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Seasonal variations of the electron density distribution in the polar region during geomagnetically quiet periods

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Seasonal variations of meridional electron density distributions have been investigated, using 55 months of electron density data derived from the plasma wave observations performed by the Akebono satellite in an altitude range of 300-10,500 km and in a region above 45 degrees AACGM MLAT during geomagnetically quiet periods in the solar maximum (monthly-averaged $F_{10.7}$ larger than 170). Electron density profiles at low altitudes are well fitted by exponential functions, while the profiles at higher altitudes are well described by power law functions. A transition of the density profile is identified in an altitude range of 1600-5500 km (above 70 degrees AACGM MLAT).

The scale height shows a remarkable seasonal variation; the scale height is the largest in the summer (about 650 km) and the smallest in the winter (about 200 km) in a region above 70 degrees AACGM MLAT in the nightside. This leads the seasonal variation of the transition height; the transition height is the highest in the summer (about 4000 km) and the lowest in the winter (about 1700 km). A large electron density ratio of 19-52 between summer (about 10^4 cm^{-3}) and winter (about $3*10^2$ cm^{-3}) is found near 2000 km altitude in 65-75 degrees AACGM MLAT in the dayside and above 65 degrees AACGM MLAT in the nightside. The maximum ratio is identified in the higher altitude (about 5000 km) and is smaller (about 12) at above 75 degrees AACGM MLAT in the dayside. On the other hand, the seasonal variation of the electron density in the trough and polar regions above 6200 km altitude is relatively small (a factor of less than 12). The seasonal variation is also small (within a factor of 2) in a region below 60 degrees AACGM MLAT (plasmasphere) above 3000 km altitude. The day-night asymmetries are less than a factor of 3 in the summer and equinox seasons. The day-night asymmetry of the electron density is up to a factor of 18 in the winter.

Furthermore, the SZA dependence of the electron density profile in the polar cap has been derived. Comparing the electron densities in SZA ranges of 50-60 degrees ($1.4*10^4$ cm^{-3}) and 120-130 degrees ($1.4*10^2$ cm^{-3}), the largest SZA dependence is identified at 2100 km altitude, with a factor of 100. Above 5300 km altitude, the SZA dependence of the electron density is within a factor of 20. The electron density, scale height and transition height decrease drastically with increasing SZA in an SZA range of 90-130 degrees. The scale height and transition height in an SZA range of 120-130 degrees (205 and 1700 km) are less than half of that in a SZA range of 90-100 degrees (569 and 4000 km), respectively. The drastic decrease near SZA of 110 degrees strongly suggests that photo-ionization processes in the ionosphere control the electron density in the polar cap during geomagnetically quiet period. The meridional electron density distribution models above 45 degrees AACGM MLAT and the SZA dependence of the electron density in the polar cap derived in the present study will contribute to investigations of the polar wind, ion outflow, and auroral acceleration.