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Interferometric Imaging for Fine-Scale Ionospheric Plasma Parameter Determination with EISCAT_3D

Devin Huyghebaert*(1)(2), Björn Gustavsson(1), Juha Vierinen(1), Andreas Kvammen(1), Matthew Zettergren(3), John Swoboda(4), Ilkka Virtanen(5), Spencer Hatch(6), and Karl M. Laundal(6)
(1) Department of Physics and Technology, UiT The Arctic University of Norway, Tromsø, Norway
(2) Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, Canada
(3) Embry-Riddle Aeronautical University, Daytona Beach, FL, USA
(4) MIT Haystack Observatory, Westford, MA, USA
(5) Space Physics and Astronomy Research Unit, University of Oulu, Oulu, Finland
(6) Department of Physics and Technology, University of Bergen, Bergen, Norway

Extended Abstract

EISCAT_3D [1] is an incoherent scatter radar (ISR) system located in northern Fennoscandia that is currently in the construction and commissioning phase. One of the novel capabilities of this ISR is the inclusion of interferometry outlier antenna arrays at the main radar site to perform interferometry of the radar signal. By using the measurements from the outlier arrays it is possible to obtain sub-beam, or in-beam, high resolution details of the signal scattered from the ionosphere [2]. Measuring the cross-baseline auto-correlation functions, also commonly referred to as cross-baseline lag-profiles, allows the plasma parameters of the ionosphere (plasma density, ion temperature, electron temperature, ion velocity) to be imaged at resolutions of 100 m or less.

We have developed a radar simulator for interferometric imaging with EISCAT_3D to investigate the feasibility of obtaining usable incoherent scatter spectra on these relatively fine scales. The software and models used in the simulator include the Geospace Environment Model of Ion-Neutral Interactions (GEMINI) model for fine-scale physics-based ionospheric simulation [3] and the ISRSpectrum package for incoherent scatter spectra generation from ionospheric plasma parameters [4]. The initial ionosphere parameters, experiment range resolution, and experiment time resolution are used to determine an approximate signal to noise standard deviation ratio (SNR) of the data. To perform the interferometric imaging we use singular value decomposition (SVD) and 0th order Tikhonov regularization, similar to what was done by Stamm et al. [2]. The SNR is used to select an optimal SVD Tikhonov regularization value. A brief discussion on the different methods to select the SVD Tikhonov regularization value is included in the presentation. From the variance of the imaged auto-correlation functions (ACFs) we obtain the expected errors in the plasma parameter fits to the data.

The processing algorithm will be described along with some examples of what we can expect EISCAT_3D to be capable of observing.

References

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