Project Details

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Selection Year: 2021
Program Element: Focused Science Topic

Topic: Impact of Terrestrial Weather on the Ionosphere-Thermosphere

Project Title:
A link between weather regimes: Large-scale teleconnections in the Earth s atmosphere and ionosphere

PI Name: Fabrizio Sassi
PI Email: atn@g.ucla.edu
Affiliation: Naval Research Laboratory
Project Member(s):
- Dhadly, Manbharat Singh;Co-I;Naval Research Lab
- Pedatella, Nicholas;Co-I;University Corporation For Atmospheric Research (UCAR)
- McDonald, Sarah E;Co-I;Naval Research Lab

Summary:
The extension of numerical models to the upper atmosphere (UA; thermosphere & ionosphere) with the inclusion of electrodynamics have produced high-fidelity whole atmosphere (WA) descriptions of the terrestrial weather, from the ground to the exobase (~500 km). Such WA interactions are mediated by traveling planetary waves, solar and lunar tides, and gravity waves that interact with the ionized atmosphere above about 100 km, and affect the structure and variability of what is called geospace weather. Thus, a link between the weather regimes of the lower atmosphere (LA; atmosphere below 100 km) and the UA exists. However, a holistic approach that includes both theory (numerical models) and observations (data assimilation), much needed to understand this connection, has been rarely implemented.
Forecasting the UA remains well behind predictive systems of the LA, due in part to compelling questions that remain unanswered: (a) what are the limitations due to forecasting errors; (b) what is the role of composition and transport to define the complex interactions between neutral dynamics and electrodynamics in the low latitude E-region; and, (c) can predictions in the UA benefit from a greater integration of modeling and observations with data assimilation techniques.
Our program focuses on large-scale interactions between the atmosphere and the ionosphere. The proposed research is articulated over four science objectives:
a. Does the seasonally changing large-scale energy propagation from the LA determine the day-to-day weather of the UA?
b. Are model errors of large-scale structures quantifiable using ensemble analyses/forecasts?
c. Are interactive composition and transport crucial to understand the large-scale low-latitude E-region electrodynamics?
d. Can the predictability of UA properties be evinced from initialized forecasts?
We will utilize a climate model (the Whole Atmosphere Community Climate Model, eXtended - WACCMX) either integrated with a data assimilation system (Data Assimilation Research Testbed DART) that includes observations in the UA, or nudged by atmospheric specifications (MERRA2; Modern Era Retrospective analysis for Research and Applications, version 2) up to about 65 km. The neutral dynamics produced by WACCMX will drive an ionospheric model (SAMI3 - Sami is Another Model of the Ionosphere) whose simulations are used to illustrate the effects of the neutral atmosphere on ionospheric dynamics, and the role of inline chemistry and transport that define the electrodynamics in the critical E-region. Observations from NASA space-based platforms such as GOLD, ICON, TIMED/SABER, and TIMED/TIDI, along with ionosonde measurements that describe the state of ionosphere, will be used to inform a data assimilation system in the thermosphere and to evaluate the forecast quality produced in both the thermosphere and ionosphere.
Ultimately, the project goals are to determine the role of the LA in the formation of the day-to-day weather of the UA, and quantify the predictability of their properties utilizing state-of-the-art tools and technique that integrate observations and theory.
Relevance: The proposed research addresses compelling questions for FST#1 in the LWS call that pertain to whole atmosphere interactions and predictions. In addition, the proposed study is directly relevant to the Decadal Survey Key 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