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Study of thunderstorm induced traveling ionospheric disturbances (TIDs) and its characteristics using GNSS-TEC

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The perturbation in the ionosphere induced by thunderstorms occurrences in the troposphere have an effect on global navigation satellite system (GNSS) signals. Atmospheric Gravity Waves (AGWs) caused by thunderstorms are one of the primary causes of short-period Travelling Ionospheric Disturbances (TIDs). We present a statistical study of thunderstorm induced fluctuations in the Total Electron Content (TEC) globally. Thunderstorms play an important role in perturbing the electron distribution in the ionosphere. We use World Wide Lightning Location Network (WWLLN) data to identify the thunderstorm event over six continents. Using the Global Navigation Satellite System (GNSS)- International GNSS Service (IGS) data, we use the Vertical TEC (VTEC) and Rate of change Of TEC Index (ROTI) as proxies for the amplitude scintillation S4 index. Using the wavelet analysis of the small-scale fluctuations in the VTEC (dVTEC) profile. We provide a time series analysis of wave-like TEC fluctuations alongside lightning stroke count as a proxy for thunderstorm activity. In this paper, TIDs with period approximately 64 to110 minutes are extracted from dVTEC and 0.2–0.4 Total Electron Content Unit (TECU) magnitude perturbations are observed when the PRNs passes near the perturbed region due to thunderstorm. It is found that, in most cases, TIDs or a local maximum of dVTEC that could be coupled to AGWs are observed during periods of peak thunderstorm activity. To find out the more reliable connection between thunderstorm and TIDs, we choose stroke energy density that is comparable with the spectral power of TID. We found for some cases, the disturbances occurred at the location of the maximum stroke energy density and some have the oblique propagation from the location. We also investigate the propagation velocity of the wave along the propagation direction for each case study. Most of the locations show that the spectral power of TIDs and the stroke energy density are high linear correlation.

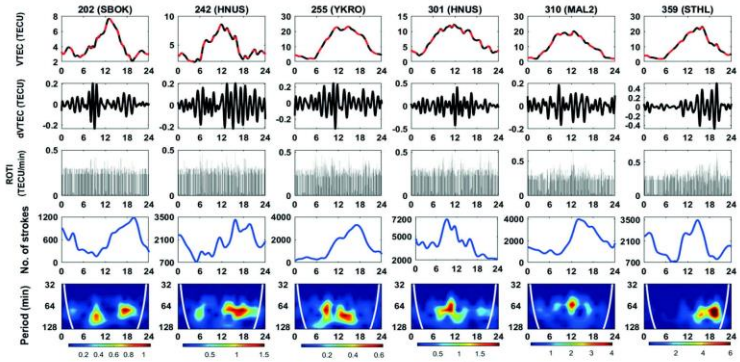

Figure 1. The temporal variation of VTEC along with fitted TEC, dVTEC, ROTI, number of strokes, and wavelet spectrum of dVTEC obtained from IGS station from top to bottom panel for Africa

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