Characteristics of ground-based wave distribution function method for ELF/VLF waves, using full wave analysis

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The ground-based wave distribution function (WDF) method is an important technique to estimate the ionospheric exit region of magnetospheric ELF/VLF waves.

We study the influence of the earth-ionosphere waveguide effect on the WDF estimation. The field components on the ground and at the ionospheric base are calculated by means of the full wave analysis. It is assumed that the wave is radiated from the end of the magnetospheric duct. The WDF method is applied to the simulated signal at any observing points on the ground, and relationship between the reconstructed WDF and the wave energy distribution of the full wave result is discussed. Contribution of the properties of the duct, such as enhancement factor and the termination height, is also discussed.

ELF/VLF waves generated in the magnetosphere propagate along ducts and observed on the ground. It is very important for the investigation of the propagation and generation mechanisms to locate the ionospheric exit region of the waves.

Some of ground-based direction finding techniques have been developed to estimate the emerging point on the ionospheric base with multiple field components of the observed VLF waves. Most of them are based on a single plane wave model to determine the arrival direction and wave polarization. Nagano (1989) has shown, by full wave calculation, systematic errors of the direction findings such as goniometer method, tracking-direction finder (T-DF), and non-polarization error (NPE) method. It is suggested that the frequency dependence of the systematic errors in the estimated arrival direction given by H. J. Strangeways evaluation (1980) is caused by the earth-ionosphere waveguide model in which multiply hopped rays are used to take account of the waveguide effect under the assumption that the ionosphere has a sharp lower boundary.

Another important technique is the wave distribution function (WDF) method. The exit region can be estimated by a reconstructed wave energy distribution in wave number space. In computer simulations to examine the effectiveness of the WDF method, the observed signal composed of a number of elementary plane waves have been used, and there was found to be a good correlation between the scale of the exit region and that of the estimated WDF.

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