Ground-based observation of magnetospheric whistler duct, using VLF transmitter signal

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We have analyzed VLF transmitter signal, which was transmitted from Khabarovsk (39N) in Russia and received at the conjugate point Ceduna (40S) in Australia. The propagation mechanism and the dynamics of the magnetospheric duct probed by the VLF transmitter wave are mainly discussed.

The ground-based direction finding techniques have been employed to estimate the ionospheric exit region of those waves.

As the result, the location and its scale vary and the variation is related to the PC3. Concerning the wave polarization, non-whistler mode (right-handed) appears alternatively.

The full-wave analysis is utilized to simulate the wave field in the ionosphere and atmosphere, and the detailed variation of the magnetospheric duct is considered.

In order to investigate the propagation mechanism of the mid-latitude whistlers, we have analyzed VLF transmitter signal, which was transmitted from Khabarovsk (39N) in Russia and received at the conjugate point Ceduna (40S) in Australia. The signal is periodically intermitted sinusoidal pulses of 23.9kHz. The observed signal is composed of the wave propagating in the Earth-ionosphere waveguide, and of the whistler-mode wave traveling through the magnetosphere. The propagation mechanism and the dynamics of the magnetospheric duct probed by the VLF transmitter wave are mainly discussed.

The ground-based direction finding techniques and wave distribution function method have been employed to estimate the ionospheric exit region of those waves. Additionally, a new method derived from the concept of the multiple signal classification (MUSIC) has been applied to the mixed waves of the whistler-mode and waveguide-mode.

As the result, the ionospheric exit region can be estimated within the distance of about 200km from the observation site. The location and its scale vary with a period of a few tens of seconds. The variation seems to be caused by the fluctuation of the propagation path in the magnetosphere and to be related to the PC3. Concerning the wave polarization, non-whistler mode (right-handed) appears alternatively in the results though the wave emerging from the lower ionosphere is expected to have the left-handed circular polarization in the southern hemisphere. It is known that the estimated wave polarization has a systematic error due to the Earth-ionosphere waveguide effect when the direction finding method is based on the single plane wave model.

It is important to evaluate the transmission property of VLF waves propagating in the ionosphere by numerical simulation in order to interpret the direction finding results with the systematic error. The full-wave analysis enables us to simulate the wave field in the ionosphere and atmosphere taking account of wave distribution in the magnetosphere and the ground effect. Consequently, it may be possible to discuss the characteristics of the direction of arrival and the wave polarization. According to the simulation, it can be seen that the wave polarization strongly depends on the distance between the observing point and the ionospheric exit region. The irregularity of the estimation may be related to the scale of the magnetospheric duct.