Project Details

ROSES ID: NNH20ZDA001N
Selection Year: 2020
Program Element: Focused Science Topic

Topic: Long Term Variability and Predictability of the Sun-Climate System

Project Title:
Investigations of the solar cycle variations in D/E-region electron density

PI Name: Dong Wu
PI Email: atn@g.ucla.edu
Affiliation: Jet Propulsion Laboratory
Project Member(s):
- Emmons, Daniel J;Co-I;Air Force Institute of Technology
- Swarnalingam, Nimalan;Co-I;Catholic University Of America

Summary:
The objective of the proposed study is to develop an accurate representation of electron density (Ne) and variability in the D/E-region from the Global Navigation Satellite System (GNSS) Radio Occultation (RO) observations, so as to better understand its roles in atmospheric ozone loss and global electric circuit. We will characterize the Ne uncertainty through validations against other data sets. We will develop empirical Ne models as a function of latitude, height and local time, as well as a parameterized function with solar forcing and magnetic activity proxies. We will study and evaluate the connection between the polar nitric oxide (NO), ozone (O3) and Ne from auroral and radiation belt electron precipitation, to quantify the role and potential contribution of Ne in NO enhancement and O3 reduction. The improved understanding and characterization of the D/E-region Ne will yield an important contribution to the Heliophysics Decadal Survey goal to "determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs .

The proposed study responds directly to FST #4: Long Term Variability and Predictability of the Sun-Climate System, in particular, impacts of solar variability and solar-driven geomagnetic variability on atmospheric composition (i.e., NO, O3). As a primary goal, the proposed investigation will address the hypothesized process that polar auroral and radiation belt electron precipitation would enhance HOx and NOx concentration and cause more ozone loss. Atmospheric ozone is an important climate variable. However, it remains uncertain about the extent to which polar auroral and radiation belt electron precipitation may affect the ozone chemistry through additional HOx and NOx production. The short-lived HOx tends to produce direct and localized effects on the ozone loss, while the long-lived NOx can be transported down to the stratosphere producing indirect effects on the ozone loss. Our investigation will provide a key observational constraint to the modeled concentrations of polar electron precipitation and quantify its impacts on NO and O3 variations.

The secondary goal of the proposed study will address an electrical coupling process of the Sun-climate system by characterizing global D/E-region Ne and variability for the upper boundary potential of the global electric circuit (GEC) system. This has an important implication on how effectively the electrified clouds in the troposphere can couple to the ionosphere under GEC. Thunderstorms and electrified clouds are the GEC driver that maintains a potential difference between the ground and the lower ionosphere, and the lower-ionospheric conductivity is directly affected by the distribution and variations of the D/E-region Ne. Our investigation will characterize the D/E-region Ne (i.e., the GEC upper boundary potential) with unprecedented spatiotemporal coverage and greatly reduce the current uncertainties about electron concentration and variations in the lower ionosphere. The proposed development of Ne empirical models will serve as a valuable tool to validate model inputs and improve model predictability.

The schedule and milestones reflect key project accomplishments. In addition to the peer-reviewed papers planned at these milestones, we will make the validated D/E-region Ne data available to the science community, as well as the associated empirical models developed from this project. The proposed project activities will include algorithm development and improvement (Year 1), characterization of Ne morphology and variations (Years 1-2), Ne validation (Years 2-3), development of Ne empirical models (Years 2-3), and investigations of Ne connections to NO and O3 variations (Years 3-4).

Publication References:

no references