Seasonal and solar cycle dependence of electron number density in the polar magnetosphere

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[Introduction]

Based on the statistical studies on seasonal solar cycle variations of electron precipitations [Newell et al. 1996;1998], auroral kilometric radiation (AKR) [Kasaba et al., 1997; Kumamoto and Oya 1998; Kumamoto et al., 2001; 2003], upflowing ion (UFI) events [Cattell et al., 1991; Collin et al., 1998], and other phenomena, it has been suggested that auroral particle acceleration processes are controlled by the upwelling cold plasma from the polar ionosphere. In order to investigate the control mechanisms, it is important to clarify the variations of number density of background cold plasma in the polar region. Vertical distributions of electron number density in the polar magnetosphere have been already reported by several studies [Mozer et al., 1979; Lysak and Hudson, 1979; Kletzing and Torbert, 1994; Kletzing et al., 1998]. However, seasonal and solar cycle variations of them have not been clarified sufficiently. In the present study, we have performed statistical analysis of seasonal and solar cycle dependence of electron number density in the polar magnetosphere based on the 13-year plasma wave data obtained by the Akebono satellite.

[Analysis Methods and Results]

Plasma wave data obtained in an invariant latitude range from 70 to 75 in evening sector from 2100 to 2400 MLT were utilized for the analyses. Electron number densities were derived mainly from upper limit frequencies of whistler waves and partly from upper limit frequencies of upper hybrid waves in case that plasma frequency is higher than electron cyclotron frequency. Vertical profiles of electron number density were obtained in following four seasonal and solar activity conditions; summer during solar maximum, winter during solar maximum, summer during solar minimum, and winter during solar minimum. The electron number density profile in winter during solar minimum shows similar properties with the profiles reported by the Mozer et al. [1979] and following studies, which is well fitted by the function of n=n_0 exp[-(z-z_0)/H]+n_1 z^r_1, where n, z, and other variables indicate electron number density [/cc], altitude [km], and other fitting parameters, respectively. However, in other conditions, vertical profiles can not be fitted by the above functions but by the power law function of n=n_0 z^r_1.

[Discussion]

The first and second terms of the fitting function proposed in the previous studies indicate the plasma components from the ionosphere and the magnetosphere, respectively. The exponential function and power law function respectively represent the vertical distribution with constant scale height H and linearly increasing scale height z/r. In summer or solar maximum case, probably because ionizations increase in the polar ionosphere, it is inferred that plasma components from the ionosphere are distributed with large and increasing scale height, superposing vertical profile of plasma components from the magnetosphere. Applying the vertical profile model of electron number density in the polar magnetosphere, determined in the present study, it will be possible to investigate seasonal and solar cycle dependences of the development processes of field-aligned current system and acceleration regions more precisely.