

Coherent seasonal, annual, and quasi-biennial variations in ionospheric tidal/SPW amplitudes: Observations and Modeling

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In this study, we examine the coherent spatial and temporal modes dominating the variation of selected ionospheric tidal and stationary planetary wave signatures from 2007 - 2013 FORMOSAT-3/COSMIC total electron content observations using Multi-dimensional Ensemble Empirical Mode Decomposition (MEEMD) from the Hilbert-Huang Transform. We examine the DW1, SW2, DE3, and SPW4 components, which are driven by a variety of in-situ and vertical coupling sources. The intrinsic mode functions (IMFs) resolved by MEEMD analysis allows for the isolation of the dominant modes of variability for prominent ionospheric tidal / SPW signatures in a manner not previously used, allowing the effects of specific drivers to be examined individually.

The time scales of the individual IMFs isolated for all tidal/SPW signatures correspond to a semiannual variation at EIA latitudes maximizing at the equinoxes, as well as annual oscillations at the EIA crests and troughs. All tidal / SPW signatures show one IMF isolating an ionospheric quasi-biennial oscillation (QBO) in the equatorial latitudes maximizing around January of odd numbered years. This TEC QBO variation is in phase with a similar QBO variation isolated in both the GUVI zonal mean column O/N₂ density ratio as well as the F10.7 solar radio flux index around solar maximum, while showing temporal variation more similar to that of GUVI O/N₂ during the time around the 2008/2009 extended solar minimum. These results point to both quasi-biennial variations in solar irradiance as well as thermosphere / ionosphere composition as a generation mechanism for the ionospheric QBO.

We also present results from numerical experiments using the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) to quantify the sensitivity of the thermosphere and ionosphere to quasi-biennial oscillations in modulated atmospheric tides as well as that present in F10.7. Our results are some of the first numerical experiments examining the generation mechanisms behind the ionospheric QBO from both above and below.