Dong
Wu
NASA Goddard Space Flight Center
Oral
A novel retrieval technique is developed for electron density (Ne) in the D- and E-region (80-120 km) using the high-quality 50-Hz GPS radio occultation (GPS-RO) phase measurements. The new algorithm assumes a slow, linear variation in the F-region background when the GPS-RO passes through the D- and E-region, and extracts the Ne profiles at 80-130 km from the phase advance signal caused by Ne. Unlike the conventional Abel function, the new approach produces a sharp Ne weighting function in the lower ionosphere, and the Ne retrievals are in good agreement with the IRI (International Reference Ionosphere) model in terms of monthly maps, zonal means and diurnal variations. The daytime GPS-RO Ne profiles can be well characterized by the a-Chapman function of three parameters (NmE, hmE and H), showing that the bottom of E-region is deepening and sharpening towards the summer pole. At high latitudes the monthly GPS-RO Ne maps at 80-120 km reveal clear enhancement in the auroral zones, more prominent at night, as a result of energetic electron precipitation (EEP) from the outer radiation belt. The D-/E-region auroral Ne is strongly correlated with Kp on a daily basis. The new Ne data allow further comprehensive analyses of the sporadic E (Es) phenomena in connection with the background Ne in the E-region. The layered (2-10 km) and fluctuated (< 2 km) Es componentss, namely Ne_Layer than Ne_Pert , are extracted with respect to the background Ne_Region on a profile-by-profile basis. The Ne_Layer component has a strong but highly-refined peak at ~105 km, with an amplitude smaller than Ne_Region approximately by an order of magnitude. The Ne_Pert component, which was studied extensively in the past, is ~2 orders of magnitude weaker than Ne_Layer. Both Ne_Layer and Ne_Pert are subject to significant diurnal and semidiurnal variations, showing downward progression with local time in amplitude. The 11-year solar cycle dominates the Ne interannual variations, showing larger Ne_Region and Ne_Layer but smaller Ne_Pert amplitudes in the solar maximum years. Enhanced Ne profiles are often observed in the polar winter, showing good correlation with solar proton events (SPEs) and geomagnetic activity. The new methodology offers great potential for retrieving low Ne in the D-region, where radio propagation and communication blackouts can occur due to enhanced ionization. For space weather applications it is recommended for GPS-RO operations to raise the top of high-rate data acquisition to ~140 km in the future.
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