PHYSICS AND ENGINEERING PHYSICS

Dawn-dusk asymmetry in the intensity of the polar cap flows as seen by the SuperDARN radars

A.V. Koustov, R.A.D. Fiori, Z. Abooalizadeh

Institute of Space and Atmospheric Studies

Outline

Justification and objectives

Effects of IMF Bz and By for weak IMF. Role of season

Effects of IMF intensification (Bt increase)

Conclusions

- SuperDARN radars measure line-of-sight velocity to produce global-scale plasma convection patterns

- Data are sorted according to bins of "external drivers of the convection", such as B_z, B_y, IEF, E_{KL}, E_{RC}

- Of interest are changes of the convection over minute-to-hour periods

- Long-term variations, on a scale of day, month or year, have not really been investigated even though >20 years of data are available

- The data are usually presented as contours of electrostatic potential from which variations of the E field (ExB drift) is difficult to infer (not possible if details are needed)

Our approach

Consider one-month long SuperDARN data sets for 1995-2013

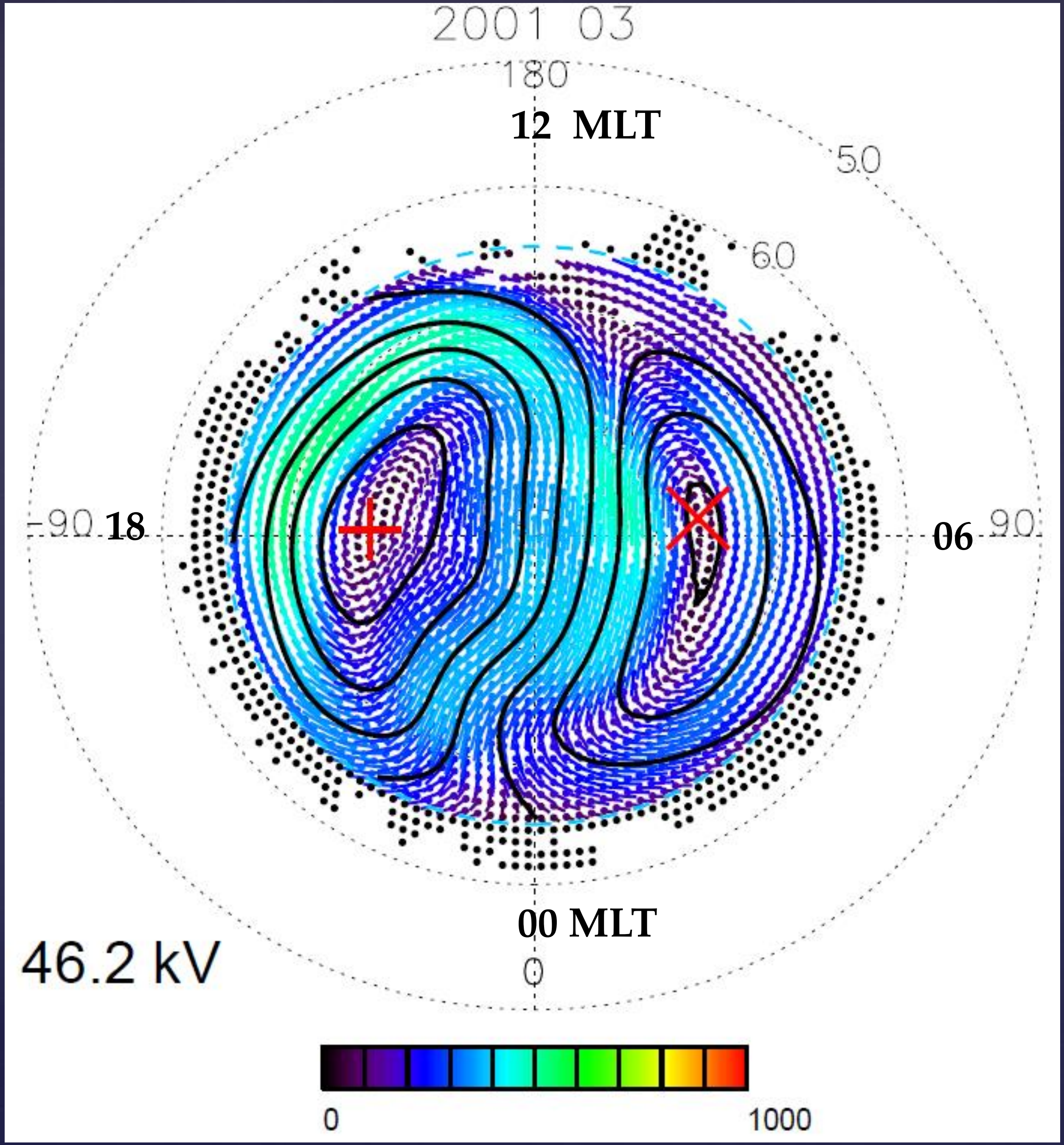
Use limited number of IMF bins to keep MLAT-MLT coverage good

Bz-: Bt=[-12,-6], [-6,-4], [-4,0]
Bz+: Bt=[0,4], [4,6], [6,12]
Bz-: By- and By+, any Bt

As in Ruohoniemi-Greenwald-96 statistical model

$$B_t^{\pm} = B_z/|B_Z| \sqrt{B_z^2 + B_y^2}$$

Infer convection pattern using Spherical Cap Harmonic Analysis (SCHA) approach by Fiori et al. (2010). The method does not require knowledge of the IMF Bz/By contrary to the traditional Potential Fit approach



Example of SCHA-based map, March 2001, Bt=[-4,0] nT

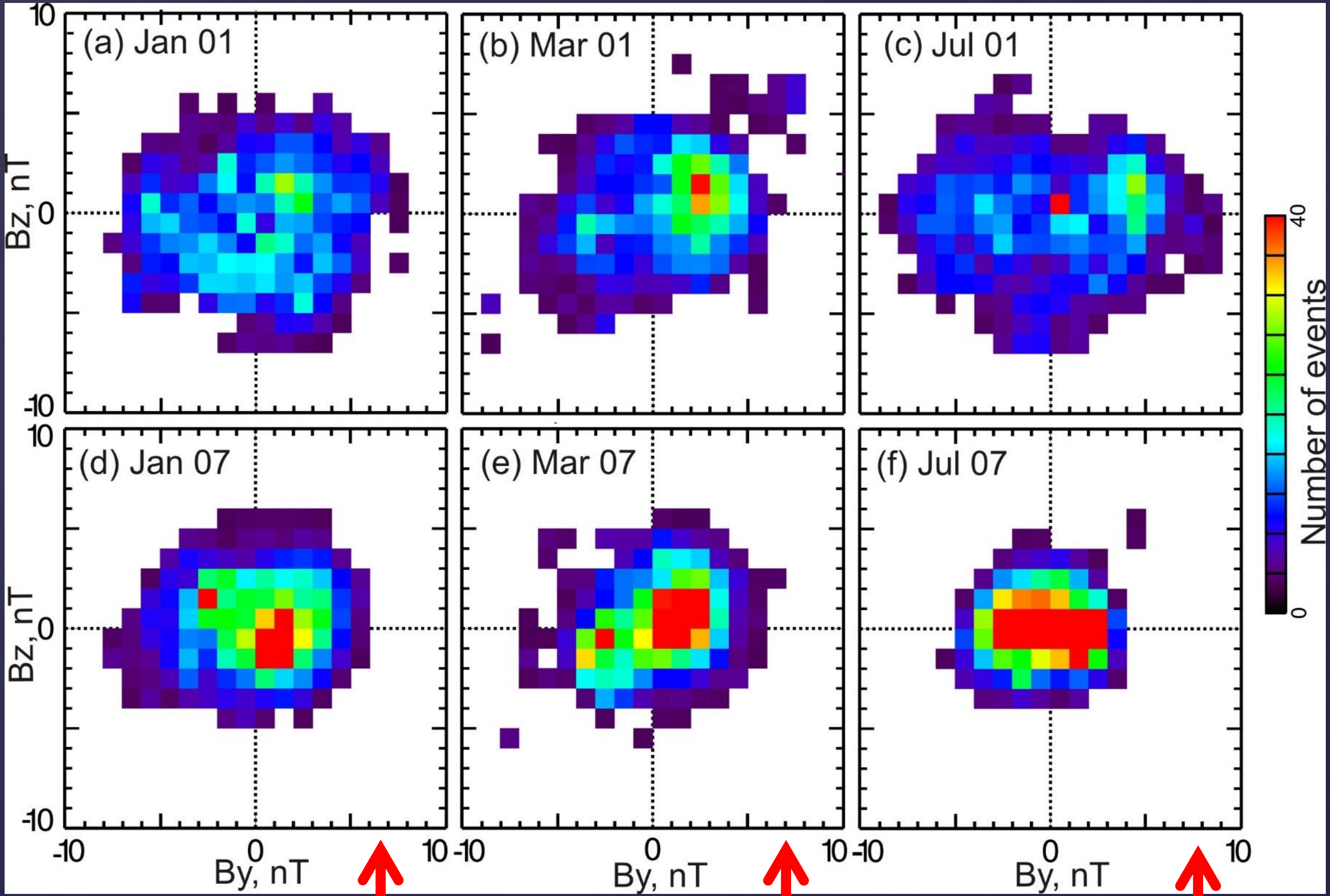
$$B_t^{\pm} = B_z/|B_Z| \sqrt{B_z^2 + B_y^2}$$

1) Good coverage everywhere

2) Faster flows

Polar cap (85 deg):	dawn
Auroral zone (72 deg):	afternoon

Typical IMF Bz-By distributions



Solar maximum

Solar Minimum

Winter Equinox Summer

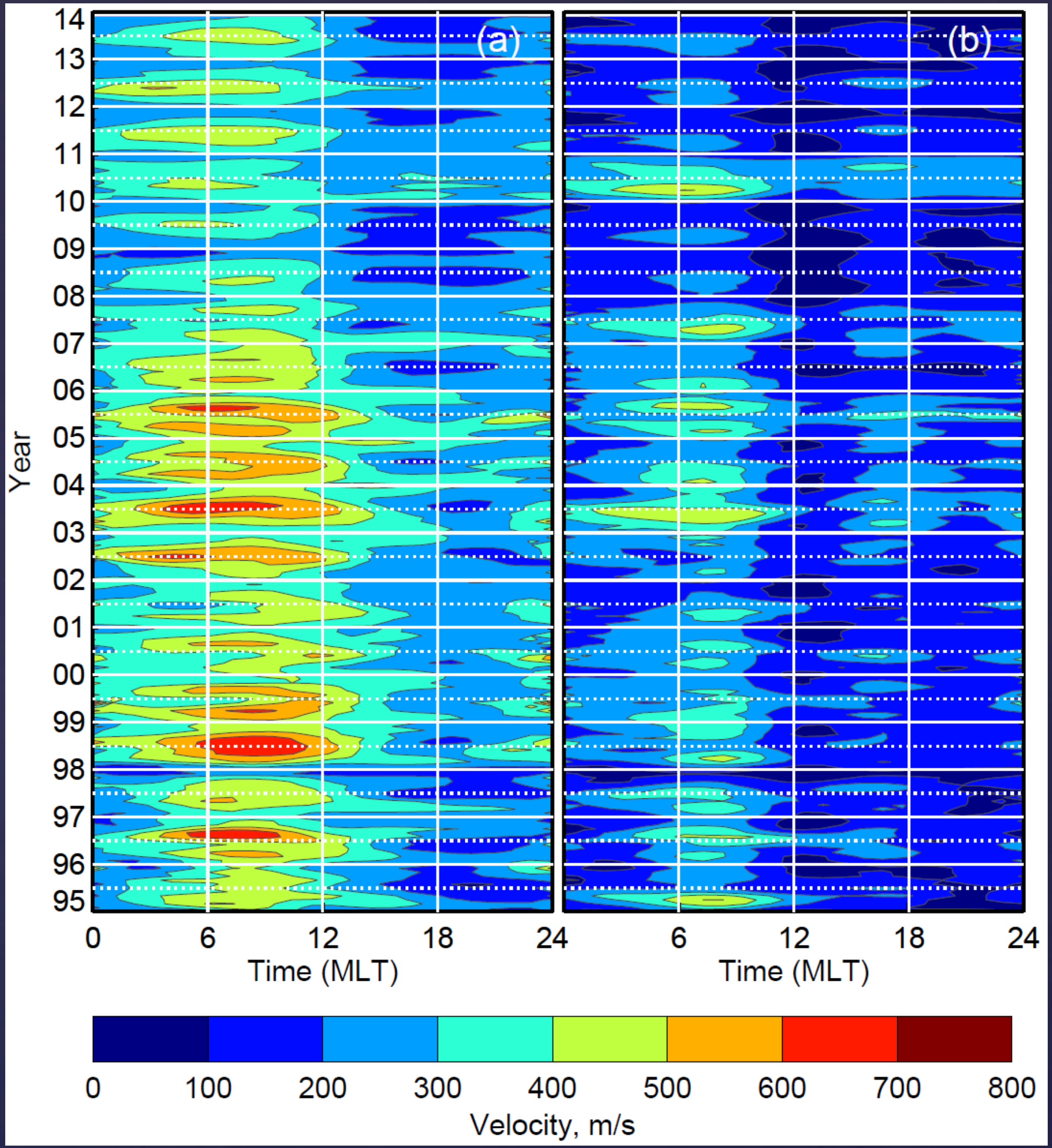
Magnitude of ExB velocity at MLAT=82º and weak Bt=[-4,0,4] nT

$$B_t^{\pm} = B_z/|B_Z|\sqrt{B_z^2 + B_y^2}$$

1) Bz- velocities > Bz+ velocities

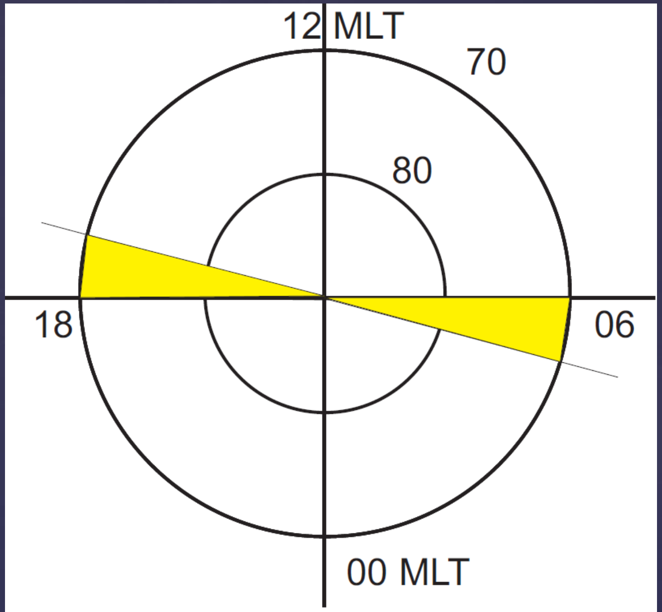
2) Maximum velocities are during pre-noon hours

3) Maximum velocities often occur in summer (dashed lines)



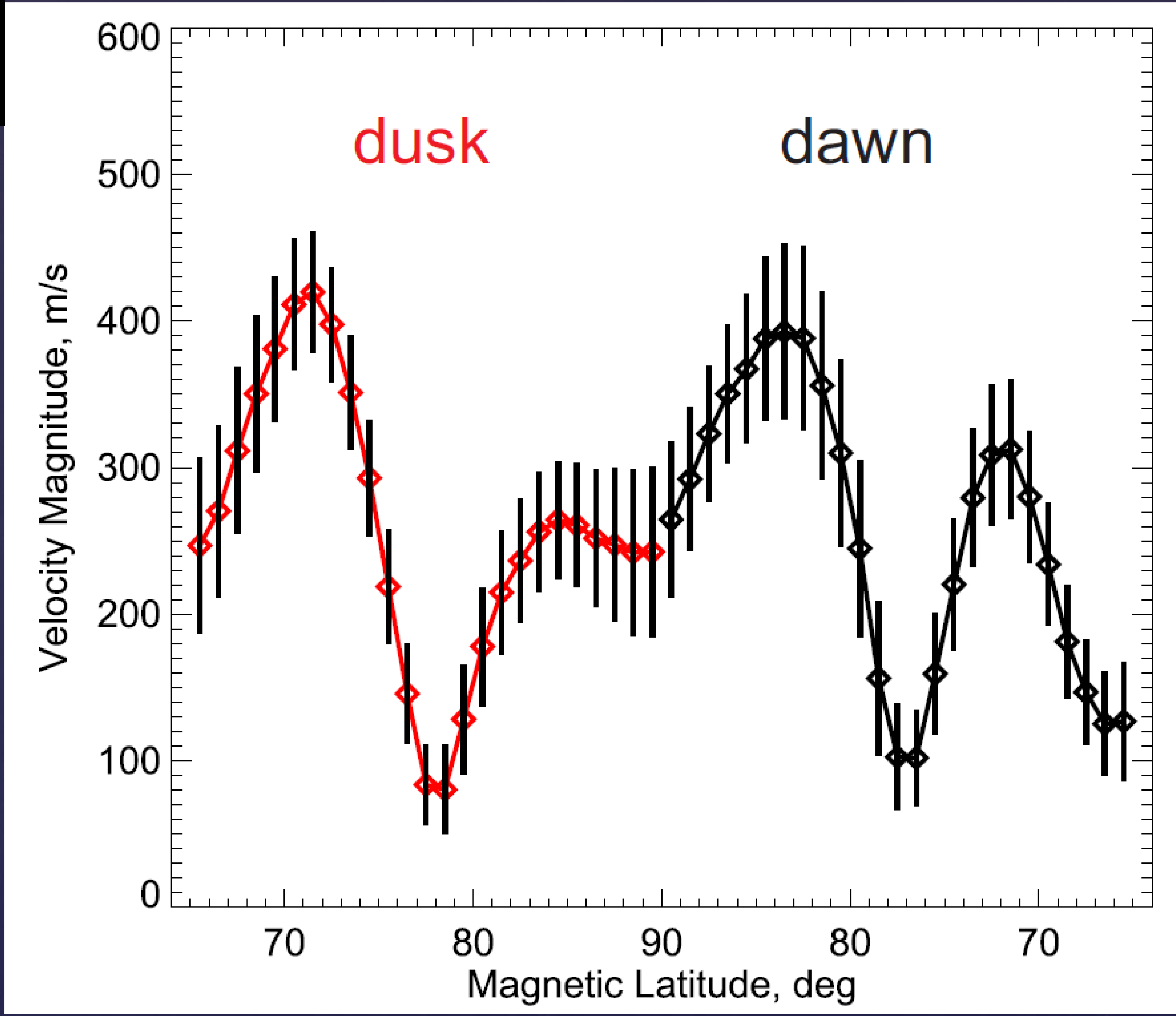
$$B_t^{-} = [-4,0]\, nT \quad B_t^{+} = [0,4]\, nT$$

Magnitude of ExB velocity vs MLAT, weak Bt=[-4,0] nT



On average, over 19 years of observations, dawn speeds in the polar cap are larger than dusk speeds. In the auroral zone, dusk speeds are faster.

No IMF By sorting was used here.



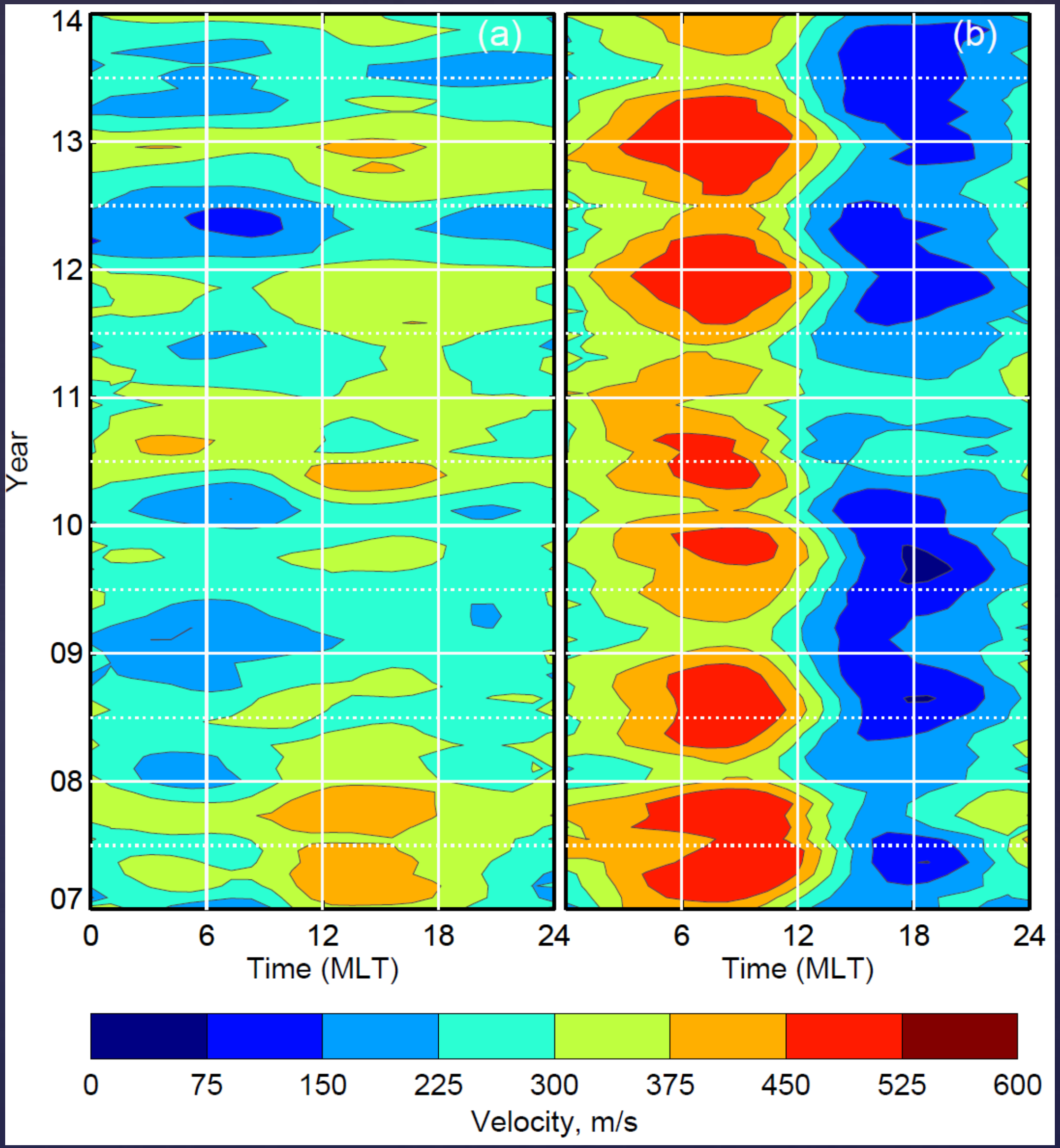
Magnitude of ExB velocity at MLAT=82° and By+/- (Bz<0, any Bt) 7 years of observations (2007-2013)

1) By+: Dawn/prenoon speeds are systematically larger than dusk speeds, by a factor of 2

2) By-: Dusk/afternoon speeds are OFTEN larger than dawn speeds, by a factor of ~1.2

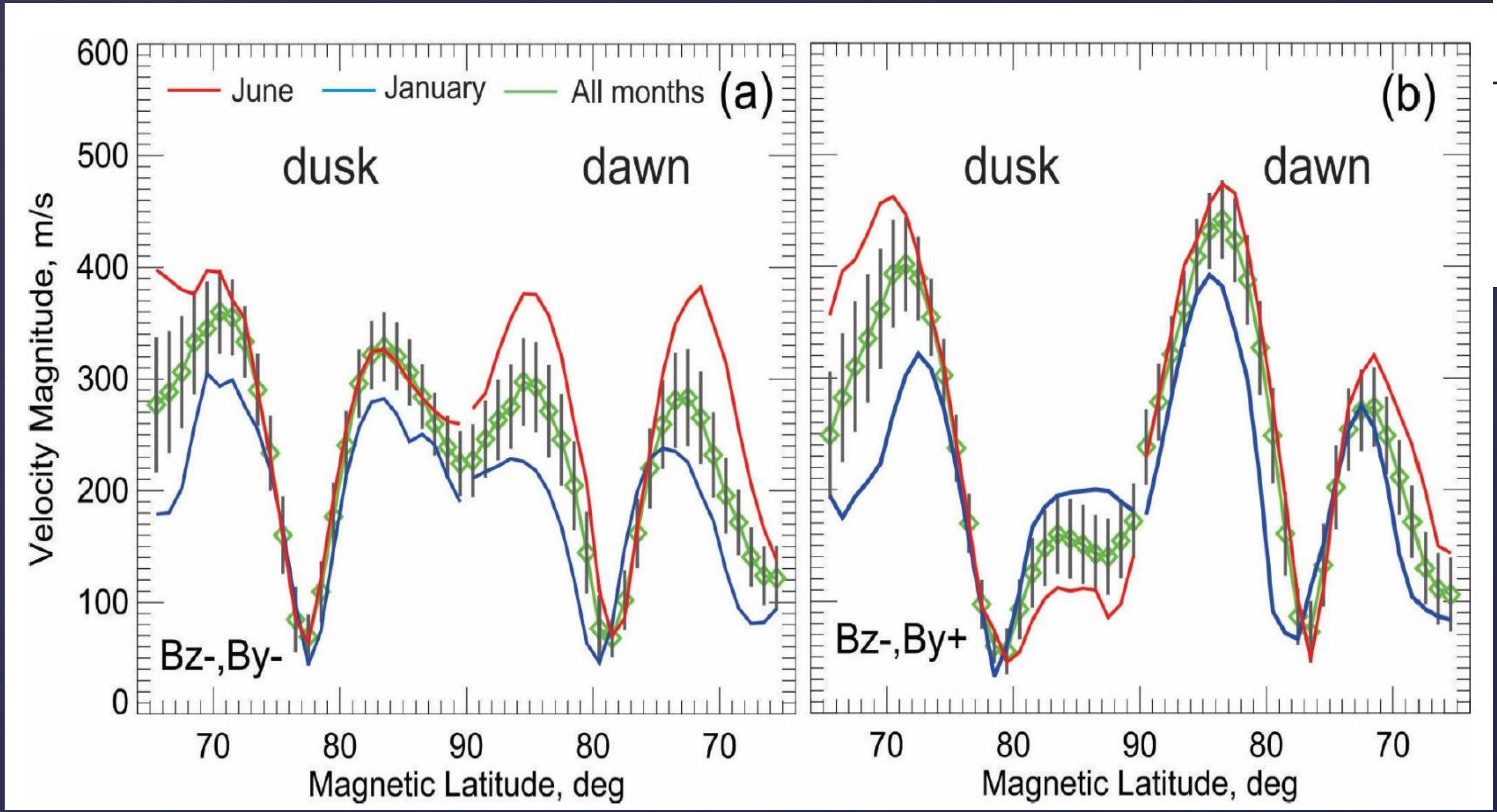
By+ vs By-: Contrast Dawn-Dusk is much stronger for By+

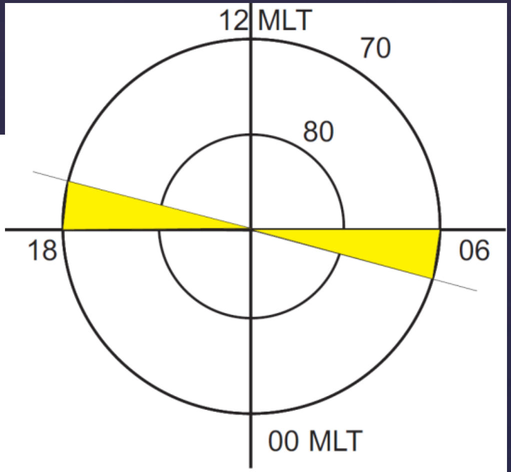
3) By+: Winter speeds < summer speeds
By-: Not clear



B_y^- B_y^+

Magnitude of ExB velocity for By+/- (Bz<0, any Bt, 2007-2013)

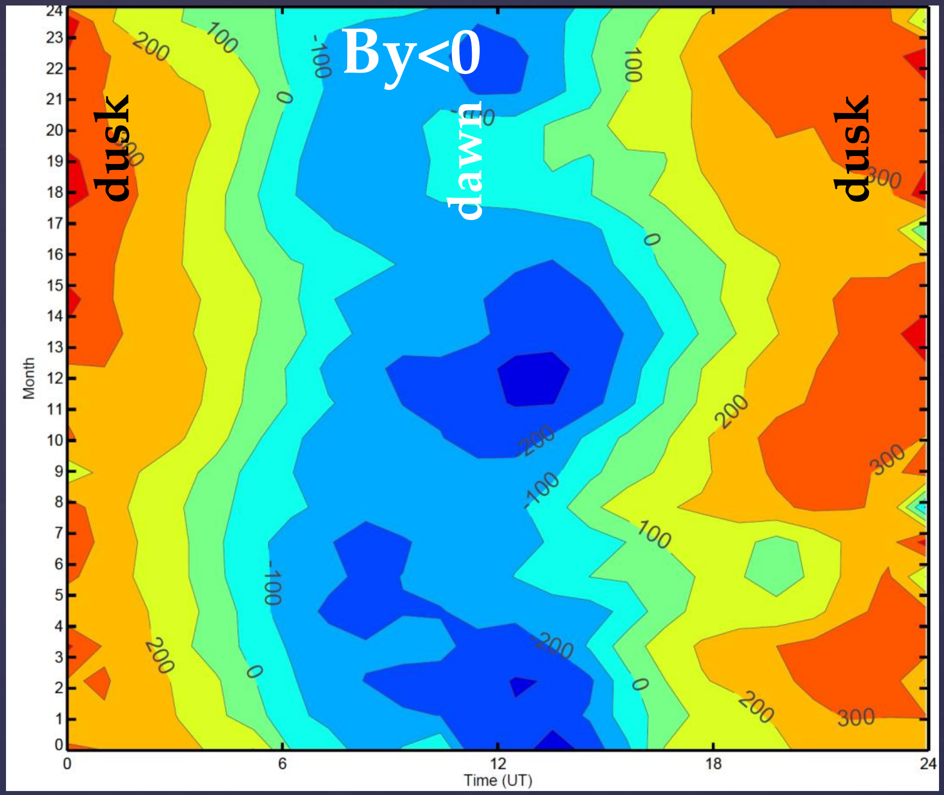


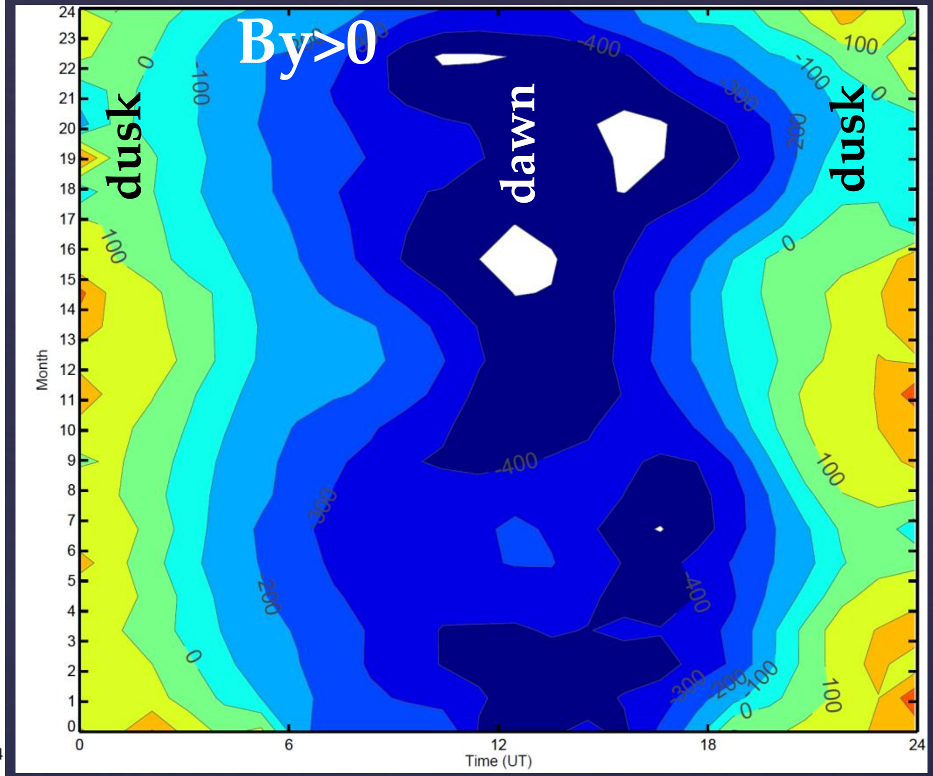


On average, over 7 years of observations, dawn speeds in the polar cap are faster than dusk speeds. For the auroral zone, dusk speeds are faster.

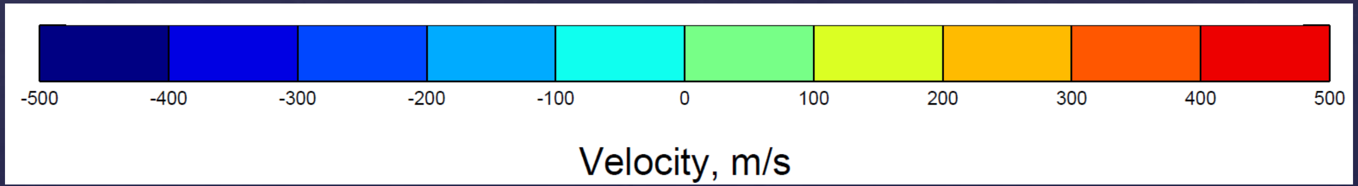
No IMF Bz filtering was applied except Bz<0 (By was either <0 (left) or >0 (right))

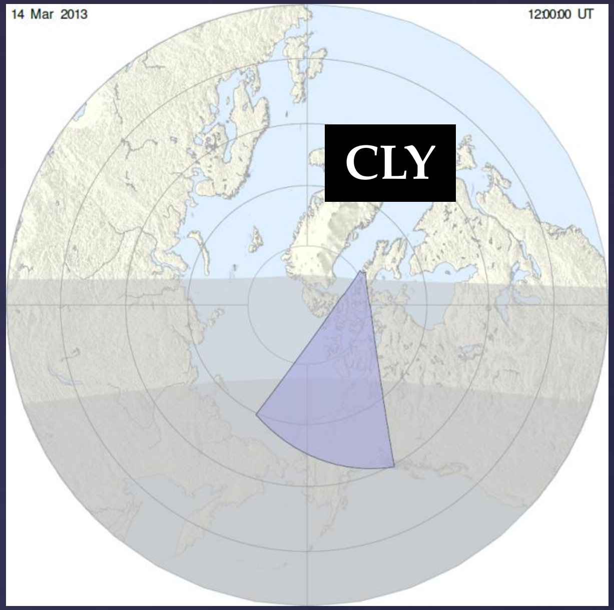
IMF By Effects in CLY River LOS velocity (Bz-)



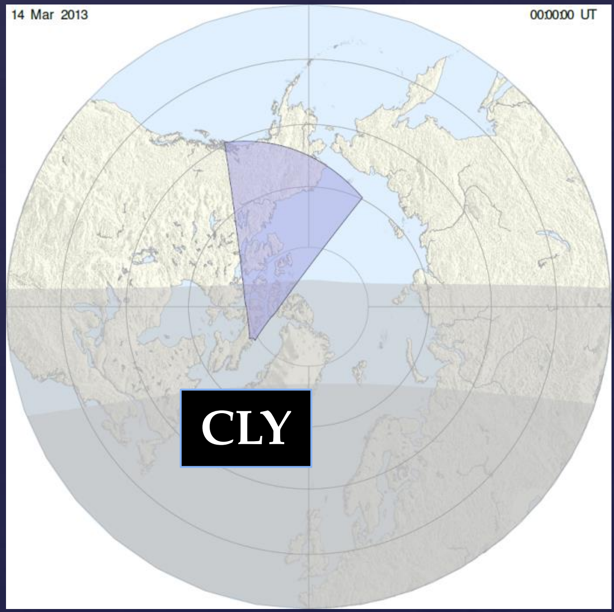


300 200 300 200 400 200 m/s





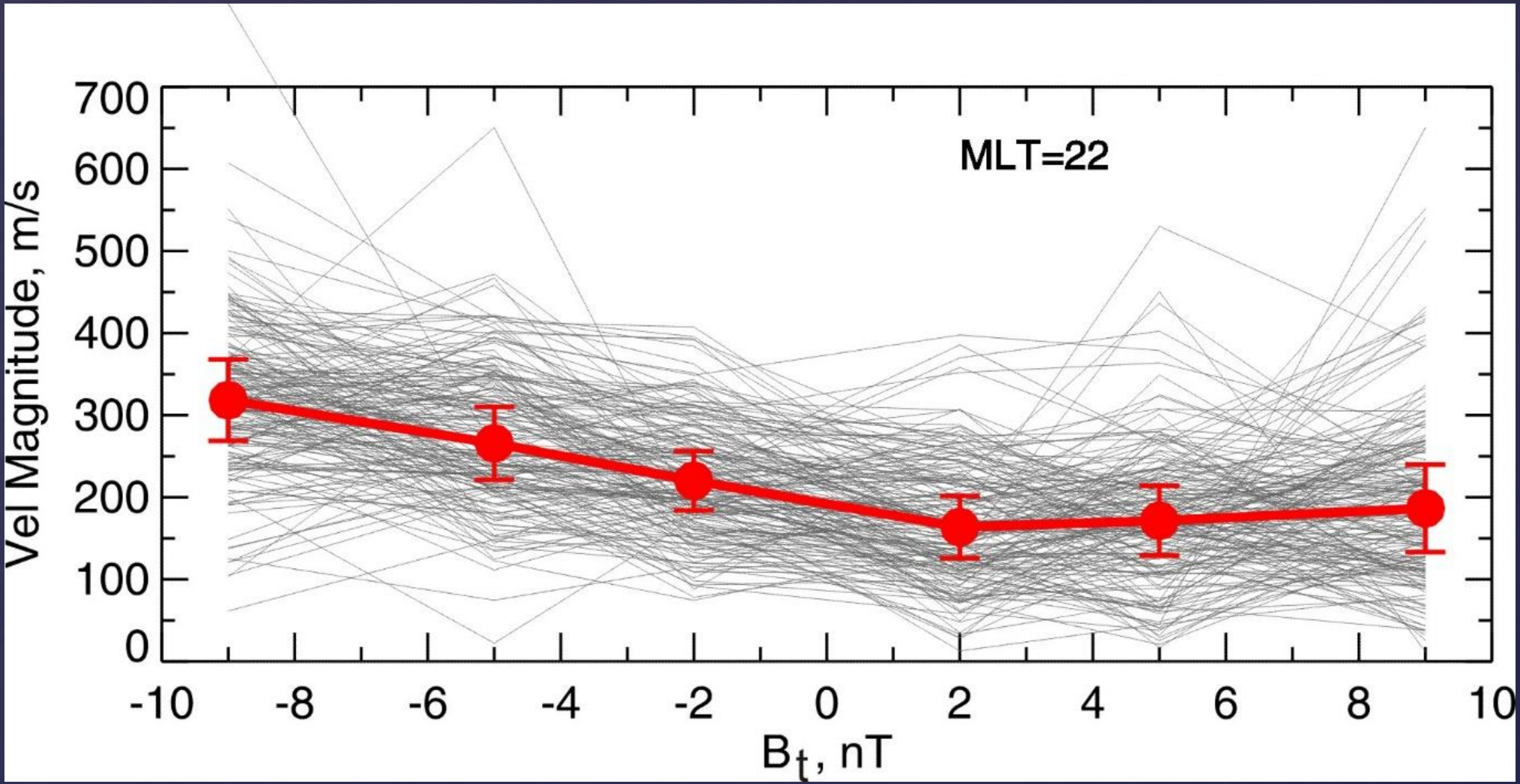
12 UT – DAWN



24 UT - DUSK

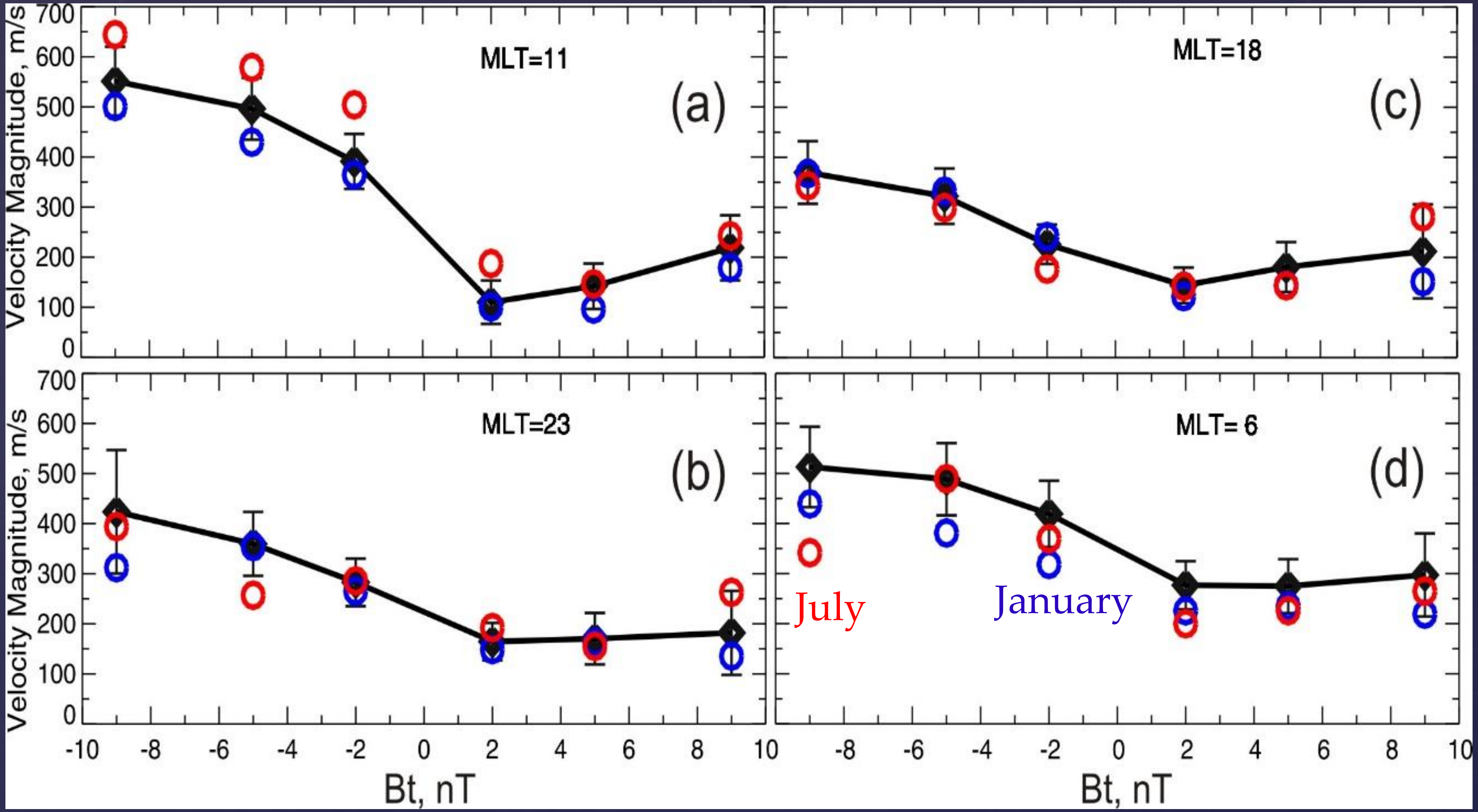
1) By+ peak velocities > By- peak velocities (400 vs 300)
2) Contrast Dawn-Dusk larger for By+ (factor 2 vs 1.5)
3) Winter velocity > summer velocity (dusk, dawn?)

Effects of IMF Bt increase at specific MLAT. Approach to analysis



Median velocity is found for every bin of Bt and specified MLT

Effect of Bt increase



Bz-: Speed “response” to the Bt increase is strongest at noon and weakest at dusk. No clear seasonal effect

Bz+: Very weak response

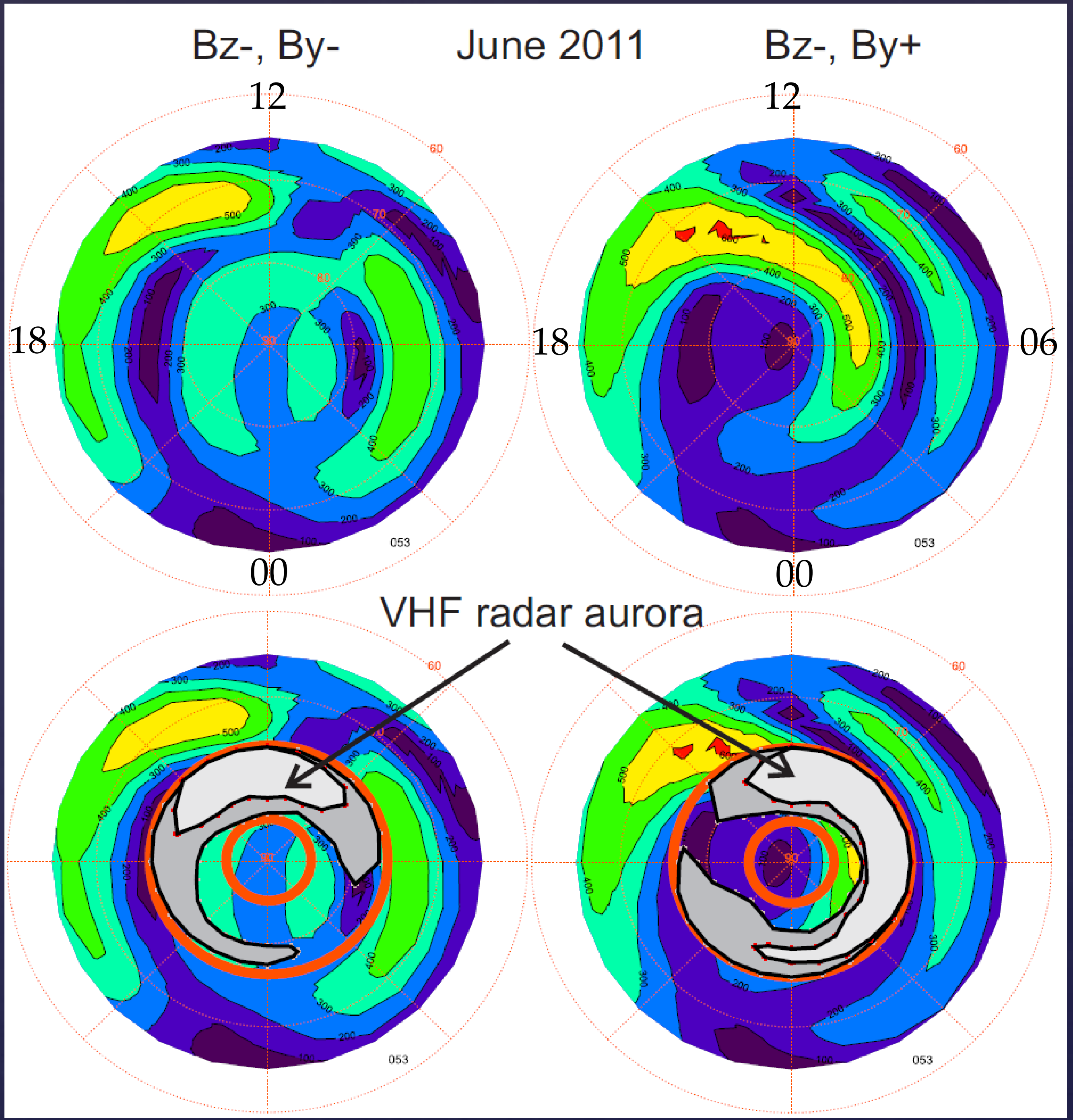
Application

Do regions of enhanced ExB drifts correspond to those with enhanced VHF echo occurrence?

Voloshinov and Troshichev (1986) reported occurrence rates of 100 MHz radar echoes depending on IMF Bz and By. They considered winter observations at MLAT=76-85 (red circle), Davis Base, Antarctica

Agreement is “reasonable”

We also found some consistency in MLT and season for IGY 50 MHz observations by Al McNamara (1972)



Conclusions

For the polar cap (MLAT>80°) the SuperDARN data show

- By+: dawn flows are faster than dusk flows by a factor of 2
- By-: dawn flows are slower than dusk flows but not significantly, by a factor of 1.2

- Dawn flows are OFTEN faster summer time, not winter time

- With the Bz (Bt) increase, the contrast between dawn and dusk speeds becomes slightly larger

- Identified MLAT/MLT regions with enhanced speeds correlate with regions of frequent occurrence of VHF radar echoes (as expected)

Thank you