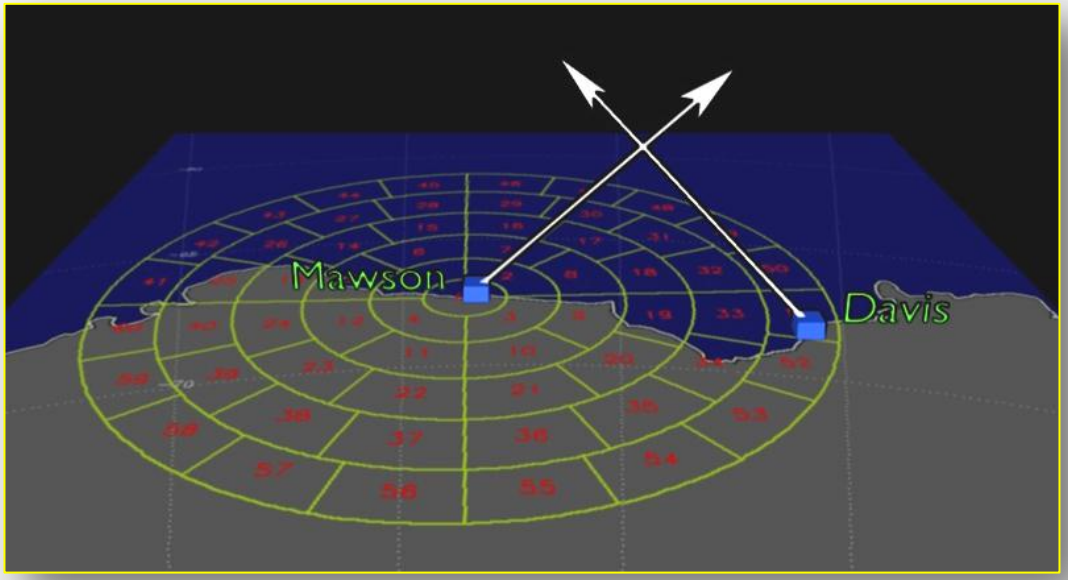
Spatial Sampling of the Thermospheric Vertical Wind Field at Auroral Latitudes

Anderson C.[1], T. Davies[1], M. Conde[2], P. Dyson[1] and M. J. Kosch[3]



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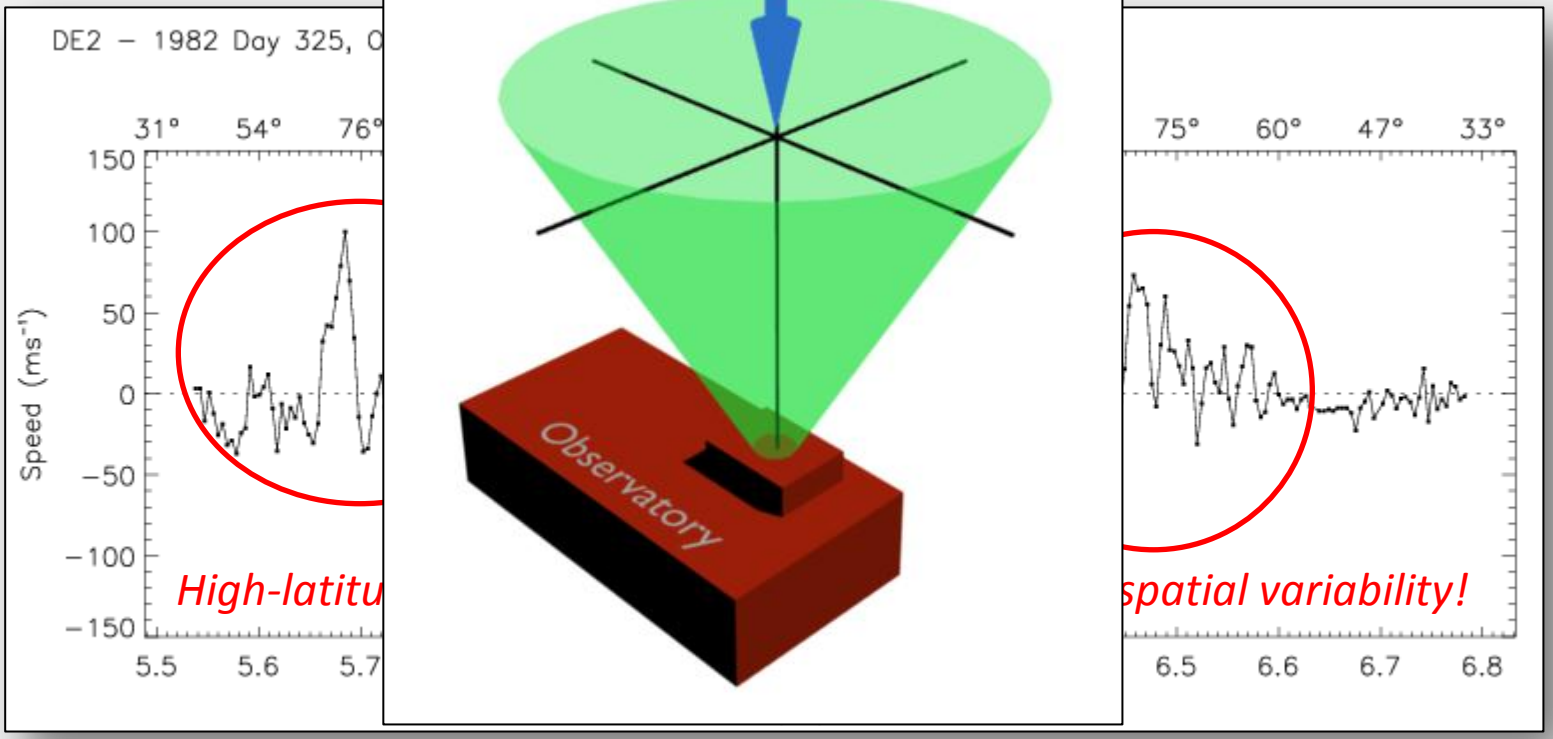
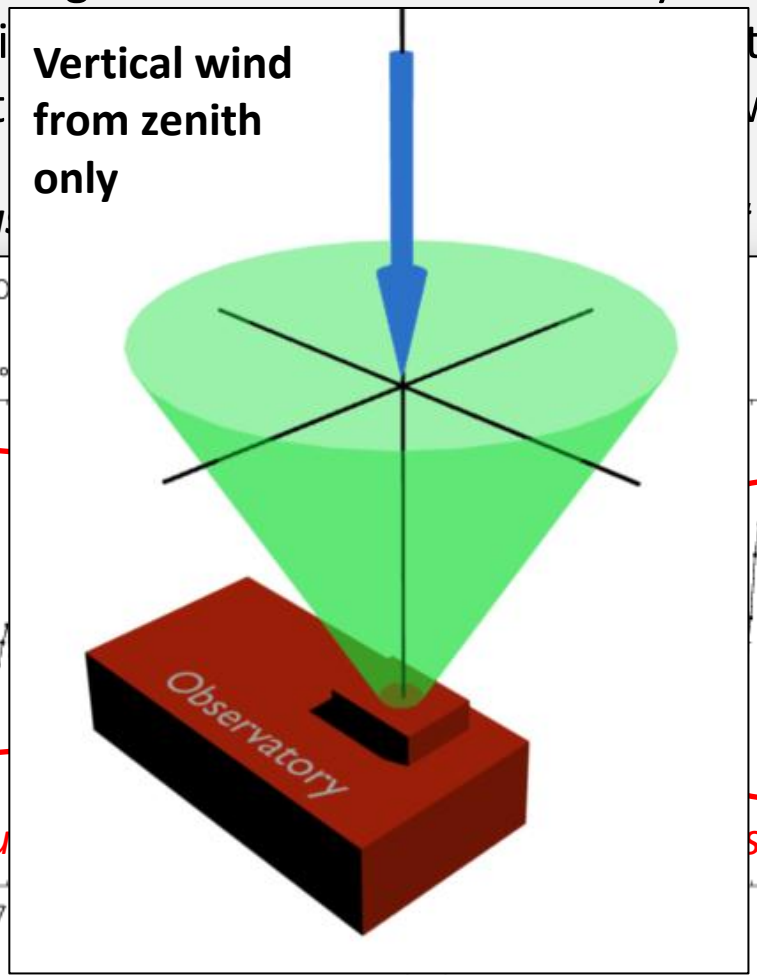
[3] Department of Physics, Lancaster University, Lancaster, UK

Overview

- Measurements of vertical wind in the thermosphere are difficult to obtain.
- From a single observatory, we are limited to the zenith viewing direction only.
- Satellites (e.g. Dynamics Explorer 2) can measure the vertical wind along their orbital track, however high orbital velocities severely limit spatial resolution, and we cannot track the ti… the satellite effectively takes a 'snapshot' in t… wind field).

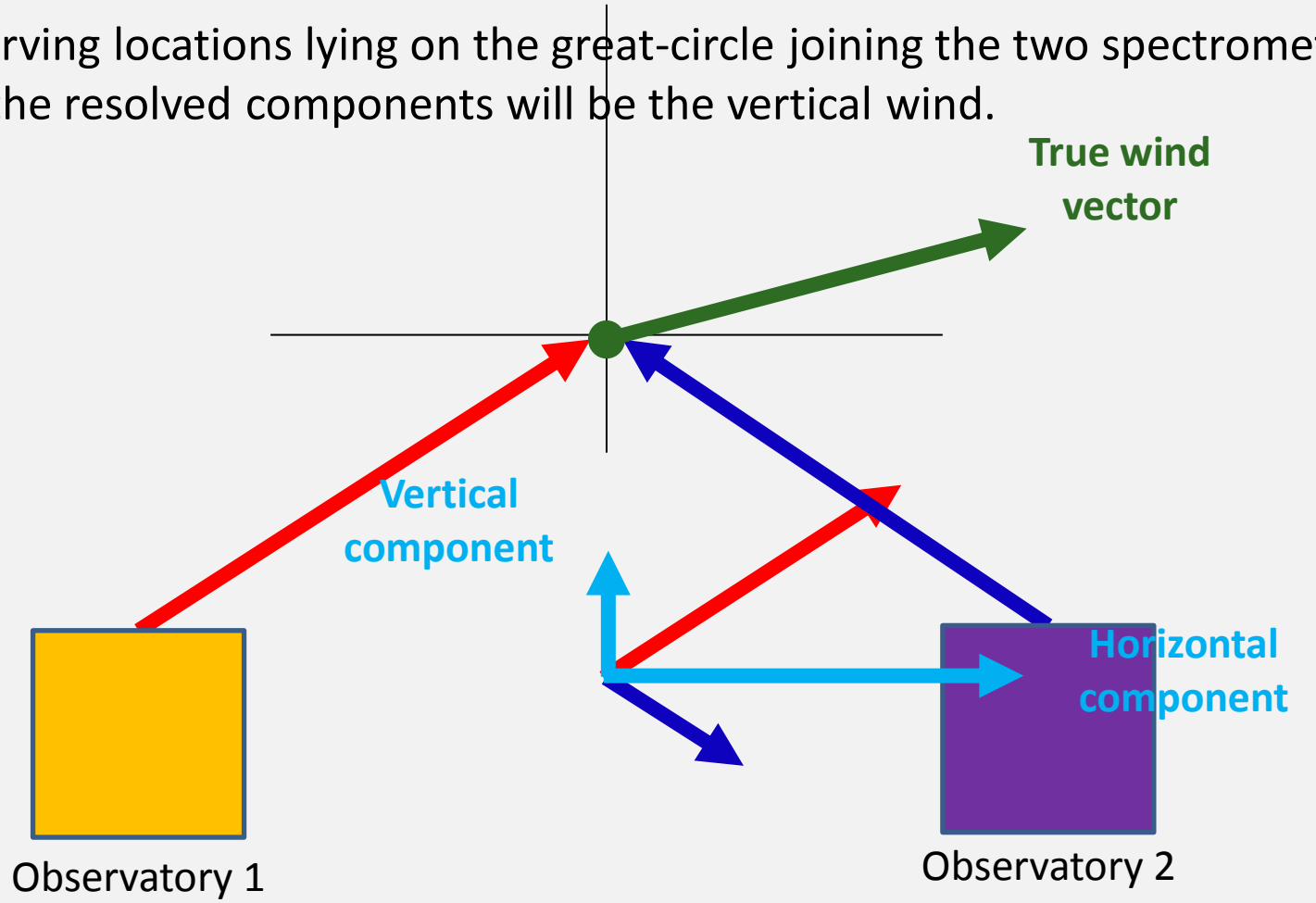
Vertical wind mea… 7164, Day 325 1982





Idea

- Use two ground-based Fabry-Perot spectrometers to sample the 3D neutral wind field at common locations ("common-volume").
- Then use the two independent measurements to unambiguously resolve two of the three wind components.
- By observing locations lying on the great-circle joining the two spectrometers, one of the resolved components will be the vertical wind.



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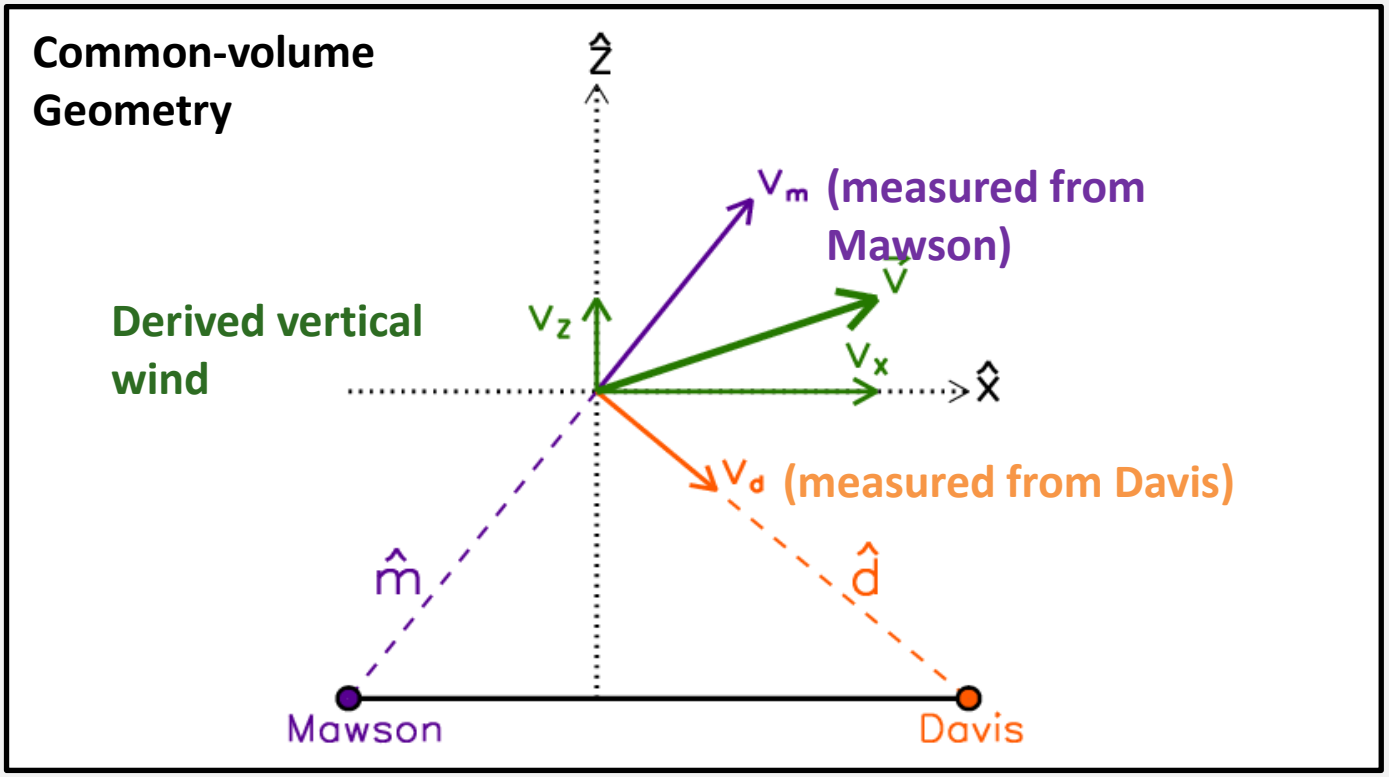
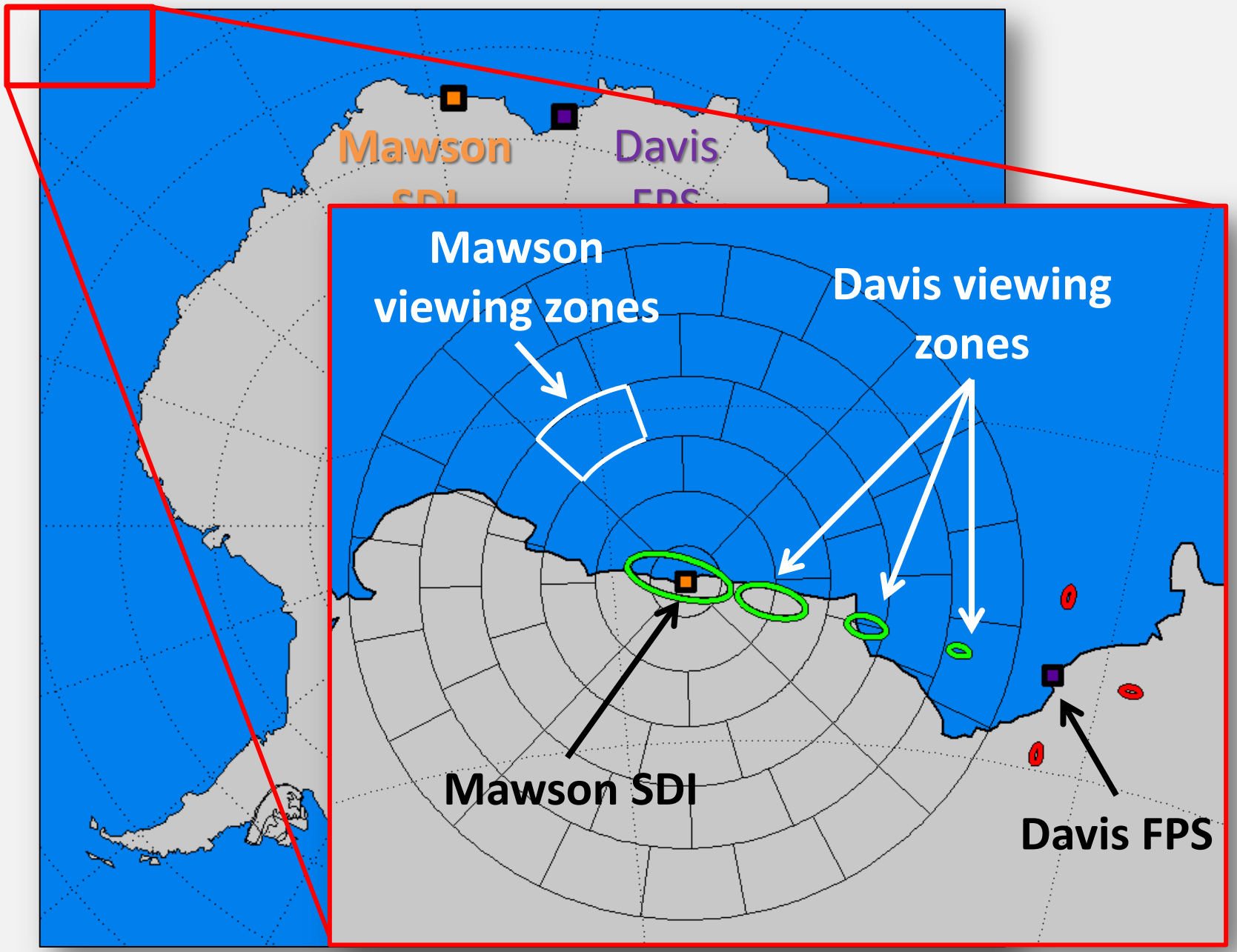


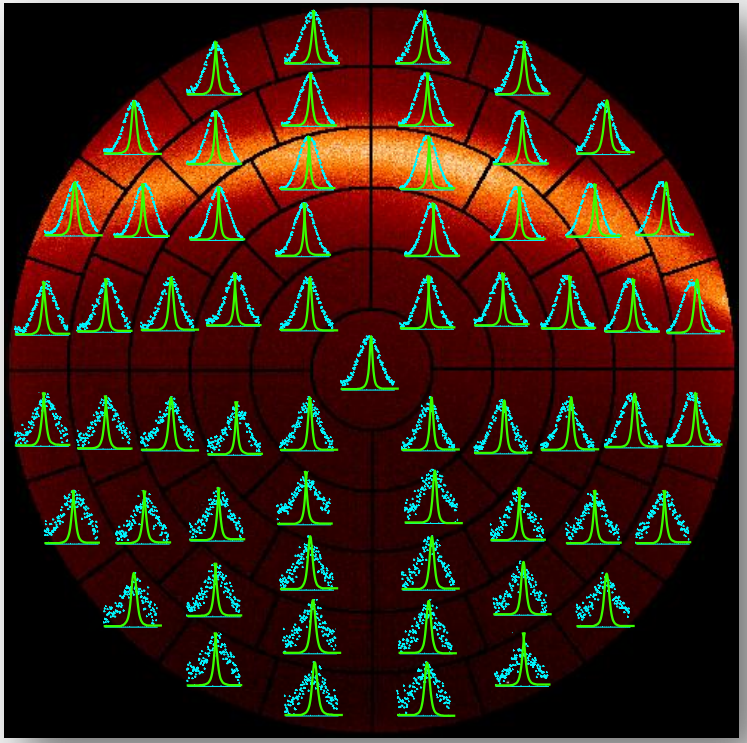
Instruments



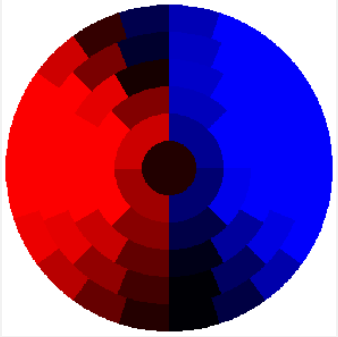
Mawson SDI

Mawson Scanning Doppler Imager (SDI)

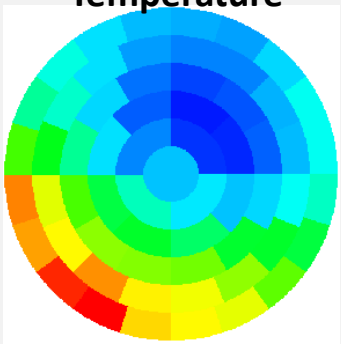
- All-sky fore-optics.
- Separation-scanning etalon.
- Measures independent airglow spectra from 61 regions (“zones”) over a 144° full-angle field-of-view of the sky.
- Records an all-sky image concurrently with spectral acquisition.

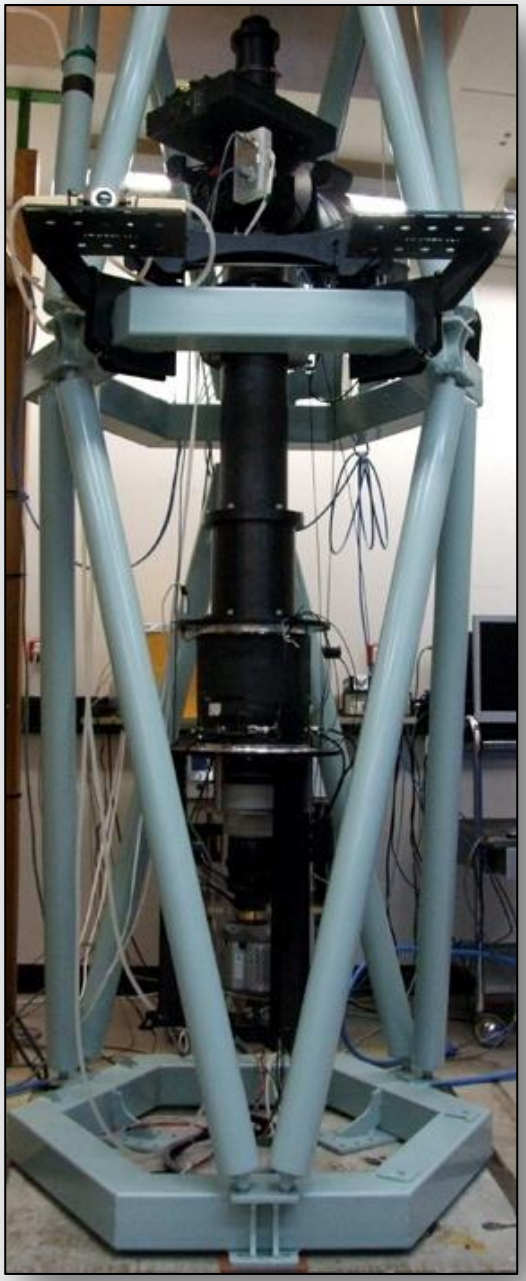


Doppler-velocity



Temperature

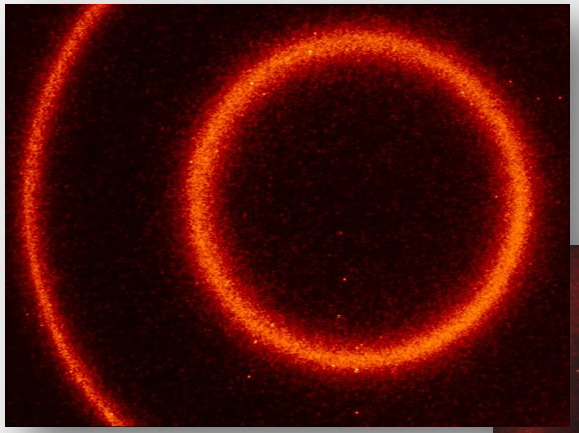




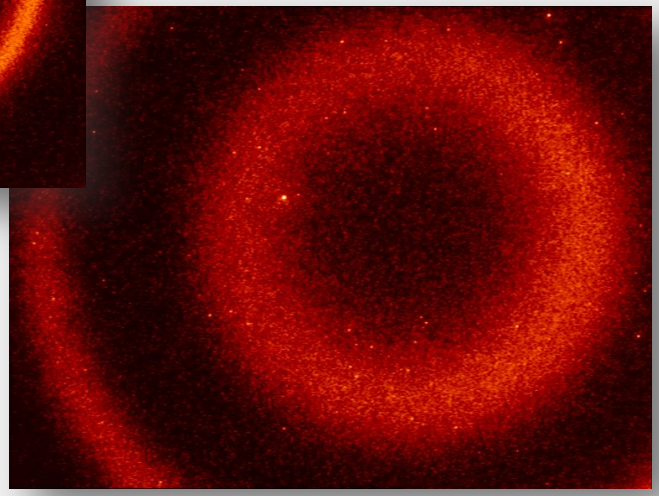
Davis FPS

Davis Fabry-Perot Spectrometer (FPS)

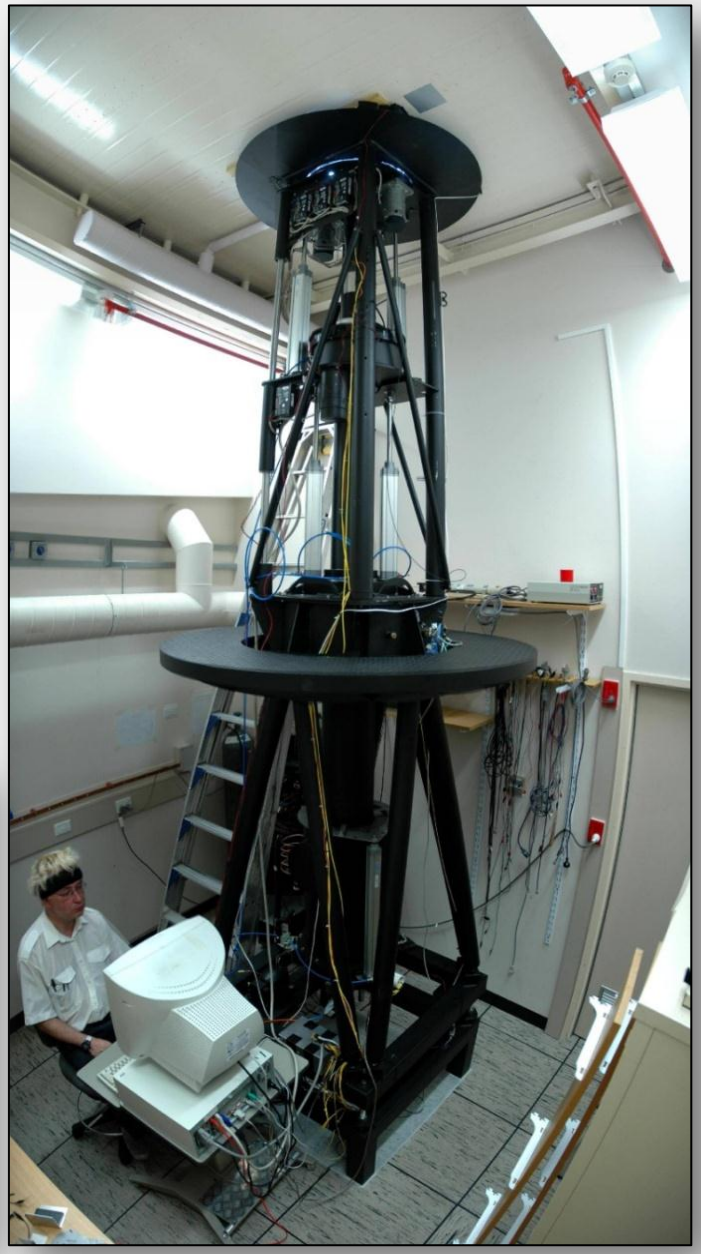
- 6 ° full-angle field-of-view, steerable to any part of the sky.
- Fixed-gap etalon.
- Records an airglow ‘fringe’ image.
- Spectral information is encoded in the spatial variation of light intensity across the image.



Laser calibration fringe, 632.8 nm.



Airglow fringe, 630.0 nm.



Results

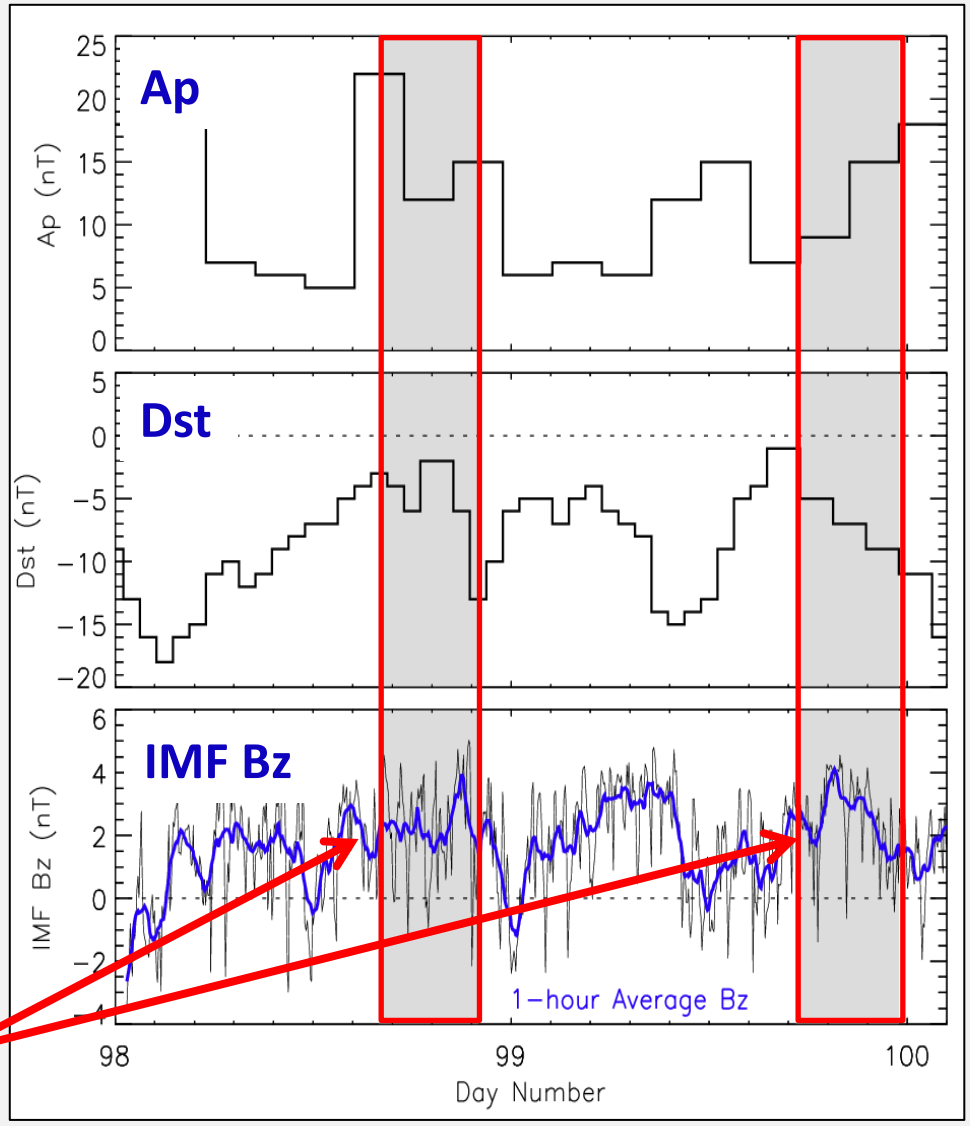
The data set recorded under clear (cloud-free) sky conditions, above and between both stations, is very small. Results from two nights will be presented.

These nights (day numbers 98 and 99, in 2008) both experienced quiet geomagnetic conditions (shaded areas in the figure). 2008 was a *very* quiet year in terms of solar/geomagnetic activity.

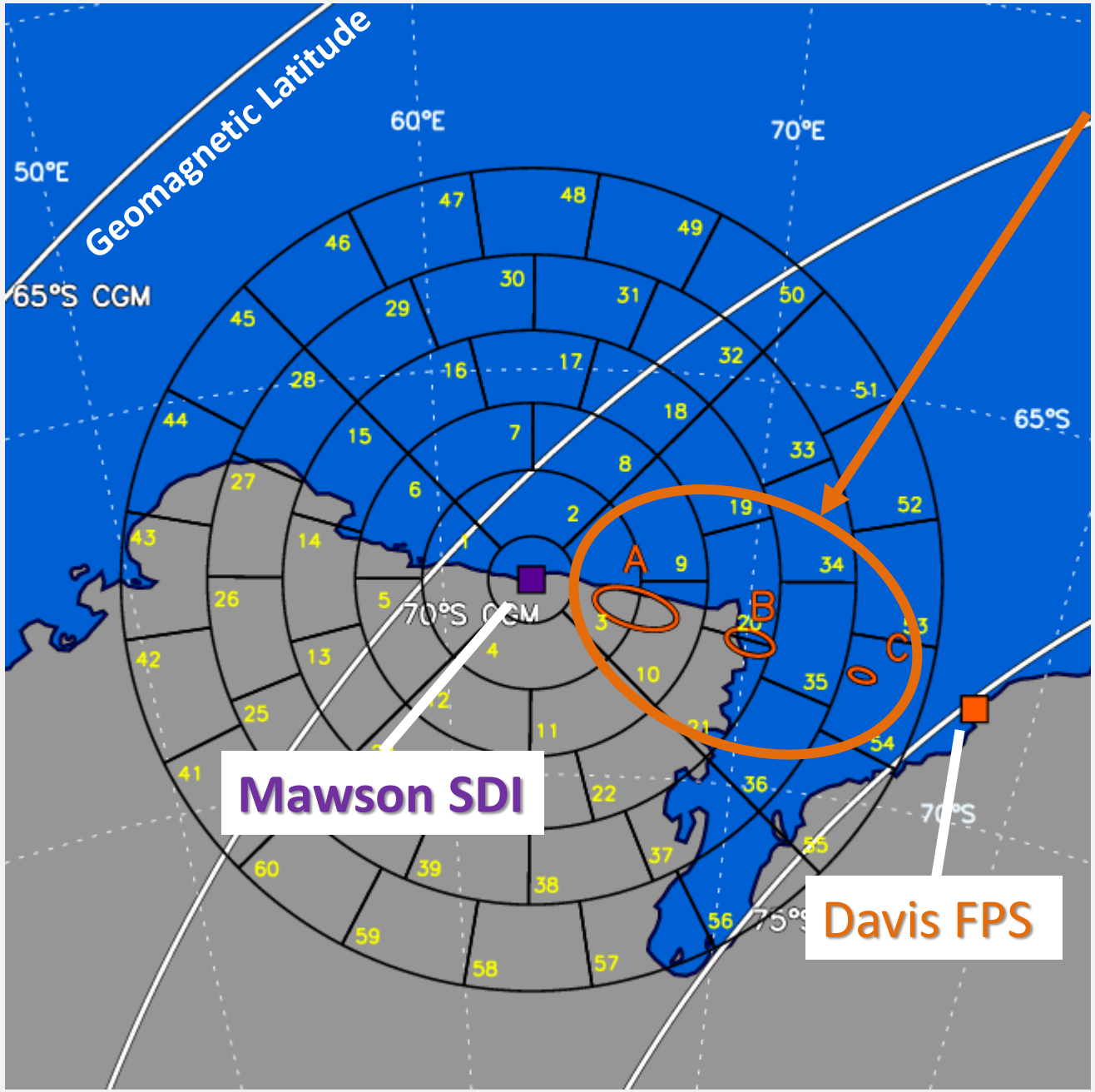
Day 99 will be presented first, as vertical wind activity on this night was minor. Day 98 showed much more variability.

Note IMF Bz was weakly positive on both study intervals.

Geomagnetic Conditions



Results



Common-volume regions will be referred to as **A, B, C**.

Both instruments observed the 630.0 nm airglow line of atomic oxygen, with an assumed peak altitude of 240 km.

Wind speeds were derived from Doppler-shifts of the airglow line.

Results – Day 99

Line-of-sight wind speeds in each of the common-volume regions.

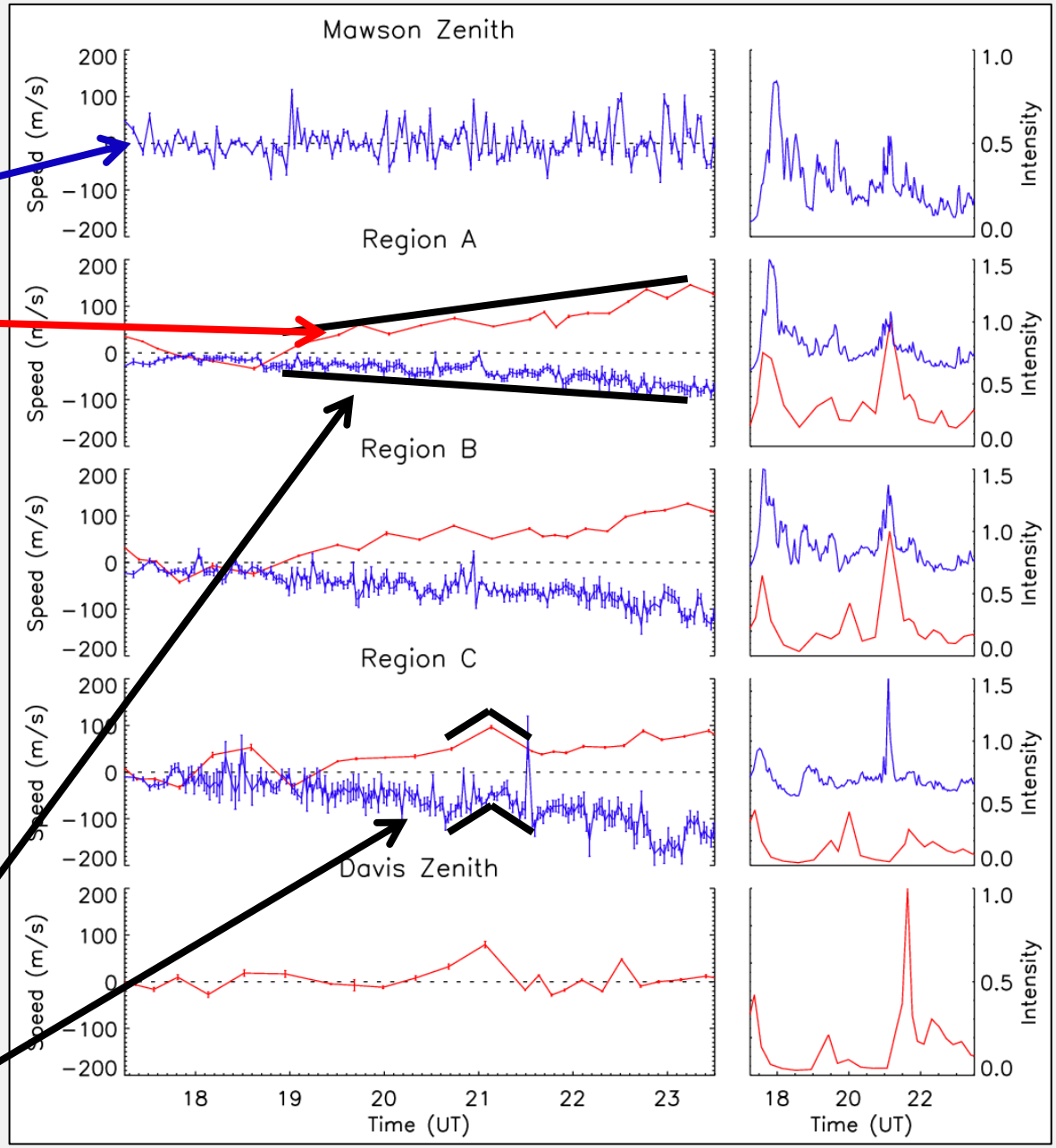
Mawson – blue

Davis – red

Note that due to the geometry of the observations, anti-correlated line-of-sight speeds indicate a horizontal wind, while a correlated wind response indicates a vertical wind.

Anti-correlated – increasing horizontal component.

Correlated – vertical wind

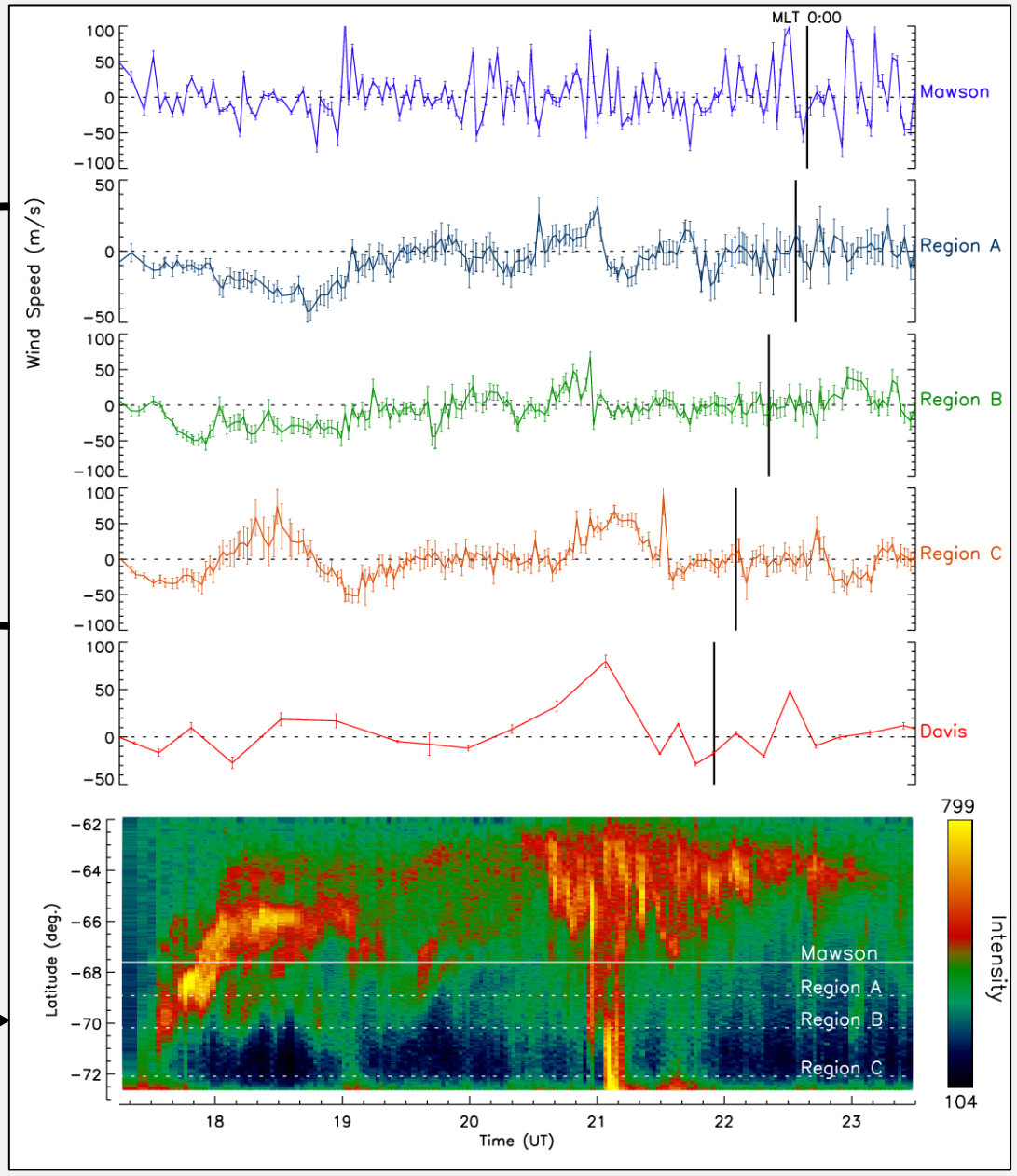


Results – Day 99

Vertical winds in each of the station zeniths and common-volume regions.

Common-volume region vertical winds derived from the line-of-sight winds observed from both instruments.

The keogram is obtained from vertical cross-sections through the all-sky images recorded by the Mawson SDI. (Geomagnetic north is toward the top of the image).

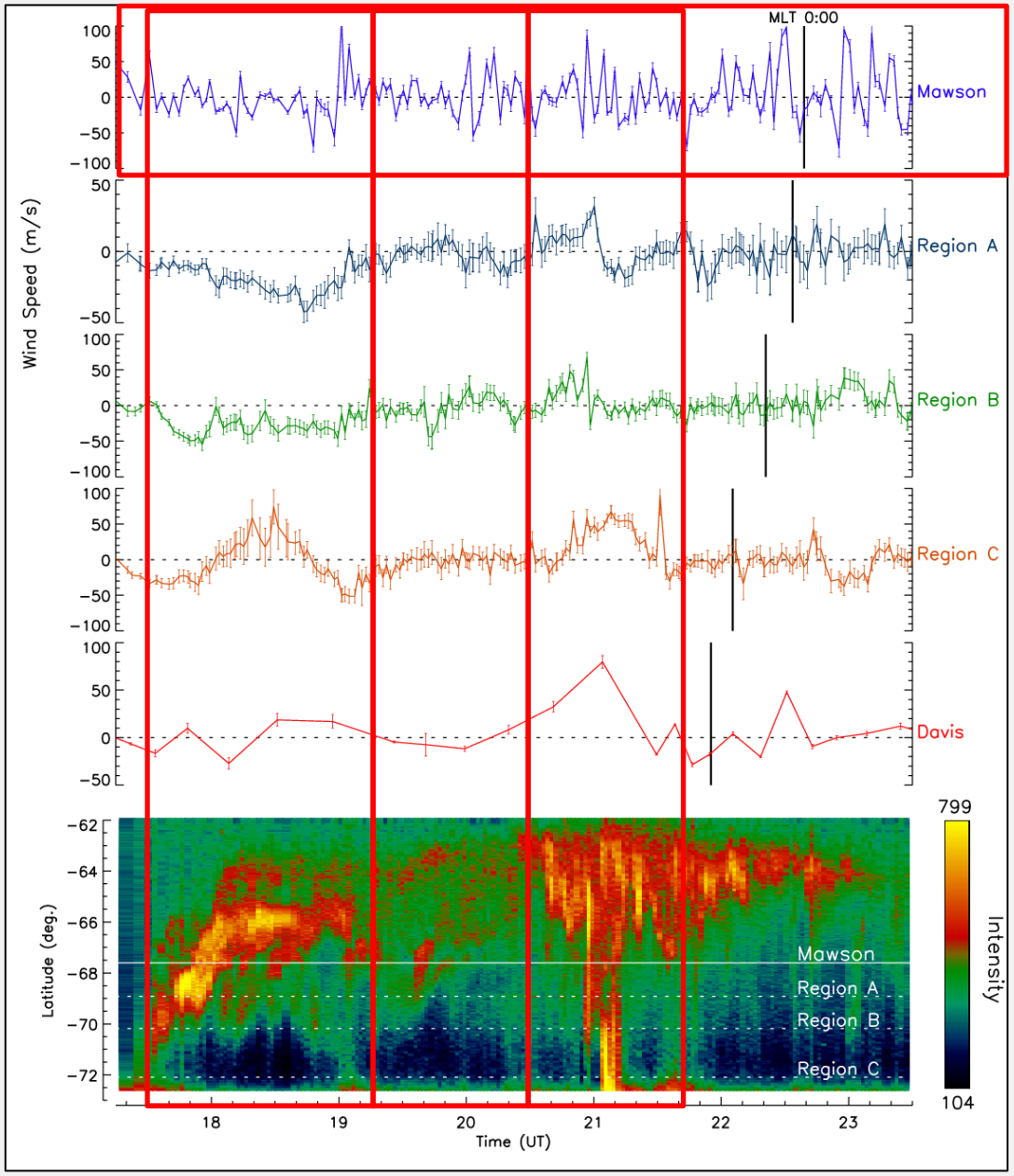


Results – Day 99

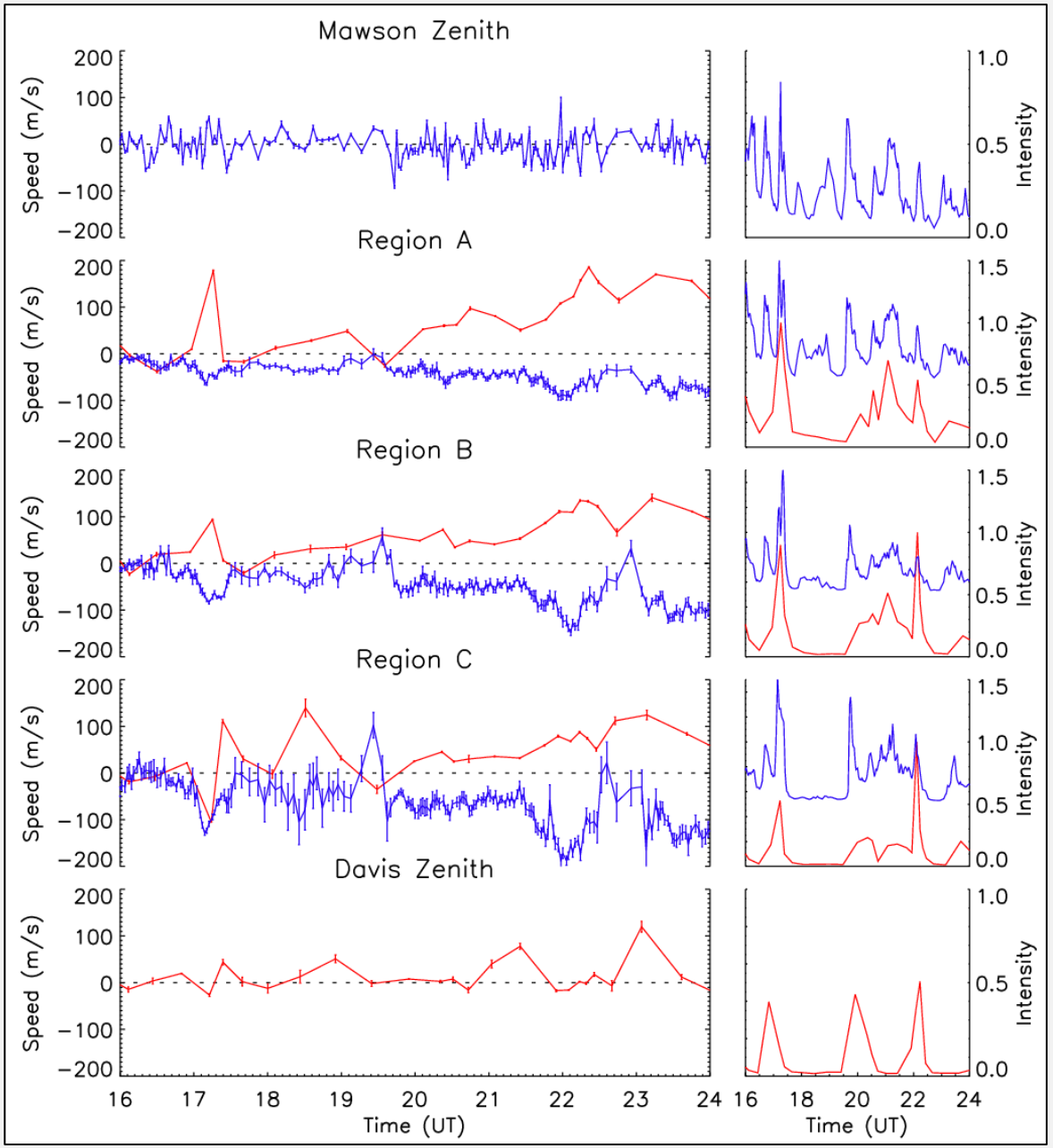
Variability above Mawson was significant for the entire period.

Periods of vertical wind disturbance corresponded well with increased auroral activity.

Quiescent vertical winds were observed as auroral activity diminished.



Results – Day 98



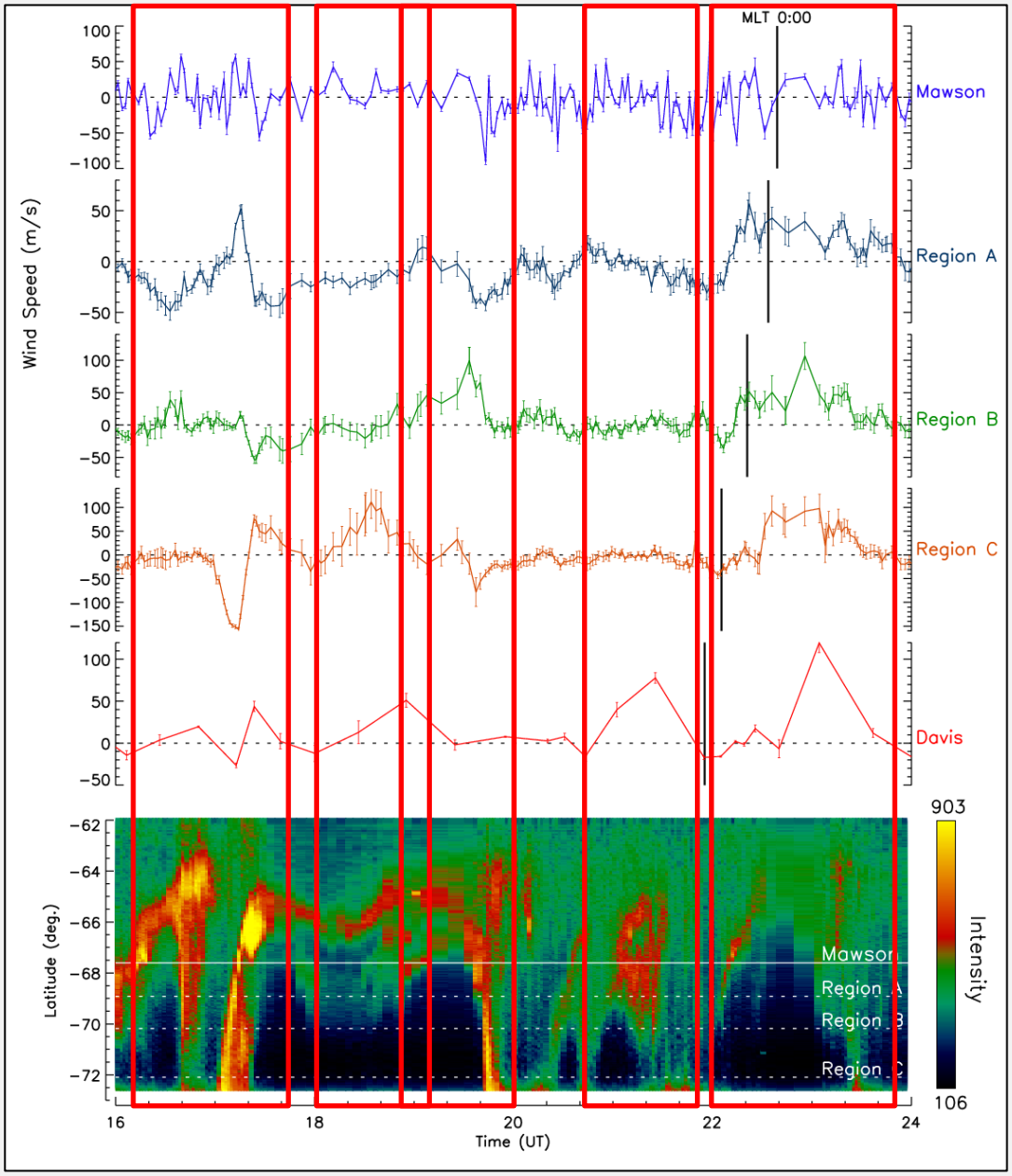
Results – Day 98

Significant wind disturbance associated with rapid equatorward motion of one arc, replaced by a second arc which also moved rapidly equatorward.

Localised disturbances, associated with moving aurora.

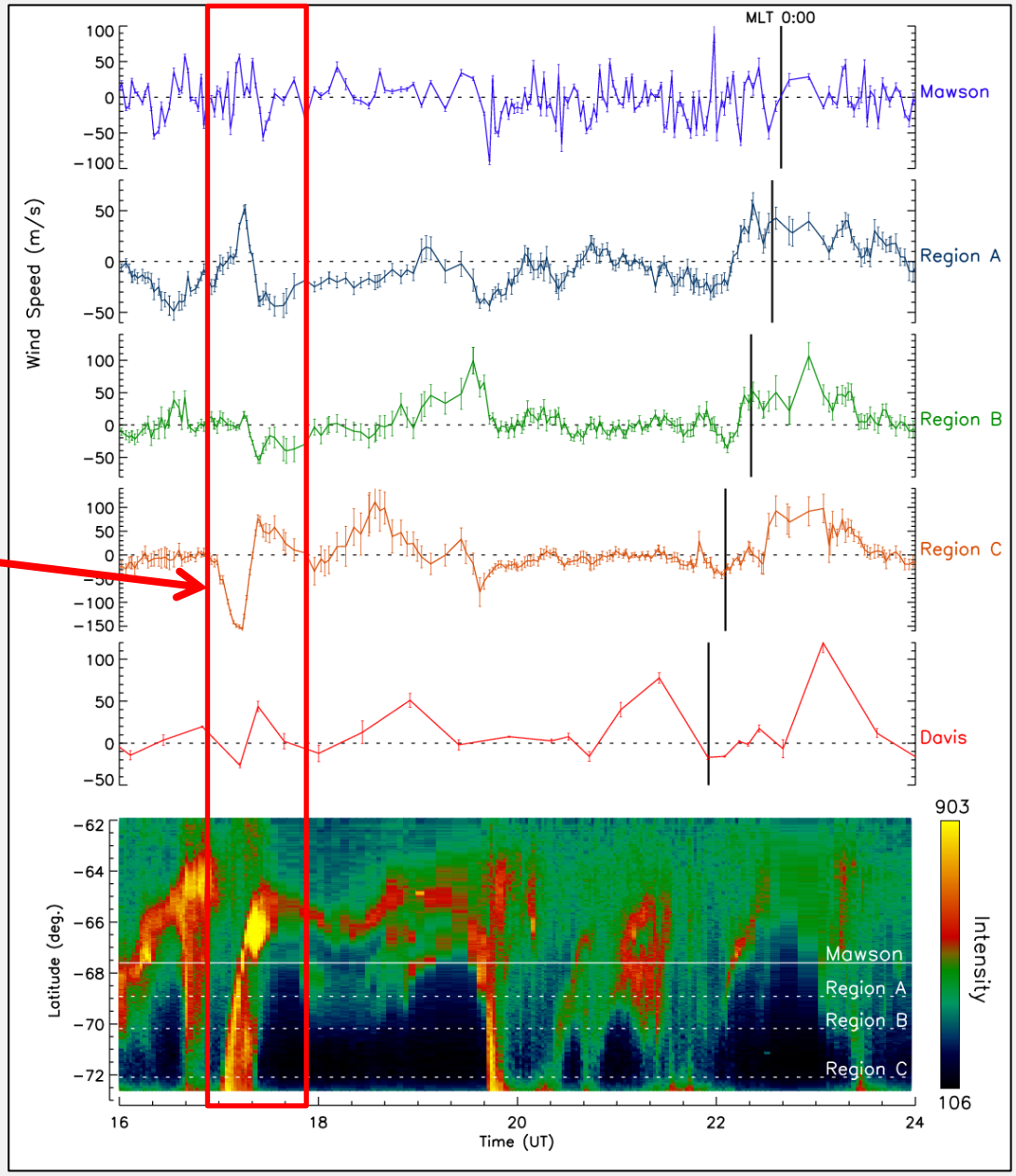
Quiet in the common-volume regions, disturbed above Davis.

Large-scale, long duration upwelling, associated with an absence of aurora overhead.



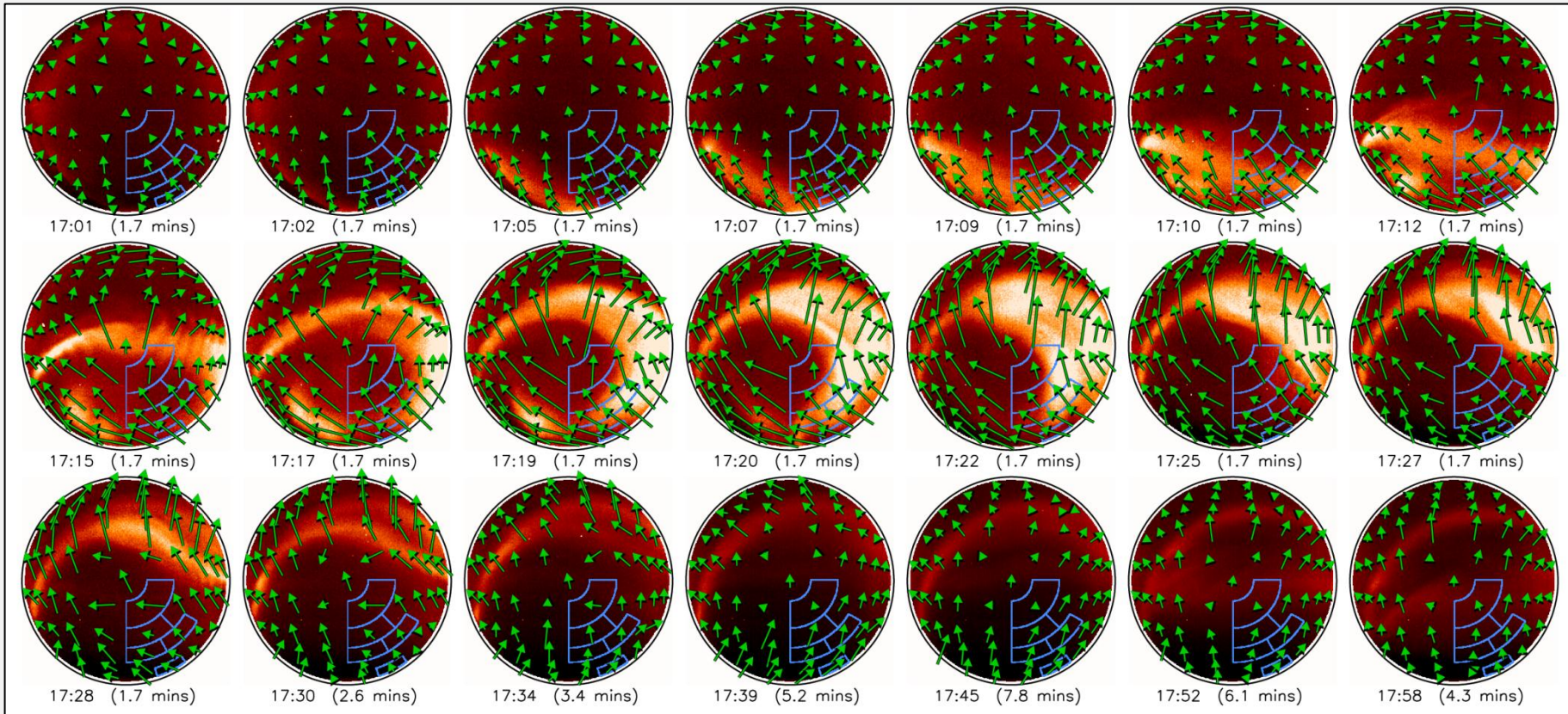
Results – Day 98

What was the horizontal wind field doing during this time?



Results – Day 98

The horizontal wind field, as inferred by the Mawson SDI, was significantly disturbed by the passage of the auroral arc.



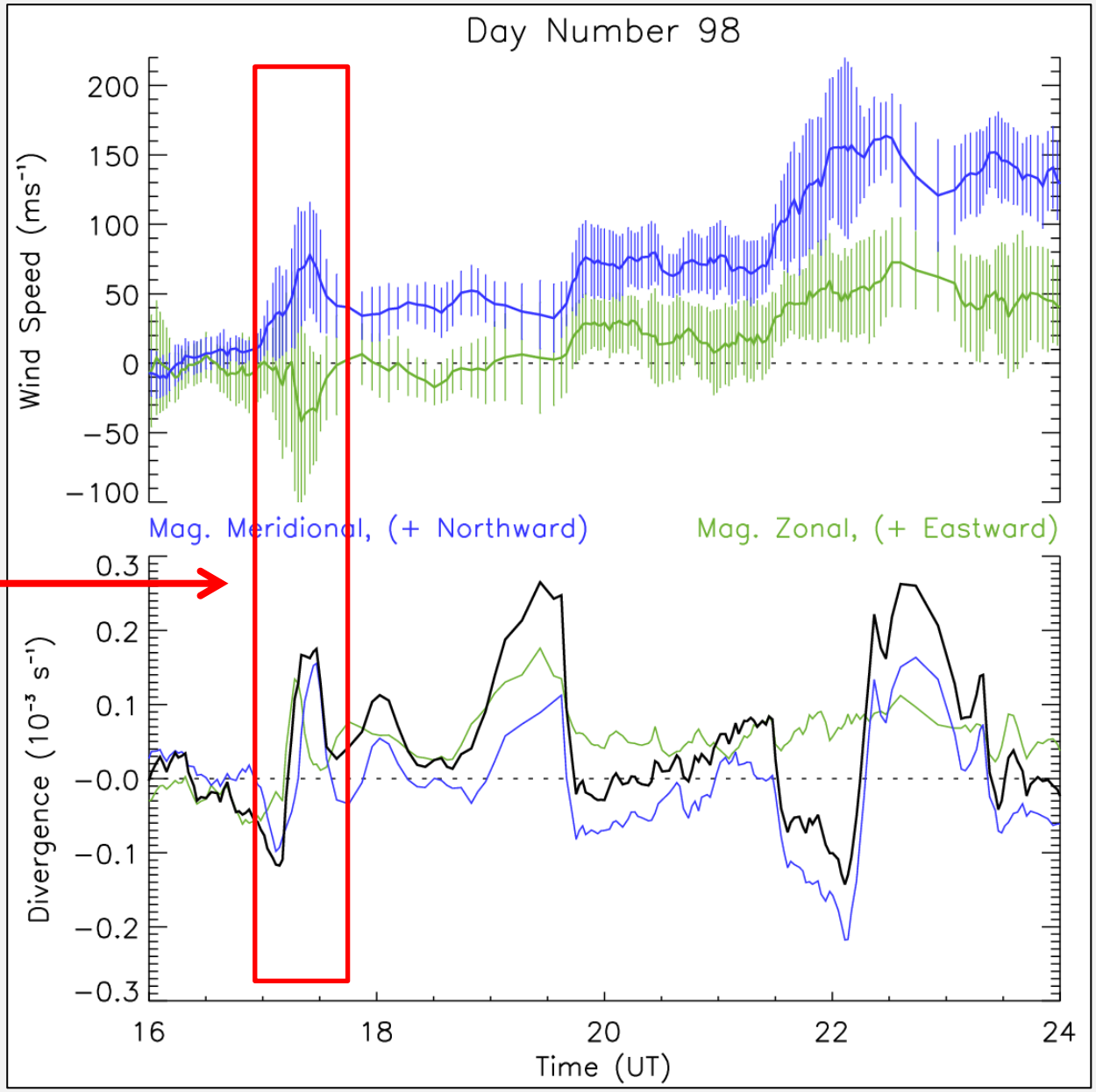
All-sky images and fitted horizontal wind field produced by the Mawson SDI, between 17:00 – 18:00 UT.

Results – Day 98

Here are shown the average wind components across all Mawson SDI viewing directions, and the average horizontal divergence across the field of view.

The auroral arc passed through at this time.

The spread of horizontal wind speeds greatly increased above background levels, as the wind flow became sharply divergent.



Conclusions

- *The thermospheric vertical wind field at auroral latitudes is highly dynamic!*
- *Vertical wind disturbances are often associated with active auroral morphology.*
- *The scale of the vertical wind response varies, from local (observed in one region only), to large scale (seen across ≈ 450 km).*
- *The ability to observe both the spatial variability and the time evolution of the vertical wind field is invaluable for studies of atmospheric gravity waves.*