Thermospheric Winds Observed by two All-sky Imaging Fabry-Perot Spectrometers

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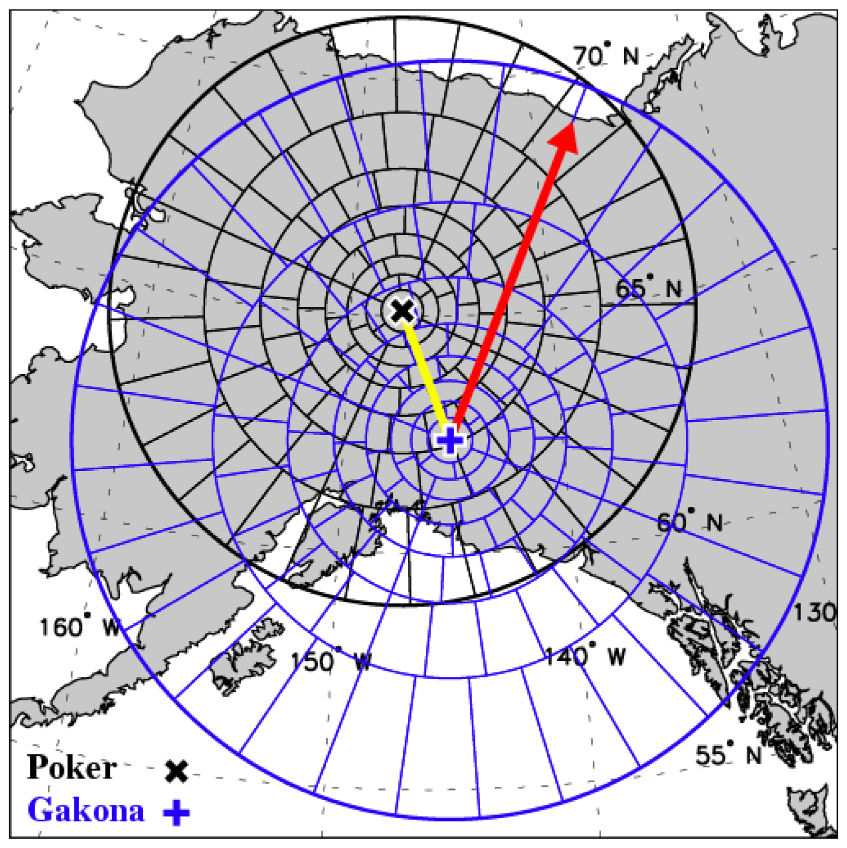
Motivation

All-sky imaging Fabry-Perot spectrometers routinely infer two-dimensional thermospheric wind fields from the azimuthal variation of line-of-sight Doppler wind measurements. These fields are derived by approximating the spatial wind variation by a first-order Taylor series about the zenith, and by assuming a value for one of the four wind gradients. The validity of this monostatic (single-station) technique has until now been difficult to assess.



Locations of the two Fabry-Perot spectrometers used in this work (marked by the black and blue crosses). Segmented circles show the locations in which simultaneous line-of-sight wind measurements are made by each instrument.

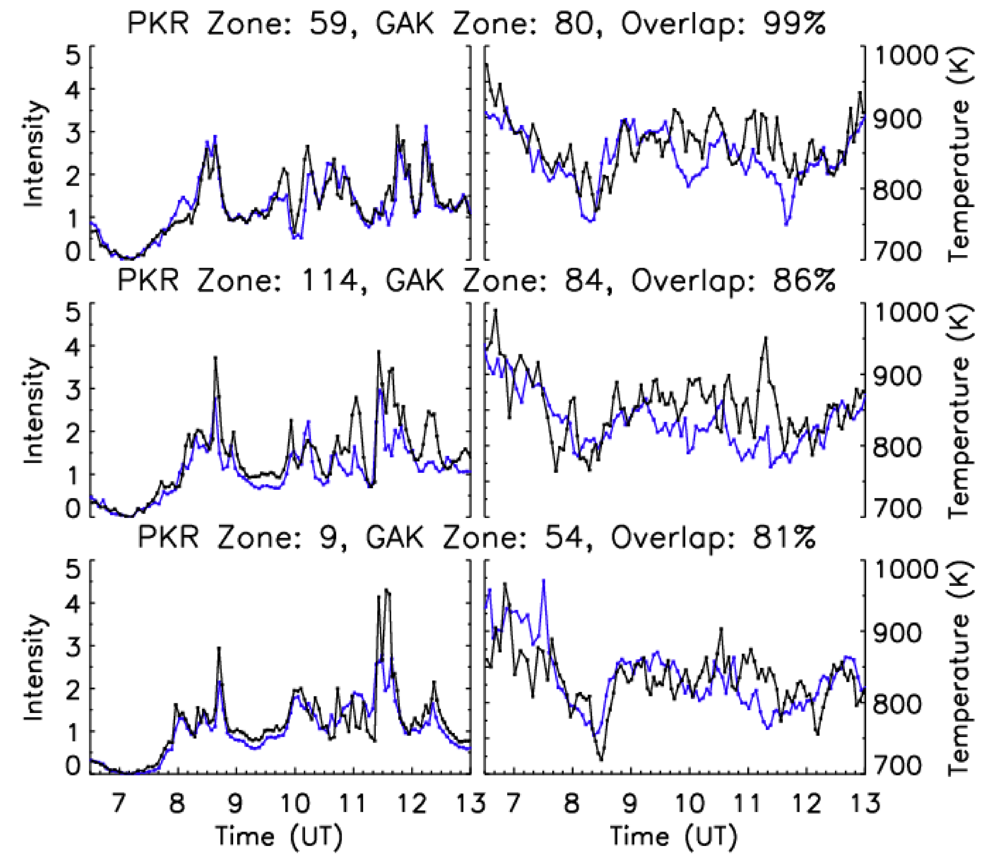
Objectives

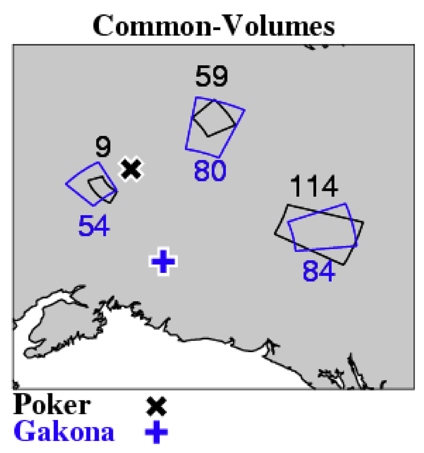
- Compare monostatic wind fields from two nearby scanning Doppler imagers (SDI's) with significant field-of-view overlap, to see how well the independently-derived fields agree in regions of overlap.
- Infer horizontal wind vectors from line-of-sight winds measured by each instrument in regions of field-of-view overlap. This (bistatic) calculation requires no assumptions other than a value for the local vertical wind, which does not significantly affect the results.

Methodology

Monostatic wind field: Zonal and meridional wind components are approximated by first-order Taylor series' expanded about the station zenith. Coefficients describing the uniform wind and gradients in both the zonal and meridional directions are calculated from the Fourier coefficients derived from the azimuthal variation of the line-of-sight wind.

Bistatic wind: In regions where the instrument fields-of-view overlap, the line-of-sight wind measurements from each instrument are used to calculate two of the three wind components in the common-volume region. The horizontal projection of these components is achieved by assuming a value for the local vertical wind. For the results presented here, the local vertical wind was assumed to be 0 ms^{-1}. The inferred bistatic horizontal winds are not very sensitive to the choice of vertical wind magnitude.





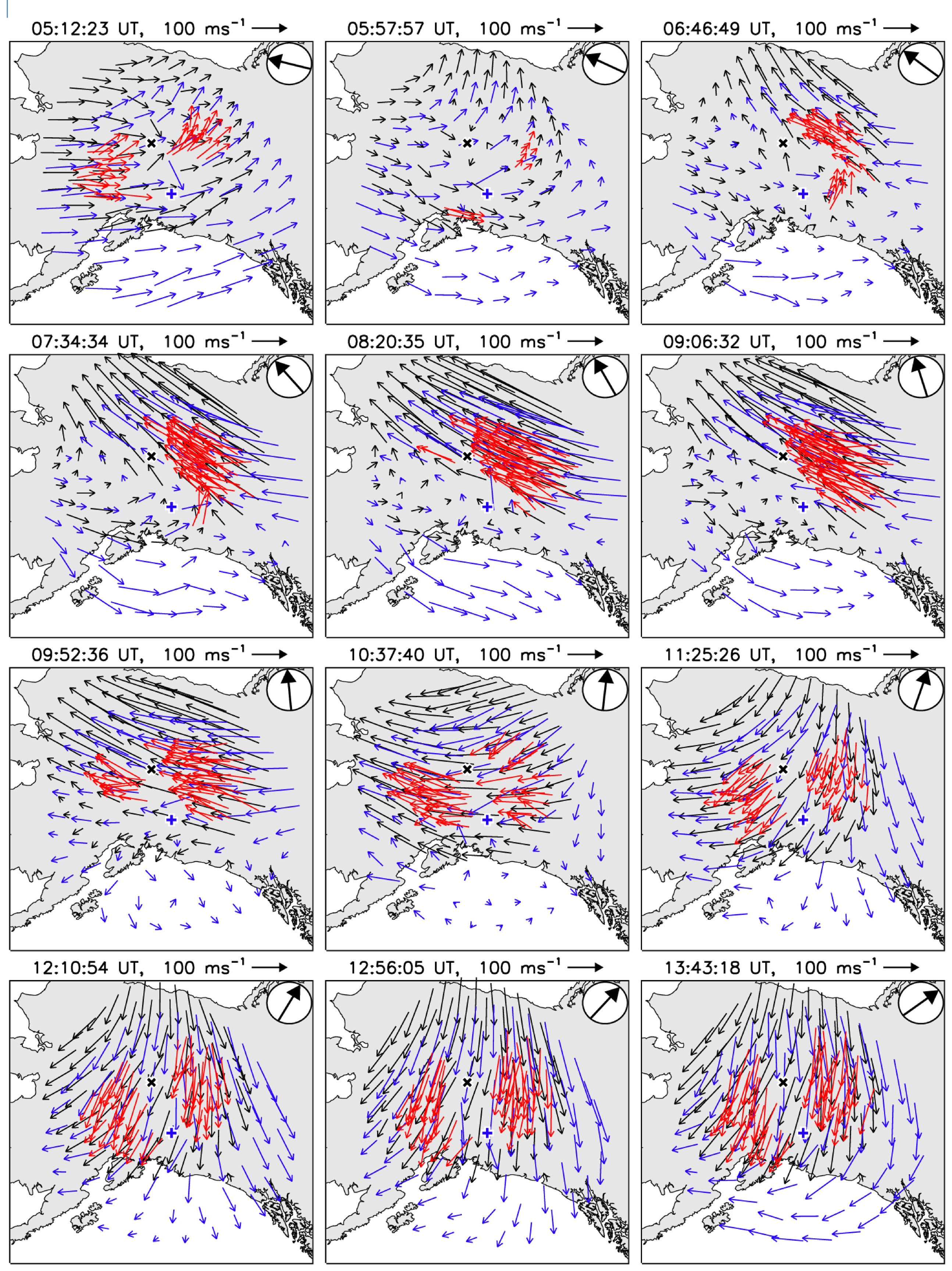
Comparisons of intensity (left column) and temperature (right column) measured by each instrument in three common atmospheric volumes. The high degree of correlation between the independent measurements indicates that both instruments were indeed observing common volumes.

Results

Monostatic and bistatic wind comparisons are shown for three different nights. Monostatic wind fields derived from Poker Flat (black arrows) and Gakona (blue arrows) are shown, along with the bistatic winds (red arrows). These wind estimates are shown projected onto a map of Alaska. The bold arrow in the top right corner of each panel indicates the sunward direction.

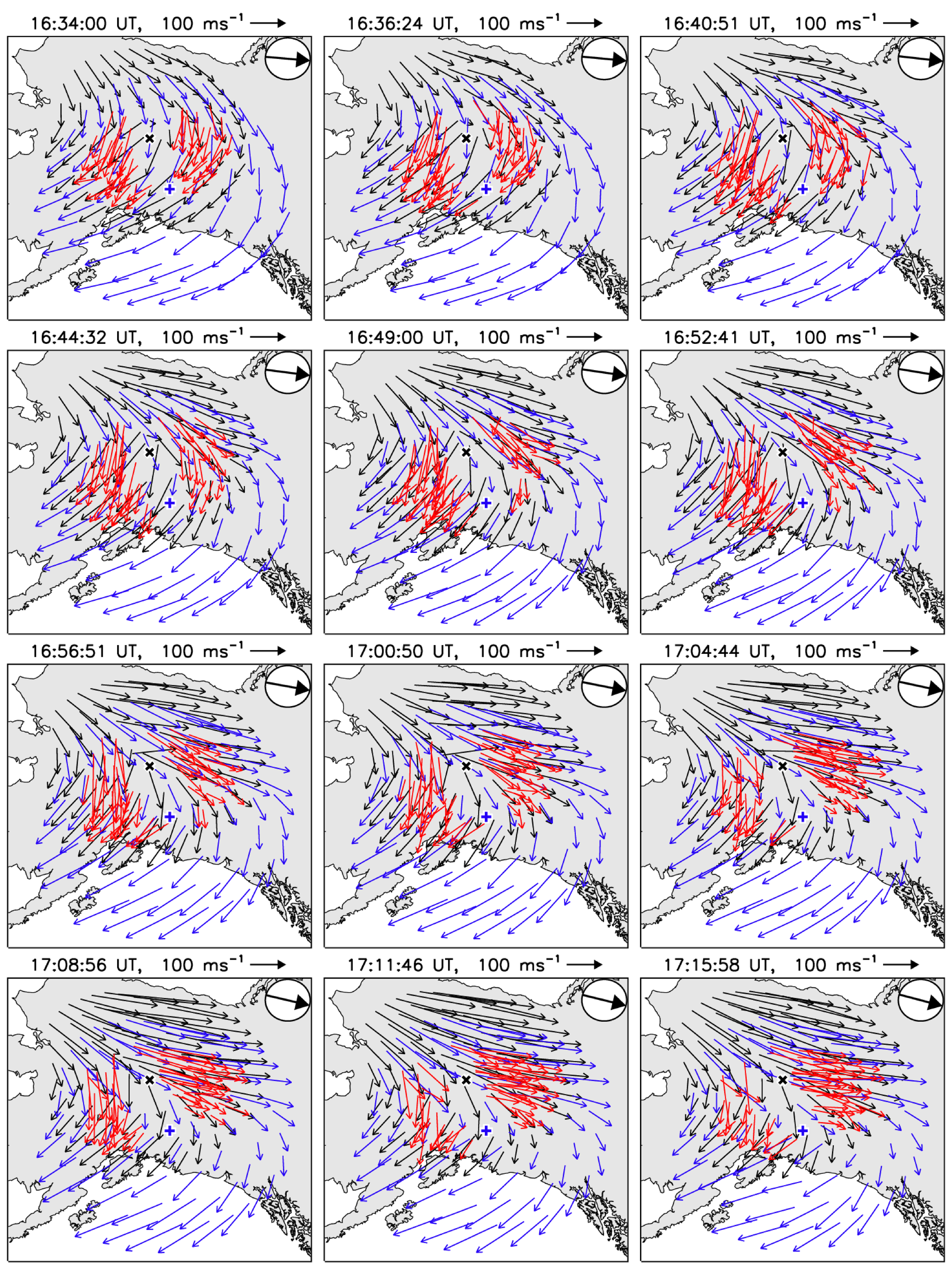
January 24, 2010

Frames in this image are separated by approximately 45 minutes, which is much less than the available time resolution for this night. The data span approximately 8 hours of local time.



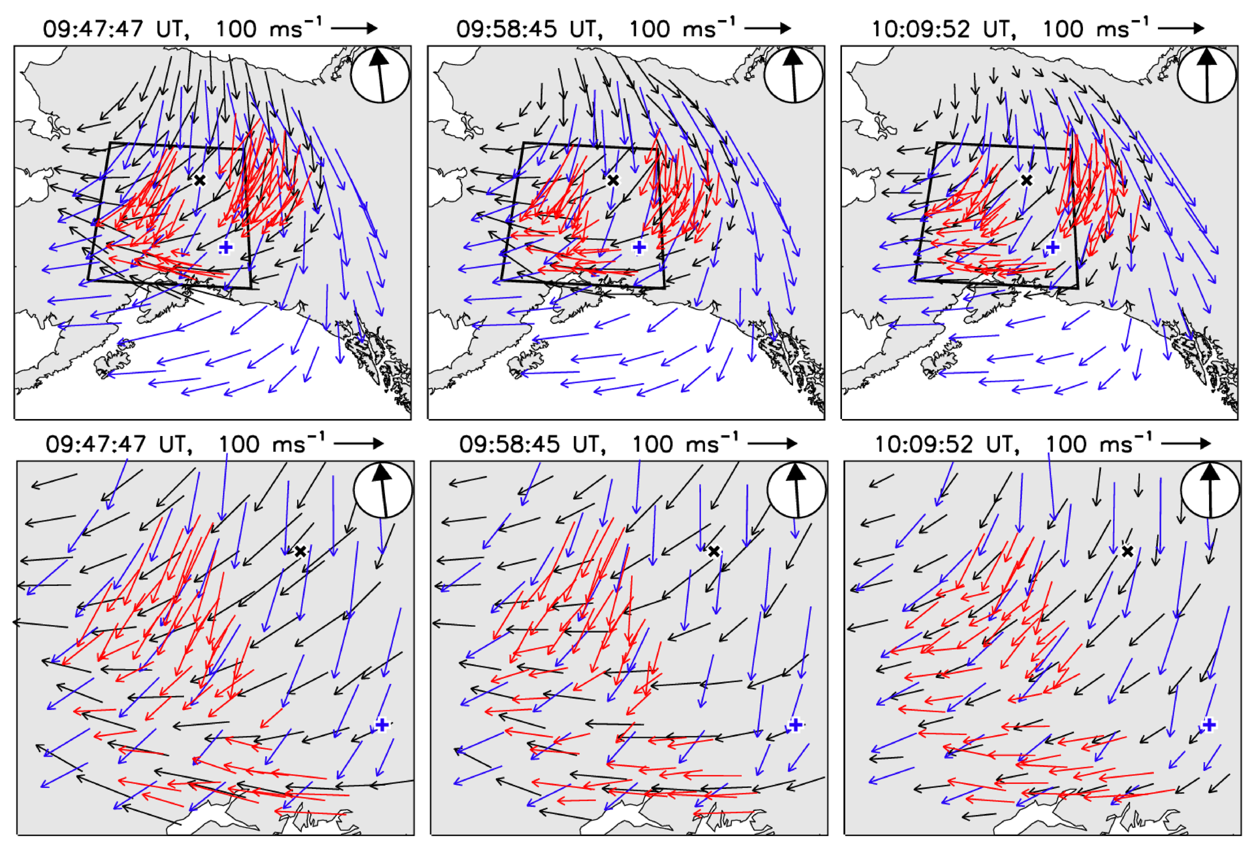
January 20, 2010

Frames in this image are separated by approximately 2 minutes, and span approximately 45 minutes of local time. The increase in magnetic meridional shear was concurrent with a large increase in magnetic field strength measured at the ground.



April 2, 2010

These frames display monostatic winds which show some disagreement between the two instruments in the highlighted region. This disagreement was evident in the first and second frames displayed below, but had disappeared by the time of the last displayed frame (approx. 20 minutes after the first frame). During the period shown, the bistatic winds remained relatively constant. This indicates that the monostatic fields were unable to accurately model the flow in this small region, while the bistatic estimates remained reliable. Both before and after this sequence of frames, there was good agreement between all three sets of estimates.



Conclusions

- Independently-derived monostatic wind fields from each instrument show very good agreement for much of the time in regions where their fields-of-view overlap.
- The monostatic technique is reliable under a large range of geophysical conditions and flow configurations. It is very capable of modeling the large-scale, first-order flow.
- Bistatic winds inferred in common-volume regions also show very good agreement with monostatically-derived wind fields.
- At small scales, the monostatic technique is sometimes restricted in its ability to model the flow (due to the underlying assumptions). In these cases, bistatic measurements are essential.
- This is the first direct comparison of wind fields independently derived from two nearby SDI's. It is also the first time that such instruments have been utilized as a bistatic array, allowing wind estimates at many locations with minimal assumptions. This represents a big step forward in our ability to accurately resolve small-scale thermospheric wind structure.