How does the Morphology of the Aurora Affect High-Latitude Plasma Irregularities?

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The morphology of the aurora is determined by the properties of the high-latitude energetic particle precipitation that causes it. These properties are in turn dictated by the precipitating particles themselves, be they ions or electrons, soft or hard. The occurrence of high-latitude plasma density irregularities are driven by density gradients and electric field modulations, both of which are strongly affected by the aurora. However, precipitating particles can affect the entire ionospheric altitude column, meaning that the coupling between the ionospheric E- and F-regions can become important.

The present study is concerned with the effect of ionospheric electrodynamics on the occurrence of F-region density irregularities. High-energy particles can strongly ionize the E-region, while softer particles can do so for the F-region. The ratio of E- to F-region conductance is an important parameter controlling the plasma irregularity dissipation rates at high altitudes, and so the aurora takes on an important moderating role: the morphology of the aurora can directly influence the rates with which plasma irregularities dissipate. This effect has been pointed out before, but direct investigations into its nature are exceedingly difficult, since they involve ionospheric conductivity measurements. We apply a fast algorithm for calculating altitude-dependent ionization profiles based on \textit{in-situ} particle detector data from the Defense Meteorological Satellite Program (DMSP). The resulting ionization curves (of which we show an example in Figure 1) can be analyzed to estimate the ratio of E- to F-region conductance, given the absence of solar photoionization.

We perform the ionization profile estimation algorithm on 70 million precipitating particle spectra from the DMSP F16, F17, F18, and F19 satellites, for both hemispheres. We compare the resulting electrodynamic climatology of E- to F-region conductance ratio with a climatology of density irregularities as measured by the European Space Agency’s Swarm mission. We find that the E- to F-region conductance ratio exhibits clear dawn-dusk asymmetries that are directly associated with asymmetries in the aurora. Here, high-energy precipitation in the dawn-sector is an important moderating factor, resulting in dawn-dissipation rates that are typically five times greater than in the dusk sector. We discuss the implications for the occurrence of F-region density irregularities. We discuss the role of E-region density irregularities in relation to the above, and whether they are viable to cause GNSS scintillations in the absence of an ionized F-region. We find that there is a considerable flux of highly energetic ions that is missing in the dusk sector from the DMSP particle detector data, due to the sensitivities in the SSJ instrument. We estimate the magnitude of this missing ion flux by comparing the dusk-side irregularity climatology to that of the dawn-side, where the high-energy ion precipitation is negligible. Our results highlight the importance of ionospheric electrodynamics on regulating F-region irregularities. The tools applied in the present study has a wide range of potential applications, as conductance ratio estimates can be of great utility to the community.

Figure 1: Example ionization profiles, based on particle detection data from DMSP F18 at 10:18 UT on 24 October 2014

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