

Solar Flare and CME Prediction From Characteristics of 1075 Solar Cycle 23 Active Regions Determined Using MDI Synoptic Line-of-Sight Magnetograms

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Abstract

This investigation uses the entire set of synoptic line-of-sight magnetograms from the Solar and Heliospheric Observatory's (SOHO) Michelson Doppler Imager (MDI) to calculate a plethora of characteristics of the magnetic field in active regions, including measures of nonpotentiality, the gradient-weighted length of neutral lines, the length along the primary neutral line, and time variation of total flux. These measures are calculated for the disk passage of 1075 NOAA active regions spanning Solar Cycle 23 from 1996 - 2008 in an attempt to determine the ability of line-of-site magnetograms to be used as a predictor of coronal mass ejections (CMEs) or flares.

Several investigators have analyzed photospheric magnetic field observations to determine the potential for solar flare and CME prediction [Falconer, 2003, 2008; Leka and Barnes, 2003, 2006]. Using data from a variety of sources, both line-of-site and vector magnetograms have been studied. Until now the studies have been restricted to a relatively small sample size and considered just a few measures of nonpotentiality.

This expansive study is accomplished by using an IDL code that automatically searches the MDI database for data related to any NOAA AR, uses a three-iteration primary neutral line finder on remapped data [Bokenkamp, 2007], applies a constant-alpha force-free field model [Allisandrakis, 1981], and calculates several measures of nonpotentiality [Falconer, 2008]. The code has also been designed as a tool for recording and displaying these variables for any specific NOAA AR or user-defined solar location. A similar program can be used with the vector magnetic field data from the Helioseismic and Magnetic Imager (HMI) that will become available after the launch of the Solar Dynamics Observatory (SDO).

This poster presents the current progress on the project outlined above. So far we have developed code to trace the primary neutral line during the evolution of an AR (Fig. 1), chosen multiple measures of nonpotentiality for an AR (Fig. 2), and run these calculations on the entire MDI history (Fig. 3). We are currently determining the predictive power of these measures in a statistically significant study.

Example - Evolution of AR 8910 in March 2000

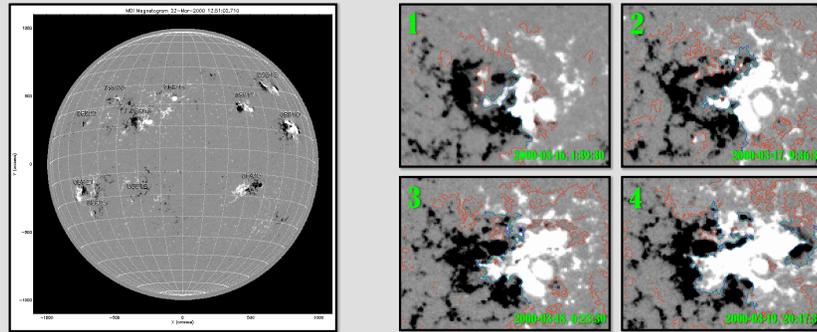


Figure 1: The evolution of Active Region 8910 as it passes within 30° of the disk center. Red lines indicate the programs first attempt to trace the Primary Neutral Line (P_{NL}). Blue line indicates 2nd attempt, using a smoothed image, and green line represents final P_{NL} calculation.

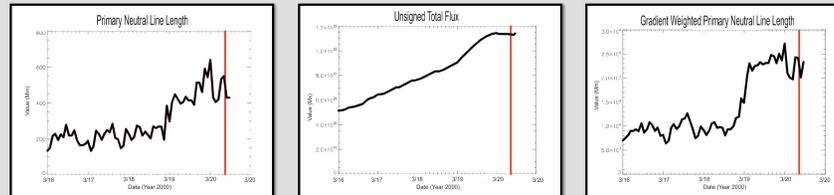


Figure 2: The evolution of primary neutral line length, unsigned total flux, and gradient weighted primary neutral line length for AR 8910. Red line represents temporal location of X-class solar flare.

AR Characteristics for the Entirety of Solar Cycle 23

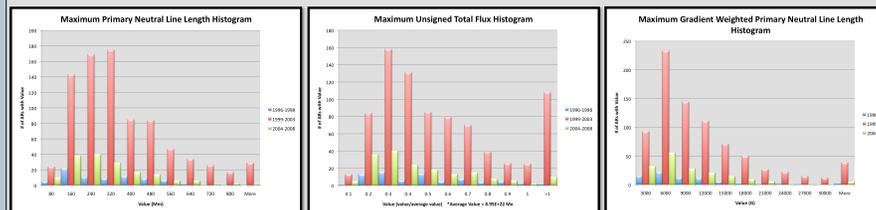


Figure 3: Maximum value of labeled variable for every sufficiently large* AR spanning MDI history. Blue series roughly represents solar minimum, red: solar maximum, and green: declining phase.
* $H\alpha$ sunspot size of AR larger than 1/10000 of visible solar hemisphere

Outline of the Tool

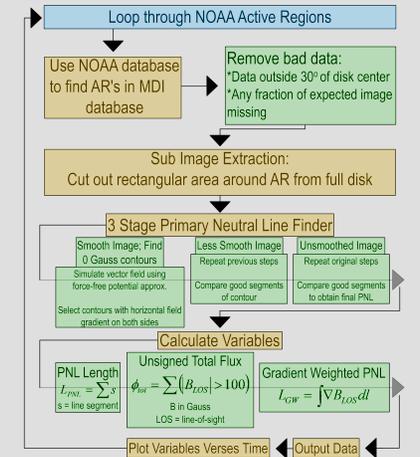


Figure 4: Description of the current automated process. Future work will be done to remove the dependence on NOAA for AR identification and include automated prediction.

Conclusion and Outlook

While these variables are fairly good measures of the line-of-sight magnetic field complexity, it remains to be seen how they are correlated with flares and CMEs. We are currently developing the code to analyze these variables. The analysis code will perform a superposed epoch analysis for each variable in an interval of time surrounding a set of solar event times. We will evaluate whether there is a significant trend associated with solar activity. For AR 8910 (Fig. 2), all three variables have a noticeable increase prior to the flare. We will test whether or not this is the general case. Ultimately we plan to apply this analysis to vector magnetic field data that will become available from HMI.

References

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