Modeling Storm-Time Plasma Stuctures

Tim Fuller-Rowell[1], Naomi Maruyama[1], Mariangel Fedrizzi[1], and Phil Richards[2]

[1] CIRES University of Colorado and NOAA Space Weather Prediction Center, Boulder, USA.
(E-mail: tim.fuller-rowell@noaa.gov)

[2] George Mason University, Farfax, USA.
(E-mail: pgrichds@gmail.com)

ABSTRACT

One of the significant storm-time ionospheric structures is the build up of plasma at mid latitudes during the early phases of a geomagnetic disturbance, now referred to as storm enhanced density (SED). When viewed by an ionosonde the SED is seen as an increase in NmF2. However when observed by ground or space-based upward looking, dual-frequency GNSS instruments, the increase to total column electron content (TEC) can appear much more dramatic. For example, a 50% increase in NmF2 might be seen as a factor four increase in TEC. This difference in the apparent response has implications for the vertical structure; space-based GNSS observations suggest that the plasma is "stored" in the topside ionosphere. Several questions emerge: What is the vertical plasma structure of these features? Where does the plasma come from? What is the relationship between the increased plasma density at mid latitude and the changes in the location and magnitude of the equatorial ionization anomaly (EIA)? Why does the SED appear to have such a strong local time dependence, where it is strong in one longitude/local time sector yet not in the longitude sector just 30 degrees to the west (just two hours different in LT). The challenge of physical models is first to be able to recreate the feature; then the physical model can be used to answer the posed questions. Understanding the physics will help to predict which longitude sector will be impacted by a storm if the UT start time is known from the predicted solar wind arrival. Understanding the physics will also help to model the vertical structure, which will impact the likely lifetime of the positive phase. Later in the evolution of a storm the rather localized positive phase is replaced by a negative phase, often over a wider geographic region. The impact on GNSS is then less severe during the negative phase, but if the F-region ionosphere is severely eroded, HF propagation will no longer have a suitable reflecting layer to operate. Again understanding the physics and being able to model the response can help in mitigating some of the potential impacts on users.

Key words: geomagnetic storm, ionosphere, physics-based modeling, storm enhanced density,

negative phase