Observational Analysis of Photospheric Magnetic Field Restructuring During Energetic Solar Flares

Group of Solar Astrophysics

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Introduction

The magnetic field has proven to be the main driver in the behavior, dynamics and evolution of several solar atmospheric phenomena including sunspots, plages, faculae, CME's and flares. Observational evidence of photospheric magnetic field restructuring during energetic flares have shown an enhancement of the transversal field component suggesting an apparent relation between this process with the generation of *sunquakes* (Fisher et. al (2011-Submitted)), expanding ripples on the solar photosphere as a result of the momentum-energy transfer into the solar photosphere and solar interior.

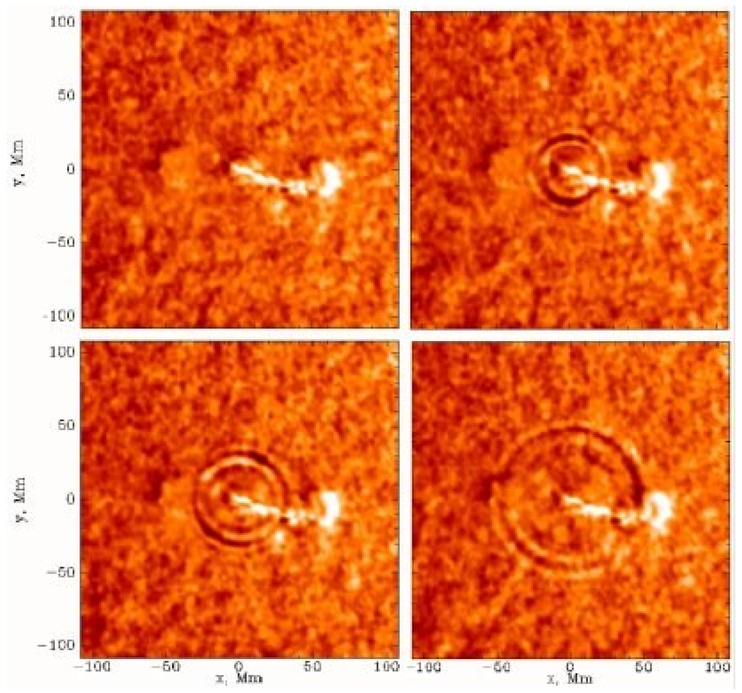

Fig. 1 The sunquake of 9 July 1996 as detected and graphically enhanced by Kosovichev and Zharkova (1998), resembling close–to–circular pattern of ripples on helioseismic Dopplergrams from MDI, expanding outward from the footpoints of the flare.

Recently Kosovichev (2011) reported a strong sunquake associated to the first GOES X-class flare (2011-02-15T01:52 X2.2) of the 24th solar cycle, detected by HMI/SDO. Zharkov et. al (2011) analyzed the same event using acoustic holography (Donea, Braun, and Lindsey (1999); Donea, Lindsey, and Braun (2000)) showing the existence of a secondary weak seismic source. Alvarado et. al (2011 – submitted) performed a comparative study between the energetics of the acoustic source and the energy delivered via the magnetic field restructuring, showing that the magnetic contribution to this event was considerable and could even be the main driver of this seismic response.

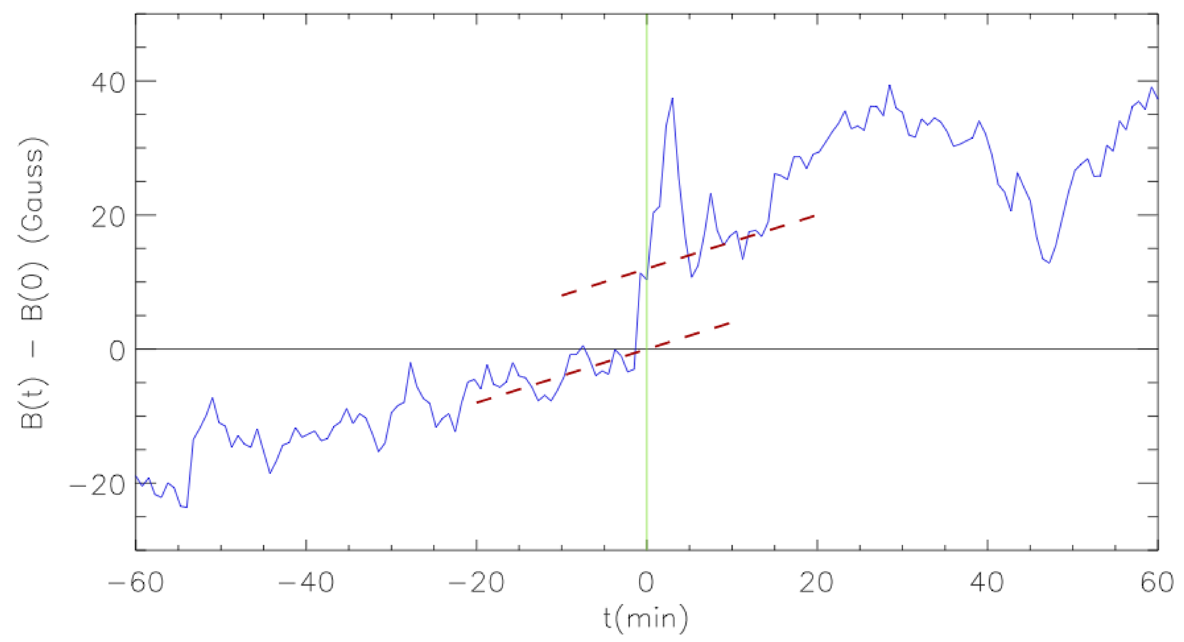

Fig. 2 Line-of-sight magnetic field evolution during the 15 February 2011 flare integrated over the acoustic source area. The vertical green line at time zero identify the impulsive phase of the flare. A step-like change is identified (segmented lines). From Alvarado et. al (2011- submitted).

In this work we present a magnetic observational study of some recent energetic flaring events (X and M type of the 24th solar cycle), using magnetogram data from HMI/SDO, trying to make a characterization of the photospheric magnetic field evolution during those flares, being this the observational basis of a future numerical modeling of the field restructuring during this phenomenon.

Observations and Analysis

The initial data set for this study consisted in HMI/SDO magnetogram data from five energetic solar flares (2 X and 3 M class) of the current solar cycle covering a time interval of 3 hours around the peak of the flare (as was reported by GOES).

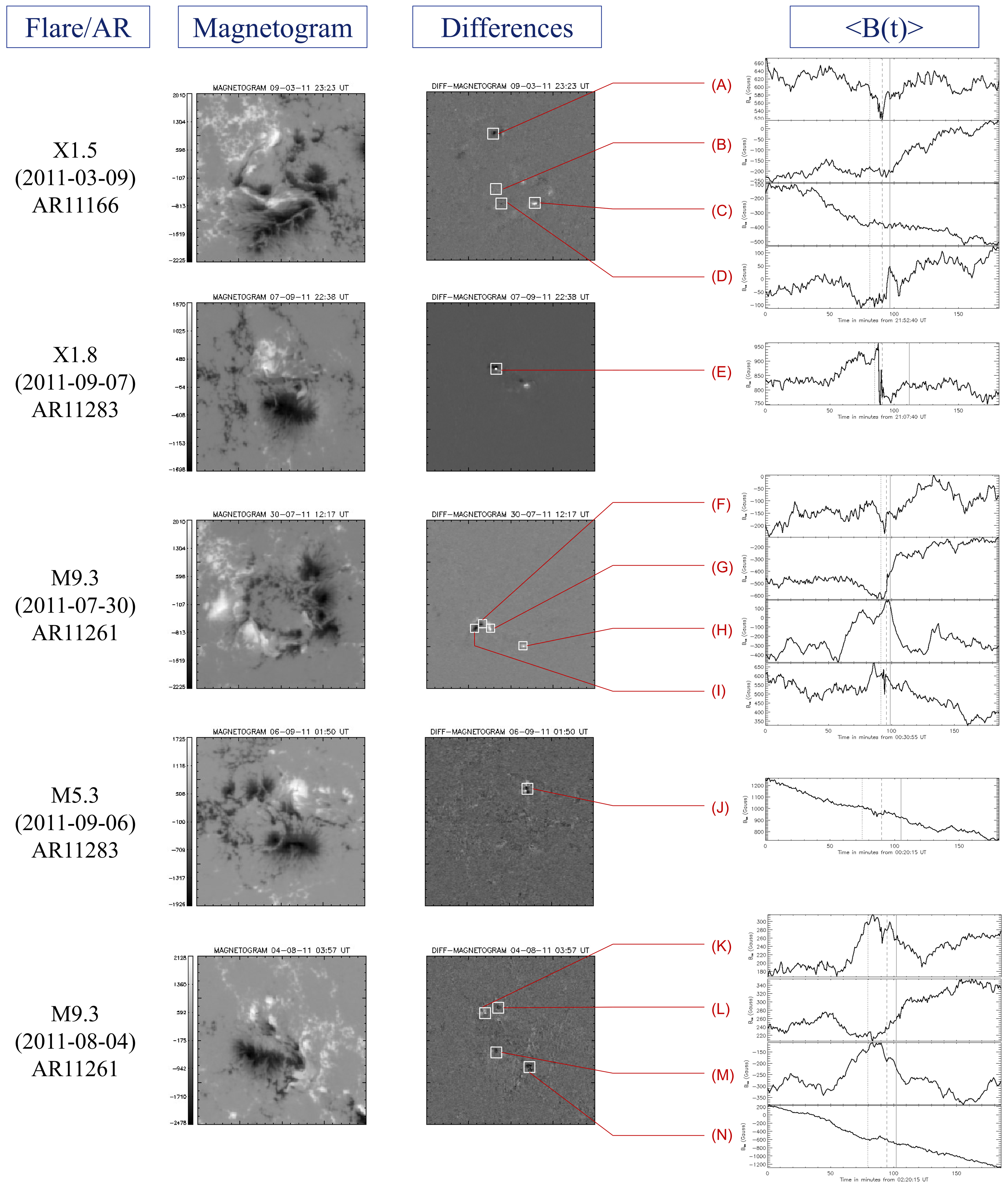

Fig. 3. From left to right the columns show the GOES classification for each flare and hosting active region (AR), HMI/SDO magnetograms at the peak of the flare, the magnetic differences at the same time and the mean of magnetic field integrated over the regions where a considerable change in the magnitude of the l-o-s was observed (white squares).

White boxes denote regions where the magnetic differences maps (third column) showed a considerable change in the field. The integrated mean line-of-sight field plots as a function of time are showed in the fourth column. Three different profiles for the field behavior are observed: Linear (C – J – N), Step-like (B – E – G – L) and Gaussian (H – K – M). We regard profile s (A – D – F – I) as noise.

Acknowledgements
The Berkeley group was supported by NASA under contract NAS 5-98033 for RHESSI.

Future Work

Once the magnetic behavior profiles have been identified the next step in our research consists in its inclusion into a numerical simulation of the evolution of the velocity field, during the flare, in order to establish which one of them could produce a sunquake. This was already developed by Moradi et. al (2009) into a Magneto-Hidrostatic (MHS) simulation, where the evolution of the field was given by a step-like change.

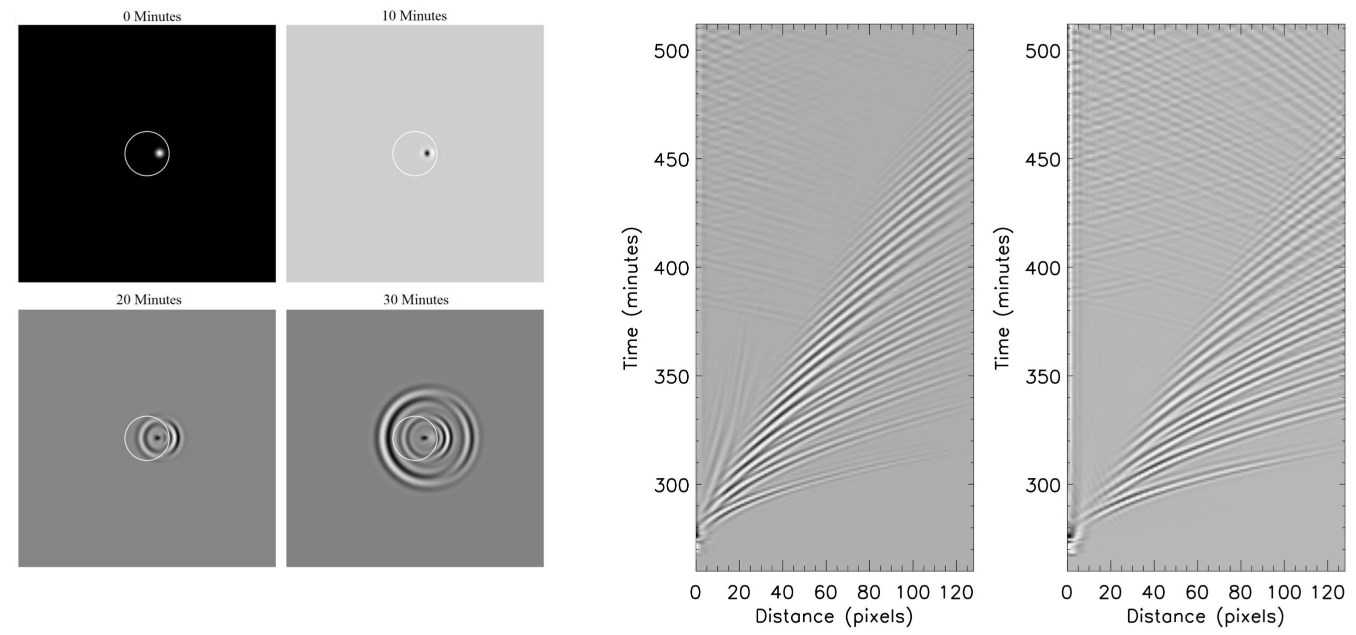

Fig. 4 *Left panel:* Dopplergrams of the simulated active region showing the evolution of acoustic waves generated by the variation of the magnetic field at 0, 10, 20, and 30 minutes from the initial perturbation. The circle represents a sunspot. *Right panel:* Time – distance plot of the amplitude of the surface ridge averaged over curves of constant radius in the azimuths 352.5° to 22.5° (Left) and 157.5° to 202.5° (Right). See Moradi et. al (2009).

In our approach the magnetic field profiles will be incorporated into a full Magneto-hidrodynamic (MHD) code (RADMHD, see Abbett (2007); Abbett and Fisher (2011)), trying to reproduce a more realistic environment for the sunquake generation. It is expected that we would be able to characterize the type of change in the magnetic field and its magnitude during this phenomenon.

Discussion

- Following the ideas presented by Fisher et. al (2011-Submitted) relating the magnetic field change during flares as a sunquake generation mechanism and the results presented by Alvarado et. al (2011-Submitted) in the 15 February 2011 sunquake, a complete observational-numerical study about the magnetic field influence is been developed.
- Under this study, we performed an observational characterization of the line-of-sight magnetic field during five energetic flares of the current solar cycle (2 X and 3 M class), finding that the some temporal magnetic profiles can be fitted to three different functions (linear, Gaussian and step-like).
- These results will be incorporated into a MHD numerical code trying to reproduce the previous results from a MHS code, but in a more realistic scenario.

References

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