Project Details

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Project Title:
A Retrospective Analysis Toolbox for Ionospheric Total Electron Content Maps

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Summary:
SCIENCE GOALS
Regional and global ionospheric total electron content (TEC) maps have been routinely produced and made publicly accessible by several research institutions around the world. These TEC maps are obtained from Global Navigation Satellite System (GNSS) measurements using different satellite constellations and selected networks of ground receivers. TEC maps are one of the key ionospheric datasets for understanding height-integrated ionospheric dynamics at various spatial and temporal resolutions. Recently, improvements in TEC data processing over areas of dense ground receiver distributions open possibilities of robust analysis of ionospheric structuring. However, comprehensive analysis of ionospheric structuring over two decades of TEC maps is currently lacking due to large data volume. Corresponding analysis tools are yet to be tailored to apply to the TEC map dataset. Characterizing key features on TEC maps and understanding their dynamic coupling with external drivers can significantly benefit space weather forecasting. The goal of the investigation is to design a software toolbox for analyzing ionospheric TEC maps retrospectively. The toolbox will be able to identify local regions of elevated TEC from TEC maps, extract characteristic features of the TEC enhancement regions, and diagnose solar and interplanetary driving of the TEC intensification. The objectives of the investigation are: 1) Develop existing image-processing programs to extract features of local TEC intensifications on both global and regional TEC maps and 2) Implement transfer entropy to analyze the connection from solar and interplanetary conditions to the extracted features of the local TEC intensifications.

METHODOLOGY
We will address the objectives by building on, improving, and integrating our existing software of feature extraction and transfer entropy. First, we will will extend the existing feature extraction program to output not only the number of TEC intensifications but also characteristics of the TEC intensifications. Second, we will implement a normalized transfer entropy calculator to compute the normalized transfer entropy from the F10.7 and solar wind data to the identified TEC intensifications.This will reveal any non-linear correlation and predictive information transfer from the solar/interplanetary conditions to the TEC intensifications. The feature extraction program and the normalized transfer entropy calculator construct the toolbox. We will test the toolbox for global TEC maps and regional TEC maps of various spatial resolutions during solar maximum and solar minimum years.

DELIVERABLES
Our toolbox will be made available to the community and applicable for analyzing TEC maps produced by any research institution. We will deliver the toolbox, including the feature extraction program and the normalized transfer entropy calculator, to GitHub and to the CCMC as one of the LWS supported tools and methods (https://ccmc.gsfc.nasa.gov/lwsrepository/index.php). The expected delivery date is April and May 2023.

RELEVANCE
The investigation is highly relevant to the LWS Objective 1 Space Science: LWS quantifies the physics, dynamics, and behavior of the sun-Earth system over the 11-year solar cycle.". It also addresses the two of the three overarching science goals of NASA's Heliophysics program: Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system" and Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth".

Publication References:

no references