Estimating the vector electric field and three-dimensional conductivity using monostatic, multibeam incoherent scatter radar measurements

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An algorithm has been developed to image the local structure in the convection electric field using multibeam incoherent scatter radar (ISR) data. The imaged region covers several degrees in magnetic latitude and longitude for the specific geometries considered (that of the Poker Flat and Resolute Bay ISRs). The algorithm implements the Lagrange method of undetermined multipliers to regularize the underdetermined problem posed by the radar measurements. The error on the reconstructed image is estimated by mapping the mathematical form to a Bayesian estimate and observing that the Lagrangian method determines an effective a priori covariance matrix from a user-defined regularization metric. There exists a unique solution when the average measurement error is smaller than the average measurement amplitude. The algorithm is tested using synthetic and real data and appears surprisingly robust at estimating the divergence of the field.

Applications of the algorithm include imaging the current systems surrounding auroral arcs in order to distinguish physical mechanisms. Auroral forms involve spatial scales that are small in comparison with the magnetosphere-ionosphere (MI) system, and yet these forms are thought to be closely tied to the overall system response. Spatially resolved measurements of the horizontal ionospheric current can, in principle, be used to determine the field-aligned currents that are responsible for energy transfer between the ionosphere and magnetosphere, leading to heating and acceleration of the neutral gas, substorms, and other instabilities.

We consider applications to stable auroral arcs, substorm triggering events, and polar cap arcs, and assess the reliability of the images produced, with the ultimate goal being diagnosis of ionospheric current closure.