

Radio propagation systems have to cope with plasma properties encountered along ray-paths within the ionosphere. Both large-scale spatial gradients and small-scale irregularities affect reliable use of radio systems for communications and navigation. Some of the most severe horizontal gradients within the ionosphere are caused by magnetospheric processes. One example is the inner magnetosphere's plasmapause. This feature has as its ionospheric signature the equatorward wall and minimum of the F-layer's main (sub-auroral) trough in electron densities and total electron content (TEC). Satellite-based radio diagnostics revealed that the gradients associated with the trough's equatorward and poleward boundaries are strongly altitude dependent. Such "topside sounder" observations can be made only along a satellite's orbital track, and thus longitudinal consistency of trough signatures must come from other means. Maps of TEC from ground-based networks monitoring GNSS signals extend trough coverage in longitude (local time). Yet, depending on the spacing of the terrestrial receivers, accurate specification of trough gradients and locations can be under-estimates of the actual gradients.

This paper deals with the use of simultaneous GPS TEC maps, orbital *in-situ* observations from DMSP satellites, and ground-based optical imaging stations to explore plasmapause locations and gradients during a moderate geomagnetic storm. The case study deals with the period 26-27 September 2011, using GPS maps over Europe, together with all-sky-imager (ASI) and DMSP data sets in both hemispheres. The contraction of the plasmapause and the inward movement of the plasma sheet – resulting in severe ionospheric gradients—are captured in ASI systems by their optical signatures. The plasmapause-ring current location can be specified by the L-values of the stable auroral red (SAR) arcs they produce, while the equatorward edge of the diffuse aurora specifies the inner L-value of the plasma sheet. For the September 2011 event, these boundaries at mid-latitudes were observed for 24-consecutive hours via the sequential use of three optical sites: Asiago (Italy), Millstone Hill (MA) and Mt. John (New Zealand).

Finally, the calibrated brightness levels of SAR arcs offer a way to estimate the magnetospheric heat flux into the thermosphere—both in magnitude and location—energy sources not yet included in global models of the ionosphere-thermosphere system. Similar estimates for plasma sheet precipitation fluxes can be made from the brightness levels of the diffuse aurora captured in the same images.