Hemispheric and seasonal variations in the cold plasma outflow source region: polar cap ionosphere electron density at 350–500 km

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The polar cap ionosphere (here defined as the region above 80° magnetic latitude) is the primary source region of cold plasma outflows observed in the magnetosphere. The two factors controlling cold plasma outflows are the availability of plasma in the polar cap ionosphere, and transport from the ionosphere to the magnetosphere. Some statistical studies have indicated that the former of these two factors, availability of cold plasma, is the limiting factor. We use 15 years of electron density measurements made by Swarm and CHAMP spacecraft, corrected for variations in observation altitude and solar activity, to investigate how variations in solar wind driving and local hemispheric season affect the polar cap ionosphere electron density $N_e$. We show that the dependence of $N_e$ on the $B_y$ component of the interplanetary magnetic field is apparently antisymmetric in the two hemispheres, that $N_e$ statistically decreases with decreasing $Dst$ index (i.e., increasing geomagnetic activity) and that $N_e$ is apparently insensitive to the $AE$ index. We also show that $N_e$ distributions around March and September equinoxes display weak evidence of hemispheric asymmetry. We show that during local summer, observed $N_e$ distributions under high solar wind driving conditions are relatively lower than $N_e$ distributions under low solar wind driving conditions. During local winter the reverse is true, with $N_e$ distributions under low solar wind driving conditions being relatively lower than $N_e$ distributions under high solar wind driving conditions. Thus solar wind driving and seasonal effects may apparently both constructively and destructively interfere. Altitude variation in Swarm and CHAMP $N_e$ measurements is accounted for via an empirical scale height derived from 1687 conjunctions between Swarm B and either Swarm A or Swarm C during 2013–2019. The approximately linear dependence of $N_e$ on $F10.7$ measurements is also accounted for. Swarm $N_e$ measurements are additionally corrected using the Lomidze et al. (2018) calibrations.
