太陽活動極大期の地磁気静穏時の極冠電離圏－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 (the so-called 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 is taken into account. The electron density and scale height decrease drastically with increasing SZA in an SZA range of 90°−120°. The sum of the ion and electron temperatures estimated from the scale height at an SZA of 120° (3200 K) is less than half of that at an SZA of 90° (6400 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°. Above the sunlit and dark ionosphere, the scale height derived by using the Akebono density data can be explained by the sum of ion and electron temperatures (~6400 K and ~3300 K) at about 1000 and 800 km altitude, respectively, obtained by ESR. The electron and ion temperature above about 300 and 600 km altitude, respectively, decreases most drastically with increasing SZA near the terminator in the ionosphere. The drastic change in the ionospheric temperature observationally proves that solar radiation strongly controls the electron density and polar wind through the plasma temperature in the topside ionosphere.

A statistical study above the sunlit ionosphere using the TED instrument onboard the Akebono satellite indicates that the electron temperature increases about 2500 K in an altitude range of 2000-3000 km compared with the almost constant electron temperature (~4000 K) in an altitude range of 1000-2000 km. This result imply that the sum of electron and ion temperatures above the sunlit ionosphere at about 3000 km altitude may reach up to 10,000 K, which is about 1.5 times higher than commonly used in simulation studies.