Variability in the response time of the high-latitude ionosphere to IMF and solar-wind variations

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Abstract. The electric potential mapping across the high-latitude ionosphere increases under IMF B_z southward conditions, and is proportional to $-v_{sw}B_z$ for $B_z<0$ where v_{sw} is the solar-wind velocity and B_z is the *z*-component of the interplanetary magnetic field (IMF). Substantial changes in the orientation and magnitude of the IMF vector and solar-wind dynamic pressure, nv_{sw}^2, where n is the number density of solar-wind particles, are known to change the shape and size of the ionospheric convection patterns, and the speed of plasma circulating within them. B_z southward turnings arriving at the dayside magnetopause are very effective at changing ionospheric convection patterns because they increase the amount of geomagnetic flux opening to the solar wind. The initial ionospheric changes are known to first arrive in the noon-sector mapping to the dayside cusp, and then quickly propagate around the open-closed field-line boundary towards the midnight sector at phase speeds of ~1–10 km s^{-1} (viz., Cowley and Lockwood, *Ann. Geophysicae*, **10**, 103–115, 1992). Many early studies, most notably using EISCAT radar data, obtained results consistent with these phase speeds. However, the time delay for the high-latitude ionosphere (and indeed, the low-latitude ionosphere) to initially respond and subsequently consolidate to changes occurring in magnetospheric boundary layers is still an active field of research. A number of studies since the late 1990s have reported SuperDARN HF radar and ground-based magnetometer observations which apparently show "the ionospheric response to changed IMF is globally simultaneous on time scales of a few minutes" (Ruohoniemi et al., *J. Atmos. Solar-Terr. Phys.*, **64**, 159–171, 2002). There can be little doubt these observations show the high-latitude ionosphere can sometimes respond far more quickly than previously thought, especially in the afternoon to dusk sector. However, we discuss difficulties with the interpretation of recent observations, and the need to obtain new and unequivocal results validating global simultaneous responses. For example, initial results obtained with the Halley and TIGER SuperDARN radar pair located diametrically opposite the corrected geomagnetic pole (i.e., separated by ~12 h of MLT) are consistent with the finite response times as per the earlier EISCAT studies, but we anticipate future analyses of other Halley-TIGER observations may reveal ionospheric responses communicated at much faster magnetosonic speeds. Lastly, there is no theoretical reason demanding an universal, rapid response time applicable to the ionosphere under a broad range of geophysical conditions. Thus we attempt to reconcile the variability in the observed response times by invoking the consequences of variability in ionospheric conductivity, the extent of field-line draping across the magnetopause, and the location of reconnection sites given by the anti-parallel merging hypothesis.