Ion-Neutral Coupling from PFISR and Ground-based Fabry-Perot Measurements

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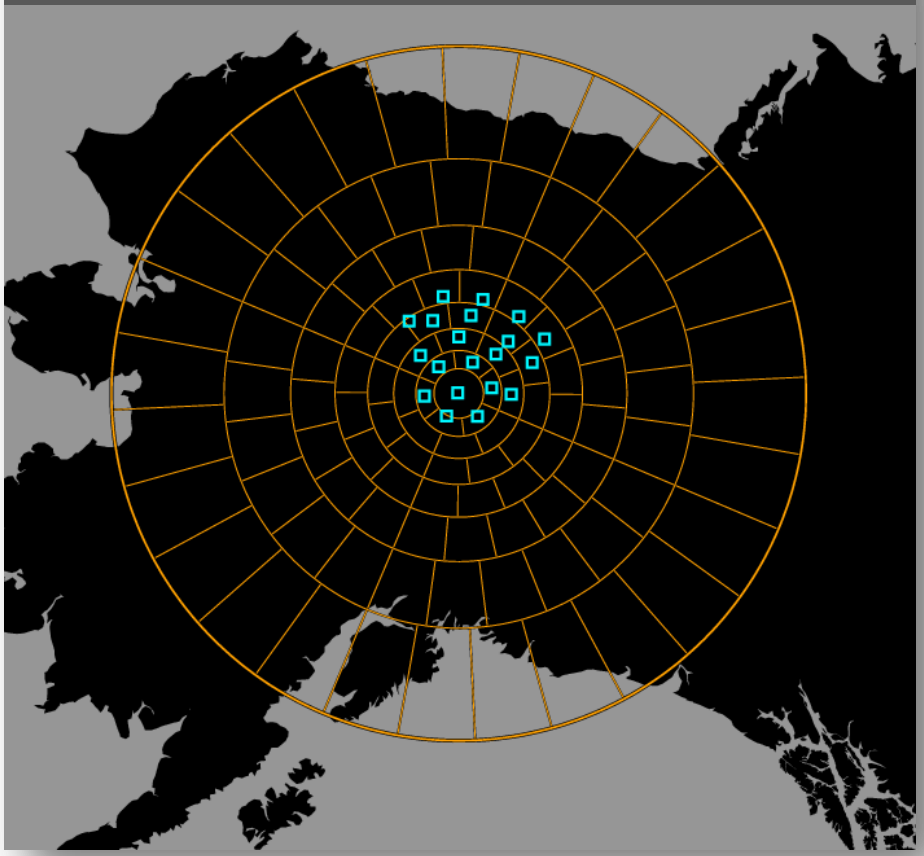
Motivation

- Studies of ion-neutral coupling require (essentially) simultaneous observations of both ion and neutral flows.
- It is also advantageous to sample at multiple altitudes, as strong vertical gradients in many parameters imply a vertical gradients in the behavior of the coupling.
- To avoid spatial/temporal ambiguities, the optimum strategy is to observe in multiple look-directions simultaneously.
- Both the Scanning Doppler Imager (**SDI**) and Advanced Modular Incoherent Scatter Radar (**AMISR**) have this capability.
- They are therefore ideally suited to imaging ion/neutral flows.
- Here we show some (***very***) preliminary results from a campaign of coordinated PFISR+SDI observations, initiated by Mike Kosch.

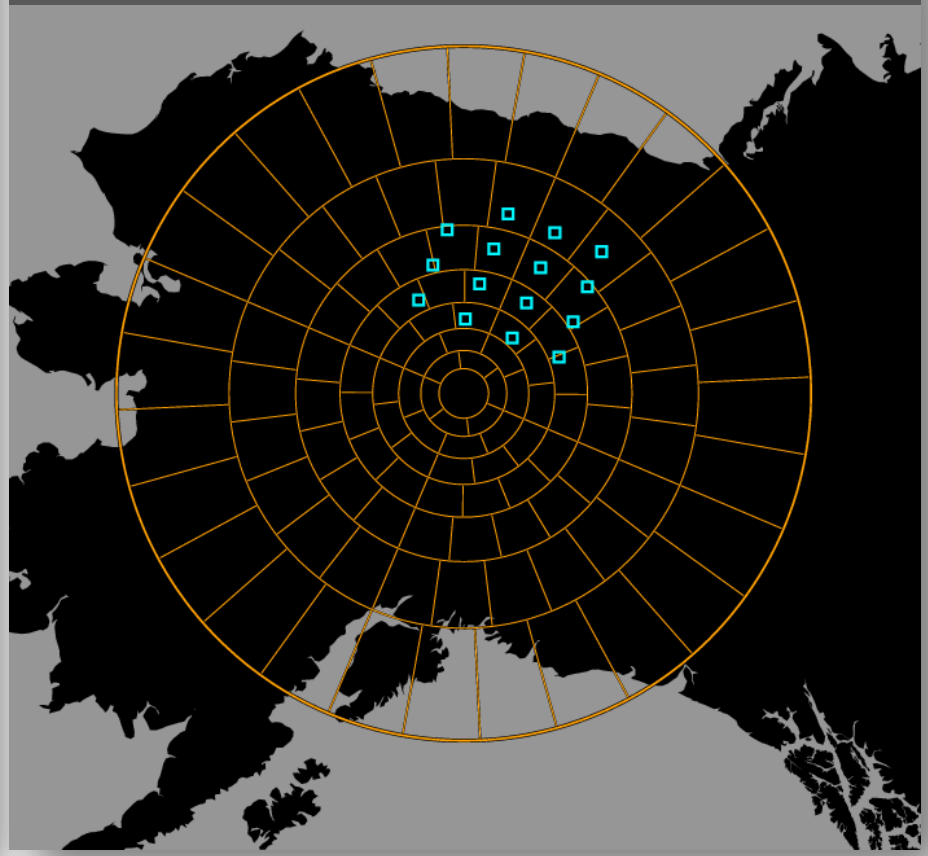
Instruments/Geometry

- SDI zones (orange sectors) and PFISR beam mappings.
- Image on the left shows beam/zone intersections at 240 km.
- Image on the right shows the locations at which (F-region) ion flow vectors were derived.

PFISR Beam Intersections at 240 km



PFISR voxel centers for discrete inversion



Analysis

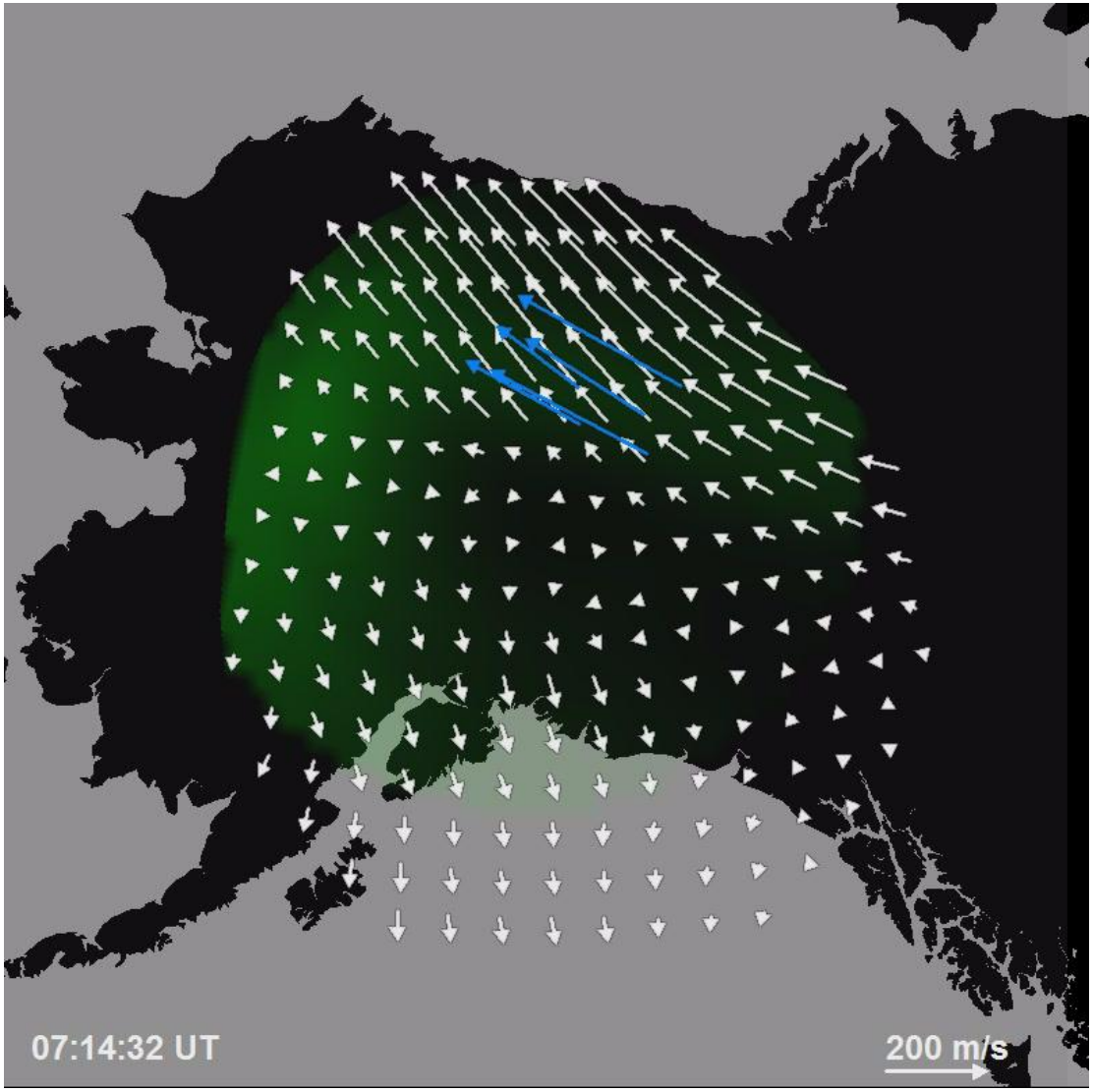
- Neutral winds were derived from single station ‘monostatic’ wind fits. These were then averaged between the Poker Flat and Gakona Scanning Doppler Imagers.

- Ion flow vectors derived through Bayesian inversion of groups of PFISR line-of-sight velocities:

  Semeter, J., T. W. Butler, M. Zettergren, C. J. Heinselman, and M. J. Nicolls (2010)
  &
  Heinselman, C. J., and M. J. Nicolls (2008)

Results

F-region data from April 5th, 2011.



Results

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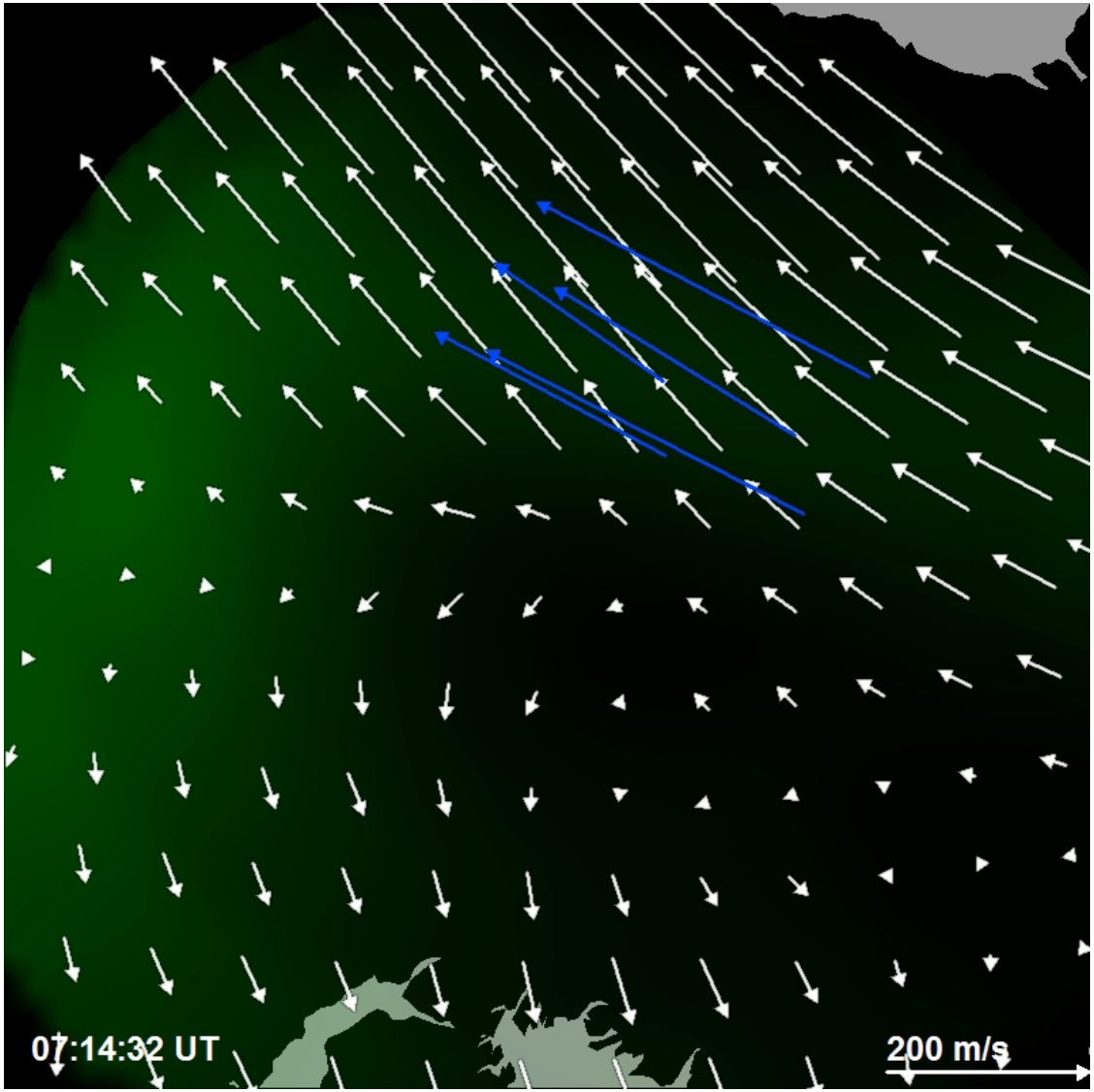
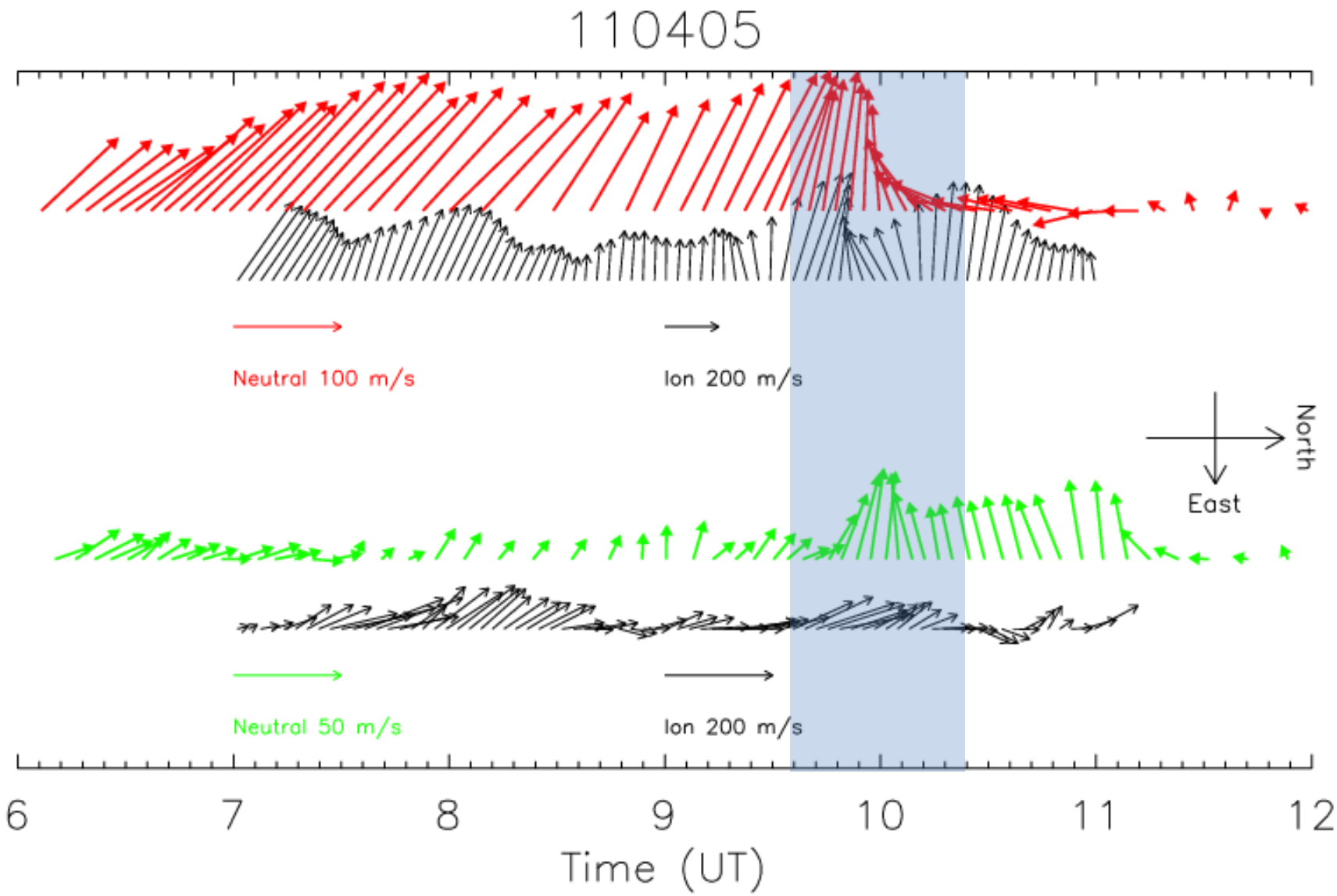


Ion-Neutral Coupling

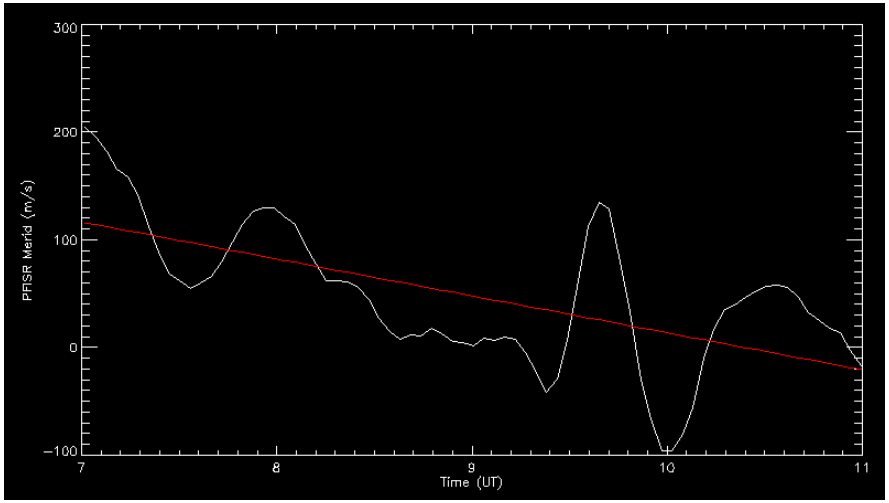


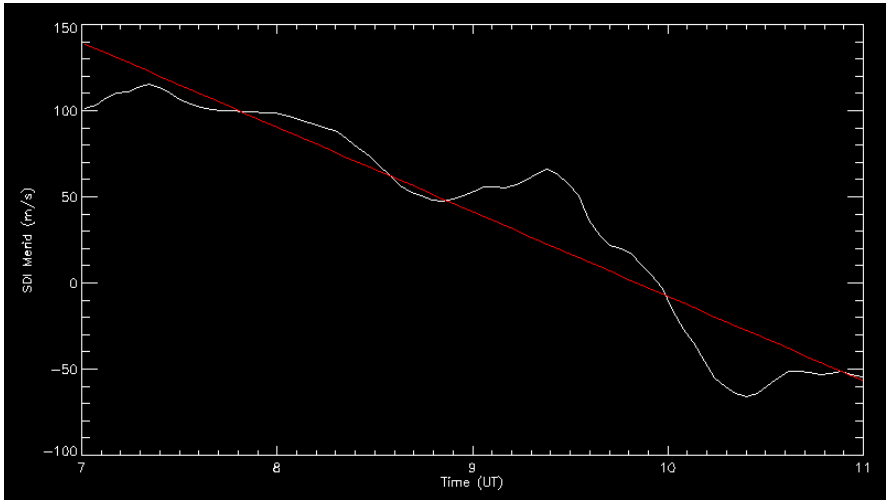
Ion-Neutral Coupling

De-trending the flow velocity components to search for correlation between perturbations.

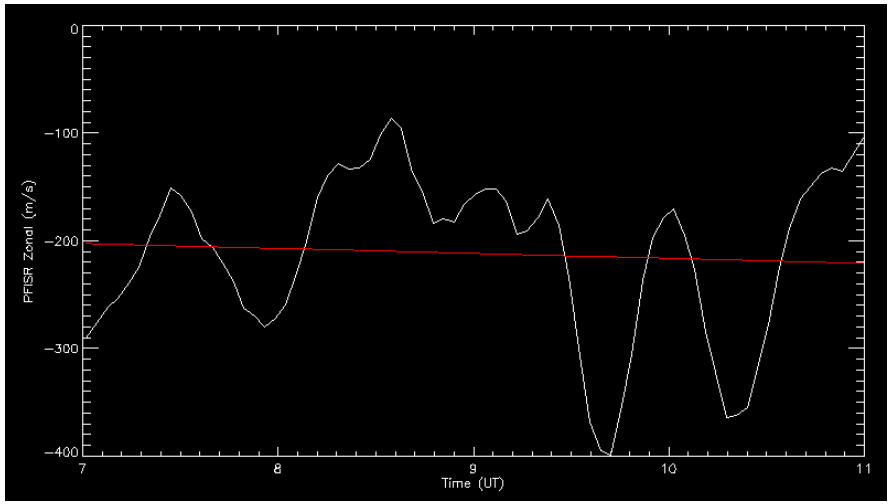
PFISR **SDI**

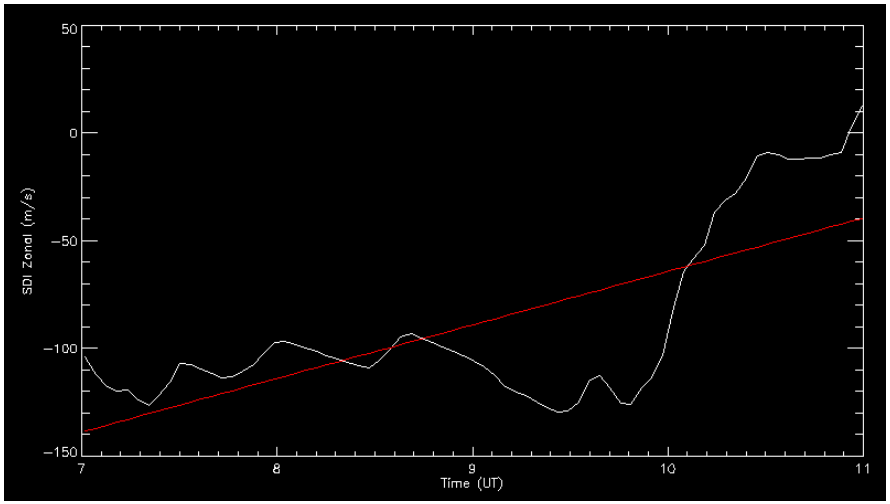
Meridional





Zonal



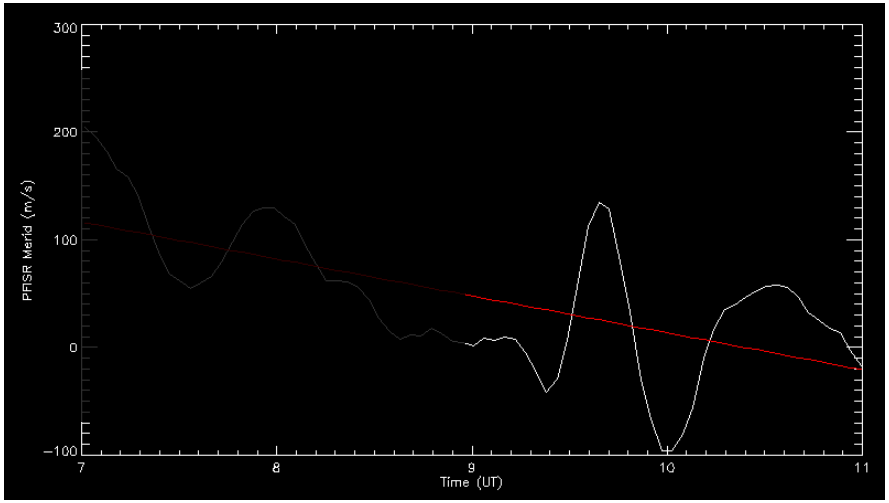


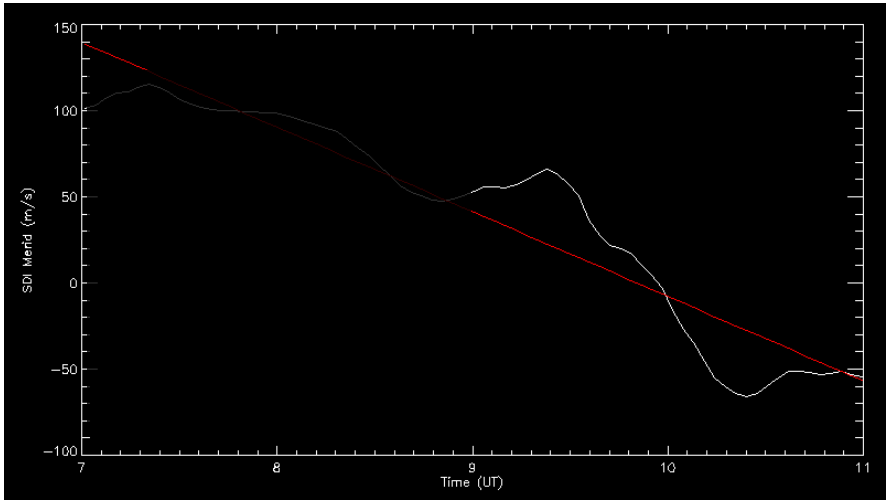
Ion-Neutral Coupling

Neutral perturbations look like a time (space?) smoothed response to the ion flow.

PFISR | **SDI**

Meridional





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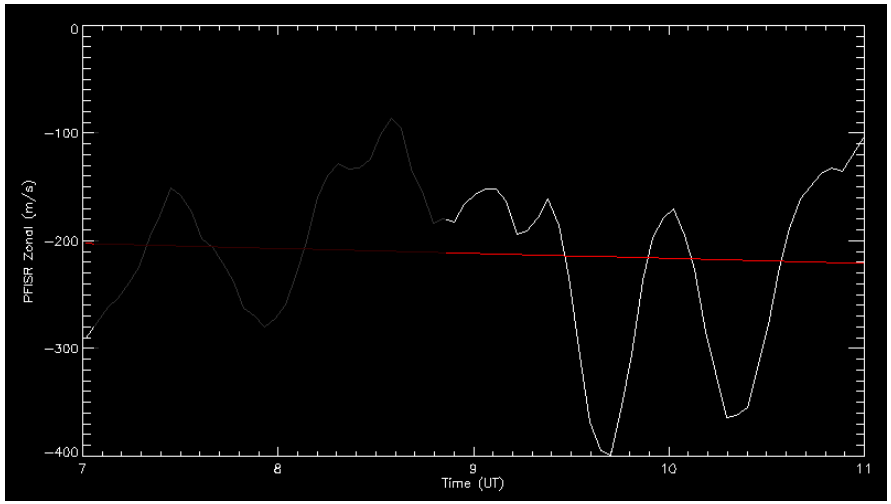
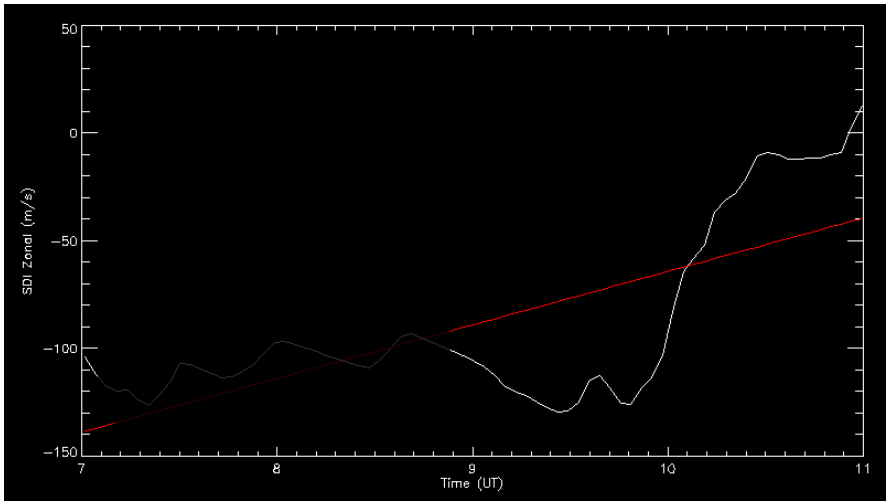
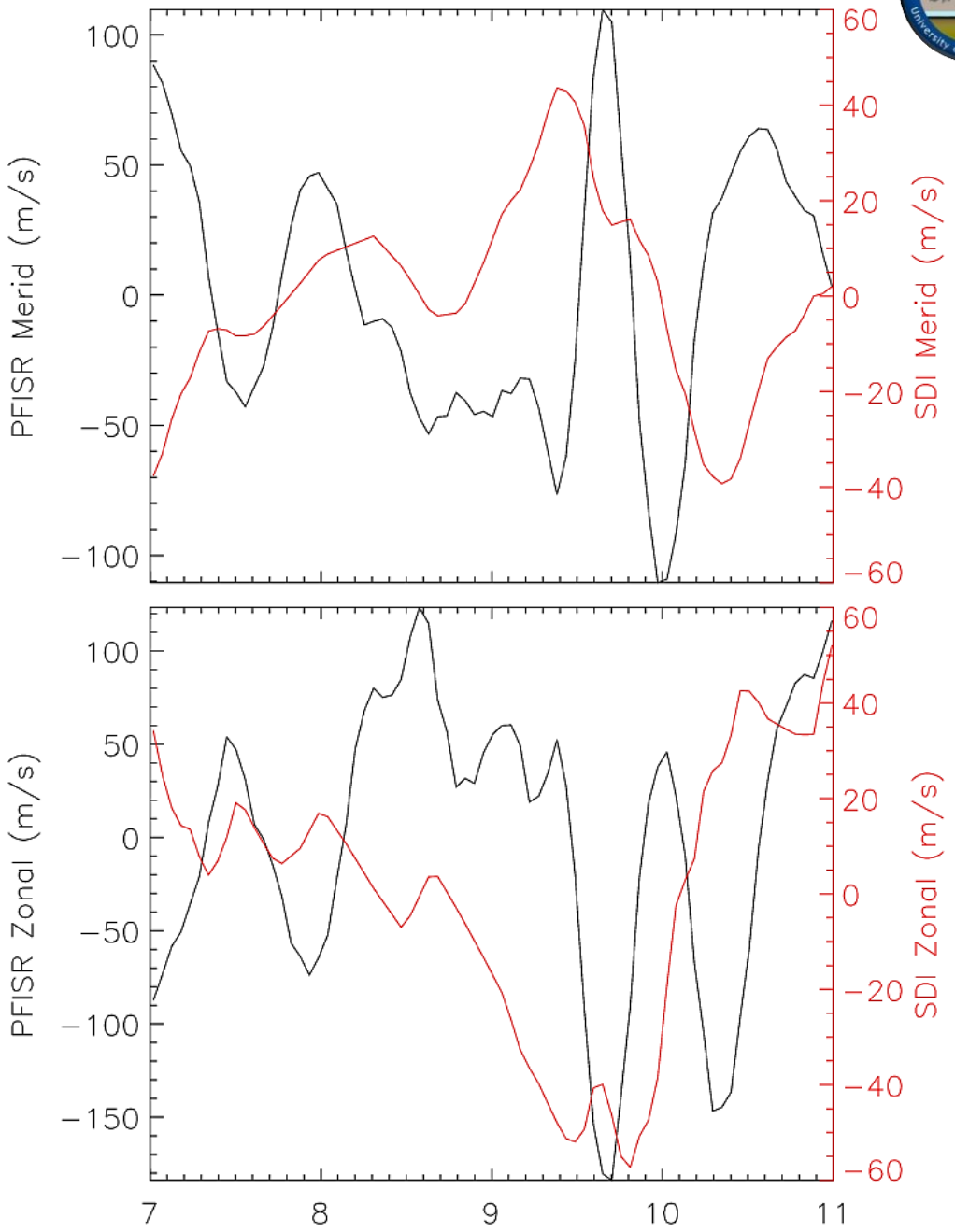




Ion-Neutral Coupling

Perturbations around the linear trend.

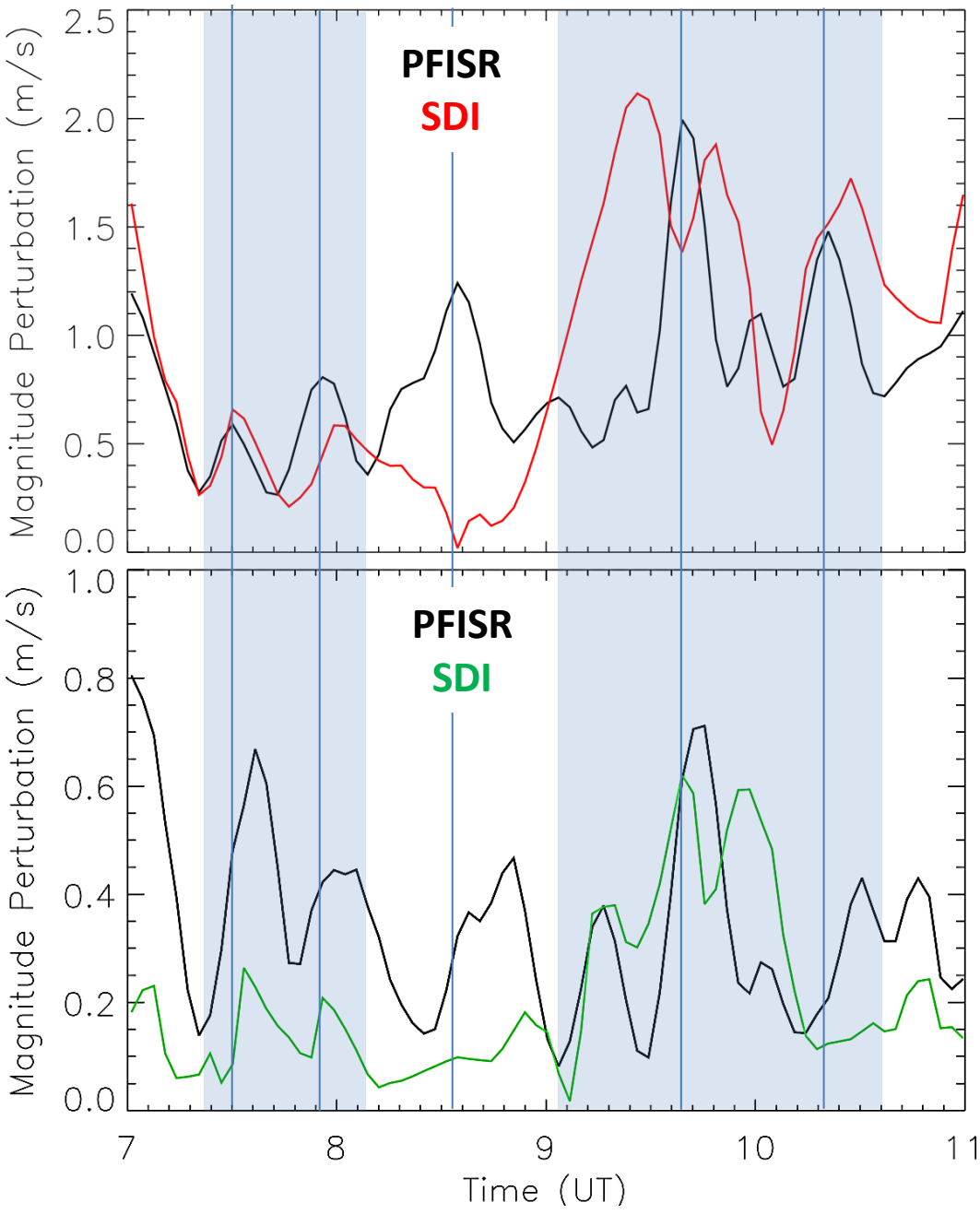


Ion-Neutral Coupling

These plots show perturbations of vector magnitude around the linear trend.

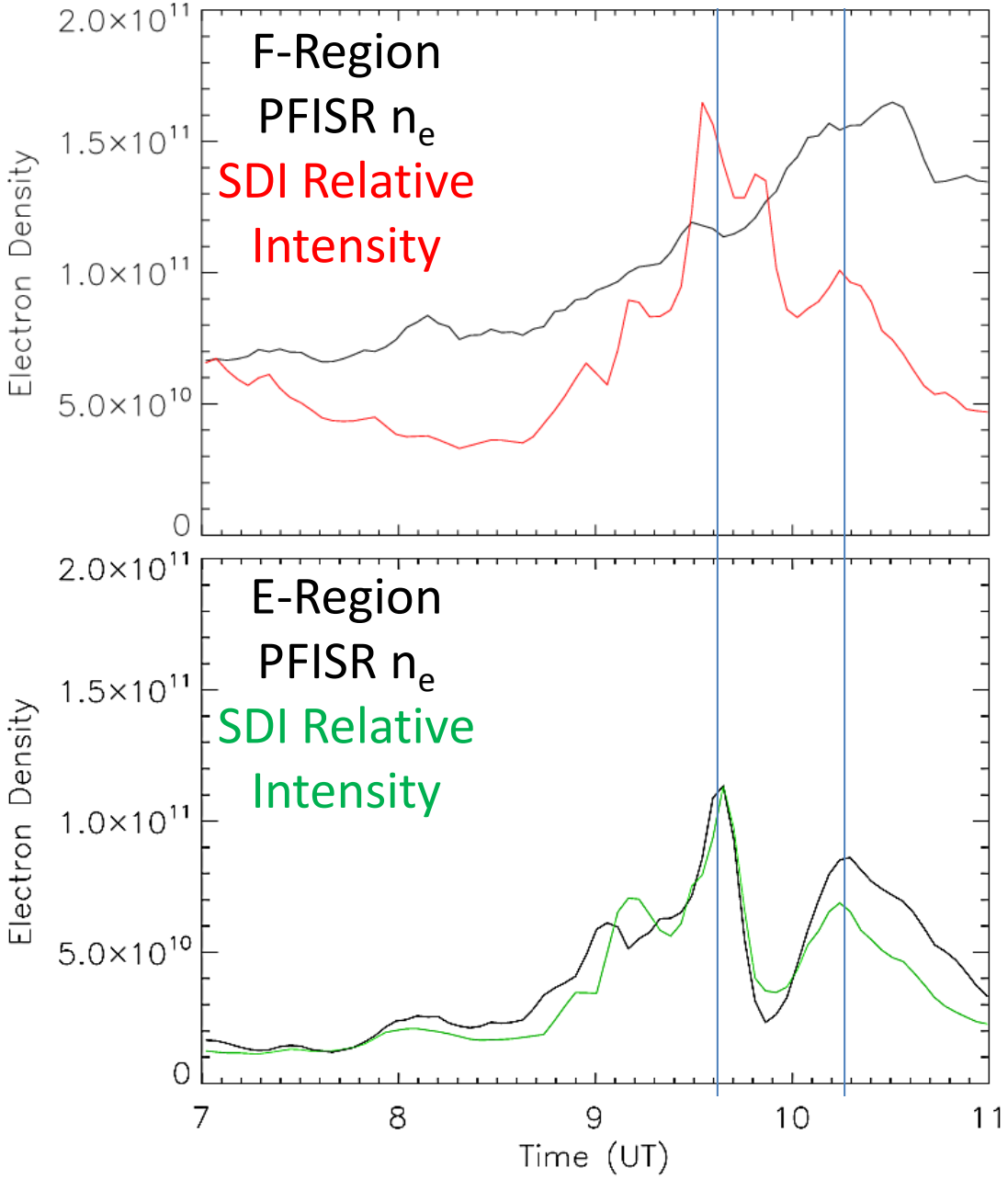
Simple linear correlation coefficients:
F-Region: **0.18**
E-Region: **0.32**

The F-region ion perturbation peaks lead the corresponding E-region ones in most cases, by 8 minutes on average.

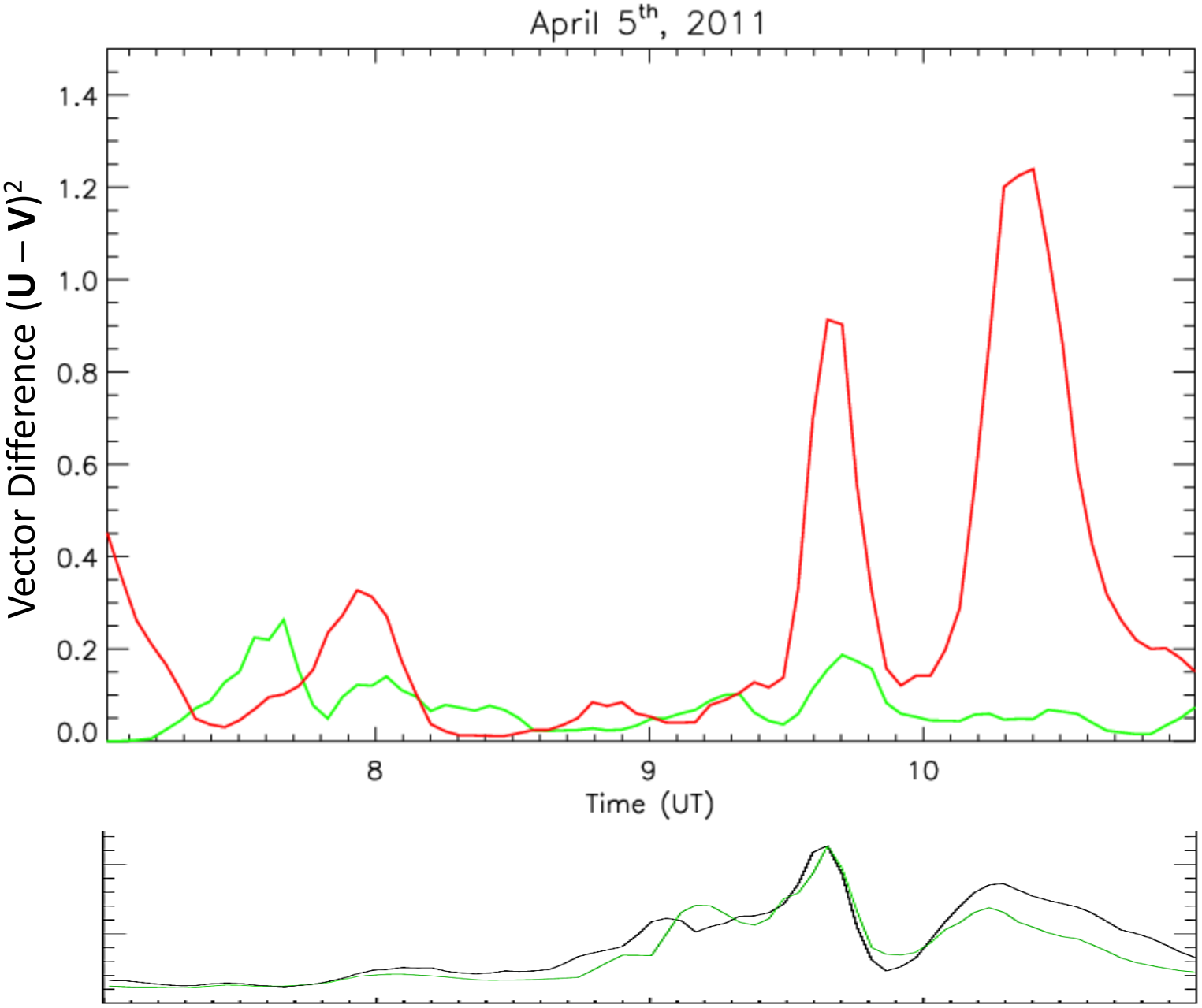


Ion-Neutral Coupling

E-region electron density measured by PFISR correlates well with E-region airglow intensity measured by the SDI.



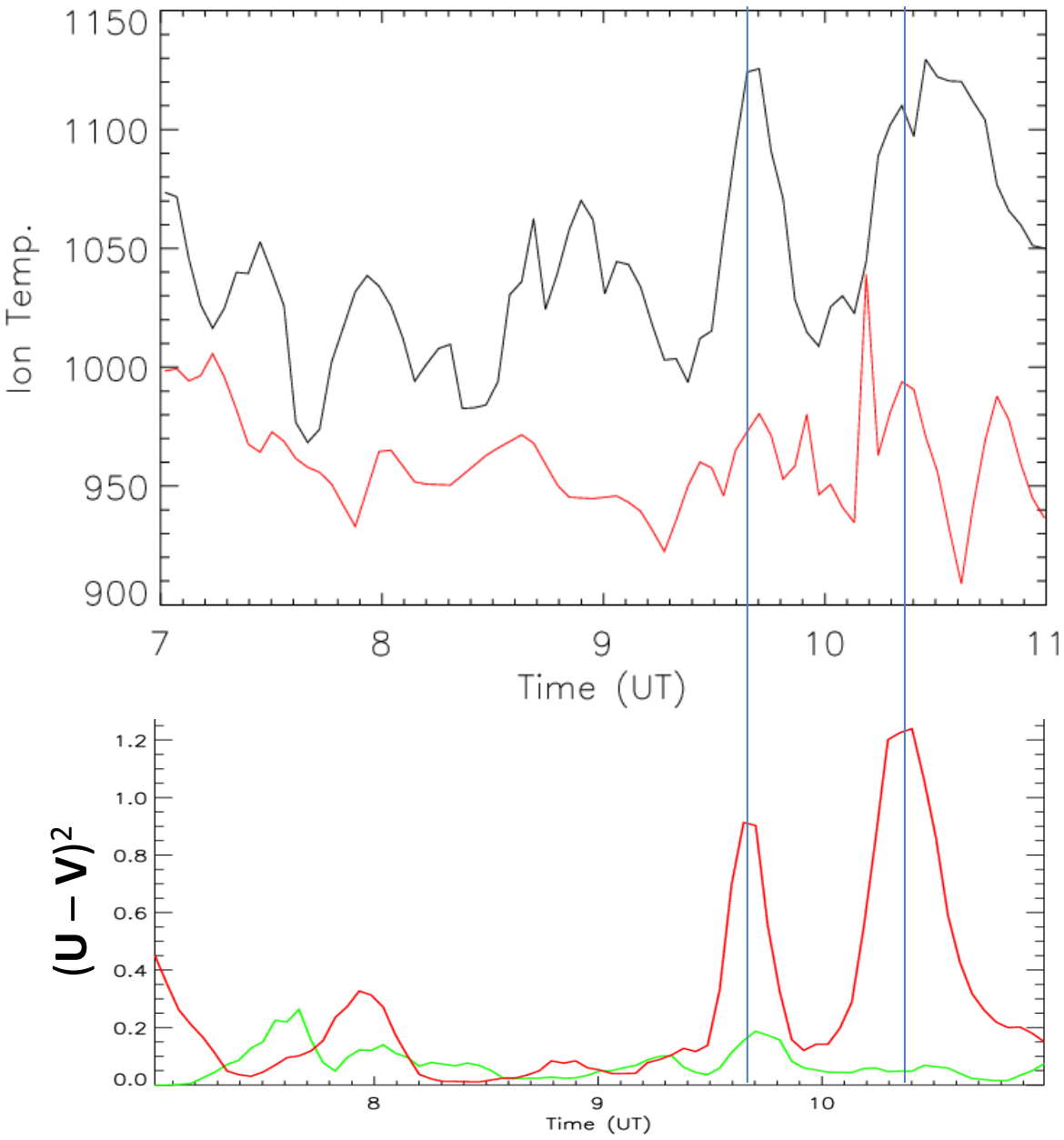
Ion-Neutral Coupling



Temperatures – F Region

Ion temperatures increase when ion-neutral velocity difference is large.

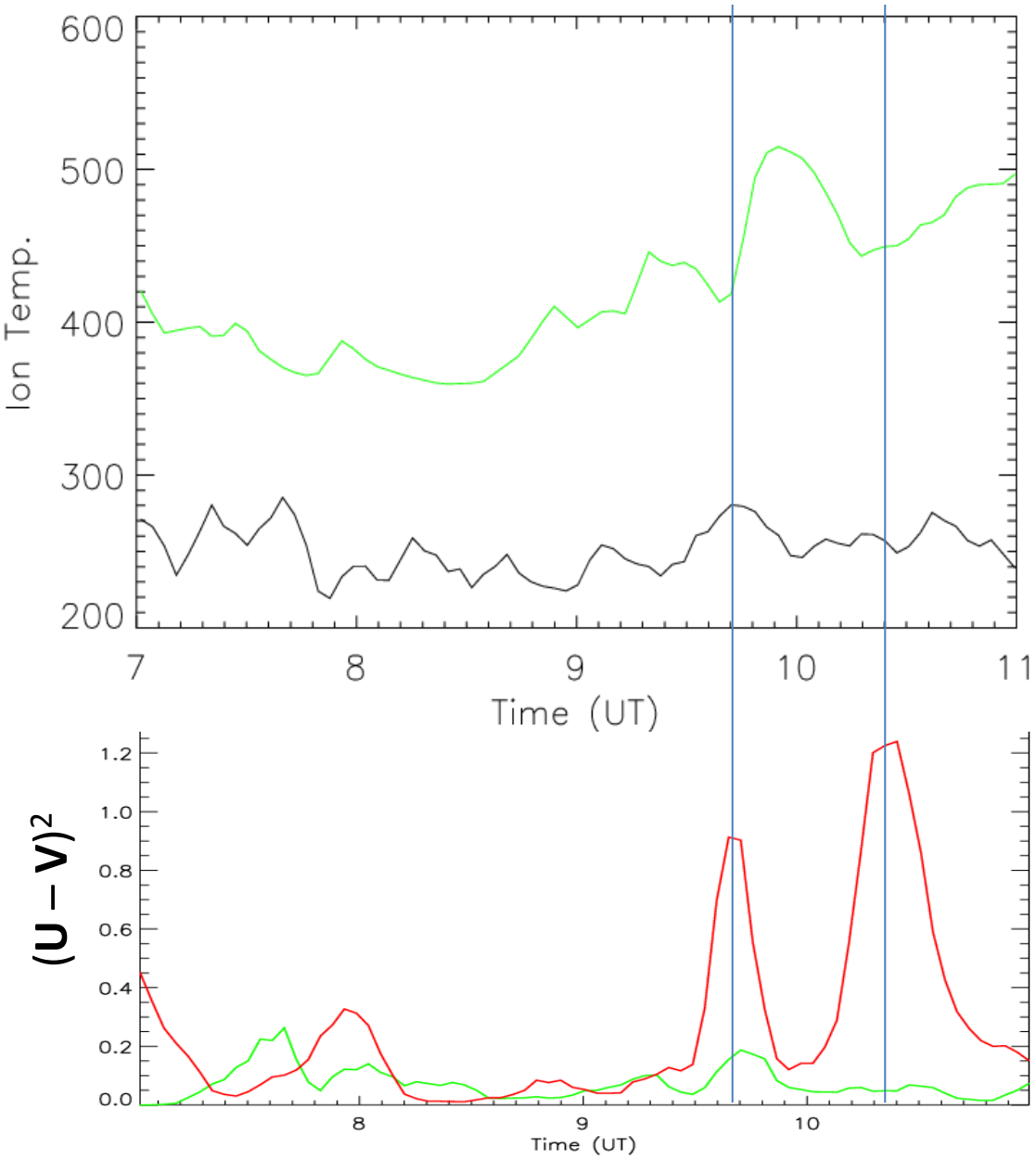
Neutral temperature response is not definitive – although there does appear to be a correlation.



Temperatures – E Region

Ambiguities in E-region wind and temperatures due to auroral precipitation.

Have to be careful when analyzing/interpreting these data.



Todo…

Derive height-resolved neutral wind profiles using PFISR measurements and the method outlined by Heinselman, C. J., and M. J. Nicolls (2008).

We should be able to do this in two dimensions (horizontally).

Compare these with SDI measured winds at E-region altitudes.

Use hi-resolution all-sky images to more accurately track the locations of the aurora.

Examine the global-scale flow, superDARN, wind model.

And lots more…

References

Heinselman, C. J., and M. J. Nicolls (2008), A Bayesian approach to electric field and *E*-region neutral wind estimation with the Poker Flat Advanced Modular Incoherent Scatter Radar, *Radio Sci.*, *43*, RS5013, doi:10.1029/2007RS003805.

Semeter, J., T. W. Butler, M. Zettergren, C. J. Heinselman, and M. J. Nicolls (2010), Composite imaging of auroral forms and convective flows during a substorm cycle, *J. Geophys. Res.*, *115*, A08308, doi:10.1029/2009JA014931.