Project Details

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Topic: Impact of Terrestrial Weather on the Ionosphere-Thermosphere

Project Title:
Exploring the response of the ionosphere/thermosphere to the Madden Julian Oscillation

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Summary:
The overarching science goals are to explore and understand the global response of the ionosphere/thermosphere (IT) system to the Madden-Julian Oscillation (MJO) in the tropical troposphere, particularly ionospheric plasma and drifts. We will comprehensively analyze the MJO modulation of tides, Ultra-Fast Kelvin Waves (UFKW) and the mean in neutral and plasma parameters using a variety of spaceborne assets (ICON, GOLD, COSMIC-2, TIMED), ground-based observations (Poker Flat Incoherent Scatter Radar), and investigate the physical coupling mechanisms into the IT system using dedicated SD-WACCM-X and TIEGCM simulations, and MERRA-2.

The MJO is a recurring tropical weather pattern that shifts low-latitude convection patterns on intra-seasonal time scales (30-96 days). Recent progress in neutral dynamics data analysis mainly from SABER/TIMED and MERRA-2 has unequivocally revealed that the MJO impacts tidal and GW activity in the upper mesosphere (80-100 km) on the order of 10-20%, depending on latitude, season, and MJO location. Similar effects have been found in Kelvin waves and in thermospheric density from in-situ satellite measurements (i.e., GOCE). The new COSMIC-2, ICON and GOLD data allow us to make the next step and explore how the ionosphere responds to the MJO, a challenge that could not be met before due to a lack of data to resolve wave and mean variations originating from the lower atmosphere on weather timescales. Consequently, the MJO-modulation of the ionospheric plasma and drifts is not known to date. It is, however, likely that a strong response exists due to the MJO in tides, UFKW and GWs that either (i) impart the signal on the ionosphere through E-region dynamo or (ii) direct upward propagation and/or composition changes.

The ICON precession rate is fast enough to diagnose the tidal spectrum (period/wavenumber) with a time resolution ~1 month, which is sufficient to extract a MJO modulation of the tides in E-region winds and in F-region drifts & ion densities. This will be supported by high resolution SABER/TIMED tidal diagnostic and GOLD composition observations at constant local times. The COSMIC-2 constellation allows one to obtain the ionospheric tidal wave spectrum every day, e.g., using the hourly GIS data product, the radio occultation and in-situ observations. As such, we will be able to directly connect driving and response from the data. By nudging the observed E-region wind fields with/without MJO into TIEGCM, the model will be used to diagnose the propagation of MJO signals into the IT parameters such as vertical ion drifts and plasma density. Running SD-WACCMX with the MJO removed in the nudged MERRA-2 data will allow one to investigate the coupling mechanisms from the troposphere into the ionosphere through term analysis. Our study will also shed light into the physical coupling of the MJO into the high latitude ionosphere, to explain a surprisingly large MJO signal that we identified in a preliminary analysis of PFISR electron density observations.

The proposal directly addresses FST #1 as it will quantitatively connect an important and recurring tropospheric weather phenomenon with its impact on the IT system using new satellite data sets, ground-based data, and state-of-the-art models. All data are publicly available through the NASA SPDF, the COSMIC-2 data repositories, and the CEDAR Madrigal database.

Publication References:

no references