Project Details

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Project Title:
Forecasting of Solar Eruptive Events

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Summary:
The magnetic structure and its evolution in active regions are determining factors of solar eruptions such as flares and coronal mass ejections (CMEs). Using data from Solar Dynamic Observatory (SDO) along with other space and ground-based observations, we propose to study the relation between evolution of solar magnetic fields and flares/CMEs, and furthermore establish a system of flare/CME prediction that involves two linked components:

(1) We will establish statistical correlation between magnetic fields measured in solar surface and productivity of flares/CMEs. In the past, we have extensively studied the following parameters: unsigned magnetic flux, magnetic gradient along the neutral line and magnetic energy dissipation. In the proposed study we will expanding the parameters to include (a) magnetic helicity injection (based on tracking the motion of surface magnetic fields) which takes the evolution of magnetic fields into consideration, (b) photospheric excess energy and (c) free magnetic energy which would be the most direct parameter describing the available energy in solar corona to power flares/CMEs. The first two parameters can be derived from photospheric vector magnetograms while the third one requires extrapolating three-dimensional (3-D) non-linear force-free (NLFF) fields using the observed vector magnetograms as the boundary condition. We are cautious that the proposed work will not largely rely on the NLFF extrapolation. The first two parameters can be studied with confidence. We will use SDO/AIA data for validation of NLFF extrapolation and the use of the third parameter. In addition to the correlation study, using the same data sets to follow the evolution of magnetic fields in flare productive regions will likely disclose the triggering mechanism of eruptive flares/CMEs, such as flux emergence, formation of magnetic channel and injection of helicity in the opposite sign.

(2) Using established correlation between magnetic parameters and the flare productivity, we will develop statistical and machine learning techniques to predict occurrence of solar flares. Based on preliminary results obtained so far, a promising tool that we will develop is a combination of ordinal logistical regression and Support Vector Machine (SVM) classification. Although our codes are developed for flare forecasting, they can be adapted for CME forecasting. We will explore the relation between magnetic helicity and CME occurrence.

Our proposed research aligns with the Living with a Star (LWS) strategic goals No.1 in that it helps to ``deliver the understanding and modeling required for useful prediction of the variable solar particulate and radiative environment''. The proposed research addresses the ``Science Analysis for the SDO'' component of the LWS Targeted Research and Technology Program (Tr&T), in particular, the ``Use of observations to predict future solar activity''. Our research will deliver new understanding of solar eruptions through the energy and helicity budgets of active regions, and will therefore contribute to predict flares/CMEs.

Publication References:

Summary: no summary

Reference: Li, Yixuan; Jing, Ju; Fan, Yuhong; Wang, Haimin; (2011), Comparison Between Observation and Simulation of Magnetic Field Changes Associated with Flares, The Astrophysical Journal Letters, Volume 727, Issue 1, article id. L19, 6 pp, doi: 10.1088/2041-8205/727/1/L19

Summary: no summary

Reference: Li, Yixuan; Jing, Ju; Fan, Yuhong; Wang, Haimin; (2011), Study of the change of surface magnetic field associated with flares, The Physics of Sun and Star Spots, Proceedings of the International Astronomical Union, IAU Symposium, Volume 273, p. 417-421, doi: 10.1017/S1743921311015675

Summary: no summary

Reference: Xu, Yan; Liu, Chang; Jing, Ju; Wang, Haimin; (2012), On the Relationship between the Coronal Magnetic Decay Index and Coronal Mass Ejection Speed, The Astrophysical Journal, Volume 761, Issue 1, article id. 52, 6 pp, doi: 10.1088/0004-637X/761/1/52