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An Initial Investigation of Ionospheric Gradients for Detection of Ionospheric Disturbances over Turkey

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Ionosphere is an ionized layer of earth's atmosphere which affect the propagation of radio signals due to highly varying electron density structure. Total Electron Content (TEC) and Slant Total Electron Content (STEC) are convenient measures of total electron density along a ray path. STEC model is given by the line integral of the electron density between the receiver and GPS satellite. TEC and STEC can be estimated by observing the difference between the two GPS signal time delays that have different frequencies L1 (1575 MHz) and L2 (1227 MHz). During extreme ionospheric storms ionospheric gradients becomes larger than those of quiet days since time delays of the radio signals becomes anomalous. Ionosphere gradients can be modeled as a linear semi-infinite wave front with constant propagation speed. One way of computing the ionospheric gradients is to compare the STEC values estimated between two neighbouring GPS stations. In this so-called station-pair method, ionospheric gradients are defined by dividing the difference of the time delays of two receivers, that see the same satellite at the same time period. In this study, ionospheric gradients over Turkey are computed using the Turkish National Permanent GPS Network (TNPGN-Active) between May 2009 and September 2012. The GPS receivers are paired in east-west and north-south directions with distances less than 150 km. GPS-STEC for each station are calculated using IONOLAB-TEC and IONOLAB-BIAS softwares (www.ionolab.org). Ionospheric delays are calculated for each paired station for both L1 and L2 frequencies and for each satellite in view with 30 s time resolution. During the investigation period, different types of geomagnetic storms, Travelling Ionospheric Disturbances (TID), Sudden Ionospheric Disturbances (SID) and various earthquakes with magnitudes between 3 to 7.4 have occured. Significant variations in the structure of station-pair gradients have been observed depending on location of station-pairs, the path of the satellites, strength of the geomagnetic storms and type, depth and magnitude of the earthquakes. For a typical geomagnetic storm the gradients can get as high as 30 mm/km. For the earthquakes, both the magnitude and the structure of the ionospheric delay gradients exhibit strong variability. This study forms a basis for a comprehensive understanding of ionospheric variability for midlatitude GBAS and SBAS systems. This study is supported by a joint grant of TUBITAK 112E568 and RFBR 13-02-91370-CT_a.