Thermospheric Winds and Temperatures Above Mawson, Antarctica, Observed with an All-sky Imaging, Fabry-Perot Spectrometer

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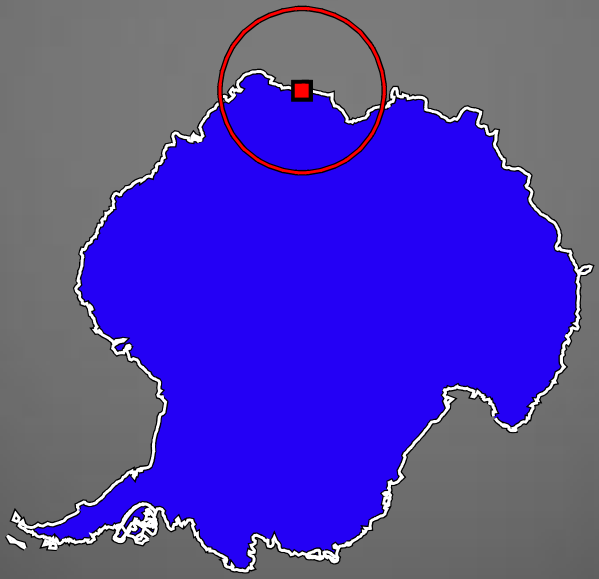

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Abstract

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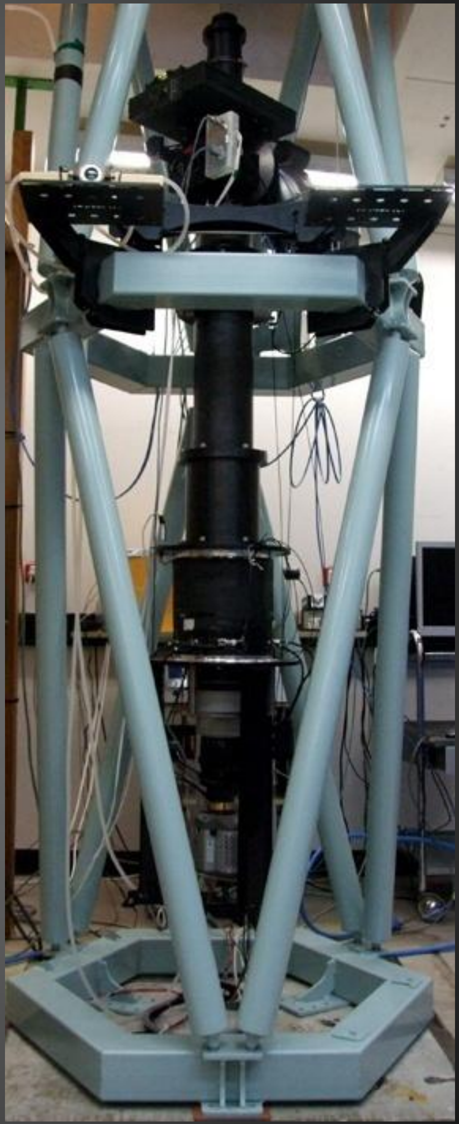
During the 2006/2007 summer, La Trobe University completed the installation of a new, all-sky, scanning imaging Fabry-Perot specrometer at Mawson station, Antarctica. This instrument is capable of recording independent spectra from many tens of locations across the sky simultaneously. Useful operation began in March 2007, with spectra recorded on a total of 186 nights.

Initial analysis has focused on large-scale daily and climatological behavior of winds and temperatures derived from observations of the 630.0 nm airglow line of atomic oxygen, emitted from a broad layer centered around 240 km altitude, in the ionospheric F-region.

Data from the 2007 observing season (March-October) are presented.



Instrument Description

The instrument is an all-sky imaging, separation-scanned Fabry-Perot spectrometer of the type described by Conde and Smith (1997):

- 75° half-angle field-of-view
- 6-position filter wheel placed beneath the fore-optics and above the calibration light source
- 150 mm aperture, capacitance-stabilised, piezoelectrially -scannable etalon
- Very fast, 300 mm f/2 Nikon fringe-forming lens
- Thermoelectrically-cooled, back-illuminated, Andor Ixon EMCCD

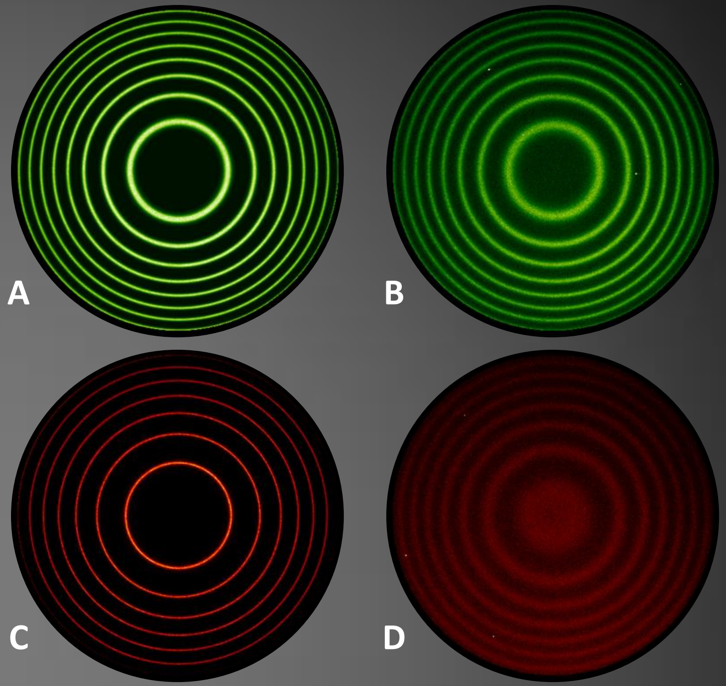
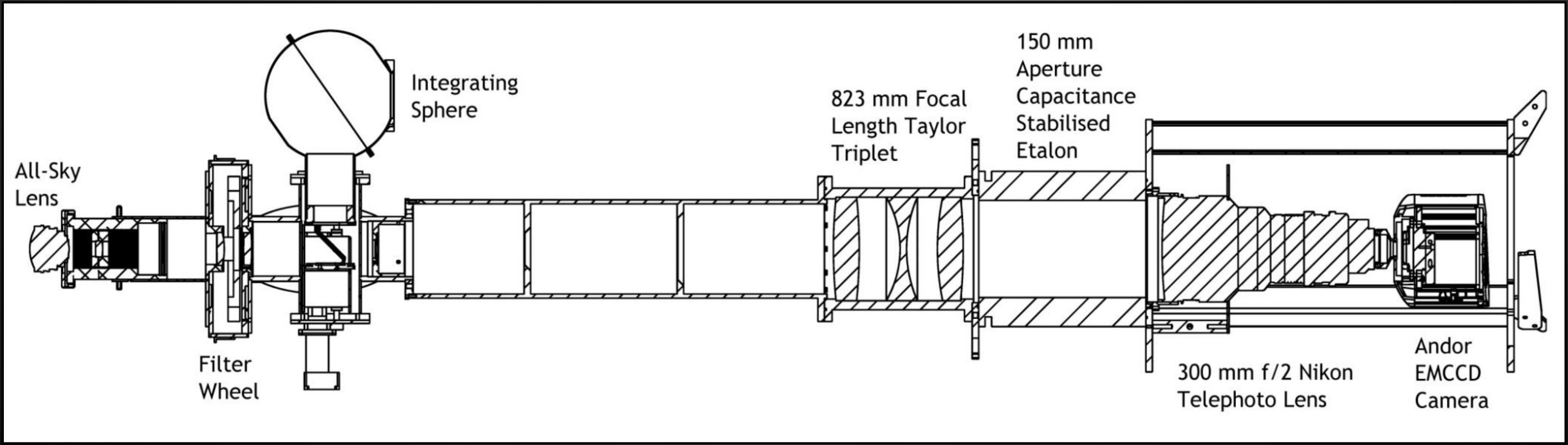


Figure 2 (above): Recorded fringes (false colour) A) 543.5 nm laser B) 557.7 nm airglow C) 632.8 nm laser D) 630.0 nm airglow

Figure 1 (below): Instrument schematic



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Data Output

- Field of view is divided into groups of adjacent pixels called ***"zones"***
- Spectra from pixels within each zone are co-added to produce a single spectrum for each zone
- This represents a trade-off between spatial and temporal resolution
- One ***"exposure"*** is the result of summing spectra recorded during multiple ***"scans"*** of the etalon
- Co-adding multiple rapid scans in this way reduces fringe distortion due to temporal variations in source brightness
- As well as recording spectra, the instrument is able to build up its own all-sky image by co-adding the interference fringe images which are recorded at step in a scan.
- Each exposure thus generates an image of the ***sky at the same wavelength as the sky spectra, and over an identical field-of-view (and exposure time)***.

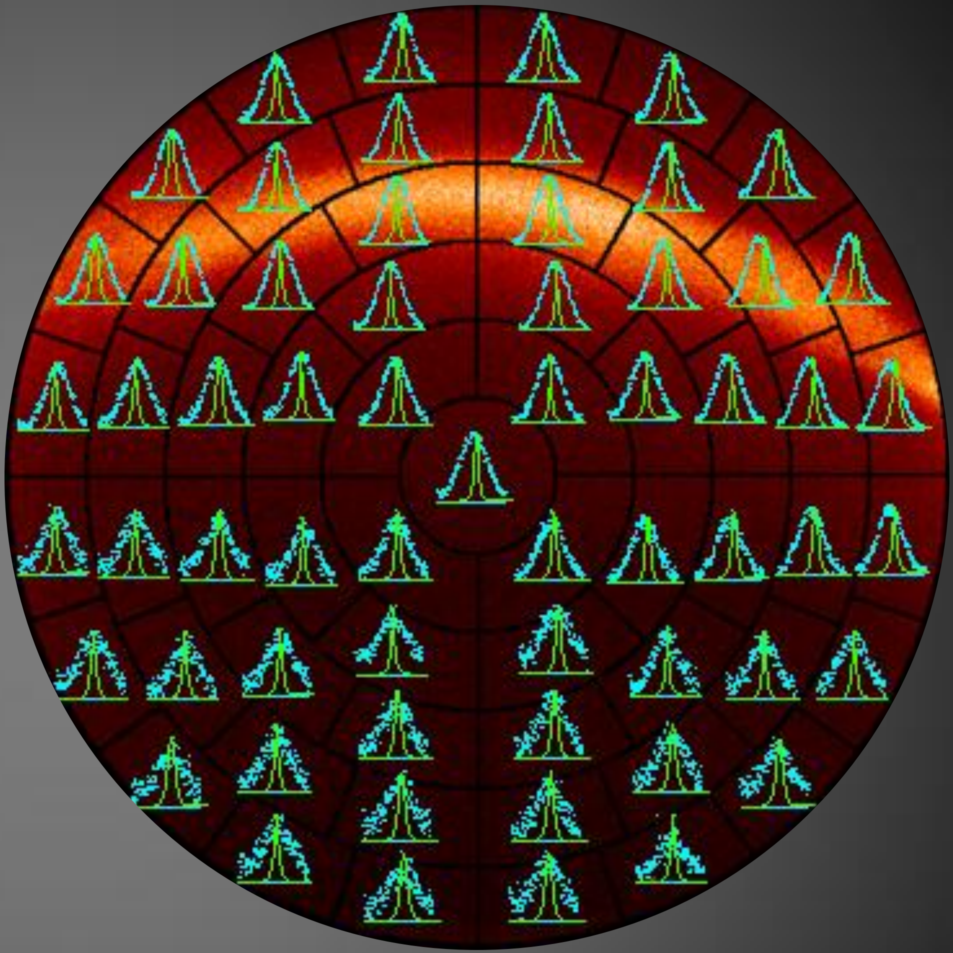


Figure 3: Recorded 630.0 nm sky spectra (cyan), 632.8 nm laser calibration spectra (green), superimposed over the instrument's recorded all-sky image. Black lines show the subdivision of the field of view into 60 'zones' for the purpose of spectral accumulation.

Data Analysis

- Line-of-sight Doppler-shifts are obtained by assuming an ***average vertical wind speed of 0 ms^{-1}*** throughout the night. This defines our zero Doppler-shift.

- A 2-dimensional vector wind field is then fitted to the horizontal component of the line-of-sight Doppler-shifts, using the method of Conde and Smith (1998).

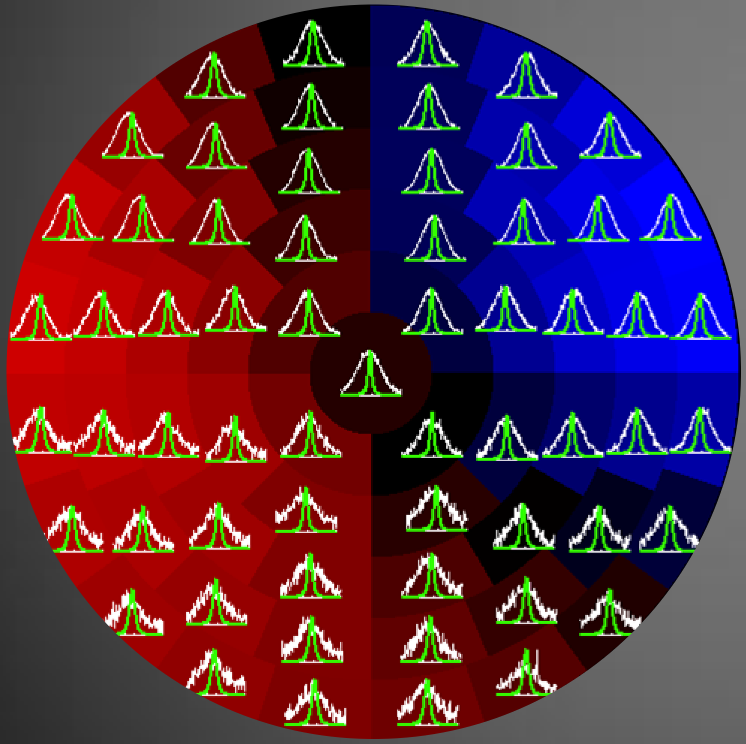


Figure 4: Doppler-shifts (red/blue hues) calculated by assuming 0 ms^{-1} vertical wind throughout the night.

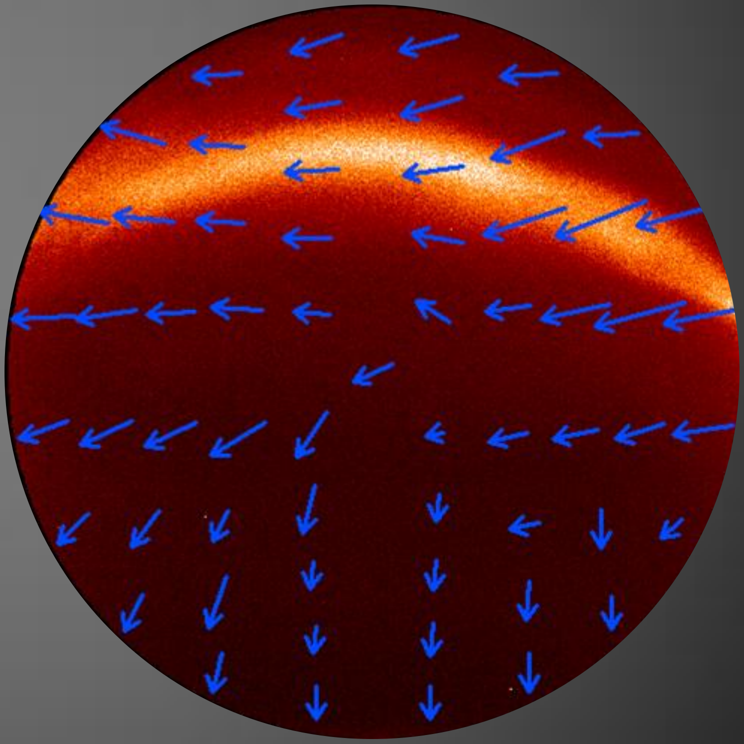


Figure 5 (right): Vector wind field fitted to the Doppler-shifts of figure 4, superimposed over the all-sky image.

Results

- Results from two nights of observation are presented.

- These nights highlight the effect that geomagnetic activity has on observed winds and temperatures.

- All-sky averages are taken of the temperature, intensity, and meridional and zonal components of the fitted wind field, and plotted as functions of universal time.

Three models were used for comparison with the observed data:

- *1993 Horizontal Wind Model (HWM93)*
  - Empirical: *neutral winds*
  - (Hedin et al., 1988; Hedin, 1991)

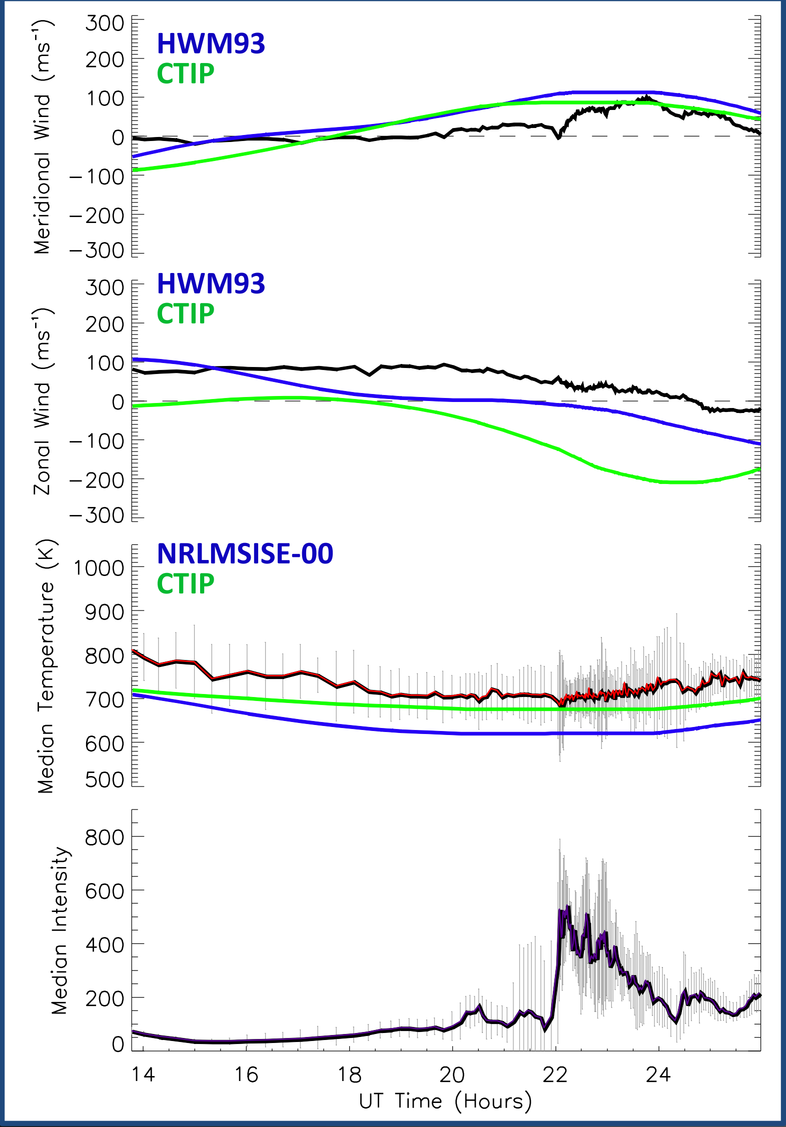
- *NRL Mass-Spectrometer and Incoherent Scatter Radar (Extended) (NRLMSISE-00) Atmospheric Model*
  - Empirical: *neutral temperature*
  - (Picone et al., 2002)

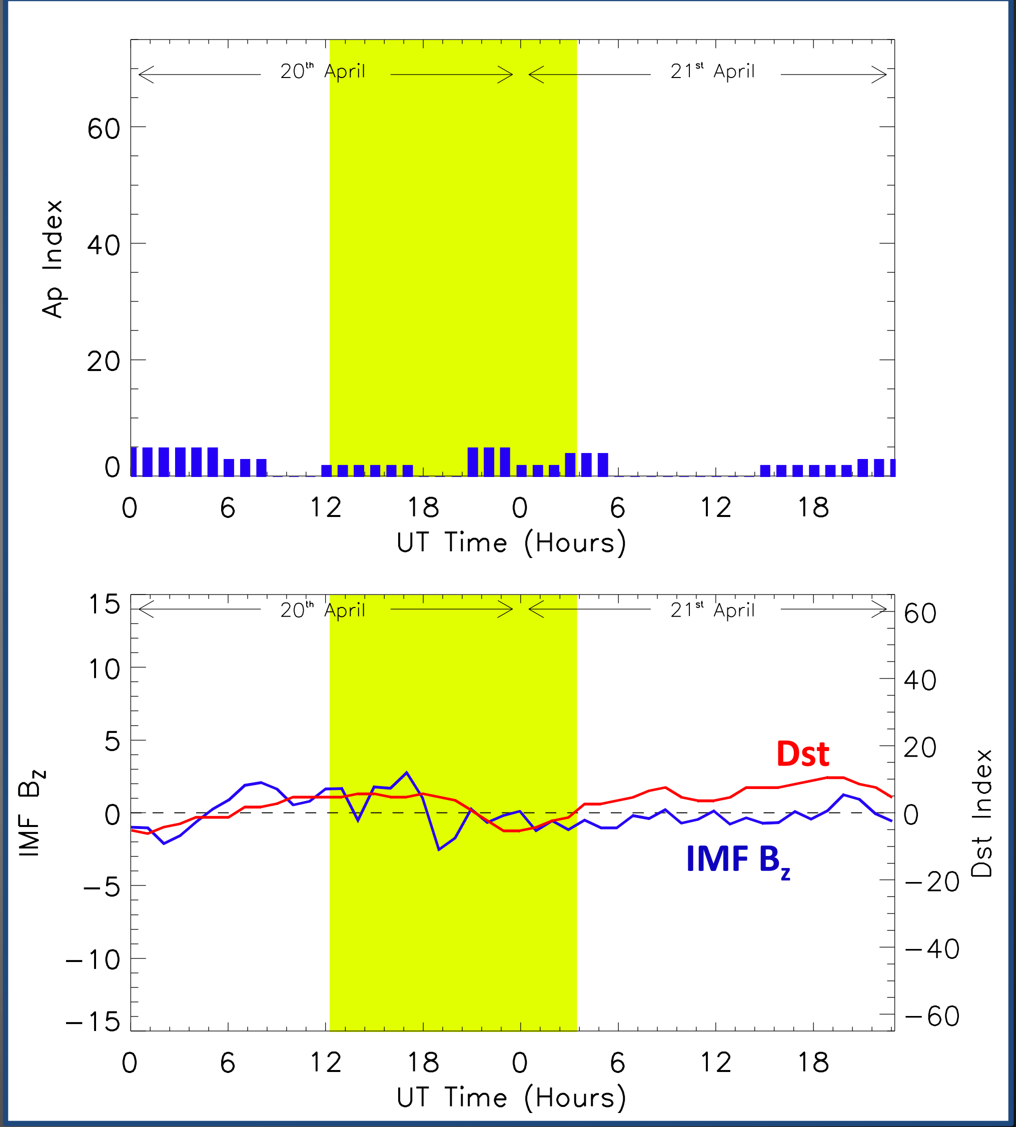
- *Coupled Thermosphere/Ionosphere Plasmasphere (CTIP) Model*
  - Global-scale, numerical model: *neutral winds and temperatures*
  - (Fuller-Rowell et al., 1996; Millward et al., 1996)

All three models were run with constant geomagnetic and solar activity inputs: averages of the observed values over each night.

Results

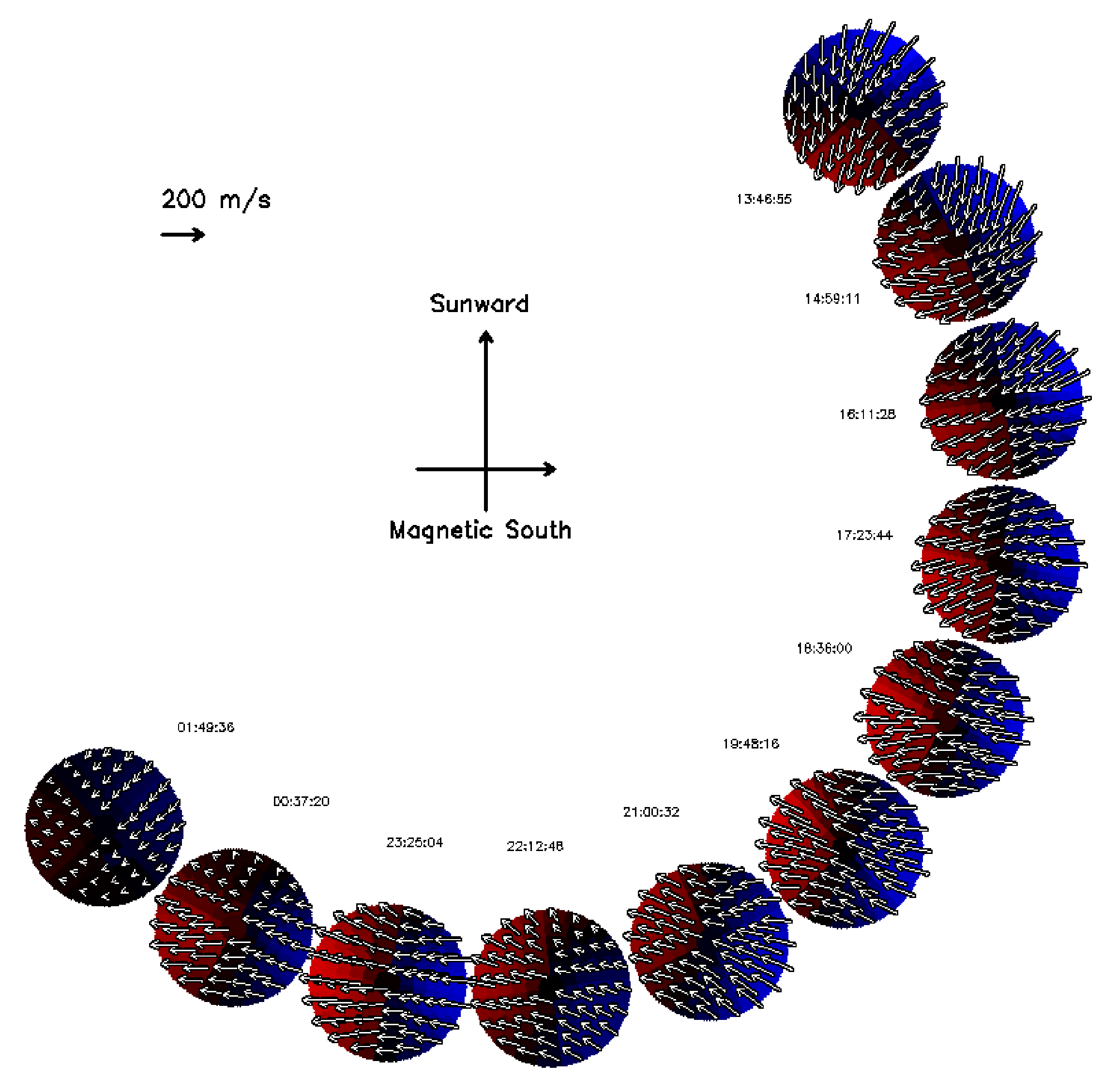
NIGHT A - April 20th 2007, Quiet Conditions





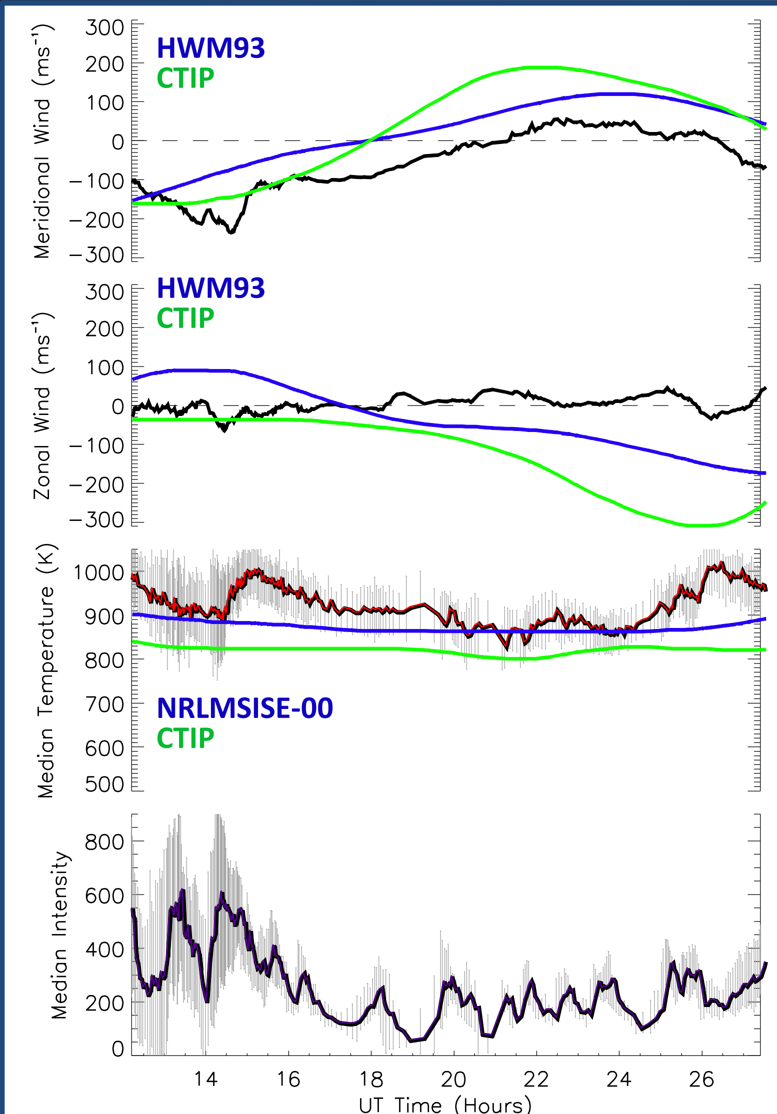
Results

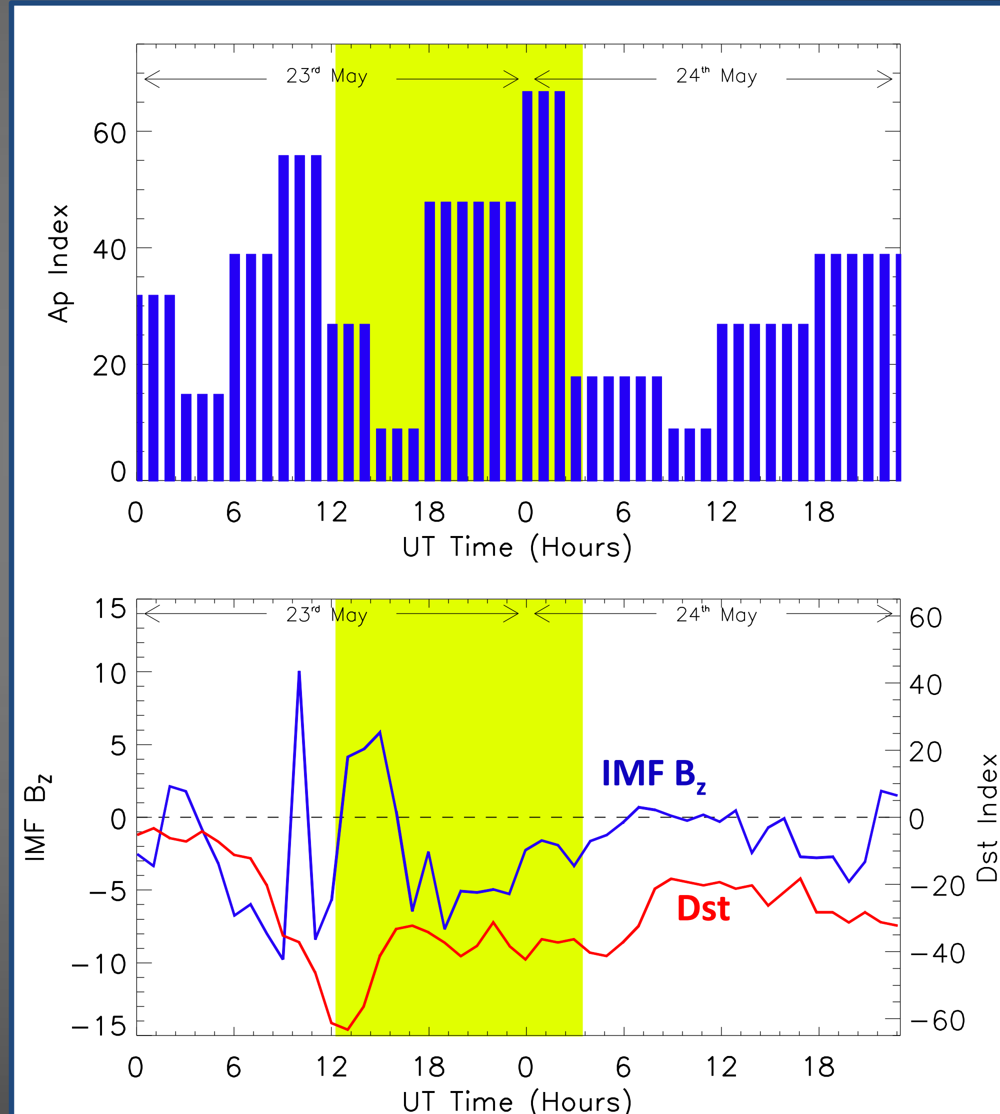
NIGHT A - April 20th 2007, Quiet Conditions



Results

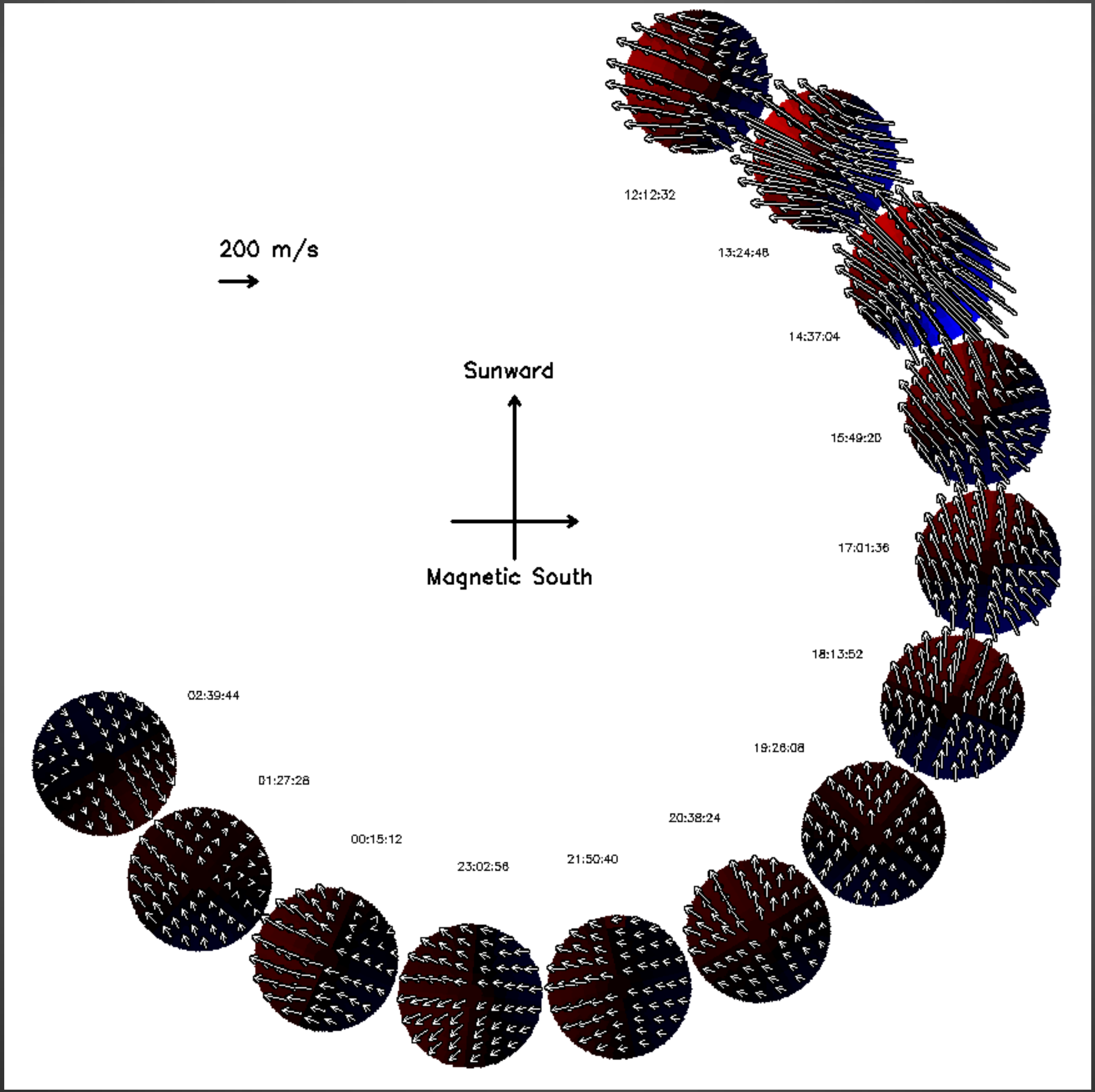
NIGHT B - May 23rd 2007, Active Conditions





Results

NIGHT B - May 23rd 2007, Active Conditions



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Results

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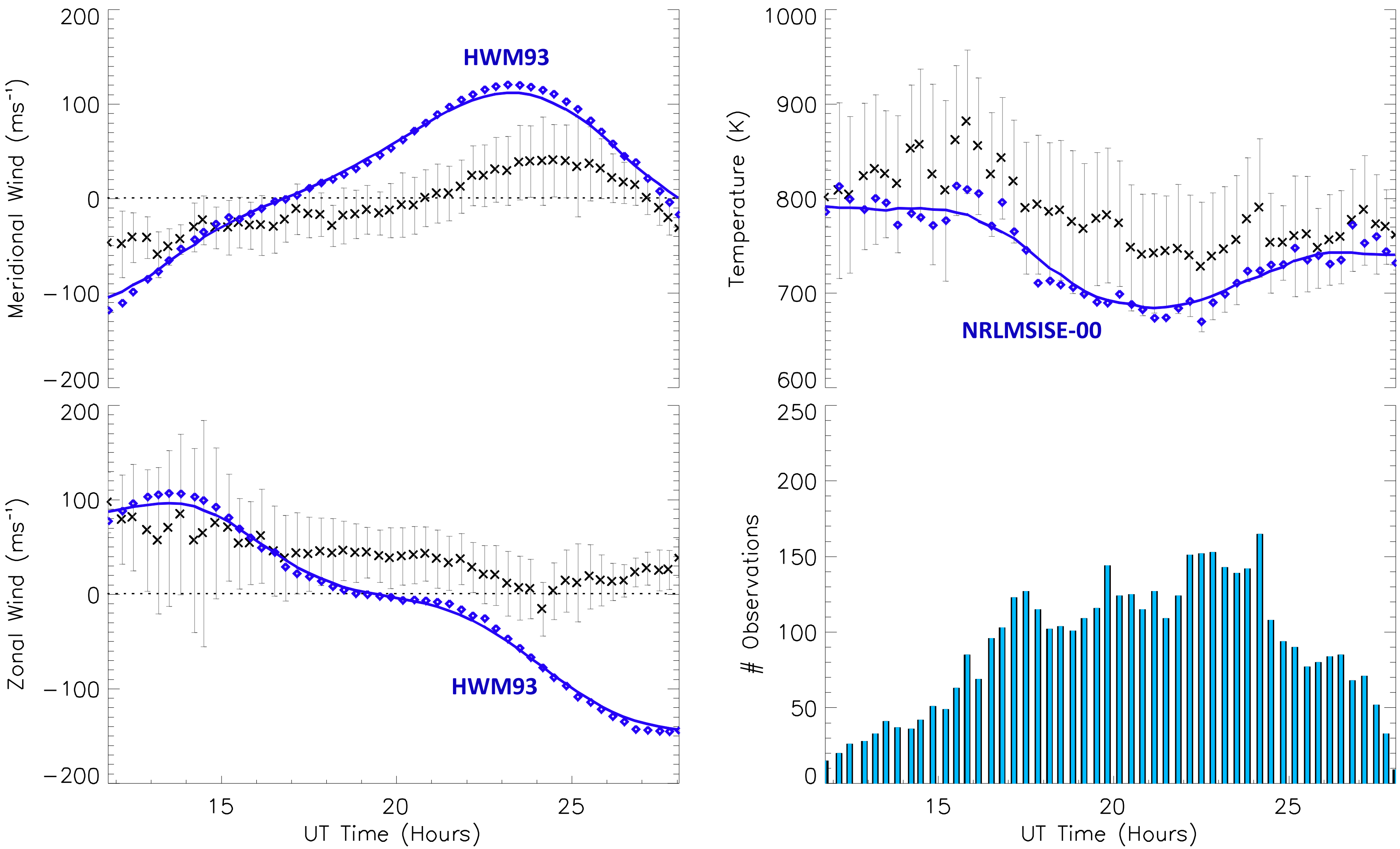
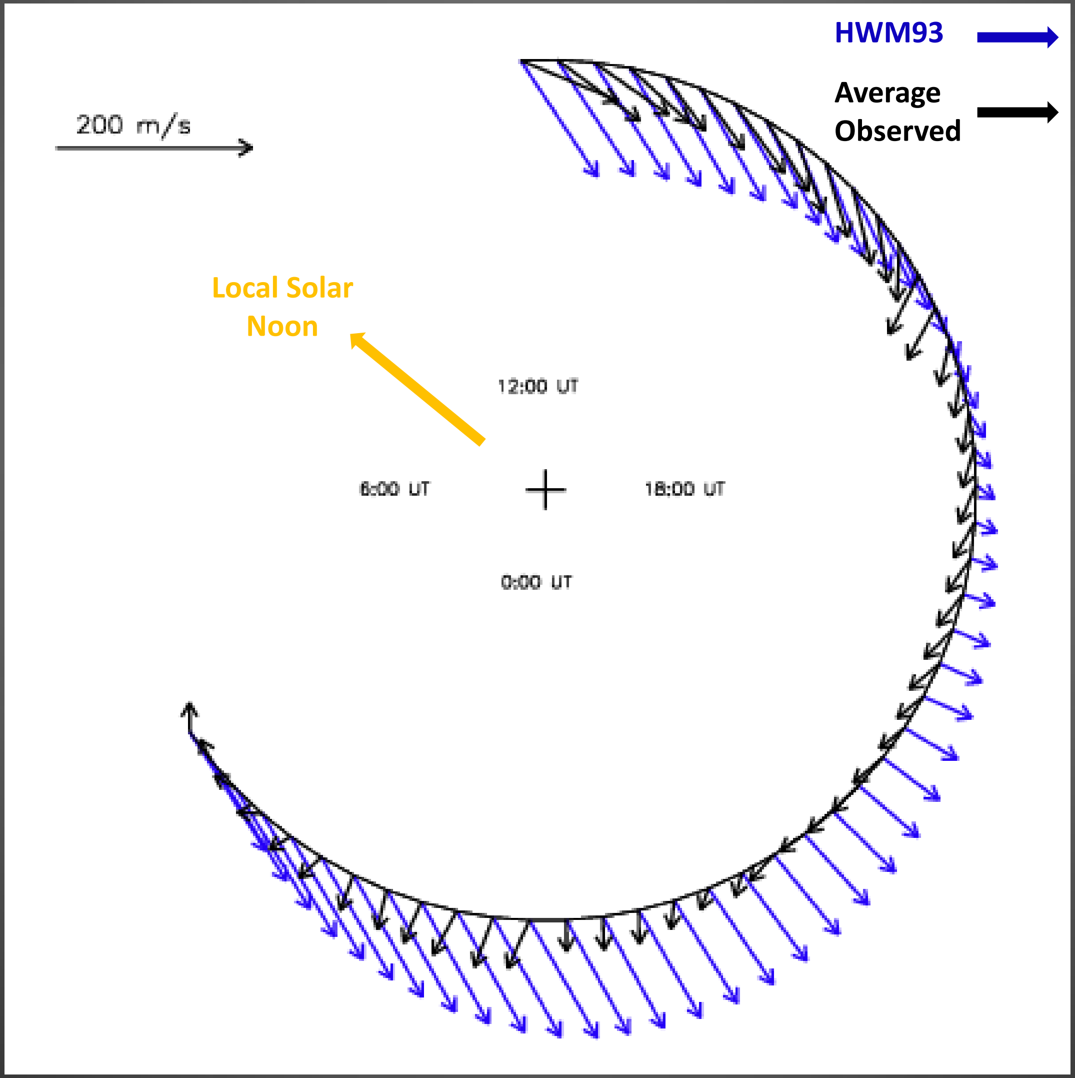
Climatological Analysis – All observations for which cloud ≤ ⅜



Results

Climatological Analysis – All observations for which cloud ≤ ⅜



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Future Work

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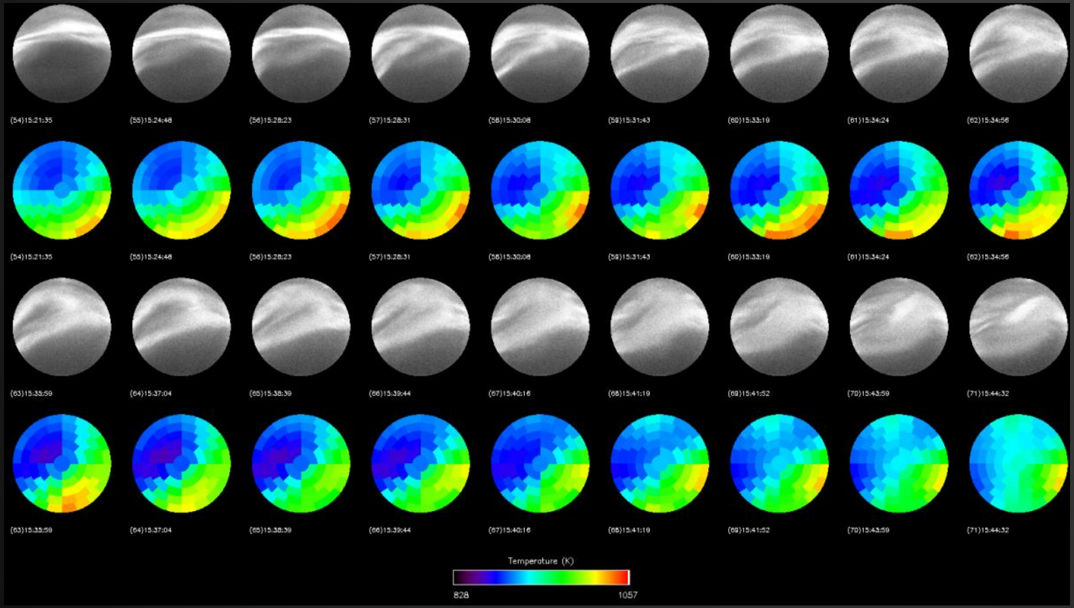
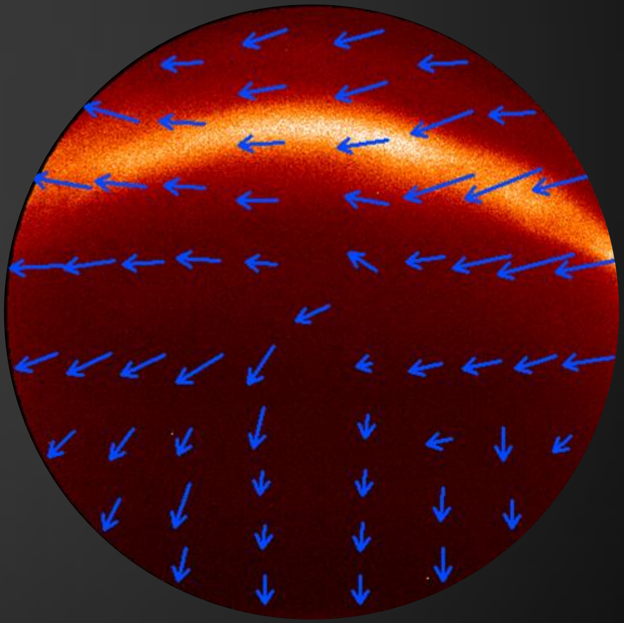
- Initial analysis has focused on large-scale daily and climatological variations.
- An imaging instrument such as this is ideally suited to the observation of small-scale structure.
- Examples are shown below: temperature variations in the vicinity of auroral structures, and vorticity and divergence in the wind field.
- As well as investigating this small-scale structure, opportunities exist for common-volume campaigns with a Fabry-Perot spectrometer located at Davis station, as well as studies at lower thermospheric (E-Region) heights using the 557.7 nm green line of atomic oxygen.





Left: Small scale temperature variations caused by height-varying particle precipitation.
Right: Vorticity and divergence in the wind field.

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