Ground-based direction findings of VLF wave propagating through the magnetospheric duct

Tomoya Sakai[1], Satoshi Ujigawa[2], Shin Shimakura[3]

[1] IMIT, Chiba Univ., [2] Sci. and Tech., Chiba Univ., [3] Graduate School of Sci. and Tech., Chiba Univ.

In order to investigate the propagation mechanism of the mid-latitude whistlers, the ground-based direction finding (DF) methods are applied to the observed VLF wave, which was transmitted from Khabarovsk (39N) in Russia and received at the conjugate point Ceduna (40S) in Australia. In this paper, the numerical simulations of the VLF wave propagation in the ionosphere are performed by the full-wave analysis, and the DF methods are examined with the simulated wave field on the ground. The propagation characteristics in the magnetosphere and ionosphere are studied, comparing the DF results of simulations and the data from Ceduna.

The ground-based DF techniques have been developed to locate the exit region of the magnetospheric waves emerging from the ionospheric base and determine the wave polarisations with multiple field components of the observed VLF waves. It is suggested that the DF method based on a single plane wave model has systematic error in the estimated direction and polarisation. The ground-based wave distribution function (WDF) method is an important technique to obtain the information concerning the scale and location of the ionospheric exit region. The WDF method, however, assumes the wave polarisation to be given, and this assumption causes the systematic error in the estimated wave energy distribution. Therefore, it is very important to evaluate the systematic errors by the numerical simulations in order to interpret the DF results properly.

According to the full-wave analysis, the following features are found. (i) In case that that the random wave with the Gaussian energy distribution incidents on the ionosphere and it spreads over 100km, the ionospheric exit region can be located by the DF methods at the observation site within the distance of about 100km from the center of the energy distribution on the ground. (ii) The DF methods based on the single plane wave model fail when the exit region resides more than 100km away from the observing point, and the wave polarisation of non-whistler mode might be estimated. (iii) The wave energy distribution estimated by the WDF method represents the scale of the exit region. (iv) The estimated direction by the methods based on the single plane wave model.

The results of the DF methods applied on the observation data from Ceduna are shown and the explanation of dynamics of the magnetospheric duct is given.