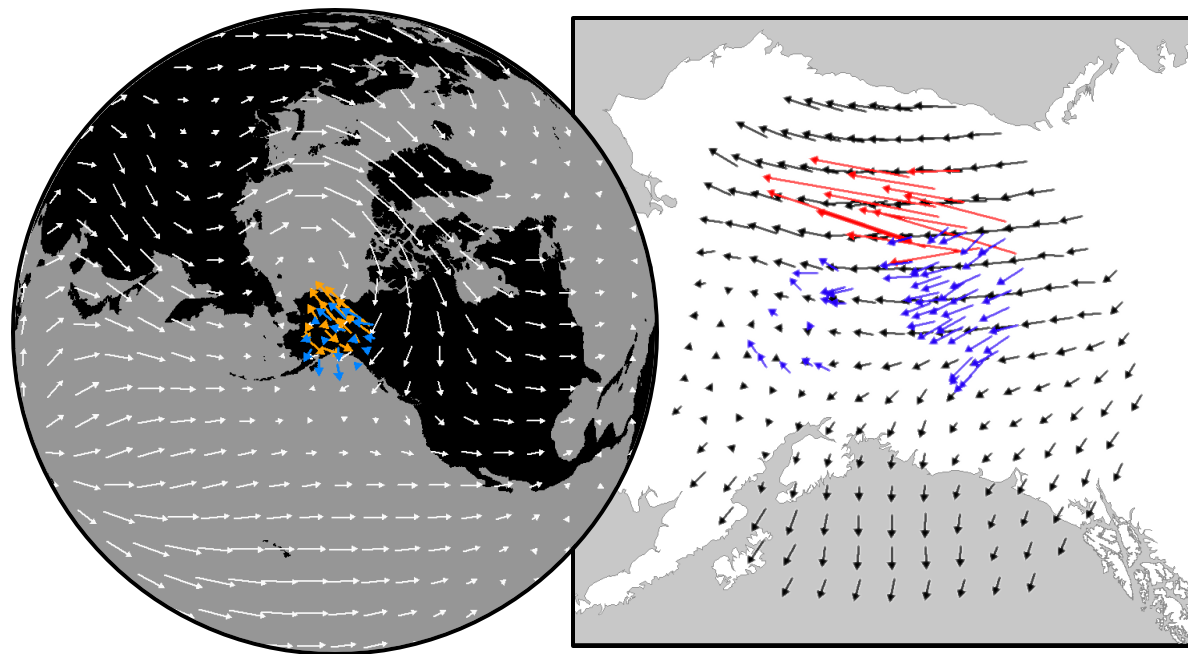


Exploring Flow Structures of Thermospheric Winds using a Bistatic Array of All-sky Imaging Fabry-Perot Spectrometers

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- Our goal is to understand how thermospheric wind structures evolve in response to the dynamic forces associated with the auroral ionosphere.
- To do this, we seek to produce high-resolution 2-dimensional (horizontal) wind maps at a given nominal altitude.
- The instruments we use to do this are all-sky imaging Fabry-Perot spectrometers (**SDI's**). These instruments record upwards of 100 spectra across a large field-of-view of the sky simultaneously, with an integration time of approximately 3 minutes under good viewing conditions.
- Monostatic vector wind maps can be fitted to the radial line-of-sight winds, however this fitting procedure requires some assumptions.
- Using two such instruments as an array, we can uniquely resolve two of the three wind components where the instruments observe the same atmospheric volume. This bistatic technique requires fewer assumptions than does the monostatic technique.

- The move to bistatic imaging is very important for two reasons:
 1. It provides us with an independent analysis technique for deriving wind maps. We can therefore use it as cross-validation tool for our monostatic wind imaging technique. This gives us far greater confidence in our monostatic wind maps.
 2. Secondly, and more importantly, the bistatic wind measurement involves very few assumptions about the wind field, and the assumptions that we do make don't strongly affect our results. Therefore these results are much closer to a direct local vector wind measurement, and this allows to probe the wind field at much smaller spatial scales than does the monostatic technique.

Instrumentation - Monostatic

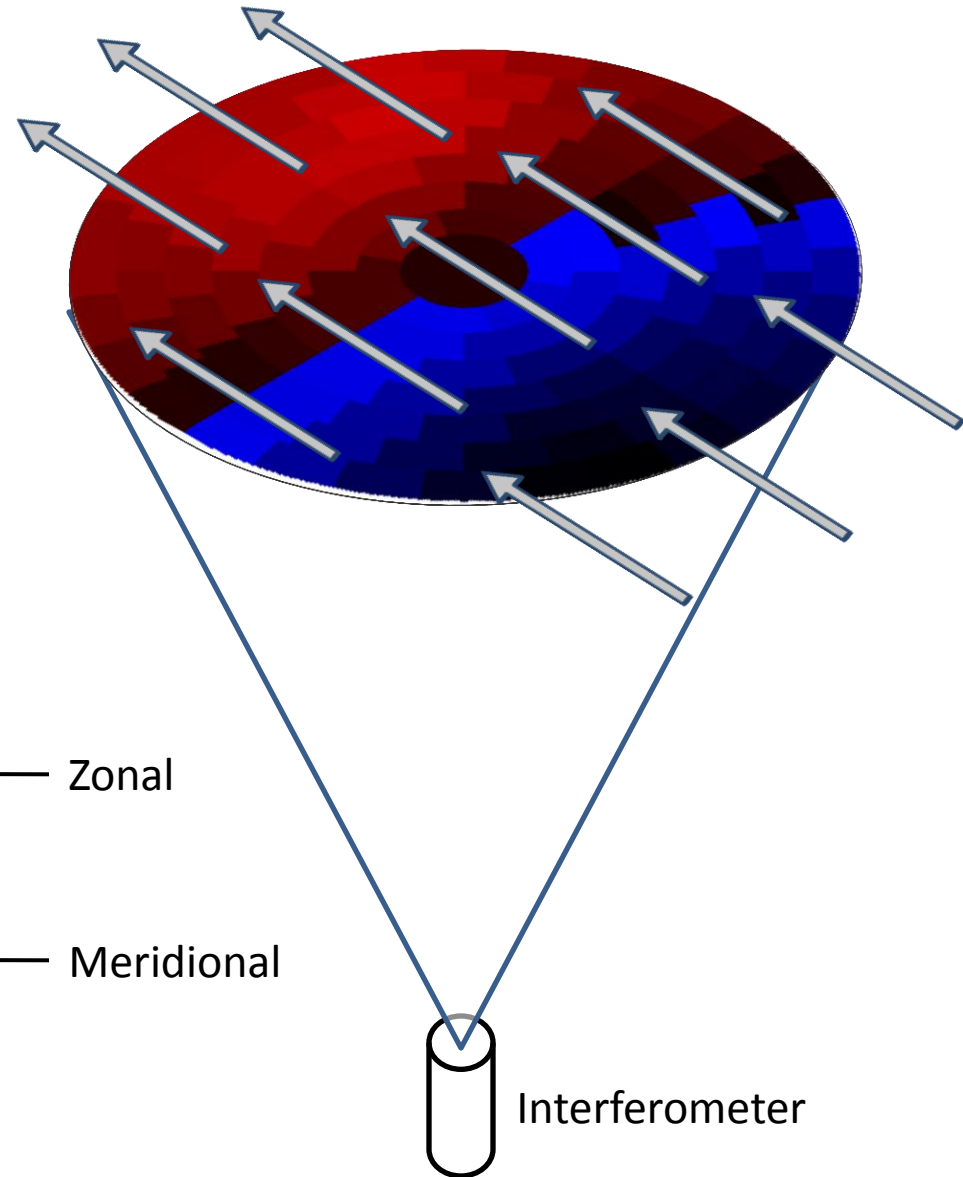


- Horizontal vector wind fields are fitted to the spatial variation of the measured line-of-sight wind.
- This requires an assumption about the functional form of the spatial wind variation (a first-order Taylor field) and one of the four wind gradients.
- The wind model is (assuming geomagnetic coordinates):

$$u(x, y) = u_0 + \frac{\partial u}{\partial x} x + \frac{\partial u}{\partial y} y \quad \left. \vphantom{\frac{\partial u}{\partial x}} \right\} \text{Zonal}$$

$$v(x, y) = v_0 + \frac{\partial v}{\partial x} x + \frac{\partial v}{\partial y} y \quad \left. \vphantom{\frac{\partial v}{\partial x}} \right\} \text{Meridional}$$

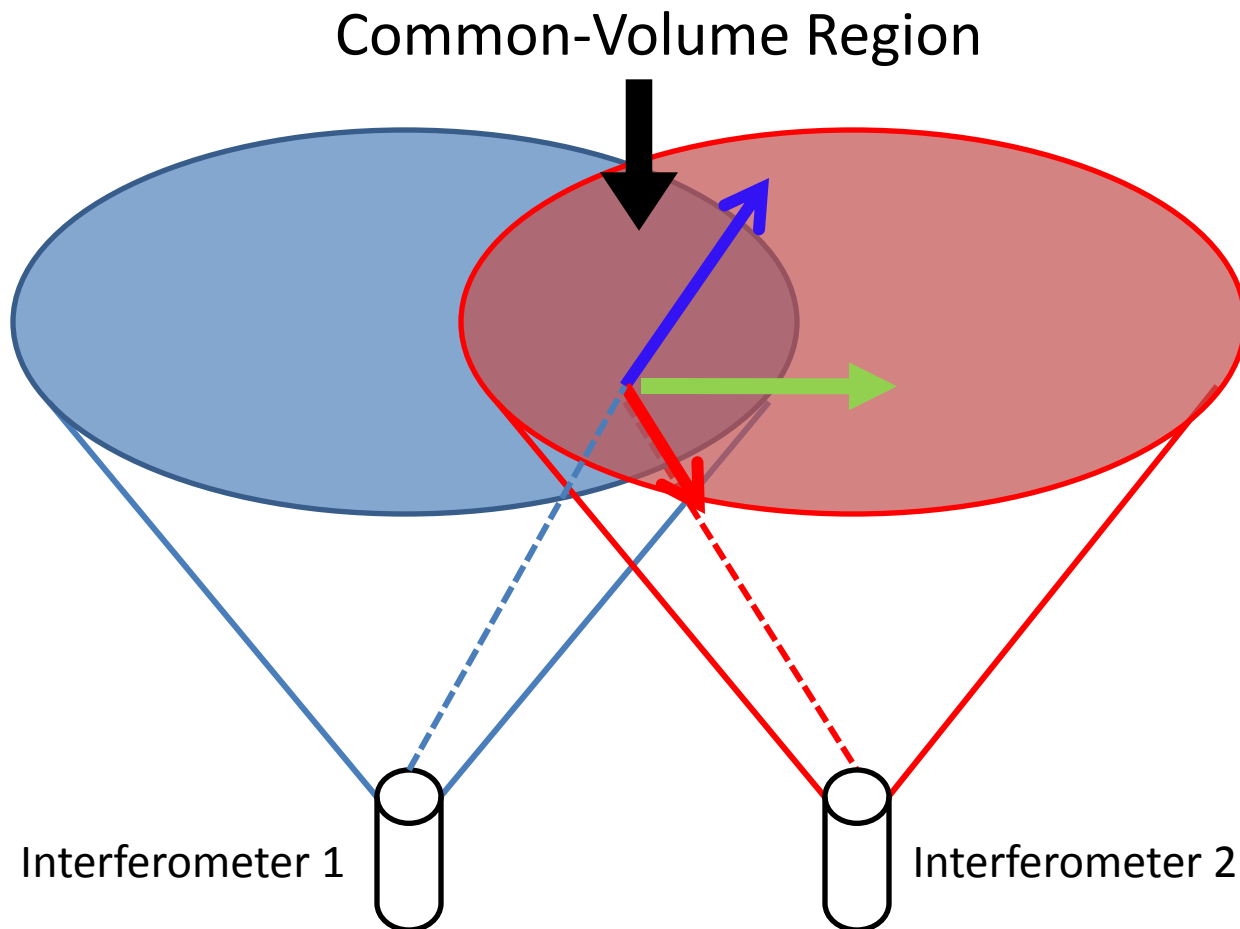
Assumed = 0



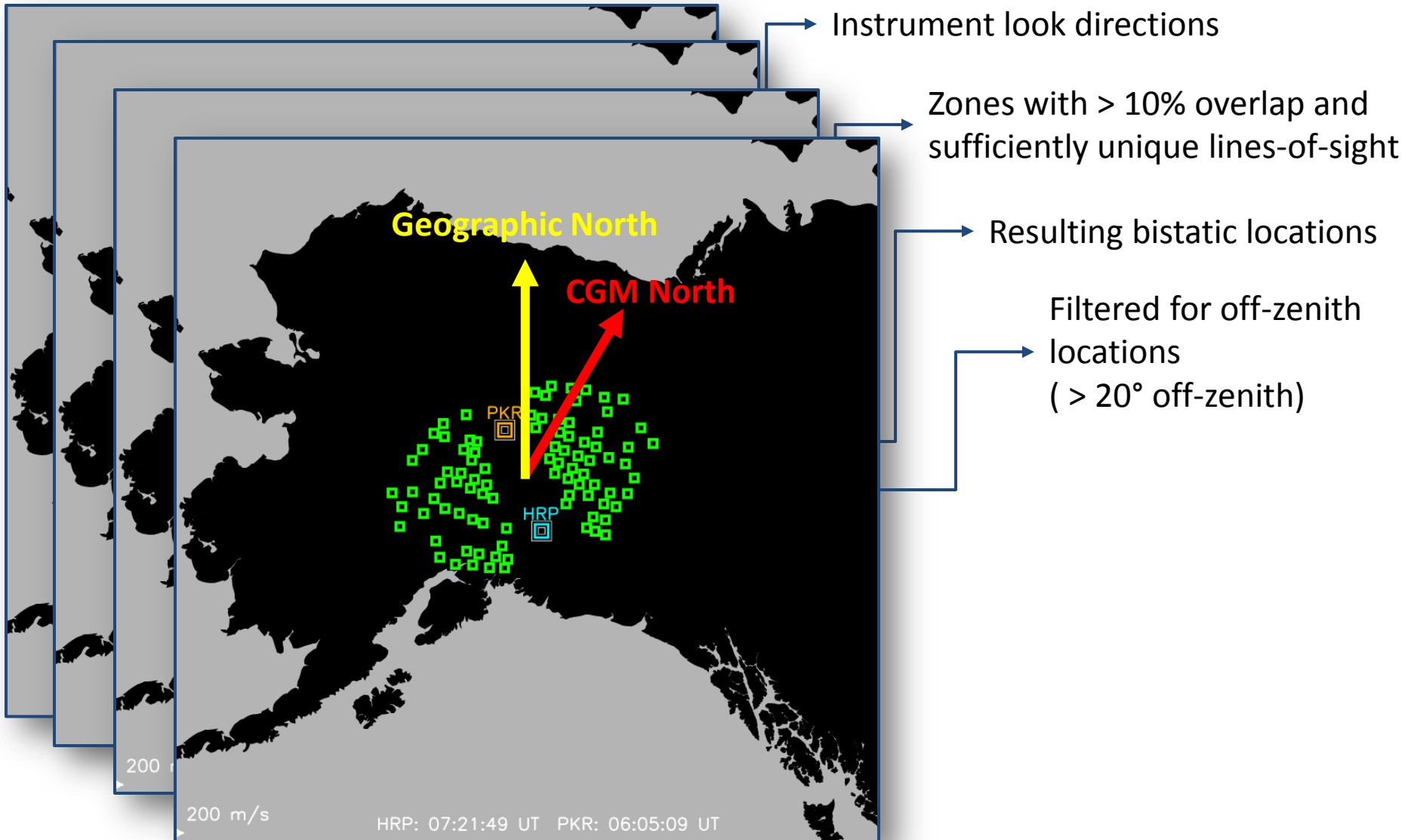
Instrumentation - Bistatic



- With two interferometers, we can arrange to have their fields-of-view overlap.
- In the common-volume region, two independent samples are obtained of the same nominal wind vector.
- These independent samples can be inverted to give two of the three wind vector components. We project this onto the horizontal by assuming a vertical wind.



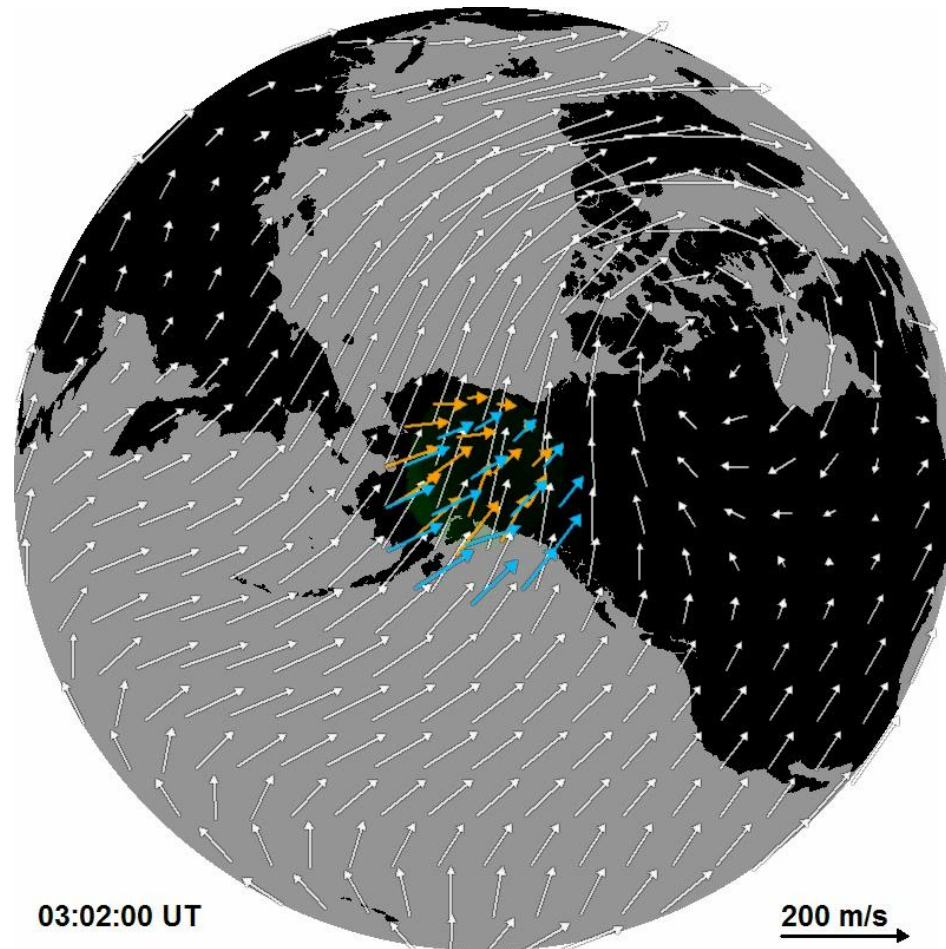
Array Geometry



Results – Monostatic Winds



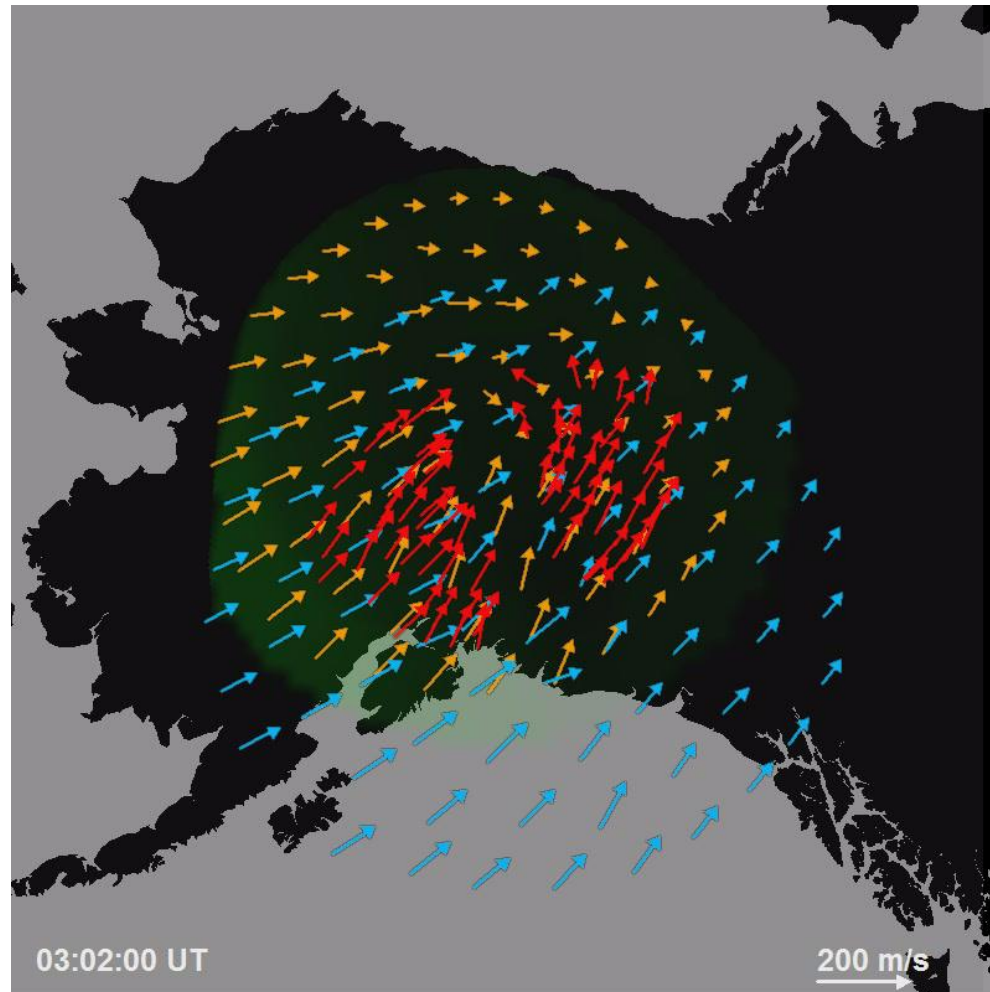
- An obvious test of the monostatic technique is to compare the independently inferred wind maps from the two nearby instruments.
- Here is such a comparison in the context of the global-scale thermospheric circulation. Data are from January 24, 2010.



Results – Bistatic Winds



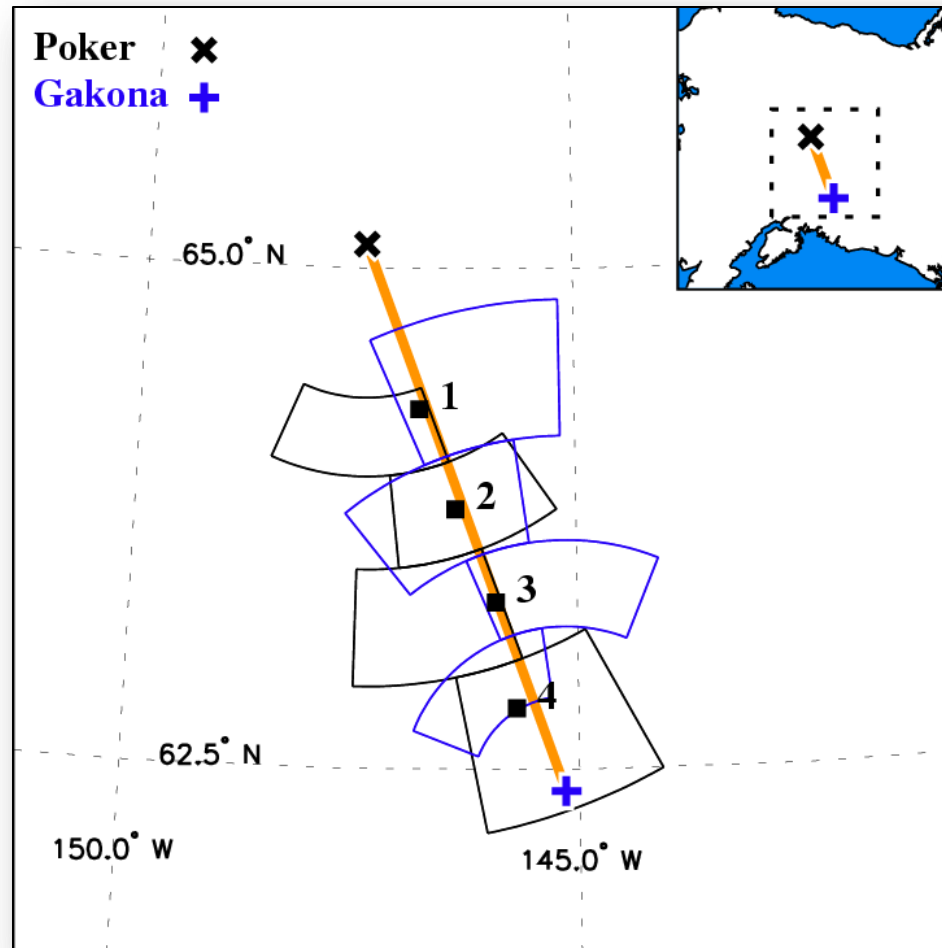
- Now we compare the bistatically inferred vector winds with the two monostatic wind fields.



Results – Bistatic Vertical Winds

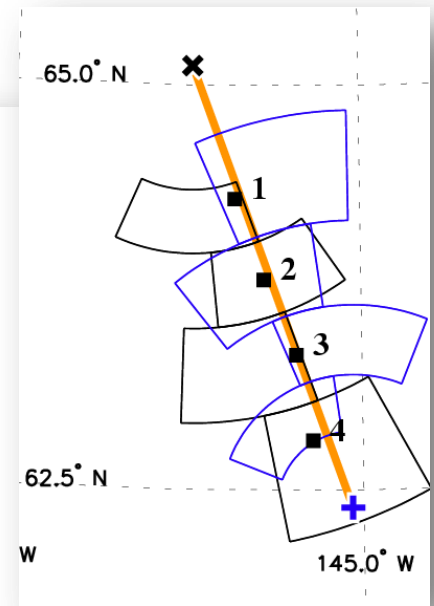
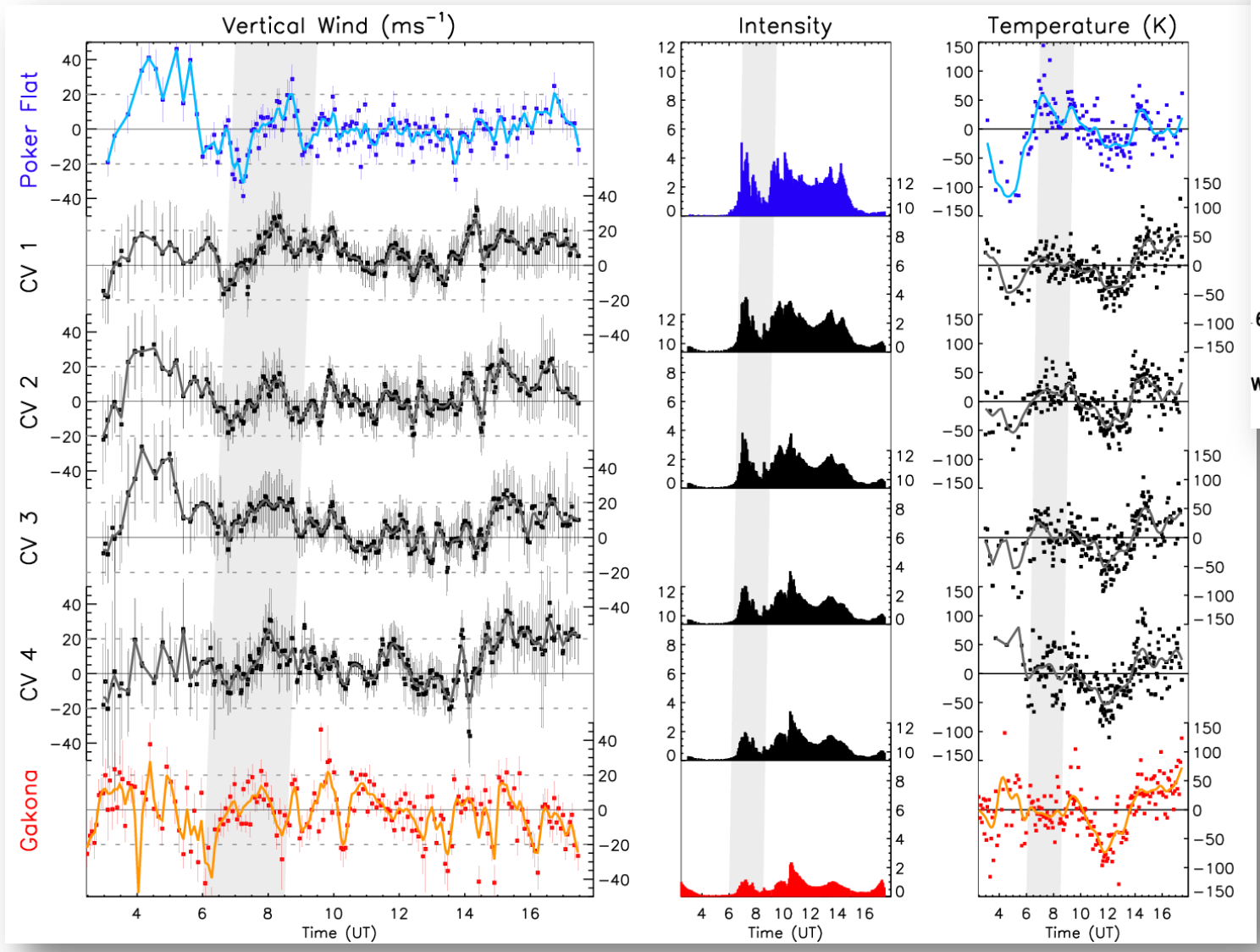


- Another advantage of the bistatic array is that it allows us to uniquely resolve the vertical wind at locations lying along the great circle joining the two spectrometers.
- The map below shows four such locations.



Results – Bistatic Vertical Winds

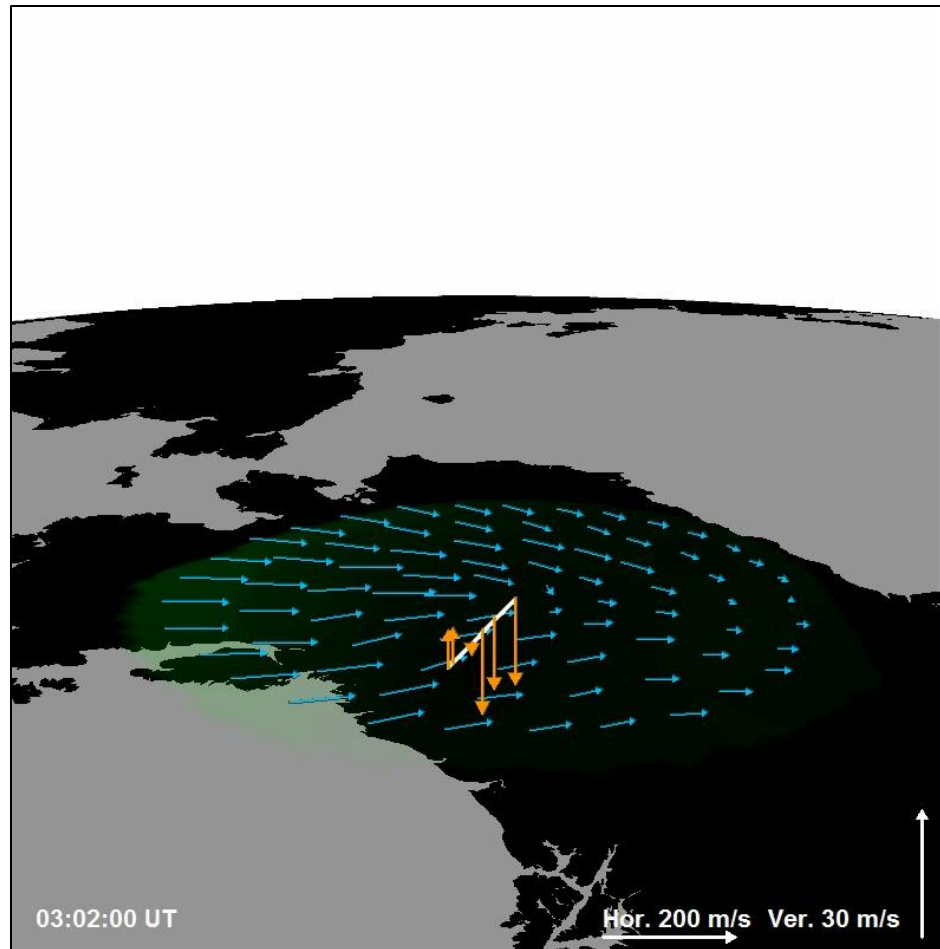
- Vertical winds at these locations (in addition to the station zeniths) are shown below for January 24, 2010.



Results – Bistatic Vertical Winds



- The spatial distribution of vertical winds may then be compared with horizontal flows and auroral morphology.

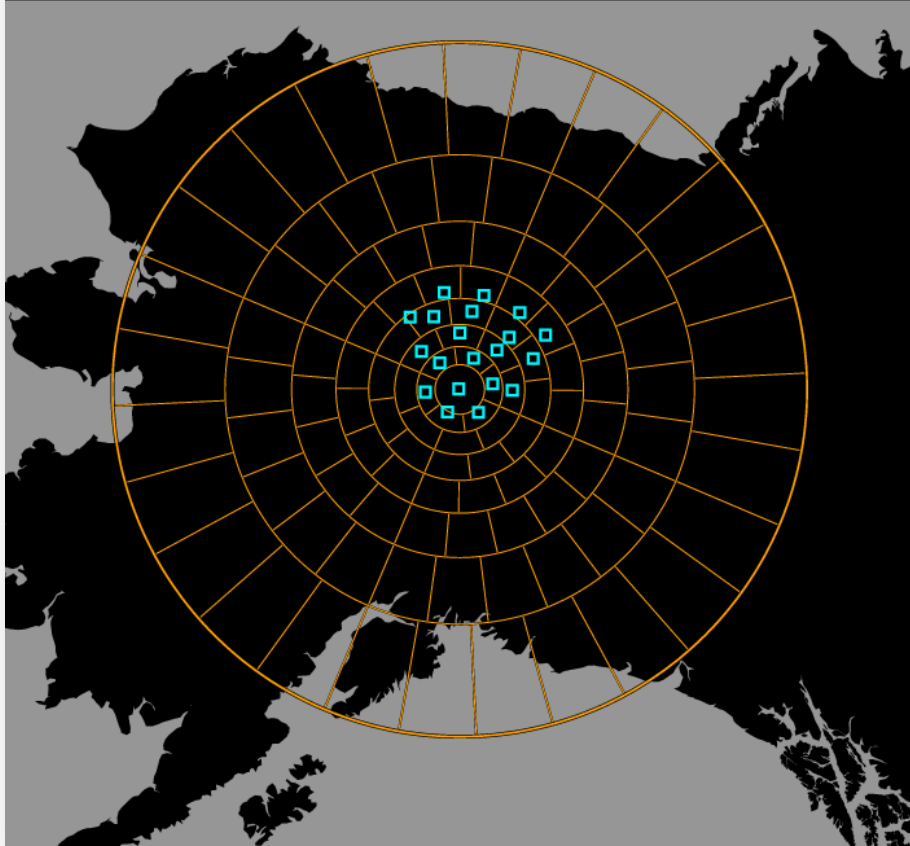


Results – Neutral & Ion Flows

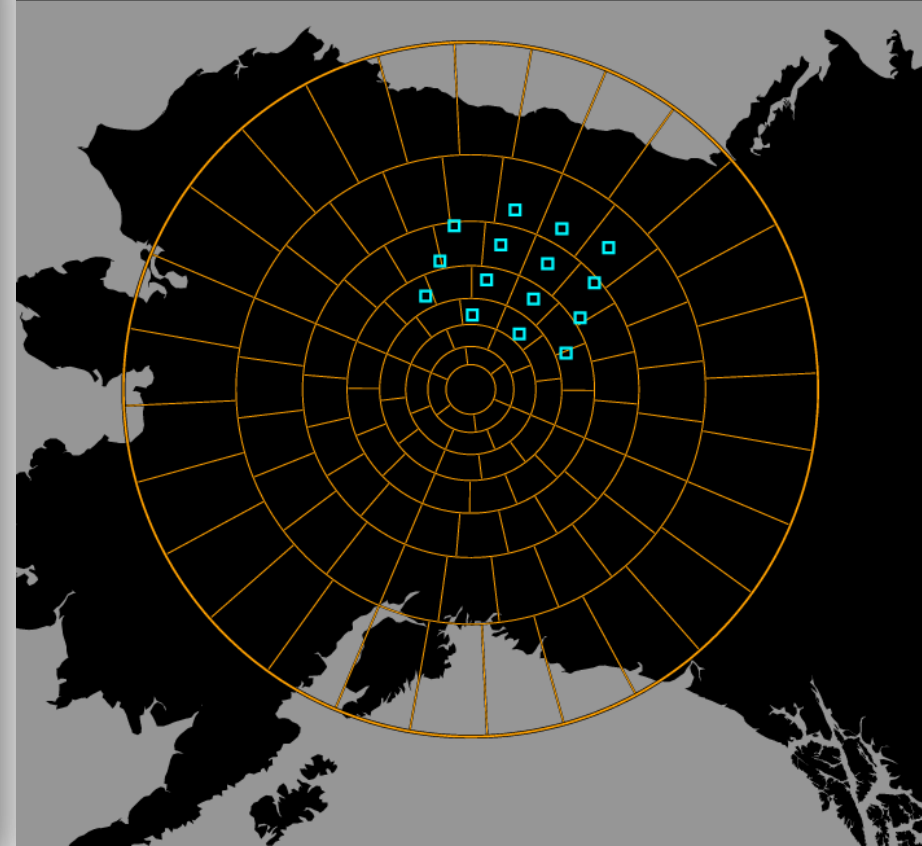


- Collocated with the Poker Flat SDI is the Poker Flat Advanced Modular Incoherent Scatter Radar (**PFISR**).
- These two instruments are ideally suited to imaging local-scale neutral and ion flows.
- A campaign of coordinated SDI + PFISR observations was recently completed (25 Mar-5 Apr). This campaign was initiated by Prof. Mike Kosch of Lancaster University.

PFISR Beam Intersections at 240 km



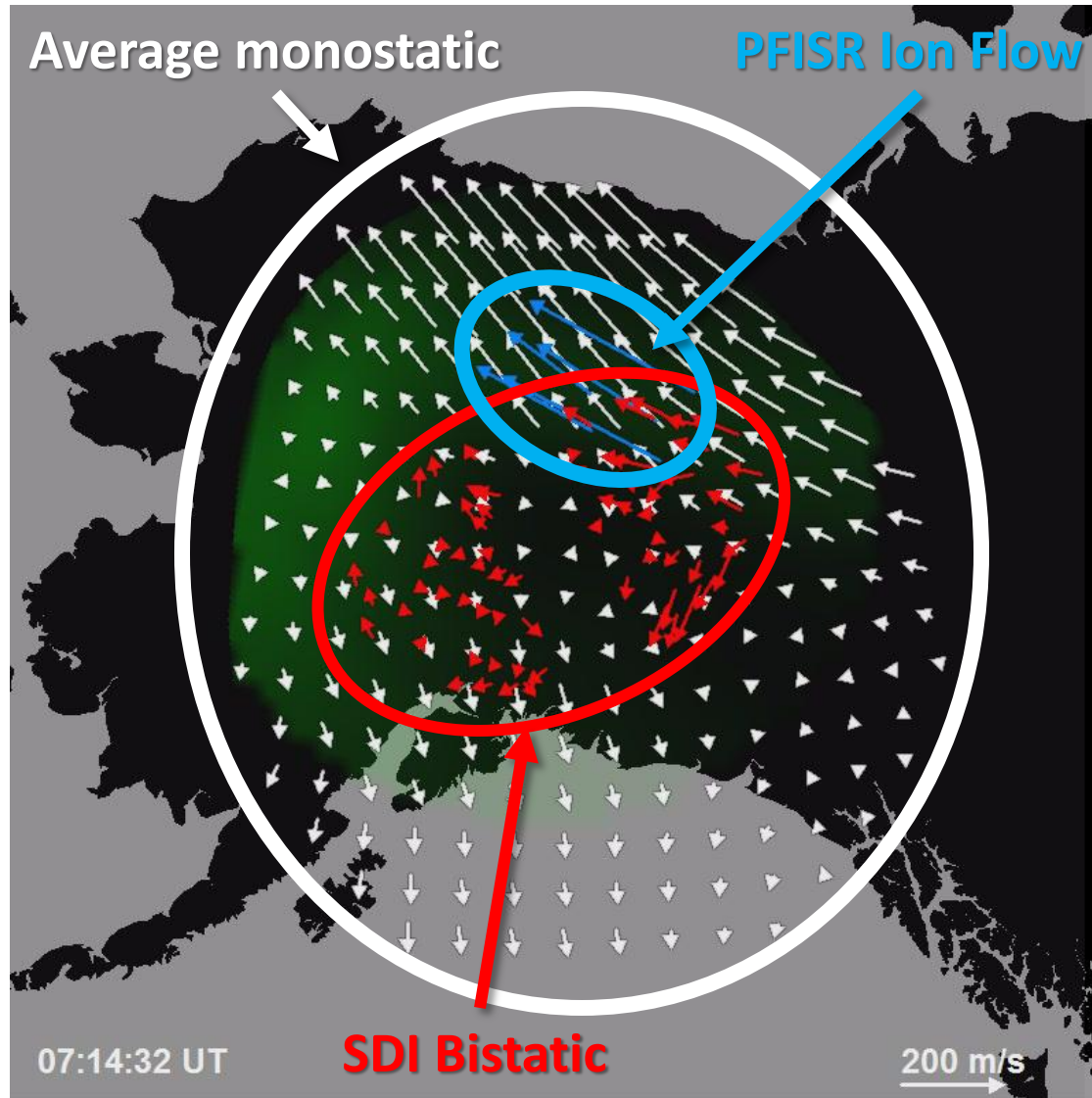
PFISR voxel centers for discrete inversion



Results – Neutral & Ion Flows



- Average monostatic wind field is compared with bistatic neutral winds and ion flow derived from **PFISR** measurements. These data were recorded on April 5th, 2011.

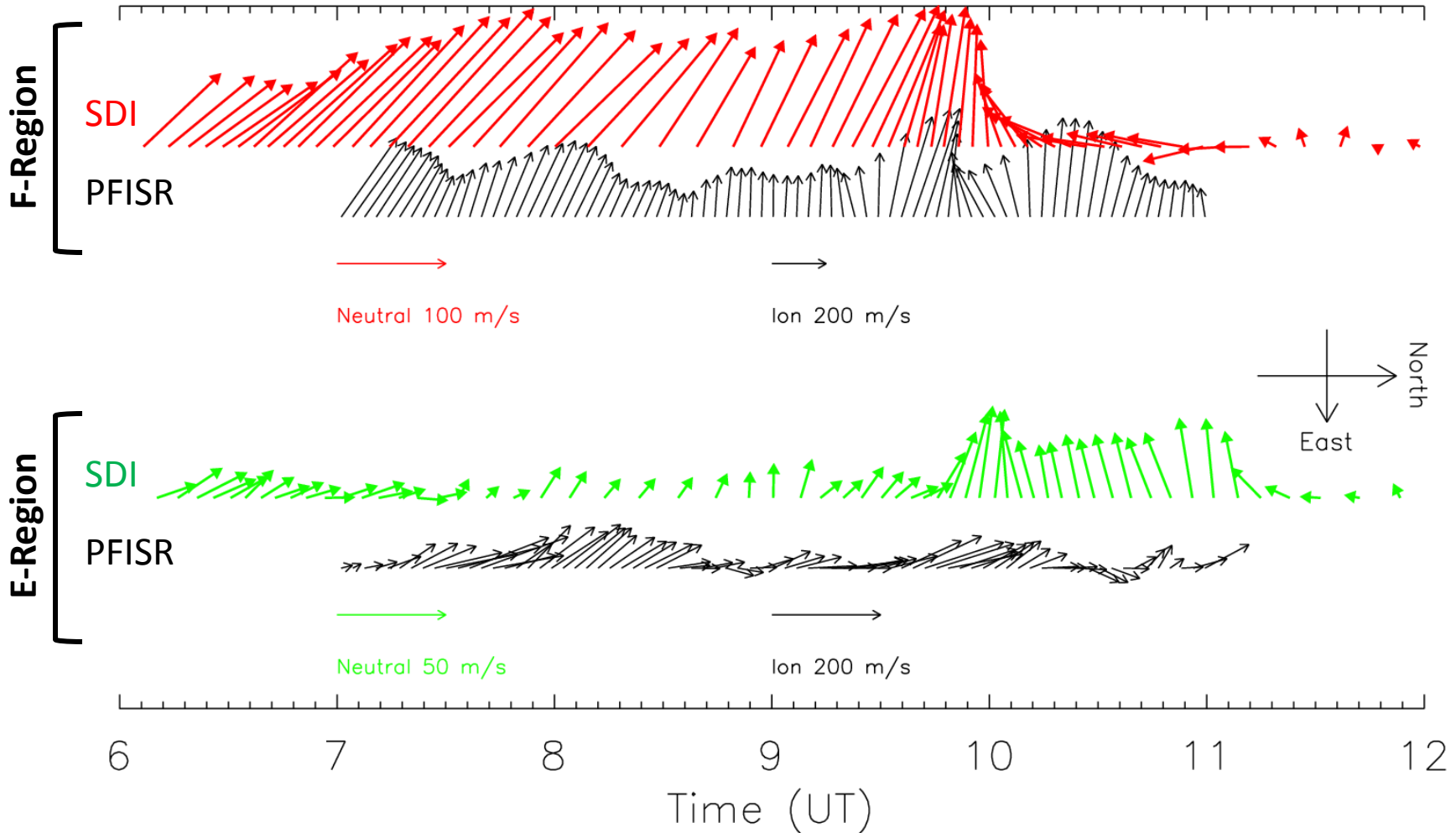


Results – Neutral & Ion Flows



- Average SDI neutral and PFISR ion flows at two different altitudes.
- Average flow vectors in the same atmospheric volumes at each altitude are compared.

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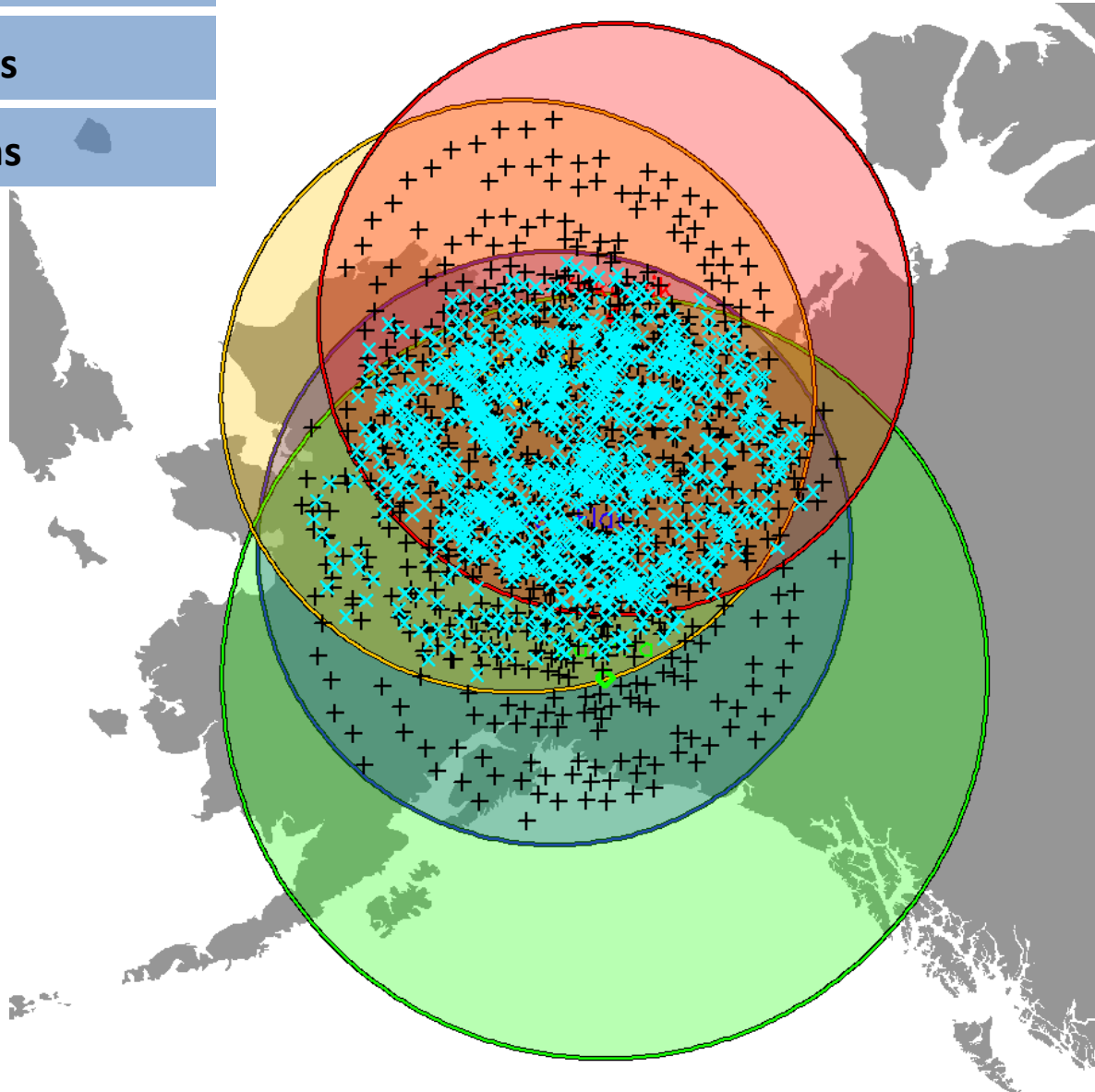


Looking Ahead

Monostatic Fields-of-view

+ Bistatic Locations

x Tristatic Locations



- Monostatic wind imaging can provide a good first-order estimate of the wind field over a very large field of view. The technique is robust and valid under a large range of geophysical conditions.
- When accurate knowledge of the small-scale wind structure is required, bistatic (or tristatic) wind inversion is required, since these are direct measurements of the **local** wind.
- The bistatic array not only allows us to measure horizontal wind vectors with better spatial resolution and fewer assumptions, but also allows us to map the spatial variation of the vertical wind between the two instruments.
- With the addition of more SDI instruments, the possible bistatic locations increase dramatically, and in addition we can then do **tristatic** wind **imaging**.
- When combined with the ion flow imaging capability of instruments such as PFISR, we can begin to examine both neutral and ion flow structures at both large and small-scales, and to identify the extent to which these scales are coupled.

Thank You!