Thermospheric Winds Above Multiple Antarctic and Northern Hemisphere Sites

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Abstract

The 2010/2011 Antarctic summer season saw a new narrow-field Fabry-Perot Doppler spectrometer installed at Palmer station, while an existing all-sky instrument at Mawson station was returned to service by replacing an EMCCD camera that had failed two years earlier. This poster will discuss the opportunities that now exist to study thermospheric circulation over a range of scales – from local to global – by combining wind and temperature observations from these two instruments with the growing network of other Fabry-Perots now operating around the world. Here we will show data from several additional Fabry-Perot instruments, including those located at Davis (Antarctica), Poker Flat & Gakona (Alaska), Millstone Hill (which is approximately conjugate to Palmer), Longyearbyen (which is approximately conjugate to Davis and Mawson), Kiruna (Sweden), and Sodankyla (Finland).

Introduction

Kosch et al. [2010] presented a study that merged F-region thermospheric winds measured at Davis and Mawson in Antarctica with those measured simultaneously at near-conjugate sites in Svalbard (Norway), Kiruna (Sweden) and Sodankyla (Finland). Data from the two hemispheres were merged by mapping the Antarctic measurements to their magnetic conjugate locations in the northern hemisphere. Further, data from the northern hemisphere SuperDARN array were used to indicate the two-dimensional structure of the ion-drag forcing field. This is by far the best view yet of the degree of hemispheric conjugacy that exists in Earth's high-latitude thermospheric wind field. Figure 1, reproduced from that work, shows the results. *The overall wind field was remarkably coherent, with flow configurations very similar to those expected based on the ion convection pattern.* This study is the motivation for the additional work that is presented here.

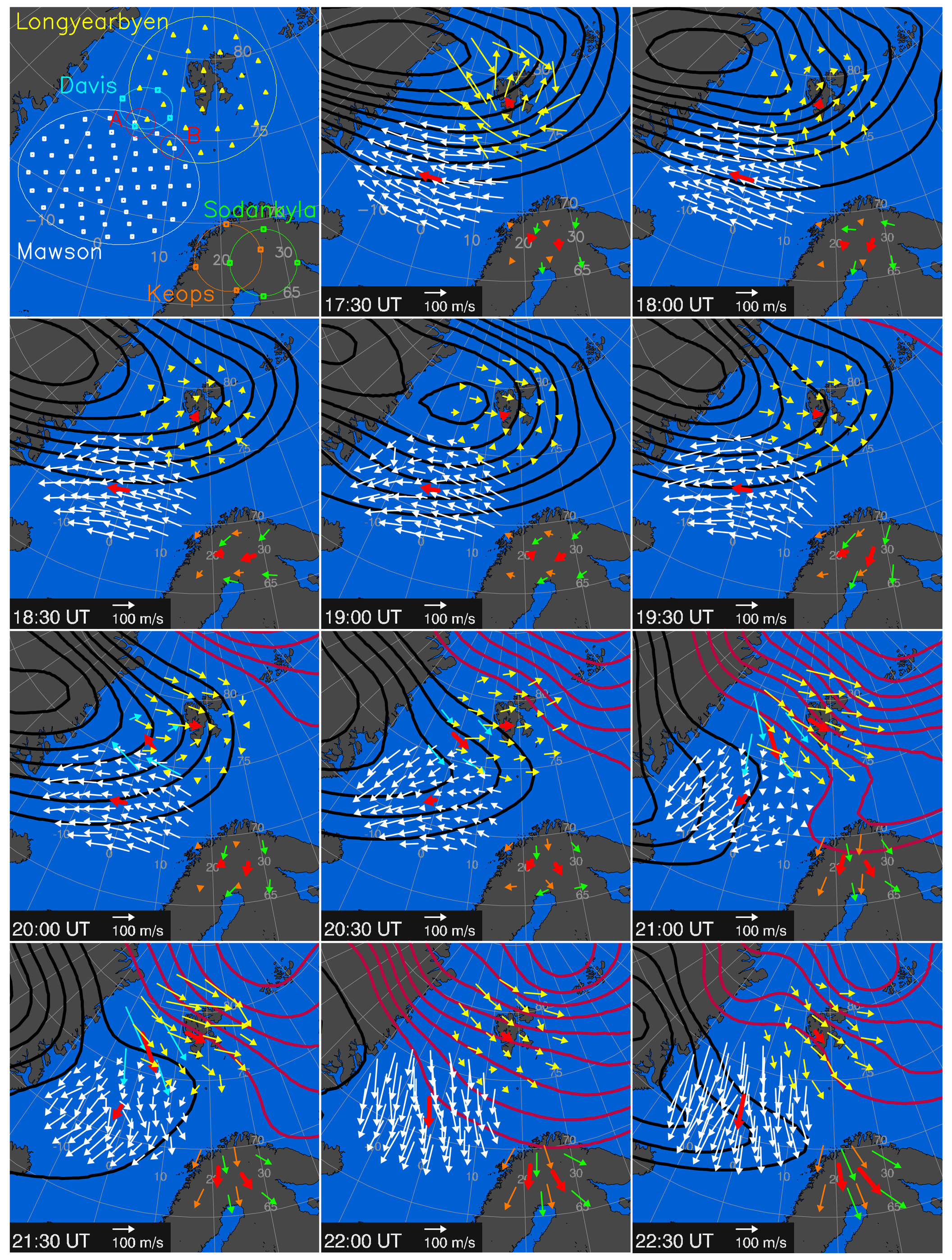

***Figure 1**: Wind vectors at 240 km altitude measured by the Mawson SDI (white) and Davis FPI (blue), geomagnetically mapped into the Northern Hemisphere, along with winds from the SDI at Longyearbyen (yellow), and FPIs at KEOPS (orange), and Sodankyla (green). Larger red vectors represent mean winds for each instrument. Northern Hemisphere SuperDARN ion convection equipotential contours at 3 kV increments are shown in black and red for the dusk and dawn convection cells, respectively. The top left frame shows Northern Hemisphere conjugate locations for the Antarctic measurements. [From Kosch et al., 2010]*

Horizontal Winds Above Mawson & Poker Flat

Because ground-based Fabry-Perot instruments require dark skies, simultaneous hemispherically-conjugate observations like those shown in Figure 1 are only possible during short time windows around the equinoxes. They also obviously require instruments at nearly conjugate sites. Thermospheric wind data are rather sparse at the best of times; these additional constraints mean that data sets like those of *Kosch et al.* [2010] will not often be available. However, if we are willing instead to examine conjugacy in a less-restrictive global-scale time-averaged statistical sense, then far more observational data can be used.

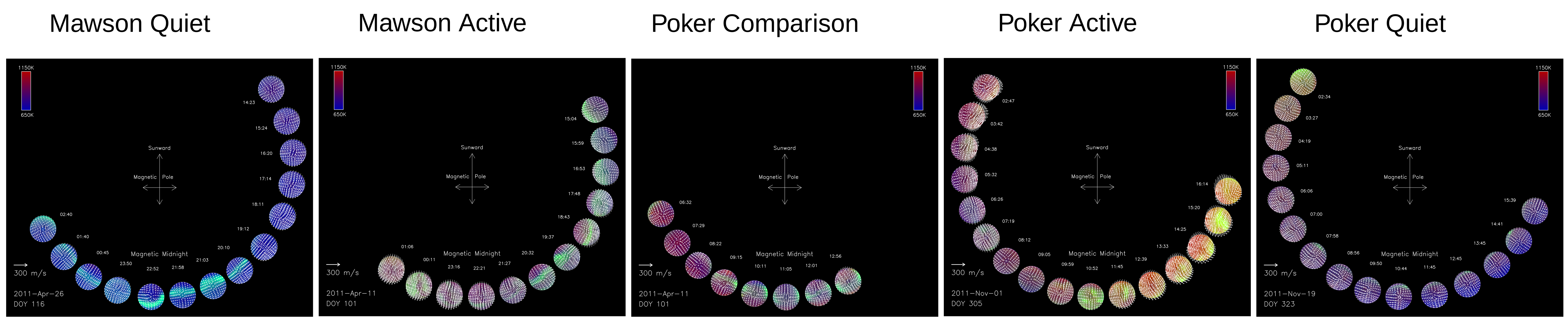

***Figure 2**: These "dial plots" show thermospheric winds as seen by an observer looking down on Earth's poles from space, in a reference frame for which magnetic noon is always at the top. As Earth rotates during the night, a southern hemisphere observatory would be seen to move in a clockwise direction, whereas a northern observatory would move anti-clockwise. Magnetic poleward is always directed toward the center in these plots, and magnetic eastward is in the direction of increasing time. Blue through red hues denote thermospheric temperature, as per the scale shown. Green hues denote emission brightness. Note the similarity between the wind patterns seen at Mawson and Poker Flat under similar conditions.*

For example, consider Figure 2. It shows winds at 240 km altitude measured by the Scanning Doppler Imager [e.g., *Conde & Smith*, 1998] at Mawson compared with those seen using a similar instrument at Poker Flat, Alaska. The geomagnetic latitudes of these two sites are similar, but not identical. At geomagnetic latitude 70.4°S, Mawson is ~ 500 km closer to its magnetic Pole than Poker Flat, which is at 65.4°N. (They are almost 180° apart in magnetic longitude)
Despite these differences, it is obvious by inspection that *generally similar wind patterns are observed at both sites, and their dependence on auroral activity is also similar.* We also observe similar local-scale responses as auroral forms move over the stations, as is apparent from Figures 2 and 3. The third and fourth panels in Figure 2 actually show winds recorded at Poker Flat and Mawson on the same UT day, although there is no overlap in time because of the two sites' large difference in longitude. Similar winds were observed, although those at Mawson were obviously more influenced by ion-drag.

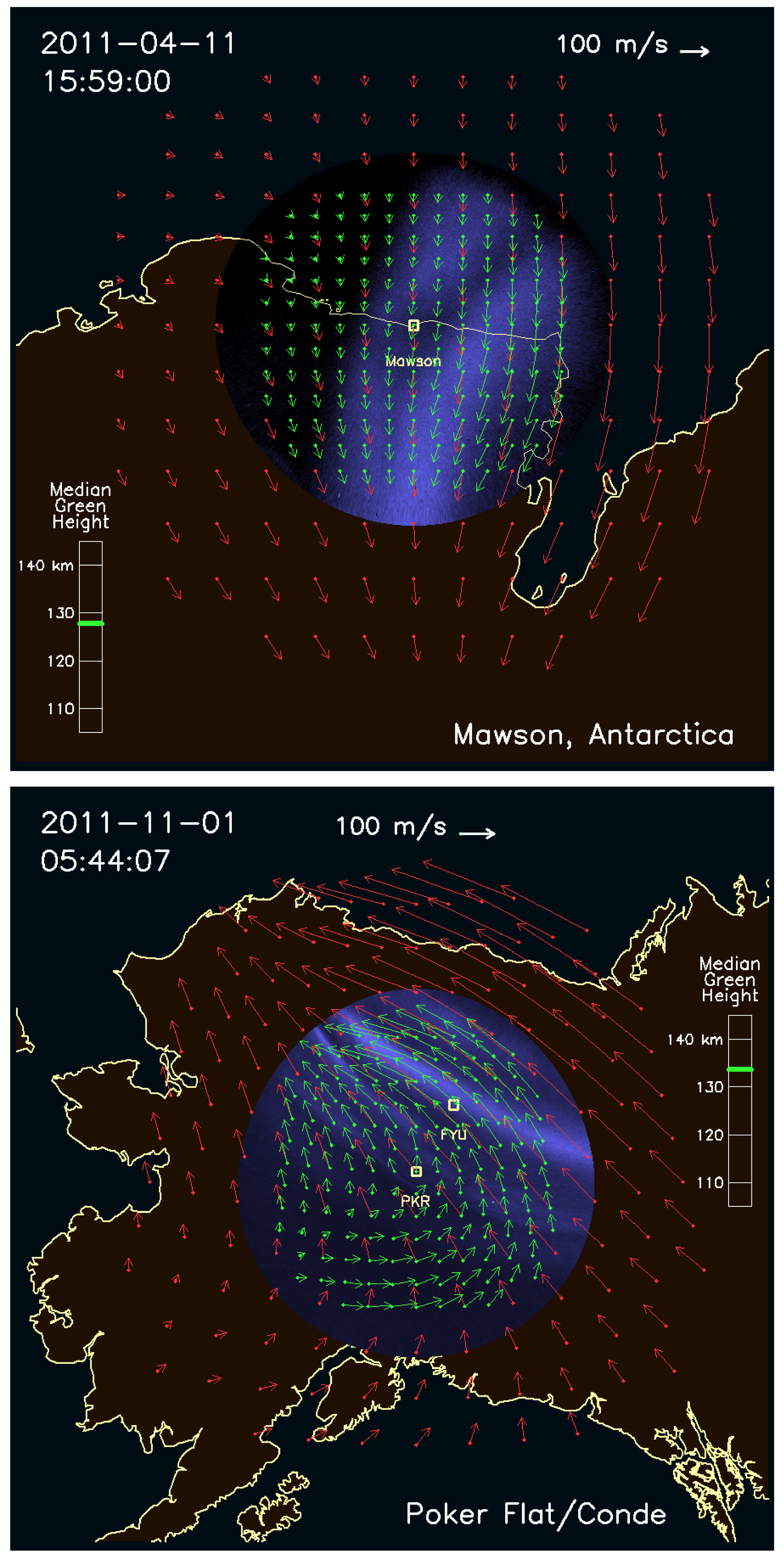

***Figure 3**: Geographically mapped wind fields above Mawson (top) and Poker Flat (bottom) at F-region heights (red arrows) and E-region heights (green arrows). All-sky auroral images are also projected onto the maps and depicted using blue hues. In both cases the winds poleward of the stations were blowing strongly geomagnetically westward, shearing to much weaker flows on the equatorward side. The two observations were taken at similar magnetic local times (roughly 18 hours MLT). The westward flow penetrated down into the E-region in both cases. These observations are typical of many others that we have recorded.*

Vertical Winds Above Antarctica & Alaska

The instruments at Mawson and Poker Flat are each paired with a second nearby Fabry-Perot with an overlapping field of view, at least in the F-region. The Mawson instrument is accompanied by one at Davis Station, which is about ~ 630 km distant, due magnetically SSE. Poker Flat's companion instrument is located at Gakona, 327 km away, again in a magnetic SSE direction. The overlapping fields of view allow unambiguous vertical wind measurements at a number of locations along the great-circle between the station pairs [*Anderson et al.*, 2011]. This is done using a bistatic analysis of the line-of-sight velocity components measured by each station in the pair. As seen in Figure 4, this analysis shows that F-region vertical winds have generally similar characteristics over the Mawson-Davis region as they do over Alaska. *Vertical wind perturbations have similar amplitude, timescales, and spatial coherence in the two regions.*

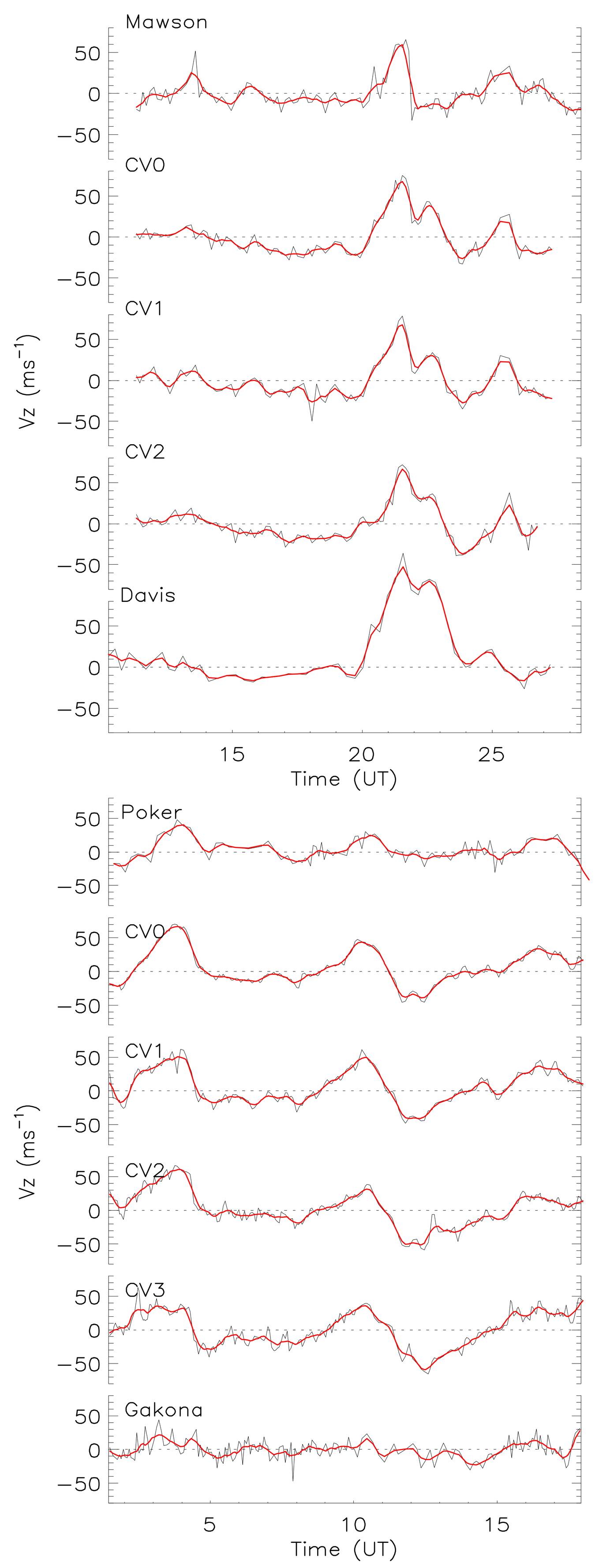

***Figure 4**: Vertical Wind time series at 240 km altitude above the Mawson-Davis region for June 19, 2011 (top) and above Alaska for December 25, 2010. In each plot the top and bottom time series correspond to winds measured directly overhead of the labeled station. Intermediate time series were recorded at locations of bistatic common-volume overlap between the sites.*

Palmer Station Antarctica & Millstone Hill MA

A number of other Fabry-Perot instruments are now operating and providing routine wind and temperature observations of the thermosphere and mesopause regions. Figures 5 and 6 show example data from another nearly conjugate pair, in this case located at Palmer station in Antarctica and at Millstone Hill in Massachusetts.

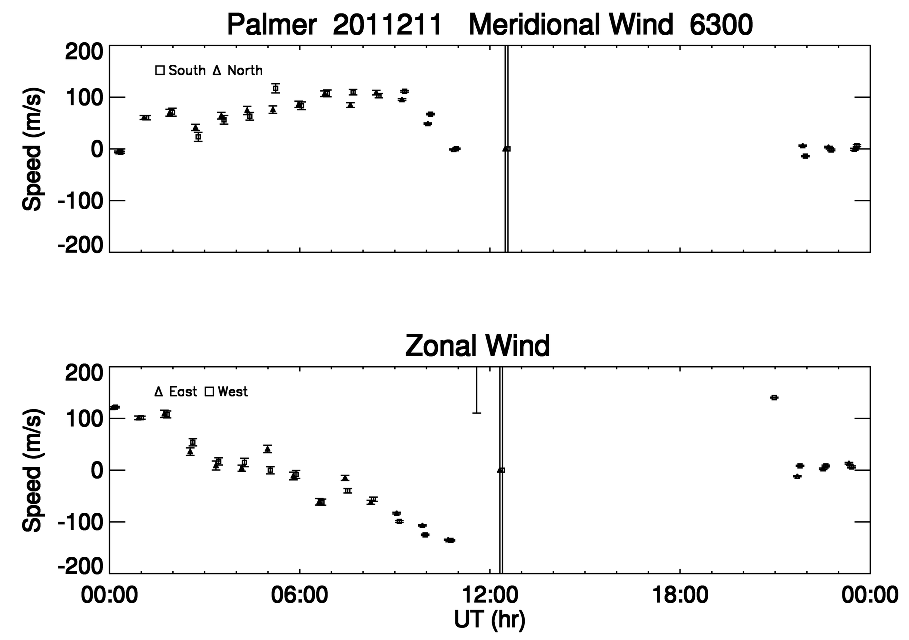

***Figure 5**: Meridional and zonal wind time series obtained on July 30, 2011 by a new Fabry-Perot spectrometer that was installed by NCAR at Palmer Station in Antarctica in late 2010.*

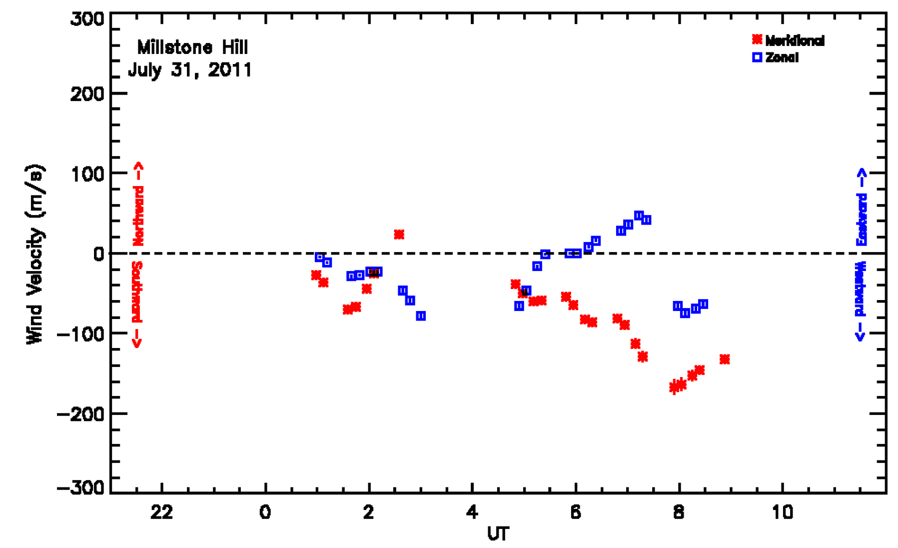

***Figure 6**: Meridional and zonal wind time series obtained on July 31, 2011 by a new Fabry-Perot spectrometer now operating at Millstone Hill in Massachusetts.*

Conclusions

A number of modern high-performance Fabry-Perot spectrometers are now operating around the globe. This new generation of instruments is characterized by high optical throughput, excellent wavelength stability, and flexible, autonomous operation. They are ideal for routine monitoring of Earth's thermospheric wind field with spatial resolutions varying from sub-100 km up to features that are global in scale.
In this poster *we have presented data from nine different Fabry-Perot sites* (Mawson, Davis, Palmer, Poker Flat, Gakona, Longyearbyen, Millstone Hill, Kiruna, and Sodankyla.) These data suggest that there is a high degree of similarity between wind patterns occurring in the northern and southern auroral zones. While this is perhaps not surprising, the observational data on hemispheric conjugacy of thermospheric winds remains sparse, and there is scope for considerably more study.
Many other excellent sites are also operating. The neutral wind community is well positioned to begin producing truly global-scale neutral wind data products.

References

Anderson, C., T. Davies, M. Conde, P. Dyson, and M. J. Kosch (2011), Spatial sampling of the thermospheric vertical wind field at auroral latitudes, J. Geophys. Res., 116, A06320, doi:10.1029/2011JA016485.
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Kosch, M. J., et al. (2010), First observations of simultaneous interhemispheric conjugate high-latitude thermospheric winds, J. Geophys. Res., 115, A09328, doi:10.1029/2009JA015178.