Project Details

ROSES ID: NNH17ZDA001N
Selection Year: 2017
Program Element: Focused Science Topic

Topic: Understanding The Onset of Major Solar Eruptions

Project Title:
Understanding the Role of Helicity Flux in Solar Eruptions from Active Regions

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Summary:
Magnetic helicity in solar active regions (ARs) is a volume-integrated quantity that quantifies complexity in ARs. As the main contributor to helicity in the corona, helicity flux through the solar photosphere drives solar activity and thus space weather. It has been suggested that there is an upper limit to the helicity in a volume. Because helicity dissipation in the corona is very slow, the only mechanism that effectively removes helicity from the corona is a coronal mass ejection (CME). When helicity is removed, more helicity can be injected into the corona from below. Thus, this ``helicity injection, ejection, replacement'' (HIER) scenario predicts variations of helicity flux with eruptions.

We propose to determine the relationship between helicity flux and solar eruptions. We will use SDO/HMI vector magnetic field and the velocity field inferred using the DAVE4VM algorithm to calculate helicity flux in active regions, combined with existing GOES data and CMEs catalogs to characterize eruptive activity.

The proposed project has three parts. First, we will improve the helicity flux calculation by implementing three additional processing steps to: A) minimize the 24-hour oscillation in HMI vector magnetic field data; B) determine the optimal temporal and spatial resolution of the input data; and C) improve the temporal consistency of disambiguation of the transverse vector field. Second, we will conduct a statistical study to characterize any helicity flux-eruptivity relationship. Third, we will compare the HIER model to alternatives (e.g., cumulative helicity flux matters, but not variability).

A) To reduce 24-hour variations we will employ an empirical relationship between magnetic field and Doppler velocity measurements using the method reported in our 2014 paper. The method demonstrably reduces the 24-hour power in the magnetic field data.

B) The calculation of helicity flux is sensitive to cadence, spatial resolution, and noise of the input data. The effects of these three characteristics are convolved each other. We will determine the optimal combination of parameters that provide the best results. The cadence of the HMI vector data can be as high as 90 seconds (135 seconds before April 2016) and the spatial resolution is 0.03 degrees. This leaves sufficient room to test and find the optimum.

C) The velocity field needed to calculate the flux is determined using DAVE4VM. The algorithm requires a time series of vector field data. Temporal consistency of the disambiguation is a key factor to assure derivation of a reliable velocity field. With CGEM support, we have already developed a scheme to remove temporal discontinuities in the transverse field direction. We will evaluate impact of this data improvement in flux calculations.

We will analyze helicity flux and solar eruptions in a large set of ARs. Active regions with no eruptions will also be included. We have already identified a sample of 535 ARs from HMI observation in 2010-2017, including 214 emerging active regions. This sample is sufficient for a statistical study.

The project is relevant to the Focused Science Topic (FST), "Understanding the Onset of Major Solar Eruptions." Our methods will also determine the energy flux in ARs. We will provide these improved measurements of energy and helicity fluxes calculated with the HMI vector field to the community. Other groups participating in the FST can use these key data products to drive simulations to understand process of buildup of free energy and instability, and evolution toward eruption. Theorists can also benefit from our products to understand magnetic energetics and instability. Our project directly supports a specified measure of success, "Production of critical derived data products such as Poynting flux, helicity flux injection, and free energy build up from the observables with appropriate estimates of uncertainties."

Publication References:

no references