Characteristics of spatial variability in high-latitude SuperDARN velocities

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Introduction

Convection of plasma in the high-latitude ionospheres can be considered to have two components: a large-scale average flow pattern and small-scale variability.

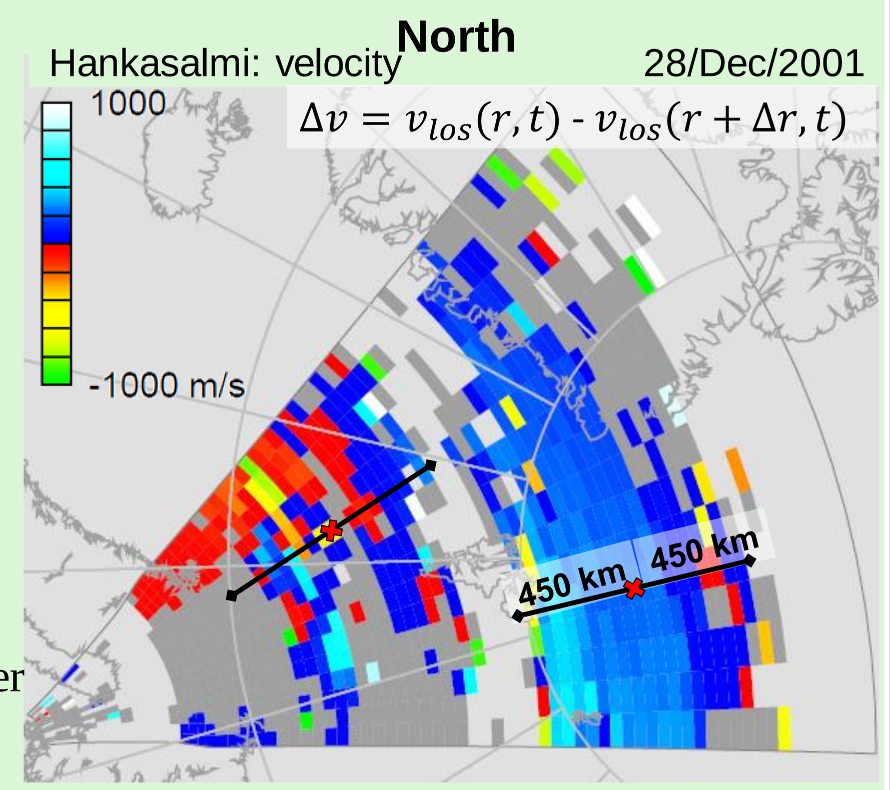
The large-scale convection pattern is well-studied and is found to vary with the interplanetary magnetic field (IMF), solar wind velocity (V_{sw}), and the Earth's season or dipole tilt angle, among other parameters.

The origin and characteristics of small-scale variability are less well-known. This variability impacts the predictive ability of statistical models and can contribute to the Joule heating rate in the atmosphere.

Calculating Variability

Data:

- **Fit-level LOS velocity values**
- **All high-latitude radars**
- **Normal scan mode**
  - Azimuthal resolution: 10 – ~200 km
  - Range resolution: 45 km
  - Temporal resolution: 2-min



Conditioning:

- Use ranges ≥765 km (range gate 13) to reduce contamination by E-region scatter
- Exclude data flagged as groundscatter
- Exclude fluctuations >1200 m/s (~3σ) to eliminate noisy or aliased data

Method:

- Calculate fluctuations in velocity, Δv, along beam (within ±10 range gates, 450 km)
- For high quality data, require: Pwr > 3 dB, V_{ERR}< 150 m/s, # measurements > 6 / 20
- RMS over all good Δv's, or randomly select one

Dependence on IMF Variability

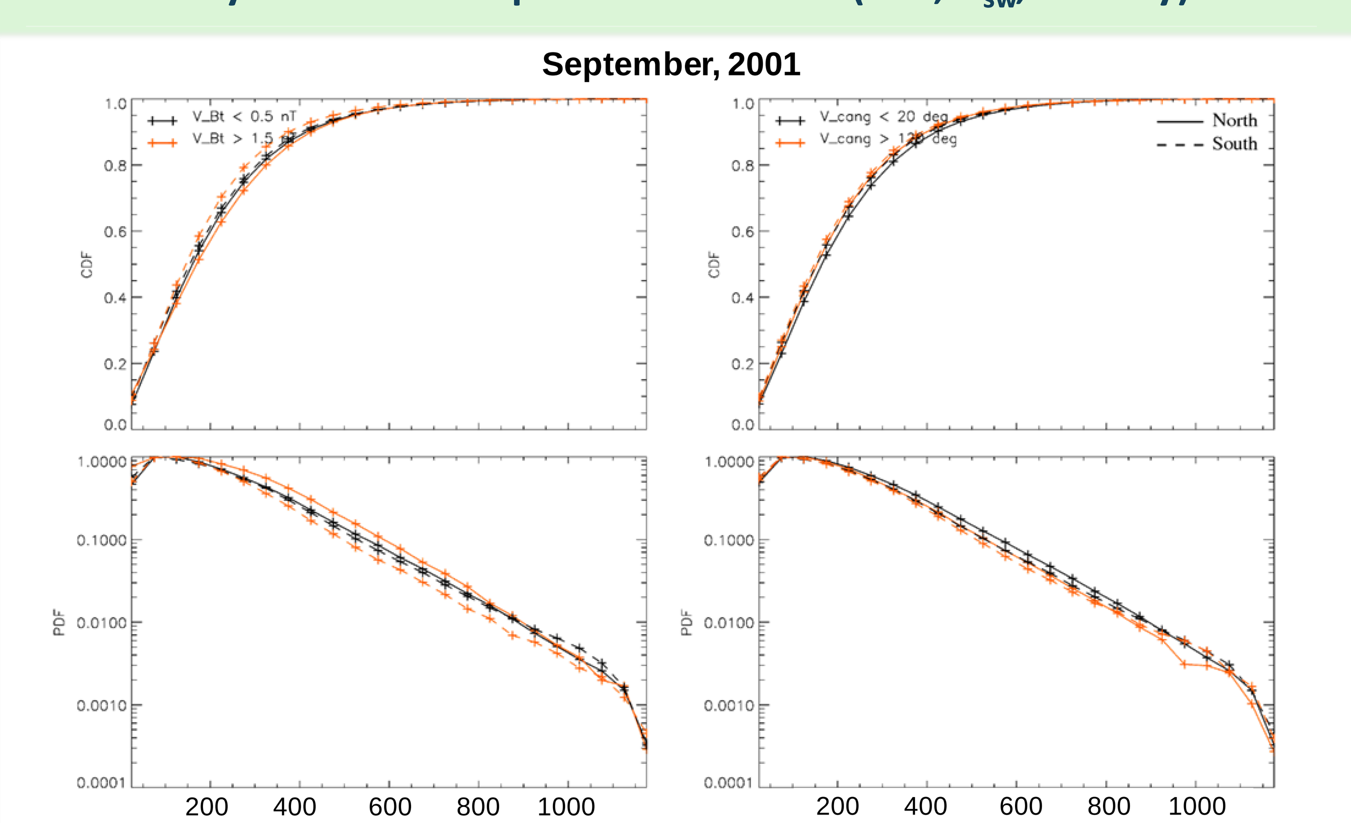
Data:

- **High-Resolution OMNI data**
  - 1-min Temporal Resolution
  - Shifted to bow shock

Method:

- **Consider 1 hr of data prior to velocity measurement**
- **Estimate level of variability using standard deviation**

Ionospheric velocity variability does not show a significant dependence on the level of variability in solar wind parameter values (IMF, V_{sw}, density).

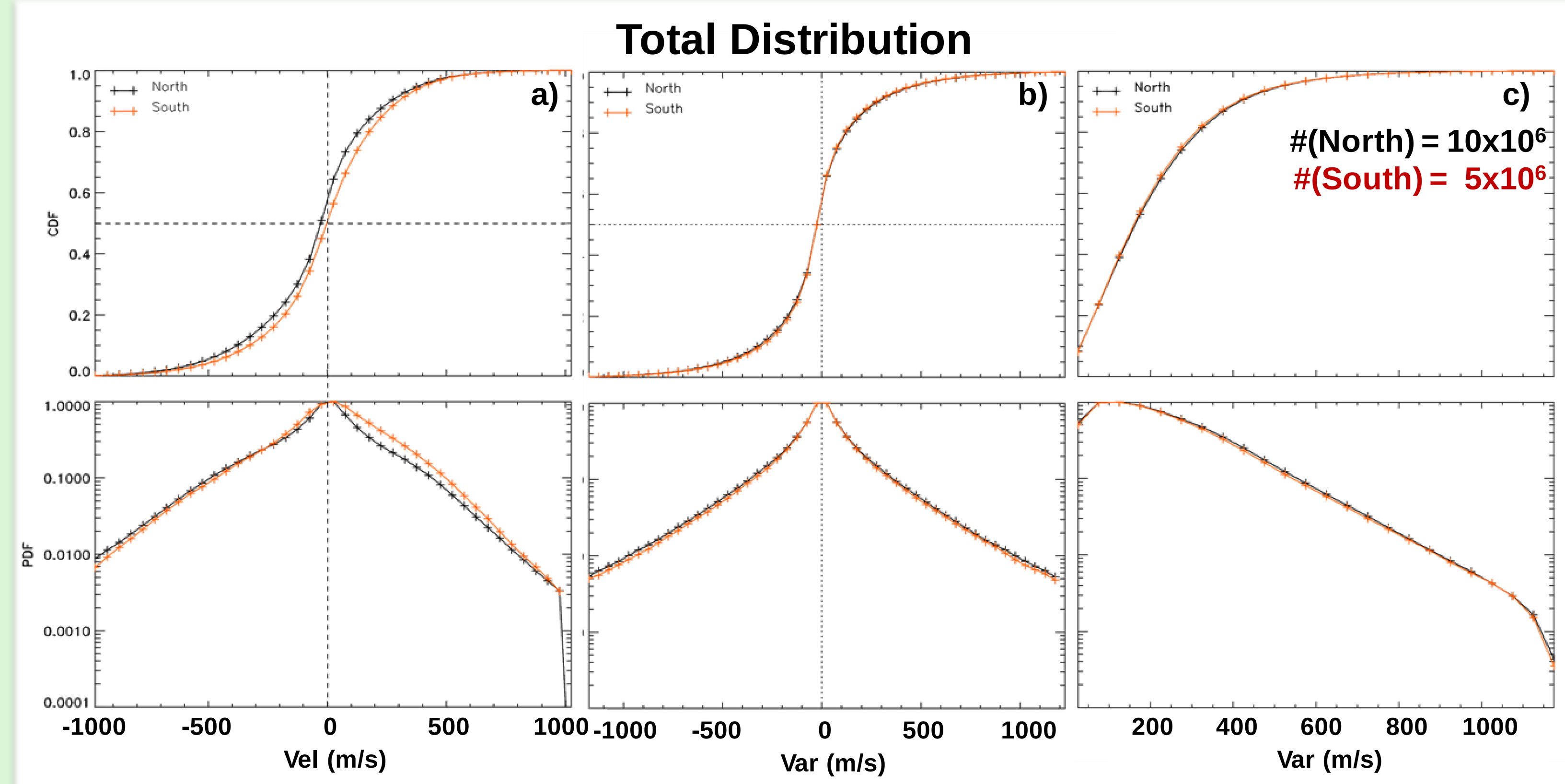


Example of variability distributions for low and high levels of levels variability in IMF parameters.

Variability Distributions

Variability analysis is performed on all available high-latitude radar LOS data from *Mar, June, Dec, 2000 and June, Sep, Dec, 2001.*

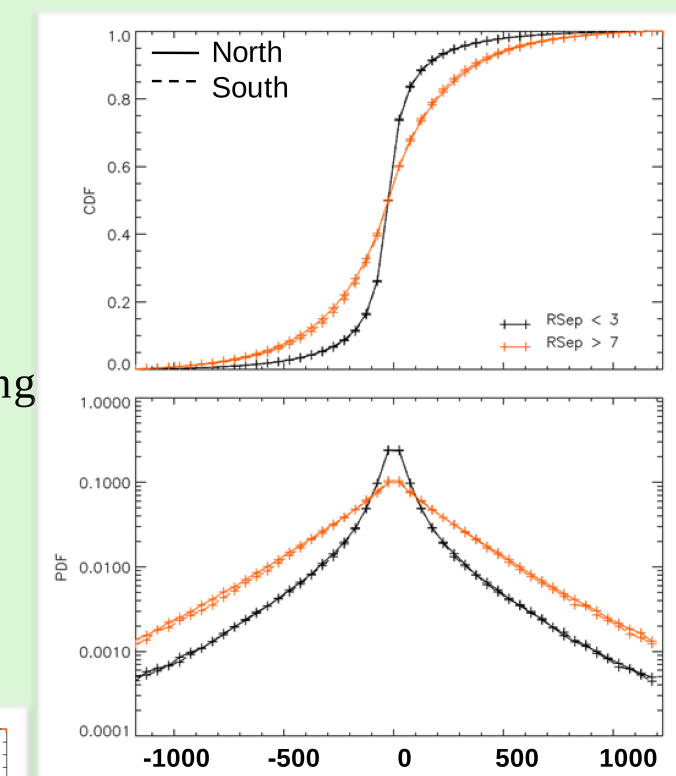
Scaled cumulative distribution and probability density functions (CDF and PDF) are calculated for Northern and Southern Hemisphere variability values independently.



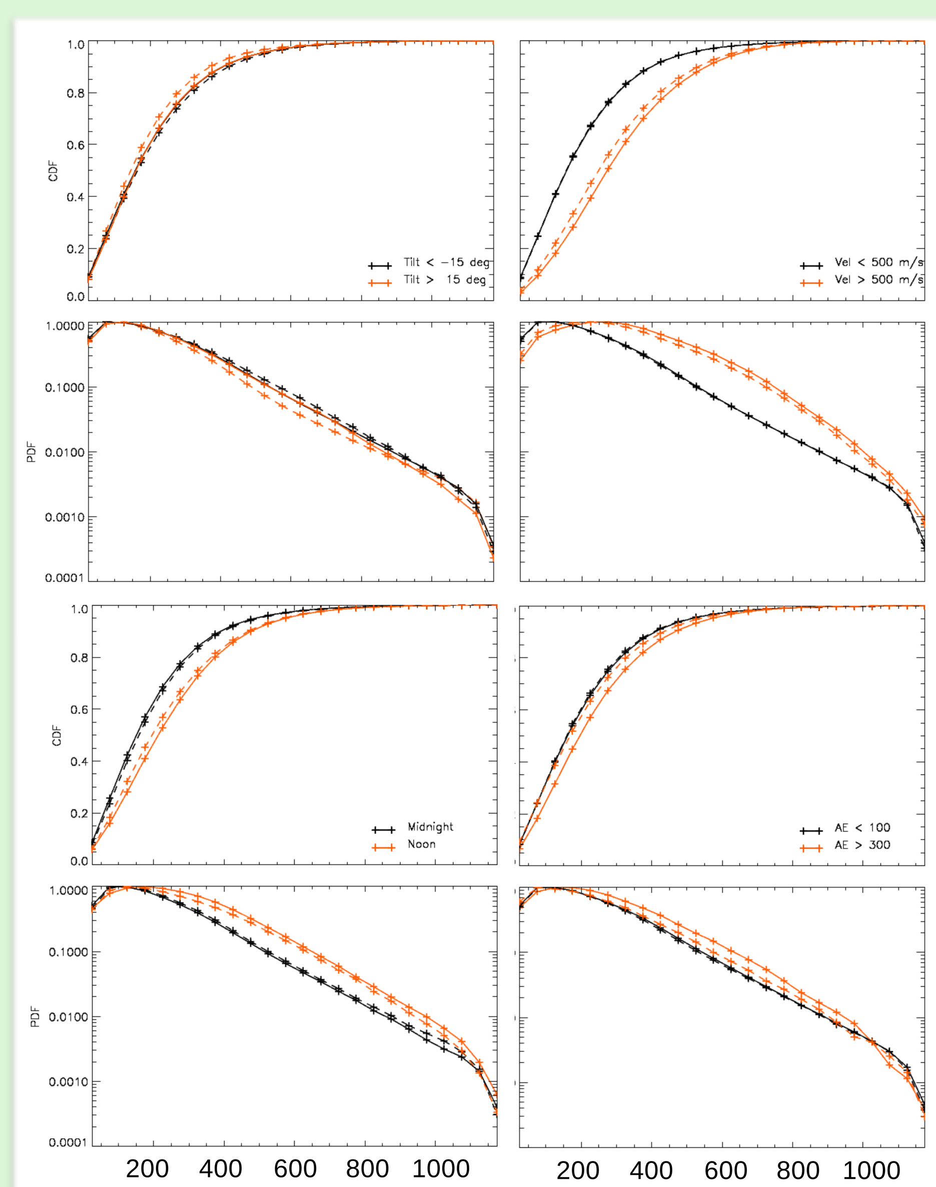
a) Velocity distribution. b) Variability distribution (randomly selected fluctuations). c) Variability distribution (RMS'd fluctuations). Bin-size for all figures is 50 m/s.

Results:

- Distribution of *velocity* values differs between hemispheres, possibly due to differing locations and orientations of radar field-of-views.
- Distribution of *variability* values is the same in both hemispheres, for both methods of calculating variability.
- Variability PDF is wider (more large values) for larger scale size. The results are consistent with those of *Abel* [2006].



Variability (randomly selected fluctuations) distributions for two different spatial scales.



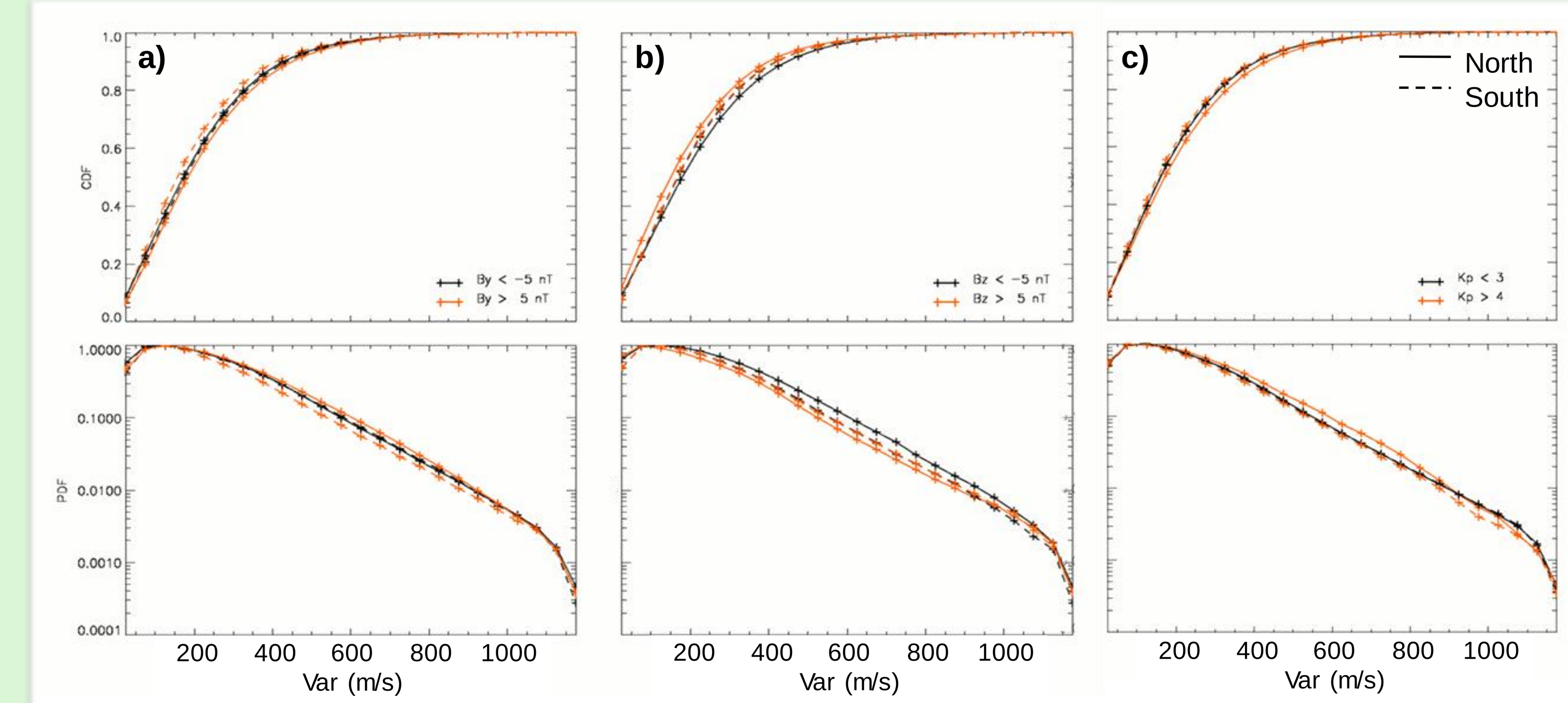
Variability distributions for various different geophysical or geomagnetic conditions.

- Smaller variability values are seen in summer-like conditions, *for the South only*.
- Variability values tend to be larger near noon than near midnight.
- Large velocity values are correlated with large variability values.
- Variability values tend to be larger for higher AE index, especially in the North.

More Variability Distributions

Results (continued):

- Variability values are slightly larger for IMF B_Y+ (B_Y-) in the North (South).
- Variability values are slightly larger for IMF B_Z- and for larger Kp *in the North only*.

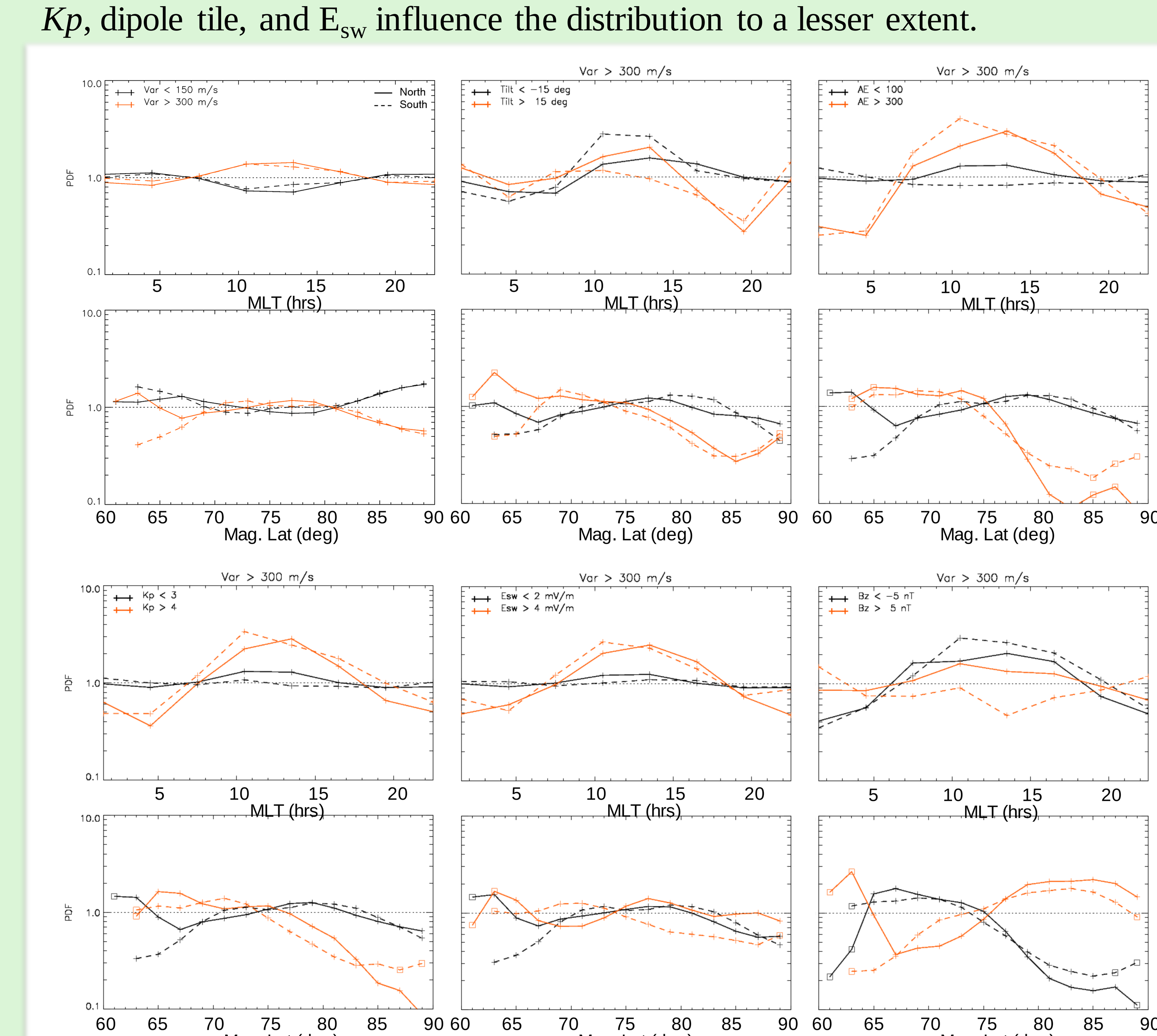


Variability distributions for low and high values of a) IMF B_Y, b) IMF B_Z, and c) *Kp*.

Location Distributions:

The distribution in Magnetic Local Time (MLT) and geomagnetic latitude of large variability values (top 25%) is calculated relative to the distribution of all values.

- AE and IMF B_Z significantly influence the location distribution of large variability. *Kp*, dipole tile, and E_{sw} influence the distribution to a lesser extent.



MLT and geomagnetic latitude distributions of large variability for various conditions.

Summary

Eight months of SuperDARN line-of-sight velocity data from both hemispheres are analyzed to determine the statistical characteristics of velocity fluctuations on scales from 45 – 450 km. It is found that:

- The overall distributions of fluctuations are the same in both hemispheres.
- Several interplanetary and geophysical parameters such as IMF, AE, and dipole tilt influence the distribution of magnitudes and locations of velocity variability.
- These parameters are not seen to have the same influence in both hemispheres.