Project Details

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Selection Year: 2020
Program Element: Focused Science Topic

Topic: Long Term Variability and Predictability of the Sun-Climate System

Project Title:
Determining the net solar and magnetospheric electron energy contributions to Earth's atmosphere by precipitation mechanism

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Summary:
Electron precipitation is a primary component of Magnetospheric-Ionospheric-Thermospheric-Mesospheric (M-ITM) coupling and therefore one of the primary means through which solar input affects the atmosphere. The mechanisms resulting in this precipitation, mainly direct solar input, wave scattering and acceleration by quasi-static potential structures (QSPS, inverted-v) or Alfv n waves, cause dramatic differences in the electron energies and isotropies precipitating. This causes different atmospheric results and can vary by solar rotation period, season and solar cycle. Determining the relative contributions of the various mechanisms has been a crucial but elusive goal. Further, FAST spectra analysis, Dombeck et al. [2018], found that multiple mechanisms occur in the same event 65-70% of the time.
We propose to determine the amount of energy flux contributable to each of the primary mechanisms in most cases, including multiple mechanism events, for intense events and for a significant amount of the weak ones and how they vary over solar rotation, season and an entire solar cycle. We will also investigate the number flux contributable to each mechanism and investigate the trends of mechanisms for weak precipitation.

Specifically, our science goals are:
1) Determine the amount of net energy flux contributable to direct solar input, electron wave-scattering, quasi-static and Alfv nic acceleration and weak precipitation by solar rotation period, season and dependence on solar cycle;
2) Determine the trends in energy contributions by mechanism under different conditions by intensity to infer relative importance of the different mechanisms in weak precipitation;
3) Investigate the net number flux contributions by mechanism by solar rotation period, season and dependence on solar cycle.

The study directly relates to the goals of FST #4 Long Term Variability and Predictability of the Sun-Climate System in that it characterizes one of the primary sources of solar input into the atmosphere on the scale of weeks to years. It improves our understanding of how solar variability and solar-driven geomagnetic variability lead to or alter atmospheric structure and coupling by providing an understanding of one of the key atmospheric inputs, directly investigates the dynamics of the M-ITM system which affects inputs to the lower atmosphere, and determines how the different precipitation mechanisms couple solar energy to Earth. It is critical for the FST as they provide inputs for models of how upper atmospheric input affects lower levels.
To address these goals, the full 2d electron distributions (2dED), not just spectra, of the entire ~13 year FAST mission (> a full solar cycle) will be analyzed to determine which mechanism(s) are occurring, the temperature and density of the source (solar direct or wave scattered) population, and the potential drop of any QSPS. With this information several interrelated models for electron precipitation and backscatter will be used to determine the amount of net energy flux contributable to the sources and QSPS. The Alfv nic contribution is then the remainder. The 2dED provide the ability to more accurately identify the precipitation mechanisms and for weaker events than the spectral methods and can be used to determine their characteristics. The energy flux attributable to the different mechanisms will then be analyzed for variability by solar rotation period, season and solar cycle.
The models to be extended and then used include: an empirical model for backscatter spectra; two partially-coupled ensemble partial tracing models for the magnetosphere and a thick ionosphere that produce 2dED that can be directly compared with the FAST data; and a physics-based model for the effects of reflection of the backscatter by QSPS.
The number flux contributions highly depend on the differential fluxes of low energy electrons which are less accurately modeled results in higher uncertainty.

Publication References:

no references