Project Details

ROSES ID: NNH21ZDA001N
Selection Year: 2021
Program Element: Focused Science Topic

Topic: Impact of Terrestrial Weather on the Ionosphere-Thermosphere

Project Title:
Ionospheric responses to thunderstorm-generated acoustic and gravity waves over the continental US

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Summary:
Intense convective systems like thunderstorms are known to generate acoustic and gravity waves (AGWs) that may reach ionospheric heights, induce complex dynamics, electromagnetic effects and seed self-evolving plasma instabilities and ionospheric irregularities including traveling ionospheric disturbances (TIDs). AGW detection and induced effects are routinely reported using ground- and space-based instrumentation. However, the characteristics of the AGW sources and the neutral and ionized background states along the path of AGW propagation, that facilitate the generation of detectable disturbances in the ionosphere, need to be understood and quantified. The continental US experiences significant thunderstorm activity in the summer months, with the mid-west identified as a global hotspot for convectively generated AGWs. This, along with the high density of suitable instrumentation, make it the perfect location for studying these phenomena. Our proposal attempts to study the dynamics, conditions and the extent of the impact of thunderstorm-generated AGWs on the mid-latitude ionosphere over the continental US. In particular, we propose to address the following science questions (SQs):
1. What are the solar, geomagnetic, and atmospheric and ionospheric conditions that lead to detectable TIDs from thunderstorm-generated AGWs?
2. What are the amplitudes and temporal and spatial characteristics of TIDs occurring in the presence of thunderstorm activity?
3. What are the momentum and energy depositions of thunderstorm-generated AGWs into the mid-latitude ionosphere and the related electrodynamic effects?
To address SQs 1 and 2, we propose to use multi-layer observations for events associated with thunderstorm activity. Lower and middle atmospheric observations include NEXRAD radar reflectivity and rainfall rate maps to infer thunderstorm activity, brightness temperature perturbations showing gravity waves in the stratosphere from the Atmospheric Infrared Sounder (AIRS) on NASA's Aqua satellite, and data from the Cloud Imaging and Particle Size (CIPS) instrument on the Aeronomy of Ice in the Mesosphere (AIM) satellite. The impacts on the ionosphere will be studied using multi-constellation GNSS total electron content (TEC) observations and ground scatter from the SuperDARN radars that show evidence of irregularities like MSTIDs, as well as airglow imagers and available ionospheric satellite data. We will study the co-occurrences of ionospheric irregularities over simultaneous occurrences of thunderstorms, AGWs and TIDs, and create a database of events from 2010-2020, spanning the majority of Solar Cycle 24.
To address SQ3, we will perform a set of parametric and case-study modeling investigations with the use of our state-of-the-art full-physics-based three-dimensional coupled atmospheric and ionospheric models MAGIC and GEMINI, spanning the atmospheric and ionospheric dynamics from the ground to exobase heights. The simulations will include highly realistic specifications of thunderstorm-generated AGWs based on NEXRAD observations, and background atmospheric and ionospheric states based on empirical and climatological models and observations.
The science objectives of this proposal directly address the LWS 2021 solicitation and in particular Focused Science Topic (FST#1), which seeks to understand the impact of terrestrial weather on the Ionosphere-Thermosphere system. The proposed effort includes observational- and modeling- based study to address the variability in the ionosphere thermosphere mesosphere (ITM) system from upward propagating AGWs over convection sources. The science goals are directly applicable to the LWS Strategic Science Areas SSA-VI and SSA-VII and also aligns with the NASA Heliophysics Decadal Survey science goal 2, Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs".

Publication References:

no references