Bayesian filtering for incoherent scatter radar analysis

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Electron precipitation and ion frictional heating events cause rapid variations in electron temperature, ion temperature and F1 region ion composition of the high-latitude ionosphere. Four plasma parameters: electron density, electron temperature, ion temperature, and plasma bulk velocity, are typically fitted to incoherent scatter radar (ISR) data.

Many ISR data analysis tools extract the plasma parameters using an ion composition profile from an empirical model. The modeled ion composition profile may cause bias in the estimated ion and electron temperature profiles in the F1 region, where both atomic and molecular ions exist with a temporally varying proportion.

In addition, plasma parameter estimation from ISR measurements requires integrating the scattered signal typically for tens of seconds. As a result, the standard ISR observations have not been able to follow the rapid variations in plasma parameters caused by small scale auroral activity.

In this project, we implemented Bayesian filtering technique to the EISCAT’s standard ISR data analysis package, GUISDAP. The technique allows us to control plasma parameter gradients in altitude and time.

The Bayesian filtering implementation enabled us to fit electron density, ion and electron temperatures, ion velocity and ion composition to ISR data with high time resolution. The fitted ion composition removes observed artifacts in ion and electron temperature estimates and the plasma parameters are calculated with 5 s time resolution which was previously unattainable.

Energy spectra of precipitating electrons can be calculated from electron density and electron temperature profiles observed with ISR. We used the unbiased high time-resolved electron density and temperature estimates to improve the accuracy of the estimated energy spectra. The result shows a significant difference compared to previously published results, which were based on the raw electron density (backscattered power) and electron temperature estimates calculated with coarser time resolution.