Project Details

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

Topic: Understanding The Onset of Major Solar Eruptions

Project Title:
The Role of Magnetic Topology in Determining the Eruptivity of Solar Flares

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Summary:
Science Objectives

The geometry, connectivity, and topology of the large-scale coronal magnetic field play a key role in determining whether a solar reconnection event will result in an eruption, either by influencing the location where magnetic reconnection releases energy for an event, or by determining the pathways and access to open field that allow an eruption to proceed. The research proposed here involves studying a large sample of flaring active regions to determine which topological features are most closely associated with both eruptive and non-eruptive events.

Knowledge of topological features that affect the eruptivity of active regions will provide insight into their cause, either in the context of the type of reconnection generating the event (e.g., whether coronal null points are most strongly associated with eruptions, as in the breakout model), or in the context of understanding why some flares lead to eruptions but others don't (e.g., whether access to open magnetic flux facilitates or enhances the chances of an eruption). By determining how often bald patches exist, the question of whether a flux rope must be present prior to an eruption, or if it can form during the eruption, will be addressed. Estimating the rate at which eruptions occur with and without particular topological features will yield probabilistic forecasts of whether the conditions are favorable for an eruption, should a flare occur. Of particular interest would be a topological feature associated with very low eruption rates, as this can be used to improve the ability to issue all-clear forecasts.

Methodology

The large-scale coronal topology will be determined in two different types of models: the oft-used Potential Field Source Surface (PFSS) model and a magnetofrictional (MF) model. Line-of-sight magnetograms are available for the PFSS models over the past two sunspot cycles from both SDO/HMI and SoHO/MDI, while for a shorter interval, SDO/HMI additionally provides vector magnetograms that will be used to drive the MF model and determine the presence of bald patches. The topology of the modeled coronal magnetic fields will be determined immediately prior to a large number of (eruptive and non-eruptive) solar flares. Topological and geometrical features of interest include the locations of null points in the coronal volume, positioning and orientation of separatrix surfaces, and the locations of domains of open fields relative to the active region cores. The importance of each feature in determining the eruption rate will be assessed by computing the Bayes factor of competing models: one for which the rate is the same with and without a given topological feature, and another for which the rate changes depending on the presence of the topological feature.

A significant part of the proposed effort will go into determining how robust the model topology is. Since the random error in vector field measurements is unlikely to be the dominant source of uncertainty in these models, we will focus on two other aspects: (1) how persistent are particular topologies given the continual evolving surface magnetic fields, and (2) how sensitive

are the topological features to the particular coronal field employed. In the first case, the focus will be on determining the lifetime of topological features. In the second case, we will characterize the similarity or difference in the topologies provided by the PFSS and MF models.

Contributions to the Focused Science Team Effort

The proposed investigation will provide guidance for more realistic modeling efforts by determining what coronal topology should be included in models for eruptive events. It can also be combined with a flare forecasting algorithm to immediately produce probabilistic forecasts of eruptive events. If the presence or absence of a particular topological feature is strongly associated with no eruptions, this could lead to a more robust determination of all-clear periods.

Publication References:

no references