Project Details

ROSES ID: NNH22ZDA001N-LWS
Selection Year: 2022
Program Element: Focused Science Topic

Topic: FST #1: Beyond F10.7: Quantifying Solar EUV Flux and its Impact on the Ionosphere - Thermosphere - Mesosphere System

Project Title:
Effect of the uncertainty and variability of solar irradiance on the thermospheric and the ionospheric weather predictability

PI Name: Chih-Ting Hsu
PI Email: chihting@ucar.edu
Affiliation: University Corporation For Atmospheric Research (UCAR)
Project Member(s):
- Qian, Liying;Collaborator;UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH
- Chamberlin, Phillip C;Collaborator;REGENTS OF THE UNIVERSITY OF COLORADO, THE
- Pedatella, Nicholas;Co-I;UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Summary:
The goal of this project is to advance our understanding of how solar irradiance variability drives the variability of Earth's thermosphere and ionosphere and improve our capability to represent this driver-response relationship in physics-based models using data. The upper atmosphere absorbs solar radiation in the ultraviolet range and generates plasma through photon ionization and dissociation processes, so the thermosphere and the ionosphere are very sensitive to changes in solar irradiance. The solar ultraviolet spectrum in most current numerical models is parameterized by the daily 10.7 cm solar ux. However, solar ultraviolet radiation is highly variable on time scales shorter than a day, and the changes in different wavelengths are not perfectly correlated. Some recent modeling efforts incorporate a more realistic solar spectrum model. Yet, the uncertainty in spectrum models is not quantified and considered in any numerical models of the thermosphere-ionosphere. It is critical to investigate the sensitivity of the thermosphere and ionosphere to short-term solar ultraviolet variability and uncertainty in the solar spectrum._x000D_
_x000D_
Building on our past work with the National Center for Atmospheric Research Whole Atmosphere Community Climate Model with thermosphere and ionosphere eXtension (WACCM-X) and the Data Assimilation Research Testbed (DART) Ensemble Adjustment Kalman Filter, this project will develop a new ensemble forecasting and data assimilation modeling framework that is interoperable with the solar ultraviolet spectrum model, Flare Irradiance Spectral Model-Version 2 (FISM2). The FISM2 model doesn't provide information of uncertainty regarding the solar irradiance data. Therefore, the solar irradiance data will first be analyzed statistically to evaluate the spectral variability and uncertainty of solar irradiance ranging from 0.1 to 180 nm. Next, WACCM-X ensemble forecasting driven by FISM2 and associated spectral variability and uncertainty will be performed to understand the sensitivity of the thermosphere and the ionosphere to both the short-term variability and the uncertainty of solar radiation. Data assimilation experiments will also be performed to examine the capability of the new method for thermospheric and ionospheric weather prediction. With the help of DART, NASA-GOLD, NASA-ICON, and COSMIC-II data will be assimilated into the WACCM-X driven in the same way as ensemble forecasting experiments. Observing system simulation experiments will be launched to help quantify the new method's impact on thermospheric and ionospheric weather prediction. Observing system experiments will further improve our scientific understanding of how solar irradiance affects the variability of the thermosphere and ionosphere._x000D_
_x000D_
This project will answer the following science questions: _x000D_
1. How does the uncertainty in the solar spectral irradiance of different wavelengths, explicitly ranging from 0.1 to 180 nm, impact the uncertainty in thermosphere-ionosphere simulations at different altitude regions? _x000D_
2. What are the relative contributions of the uncertainty of the thermosphere and ionosphere associated with uncertainties of the solar spectral irradiance during different solar activity levels and different seasons?_x000D_
3. Does improved specification of the solar irradiance enhance thermosphere-ionosphere predictability?_x000D_
_x000D_
The proposed project is highly aligned with the scientific objectives of this year's Living With a Star Focused Science Topic #1 to develop the ability to reliably specify and predict the effects of solar variability on the ITM system. We primarily focus on identifying the improved solar spectrum model for driving model predictions of IT structure. The project will advance our understanding of the connection between the short-term variability of solar irradiance and the Earth's thermosphere and ionosphere, and improve our capability to numerically predict the weather of the thermosphere and ionosphere.

Publication References:

no references