Ionosphere D Region Remote Sensing by Radio Atmospherics

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The electromagnetic (EM) wave excited by a lightning return stroke has high power and a broad frequency band. It is called radio atmospherics, or sferics for short. Most of its energy concentrates below 300 kHz and is reflected back by the ionosphere, and thus the sferic can be used as an effective tool for ionosphere D region remote sensing. In this paper, we propose a novel iterative method for the reconstruction of the electron density and collision frequency of the ionosphere D region by using the sferics.

In the forward modeling, the D region electron density and collision frequency profiles are divided into several sub-wavelength thin layers with constant parameters in each layer. Because the geomagnetic field is not necessarily perpendicular to the earth surface, the ionosphere dielectric parameters are not gyrotropically anisotropic but arbitrary anisotropic in the computation coordinate system with the vertical *z* axis. Therefore, the frequency domain dyadic Green's functions (DGFs) for layered arbitrary anisotropic media are derived first by decomposing the spherical waves from an infinitesimal dipole into a series of planes waves in the spectral domain subject to multilayer reflection and transmission and later transformed back to the spatial domain. The line source model of the lightning return stroke channel in the computation is dealt by the integration of current moment in the vertical direction. Following this, one can compute the EM waveforms in the receivers by the multiplication of the DGFs and the excitation source.

In the inversion model, it is assumed that the waveforms in the sferic receivers are measured, and it is desirable to retrieve the layered ionosphere dielectric parameters, i.e. the electron density and collision frequency in each layer. In this research, we adopt the variational Born iteration method (VBIM) to reconstruct the unknown dielectric parameters by minimizing the difference between the measured data and the computed EM fields in the forward model iteratively. In each iteration step, we obtain variations of the unknown parameters by minimizing the cost function, and then go back to the forward computation to update the ionosphere profiles and recalculate the DGFs. In this way, after several iterations, the best electron density and collision profiles can be reconstructed.

In both the forward and inverse models, not only numerical simulations but also field measured data are used to validate the proposed method.