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Ionospheric Variability: Predictability of the Magnetosphere and Lower Atmosphere Driven Components

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Ionospheric variability arises from processes driven by both the magnetosphere and lower atmosphere, and internal instabilities that are possibly chaotic. Both are mathematically deterministic, the question is are they predictable, and how far in advance.

Ionospheric processes driven by the magnetosphere, are to a large extent driven by the variable output from our Sun. It is hard to predict the timing of the launch of a coronal mass ejection (CME) from the Sun, or if it is likely to strike Earth, or the solar wind conditions on arrival. After observing the solar wind conditions at L1 the ionospheric response follows within an hour or two. How the upper atmosphere responds is reasonably well understood and predictable. A longer-term forecast, one to three days or longer, relies on the predictability of the timing of the CME launch, and how well its passage from Sun to Earth can be modeled or monitored.

The lower atmosphere also has clear imprints on the upper atmosphere and ionosphere. For instance, the longitude structure of tropical convection, sudden stratospheric warmings, and tidal amplitudes driving the electrodynamics all have potentially predictable consequences in the ionosphere and are reasonably well understood and modeled. Lower atmosphere dynamics is undoubtably chaotic, but ten-day tropospheric weather forecasts are commonplace, and are surprisingly good compared to space weather forecasts. This lower atmosphere driven component is therefore potentially more predictably than the magnetospheric component with a longer forecast times possible. Neither of these magnetospheric or lower atmosphere forcing mechanism are necessarily chaotic.

The chaotic nature of the ionosphere is often invoked for the growth of ionospheric irregularities at low latitudes. Certainly, the background conditions have to be right, and there has to be a trigger, but whether they are chaotic or not has yet to be determined. If the background conditions are known, such as the plasma drifts and neutral winds, can one say with certainty if irregularities will spawn? Possibly yes, but this remains an open question.