Statistical Study of Nightside Quiet Time Subauroral Ionospheric Convection Observed by the North American Mid-latitude SuperDARN Radars

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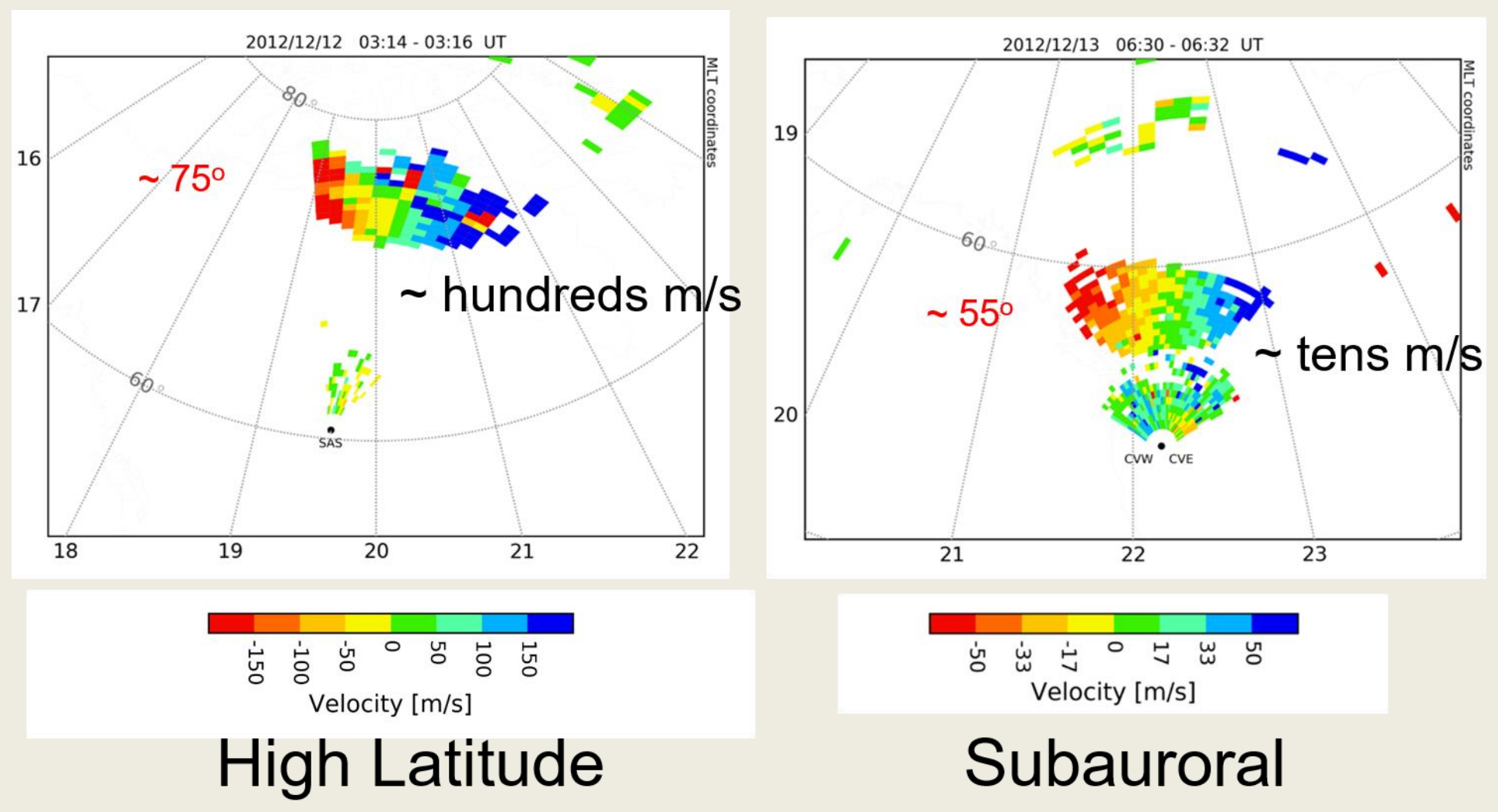
Abstract

Studies have shown that ionospheric plasma in the subauroral region exhibits drifts of a few tens of m/s under quiet time conditions. However, the exact driving mechanisms for the low velocity subauroral plasma motion are not well understood. The recent expansion of SuperDARN radars to the midlatitude regions has provided opportunities to study subauroral ionospheric convection over large areas and with greater resolution and statistical significance than previously possible. In this study we have taken two years of quiet-time nightside data from six midlatitude SuperDARN radars in the U.S. continent to derive a statistical model of mid-latitude plasma convection between 52° - 58° magnetic latitudes. The model is organized in MLAT-MLT coordinates and has a spatial resolution of 1° × 7 min with each grid counting thousands of measurements on average. Our results show that the flow is predominantly westward (20 - 60 m/s) and weakly northward (0 -10 m/s) deep in the nightside. The convection is greatly affected by season, with the flows being strongest and most variable in winter. The statistical results presented here are in basic agreement with previously reported observations from ISR measurements but also show new features. One such feature is a significant latitudinal variation of zonal flow velocity near midnight in winter. In this presentation, we describe the derivation of the nightside quite-time subauroral convection model, examine the most prominent features and discuss the results in terms of possible mechanisms.

Introduction

❑ Mid-latitude SuperDARN radars frequently observe subauroral ionospheric backscatters with low Doppler velocities on most geomagnetically quiet nights *[Ribeiro et al., 2012]*. Right panel in Figure 1 shows one of such low velocity plasma motions in a typical geomagnetically quiet night. The raw LOS velocity measurements indicate a westward flowing plasma that drifts with a magnitude of ~ 50 m/s, which is much lower than the high latitude plasma flow (left panel) that is of a few hundred m/s.

❑ In this study we use data from six mid-latitude SuperDARN radars in the U.S. continents to derive a quiet time (Kp ≤ 2+) statistical convection model of the subauroral mid-latitude regions. Figure 2 shows the fields of view of the six radars in AACGM coordinates.



High Latitude

Subauroral

Figure 1: Two-minute scan plot of westward flowing subauroral plasma drifts observed by Christmas Valley West and Christmas Valley East radars (right) and westward return flows in high latitudes observed by Saskatchewan (SAS) radar (left). Positive (blue) velocities indicate motion towards the radar. Note that the two subplots have different color scales for velocities.

Introduction (cont.)

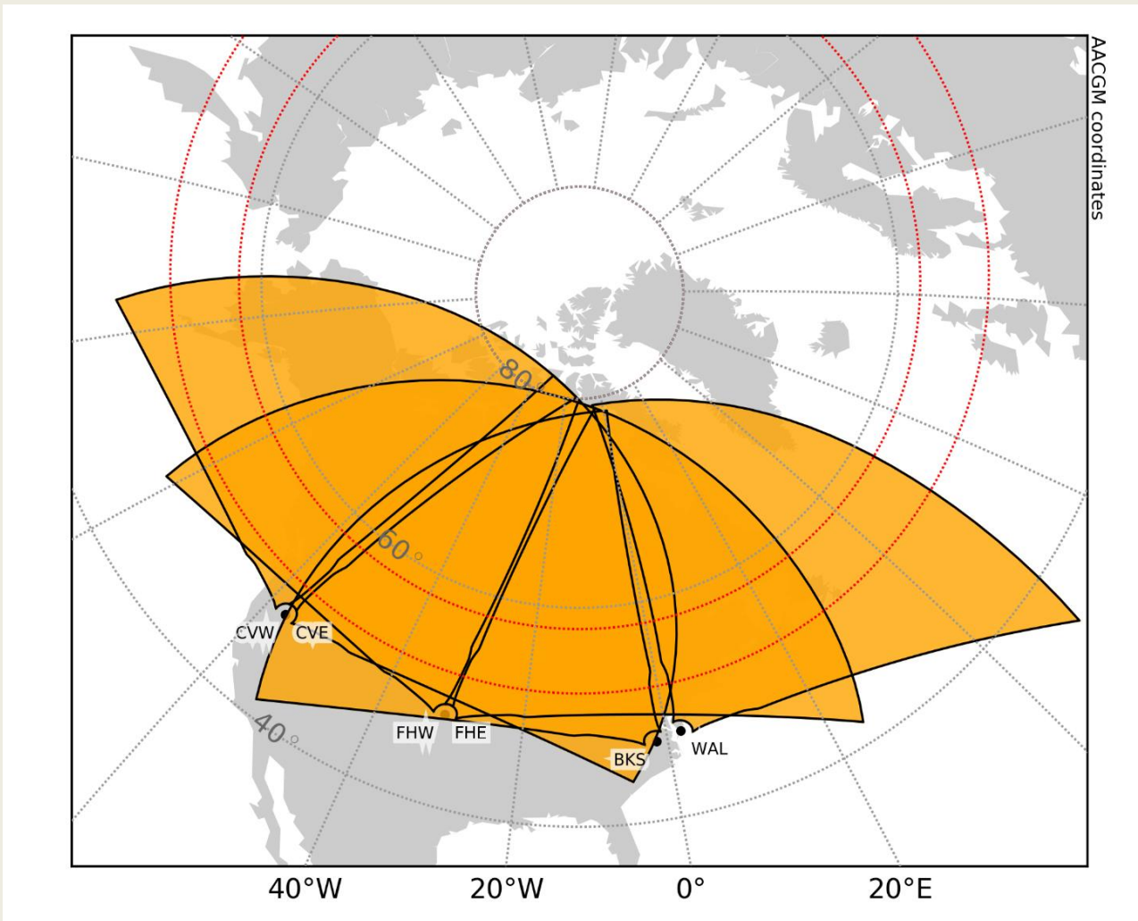


Figure 2: Fields of view of the six North American mid-latitude SuperDARN radars in AACGM coordinates. From west to east the radars are: Christmas Valley West, Christmas Valley East (Oregon), Fort Hays West, Fort Hays East (Kansas), Blackstone, and Wallops Island (Virginia). The regions of interest lie between 52° - 58° magnetic latitudes indicated by the two red circles.

Model Derivation and Results

❑ In this section we show data processing procedures (Figure 3) and the model results (Figure 4-5).

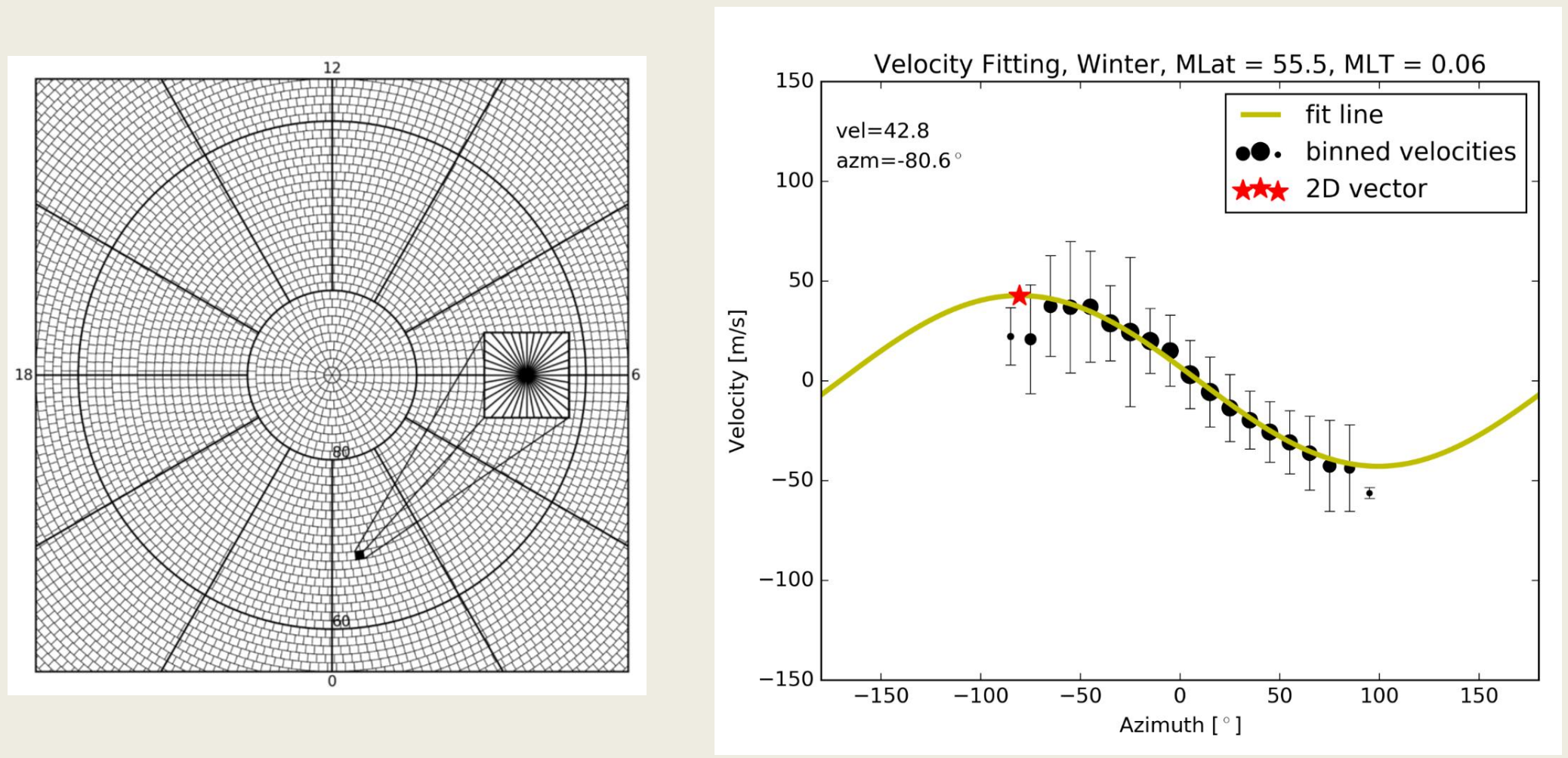


Figure 3: An overview of data processing procedures. Left panel shows the MLAT-MLT grid cells used for binning the data. The inset is an expanded view of the 10 degrees azimuth bins within each grid cell. Right panel shows an example of fitting a cosine curve to the line-of-sight velocities in each azimuth bin within a single grid cell .

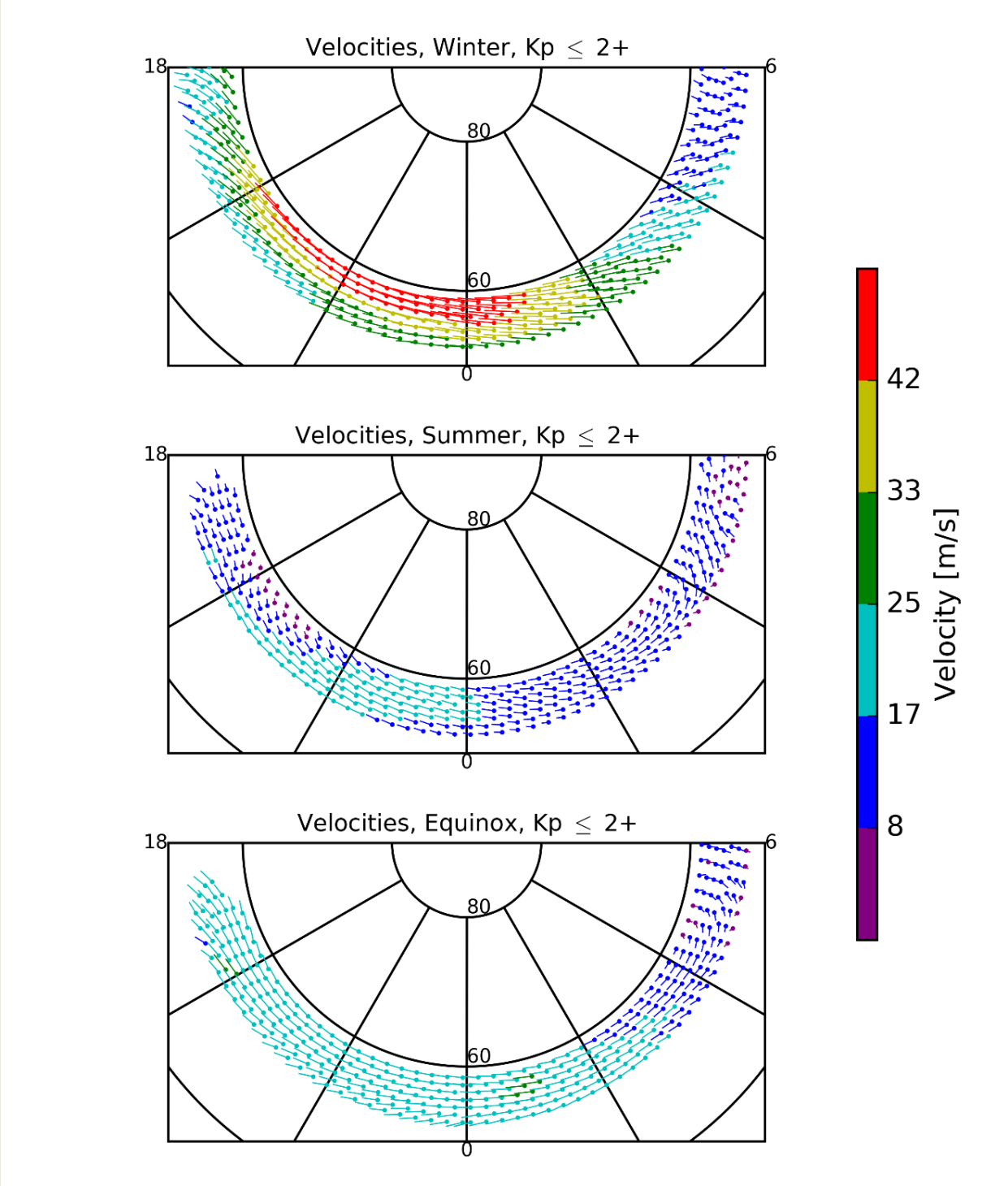


Figure 4: 2-D convection patterns calculated for winter, summer and equinox for the regions between 52° - 58° magnetic latitudes centered at zero MLT.

Model Results (cont.)

❑ Now we examine the zonal and meridional components of the 2D flow vectors shown in Figure 4 separately. Figure 5 shows the fitted zonal (top panel, positive eastward) and meridional (bottom panel, positive northward) velocities by MLAT versus MLT.

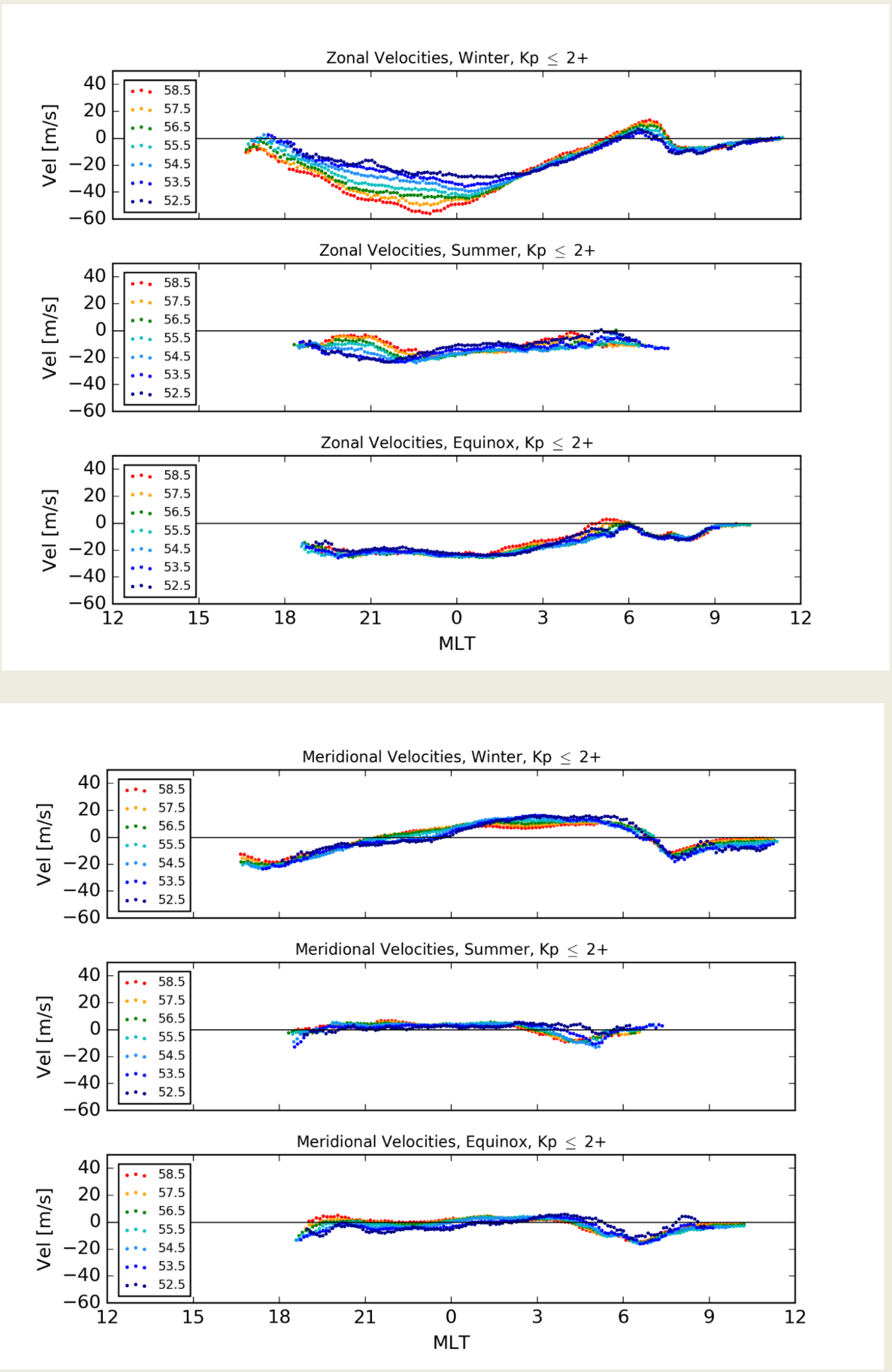


Figure 5: Fitted zonal (top panel, positive eastward) and meridional velocities (bottom panel, positive northward) by magnetic latitude versus MLT. The three subpanels in each panel, from top to bottom, are results for winter, summer, and equinox, respectively. Note that the plot is centered at 0 MLT.

Discussion

❑ In this section we discuss the above results in terms of two main possible driving mechanisms, neutral wind dynamo and penetration of high latitude convection electric fields.

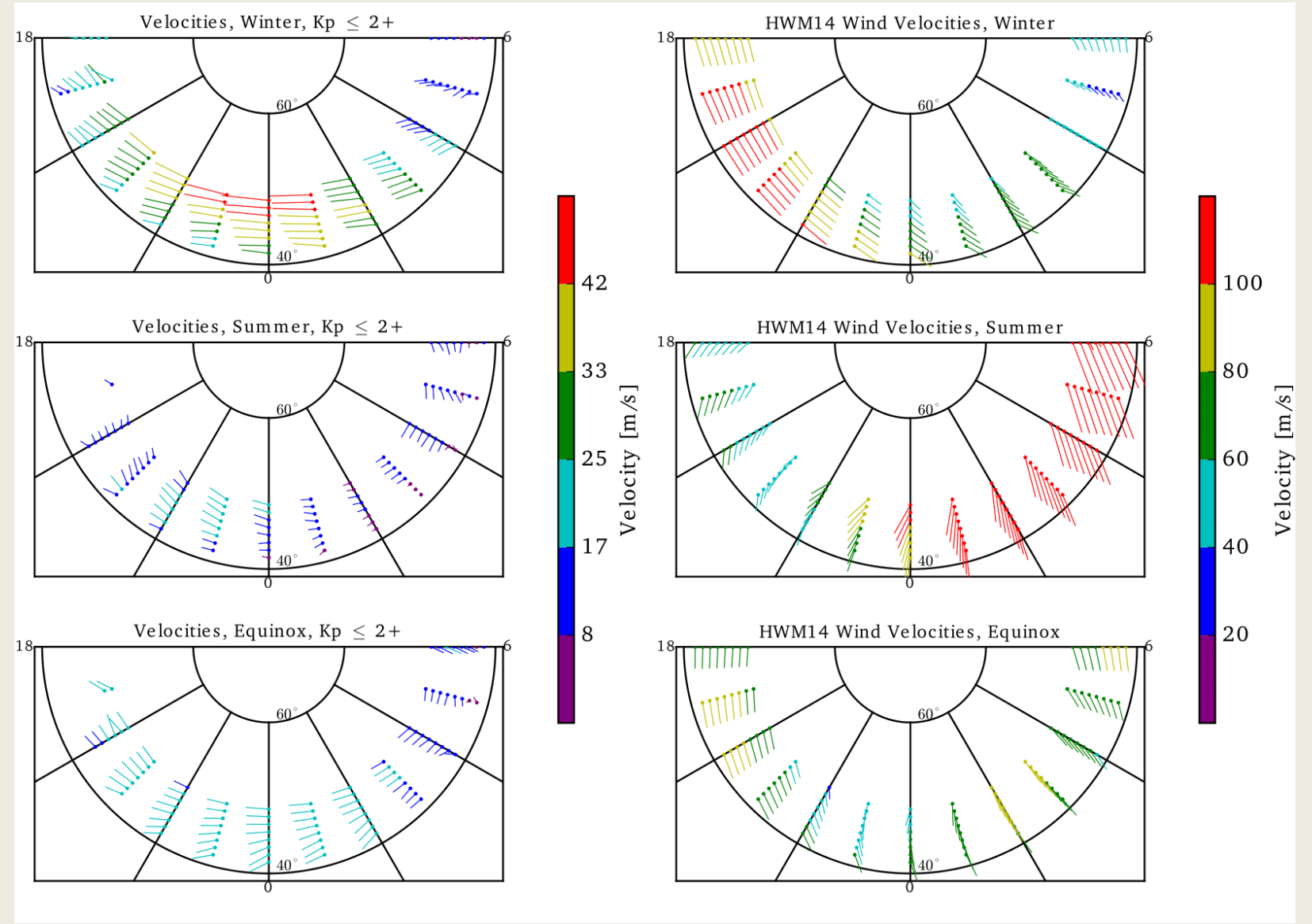


Figure 6: Fitted 2-D plasma drift (left) and horizontal neutral wind derived from HWM14 model (right) for geographic latitudes between 41° – 49° plotted at one hour apart in solar local time. From top to bottom are for winter, summer, and equinox, reflectivity. .

Discussion (cont.)

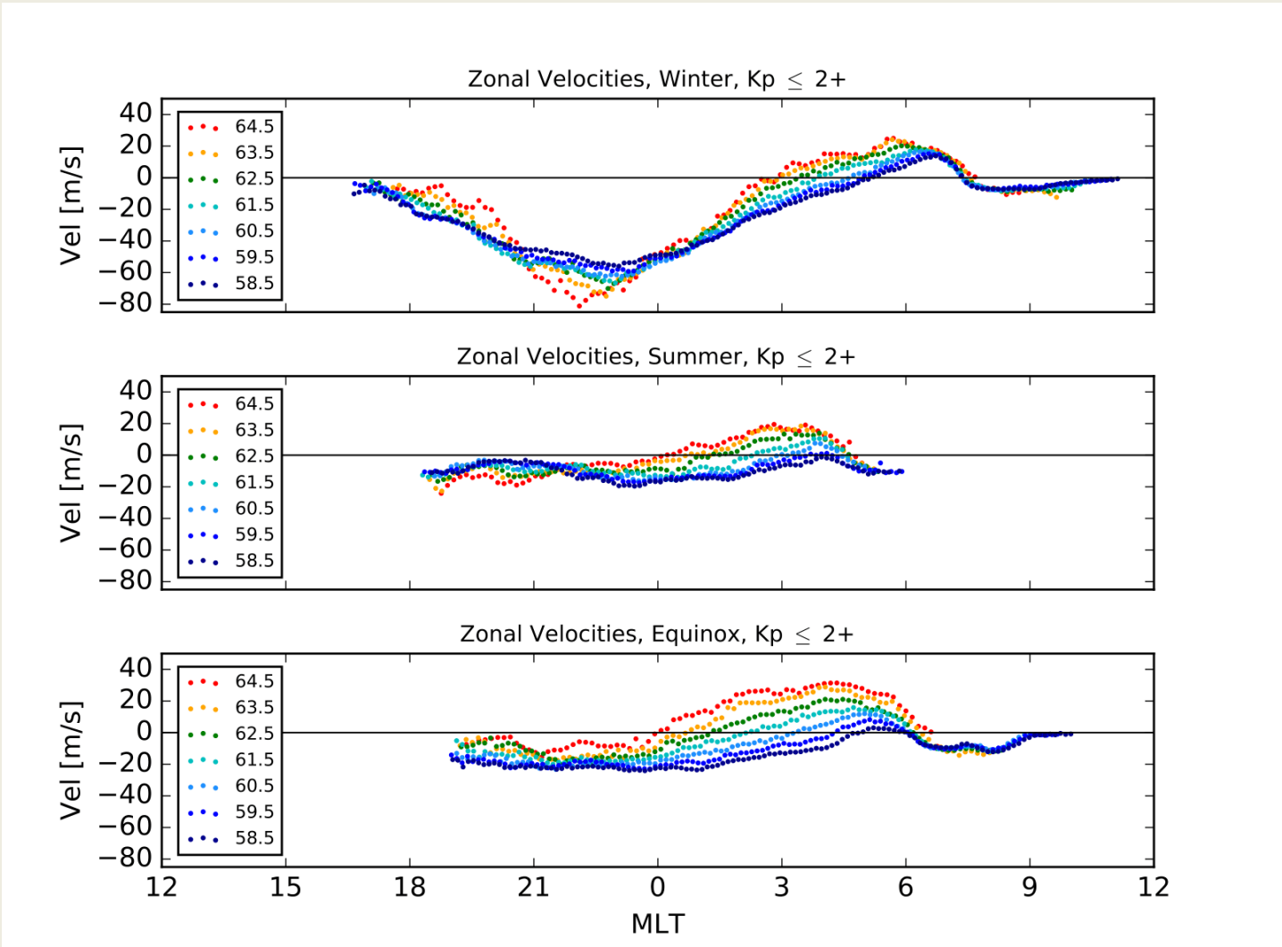


Figure 6: Fitted zonal velocities (positive eastward) by magnetic latitude versus MLT. The three panels, from top to bottom, are results for winter, summer, and equinox, respectively. Note that the plot is centered at 0 MLT.

Conclusions

❑ We have derived statistical patterns of nightside quiet-time subauroral (52° – 58°) convection with data from the mid-latitude SuperDARN radars.

❑ Flows are predominantly westward (20 - 60 m/s) and weakly northward (0 -10 m/s).

❑ Both zonal and meridional flows show pronounced seasonal variations with the strongest flows in winter.

❑ In winter there is a pronounced latitudinal variation in the zonal flow.

❑ Flows tend to become more variable towards dawn and acquire a significant meridional component.

❑ Comparison with the neutral winds extracted from the HMW14 model shows that local F-region neutral wind dynamo does not fully explain the observed convection.

❑ Neglecting the conjugacy effect, examination of the electric field variations between 52° – 64° magnetic latitudes indicate that a considerable contribution to the subauroral electric fields comes from the high latitude regions during the premidnight MLT hours even under quiet magnetic conditions.

References

❑ Ribeiro, A. J., J. M. Ruohoniemi, J. B. H. Baker, L. B. N. Clausen, R. A. Greenwald, and M. Lester (2012), A survey of plasma irregularities as seen by the midlatitude blackstone superdarn radar, Journal of Geophysical Research: Space Physics, 117(A2), doi:10.1029/2011JA017207, a02311.

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