THREE-DIMENSIONAL ELECTRON DENSITY INVERSION FOR THE DYNASONDE: PRINCIPLES AND FIRST RESULTS

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The structure of ionospheric plasma layers often differs significantly from the simplified plane-stratified model that underlies classical one-dimensional algorithms for inversion of ionograms to electron density profiles (e.g., POLAN). Horizontal gradients are always present in the ionosphere, and sometimes these become very significant. Regular examples of this situation are the sunrise/sunset ionospheres. Other important examples are Atmospheric Gravity-Wave signatures, recently recognized storm-enhanced density plumes, and the structures characteristic of equatorial Spread F.

The Dynasonde provides abundant information about the geometry of ionospheric reflections. Each ionogram echo, when accepted by physics-based classification and selection procedures, includes echolocation parameters among its physical attributes. The virtual spatial distribution of echoes often demonstrates very elaborate variations, reflecting actual properties of the three-dimensional plasma distribution. What algorithm may be used to quantify this information?

The dynasonde measures parameters of the reflected echoes at a single point on the ground. This is its main distinction in comparison with tomography and other established inversion methods. It is necessary to have a model for the propagation medium that is sufficiently flexible to represent the varying gradients of electron density, but with the minimum number of parameters suitable for a least-squares procedure applicable to measured values of virtual ranges and angles-of-arrival. We suggest the "Wedge-Stratified Ionosphere" (WSI) for this purpose. The WSI substitutes for the usual plane-stratified assumption: plasma density surfaces are represented locally (at a sequence of ranges) by tilted sections of "frame" planes; the electron density between two frame planes (inside a "wedge") depends only on the corresponding angle between the two planes.

The inversion algorithm shares some generic properties with its one-dimensional counterpart. For example, determination of the WSI model parameters proceeds upward, explicitly in radio frequency, implicitly in slant range, and consecutively from the bottom of the ionosphere. Since the radio propagation is essentially three-dimensional, the inversion problem cannot be reduced to a matrix inversion as is done in some treatments of the one-dimensional case. Numerical ray tracing methods are used instead. First results of application of this approach are demonstrated in this paper.

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