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Optimizing the plasmaspheric extension of the NeQuick topside ionosphere model through COSMIC-1 Radio Occultation and POD TEC observations

Alessio Pignalberi*(1), Bruno Nava(2), Michael Pezzopane(1), Haris Haralambous(3), Pierdavide Coïsson(4), David R. Themens(5), Fabricio Prol(6), and Artem Smirnov(7)
(1) Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy; alessio.pignalberi@ingv.it; michael.pezzopane@ingv.it
(2) The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy; bnava@ictp.it
(3) Department of Electrical Engineering, Computer Engineering and Informatics, School of Engineering, Frederick University, Nicosia, Cyprus; eng.hh@frederick.ac.cy
(4) Université Paris Cité, Institut de physique du globe de Paris, CNRS, Paris, France; coisson@ipgp.fr
(5) School of Engineering, University of Birmingham, Birmingham, UK; d.r.themens@bham.ac.uk
(6) Department of Navigation and Positioning, Finnish Geospatial Research Institute (FGI), National Land Survey of Finland (NLS), Espoo, Finland; fabricio.dossantosprol@nls.fi
(7) Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Potsdam, Germany; asmirnov@gfz-potsdam.de

NeQuick is a global empirical model describing the median climatological behavior of the electron density in the ionosphere–plasmasphere system [1], and which also allows a fast calculation of total electron content (TEC) values up to GNSS heights by numerical integration of the modeled vertical electron density profile. To ensure the highest reliability in TEC predictions, an accurate description of the topside ionosphere region is fundamental since it contains the largest fraction of TEC.
NeQuick describes the topside ionosphere and its plasmaspheric extension with a single semi-Epstein layer anchored to the F2-layer peak with a height-dependent effective scale height H [2]. H is empirically formulated based on three topside parameters: H_0, g, and r. H_0 is the scale height value at the F2-layer peak; g represents the scale height vertical gradient near the F2-layer peak; r is the parameter controlling the H behavior distant from the F2-layer peak, i.e., in the plasmasphere. While the H_0 and g parameters were reliably estimated based on COSMIC/FORMOSAT-3 (COSMIC-1) radio occultation (RO) profiles [3], the r parameter requires a different approach due to the limited altitudinal extension of COSMIC RO profiles. To constrain the r parameter, we complemented COSMIC-1 RO profiles with TEC values from precise orbit determination (POD) antennas from the same satellites. POD TEC values are representative of the electron content of the upper part of the topside ionosphere (above the COSMIC-1 satellites) and of the plasmasphere.
The r parameter optimization is based on a twofold procedure. First, given a specific RO profile, H_0, g, and r parameters are obtained from the topside section of the RO profile [3]; thereafter, H_0 and g are kept fixed while r, starting from the first-guess value obtained from the RO profile, is varied until it matches the TEC value measured by the POD antenna at the position and time of the highest measured RO point and with an elevation angle higher than 60°. In this way, the optimized r parameter improves the description of H in the plasmasphere and then the NeQuick modelling of the electron density in the plasmasphere domain. The validity and reliability of the proposed procedure have been first evaluated based on synthetic NeQuick electron density profiles, and then applied to measured RO profiles and POD TEC values from a selected dataset of COSMIC-1 observations. These preliminary results are here presented and discussed in view of the application to the entire COSMIC-1 dataset for the development and implementation of a revised NeQuick topside ionosphere model.

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[2] Pignalberi, A.; Pezzopane, M.; Themens, D.R.; Haralambous, H.; Nava, B.; Coïsson, P. On the Analytical Description of the Topside Ionosphere by NeQuick: Modelling the Scale Height Through COSMIC/FORMOSAT-3 Selected Data. *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.* **2020**, 13, 1867-1878, https://doi.org/10.1109/JSTARS.2020.2986683.

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