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Study on the predictability of imminent giant solar flares based on the analysis of triggered instability

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Solar flares are catastrophic events in the solar corona and sometimes may cause a severe space weather disaster. Although many efforts have been taken for understanding and predicting the onset of solar flares, it is still difficult to accurately predict when, where and how large giant solar flares will occur. Here, we propose a new type of physics-based prediction model which is capable to provide the information of most likely location as well as the possible energy of imminent giant solar flares. The model is constructed based on the new theory that the double-arc instability triggered by a small-scale magnetic reconnection can cause the onset of solar flares (Ishiguro & Kusano 2017). According to the theory, we evaluated the critical size of the trigger reconnection and the level of releasable energy by analyzing the three-dimensional structure of the nonlinear force-free field extrapolated from SDO/HMI SHARP data. Through the systematic analyses of 200 active regions which had largest sunspot from 2010 to 2017, we found that only in several hours prior to giant solar flares larger than the X2 class the critical size of reconnection, which is capable to cause the giant flares, shrank at least smaller than 1 Mm and it rapidly increased back to be larger than it just after flares. We also confirmed that the portion where the critical size of trigger reconnection was minimized in each active region just before the onset of flares well matched the location in the central area of initial flare ribbon. The results are consistent with the theoretical prediction that not only the amount of stored free energy but also the critical condition of trigger reconnection, which is sensitive to the structure of magnet twist flux density near the polarity inversion line, determines the onset of solar flares. Finally, based on this result, we conclude that the analysis of the critical condition of the triggered instability can improve the predictability of imminent giant solar flares.