Thermospheric Studies in Antarctica Using Fabry–Perot Spectrometers at Mawson and Davis Stations

C. Anderson [1], M. Conde[2], P. Dyson[1], T. Davies[1], M. J. Kosch[3] [1 La Trobe University, Melbourne, Australia; 2 University of Alaska, Fairbanks, Alaska, USA; 3 Lancaster University, Lancaster, UK]

Abstract

Fabry-Perot spectrometers are used to measure line-of-sight winds and temperatures at thermospheric heights (above approximately 90 km). La Trobe University recently installed a new all-sky imaging Fabry-Perot spectrometer at Mawson Station (67°36' S, 62°52' E), Antarctica. This new instrument is capable of recording spectra from many tens of locations across the sky simultaneously, making it possible to observe small-scale structures in the wind and temperature fields directly.

By combining results from a second spectrometer installed by La Trobe and already operating at Davis station (68°34' S, 77°57' E), opportunities now exist for common-volume campaigns between the two instruments. Here we present results from the first season of operation of the Mawson spectrometer, and explore some possibilities for common-volume campaigns with the Davis spectrometer.

Instrumentation

The Mawson spectrometer is an all-sky, scanning, imaging instrument, installed during the 2006/2007 summer, and operated since March 2007. It records spectra from multiple locations across the sky simultaneously, by dividing up the field-of-view (in software) into a number of 'zones', and recording a single spectrum in each zone.

- 75° half-angle field-of-view
- 150 mm aperture etalon
- 300 mm F/2 Nikon fringe-forming lens
- Thermoelectrically cooled, Andor Ixon EMCCD imager

The Davis spectrometer is a narrow-field, non-scanned, imaging instrument. It records an interference fringe image from a small region of the sky using a steerable periscope. This two-dimensional fringe image is then reduced to a wavelength spectrum through suitable analysis.

- 3° half-angle field-of-view, steerable to any part of the sky
- 130 mm working aperture etalon
- Gen III GaAs image intensifier
- Pulnix CCD imager

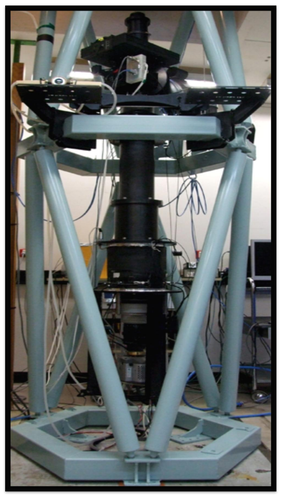

Figure 1. The Mawson spectrometer.

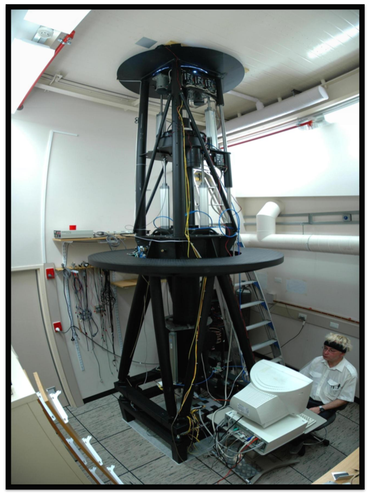

Figure 2. The Davis spectrometer.

Results from Mawson

The Mawson instrument records spectra from subdivisions of its field-of-view called 'zones'. Doppler-shifts are calculated for each zone, and a horizontal vector wind field is fitted to the spatial distribution of these Doppler-shifts. As spectra are recorded, the instrument is able to simultaneously build up its own all-sky image, at the same wavelength as the sky spectra and over an identical field-of-view (see Figure 3).

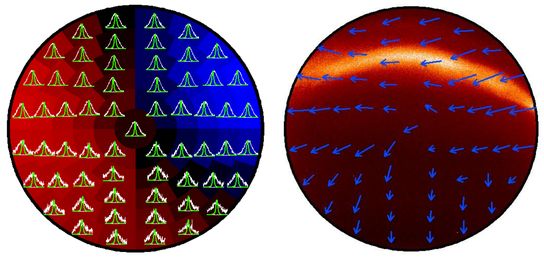

Figure 3. Left: Recorded 630.0 nm sky spectra (white), laser spectra (green), and calculated Doppler-shift, observed on May 23rd 2007. Right: Corresponding fitted wind field (blue arrows) superimposed over the recorded 630.0 nm all-sky image.

Figures 4 and 5 show results from one night of observation, May 23rd, 2007, during which time levels of geomagnetic activity were high. The instrument was looking at the 630.0 nm airglow emission, originating at an altitude of approximately 240 km. Figure 4 shows wind, temperature and intensity averaged across all 60 zones, along with modeled wind and temperature output by the 1993 Horizontal Wind Model and the NRLMSISE-00 atmospheric models respectively. Figure 5 shows the all-sky images, derived Doppler-shifts and temperatures during an approximately 1 hour period on this night.

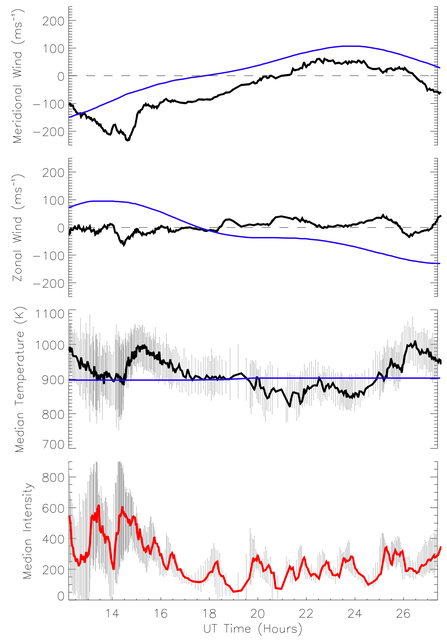

Figure 4. The top panel shows meridional wind (black curve) for the night, along with the meridional wind predicted by the 1993 Horizontal Wind Model (blue curve). Second panel down shows zonal wind (black curve), along with HWM93 zonal wind (blue curve). The third panel from the top shows median temperature across all zones (black curve), the 1-sigma widths of the distribution of temperatures across all 60 zones (grey error bars) and the predicted temperatures output by the NRLMSISE-00 model (blue curve). The bottom panel shows median intensity across all zones (red curve), along with the 1-sigma widths of the distribution across all zones.

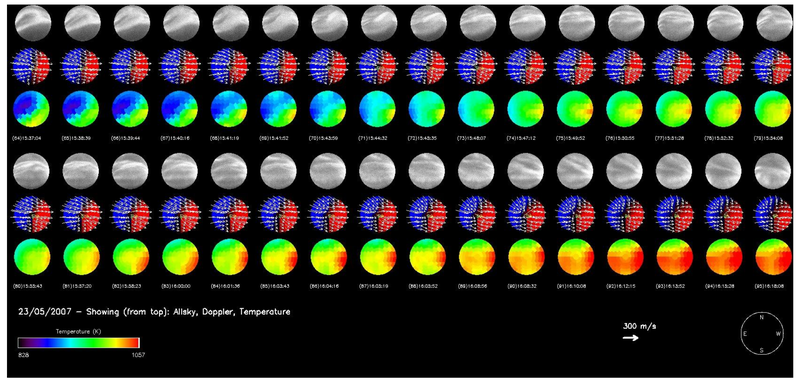

Figure 5. All-sky images, derived Doppler-shifts and fitted vector wind fields, and temperatures on the night of May 23rd, 2007. This figure represents an approximately 1 hour period early on in the night. Universal time is indicated under the temperature plots, along with exposure number in parenthesis. Magnetic north is at the top of these figures, magnetic west to the right (these images are looking up at the sky from the ground).

Mawson-Davis Campaigns

Davis is located some 635 km east of Mawson, and is at a similar geographical latitude. Any observations by the Davis spectrometer in the common-volume region (see Figure 6), when combined with the Mawson observations, give two components of the three-component vector wind field within this region.

Furthermore, by observing points along the great-circle joining the two stations, we can combine the Davis and Mawson observations to unambiguously calculate the vertical wind at those points along the great-circle.

This provides us with a unique opportunity to study spatial variations in the vertical wind, by looking at multiple locations between the two stations.

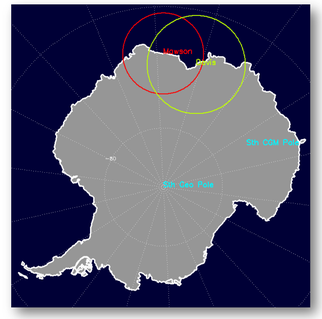

Figure 6. Fields-of-view (maximum) of the Mawson and Davis spectrometers.

Conclusion

A new all-sky, scanning imaging Fabry-Perot spectrometer is now in its second season of operation at Mawson station, Antarctica. This instrument measures thermospheric winds and temperatures over a large region of the sky (approx. 800 km radius). Its imaging capabilities make it very useful in studying small-scale spatial variations in the wind and temperature fields, such as can be caused by auroral activity.

In addition, by combining data from the Mawson spectrometer with that from a second spectrometer located at Davis station, we now have the capability to measure two components of the three-component vector wind field in the region of overlap of the fields of view of these instruments, as well as to completely determine the vertical wind at locations along the great-circle joining the two stations.