Understanding Storm Time Poynting Flux Variability

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Background

Geomagnetic Storms
The solar wind (V_sw) plasma (n) carries the Interplanetary Magnetic Field that, when field polarity (Bz) is southward, couples with the Earth’s northward geomagnetic field at a point on the day side magnetopause.

The coupling and subsequent transfer of energy to the magnetosphere increases plasma motion, resulting in increased electrical current in the magnetosphere and ionosphere.

When coupling is strong, plasma convection in the magnetosphere is enhanced and a ring current forms around the Earth’s equatorial region. A geomagnetic storm, therefore, is a time of increased geomagnetic disturbance over the entire magnetosphere.

Disturbance Storm Time
Storms create geomagnetic disturbances in the Earth’s magnetic field. The level of the disturbance is measured by the Disturbance Storm Time index (Dst).

Poynting Flux, Auroral Precipitation, Hemispheric Power Index
Poynting Flux (S_e) and precipitating energetic electrons (J_e) within the auroral oval deposit energy into the ionosphere. Hemispheric Power (HP) is the integrated J_e energy over the hemisphere.

Joule and Auroral Heating
S_e results in Joule heating that dissipates energy in the ionosphere. Precipitating J_e collide with neutral and ionized gases in the auroral regions. Both result in heating and expansion of the ionosphere/thermosphere.

Why Is This Important?
Geomagnetic storm effects cause drag on spacecraft, resulting in orbital perturbations and difficulty in tracking and predicting their orbital paths.

Lack of understanding of geomagnetic storm energy deposition into the thermosphere by auroral heating processes diminishes the ability to accurately predict spacecraft orbits that are affected by heating and expansion of the ionosphere during and after storms.

Data and Methods
- Dst, Kp data for all days during 2000-08 were collected from WDC for Geomag., Kyoto. Large and super “classic” storms were isolated according to criteria.
- S_e, J_e, HP data were collected from the DMSP database.
- Bz, V_sw, n data were collected from the NASA OMNI database.
- Using IDL programs, hourly averages of storm time parameters for large and super storms were plotted to identify temporal and spatial variability.

Results

Conclusions and Future Work
- Typically for all storms, V_sw and n increased and Bz became strongly southward. Dst became negative upon Sudden Storm Commencement (SSC) and decreased to a minimum (Dst_min) (P1).
- S_e peaked at Dst_min, indicating that energy deposited by S_e per square-meter increased (P2, P3, P4).
- Energy deposited by J_e did not increase, though HP increased, indicating that the area of the auroral oval increased (P2).
- S_e from Central and Boundary Layer Plasma Sheet regions (on closed field lines) was enhanced between SSC and Dst_min (P3); enhancement from the Mantle, Cusp, and Polar Rain regions (on open field lines) was significantly more enhanced (P4).
- Research is needed to better understand larger S_e on open field line regions than on closed field line regions.
- Research is needed to understand the observed secondary peak in S_e for open field line regions (P4).
- It is desired to develop an empirical model of S_e to be used as an input for ionosphere modeling.
- Mapping S_e spatial variability will validate temporal variability and provide a basis for empirical modeling.
- Study of more storms with larger Dst (>93 nT) will provide better statistics.

Research Goal
To explore the relationship between S_e and Dst. It is known that the energy deposited by S_e is greater during storms; spatial and temporal variability are less well understood.

Understanding storm time S_e variability would result in improving accuracy of orbital track prediction for spacecraft during and after geomagnetic storms.