A New Parameter of Photospheric Magnetic Field to Determine Eruptive-Flare Producing Solar Active Regions

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Solar flares and coronal mass ejections (CMEs) are eruptive phenomena caused by the coronal magnetic fields. In particular, large eruptive events originate in active regions (AR) with strong surface magnetic fields. However, it is still unclear what determines the capability of an AR to specifically produce eruptive flares and CMEs, and this hinders our knowledge of the initiation mechanism for the eruptive component of these phenomena. In this study, we propose a new parameter r_m to measure the possibility that a flare which occurs in an AR can be eruptive and produce a CME. The parameter r_m is defined by the ratio of the magnetic flux of twist higher than a threshold Tc to the surrounding –and specifically the overlying –magnetic flux. The value of r_m for each AR can be estimated using the nonlinear force-free field (NLFFF) extrapolation models of the coronal magnetic field. Based on the data obtained by the Solar Dynamics Observatory (SDO)/Helioseismic and Magnetic Imager (HMI), we calculated the values of r_m for 29 ARs at 51 times prior to flares larger than M5.0 class. We find that the foot-point of field lines with twist larger than 0.2 can well represent the flare ribbons, and field lines overlying and “fencing in” the highly twisted region will work to confine the eruption, generating confined flares. Discriminant function analysis shows that r_m is moderately able to discriminate those ARs which have the capability to produce eruptive flares. Regarding the events that cannot be classified according to r_m correctly, we find that there are external overlying field lines that are not captured by NLFFF extrapolation in those confined events with large r_m. This is probably one of the reasons to cause the failed classification. The other events that cannot be well classified based on r_m are also discussed in this study

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