A comparative study of the empirical and physics-based methods for solar flare predictions

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Solar flares suddenly emit electromagnetic waves, plasma, and energetic particles into the interplanetary space, and cause space weather disturbances. Therefore, the prediction of solar flares is important to mitigate the space weather impact. For predicting solar flares, various types of empirical methods have been developed so far, and very recently the physics-based prediction of large solar flares, called the kappa-scheme, has been developed by Kusano et al. (2020). In this study, we conduct a comparative study of empirical and physics-based predictions of solar flares with the aim of developing a new type of solar flare prediction by combining empirical methods and the physics-based method. As the preliminary study, we focus on Schrijver’ s R-parameter (Schrijver 2007), which is given by the unsigned magnetic flux near the polarity inversion line (PIL) of the high magnetic gradient, as a typical empirical method. First, we use the vector magnetic field data of the active region NOAA 12673 observed by the Solar Dynamics Observatory before the onset time of the largest solar flare in the solar cycle 24 (11:48 UT on September 6, 2017), and calculated the unsigned magnetic flux (local magnetic flux) within a circle of radius 2 Mm centered at each point on the PILs. As a result, we found the following features. (1) The local magnetic flux correlates well with the magnetic gradient on PIL. (2) The local magnetic flux was also high at the flaring point predicted accurately by the kappa-scheme. (3) However, there were places where the local magnetic flux was high although flare did not occur. The results suggest that the local magnetic flux near PIL is only partially related to the predictors of the kappa-scheme. Second, we calculated the total unsigned magnetic flux within 2 Mm from all points on PILs for the two groups of active regions. Group 1 is seven active regions that produced flare larger than the GOES X2-class and group 2 is 199 active regions that did not produce any X-class flare for 20 hours after the observation. The comparison between the analyses of the unsigned total flux and the kappa-scheme suggests that the kappa-scheme can better discriminate the two groups than the unsigned total flux while the unsigned total flux has a moderate power to discriminate the flaring active regions. We consider a new scheme using these results.

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