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Short-term Variability of DE3 from MIGHTI, SABER, and TIDI: Potential Sources and Ionospheric Impacts

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A growing body of research indicates that upward propagating waves of terrestrial origin play an important role in shaping the dynamical structure of the mesosphere, thermosphere, and ionosphere on daily to interannual timescales. Understanding these variations is crucial for space weather studies and applications, including radio wave propagation, satellite communication, and navigation systems. Important progress has been made in understanding their role as coupling agents between the terrestrial weather and space weather on monthly to interannual timescales. However, due to the limited local time sampling by space-based observations and spatial gaps in the observations by ground-based chain of instruments, their short-term (<30 day) variability has not been resolved. Among these oscillations, the diurnal eastward-propagating tide with zonal wave number 3 (DE3) holds particular importance. This oscillation, driven by expansive tropospheric weather systems, can attain substantial amplitudes in the upper atmosphere.

This study addresses the short-term variability of the DE3 nonmigrating tide and investigates its connection with the ionosphere. First, we demonstrate and validate a short-term estimation technique at the equator utilizing physics-based model simulations and then implement the technique on SABER, MIGHTI, and TIDI measurements in the MLT region. We find that daily tidal DE3 estimates from SABER, MIGHTI, and TIDI at the equator are in mutual agreement, with correlation coefficients ranging from 0.76 to 0.85. The daily tidal variability in TIDI and SABER amplitudes is typically ∼7 m/s and ∼3 K, respectively. Smoothed daily DE3 tidal amplitudes from TIDI, MIGHTI, and SABER show strong intra-seasonal oscillations (residual amplitudes reaching 40%) with periods of 30-50 days. Comparison with the Madden–Julian oscillation (MJO) suggests that the MJO is modulating the upward propagating DE3. MJO is a major fluctuation in tropical tropospheric weather that typically recurs roughly every 30 to 60 days. We find similar behavior in F-region ionospheric electron density from the COSMIC-2 Global Ionospheric Specification (GIS) data product. This study aims to offer fresh observational insights into the pivotal role of tropospheric weather in shaping the dynamic attributes of the mesosphere, thermosphere, and ionosphere.