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Monitoring and modelling the plasmasphere by space based GNSS measurements

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The topside ionosphere and plasmasphere of the Earth contribute usually by more than 50% to total electron content (TEC) measurements from ground or satellite platforms using signals from Global Navigation Satellite Systems (GNSS) such as GPS. Even the plasmaspheric electron content alone varies between about 10% at day and 50% at night time [1]. Thus, the plasmaspheric electron content impacts in particular the mapping function needed for accurate TEC estimates in calibration and monitoring techniques. On the other hand, the topside ionosphere-plasmasphere coupling plays a key role for understanding ionospheric phenomena in particular under perturbed conditions [2].

GPS measurements onboard the CHAMP satellite have been used to derive the electron density distribution of the topside ionosphere and plasmasphere in the vicinity of the satellite orbit plane covering the years 2001-2005 [3]. This comprehensive data base is used to study ionosphere-plasmasphere coupling and to model the plasmaspheric electron density from 1000 km height upward. The comprehensive data set has been validated by using plasmaspheric electron density profile data from IMAGE/RPI measurements over the same time period [4]. The measurements agree quite well up to the McIlwain parameter L=3 thus covering the main part of the plasmasphere up to GNSS orbit heights at around 20000 km height.

It will be shown that space borne GNSS monitoring is a powerful technique for studying coupling processes between ionosphere, plasmasphere and magnetosphere under quite different conditions. Thus, enhanced plasma outflow into the plasmasphere and enhanced downward plasma fluxes due to a compression of the plasmasphere during geomagnetic/ionospheric storms may be observed. Furthermore, also regular ionospheric phenomena like the nighttime winter anomaly (NWA) effect are visible indicating a significant impact of the plasmaspheric electron content and its dynamics on the ionospheric behavior.

The talk addresses various aspects related to the applied electron density reconstruction technique, to topside ionosphere/plasmasphere monitoring under quiet and perturbed conditions and presents a mathematical approach that describes the plasmaspheric electron content as a function of daytime, season, geographic/geomagnetic location and solar activity [5]. The model is in line with a family of other models for TEC, NmF2 and hmF2 that have been developed in DLR. It is robust, fast and sufficiently accurate to be used as background model for fast reconstruction of TEC or electron density distribution in near real time GNSS application and services.

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