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:
The missing link: Relating decades of solar and cosmic ray observations to Lightning and extreme weather patterns on Earth

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Summary:
Motivation and Science Objective:
While the impact of solar variability on the upper atmosphere and geospace is well established and understood, solar impact on terrestrial weather and climate is much harder to assess. The main solar variables with potential links to terrestrial weather are Galactic Cosmic Rays (GCRs) and total (TSI) and spectral (SSI) solar irradiance.
We propose to make a detailed, quantitative measure of the non-linear causal connection, sensitivity, and significance between water precipitation, cloud coverage, lightning, cyclonic storm strength and frequency, and GCRs and TSI.

To accomplish our objective, we address the following questions:
SQ1. How do solar and cosmic ray variability affect tropospheric weather parameters as functions of latitude and longitude?
SQ2. What are the temporal lagging times between solar and cosmic ray variability, and multi-scale (days to years) changes in tropospheric weather parameters?
SQ3. How do solar and cosmic ray variability affect terrestrial extreme weather events on different time scales (e.g., Hurricanes, droughts, extreme precipitation, enhanced/extreme lightning activity)?

Data and Methodology:
We use public data from multiple resources: Plasma and energetic particle data from space-based platforms (ACE/CRIS and OMNI), ground-based neutron monitors, and major ground-based and space-based meteorological data sets (e.g., Global Lightning Monitor, MODIS cloud coverage, CCMP wind vector, NCEP/DOE water precipitation among others). Our team comprises experienced scientists who worked on and are very familiar with these multidisciplinary datasets.
We carefully assemble a comprehensive unified database that comprises temporal and spatial binning on different scales (e.g., days to years, seasons, geographic coordinates). We perform lagged cross-correlation, linear causality, and transfer entropy analysis on this data to determine and quantify (i; SQ1) solar and cosmic ray correlations with spatial weather parameters; (ii; Q2) their temporal correlation; and (iii; Q3) How solar and cosmic ray variations affect extreme weather events. We take advantage of rigorous significance analysis to account for uncertainty in our data

Relevance:
This project responds to Strategic Science Area (SSA-IX) determined by the LWS TR&T steering committee, 2 key science goals of the 2012 Heliophysics Decadal survey (2&4), and this LWS Focused Science Team (FST) program elements. It is a data analysis study that examines the relationship between long-term solar variability and atmospheric responses , which focuses on variations in atmospheric temperature, winds, and composition and clouds and precipitation . Additionally, by taking advantage of novel information theory causality analyses, we move beyond simple correlations and enable a proper quantification of causality and its significance.

Contribution to the FST:
Our project will collate a set of diverse space and terrestrial tropospheric data in standardized cubes that we will share with the FST team to further probe their intertwined physical connections. Our results will include a relevance score to different space-related quantities, when determining their causal connections to tropospheric weather. This will provide new physical insights into the mechanisms that connect space phenomena with weather variations on Earth.

Publication References:

no references