# Nonlinear force-free modeling of the flare-productive magnetic fields observed in the solar active region 12673

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The solar active region (AR) 12673 was one of the most flare-productive AR through the solar cycle 24. This AR produced not only multiple M-class flares but also several X-class flares. Among them, the X9.3 flare observed on September 6th 2017 was the largest solar flare in the solar cycle 24. The purpose of this study is to comprehensively understand the flare-productive magnetic fields and flare activities observed in the AR12673. In this study, based on the nonlinear force-free field (NLFFF) extrapolation, we investigated a temporal evolution of the three-dimensional (3D) magnetic field producing the several M-class flares, which occurred around 2 days prior to the X9.3 flare. Furthermore, we analyzed 3D magnetic field structure few minutes before the M5.5 flare, which was accompanied with coronal mass ejection (CME), and discussed the flare onset mechanism. The NLFFFs were extrapolated from the time series data of the photospheric vector magnetic field, which cover before and after the M5.5 flare, from Helioseismic and Magnetic Imager (HMI) on board the Solar Dynamics Observatory (SDO). As a result, we found the followings; (1) Three magnetic flux ropes (MFRs) evolved from September 4th, one of which produced the X9.3 flare on September 6th. One of the MFRs had a positive helicity which had a different sign from other two MFRs. Since, the temporal evolution of the magnetic flux occupied by the positive helicity captures one of the GOES X-ray flux well, we suggest that the positive helicity injection is related to the occurrence of the M-class flares including the M5.5 flare. (2) We investigated the 3D magnetic field structure before the M5.5 flare. We found a null point in the magnetic field surrounding the MFRs. By comparing to the AIA 1600 angstrom images, the footpoints of the overlying field lines are well anchored to the area where the initial brightening of the AIA 1600 angstrom was strongly enhanced, and the flare ribbons were observed at the footpoints of the MFR with positive twist. Therefore, we suggest that a reconnection occurred at the null point possibly drives the M5.5 flare. (3) Most of the M-class flares were far from the PIL where the X9.3 flare was observed. Therefore, we suggest that the MFR concerned with the X9.3 flare would be stable before September 6th.

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