Project Details

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Topic: Impact of Terrestrial Weather on the Ionosphere-Thermosphere

Project Title:
Impacts of atmospheric planetary-scale waves on the equatorial ionosphere

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Summary:
We propose to systematically investigate where and how tides and planetary waves from the lower atmosphere drive the longitudinal structures and day-to-day variations of the low-latitude ionosphere. Tides, such as DE3 excited by latent heat release in the tropical troposphere can propagate upward to the lower thermosphere, where they modify the wind-driven dynamo electric fields causing the ionospheric four-peaked structures. Although most planetary waves are trapped in the middle atmosphere, they may still extend their influences into the ionosphere. By modulating tides, the multi-day periodic signatures associated with planetary waves could be carried to high altitudes. In addition, fast (short period) planetary waves, such as the 3-day waves may propagate to the F-region, directly driving variations in the density and height of the ionospheric F-layer peak. Through various pathways, the lower atmosphere forcing contributes significantly to the large-scale variability of the equatorial ionosphere.

Previous studies have identified tides and planetary waves in the E-region (~100 km altitude), but the vertical extents of these waves and how exactly they impact the ionosphere have not yet been determined due to lack of sufficient observations at higher altitudes. Here we will use newly obtained concurrent observations of both the atmosphere and the ionosphere from multiple data sources of ICON, GOLD, COSMIC-2, TIMED, Aura, COSMIC, and ground-based GPS that provide the necessary coverage. Our work will incorporate a systematic analysis of various tides (DE2, DE3 etc.) and planetary waves (2-, 3-, 5-, 6-day wave etc.) across a broad altitude range from ~90-300 km and simultaneously search for their corresponding signatures in the F-region ionosphere. These results will be compared to the simulation results from NCAR's Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X), including validating large-scale waves and their effects in the model. The WACCM-X results will be used to interpret the observed signatures and determine the processes responsible for tides and planetary waves to drive the ionospheric structures and variations.

Objective 1: Which tides and planetary waves are observed to strongly impact the equatorial ionosphere? At what altitudes do these waves exert their impacts on the ionosphere? We will analyze the observational datasets to identify each tide and planetary wave (characterized by period, amplitude, zonal wavenumber, vertical wavelength etc.) and the corresponding ionospheric structures and variations throughout multiple years from 2002-present. This will allow for identifying which waves and characteristics are influential. The ICON neutral wind data span both E- and F-regions, enabling observations of the altitude limits where these waves propagate.

Objective 2: Are there seasonal dependences for tides and planetary waves to strongly impact the equatorial ionosphere? What impacts do these waves have on the ionosphere at the solar minimum condition? These available datasets are adequate to identify tides and planetary waves and their ionospheric signatures in all seasons. Moreover, the ICON and GOLD data at the current solar minimum are extremely useful to examine the vertical propagations of these waves and their modifications on the ionosphere during quiet solar activities.

Objective 3: How do tides and planetary waves impact the structures and variations of the equatorial ionosphere? We will compare the WACCM-X simulations against the observations, and perform model runs with different resolutions and schemes to achieve the best model and observation agreements. We will analyze the model results to understand the pathways for tides and planetary waves to impact the ionosphere. Using controlled model runs, we will be able to quantify the contribution of each of the processes that are most significant to drive the ionospheric variability.

Publication References:

no references