Contributions to The Ionosphere Disturbances Investigations by GNSS Data Due to Natural and Anthropogenic Hazards

Mohamed Freeshah[1,2], Erman Şentürk[3], Xiaohong Zhang[1], Xiaodong Ren[1], and Nahed Osama[4]

[1]School of Geodesy and Geomatics, Wuhan University, 129 Luoyu Road, Wuhan 430079, China; mohamedfreeshah@whu.edu.cn; xhzhang@sgg.whu.edu.cn; xdren@whu.edu.cn
[2]Geomatics Engineering Department, Faculty of Engineering at Shoubra, Benha University, 108 Shoubra St., Cairo 11629, Egypt;
[3]Department of Geomatics Engineering, Kocaeli University, Turkey;
erman.senturk@kocaeli.edu.tr
[4]State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, 129 Luoyu Road, Wuhan 430079, China; nahed.osama@whu.edu.cn

Abstract

Satellite communication and navigation systems can substantially be perturbed by ionospheric disturbances. Consequently, investigating ionospheric anomalous has great significance. In this work, we focus on the short-term irregular disturbances has been studied by our team during several hazards such as a strong thunderstorm in Wuhan city, super typhoon Mangkhut in the Northwest Pacific Ocean, and Beirut Port Explosion. Ground-based GNSS observations from dense Continuously Operating Reference Stations (CORS) and International GNSS Service (IGS) were utilized to derive total electron content (TEC) to analyze the TEC response due to hazards. TEC sequences were investigated under meticulous observations of the solar-terrestrial environment and geomagnetic storm indices in each study period to recognize the causes of the ionospheric disturbances. We used superior approaches to detect the ionospheric disturbances over the corresponding hazards. The main results showed that: (1) the maxima and minima values of TEC deviations were ~2.5 and 0.5 TECU, respectively. Three methods of Detrended Fluctuations Analysis (DFA) were applied to assess the ionospheric disturbances over GNSS CORS stations over Wuhan city. (2) significant ionospheric variations over the maximum spots during the powerful tropical cyclone within a few hours before the extreme wind speed. Moreover, the ionosphere showed a positive response where the maximum VTEC amplitude variations coincided with the cyclone rainbands or typhoon edges rather than the center of the storm. (3) the ionosphere responds to the Beirut Port blast with two-time arrivals. The first time arrival was after the blast

within a few minutes and it has a low frequency. Meanwhile, the second time arrival for the ionospheric disturbance was after more than 2 hours from the explosion time with high frequency than that of the first one. These ionospheric disturbances were associated with the time and space of the blast. Our results are a significant indication that the ionospheric disturbances are influenced by the acoustic-gravity waves' activity which has been induced by the thunderstorm, typhoon, and Beirut blast rather than by other random events.

Keywords: GNSS; Ionosphere, Hazards, total electron content (TEC)