Calibration Issues for Wind Measurements Using the 558 nm Oxygen Green Line

- This talk will discuss Fabry-Perot wind measurements using the 557.7 nm "green line" emission line from atomic oxygen.
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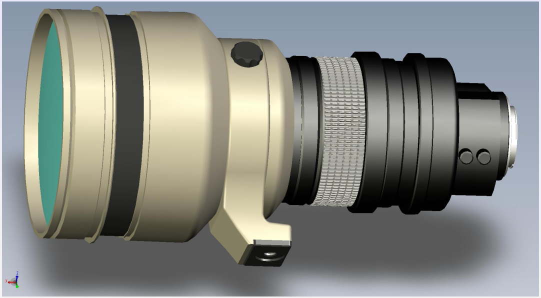
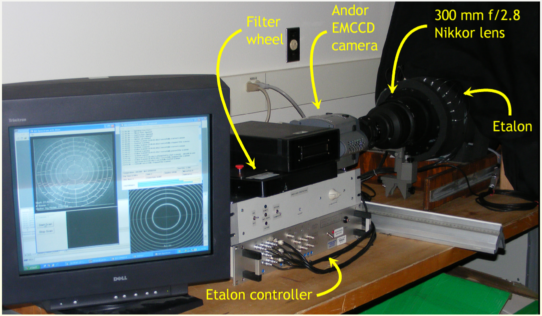
- Unfortunately, however, *real instruments exhibit chromatic aberration*, so that *their actual behavior at 557.7 nm may depart from that predicted by an ideal transform from another wavelength*.
- In this talk I will discuss how we address this issue for the scanning Doppler imager at Poker Flat.

High-Quality Fringe Imaging Lenses





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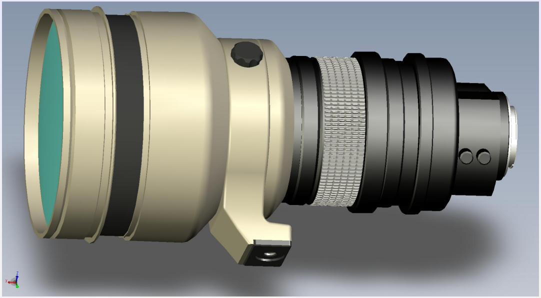
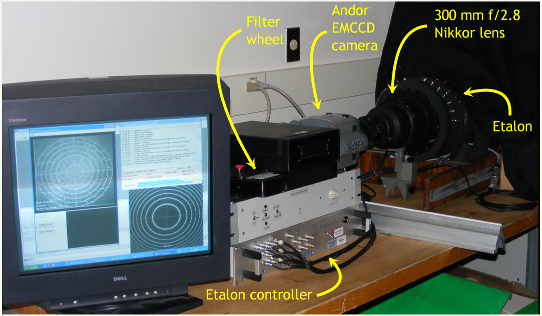
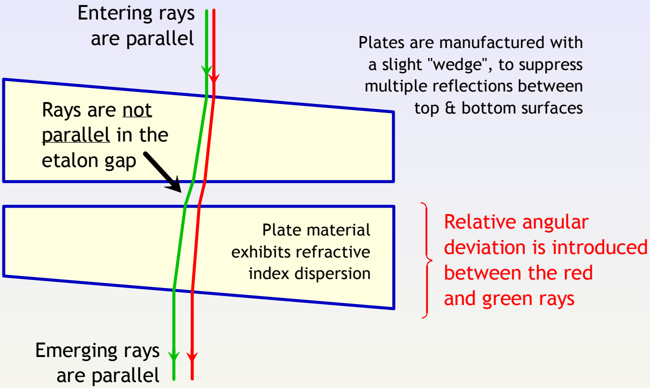




- The first thing to do to control chromatic aberration is to use a high quality lens to form the fringe images.
- The top figure is a Solid Works model of the 300 mm f/2 Nikkor lens used in the all-sky Fabry-Perot currently at Mawson, Antarctica.
- The bottom figure shows the 300 f/2.8 Nikkor lens used in the Poker Flat instrument.

Chromatic Aberration from the Etalon Itself



- Unfortunately, there is one source of chromatic aberration that cannot be suppressed regardless of the lenses used.
- It arises in the etalon itself, because etalon plates are typically manufactured to be slightly "wedge" shaped.

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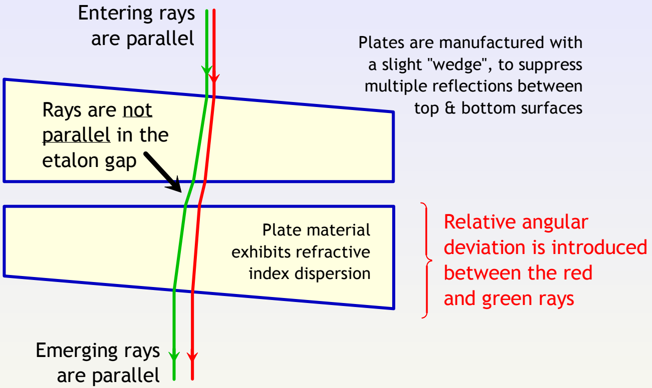
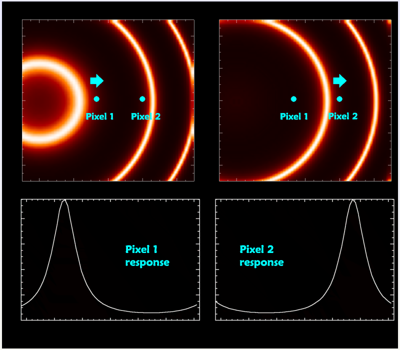
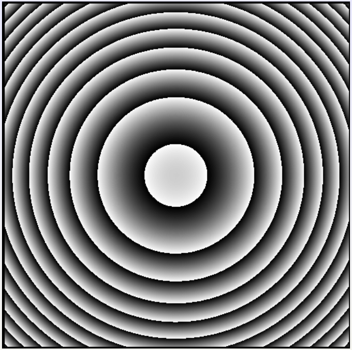


- Unfortunately, there is one source of chromatic aberration that cannot be suppressed regardless of the lenses used.
- It arises in the etalon itself, because etalon plates are typically manufactured to be slightly "wedge" shaped.
- Rays emerging from the etalon must therefore pass through a (very) narrow-angle prism, which introduces wavelength dispersion – effectively introducing a shift in the fringe center between red and green wavelengths.

Scanning Doppler Imager





- In a conventional imaging FPS, correction for the etalon-induced chromatic aberration would amount to finding the fringe center at 558 nm. This would normally be determined using calibration fringes, but here of course it must be done using sky fringes – or with an averaging procedure using a large number of sky fringes.

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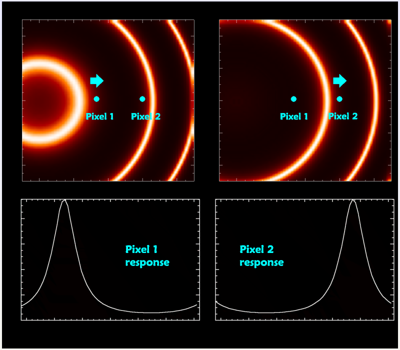

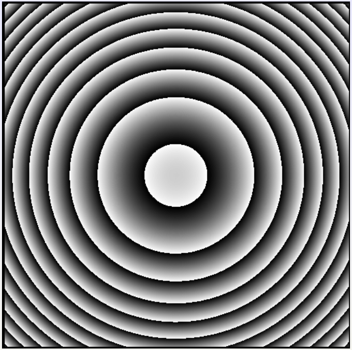

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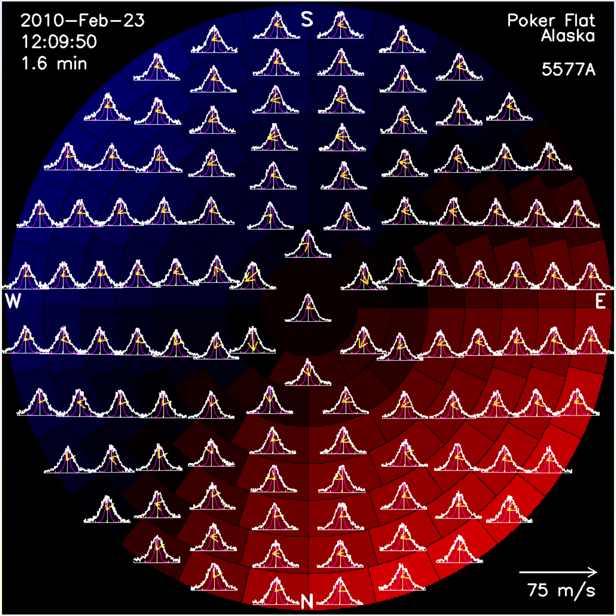
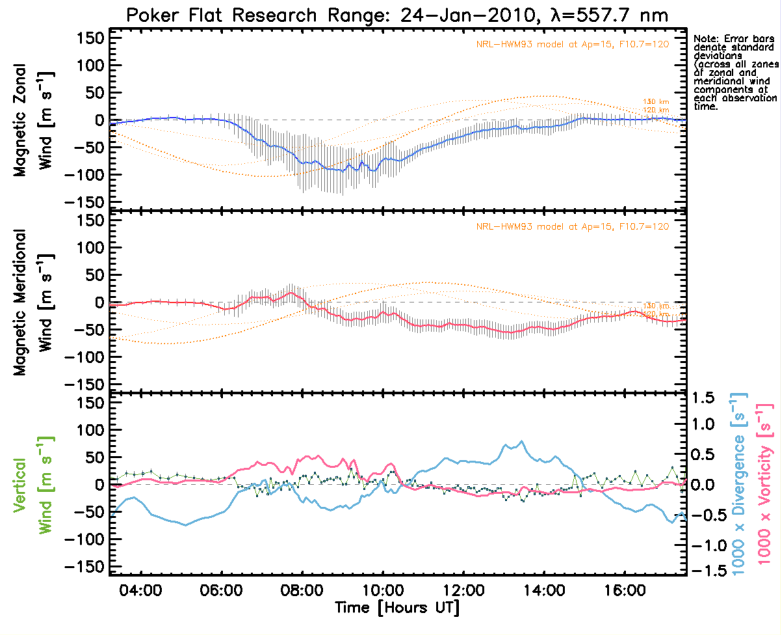
- But the *SDI instruments do not retain fringe images*. Phase and zone maps are applied to fringe images in real time while the etalon scans, so that only 1D spectra are recorded (individual fringe images are discarded.) Thus, *an alternative chromatic aberration correction scheme is needed*.

Effect of the Chromatic Shift



- The effect of the chromatic shift is to introduce an apparent uniform background wind.
- This is illustrated here. The correct wind field in this (cloudy sky) case was essentially zero, as shown by the yellow arrows (which have been corrected for the chromatic shift.)
- But the raw Doppler shift map seen by the instrument at this time is shown by the blue-red hues.
- The wind artifact is obvious.

Green-Line Winds from Clear Skies



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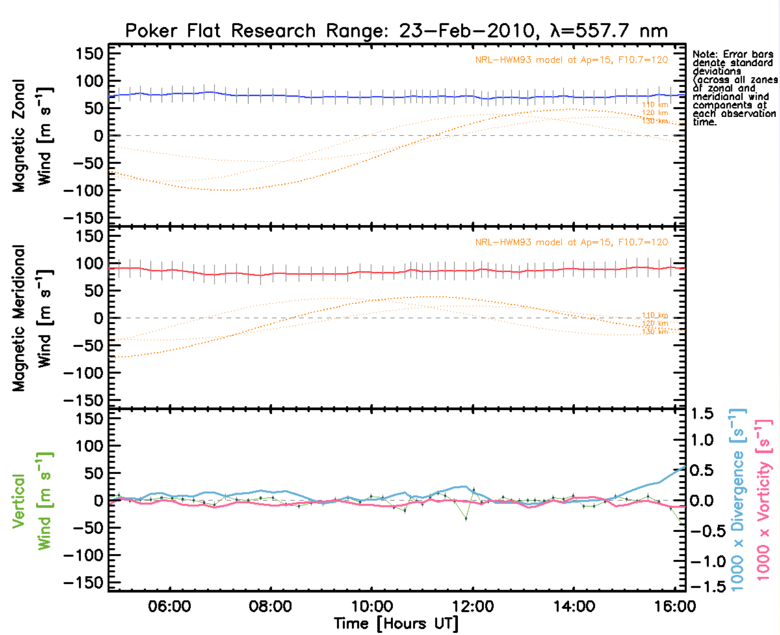
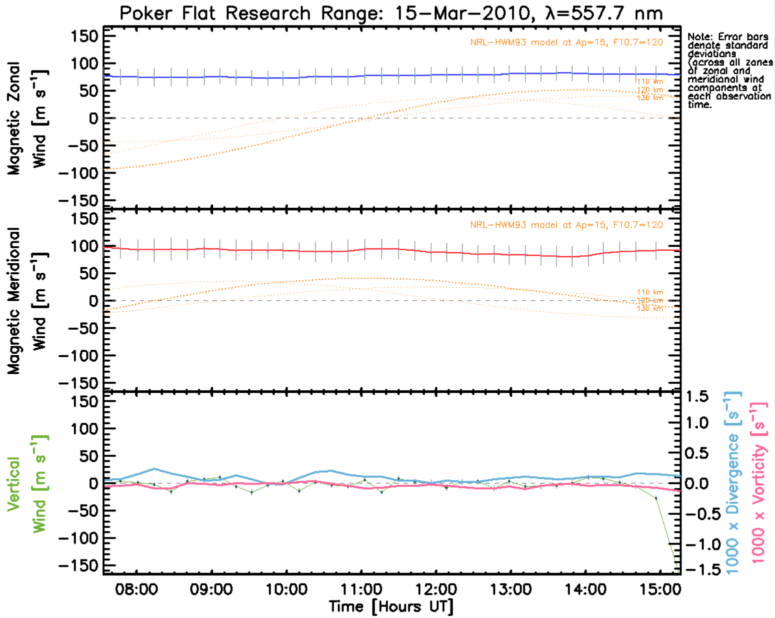
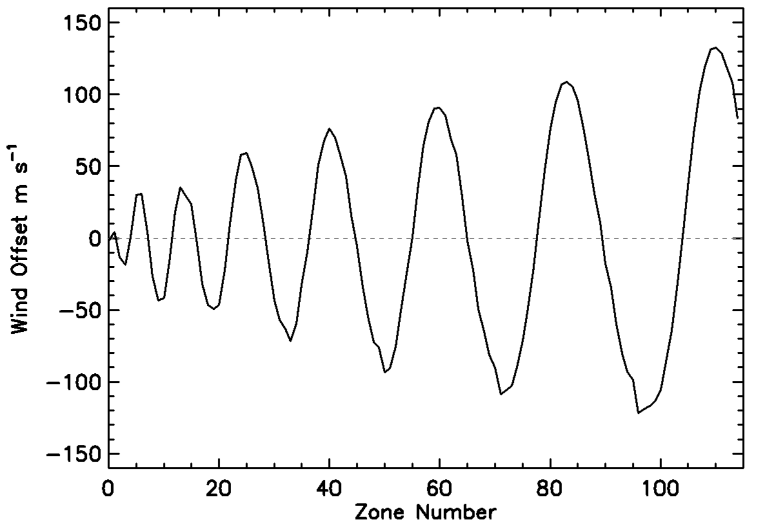


Green-Line Winds from Cloudy Skies – Another Example

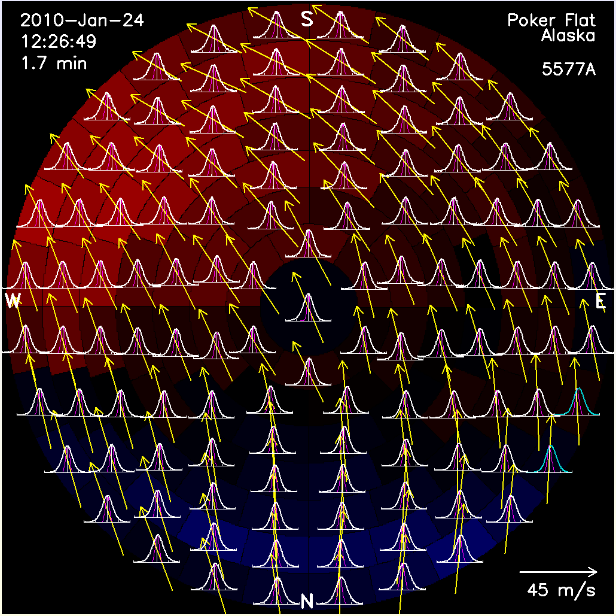


Doppler Shift Correction Map



Averaging uncorrected "Doppler shifts" over a large number of dense-cloud sky observations produces the required velocity offset correction for each zone. The characteristic signature seen here arises because the zones "spiral" out from the center with increasing index number.

Corrected Wind Field



- This is an example of a Doppler sky map after zero velocity correction, along with the 2-dimensional horizontal vector wind field that was fitted to it.
- The vector arrows are consistent with the Doppler shift map.

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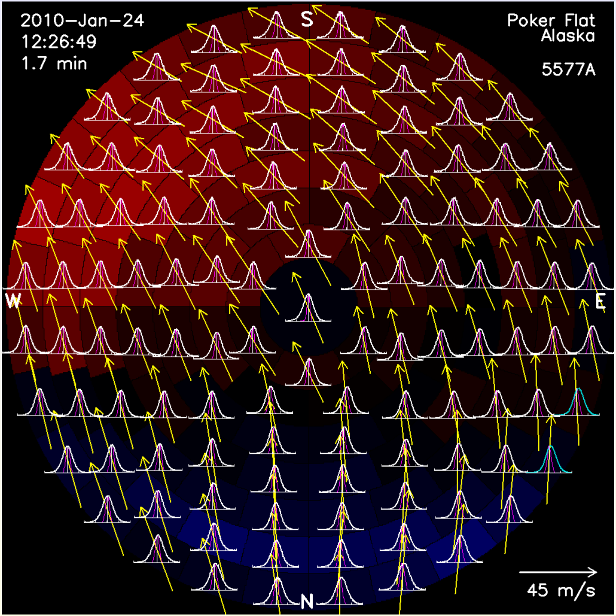

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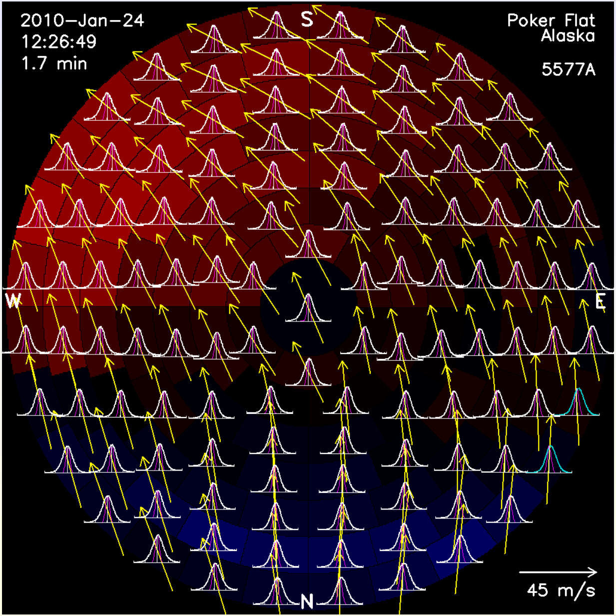

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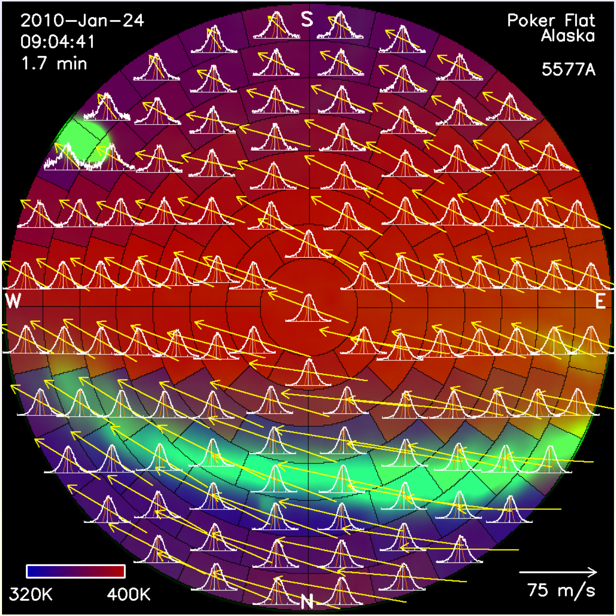
- The vector arrows are consistent with the Doppler shift map.
- Note that the "dipole component" of the Doppler shift map is rotated almost 180° from the wind offset shown previously.
- The wind field exhibits curvature not present in the offset field; it must be geophysical.

Winds and Temperatures Near the Aurora



- One validation technique is to look at winds near auroral arcs – typically, these blow westward in the evening, even down in the E-region.

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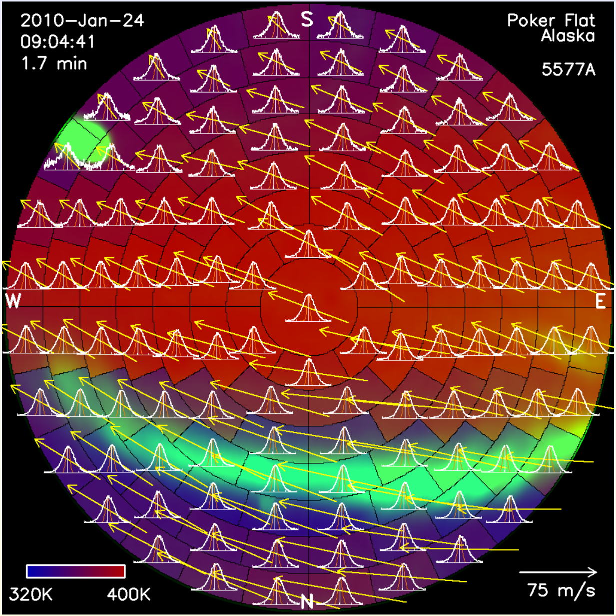

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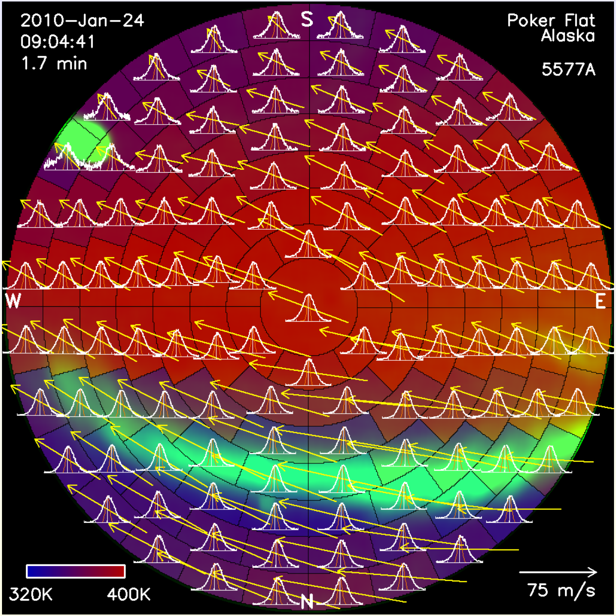

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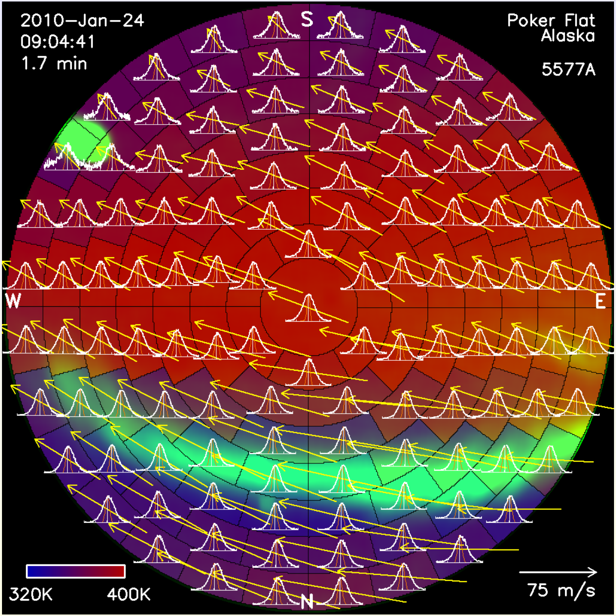

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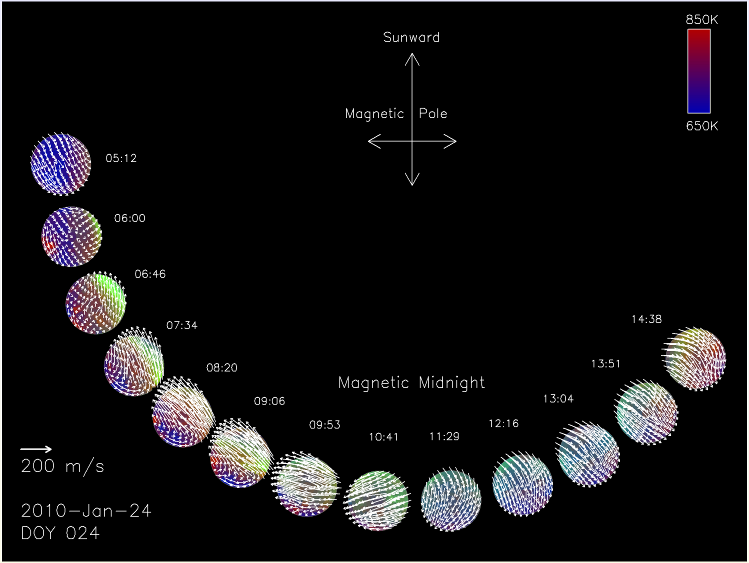
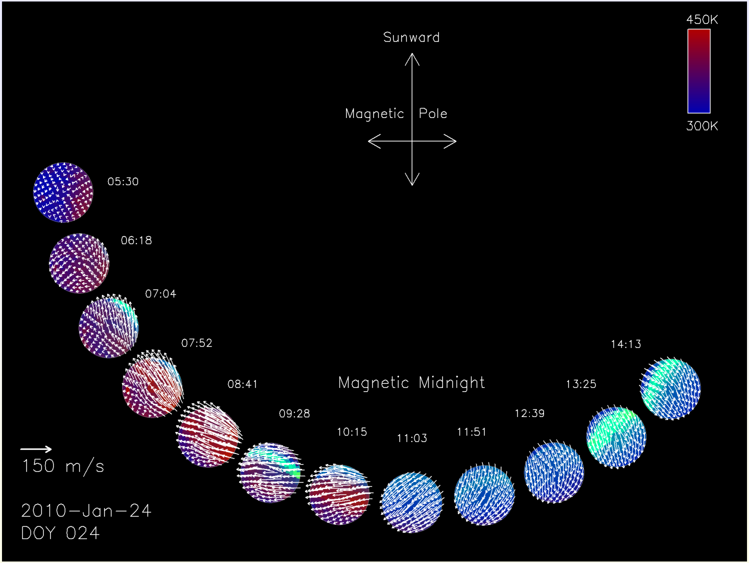
- The large green blob at the "10 o'clock" position is the moon.

F-Region Winds



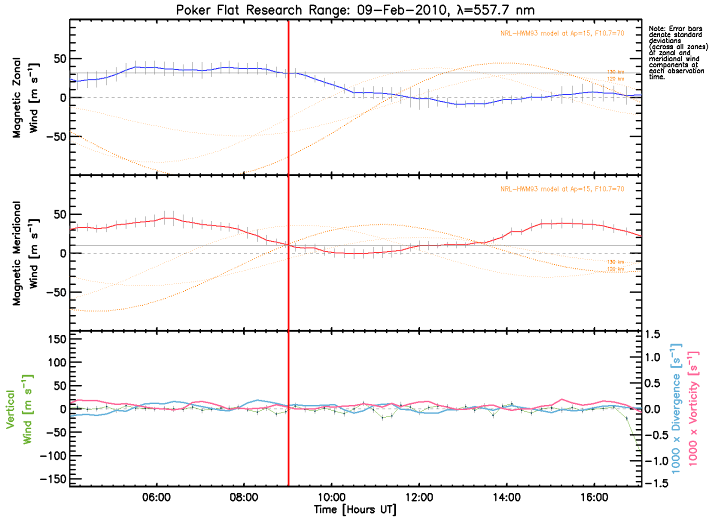
This figure shows F-region winds derived from the 630 nm emission on 24-Jan-2010. Note the westward flow before magnetic midnight.

E-Region Winds



These are the E-region winds for the same night as the previous figure. Note the broad (but not exact) similarity.

Comparison with Winds Measured by Chemical Release



Winds @ 9 UT

$u \simeq +30\,\mathrm{m\,s^{-1}}$

$v \simeq +10\,\mathrm{m\,s^{-1}}$

$w \simeq \pm 5\,\mathrm{m\,s^{-1}}$

The "gold standard" for thermospheric wind validation would be to compare with in-situ measurements derived from chemical releases. Fortunately, we do have such measurements, from the "Ampules" mission at 9 UT on Feb 9, 2010.

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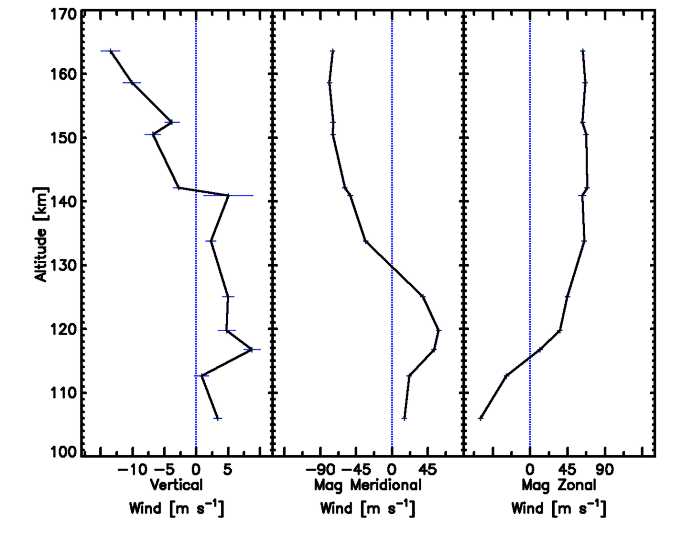

Unfortunately, the in-situ winds vary with height a lot in the 110 km to 130 km height range that the 558 nm emission might be coming from. But the two techniques are not inconsistent, especially given their very different spatial sampling volumes.

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- The resulting wind field fields make sense based on our current knowledge of winds in the E-region should behave.
- There is reasonable agreement with in-situ E-region wind measurements by chemical release – although issues of the horizontal and vertical extent of the Fabry-Perot sampling volume make one-to-one comparisons difficult.