太陽活動極大期の地磁気静穏時の極冠電離圏ー磁気圏におけるプラズマ密度、温度の太陽天頂角依存性

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SZA dependence of the plasma density and temperature in the polar ionosphere-magnetosphere during quiet periods at solar maximum

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Plasma density and temperature in the polar region are important parameters for acceleration of outflowing thermal energy ions (polar wind). However, the lack of observations, especially in altitude ranges of 1000-4000 km (density) and above about 1000 km altitude (temperature), have made it difficult to determine how the solar radiation influences the electron density distribution and ion acceleration. Since the plasma densities strongly depend on the geomagnetic condition and solar activity, we focus on the geomagnetically quiet periods (the *Kp* index less than or equal to 2+ for the preceding 3 hours and the *SYM-H* index being in a range from -10 to 40 nT) at solar maximum (monthly-averaged $F_{10.7}$ larger than 170). To evaluate the importance of solar radiation for the plasma density and temperatures quantitatively in the polar topside ionosphere and magnetosphere, we investigated the solar zenith angle (SZA) dependence of these parameters in the polar cap.

The electron density data used in the present study were obtained from 63 months records of plasma wave observations by the Akebono satellite in an altitude range of 500-10,500 km. Electron density profiles at low altitudes are well fitted by quasi-hydrostatic equilibrium functions, while those at higher altitudes are well described by power law functions. In the quasi-hydrostatic equilibrium functions, we assumed a constant temperature, and altitude dependence of the gravitational force and magnetic field strength are taken into account. The electron density and scale height decrease drastically with increasing SZA in an SZA range of 90-120 degrees. The sum of the ion and electron temperatures estimated from the scale height at an SZA of 120 degrees (3600 K) is less than half of that at an SZA of 90 degrees (8200 K).

Furthermore, to compare the change in the ionospheric plasma temperature with that obtained by the Akebono satellite, we have investigated the SZA dependence of the electron and ion temperatures in the topside ionosphere in an altitude range of 300-1200 km using 19 months records of data derived from EISCAT Svalbard Radar (ESR), located at an invariant latitude of 75.2 degrees. The electron (ion) temperature above about 300 (600) km altitude decreases most drastically with increasing SZA in an SZA range of 80-110 degrees, which is near the terminator in the ionosphere. Although the SZA range of the drastic temperature change was about 10 degrees lower than that derived by the Akebono data, the drastic change in the ionospheric temperatures strongly suggests the dominant role of heating and photo-ionization processes by solar radiation in determining the electron density in the polar cap. Above the dark ionosphere, the scale height derived by using the Akebono density data can be explained by the sum of ion and electron temperatures (~3300 K) at about 800 km altitude obtained by ESR. Above the sunlit ionosphere, the sum of the ion and electron temperatures (~6400 K) at about 1000 km altitude obtained by ESR was about 2000 K lower than that estimated by using the Akebono density data. Since the quasi-hydrostatic equilibrium functions, which is used to estimated the temperature, well fits the density profile up to about 3500 km altitude above the sunlit ionosphere, the estimated temperature may represent that above 1000 km altitude.

A statistical study above the sunlit ionosphere using the TED instrument onboard the Akebono satellite indicates that the electron temperature increases about 2000 K in an altitude range of 1500-2500 km compared with the almost constant electron temperature (~3300 K) in an altitude range of 600-1500 km. The temperature increase can explain the scale height up to about 3500 km altitude. These results imply that the sum of electron and ion temperatures above the sunlit ionosphere at about 3000 km altitude reaches up to 9000 K, which is about 1.5 times higher than commonly used in simulation studies.