Ray tracing of whistler mode waves used the external geomagnetic field model

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Abstract

To study whistler mode wave propagation characteristics up to the near magnetotail region, the ray tracing program is modified to accomodate a more realistic geomagnetic field model, including the external geomagnetic field model in addition to the dipole. A magnetospheric electron density model, which is also an important factor to determine wave propagation vector, is made. It is found by ray tracing that the two different geomagnetic field model, for example, the external geomagnetic field model including the dipole and the dipole, make a large different wave propagation.

Introduction

In this study, we use the external geomagnetic filed model, which is compressed and confined by the solar wind in the dayside, and is stretched out into magnetotail. This geomagnetic field configuration, especially in high latitude are largely different from those of dipole and IGRF magnetosphere. Since whistler mode wave propagation are strongly controlled by earth's geomagnetic field configuration, it is thought that the different geomagnetic field models makes a difference in outer magnetospheric wave propagation. For these reasons, even if ray tracing of the whistler mode waves has been made to interpret various whistler mode waves observed on the ground and on the low altitude satellites, it is not available to the whistler waves observed in the magnetotail.

Ray tracing

Ray tracing program, which is used as the tool of the whistler mode wave propagation analysis, is made by using empirical T89c external geomagnetic field model[1] in addition to the dipole. Wave propagation directions are also strongly controlled by earth's magnetospheric plasma density structure. But, as we have no equations representing the global plasma density model from ionosphere to magnetotail, three dimensional density model is made by giving the plasma density, which is based on diffusive equilibrium model with a temperature gradient along geomagnetic field line[2], so as to fit the spatial electron density distributions observed by ISEE-1 and Geotail. Although it is poor physical significance in the outer magnetosphere, it is thought to be available to calculate the ray path. As expected, it is found that the difference between the two geomagnetic filed models make a largely different wave propagation characteristics, especially in high latitude. In the dayside, waves starting from the closed field line can propagate counter hemisphere along the geomagnetic field line, but that of the open field line can propagate toward magnetotail. In the nightside, VLF waves starting from high latitude can propagate directly toward magnetotail, or after refraction at the neutral sheet can propagate to the plasma sheet.

Conclusion

Upward propagating auroral hiss has a sharp upper cutoff frequency by decreasing electron plasma or cyclotron frequency with increasing altitude whichever is lower. Therefore, it is found that hiss starting from the nightside auroral region can't be observed by satellite in the near magnetotail, where the lower cutoff frequency is the same as electron cyclotron frequency, for example, hiss having 0.5 and 1.0 kHz lower cutoff of frequencies can propagate to around 30,15(Re) respectively, and also found this whistler mode waves can't enter the neutral sheet due to weak geomagnetic field strength.

References

[1] Tsyganenko, N. N., Planet. Space Sci., 37, 5-20, 1989.
[2] Strangeways, H. J., J. Atmosph. Terr. Phys., 48., 671-683, 1986.