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Directional and Time Analysis of Wave-like Ionospheric Disturbances over Turkey Using Near Real Time Indicator DROT

Meltem Koroglu[1,2], Feza Arikan[1]
(1) Department of Electrical and Electronics Engineering, Hacettepe University, Beytepe, Ankara, Turkey 06800,
e-mail: meltem.koroglu, arikan@hacettepe.edu.tr.

Ionosphere causes a variable time delay on the propagation speed of GPS signals which affects positioning. In order to get high position accuracy on GPS receivers, ionospheric variability should be understood correctly. Variability of ionospheric structure highly depends on electron density. Electron density of ionosphere changes due to various effects such as sunspot number, geomagnetic activities. Wave-like oscillated disturbances named as Traveling Ionospheric Disturbance (TID) can occur due to these ionospheric variations. TIDs affect amplitude and phase of GPS signals. Consequently degradation of position accuracy occurs on GPS receivers.

Slant Total Electron Content (STEC) is defined as the total number of electrons along a ray path from satellite to receiver and it is commonly used for ionospheric analysis. One of STEC estimation methods is IONOLAB-STEC which utilizes dual frequency GPS receiver measurements as detailed in www.ionolab.org. It is computed from the ionospheric delay by using the difference of code and phase measurements that are measured in L1 and L2 frequencies. Rate of TEC Index (ROTI) is an indicator that is used commonly in literature for detection of TIDs. In addition to ROTI, there is a novel near real-time indicator named as Differential ROT (DROT) developed recently. DROT indicates the intensity of the difference between ROT and its trend. According to DROT method can detect wave-like disturbances with approximately %80 percent reliability. 50% and 70% DROT values indicate that there might be a single disturbance due to an earthquake; possible Medium Scale Ionospheric Disturbances (MSTID) or weak disturbances due to geomagnetic storms. DROT values that are larger than 70% are indicators of severe disturbances, Large Scale Traveling Ionospheric Disturbances (LSTID), or some strong MSTIDs.

For the purpose of investigating the mid-latitude behavior of irregularities over ionosphere, Turkey region is selected in this study. Turkish Permanent GPS Network Active (TNPGN-Active) stations that contain 146 stations are used for estimation of STECs over Turkey. After estimating STEC values for each receiver - satellite pair and each day, DROT values are computed. To eliminate the fault measurements caused by receiver or satellite, K-means classification method is applied to STEC estimates. Valid DROT values are grouped in six time interval in a day according to sun position. For each time interval, daily median, daily first and third quartiles are calculated to generate a general bound of DROTs for each day. Annual general trend of DROTs for each time interval are computed by using a moving mean smoothing method IONOLAB-KAPA over daily medians and daily quartiles. After this process, satellite tracks are grouped as over, west, east and north according to their tracks over Turkey. For detection of the disturbed days and directions, DROT values are grouped into 24 classes according to a time interval and a direction. Subsequent to grouping directions, daily medians are computed for each class. Computed daily medians for a direction and a time interval are compared with corresponding daily bounds of DROT.

In conclusion, general behavior of DROT values over Turkey is investigated according to direction and time intervals. 870000 valid DROT values are computed for year 2012. 16.4% of computed DROT values are higher than 70 and 28.72% of DROT values are observed between 50 and 70. In addition, DROT values are larger in winter days for each time interval. In summer days, between sunrise and local noon time interval DROT values are smaller. DROT values reduce to less than 60% during daylight times in spite of the fact that the amplitudes of slant delays caused by TIDs increase during these periods. During night hours, although the DROT values increase slant delays are not affected by the possible disturbances. Most of the detected disturbances are mostly observed from the north and west directions. On geomagnetic storm days, daily DROT median values are observed above the computed annual bound of DROTs. This study is supported by 115E915 and joint TUBITAK 114E092 and AS CR 14/001.
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