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Recurrent flares in active region NOAA 11283*

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ABSTRACT

Context. Flares and coronal mass ejections (CMEs) are solar phenomena that are not yet fully understood. Several investigations have been performed to single out their related physical parameters that can be used as indices of the magnetic complexity leading to their occurrence.

Aims. In order to shed light on the occurrence of recurrent flares and subsequent associated CMEs, we studied the active region NOAA 11283 where recurrent M and X GOES-class flares and CMEs occurred.

Methods. We use vector magnetograms taken by HMI/SDO to calculate the horizontal velocity fields of the photospheric magnetic structures, the shear and the dip angles of the magnetic field, the magnetic helicity flux distribution, and the Poynting fluxes across the photosphere due to the emergence and the shearing of the magnetic field.

Results. Although we do not observe consistent emerging magnetic flux through the photosphere during the observation time interval, we detected a monotonic increase of the magnetic helicity accumulated in the corona. We found that both the shear and the dip angles have high values along the main polarity inversion line (PIL) before and after all the events. We also note that before the main flare of X2.1 GOES class, the shearing motions seem to inject a more significant energy than the energy injected by the emergence of the magnetic field.

Conclusions. We conclude that the very long duration (about 4 days) of the horizontal displacement of the main photospheric magnetic structures along the PIL has a primary role in the energy release during the recurrent flares. This peculiar horizontal velocity field also contributes to the monotonic injection of magnetic helicity into the corona. This process, coupled with the high shear and dip angles along the main PIL, appears to be responsible for the consecutive events of loss of equilibrium leading to the recurrent flares and CMEs.

Key words. Sun: activity – Sun: flares – Sun: coronal mass ejections (CMEs) – Sun: magnetic fields

1. Introduction

Recent advances in the modelling of flares and coronal mass ejections (CMEs) have indicated that a catastrophic loss of mechanical equilibrium in the coronal magnetic configuration could be the trigger mechanism for these complex solar phenomena. Such a loss of equilibrium might drive magnetic reconnection in the magnetic field, which is stretched out by the eruption itself (Lin et al. 2003). The more complex the magnetic field configuration is, the higher the probability of a catastrophic loss of equilibrium is.

Several scenarios have been proposed to describe the magnetic configurations adequate to drive this dynamical instability. Various numerical experiments have demonstrated the importance of magnetic flux emergence or shear motions for driving CME-like eruptions associated with flaring activity (Shibata & Magara 2011; Kusano et al. 2012). Moreover, in many models the flux rope is considered to be a crucial magnetic configuration. It has been shown that a flux rope can rearrange in the corona after its emergence from the convection zone, i.e., the magnetic field lines can wrap around a new central axis that is different from the original flux tube axis (Fan et al. 1998; Magara 2006).

In this regard, the so-called homologous flares are particularly interesting phenomena: the initial magnetic configuration, which was able to drive the event, is reformed after a previous

* A movie associated to Fig. 4 is available in electronic form at http://www.aanda.org