Characteristics of Auroral Precipitation based on DMSP observations

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NCAR

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-off 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.

DMSP

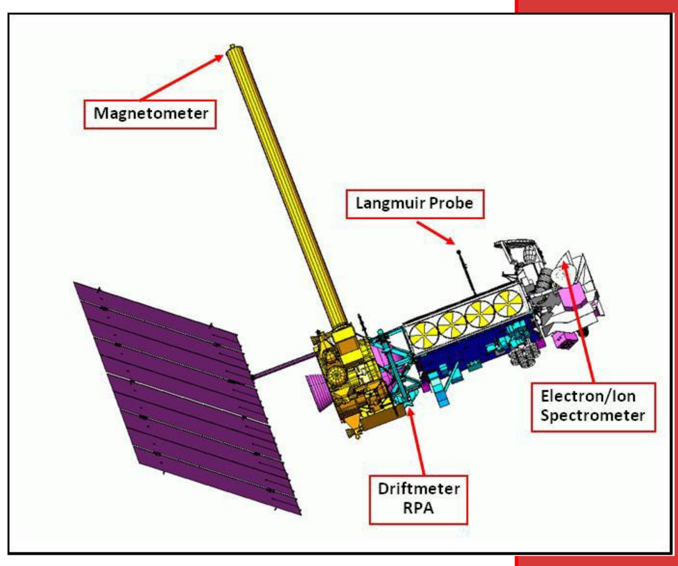
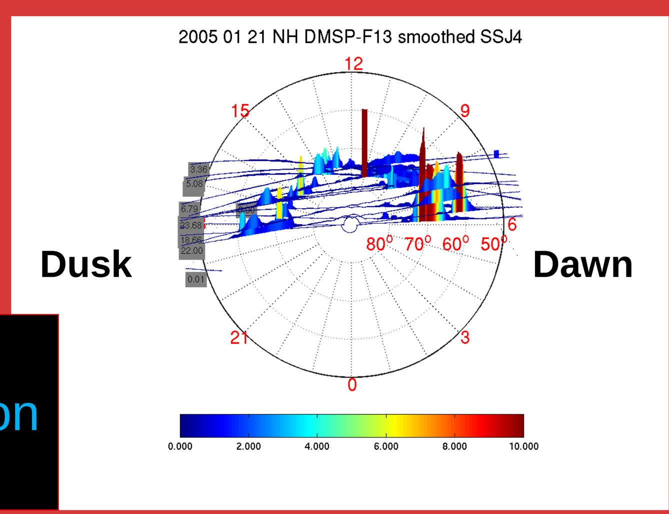


Fig.1: Shows configuration of the DMSP F13 satellite

- Ion Driftmeter (IDM)
- Precipitating and Electron Ion Spectrometer (SSJ/4)

Geomagnetic storm occurred on this day

DMSP passes follow sun synchronous, dusk-dawn orbit from 0600-1800 LT



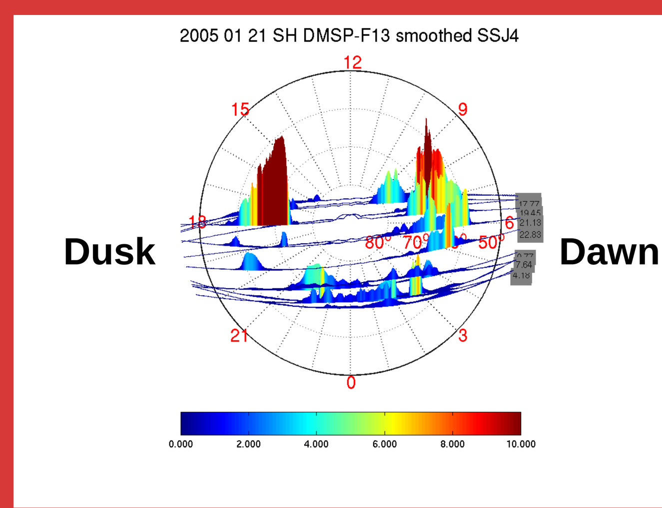


Fig.2: Total DMSP F13 passes for one day in the Northern Hemishphere (left) and Southern Hemisphere (right). Plots smoothed 25 second averaged electron energy flux data

OMNI

- 5 minute data
- Used to calculate average IMF conditions
- Compensate for travel time between Omni measurement and ionosphere by averaging data between 5-20 minutes before time considered

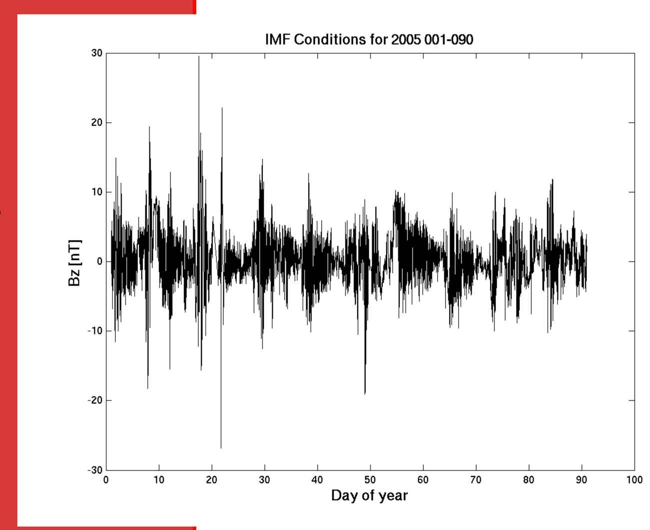


Figure 3: Displays the -Bz conditions for the first three months of 2005

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

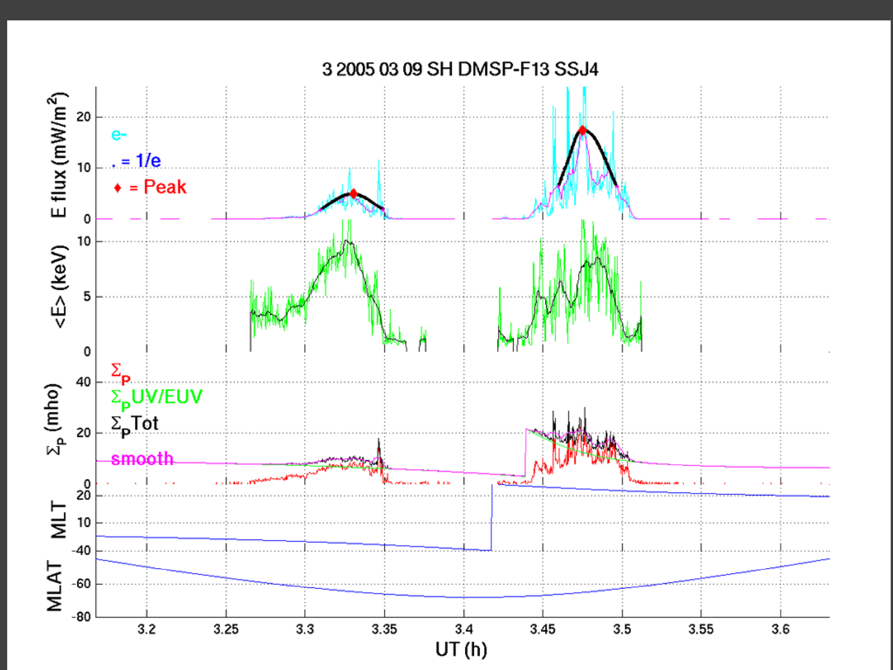


Fig.4: Comparison of (from top) electron energy flux, mean energy, and conductivities shown with corresponding MLT and MLAT

Mean Energy: Corresponds to how deep the energy penetrates into the atmosphere

Electron Energy Flux: Corresponds to how much energy comes into the atmosphere

1. 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

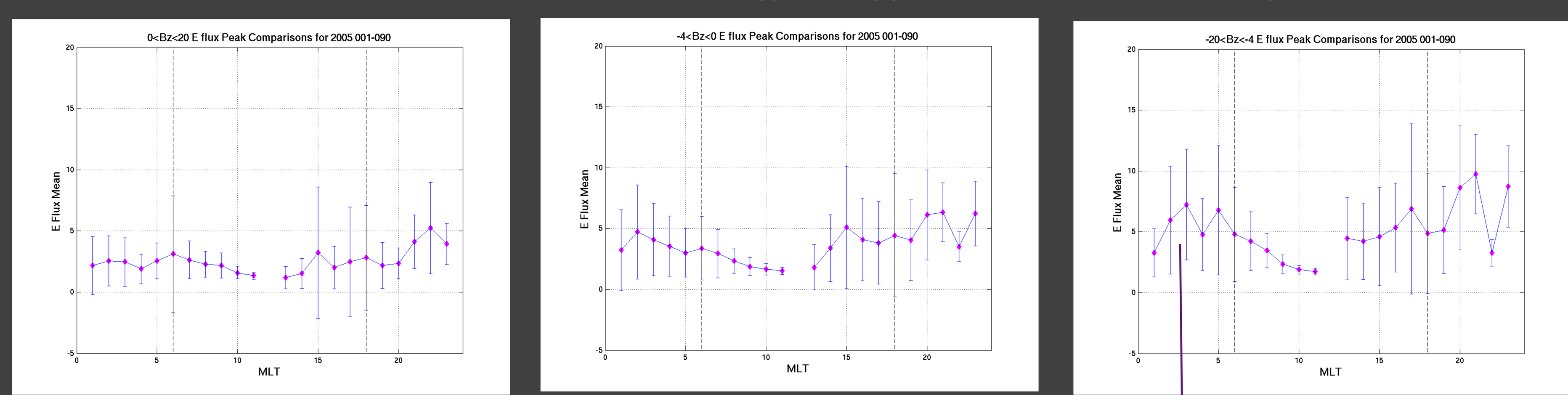


Fig 5: Comparison of electron flux activity with varying Bz conditions.

The MLAT delta h which is the half-width distance from the peak to the 1/e fall-off value is plotted (bottom). This value seems to be smaller for larger mean E-flux peak values (Fig. 5).This suggests smaller peaks are associated with a slower fall-off along the auroral oval, and larger peaks are associated with a sharper fall-off.

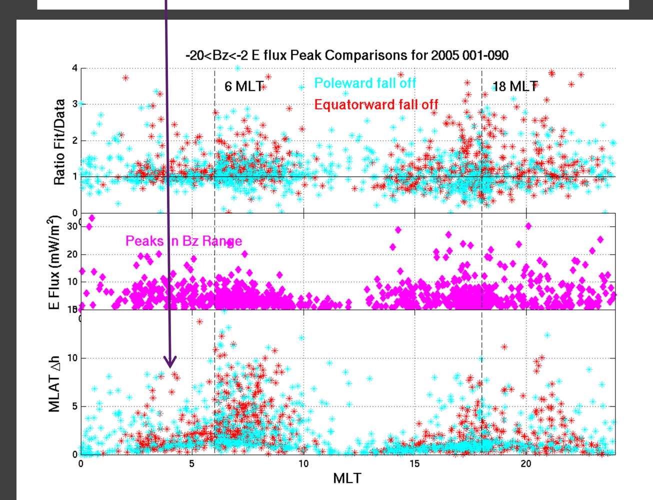


Fig. 6: Shows ratio of Gaussian fitted curve (top), peaks in electron energy flux (middle), and the MLAT delta h (bottom) binned by Bz negative conditions

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)

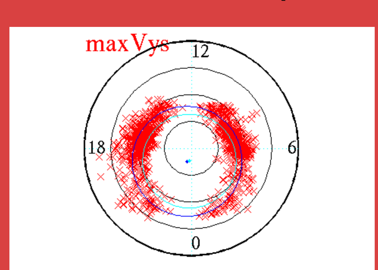


Fig.5: Peak ion drift values for Northern and Southern Hemisphere for first three months of 2005 for Bz,|By|=-1.4,0.6nT

Calculate Electric Field using ion drift velocity and Magnetic Field from the International Geomagnetic Reference Field Model (IGRF)

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

$$q_j = j\,E = \Sigma_P * E^2$$

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

Acknowledgements

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