Automatic TEC Mapping Using a GPS Network and GIM-TEC

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Ionosphere is an important layer of atmosphere, extending from 60 km to 1000 km altitude. The primary source of ionization is solar radiation. Yet, various factors from geomagnetic field to atmospheric structure complicate the ionization and recombination processes. Ionosphere has a spatio-temporal variable structure which is also, inhomogeneous, anisotropic, and dispersive. In order to determine the effects of the ionosphere over the HF and satellite communication and space-based positioning signals, the structure of the ionosphere must be understood and the variability of the ionosphere must be continuously monitored. Total Electron Content (TEC) is one of the most important observables for monitoring Space Weather. Global Positioning System (GPS) Networks provide cost-effective solution for estimation of TEC. Due to various physical or operational disturbances, TEC data which is estimated from GPS may have gaps in space and time. In order to obtain regular and dense TEC values in a given region, TEC can be interpolated spatially which is called as TEC map. A widely used source of TEC maps can be obtained as Global Ionosphere Maps (GIM) from International GNSS (Global Navigation Satellite Systems) Service (IGS) website (ftp://igscb.jpl.nasa.gov). The spatial resolution of GIM maps are 2.5^0 in latitude and 5^0 in longitude, and typical temporal resolution of GIM is 2 h. In this study, an automatic spatial interpolation algorithm is developed for TEC maps using combination of a GPS Network and GIM-TEC. With the developed algorithm, high space and time resolution maps can be obtained automatically. The developed technique is applied to a midlatitude regional GPS Network, namely, Turkish National Permanent GPS Network (TNPGN-Active). At the first step, GPS-TEC values are estimated as IONOLAB-TEC (www.ionolab.org) and the missing TEC data are interpolated with spatial interpolation method from GIM-TEC. The algorithm utilizes two different Kriging algorithms, isotropic Universal Kriging with linear trend for midlatitude regions and Ordinary Kriging for other regions. The theoretical semivariogram function is chosen to be from the Matern Family which includes most of the other semivariogram functions and the Matern parameters are estimated using Particle Swarm Optimization (PSO). Using the proposed automatic TEC mapping method with ingestion of GIM-TEC is applied to TNPGN-Active and high spatio-temporal resolution TEC maps are obtained between May 2009 and May 2012 with 2.5 minute temporal update period, and 0.25^0 to 0.3^0 spatial resolution, in latitude and longitude, respectively.

This study is supported by the joint grant of TUBITAK 112E568 and RFBR 13-02-91370-CT a.