Characterizing and Modeling the Sources of Ionospheric Variability Impacting Radio Wave Propagation

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Ionospheric variability impacting radio wave propagation can be driven by changes in solar extreme ultraviolet (EUV) radiation, geomagnetic activity, the spectrum of lower atmosphere waves propagating from below, and internal instabilities. The neutral upper atmosphere response to EUV change is relatively slow, about a day, but the D, E, and F-region ionospheric plasma responds within seconds to minutes. The total electron content responds more slowly as plasma gradually fills the topside and plasmasphere. The magnetospheric sources responsible for geomagnetic activity drive the ionosphere through several pathways: direct auroral precipitation, transport by the convective electric field, and the impact of the storm neutral wind system pushing plasma along the magnetic field, changing neutral composition and loss rates, and driving a disturbance dynamo. Some of the biggest changes in plasma density during a geomagnetic storm appear to come from expansion of the magnetospheric convection to mid and low latitudes at a time when the atmosphere is still sunlit. The combination of stagnation and vertical motion can lead to huge increases in plasma density. The spectrum of waves from the lower atmosphere also has significant impact on the ionosphere. The day-to-day and multiday tidal variability, both migrating and non-migrating, drives neutral winds changes in the dynamo region altering the strength of equatorial electric fields, the ionization anomaly, and longitude structure. The rich wave spectrum also includes gravity waves at shorter periods, which drive the ionosphere directly and which likely modulates the day-to-day occurrence of ionospheric irregularities. The range of ionospheric variability affects radio wave absorption, satellite communications, navigation accuracy, and HF propagation paths.