First Results from Two New Fabry-Perot Instruments for Mapping Thermospheric Winds Above Antarctica

PI:	Mark Conde	GI/UAF
Co-Authors:	Bill Bristow	GI/UAF
	Don Hampton	GI/UAF
	Mike Kosch	SANSA (South Africa)
	Theo Davies	La Trobe U. (Australia)
	Mamoru Ishii	NICT (Japan)
	Larry Paxton	JHU/APL

Overview

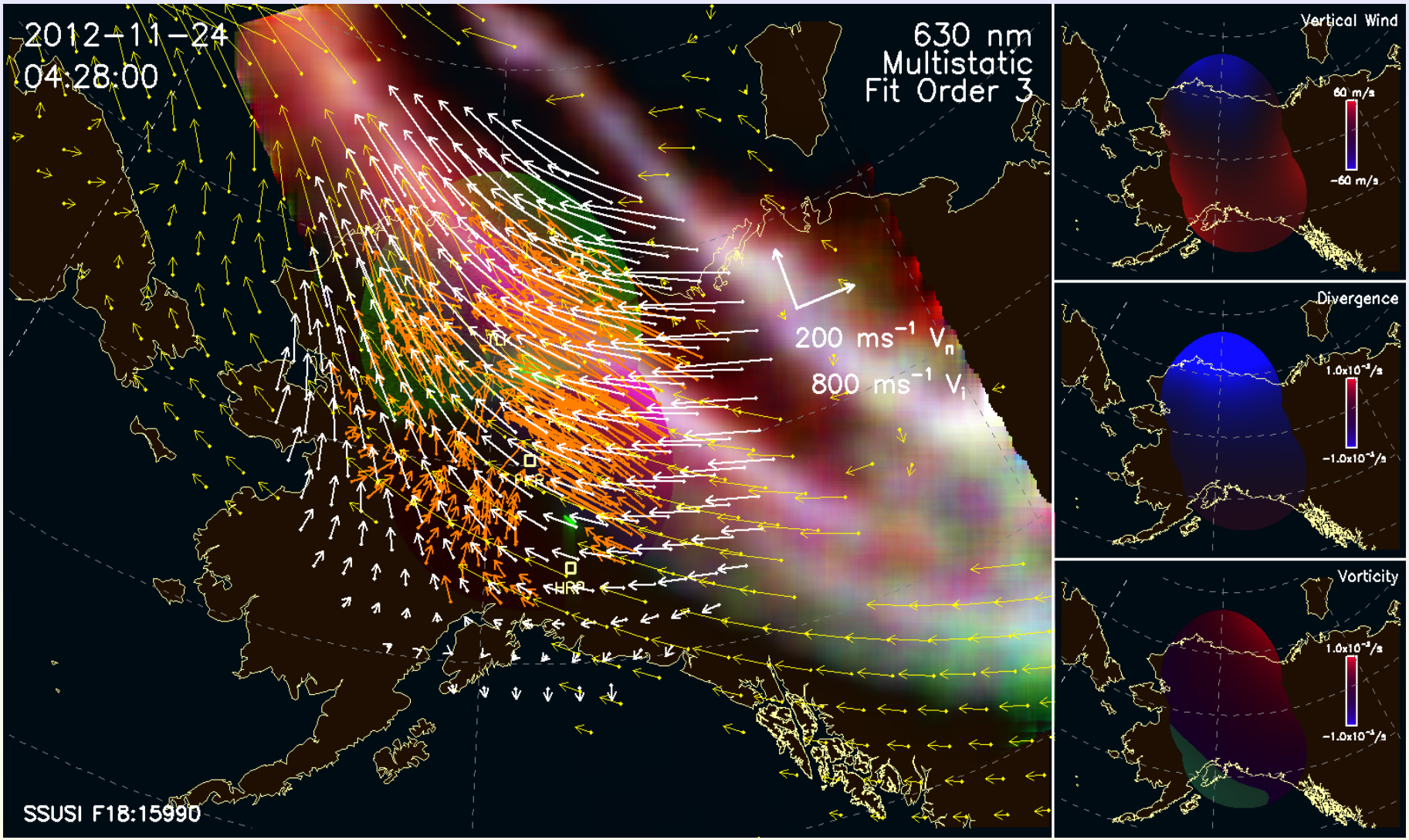
The objective of this talk is to introduce the CEDAR-GEM community to two new instruments recently installed in Antarctica for measuring thermospheric winds and temperatures.

McMurdo – Arrival Heights

South Pole – ARO Lab

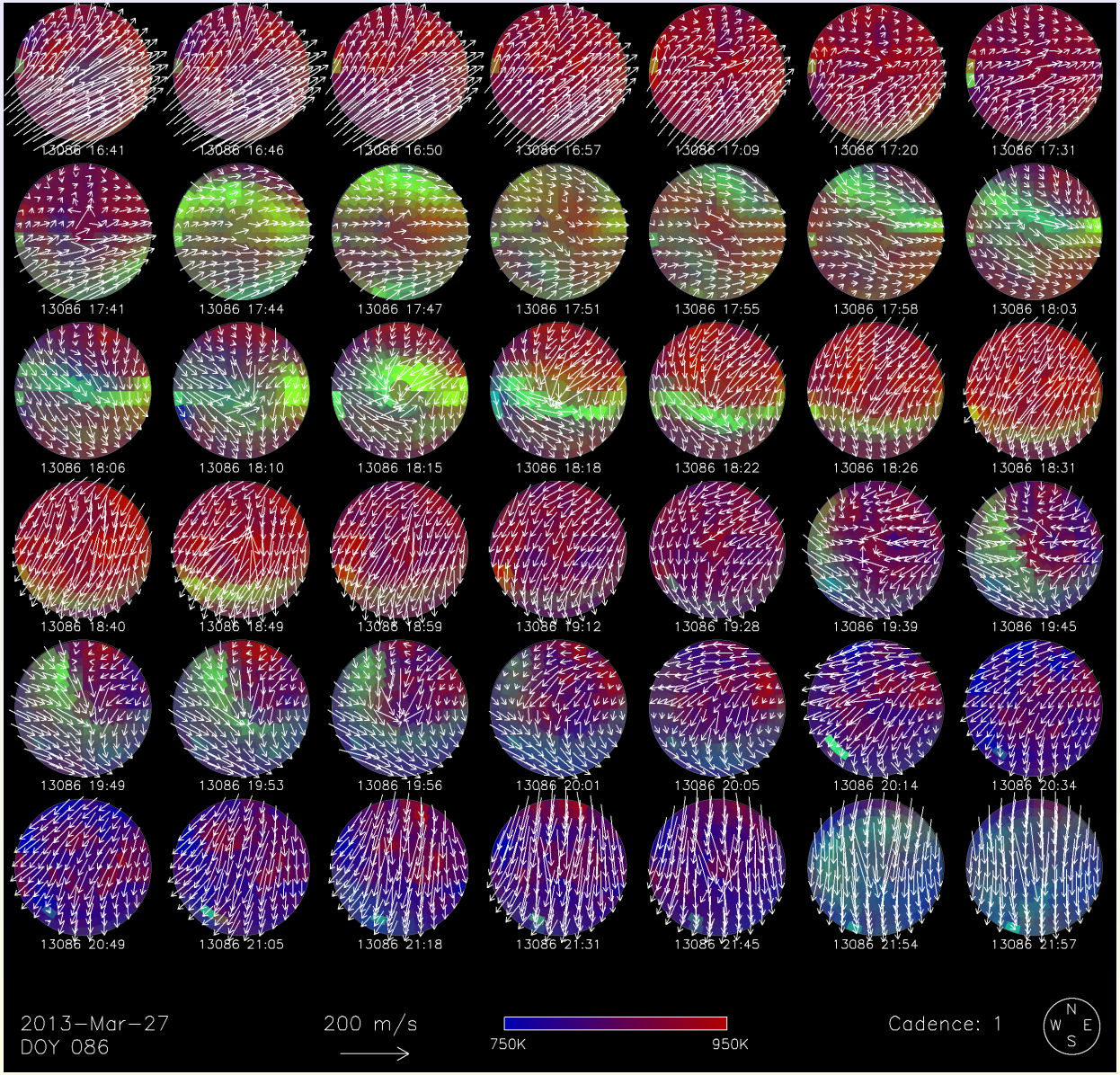
- The new instruments are *all-sky Fabry-Perot spectrometers*, designed to measure thermospheric wind, temperature, and optical emission brightness.
- Two filters are available, allowing us to view airglow and aurora at $\lambda 630\,\mathrm{nm}$ and $\lambda 558\,\mathrm{nm}$,which originate from around $240\,\mathrm{km}$ and $100\,\mathrm{km}$ –$140\,\mathrm{km}$ respectively.

Motivation – Understanding Thermospheric Weather



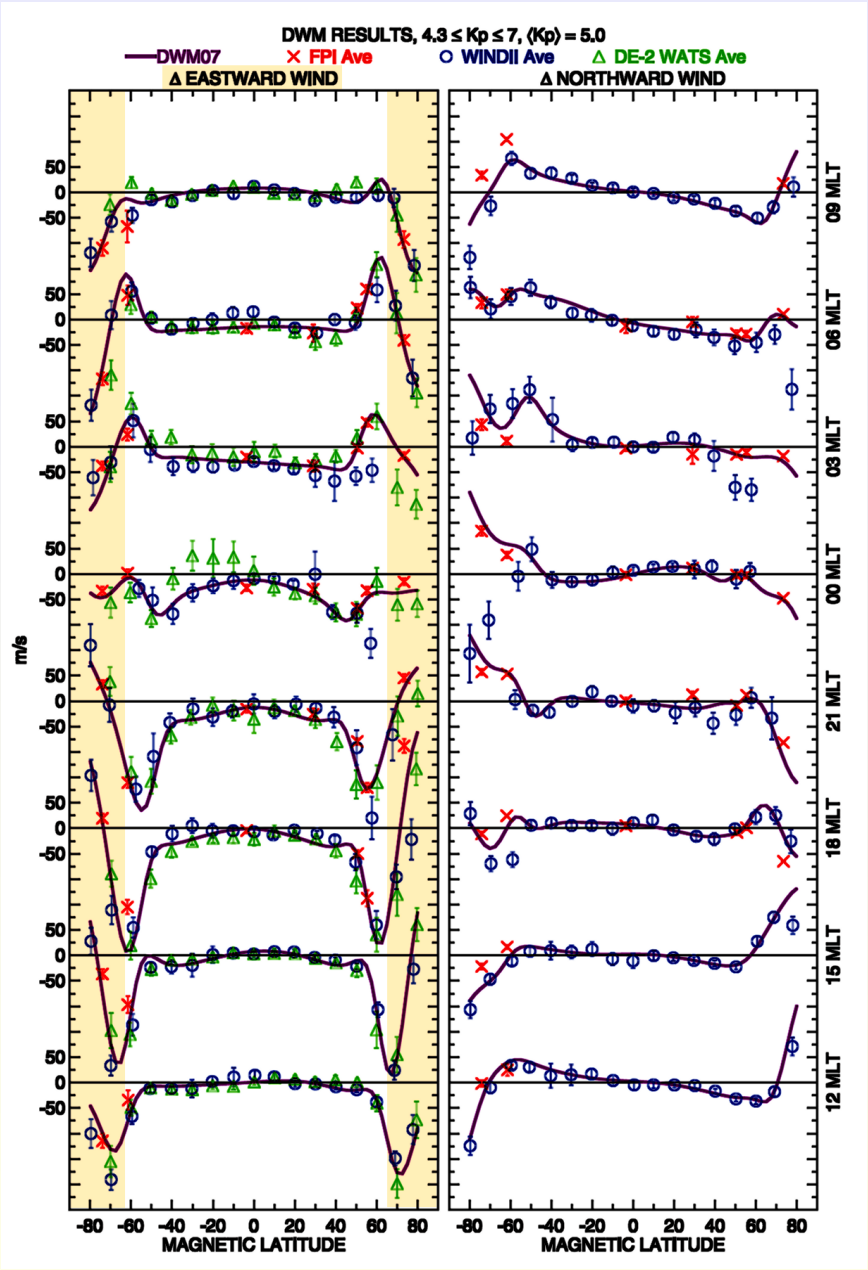
- Observations from Alaska over many years indicate that F-region thermospheric winds are strongly coupled to the ion velocity field and to auroral precipitation.
- Complex "weather" occurs in response to auroral and ionospheric forcing.

Winds at Mawson Antarctica



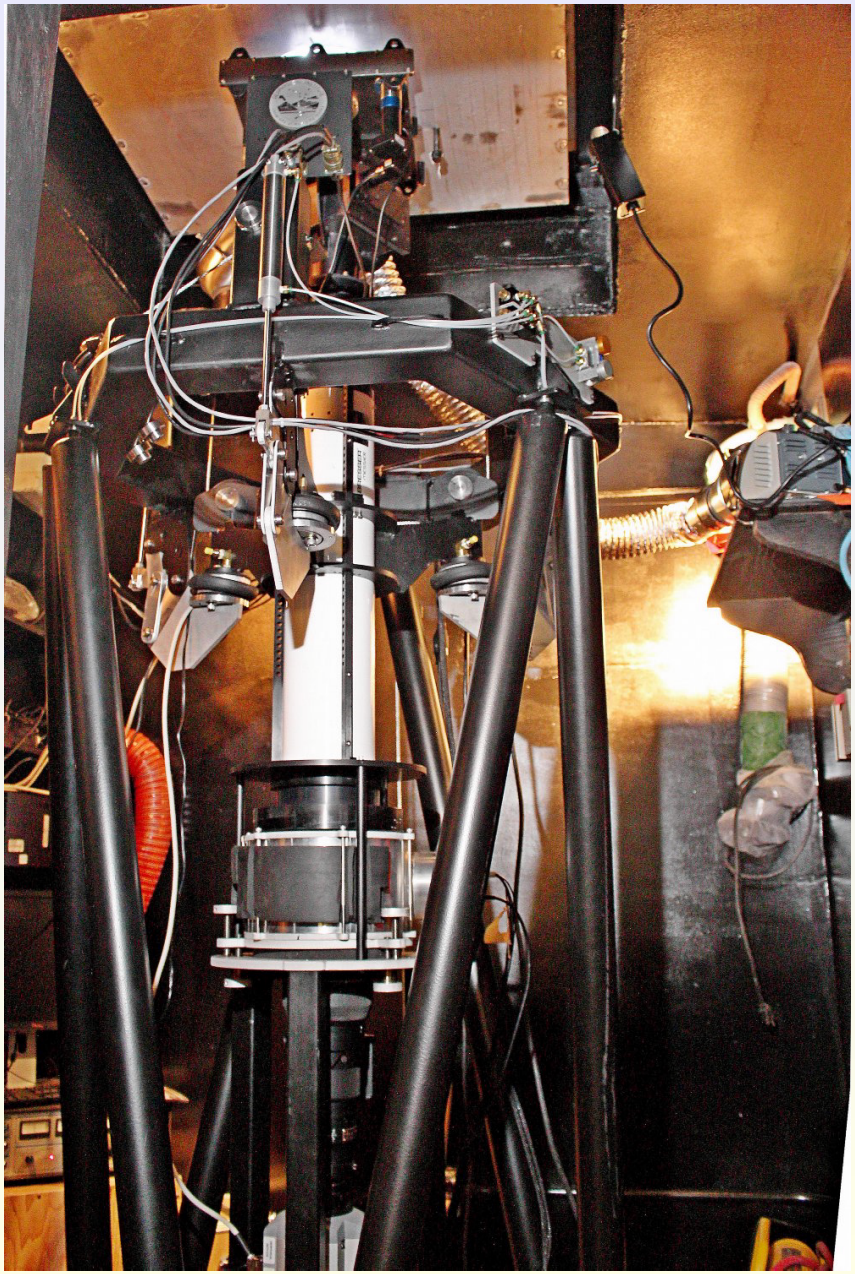
- The instrument now at South Pole was previously deployed at Mawson, Antarctica, which is also an auroral oval location.
- Mawson data show similar (although not identical) weather responses to those observed in Alaska.
- The main question driving our deployments to McMurdo and South Pole is *"how does thermospheric weather behave at higher latitudes?"* (i.e. near the polar cap/auroral oval boundary.)

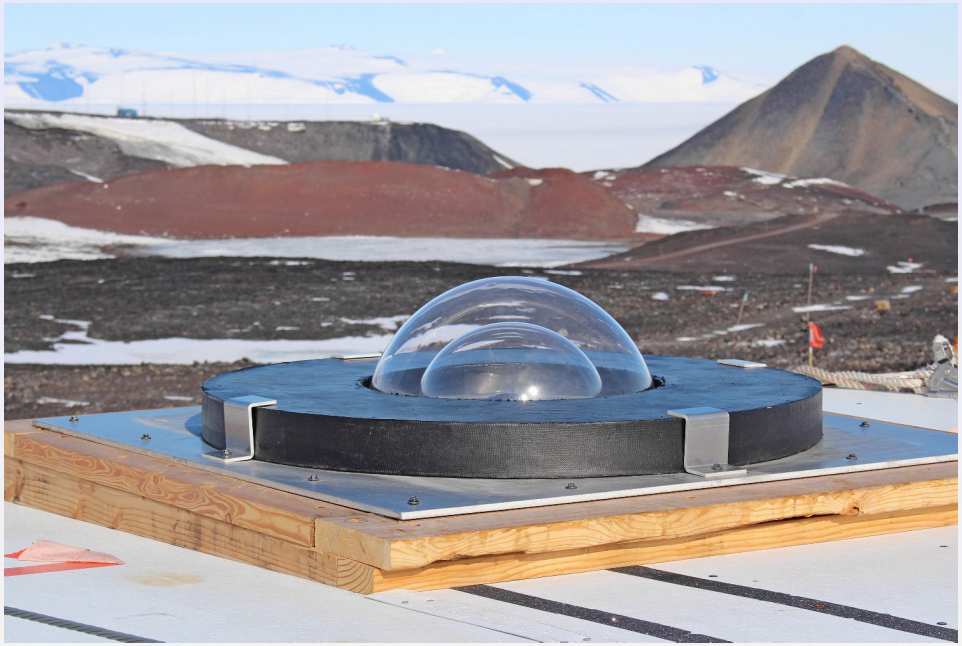
Motivation – Our Experimental Hypothesis



- *Emmert et al.* [2008] studied global thermospheric winds using data from DE-2, UARS-WINDII, and seven ground-based narrow-field Fabry-Perot interferometers.
- Results showed very strong gradients in the "disturbance" wind component near the polar cap/auroral oval boundary.
- These results led to the fundamental hypothesis motivating this study, i.e. that *"the thermosphere's most dynamic weather region lies at and immediately poleward of the boundary between the auroral oval and the polar cap."*
- The primary goal of the study is to test this hypothesis.

The Instrument at McMurdo

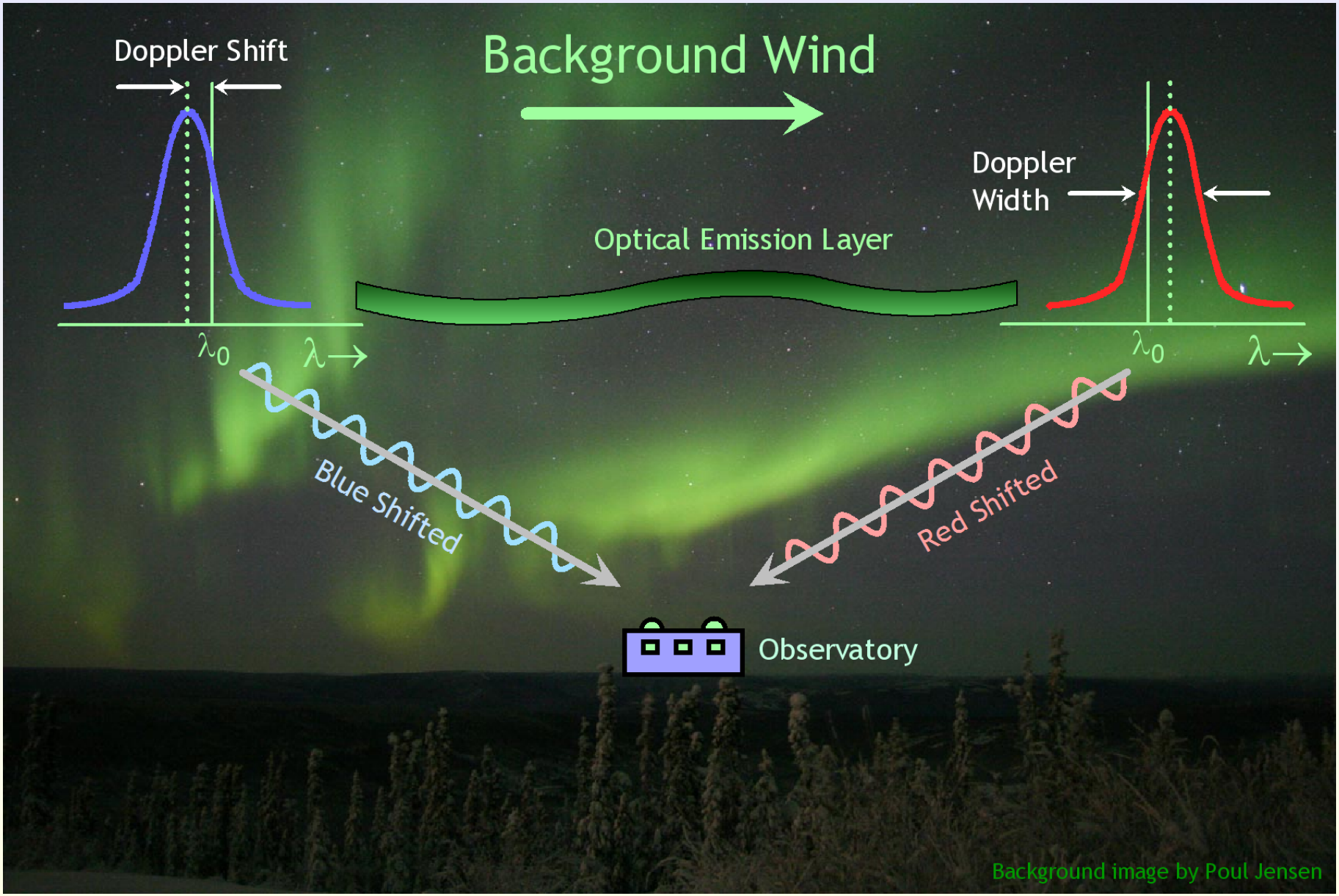




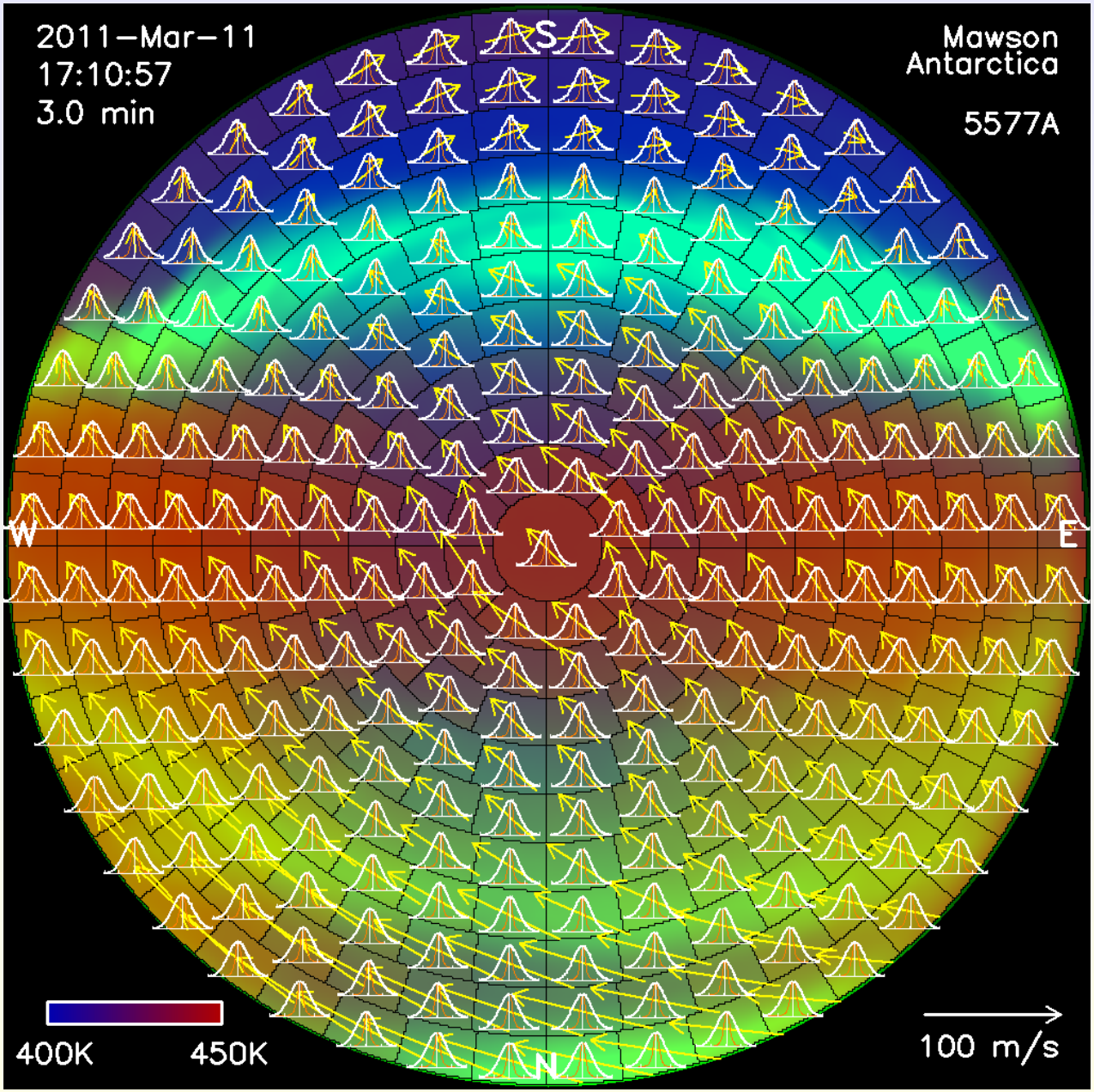
- The figure on the left shows the new McMurdo instrument installed inside the lab at Arrival Heights.
- The figure above shows our double-dome assembly installed on the roof of the lab. This super insulated dome system is especially important at South Pole, where ambient temperatures can drop to $-100\,^{\circ}\mathrm{F}$ ($\simeq -75\,^{\circ}\mathrm{C}$.)

The Instrument at South Pole

Fabry-Perot Wind Measurements

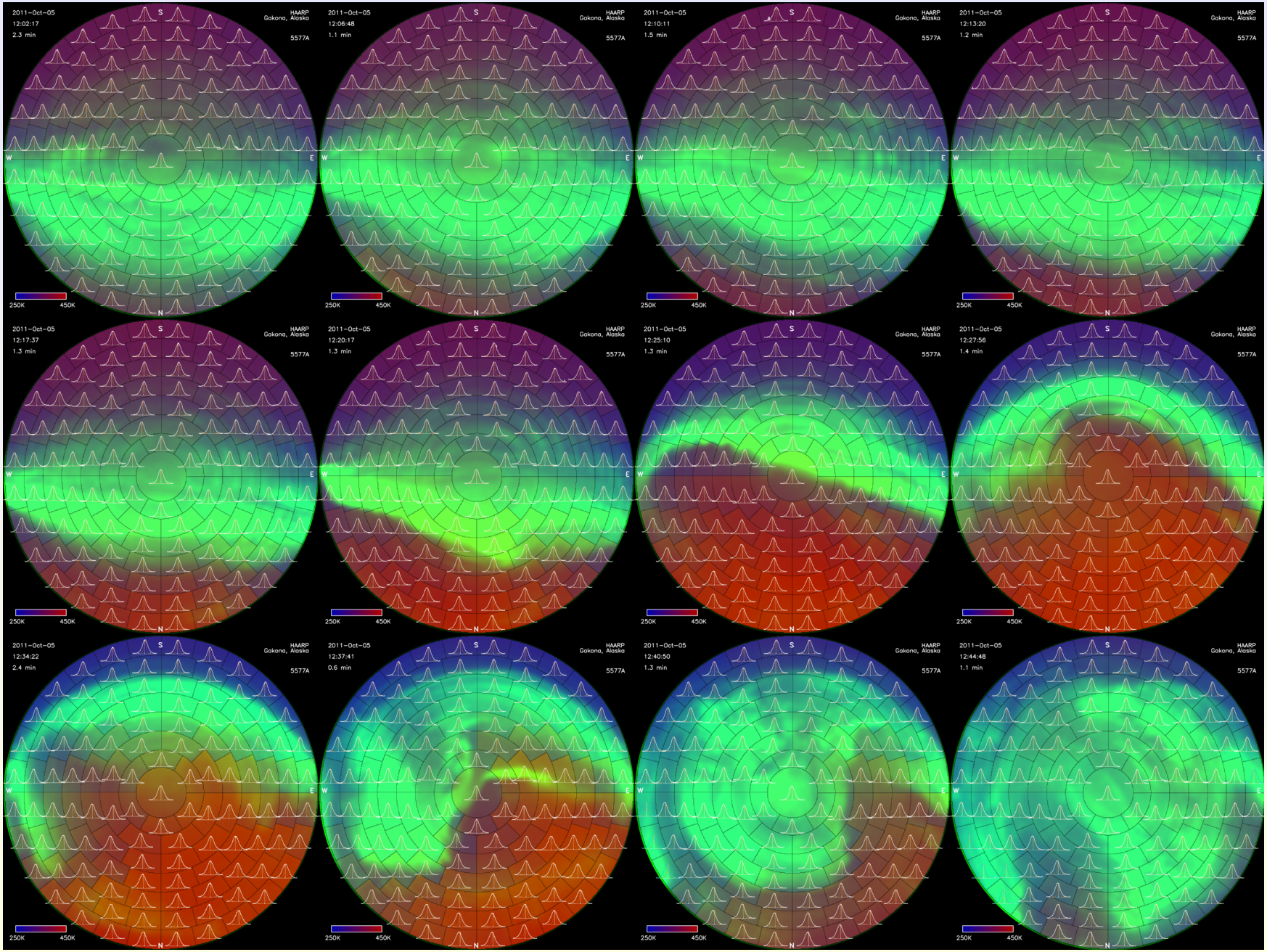


Fabry-Perot Wind Measurements

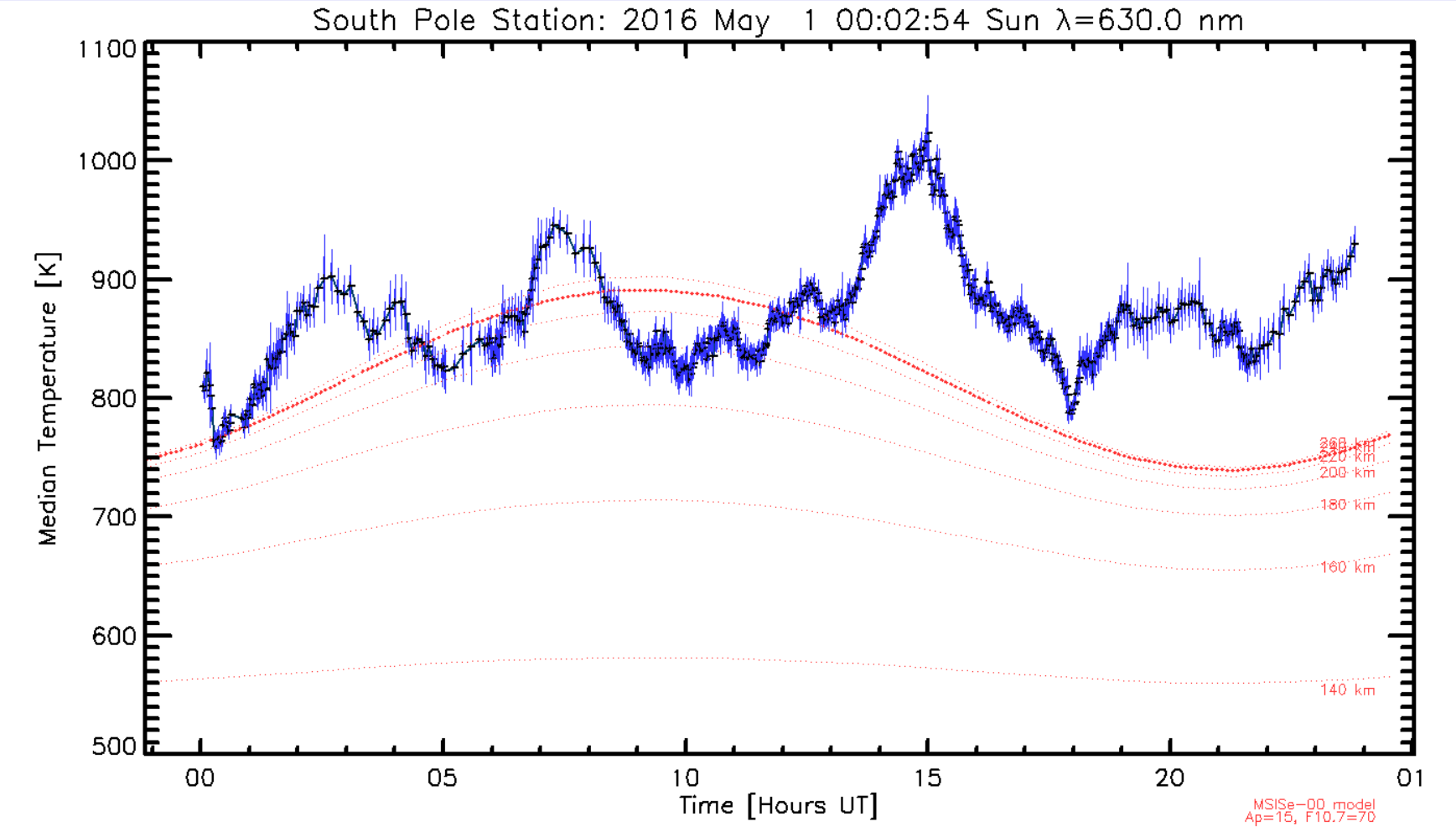


- The SDI records monochromatic images of the sky, modulated by a Fabry-Perot interference pattern. Scanning the etalon gap produces spectra spanning $\sim 10\,\mathrm{pm}$ in wavelength.
- This image shows $\lambda 558\,\mathrm{nm}$ spectra from 261 "zones" across the sky.
- Green hues show $558\,\mathrm{nm}$ brightness, blue through red hues show Doppler temperature, and yellow arrows show the fitted horizontal wind field.

Doppler Imaging

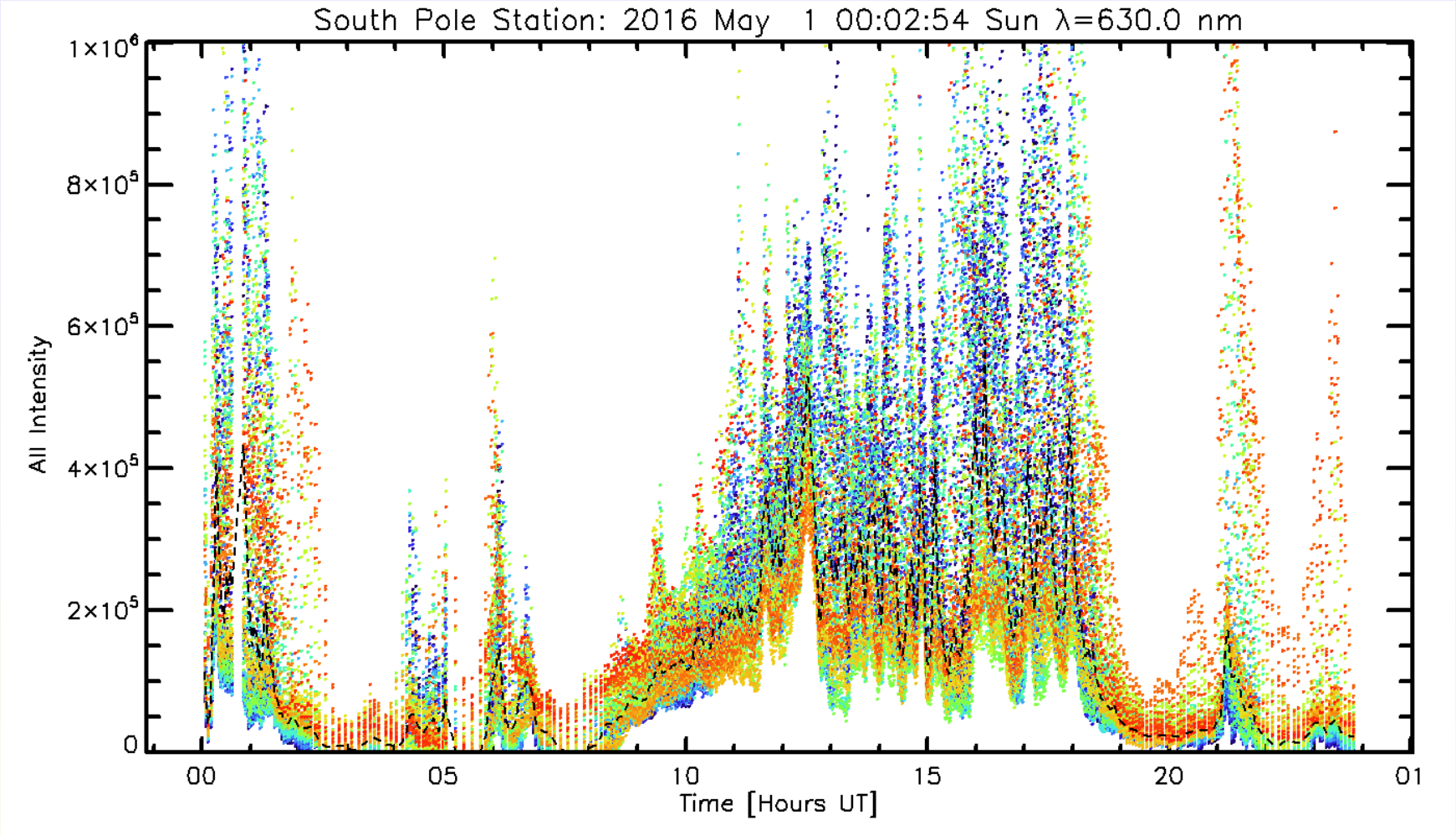


Basic Data – Temperature Time Series



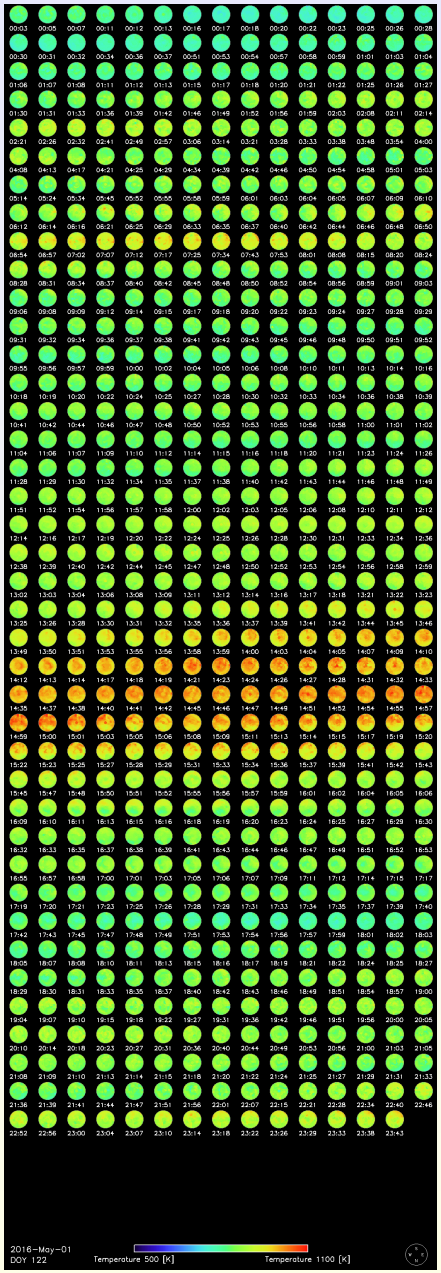
- Time series of F-region temperatures, calculated at each time from the median temperature across all sky viewing zones.

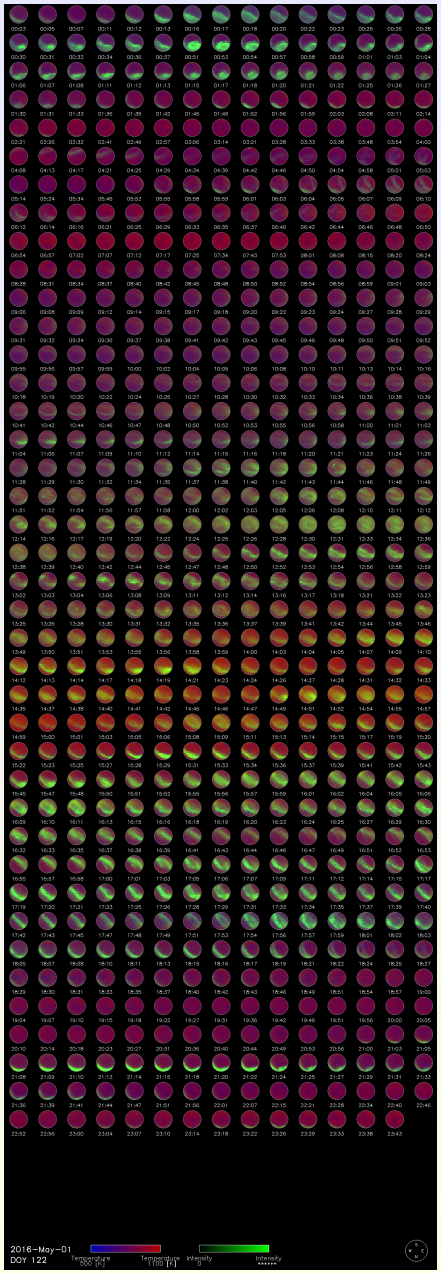
Basic Data – Emission Intensity Time Series



- Time series of emission intensity from each zone, in arbitrary units. Colors correspond to different viewing zones.

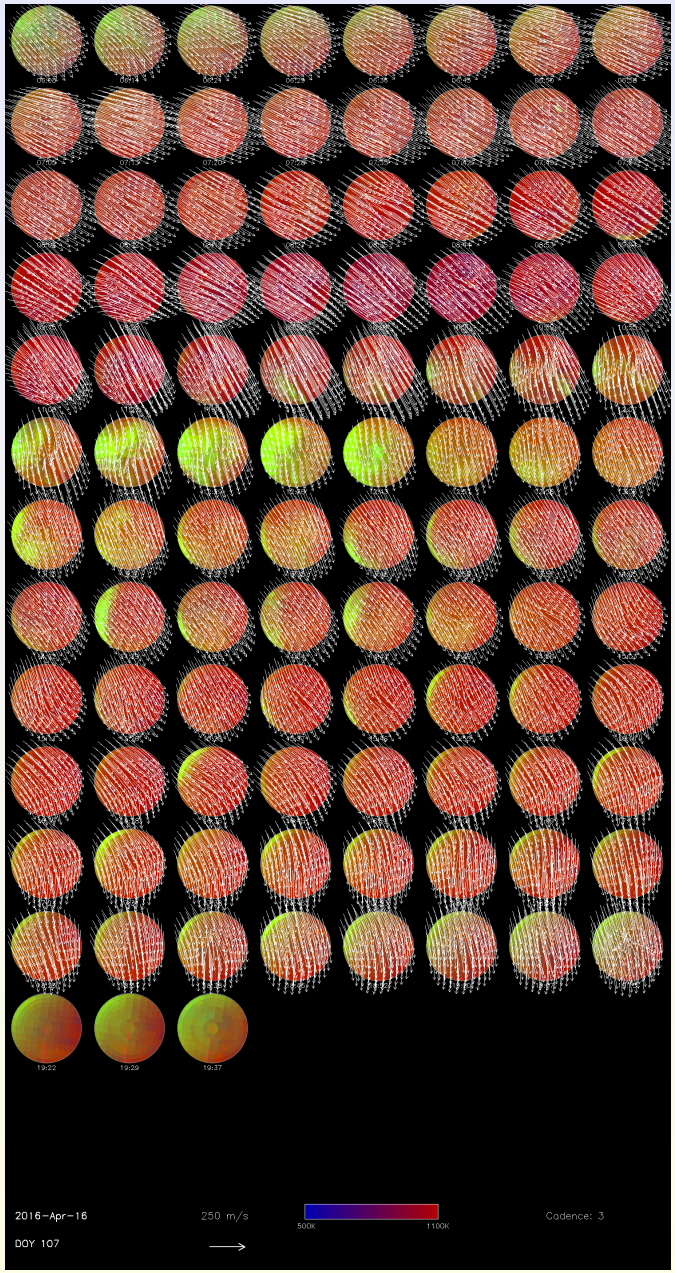
Basic Data – Skymaps of Scalar Spectral Fit Results

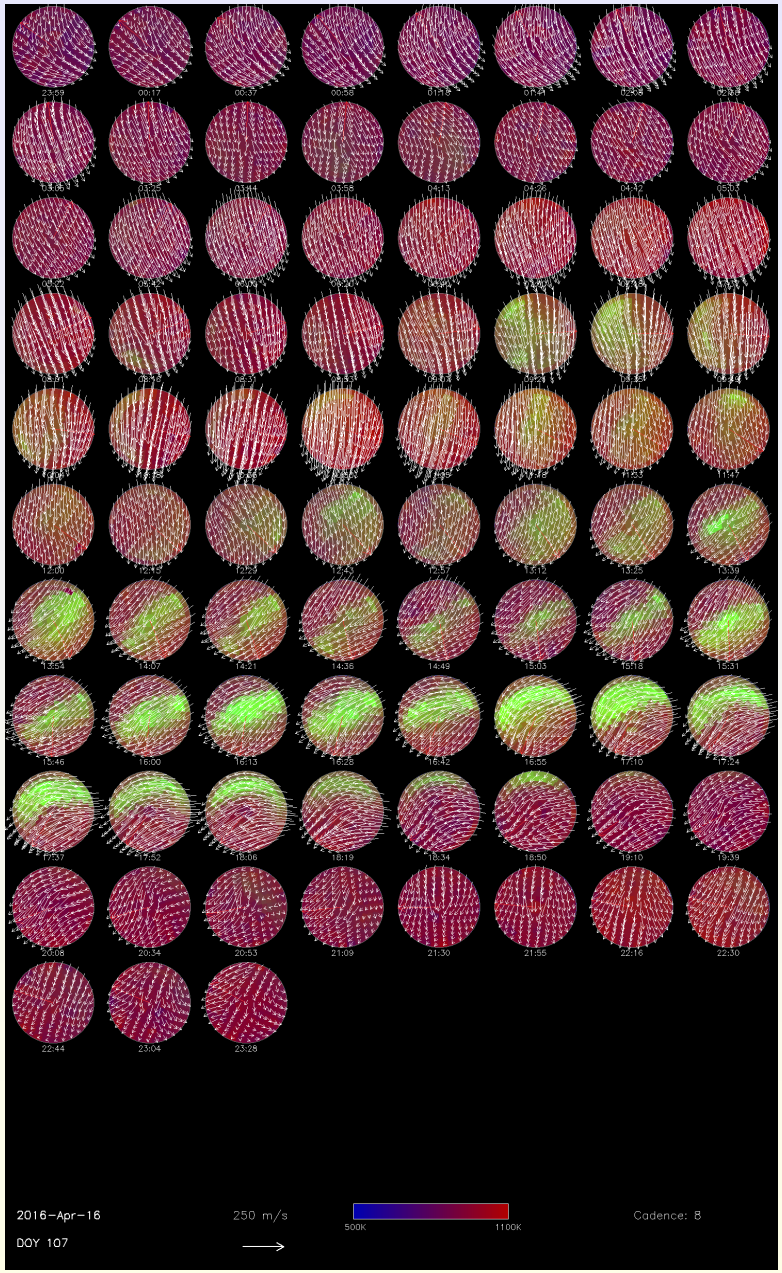




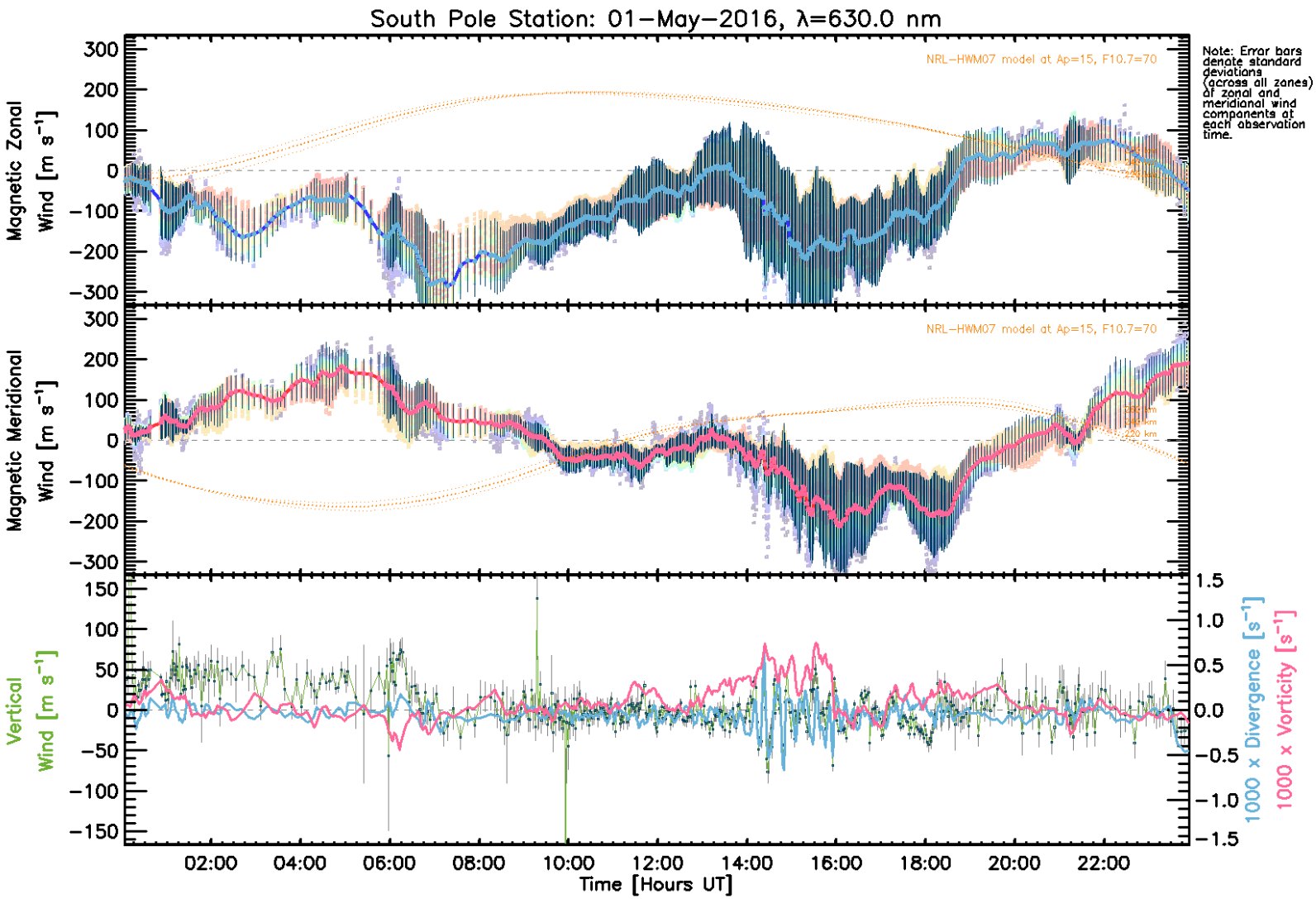
Analysis results for >69,000 spectra!

Basic Data – Skymaps of Fitted Vector Winds



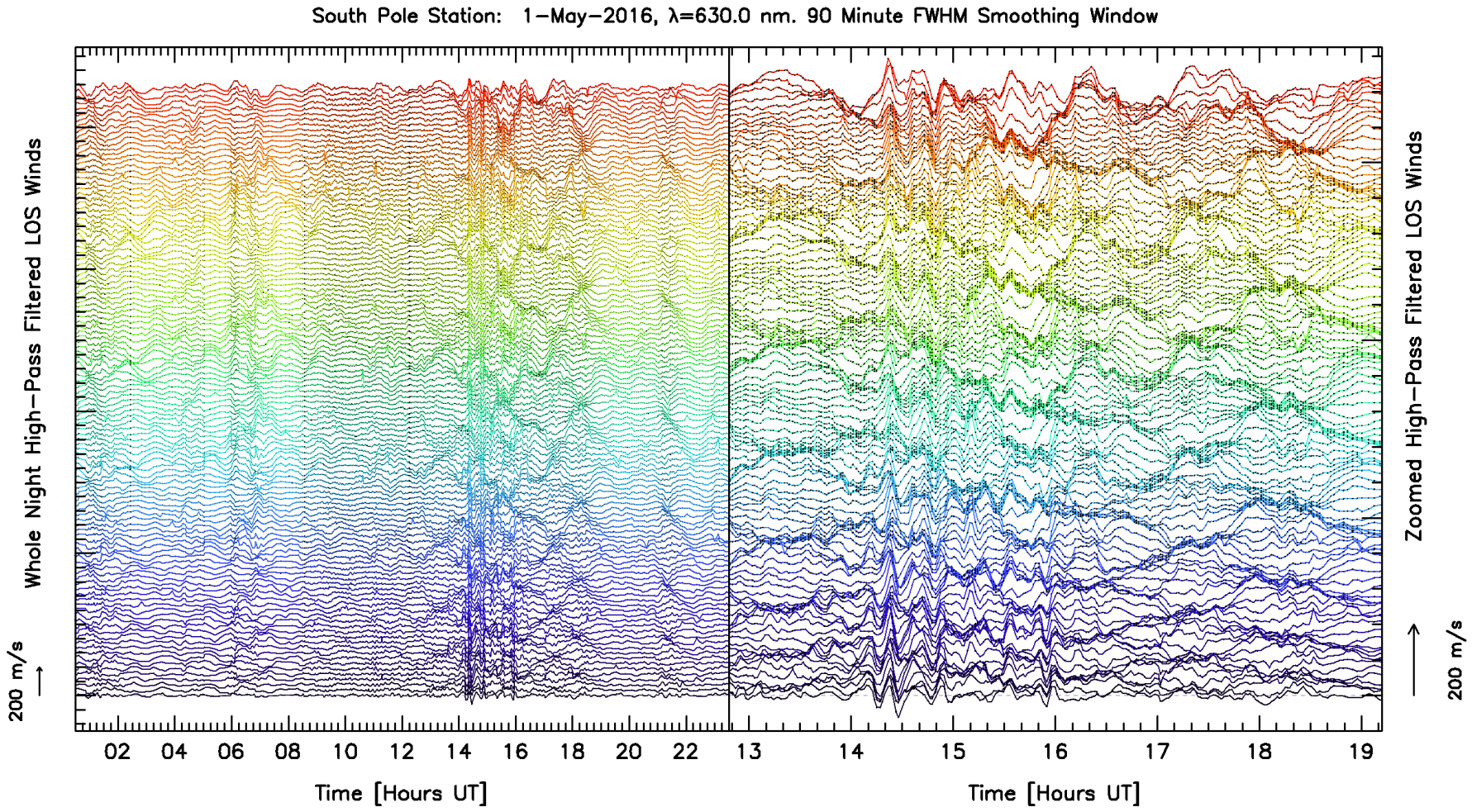


Basic Data – Wind Time Series



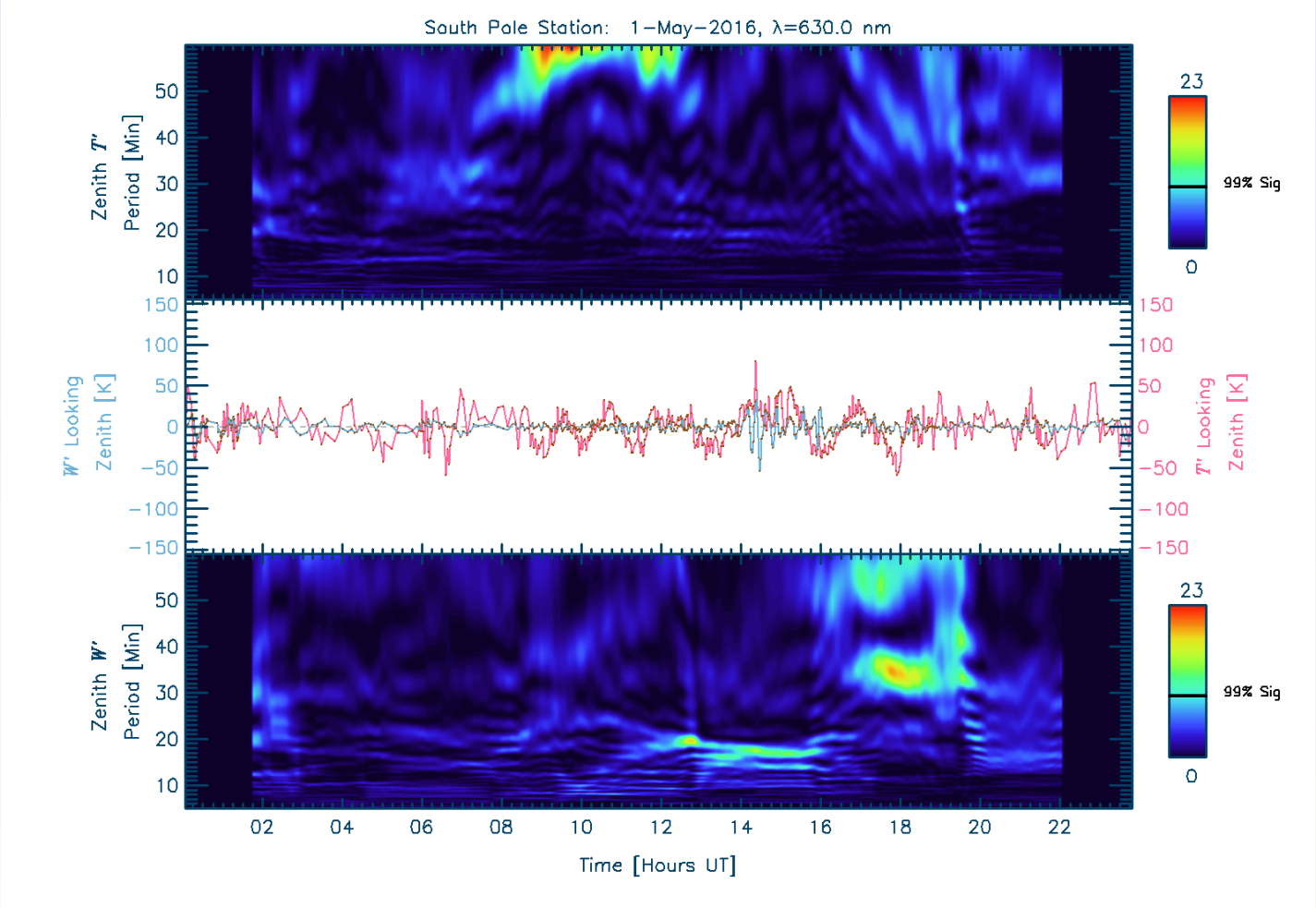
- F-region wind components measured at South Pole on 01-May-2016.
- Note the burst of wave-like activity between roughly 14 to 16 UT.

High-Pass Filtered LOS Winds From South Pole on 01-May-2016



- These panels show high-pass filtered time series of line-of-sight wind from each viewing zone. Again, note the prominent wave event.
- Left panel is for the whole night, right panel is a "zoom in" on the wave event.

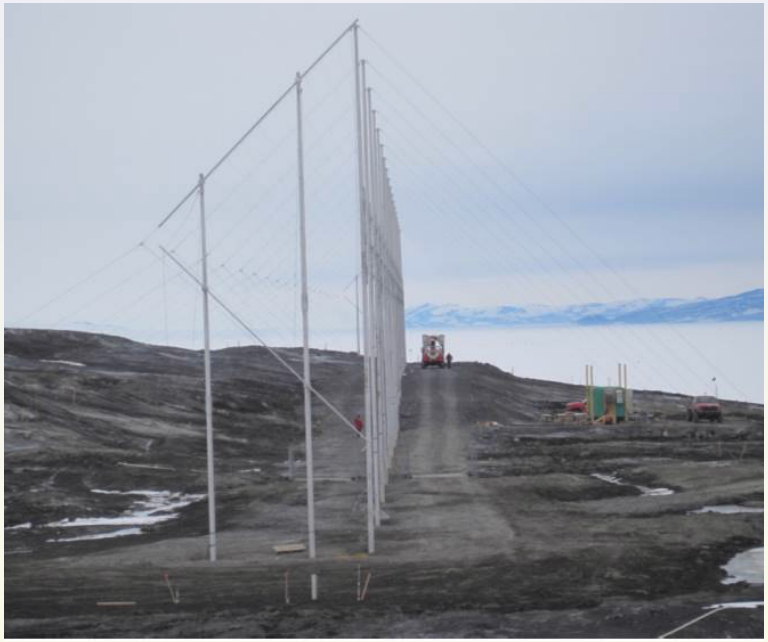
Wave Event Periodograms



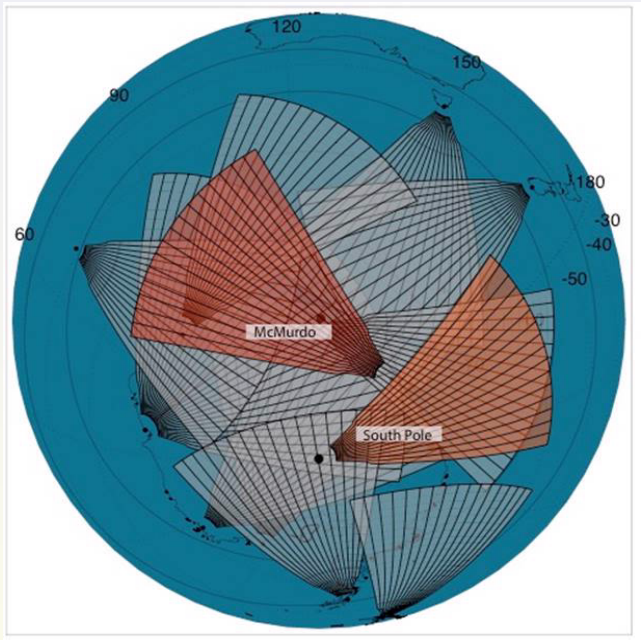
- Periodograms of vertical wind show significant wave power at 17 min period between roughly 14-16 UT, followed by longer period (~ 35 min) waves between 17-20 UT.
- Surprisingly, there were no corresponding temperature oscillations.

SuperDARN Radar Data

SuperDARN Antenna Array at South Pole



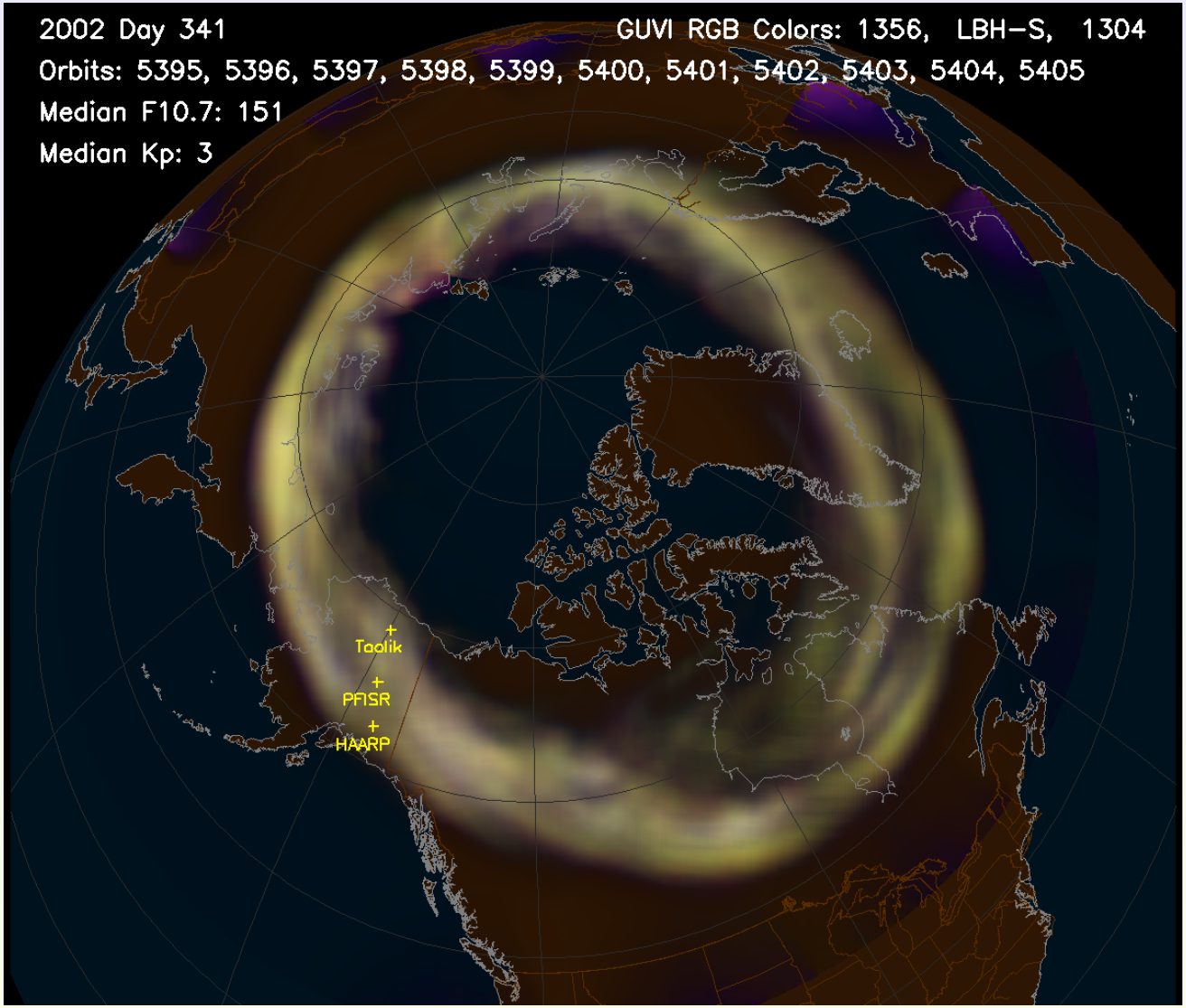
SuperDARN Antenna Array at McMurdo



SuperDARN Geographic Coverage

- SuperDARN radars are used here to provide ion convection velocities for comparison with measured neutral winds.

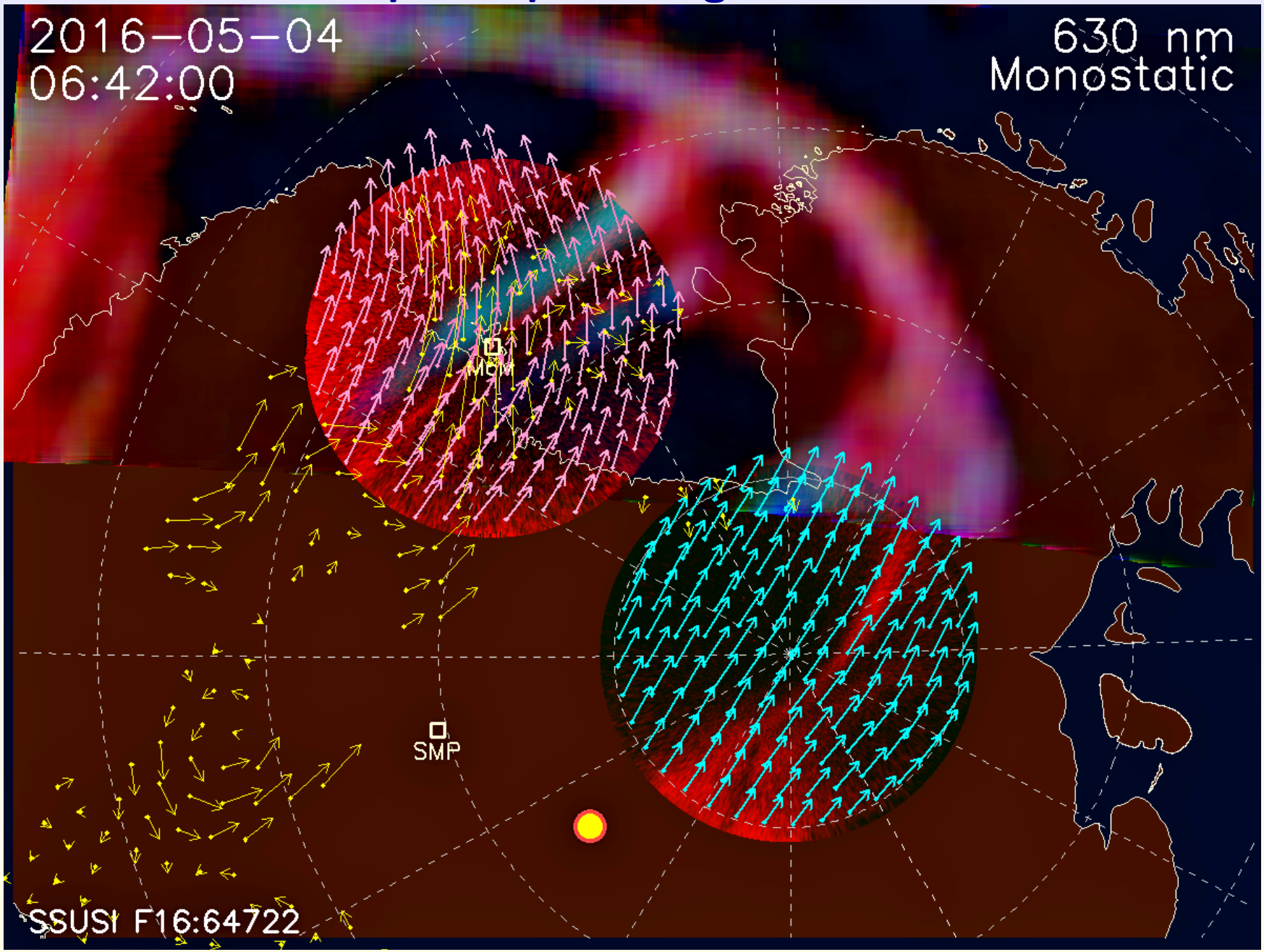
Satellite Ultraviolet Images of the Aurora Using SSUSI



Montage of GUVI images showing the full auroral oval. SSUSI instruments are very similar to GUVI.

- Data from DMSP/SSUSI are used here to provide auroral images with a wider geographic context.
- The SSUSI sensor contains a line scanning imaging spectrograph covering the far ultraviolet spectrum.
- Images here use the 1304, 1356, and LBH-S color channels.

Example Map of Merged Data Sets

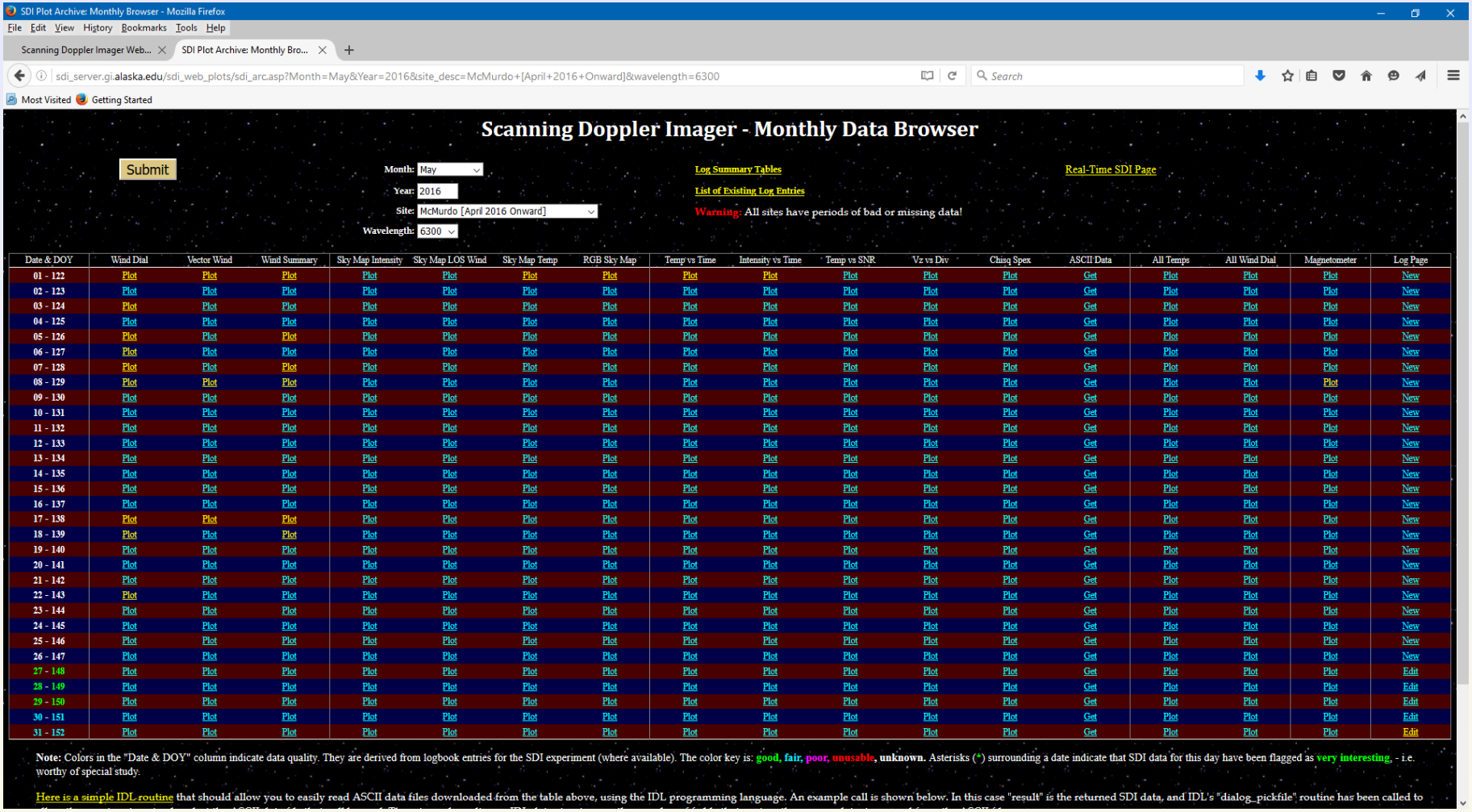


Combined Data for 01-May2016

Combined Data for 03-May2016

Combined Data for 04-May2016

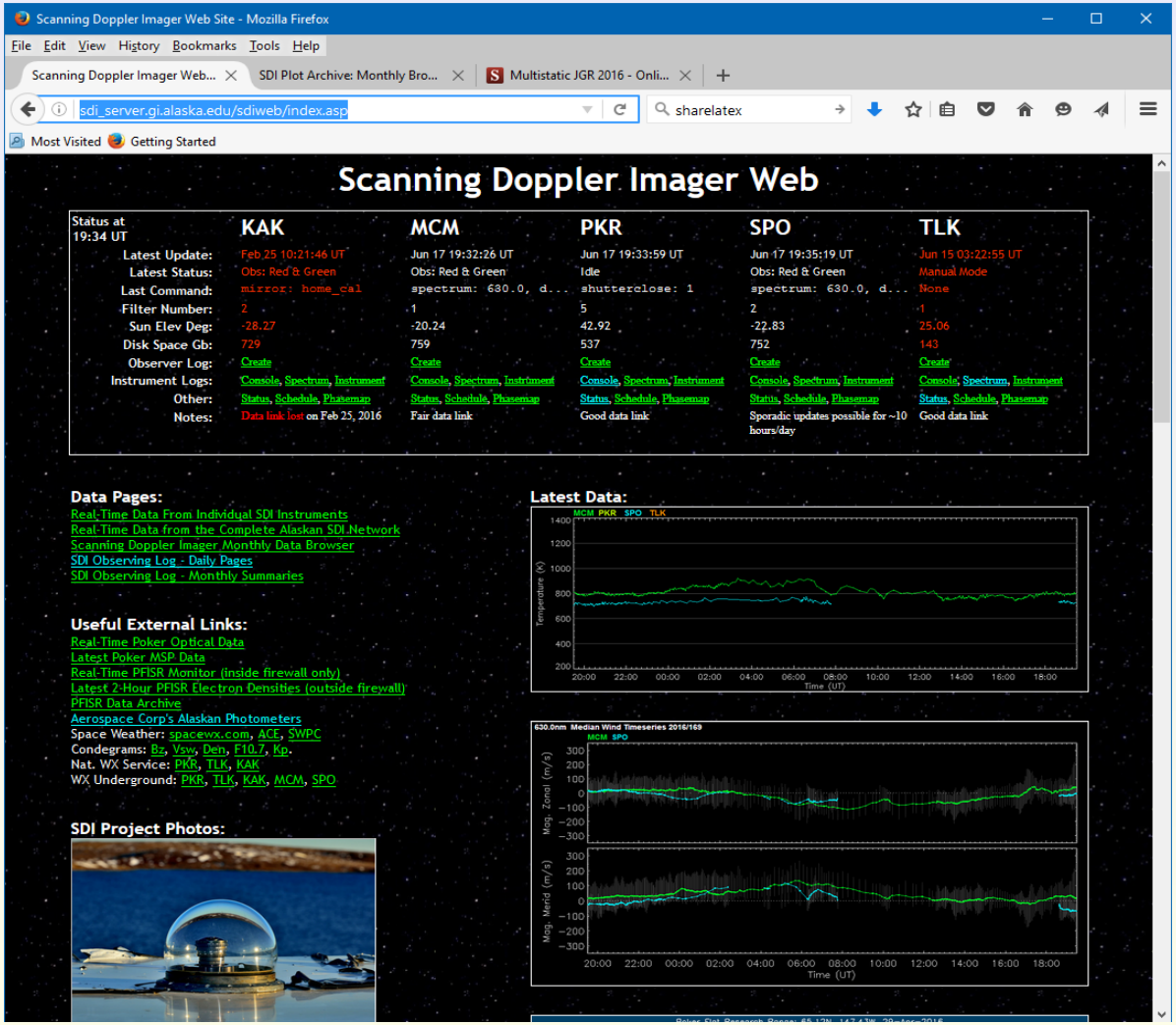
Monthly Data Browser



- Data are available online, both as pre-made plots and in numeric (ascii) form. Access data from http://sdi_server.gi.alaska.edu/sdiweb/index.asp.
- Please contact the PI Dr. Conde for advice on appropriate use.

Conclusions

Two new all-sky Fabry-Perot instruments are now running in Antarctica.



- *Initial data do not show strong shears and large-scale structure* as we had hypothesized based on the Emmert et al. [2008] study.
- Rather, observations so far typically show antisunward winds, but with *more small-scale short-period perturbations* than seen in Alaska. Wave activity appears common.
- More data will be needed to determine whether this description is true in general.