Estimating Precipitating Electron Energy Flux using Field Aligned Current Measurements from AMPERE

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Introduction & Objectives

Energy that is released during solar storms through radiation and energetic particles can be deposited into Earth’s upper atmosphere, altering its structure and physical properties. For many years, global optical imaging of the aurora was used to compute the energy deposition caused by auroral precipitation; however, there are no longer any satellites in operation that can provide us with this kind of data. This study aims to obtain a quantitative measurement of the energy transferred by incoming auroral electrons using field aligned current (FAC) measurements.

Data & Methodology

Spatially and temporally continuous FAC data was provided by the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE), a constellation of 66 satellites. Far ultraviolet (FUV) auroral emission data was provided by the Global Ultraviolet Imager (GUVI) on the Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite. Using the relation found by *Zhang and Paxton* (2008), FUV data in the Lyman-Birge-Hopfield bands (LBH-Long and LBH-Short) was used to compute energy flux which was then compared to the AMPERE data. Statistical analysis was preformed on more than 400,000 simultaneous and coincident points of GUVI-TIMED and AMPERE measurements.

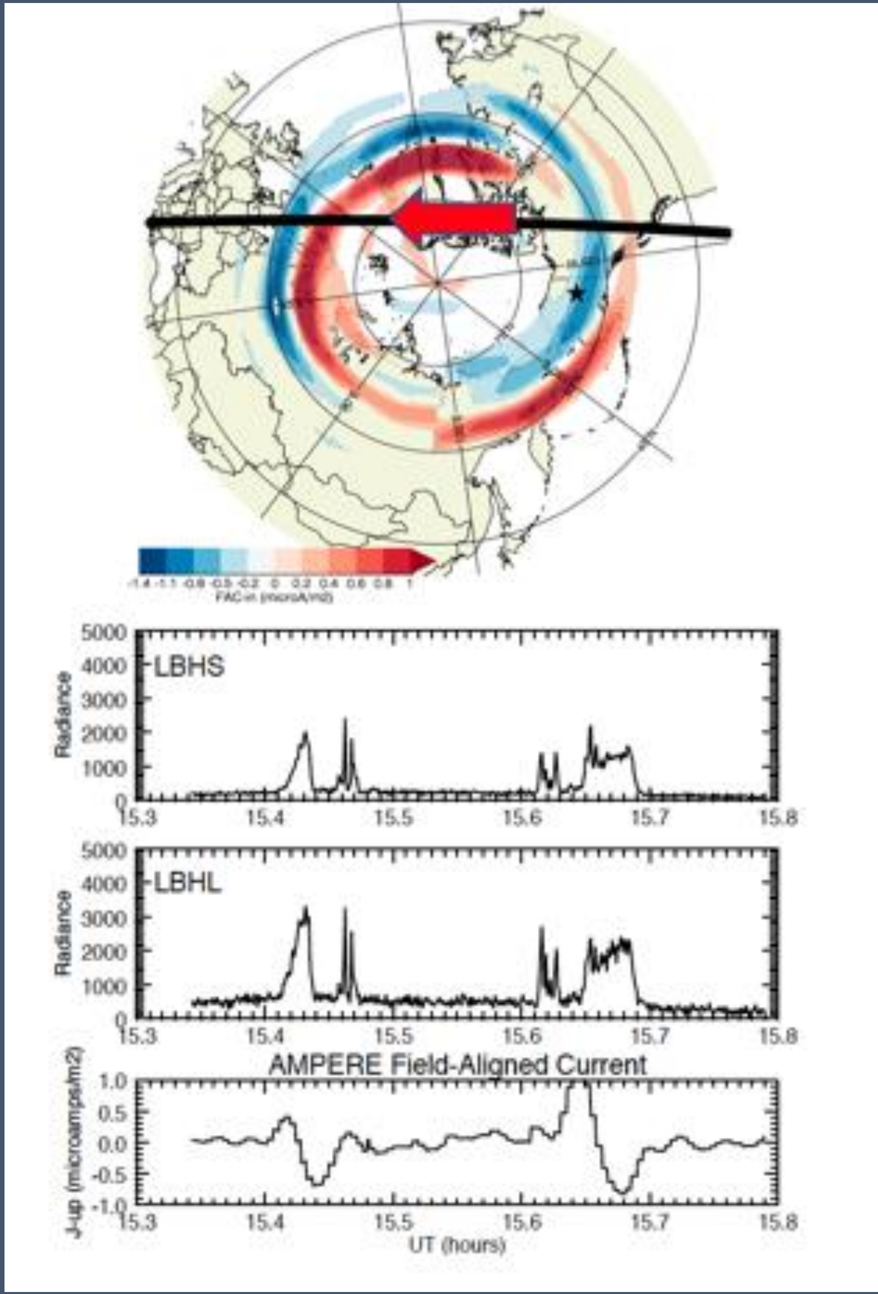

Figure 1. Top plot shows the TIMED satellite path over a global map of FAC measurements provided by AMPERE. The red arrow denotes the direction of the satellite. The bottom three plots show simultaneous and coincident AMPERE and GUVI measurements. Qualitatively, there appears to be good correlation between peaks in the LBHL and LBHS bands and both upward and downward FACs.

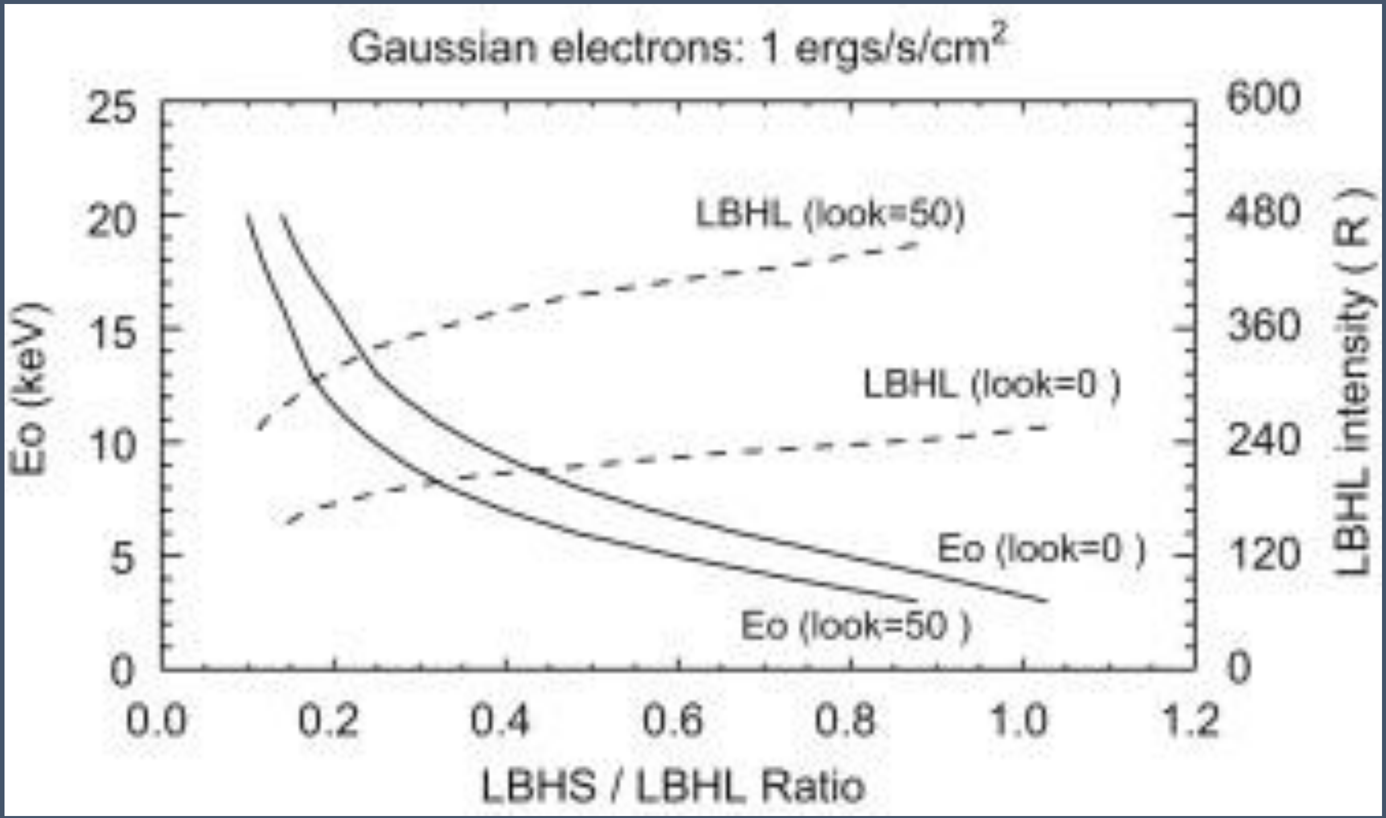

Figure 2. Relation between FUV measurements and energy flux from *Zhang and Paxton* (2008). The look angle for GUVI is now fixed at approximately 47° from nadir, so the relation for look=50 was used for this study.

Results

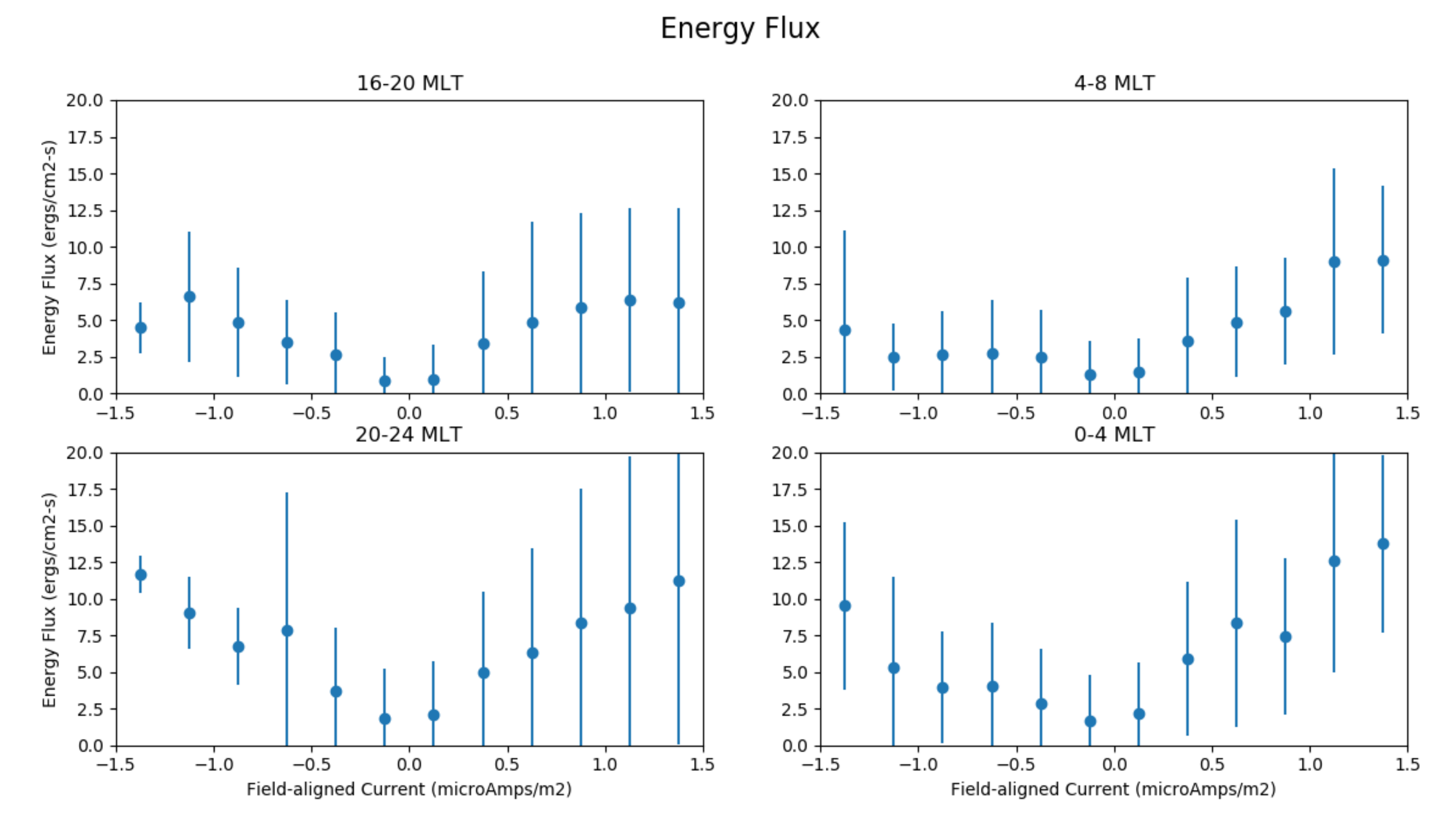

Figure 3. Comparisons between FAC measurements and energy flux in four different magnetic local time sectors. Our 400,000 data points were binned over FAC every 0.2 µAmp/m^2. The mean of each bin is represented here with the error bars representing the standard deviation. Correlation appears strongest in the sectors around magnetic midnight.

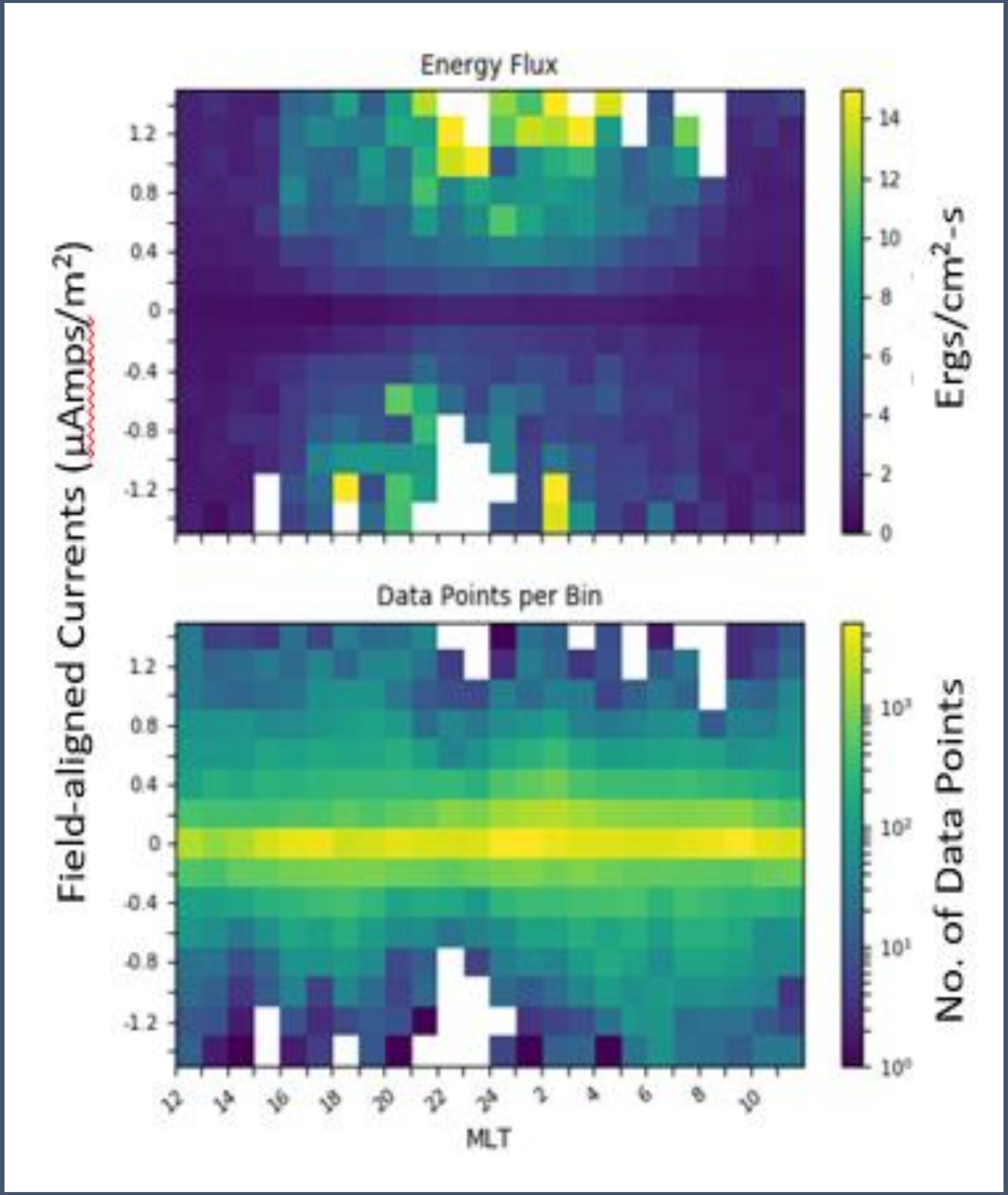

Figure 4. Data was binned according to FAC every 0.2 $\mu Amp/m^2$ and magnetic local time (MLT) every hour. The mean of each bin is shown in the upper plot, while the number of points in each bin is shown in the lower plot.

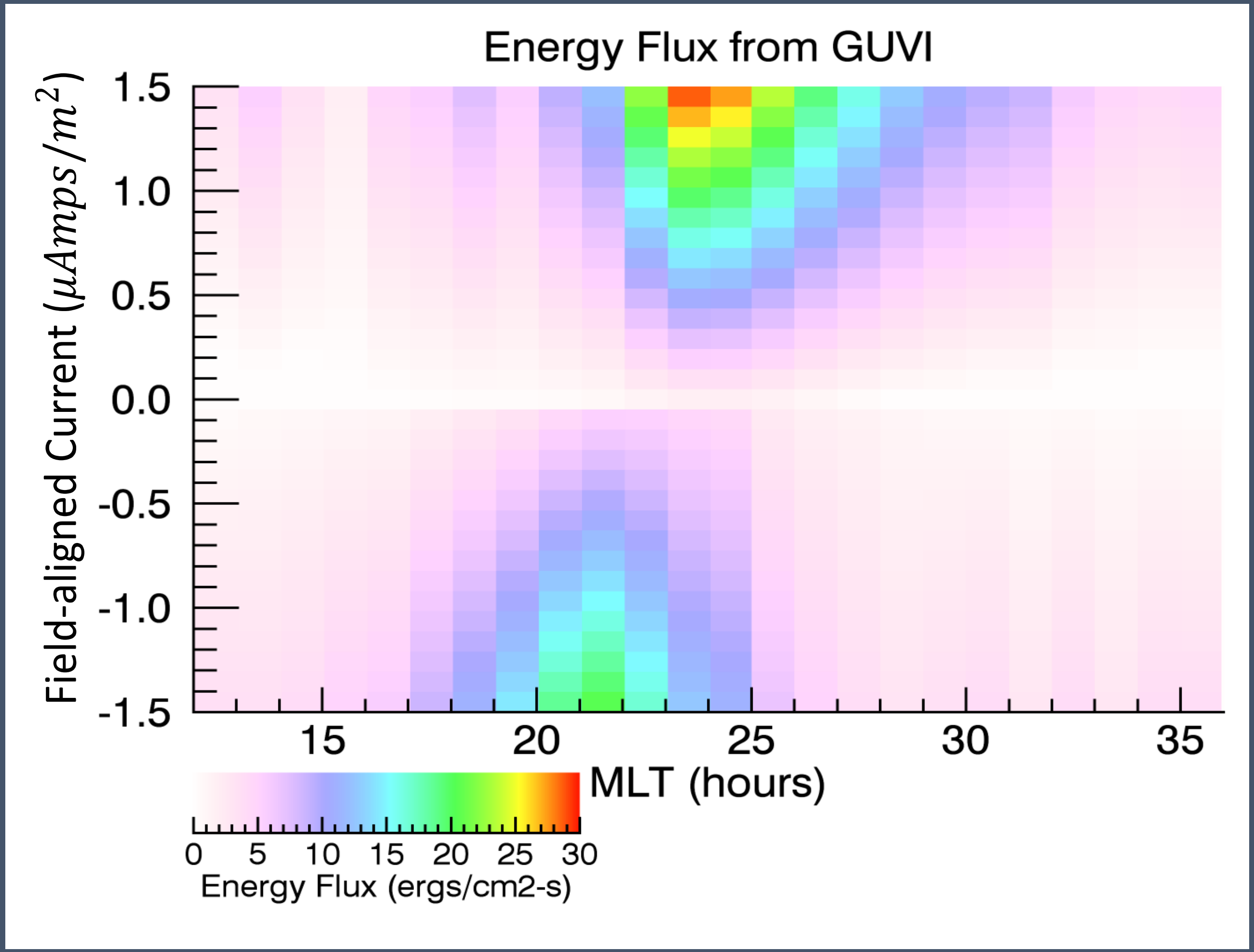

Figure 5. Linear fits of each MLT bin in Figure 4 were made and then the parameters were smoothed to create this plot. For upward FAC, energy flux increases most strongly with FAC between magnetic midnight and morning, while for downward FAC, energy flux increases most strongly between evening and magnetic midnight.

Validation Using Electron Density Profiles

58 specific events were selected to compare the values we used for energy flux to values obtained by integrating over the electron density profile from 100 km to 200 km. Data for the electron density profiles was provided by the Poker Flat Incoherent Scatter Radar (PFISR). Preliminary results are presented in Figure 6.

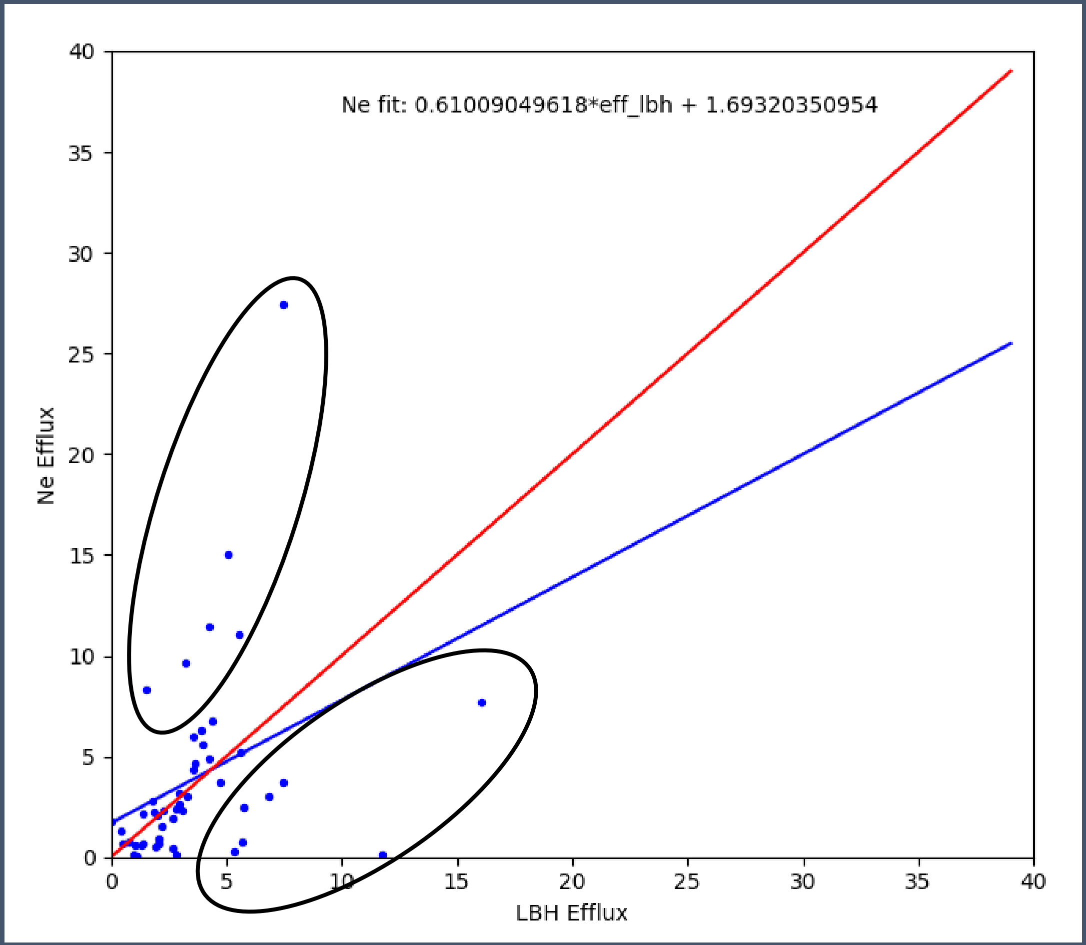

Figure 6. Energy flux calculated using GUVI data and the relation from *Zhang and Paxton* (2008) compared to energy flux calculated by integrating over the electron density profiles using PFISR data. The red line represents a 1:1 correspondence, while the blue line represents the real linear fit. Data in the circled regions is being analyzed more closely to identify sources of error.

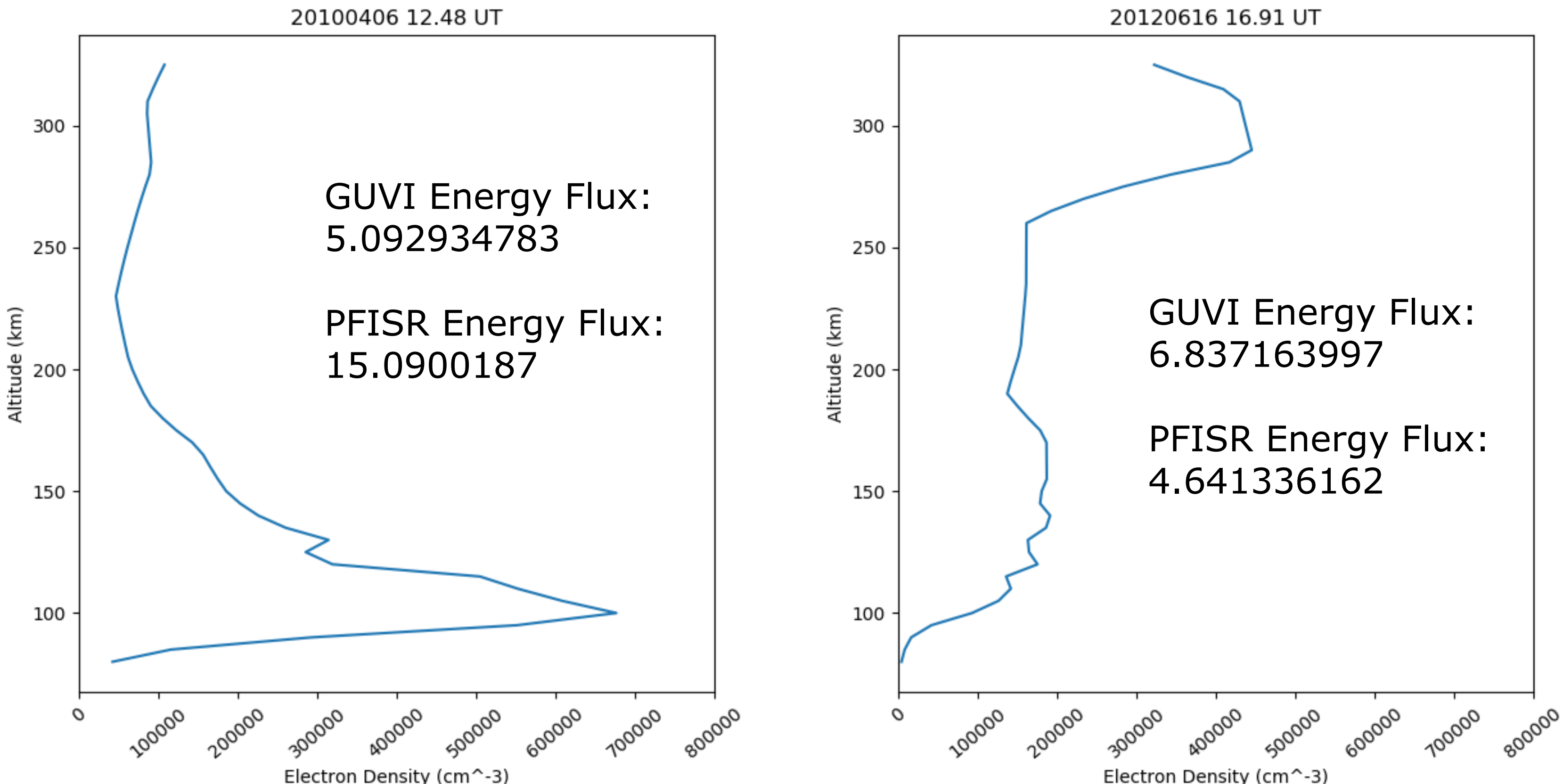

Figure 7. Two examples of electron density profiles from PFISR. Days with hard electron precipitation (left) will cause the profile to peak below 100 km and can result in underestimated values when calculating energy flux using GUVI. Days with soft electron precipitation (right) will cause the profile to peak above 200 km and can result in overestimated values for energy flux.

Conclusions

FAC measurements correlate with energy flux in both upward and downward regions and this relation varies with magnetic local time. For upward regions, energy flux increases most strongly between magnetic midnight and morning. For downward regions, energy flux increases most strongly between evening and magnetic midnight. Continued analysis will have to be performed to ensure we are using accurate values of energy flux to compare to AMPERE measurements.