Project Details

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Program Element: Targeted Science Team

Topic: Ion-Neutral Interactions in the Topside Ionosphere

Project Title:
The Topside Ionosphere and Thermosphere: Dynamics and Coupling During Geomagnetic Storms

PI Name: Yongliang Zhang
PI Email: atn@g.ucla.edu
Affiliation: Johns Hopkins University Applied Physics Laboratory
Project Member(s):
- Burns, Alan G; Co-I; University Corporation for Atmospheric Research
- Paxton, Larry J; Co-I; Johns Hopkins University
- Zhang, Shun-Rong ; Co-I/Institutional PI; MIT
- Erickson, Philip J.; Co-I; MIT Haystack Observatory
- Yue, Xinan ; Co-I; University Corporation for Atmospheric Research
- Wang, Wenbin ; Co-I/Institutional PI; University Corporation for Atmospheric Research
- Huang, Chaosong ; Co-I/Institutional PI; Air Force Research Laboratory
- Mayr, Hans Georg; Co-I; The Johns Hopkins University Applied Physics Laboratory

Summary:
(a) Key objectives and their scientific importance

The key objectives of the proposed work are to determine the characteristics of the storm-time topside ionospheric and thermospheric variations, identify the key drivers for these variations and determine their relative contributions so physics based predictive capability of the storm-time TEC can be improved. The topside ionosphere is very dynamic, especially during storm times. However, detailed quantitative (within data and model error limits) understanding of its storm-time behavior remains inadequate, especially regarding changing roles of the competing drivers. The proposed work is to address following scientific questions that are critical to understanding the storm-time topside ionosphere over mid, low and equatorial latitudes.

(1) What are the characteristics of the topside ionosphere and the thermosphere responses to geomagnetic storms under different solar-geophysical conditions?

(2) How do F2-peak region conditions and topside mass flows affect the storm-time topside ionosphere?

(3) What are the impacts of neutral composition and temperature on the storm-time topside ionosphere?

(4) How do storm-time neutral winds and electric fields shape the topside ionosphere?

(5) What are the relative contributions of those drivers listed in (2)-(4) to the topside ionosphere and TEC variations?

(b) Methodology

We will analyze comprehensive global data sets from satellite and ground based measurements over one solar cycle (2002-2013) using a ionospheric assimilation/reanalysis method and will carry out physics based diagnostic simulations using the TIME-GCM (Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model) to address these questions. These data sets include (partial list): (a) topside ionosphere density, ion composition, temperature, electric field, plasma drift and topside TEC from satellites (e.g. COSMIC, DMSP, C/NOFS, CHAMP, GRACE, JASON, SACC, Metop-A/B, Demeter, TerraSAR-X/TanDEM), ground based incoherent scatter radars, and ground GNSS receivers and ionosondes; (b) thermosphere neutral density, temperature, composition and wind from TIMED, DMSP, GRACE, CHAMP and ground based FPIs; (c) solar and geomagnetic conditions from TIMED, SDO, WIND, ACE and World Data Center repositories. We will select representative storms (up to 20) and run our existing ionospheric assimilation/reanalysis method to reconstruct global ionospheric density profiles for the selected storms and the quiet times before and after the storms. The physics based TIME-GCM will be updated (extending topside boundary altitude and using topside flux derived from data as topside boundary) and run for the storms. The above five science questions will be addressed through the global data analysis/reanalysis and model runs.

(c) Significance and Relevance to NASA Objectives

The expected results from the proposed work will advance our understanding of the dynamics of the topside ionosphere and thermosphere and their coupling. The proposed work is directly relevant to the 2014 NASA LWS Targeted Research and Technology focused science topic 3.1.3 Ion-neutral interactions in the topside ionosphere . The proposed work also supports the NASA Heliophysics Division Objectives of Understanding the connected Sun-Earth system and Understanding of the Sun and planetary space environments and potentially supports the NASA s new GOLD and ICON missions.

Publication References:

no references