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ISR electron precipitation observation with high time resolution

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Electron precipitation is a magnetosphere-ionosphere coupling mechanism that causes night-time electron density enhancements and displays of aurora in the high-latitude E region ionosphere. Indirect estimation of precipitating electrons' energy distribution from electron density altitude profile measurements is a well-known remote sensing method of electron precipitation. The electron density data is customarily obtained from incoherent scatter radar (ISR) observations of the E region ionosphere.

The so-called raw electron density estimates have been used to observe electron precipitation events with rapidly varying differential energy fluxes. The raw electron density is obtained from the back-scattered power profile measurements of ISR under the assumption of equal ion and electron temperatures. However, it is apparent that during enhanced precipitation events there is electron heating $(T_e > T_i)$ because of the large energy flux deposited by precipitating electrons. During such periods, the incorrect assumption $T_e = T_i$ will introduce biases to the raw electron density and electron differential energy flux estimates. Previous precipitation investigations have relied on the raw electron density estimates, because high time resolution fits of electron density, electron and ion temperatures, and ion velocity to the measured autocorrelation function (ACF) of incoherent scatter signal have not been possible using existing ISR data analysis packages [3, for example].

In this study, we use a new ISR data analysis package, BAFIM [1], to retrieve electron density, electron and ion temperatures and ion velocity from ACF data with 4 s time resolution and 1.8 km range resolution. BAFIM is an extension module that adds Bayesian filtering in time and full-profile analysis along the range to GUISDAP [3] to control gradients of plasma parameters in time and space.

We used the ELSPEC software [2] for a precipitation event occurred on March 09, 2016 to fit the differential energy flux of precipitating electrons to the raw and BAFIM-fitted electron densities. Integrated parameters such as auroral power (total energy flux) and field aligned current (proportional to total number flux of precipitating electrons) are then calculated from the energy spectra fit results. We found that wider electron energy distribution is observed in the differential energy flux obtained from BAFIM N_e than in the differential energy flux obtained from raw N_e. Specifically, the lower energy ends of the differential energy fluxes obtained from BAFIM N_e contain larger fluxes than the differential energy flux obtained from raw N_e. In this specific event, the auroral power and FAC obtained from BAFIM N_e exceed the ones obtained from raw N_e by as large as 44 % and 70 %, respectively.

References

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