Characteristics of Auroral Precipitation based on DMSP observations

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Abstract

Energy input into the Earth’s upper atmosphere via the magnetosphere is the driving force of the formation of the auroral oval. It is composed of precipitating energetic ions and electrons. The conductivities are highly dependent on the particle precipitation. The ion convection together with the conductivities define the energy input known as Joule heating. Strong auroral precipitation and fast ion convection are produced by strong solar storms. Careful alignment of the regions of high electron-energy flux and fast ion drift velocities can optimize these effects. Therefore, this alignment is essential in numerical models. The results from the Defense Meteorological Satellite Program’s (DMSP) Precipitating and Electron Ion Spectrometer (SSJ/4) were used in a study of the relative positions of the peak auroral electron energy fluxes in the Earth’s upper atmosphere. The SSJ/4 sensor was carried by the DMSP F13 satellite following a sun-synchronous, dawn-dusk orbit. SSJ/4 recorded the electron and ion particle fluxes between 30 eV and 30 keV every second. Three months of data (January-March) from the 2005 DMSP archive were smoothed over 25 second averages. These results were plotted to analyze trends in the relative location and magnitude of the peaks in electron energy flux and their corresponding 1/e poleward and equatorward fall-offs values. A Gaussian fit was then applied to the peaks between the fall offs. OMNI data was used to calculate the average IMF conditions for each pass. Accordingly, the electron energy flux peaks were binned with respect to particular IMF conditions. Through comparing the alignment of these relative peaks in electron energy flux with those of the ion drift, regions of optimum energy input can be located and used for input into the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIEGCM). Further analysis using the remaining DMSP data from 2005 in combination with ion drift data from the Ion Driftmeter (IDM) must be done in order to quantify the relationship.

SSJ/4 Data Analysis

1. Comparisons of Energy Flux, Mean Energy, and Conductivities
   - Gaussian curves applied between 1/e fall-off values:
   - Peaks in mean energy <E> correlating to peaks in electron energy flux suggest a possible relationship between the two.
   - Peaks in electron energy flux correlate to peaks in the conductivities

   Fig.4: Comparison of (from top) electron energy flux, mean energy and conductivities shown with corresponding MLT and MLAT

2. Comparisons of electron energy flux with varying Bz conditions
   - The mean electron flux is binned by Bz positive, Bz negative moderate, and Bz negative extreme conditions.
   - As Bz becomes more negative, the mean energy flux increases.
   - Peaks in energy flux appear shifted towards midnight

   Fig.5: Comparison of electron flux activity with varying Bz conditions.

   Fig.6: Shows ratio of Gaussian fitted curve (top), peaks in electron energy flux activity, and the MLAT data (bottom) binned by Bz negative conditions.

Further Studies

- Integrating results with Ion Driftmeter data
- To compare relative peak positions of electron energy flux with those of Ion drift
- Alignment of relative peak positions of ion drift and energy flux will give regions of optimum energy
- Creating a circle plot with energy flux peak and fall off data to compare with that of the ion drift (below)

Calculate Electric Field using Ion Drift Velocity and Magnetic Field from the International Geomagnetic Reference Field (IGRF):

Eventually, calculate Joule heating using Pederson Conductivities and Electric Field:

Conclusions

- Small MLAT delta h values tend to correspond to large electron energy peaks and large MLAT delta h values tend to correspond to small peaks. This suggests sharp fall-offs for large peak values and a slower, more gradual fall-off for smaller peaks in electron flux.
- Trends show the average electron energy flux often peaks at pre-midnight
- Further study using more data and considering various geophysical conditions must be considered in order to verify these results and to make a complete survey of all 15 years of DMSP data

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