



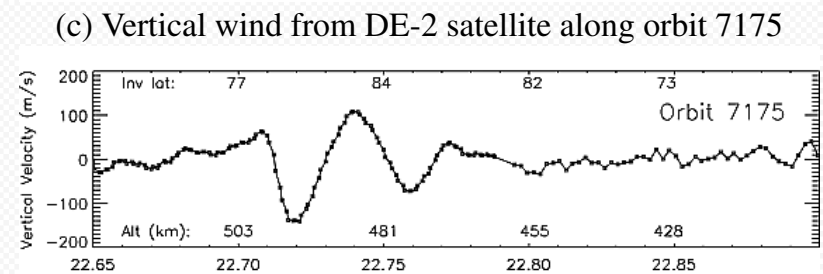
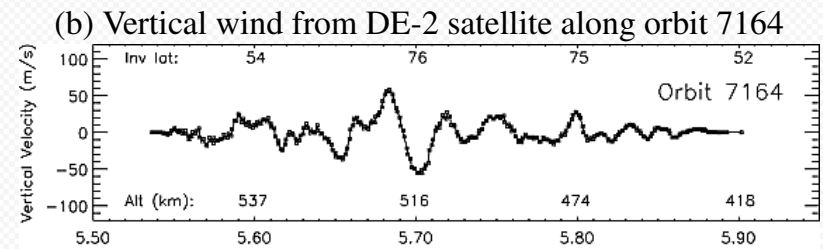
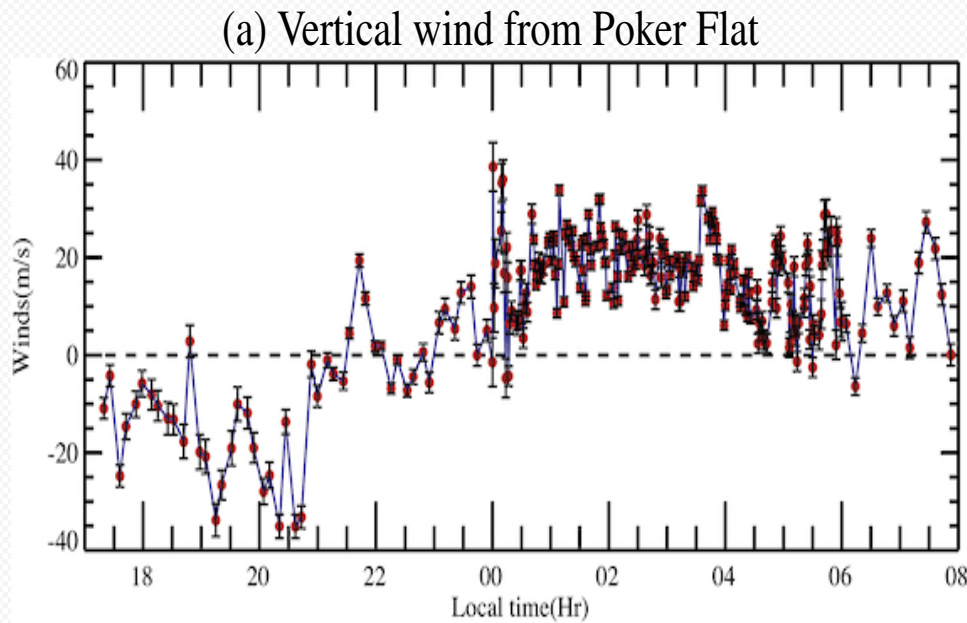
Analysis of equatorial F-region vertical neutral winds from Brazil FPI observations

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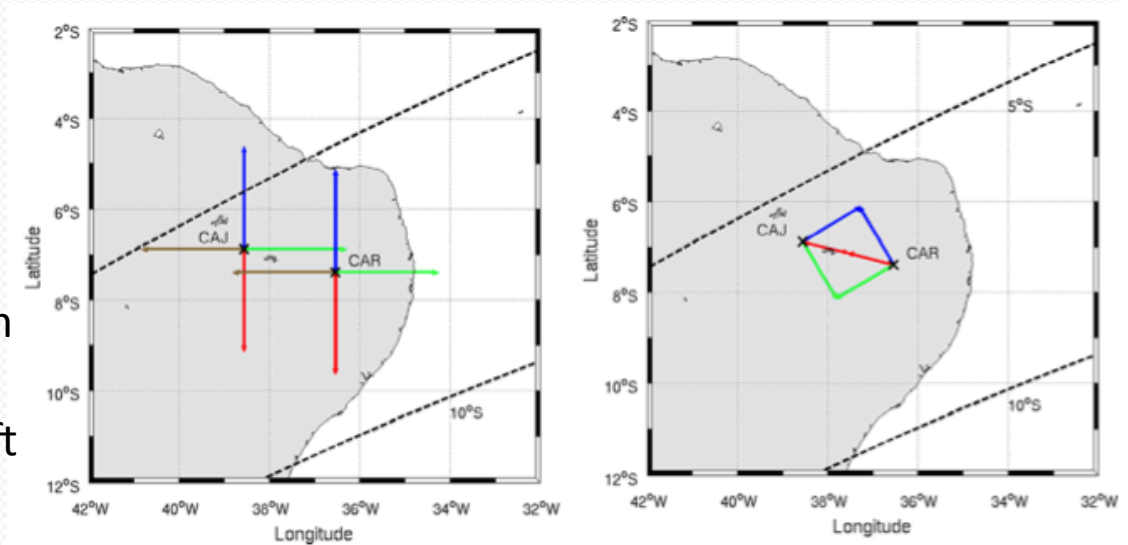
Motivation:

- 1) Although the vertical winds are typically small, significantly smaller than typical zonal and meridional winds, they can be non-zero under certain conditions.
- 2) Influence of the vertical neutral wind on the thermosphere can be substantial due to the large gradient of neutral density in the vertical directions.



Bi-static FPI experiment in Brazil:

- 1) FPIs are located at Cajazerias (6.871S, 38.561W) and Cariri (7.381S, 36.521W), which are separated by 230 km.
- 2) Each FPI consists of a 42-mm diameter etalon with fixed 1.5-cm plate spacing.
- 3) The FPIs observe the Doppler shift and broadening of the nighttime 630.0-nm emission originating at altitudes of ~ 240 km.
- 4) For this study, FPI data during 2010-2014.
- 5) Cardinal mode and common volume mode.
- 6) Parameters: neutral temperature, meridional, zonal and vertical winds.



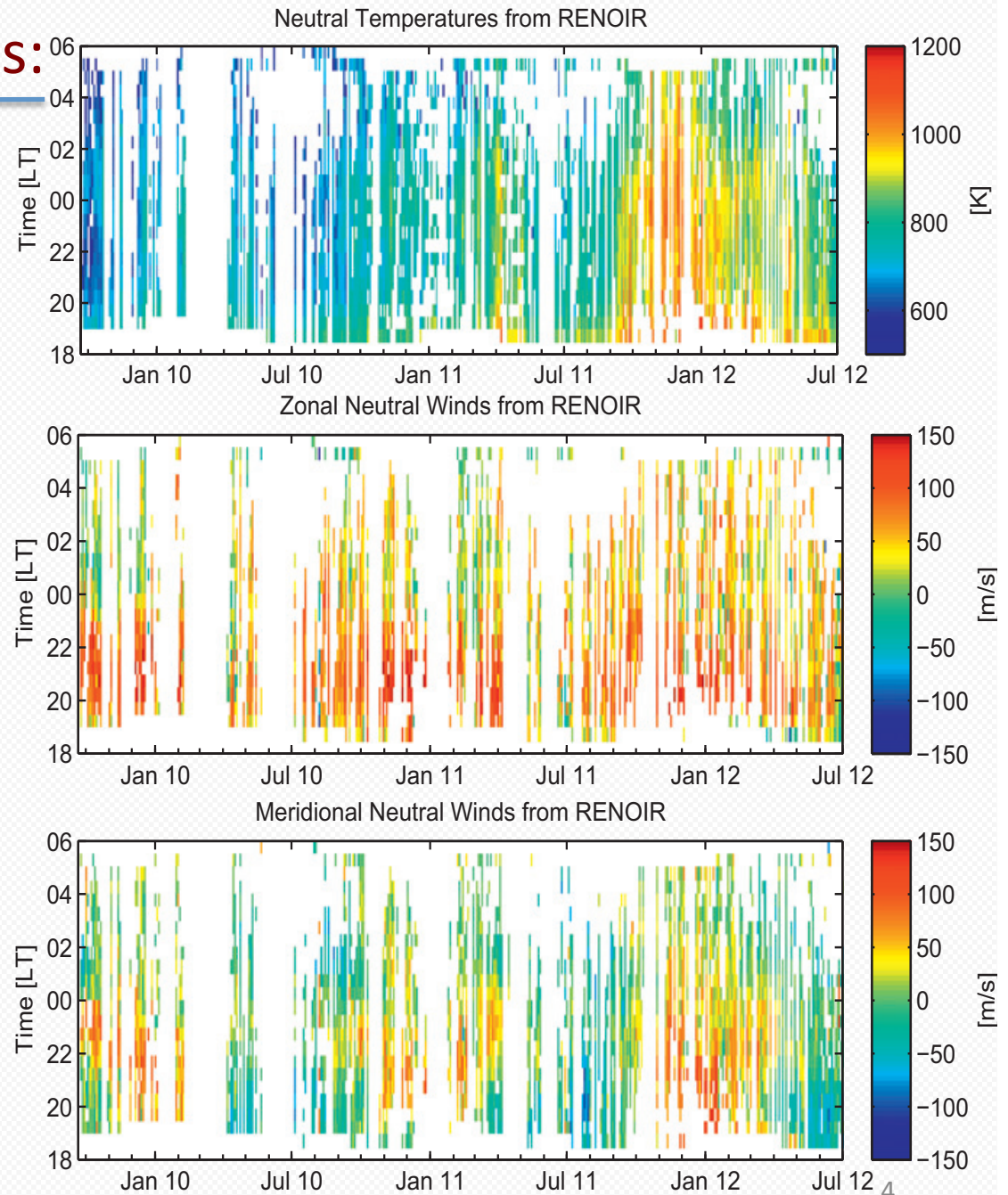
Makela et al., 2013

The left figure shows the FPIs operating in a cardinal direction mode.

The right panel shows the FPIs operating in the common volume viewing geometry.

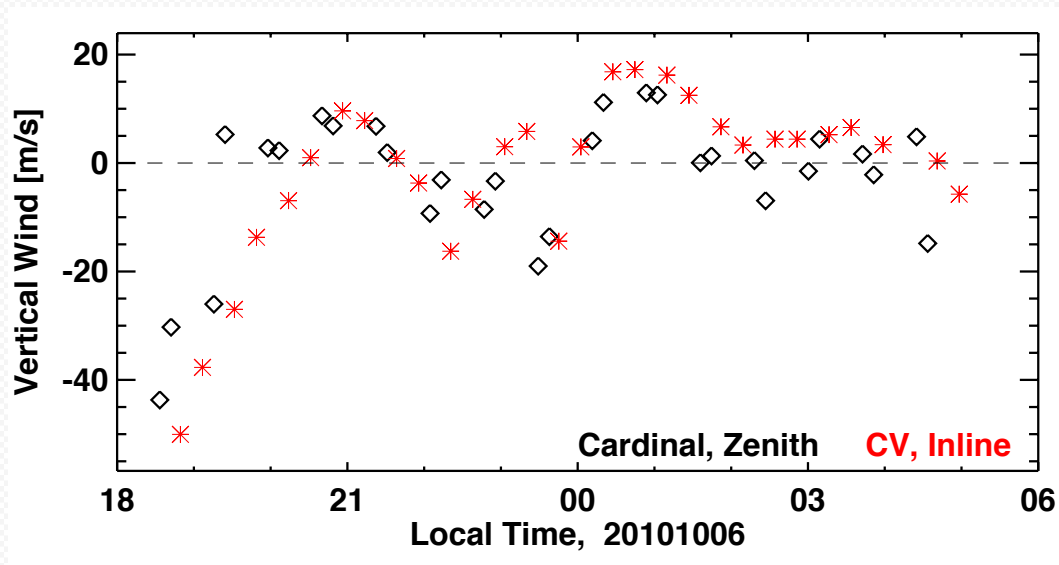
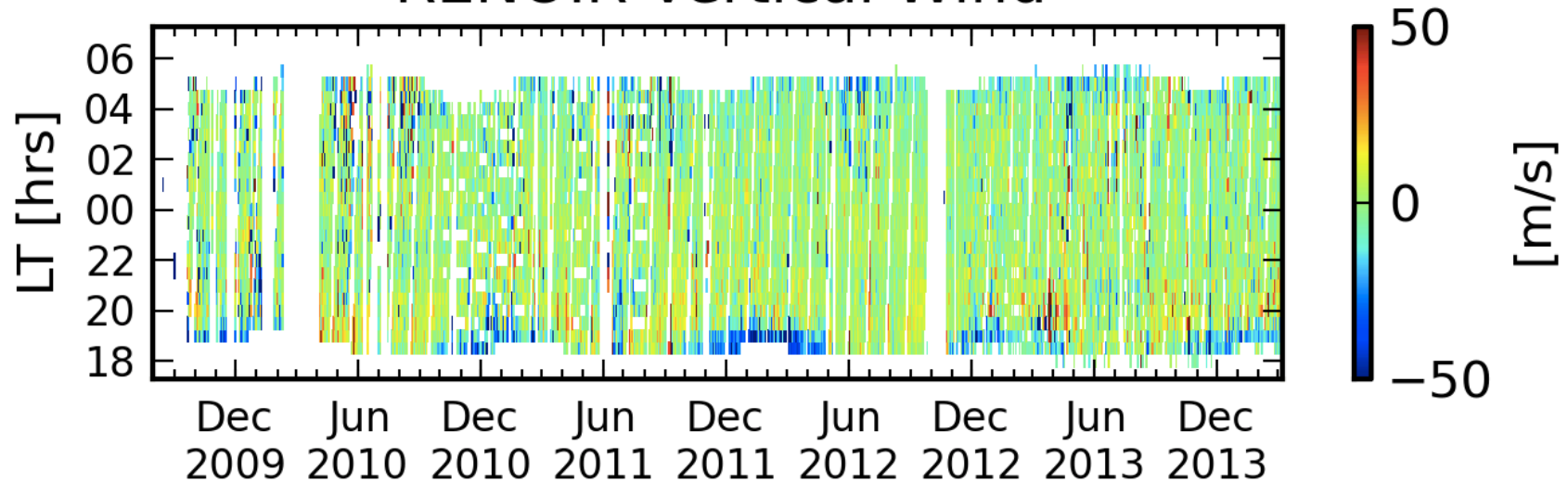
Tn and Horizontal winds:

- The period of September 2009 through June 2012
- The temperatures indicate a strong dependence on solar flux conditions.
- Zonal winds show an initial increase in eastward flow after sunset followed by a reduction in the midnight and early morning hours.
- Meridional winds show the expected signature of trans-equatorial flow from the summer to winter hemisphere.



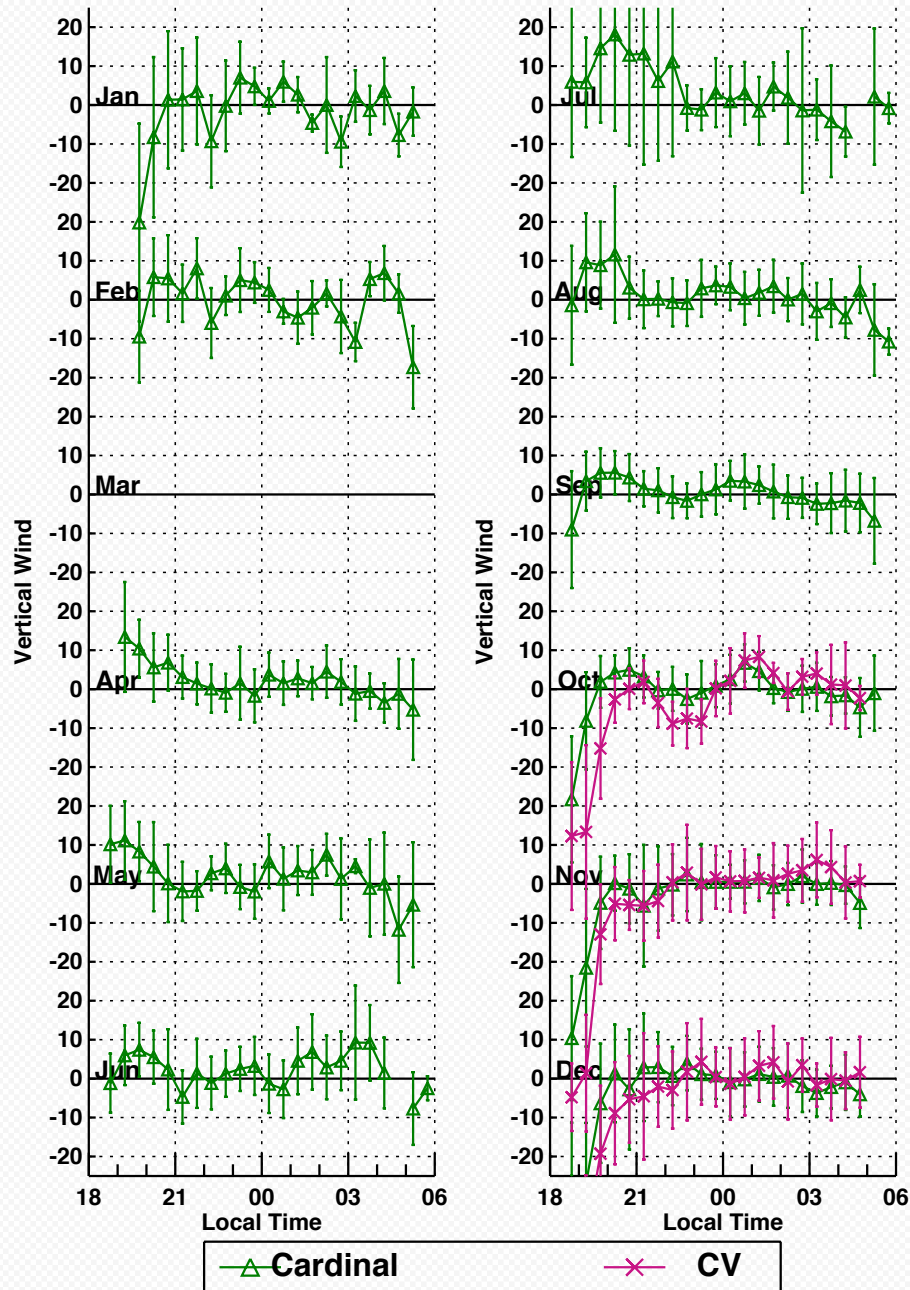
Vertical Wind: Seasonal Dependence

RENOIR Vertical Wind

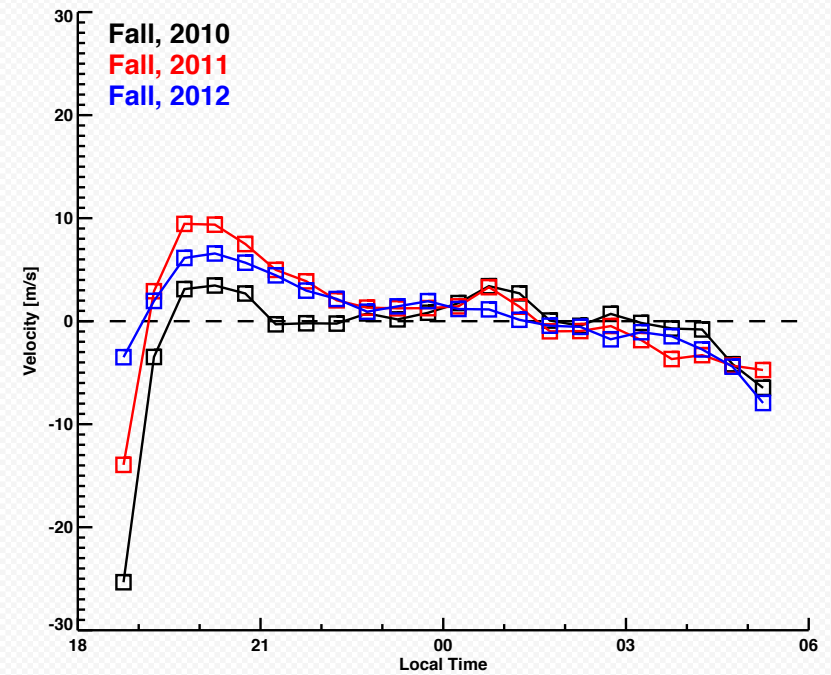
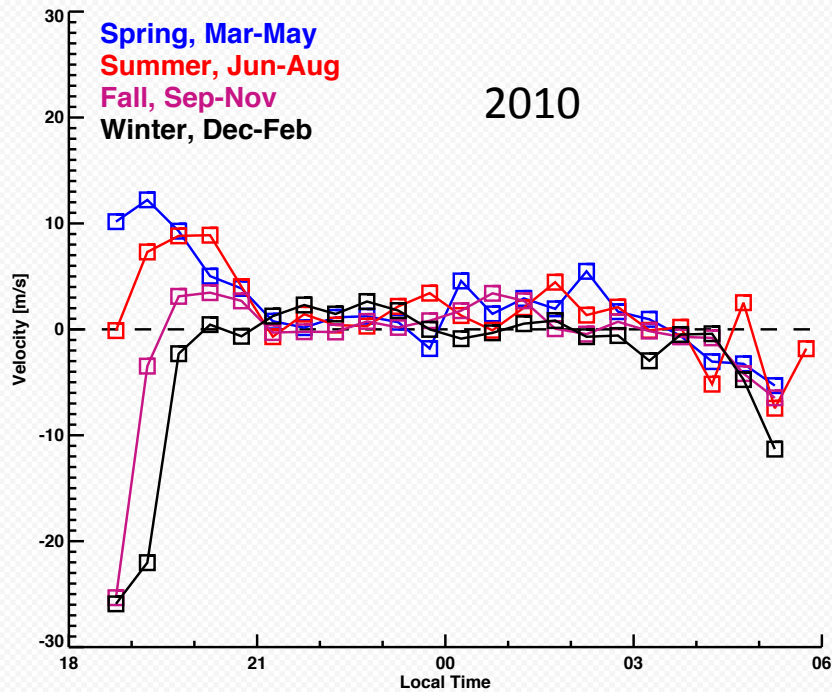


Cardinal mode vs. CV mode

2010



- Cardinal mode zenith look direction data vs. Common Volume mode
- Bin vertical wind data according to LT with 30-min bin size
- Variation is large compared to the average
- Vertical winds are statistically non-zero at certain local time.
- Clear dependence on the local time and month.
- Cardinal mode and CV mode are consistent in general.

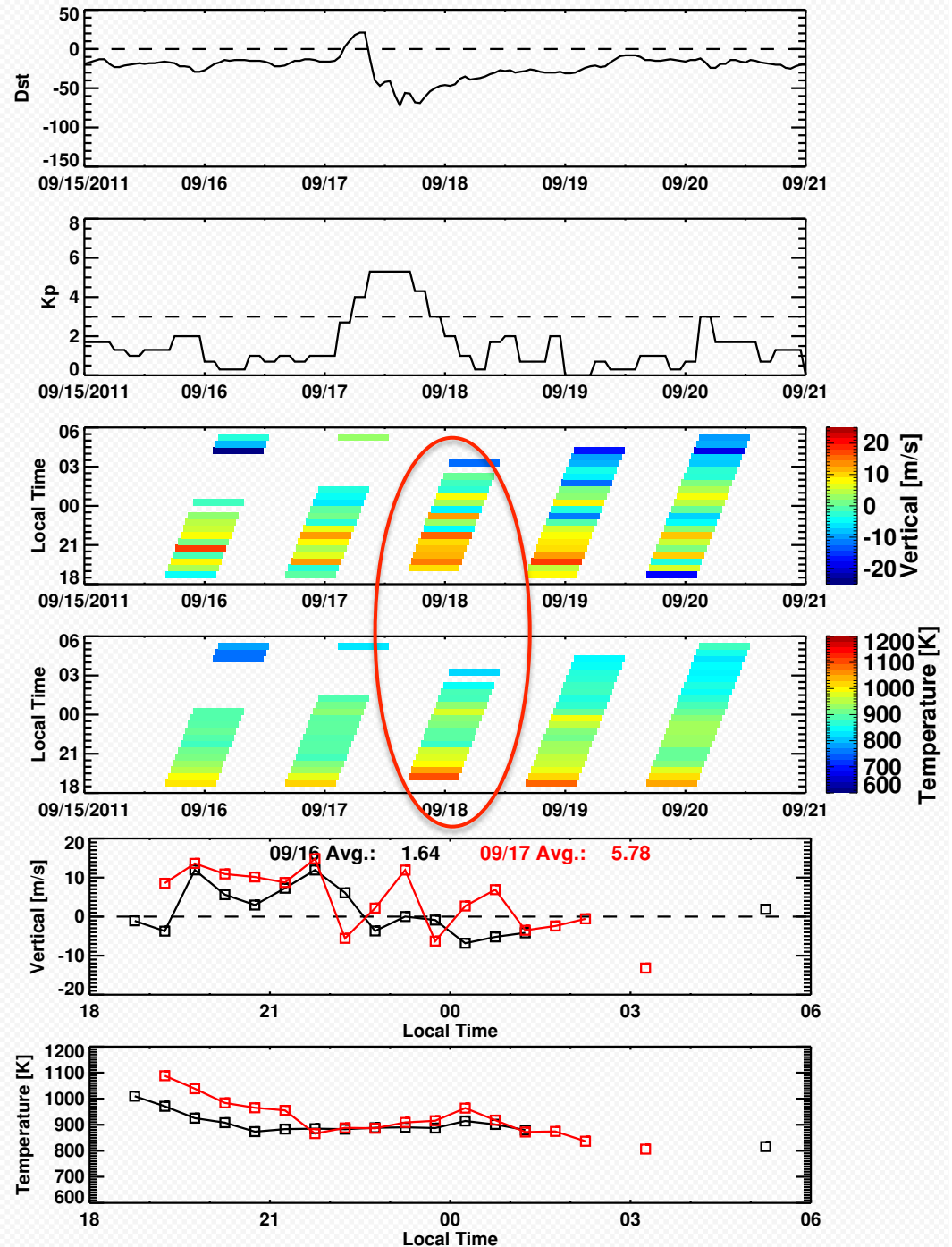


- Strong seasonal variation in [19-21] LT
- Dependence on year or solar activity

Vertical wind variation during storm periods:

Sept. 17th, 2011 storm

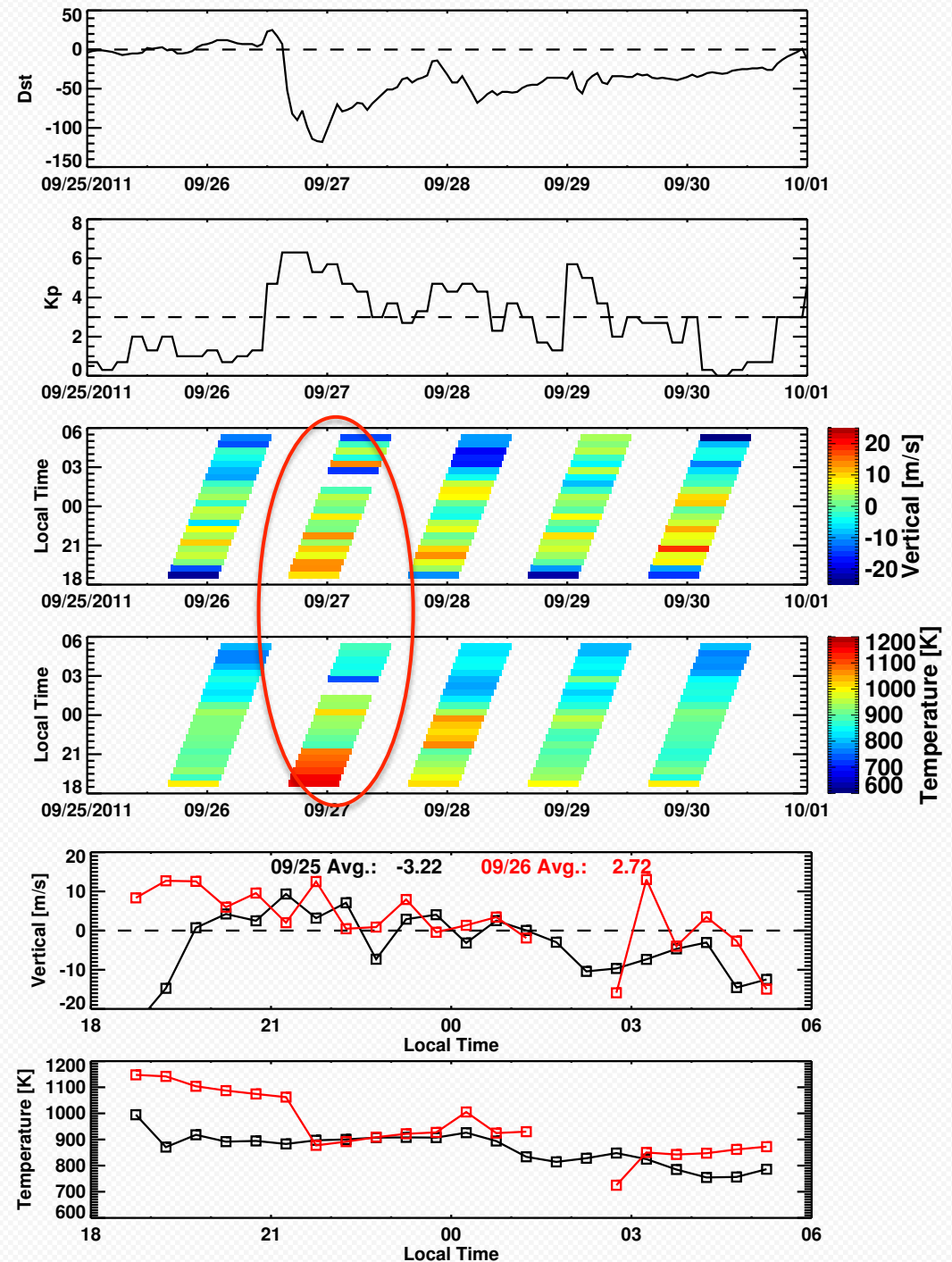
- Variations of neutral temperature and vertical wind have been shown during two storm periods.
- The neutral temperature increased significantly (100 - 200 K) at [18, 21] LT on the Storm day when compared with the quiet time.
- The vertical winds also increased clearly on the storm day. On average, vertical winds shift upwards by ~5 m/s during storm time.



Vertical wind variation during storm periods:

Sept. 26th, 2011 storm

- Variations of neutral temperature and vertical wind have been shown during two storm periods.
- The neutral temperature increased significantly (100 - 200 K) at [18, 21] LT on the Storm day when compared with the quiet time.
- The vertical winds also increased clearly on the storm day. On average, vertical winds shift upwards by ~5 m/s during storm time.



Conclusion:

- While the vertical wind data are quite variable, the vertical winds are statistically non-zero at certain local time.
- Clear seasonal and solar activity dependence can be identified at [19,21] LT and [4,6] LT.
- The cardinal mode and CV mode are generally consistent.
- During storm time, neutral temperature increases $\sim 100 - 200$ K at [18, 21] LT and the vertical wind shifts upwards by ~ 5 m/s.

Future works:

- More data will be included in the analysis, including observations in 2013 and 2014.
- Statistic study, such as epoch analysis, of the vertical wind variation during storm time will be done as well.