Simultaneous measurements of convection changes in the high-latitude day- and night-side ionosphere with the Halley and TIGER HF backscatter radars – early results

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Introduction

Measuring the time delay for the large-scale high-latitude ionospheric convection to respond to sudden changes in the interplanetary magnetic field (IMF) is an important part of understanding geospace weather. The actual time delay has a bearing on the role of IMF line draping, fast Alfven mode waves, and the ionospheric drift in communicating ionospheric convection changes. Recent measurements suggest that the convection response to changes in the *By* and *Bz* components of the IMF can be simultaneous across the dayside ionosphere (<2 minutes) (e.g., see [1], [2], [3]). By contrast, Cowley and Lockwood [4], supported by some radar and magnetometer studies, have suggested that convection pattern changes propagate with a velocity of 5 to 10 km/s across the polar cap. This propagation speed is controlled by the time it takes the magnetic field lines to be swept from the dayside reconnection site across the polar cap into the geomagnetic tail lobe.

Experimental Design

Figure 1 shows that the Halley SuperDARN HF radar and the recently commissioned Tasman International Geospace Environment Radar (TIGER) are favourably located for making comprehensive measurements of simultaneous day- and night-side convection changes. Halley beam 8 and TIGER beam 4 both point approximately southward down the magnetic meridian and have geomagnetic longitudes diametrically opposite the corrected geomagnetic pole. One of the radar beams can be used to measure the time for an IMF-driven convection change to start in the dayside ionosphere while the other can be used to measure the time for the convection change to reach the nightside ionosphere. Coordinated high time resolution (6-sec) discretionary campaigns using the two radars have been conducted since December, 1999. An example of an early result is shown in Figure 2.

Observations

Figure 2(a) shows that on February 12, 2000 at ~06 h UT the *Bz* component of the IMF swung from +9 1/2 nT to –13 nT during 29 minutes. Figure 2(b) shows that the line-of-sight Doppler velocities measured on Halley beam 8 during ~03 h MLT quickly changed from large approaching values (blue and black) to large receding values (green). Our best estimate of the time of this convection change is 0608 UT, as delineated by the thin vertical black line. Although we expect the line-of-sight velocities to gradually change from approaching to receding values in the early morning as the radar look direction shifts across the center of the dawn convection cell, the observed change was rapid and thus probably represented a large-scale reconfiguration of the convection pattern. Figure 2(c) shows that cusp-like scatter with large receding velocities (red) was detected in TIGER beam 4 during 16 h MLT. Our best estimate of the time at which the dayside convection pattern initially responded to the southward turning of the IMF is 0602 UT, or possibly earlier. An analysis of the full-scan data supports our basic interpretation of the single-beam time series data. Hence the convection change at ~(0322 MLT, 70°S AACGM latitude) started ~6 minutes after it first appeared at ~(1627 MLT, 75°S) in response to a southward turning of the IMF.

Conclusion

The finite time delay of the example shown in Figure 2 is consistent with the time it takes for the newly opened magnetic field lines to be swept from the dayside reconnection site across the polar cap into the tail lobe. However, it does not disprove the importance of other mechanisms communicating ionospheric electric fields at large scales, including slow- and fast-mode hydromagnetic disturbances propagating in the Earth-ionosphere wave-guide, the ionospheric duct, or the magnetospheric cavity. These competing mechanisms may have there own HF radar, magnetometer, or optical signatures.

In passing we note that the high-time resolution TIGER data reveals a very sharp nightside boundary between the large velocities and spectral widths of the magnetospheric convection and the slow westward drifts and narrow spectral widths associated with the main ionospheric trough. When the magnetospheric convection intensifies the plasmaspheric drifts measured by the digital ionosonde located at Bundoora, Victoria are seen to surge ~10 minutes latter in response to the prompt penetration fields of magnetospheric origin. We are in the process of compiling statistics for these events.

References

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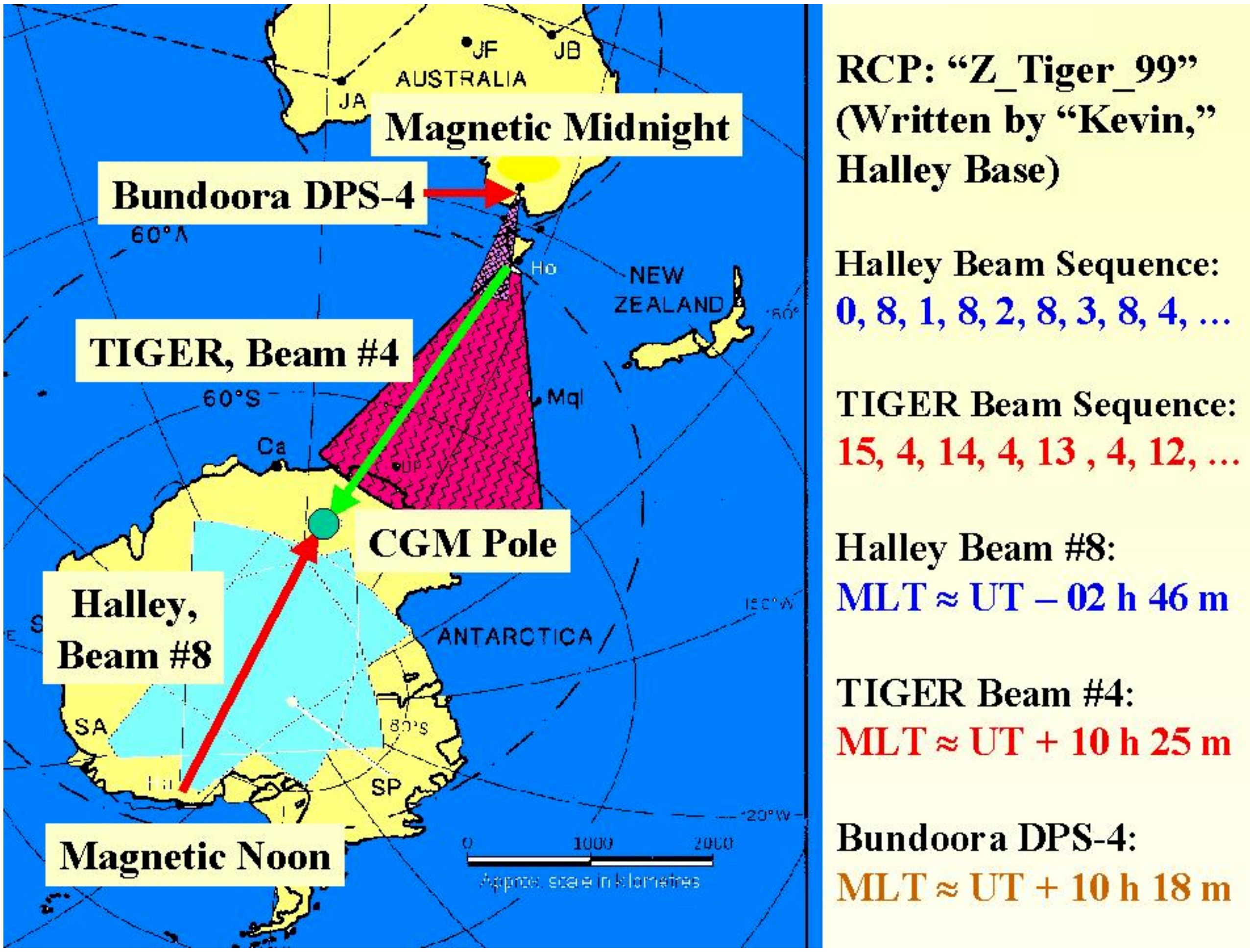

Figure 1: *Layout of the experiment designed to measure the time delay between the start of an IMF driven convection change in the dayside ionosphere and its manifestation in the high-latitude nightside ionosphere, and the subsequent penetration of magnetospheric convection fields into the plasmasphere.*

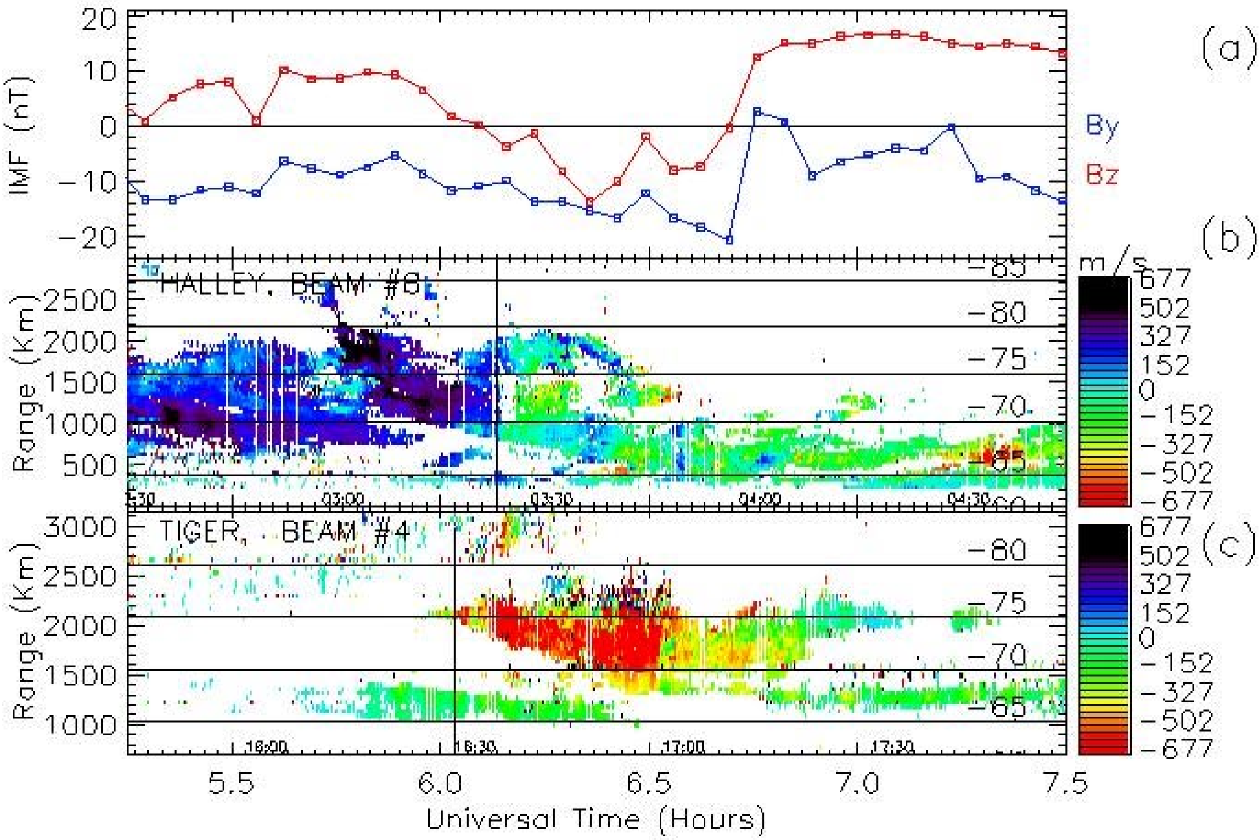

Figure 2: *(a) Four-minute averaged values of the By (blue) and Bz (red) components of the IMF measured on board the ACE spacecraft during February 12, 2000, 0515 to 0730 UT. The time series was advanced in time to correct for the propagation delay from the spacecraft to the magnetopause, but the correction has a nominal error of 10 minutes. (b) Line-of-sight Doppler velocities for Halley beam 8 for the same time interval as the IMF. (c) Similarly, line-of-sight Doppler velocities for beam 4 of TIGER. The Doppler velocities were color-coded blue to black for approaching velocities and green to red for receding velocities for both radars. The thin vertical white lines are brief outages caused by a bug in an early version of the radar control program. Velocities for sea echoes were rejected and tick marks are at 2-min intervals.*