2-D Radio Imaging of Ionospheric Electron Density in the Equatorial Plane: Algorithms and Results

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Local depletions in the equatorial ionospheric electron density, known as Spread-F events, have been an active area of scientific research in the last decades. These are of special interest to the research community because of their potentially deleterious impact on trans-ionospheric communication links and navigation systems. The impetus for focused modeling and experimentation is the ultimate goal of predicting these events and subsequent mitigation of their negative impacts.

A promising technique for direct imaging of these irregularities is based on a combination of satellite-borne and ground instruments, together with tomographic inversion techniques, to obtain multi-dimensional images of the ionospheric electron density. However, the inverse problem has some noted challenges due to inherent constraints on the acquisition geometry.

One such system is based on coherent VHF and UHF transmission of radio signals by the Coherent Electromagnetic Radio Tomography (CERTO) beacons on board the Communications/Navigation Outage Forecasting System (C/NOFS) satellite, measured by a ground array of receivers located in a near-horizontal line around -12 degrees latitude. The resulting signals yield a set of electron density projections, known as the Total Electron Content (TEC), which can subsequently be used to produce two-dimensional images of ionospheric irregularities.

The inherently exotic sampling geometry yields an under-determined, limited-angle tomography problem making it difficult to reconstruct accurate vertical variations in electron density. Moreover, the non-uniform sampling dictated by the acquisition geometry demands rigorous quantification of the information content in the reconstructed images. In the present work, we develop algorithms optimized for reconstructing ionospheric images containing such irregularities and apply them to experimental data to illustrate the capability and limitations of this approach for experimental investigation of this ionospheric phenomenon.