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Experimental and theoretical analysis of the ionospheric impact on the amplitude and phase oscillations of GPS signals in the satellite-to-satellite and satellite-to ground communication links

A.G. Pavelyev (1), K Zhang (2), Y Liou (3), C. Wang (2), J Wickert (4), T Schmidt (4), A.A. Pavelyev (1), and Yu. Kuleshov (5)

(1) Kotelnikov Institute of Radio Engineering and Electronics RAS, Space Radio physics, Fryazino, Russian Federation (alxndr38@mail.ru), (2) RMIT University School of Mathemathical & Geospatial Sciences, GPO Box 2476V Melbourne Australia 3001, (3) Center for Space and Remote Sensing Research, National Central University, Chung-Li, 320, Taiwan, (4) GeoForschungsZentrum Potsdam (GFZ-Potsdam), Telegrafenberg, 14473 Potsdam Germany, (5) National Climate Centre, Bureau of Meteorology, Melbourne, Australia

By using the CHAllenge Minisatellite Payload (CHAMP) radio occultation (RO) data, a description of different types of the ionospheric impacts on the RO signals at the altitudes 30-90 km of the RO ray perigee is given and compared with the results of measurements obtained earlier in the satellite-to-Earth communication link at frequency 1.5415 GHz. An analytical model is introduced for describing propagation of radio waves in a stratified medium consisting of sectors with spherically symmetric refractivity distribution. This model gives analytical expressions for the phase delay, eikonal, bending angle, and refractive attenuation of radio waves given and is applied to the analysis of radio wave propagation phenomena along an extended path including the atmosphere and two parts of the ionosphere. Analytical model can be used for analytical ray tracing. Analytical ray tracing can control different regimes of the GPS signal propagation (multipath, diffraction, waveguide, etc.) and can be performed in general case for the analysis of radio communication and GPS navigation in trans-ionospheric links (satellite-to-satellite, satellite-to-Earth).The model explains significant amplitude and phase variations at altitudes 30-90 km of the RO ray perigee and attributes them to inclined ionospheric layers. Based on this analytical model, an innovative technique is introduced to locate layers in the atmosphere and ionosphere. A necessary and sufficient criterion is obtained for a layer to be located at the radio occultation (RO) ray perigee. The displacement of an ionospheric or atmospheric layer from the RO ray perigee can be assessed both, qualitatively and quantitatively using this criterion. The new criterion opens a new avenue in terms of measuring the altitude and slope of the atmospheric and ionospheric layers. The new criterion provides an improved estimation of the altitude and location of the ionospheric plasma layers compared with the back-propagation radio-holographic method previously used.
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