Project Details

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Program Element: Focused Science Topic

Topic: Understanding the Large-Scale Evolution of the Solar Wind

Project Title:
Global Evolution of Solar Wind along Solar Cycles

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Summary:
Science Goals and Objectives

The variation of the Sun and the solar wind influence every aspect of the Heliosphere. Since the unusual solar minimum between cycle 23 and 24, the weakened solar activity level has been directly influencing the solar wind properties and the interplanetary magnetic field. How the Sun's weakening activity level affects the large-scale evolution of the solar wind throughout the heliosphere becomes a more crucial question than ever. To answer this question, we propose a 4-year research project to investigate the variation of the solar wind and the interplanetary magnetic field in responding to the changing solar cycle. This proposed project will directly address one of the 2021 LWS Focused Science Topics (FSTs): Understanding the Large-Scale Evolution of the Solar Wind throughout the Heliosphere through the Solar Cycle". Particularly, we will focus on the following scientific goals:

1) To understand the impact of the changing solar cycle on the long-term and large-scale evolution of solar-wind structures ;
2) To understand the impact of the changing solar cycle on the topology of the solar coronal magnetic field and the Heliospheric Current Sheet (HCS).

Data and Methodology
We will perform three different types of investigations, including data analysis, numerical modeling and Machine Learning (ML) / Artificial Intelligence (AI) prediction. Specifically, we will use solar wind and magnetic field data from instruments across the Heliophysics System Observatory (HSO): ACE, Wind, STEREO, SOHO, Hinode, Parker Solar Probe (PSP), and the observations of the joint ESA-NASA missions, Ulysses and Solar Orbiter (SO). We will utilize the Potential Field Source Surface (PFSS) model and the Current Sheet Source Surface (CSSS) model to track the coronal magnetic field from the Sun to the Earth. In addition, ML/AI techniques will be applied to the data to more objectively categorize the solar wind types and to predict the future behaviors of the Sun's magnetic field topology. In details, we will:

1) Utilize the long-term solar wind measurements to quantify how the solar-wind properties change responding to the changing solar cycle. Solar wind plasma in-situ properties will be examined and compared across different phases of solar cycles. We will use coronal EUV images to examine the evolution of the corona.
2) Apply ML/AI data analysis techniques to solar wind data to classify the wind types.
2) Connect the in-situ measurements of the long-term solar wind to the Sun by using PFSS and CSSS models, to explore the wind's coronal sources. We will examine the coronal origins of the solar wind with S-web (Q-map) calculated by PFSS, to investigate whether the winds are HCS/helmet streamer or pseudostreamer-associated.
3) Use the Sun's source surface synoptic maps (calculated by the PFSS) to examine the evolution of the HCS topology. We will investigate how the changes of HCS topology affect the solar wind structure. We will apply AI/ML techniques to predict the topology of the HCS, so that to predict solar wind structure.

Relevance and Contributions to the Focus Team Effort:
Our proposed work is directly related to one of the FSTs, Understanding the Large-Scale Evolution of the Solar Wind throughout the Heliosphere through the Solar Cycle. The outcomes of our project will provide: 1) a full picture of how the solar wind structure evolves in a large-scale in the recent three solar cycles. 2) A new view of how the HCS controls the equatorial solar wind in the heliosphere in a long-term. And 3) a new insight of how the changes of the solar corona affect the solar wind that engulfs the whole Helioshpere. The achievement of our science goals will be the key milestones in addressing this FST.

Publication References:

no references