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Strong evidences for the coupling between the ionospheric wave-4 structures and atmospheric tides: empirical model with COSMIC data

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Longitudinal variations in ionosphere are usually explained in terms of the differences in geomagnetic field configuration. However, recently, the so-called wave-4 structure, characterized by enhancing at four longitude sectors separated about 90° from each other, was proposed to originate from the difference between the land and sea in heating the troposphere, through exciting the tide mode of DE3 (diurnal eastward-propagating with zonal wavenumber-3). Here, using principal component analysis with COSMIC data, we produce an empirical model to investigate the wave-4 structure. Considerable interhemispheric asymmetries are observed in wave-4 structures of NmF2 and hmF2. In particular, around midnight nearly antiphase wave-4 component in hmF2 is observed at the equatorial flanks. The wave-4 structures are decomposed into interhemispheric symmetric and anti-symmetric components (SYMW4 and ASYMW4). The ASYMW4 components in both NmF2 and hmF2 shift eastward at the rate of 4π/day while the SYMW4 components at the rate of 2π/day during daytime. The daytime SYMW4 components are attributed to the DE3 modulation of the E-region dynamo, while the ASYMW4 components are attributed to a SE2 (Semidiurnal eastward propagating with zonal wavenuber-2) tide in transequatorial wind. Evidence supporting the above hypotheses includes: 1) The NmF2 SYMW4 at the equator is in antiphase to that at the 15—25° during daytime, indicating the draining and diffusing effects of the fountain. 2) During the daytime, the hmF2 SYMW4 enhances within a U-shape pattern, which could be ascribed to the daytime variation of eastward electric field and the associated upward drift. 3) At the subequatorial latitudes, the hmF2 ASYMW4 is largely opposite in phase to the NmF2 ASYMW4, which could be explained in the terms of SE2 tide in transequatorial wind. Specifically, the anti-symmetric component dominates the wave-4 structure in hmF2 from local time 18 hour to 10 hour, suggesting in this period the SE2 transequatorial wind is the leading contributor to the wave-4 structure in hmF2.