Project Details

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Topic: Understanding Physical Processes in the Magnetosphere--Ionosphere / Thermosphere / Mesosphere System During Extreme Events

Project Title:
Ionospheric Response to Super Storms and Its Role in Geospace Coupling

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Summary:
Geomagnetic storms produce significant changes in the ionosphere. The equatorial ionization anomaly (EIA) becomes enhanced, with its crests moving poleward and its peaks becoming larger. In the mid-latitudes, typically following a significant uplift in the height of the F-layer, a large increase in the electron density is observed. A plume of storm enhanced density (SED) can form with its base in the mid-latitudes and can extend into the polar region. Associated with this plume are sharp gradients in the electron density that can cause scintillation and degradation of radio signals. These ionospheric storm time features are encompassed by what is known as the positive storm phase. Several hours after storm commencement, associated with changes in thermospheric composition and neutral winds, a prolonged depletion of the ionospheric electron density, known as the negative storm phase, is observed. This phase can last from a few hours to a few days. Storm-time electric fields play significant roles in producing these effects, and they can be generated by the disturbance wind dynamo and/or by the magnetospherically-imposed electric fields such as the penetration electric field or the sub-auroral polarization stream (SAPS). Which mechanism plays the dominant role is not well understood and may depend on the size of the geomagnetic storm in addition to season, time of storm onset, and solar activity. How these " typical " storm-time features are modified during superstorms is the key question that this proposal will address.

Our goal is to illuminate the role of these mechanisms during ionospheric superstorms and to better understand the coupling between the magnetosphere and ionosphere and between the thermosphere, ionosphere, and mesosphere. Using multipoint and multi-instrument observations during superstorms and other storms, we will explore: the development of SAPS and the associated SED feature; the formation of the equatorial super-fountain; the relationship of the thermosphere density and winds to strong SAPS; the launching of large scale traveling ionospheric disturbances (LSTIDs) from the polar regions; temperature and wind changes in the mesosphere-lower thermosphere region; and the length and duration of the ionosphere " s recovery from superstorms. We will also evaluate the potentially huge deviation of the ionospheric parameters during superstorms from empirical data models.

The types of data that will be used for storm analysis include: 1) two-dimensional global electron content data that will be produced from ground-based and space-based GNSS receivers; 2) regional observations of the ionosphere by SuperDARN, Fabry-Perot interferometers, and incoherent scatter radars; and 3) in situ data by DMSP and TIMED/GUVI, and potentially by ICON and GOLD. MIT Haystack ground-based TEC maps are available from the year 2000 on. For selected storm periods, low earth orbiting (LEO) satellite data will be merged into our routine TEC data product. These data will be used to study a range of storm-time ionospheric features at equatorial, midlatitude, and high latitudes.

Our proposed contributions to the focus team effort will include providing multiple data sets, e.g. ISR data, DMSP data, TEC ground maps, LEO-TEC observations, FPI data, for superstorm (mostly in 2001-2004) and other major storm periods. The data can be used to verify simulation results and to examine the limits of state-of-the-art models for superstorm events. Model-data comparisons can also provide more insight into our physical understanding of superstorm features. In addition, our analysis of ionospheric superstorm effects will be brought to the team, and we will use the modeling capabilities of other team members to study the role of the ionosphere in geospace coupling. Of particular interest is the simulation of SED/TOI, the role of SAPS in shaping SED, and the influence of SAPS on the local and global thermosphere and ionosphere.

Publication References:

no references