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Plasmaspheric Electron and Ion Densities Along the Geomagnetic Field Lines (1.7<L<3.3) Under Quiet to Moderate Geomagnetic Conditions

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Knowledge of electron and ion densities along the geomagnetic field lines is required to quantitatively understand the coupled magnetosphere-ionosphere-thermosphere (MIT) system and address the questions related to plasmasphere erosion and refilling. Using the whistler mode (WM) radio sounding data from the IMAGE satellite [1], we present field-aligned electron and ion densities and O+/H+ transition height (H_T) during two periods (16-23 Aug 2005; 24 Sep-06 Oct 2005) when geomagnetic conditions were quiet (maximum Kp in the past 24 hours, Kpmax,24 ≤ 2) to moderately active (2 < Kpmax,24 <4). The measurements were obtained in the L=1.8 to 3.3 range (90- 4000 km, ~13 or ~15 MLT) using 42 cases of whistler mode echoes. During these periods, RPI/IMAGE passive recordings showed that the plasmapause was located in the L-shell range 3.6≤L≤5, indicating electron and ion densities measurements were inside the plasmasphere.

We summarize below the salient results obtained from our measurements.

(1) The O+/H+ transition height (H_T) increased with L-shell. The transition height was within ±12% of 1100 km at L = 2.0±0.1, and within ±8% of 1350 km at L~3±0.1 for quiet as well as moderate geomagnetic conditions.
(2) Above H_T: (a) electron density and H+ density (major ion) decreased with L-shell. From L~2 to L~3, electron density decreased by ~50-60%, (b) electron density at any given L-shell increased with increase in Kp.
(3) Below H_T: (a) electron density and O+ density (major ion) showed no trend with L-shell, (b) electron density showed no trend with increase in Kp.
(4) F2 peak electron density was within 30% of $2x10^5$ el/cc and showed no trend with increase in L-shell or Kp.
(5) At all altitudes, the He+ density along flux tubes varied by ±20% with increase in L-shell and Kp.

WM radio sounding measurements of electron and ion densities are in agreement with near-simultaneous in situ measurements from CHAMP (electron), DMSP (electron and ion), and other past spaceborne measurements (e.g., ISIS) but deviated from IRI model predictions. Measurements of transition height are in general consistent with past radar (e.g., Arecibo) and spaceborne measurements (OGO 4, Explorer 31, and C/NOFS) as well as IRI predictions but deviated from GCPM predictions.

WM radio sounding results coupled with physics-based model simulations (e. g., SAMI3) provides a novel approach to investigate coupled MIT system dynamics [2]. Such a study should lead to a new understanding of the importance and relative contributions of electric fields, neutral winds, composition, and temperature of neutrals, and plasma temperature in the thermosphere in causing variations in plasmaspheric electron and ion densities under varying geomagnetic conditions.

References

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[2] Reddy, A., Sonwalkar, V. S., & Huba, J. B., "Evolution of field-aligned electron and ion densities from whistler mode radio soundings during quiet to moderately active period and comparisons with SAMI2 simulations," *Journal of Geophysical Research: Space Physics*, 2018, **123**, pp. 1356–1380. https://doi.org/10.1002/2017JA024348.