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Dipole Tilt Effect on the Reconnection X-Line and its Impact on the Ionosphere in Global Magnetospheric Simulations

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Magnetic reconnection is a key driver of magnetospheric dynamics at Earth. Although locally magnetopause reconnection appears as a quasi-2D process with a well-defined X-line and inflow/outflow regions, the full 3-D nature of reconnection is much more complex, occurring predominantly along the magnetic separator: a continuous line along which differing magnetic topologies meet and which is terminated by magnetic null points.

The global reconnection rate (i.e. reconnection voltage) is determined by the length of the separator and the parallel electric field along its extent, both of which are highly sensitive to changes in driving conditions. Under steady-state and in the absence of parallel electric fields within the magnetosphere, this voltage maps down as the ionospheric cross-polar cap potential (CPCP). Diurnal and seasonal variations in dipole field orientation (and hence the location of the separator) can therefore directly affect ionospheric conditions, and the potential impact of a severe space weather event. Understanding the response of the separator to changes in dipole tilt is thus crucial in fully describing the factors which control the coupled magnetosphere-ionosphere system.

Using the Gorgon MHD code, we have implemented an algorithmic approach to tracing out the separator in global magnetospheric simulations. The location of the separator for various interplanetary magnetic field orientations and dipole tilts is identified, and thus the impact on energy transfer rates across the magnetopause. We investigate changes in the strength and morphology of the ionospheric region-I field-aligned currents and convection patterns, revealing a non-linear dependence of CPCP on dipole tilt. We show that for southward IMF the CPCP reaches a maximum at northern/southern summer, and explain this in the context of varying separator geometry by comparing to the reconnection voltage. This demonstrates a strong sensitivity of the magnetospheric response to the onset time of a given severe space weather event, due to changes in the location of the separator on the magnetopause.