI-SuperDARN consistency during Fall-Winter months

Magnetic Local Time



There is better EDI-SuperDARN consistency in the late evening sector

Magnetic Latitude



There is better EDI-SuperDARN consistency at higher latitudes