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New results from the Poker Flat all-sky imaging Fabry-Perot spectrometer

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Abstract

An all-sky imaging Fabry-Perot spectrometer has been operating at Poker Flat since the mid 1990's. It was recently upgraded, primarily by:replacing its old intensified CCD detector with an electron-multiplying CCD camera. This has yielded a sensitivity gain of several times relative to the previous system. The instrument control software was also upgraded to a new version, produced by La Trobe University in Australia. As a result, several new observing modes and capabilities are now available. We will present some preliminary data acquired with the upgraded instrument during the 2008 spring observing season.

The Poker Flat Instrument Upgrade

Since the mid 1990's, thermospheric winds and temperatures have been monitored from Poker Flat using a (nearly) all-sky imaging Fabry-Perot spectrometer [*Conde & Smith* 1995, 1997, 1998; *Conde et al.*, 2001; *Holmes et al.* 2005].. The instrument has been upgraded several times previously, most recently beginning in the fall of 2007. This latest effort is ongoing, with completion expected in the late fall of 2008. The key aspects of the current upgrades are:

- Upgrade to EMCCD detector. (Completed)
- Install Nikkor 300 mm f/2.8 fringe-imaging lens. (Completed)
- Upgrade to La Trobe University instrument operating software (Completed)
- Rebuild fore-optics. (Fall 2008)
- Implement automated 2-color phase map calibrations (Fall 2008)

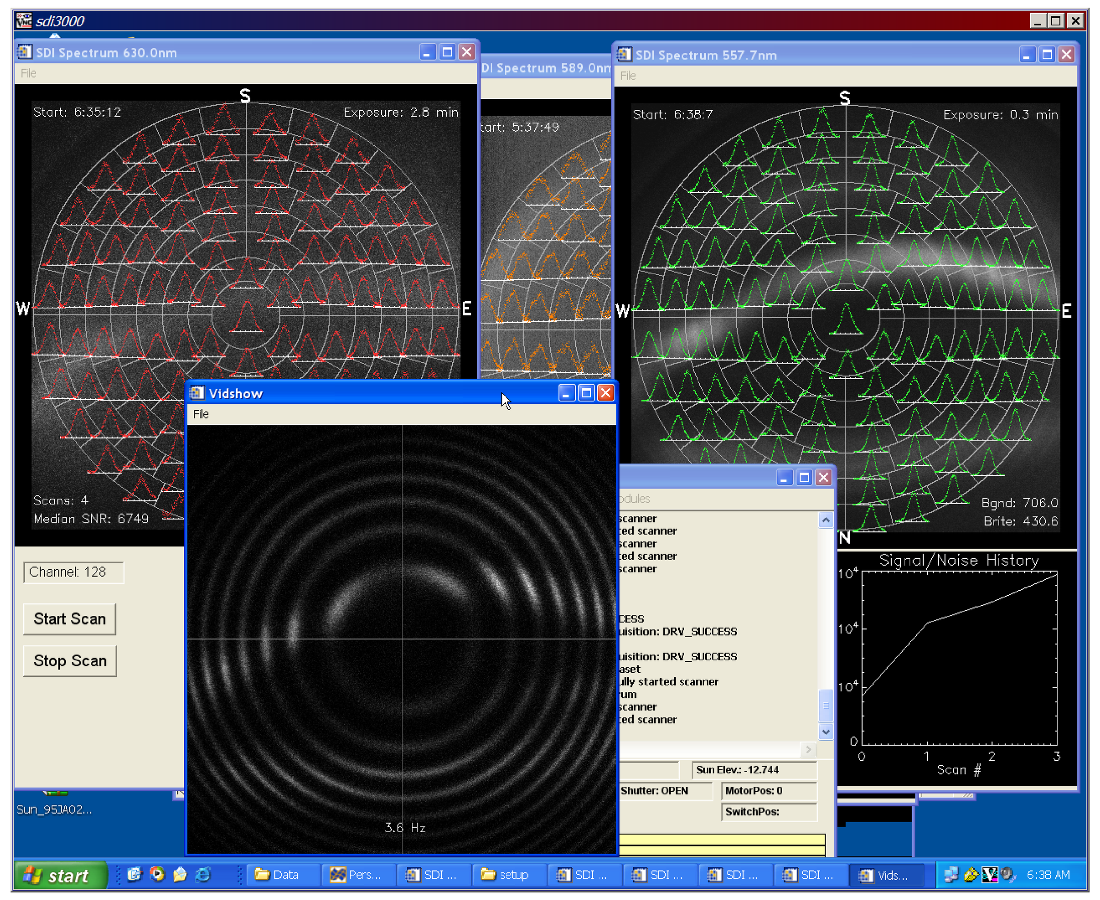

***Figure 1**: This is a screen capture of the control computer running the new La Trobe University operating software. This image was captured at 0638 UT on 27-March-2008. It shows the software running "plugins" for acquiring spectra at 630 nm, 558 nm, and 589 nm, as well as as a plugin displaying the instantaneous video from the EMCCD camera. (Another plugin was also running, acquiring calibration spectra at 633 nm, but is not visible here.) In this case we allocated 115 spectral "zones" across our field of view; individual spectra are compiled from these zones.*

February 10, 2008

To illustrate the current instrumental capabilities, we focus on geophysical parameters derived from spectra of the thermospheric 630 nm oxygen emission that were obtained on February 10, 2008. This was a very active night, as is apparent from the magnetometer data shown in Figure 2. In particular, a very large magnetic disturbance commenced around 12 UT, producing a very dramatic response in the F-region thermospheric neutral wind field.

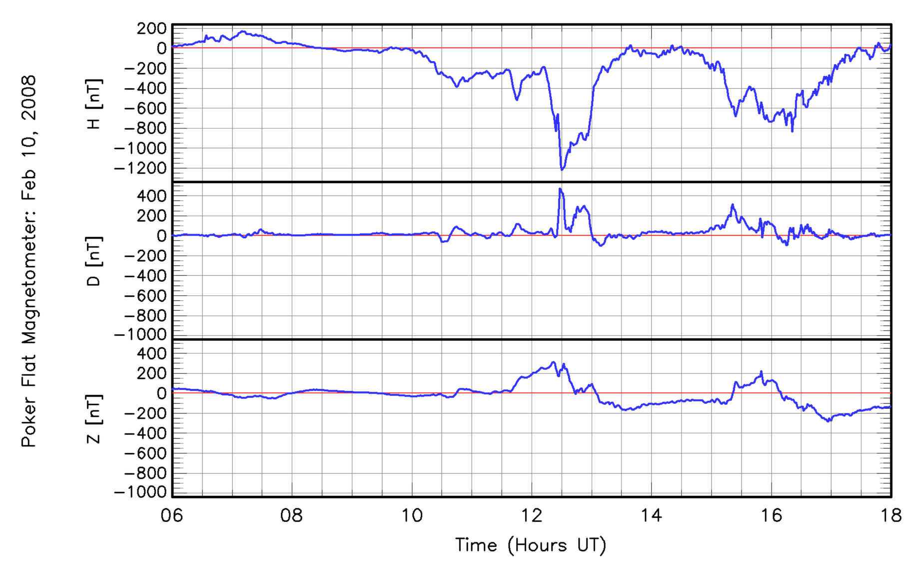

***Figure 2**: Time series of the H, D, and Z data recorded by the Poker Flat magnetometer during the night of February 10, 2008.*

Brightness, Temperature, and Vertical Wind

Figure 3 presents time series of emission brightness, Doppler temperature, and vertical wind obtained during this night. Even at the start of the night, the Doppler temperature was already perhaps 50 K higher than expected from MSIS, and a gradual warming trend continued throughout the night – presumably as a consequence of the substantial heating that would be expected during this level of magnetic disturbance.

The vertical wind data have high time resolution (typically around 2 minutes) and show several short-lived events exceeding $50\,\mathrm{ms}^{-1}$ in amplitude, superimposed on the familiar quasi-random background oscillations that usually fall in the $\pm 25\,\mathrm{ms}^{-1}$ range. As has been seen before, the vertical wind events do not necesarily correlate with periods when there is bright aurora in our field of view. For example, there was elevated vertical wind activity in the interval 0830-0900 UT, whereas the 630 nm emission brightness was (relatively) weak at this time. Conversely, the only apparent vertical wind signature of the breakup event that began around 1215 UT was a brief *downward* spike in vertical wind speed.

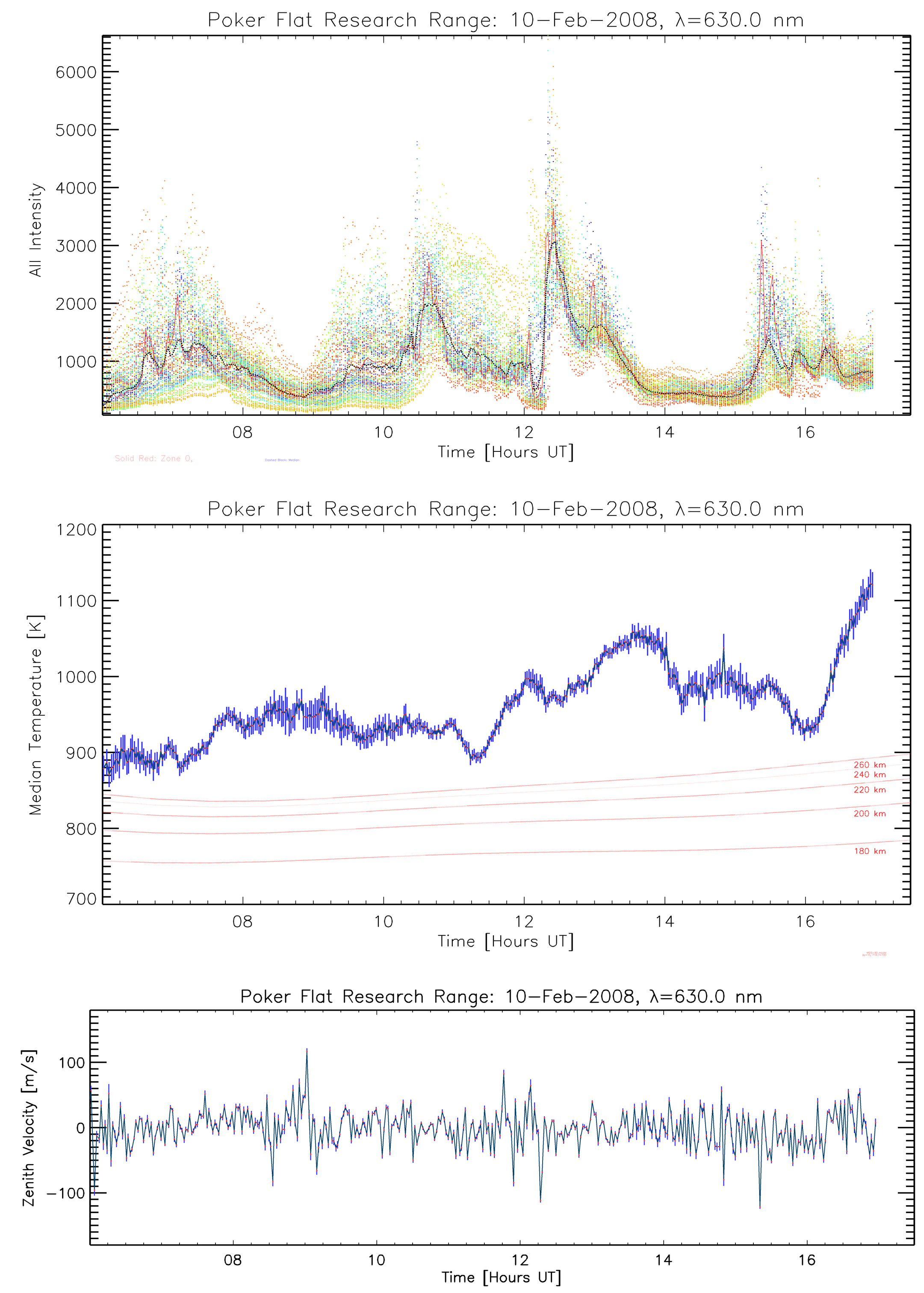

***Figure 3**: The top panel shows the time-series of 630 nm emission brightness measurements recorded in each of the 115 zones. Different colors are used for each zone. The middle panel show the time series of median Doppler temperature calculated at each time using all 115 zones. Error bars indicate ±one standard deviation in the distribution of the 115 temperature estimates derived at each time. The bottom panel shows the time series of vertical wind estimates obtained from Doppler shifts of the spectra from the zenith viewing zone.*

Conclusions

The recently upgraded all-sky Fabry-Perot spectrometer at Poker Flat now allows us to study the F-region wind field at spatial scales of 100 km or less and temporal scales of a few minutes. Consistent with long-held expectations, thermospheric winds often do appear uniform and unchanging when viewed at these scales. However, the new data clearly demonstrate that this is not always true – dramatic changes in the wind field can occur in less than 10 min during an energetic auroral event. Further, careful examination of the data shows that less dramatic perturbations in the wind field actually occur quite often, as a result of some auroral feature passing through our field of view. When the ongoing instrumental upgrade is complete, we will be able to monitor the response of the thermospheric wind at both E and F-region heights.

References and Acknowledgements

Conde, M., and R. W. Smith, 1995. Mapping thermospheric winds in the auroral zone, *Geophysical Research Letters, 22*, 3019-3022.

Conde, M. and R. Smith. 1997, Phase compensation of a separation scanned, all-sky imaging Fabry-Pérot spectrometer for auroral studies, *Appl. Opt., 36*, 5441-5450.

Conde, M., and R. W. Smith, 1998. Spatial structure in the thermospheric horizontal wind above Poker Flat, Alaska, during solar minimum, *Journal of Geophysical Research, 103*, 9449-9471.

Conde, M., J. D. Craven, T. Immel, E. Hoch, H. Stenbaek-Nielsen, T. Hallinan, R. W. Smith, J. Olson, and Wei Sun, 2001, Assimilated observations of thermospheric winds, the aurora, and ionospheric currents over Alaska, *J. Geophys. Res., 106*, 10493-10508.

Holmes J. M., M. Conde, C. Deehr, D. Lummerzheim, Morphology of evening sector aurorae in ■557.7-nm Doppler temperatures, *Geophys. Res. Lett., 32*, L02103, 10.1029/2004GL021553, 2005.

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F-Region Horizontal Wind Maps

Figures 4 and 5 present two examples of the response of the two-dimensional horizontal wind field to the changing auroral forcing, on time scales of several minutes and at length scales of less than 100 km. These vector maps were derived from Doppler shifts recorded at a single site (Poker Flat) using the method described by *Conde & Smith* [1998]. This method only achieves a unique solution by applying some assumptions regarding the form of the wind field. Artifacts due to these assumptions may thus appear in the wind maps shown below. Movies of these data are also available, at http://www.gi.alaska.edu/ conde.

While the Poker Flat all-sky FPS has been generating thermospheric wind maps for many years, the latest data have much higher spatial and temporal resolution. It is finally possible to see in these data the effects of individual auroral features on local-scale thermospheric flow, and to watch how this evolves over time.

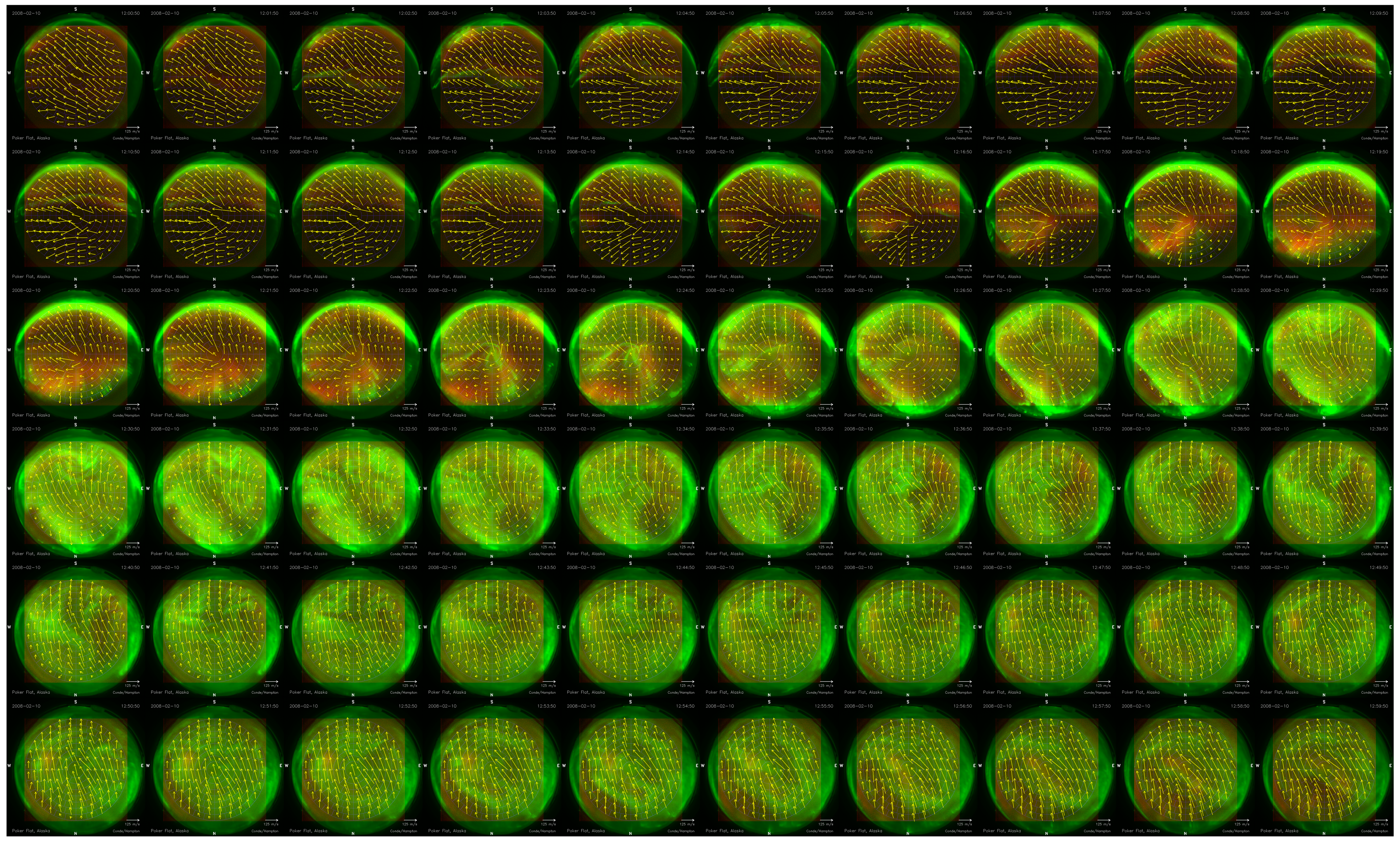

***Figure 4**: Yellow arrows in these panels show the horizontal neutral wind field inferred from the distribution of Doppler shifts across all 115 zones, during the period 12-13 hours UT. Background images were generated by superposing broadband digital all-sky camera images (green hues) with sky images recorded at λ630 nm by the Fabry-Perot spectrometer itself (red hues.) Wind fields are shown at 1 min intervals, which is only 1/3 of the time resolution of the all-sky camera data for this night, but around twice the typical cadence of the Fabry-Perot data. Thus, the wind data shown here is interpolated in time.*

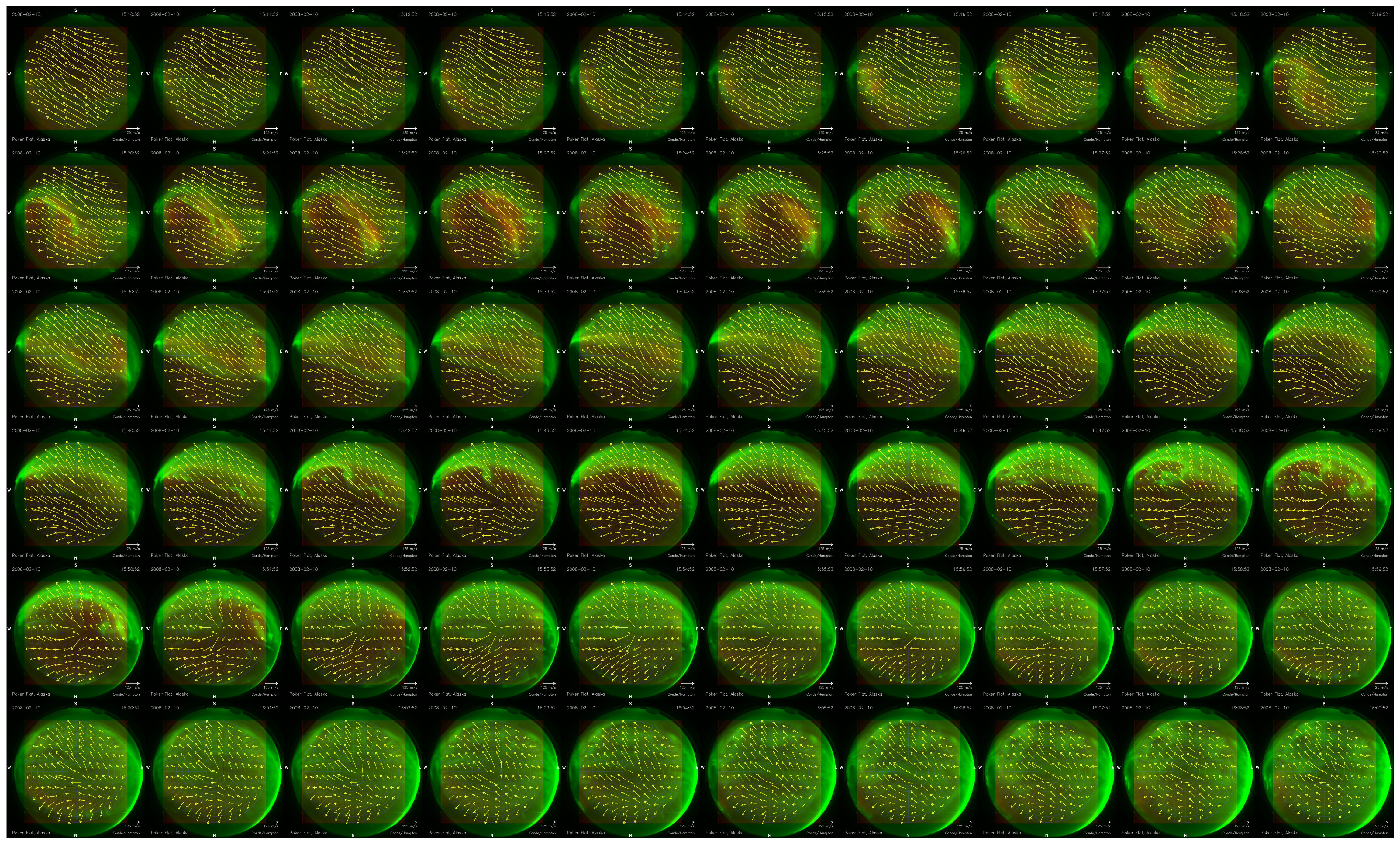

***Figure 5**: As for Figure 4, but in this case for the period 1510-1610 UT.*