PHOTOSPHERIC MAGNETIC FIELD VARIATIONS DURING SOLAR FLARES AND THEIR IMPLICATIONS FOR THE GENERATION OF SUNQUAKES

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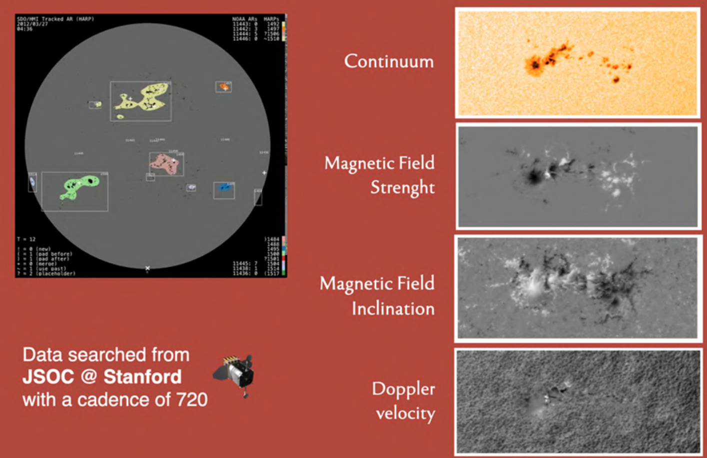
ABSTRACT

Solar flares are an explosive manifestation of complex magnetic loop reconfigurations in the vicinity of active regions in the solar atmosphere. In this work, we investigate the temporal and spatial evolution of permanent changes in the magnetic field geometry in a sample of five acoustically active flaring events using vector magnetograms acquired with the SDO/HMI instrument. The highly energetic events under study occurred during the past solar cycle 24, and cover a range of high and low GOES classes. The analysis carried out represents a crucial input for the investigation of sunquakes origin and dynamics.

INTRODUCTION

During a flaring event, the magnetic field topology changes rapidly, abruptly, and significantly. Some of these eruptive events inject enough energy into the photosphere and sub-photosphere to generate acoustic responses observed as sunquakes.The precise physical mechanism causing the acoustic source of a sunquake is still a topic of debate. Most authors agree that magnetic field restructuring must play a fundamental role in causing such acoustic drivers. Previous studies have mainly probed the line-of-sight component of the magnetic field in such scenarios. In this work, we investigate the temporal and spatial evolution of permanent changes in the magnetic field geometry.



Data searched from **JSOC @ Stanford** with a cadence of 720

DATA

We use a sample of five acoustically active flaring events using vector magnetograms acquired with the SDO/HMI instrument, The highly energetic events under study occurred during the past solar cycle 24, and cover a range of high and low GOES classes.

List of Flaring Events

(From a total of 14 events)

#	Flare	Heliospheric position	AR
1	SOL20130217T15:50-M1.2	[-338,307]	11675
2	SOL20131106T13:49-M3.8	[-549,-267]	11890
3	SOL20131107T03:40-M2.3	[-450,-272]	11890
4	SOL20120509T14:02-M1.8	[-351,159]	11476
5	SOL20170904T15:11-M1.5	[-490,252]	12673
6	SOL20110213T17:28-M6.6	[-37,-132]	12297

Selected from Sharykin, 2019. Buitrago-Casas 2015

- **JSOC @ Stanford** http://jsoc.stanford.edu/ajax/lookdata.html
- **Data:** Magnetic field, intensity, Doppler velocities, inclination and others - SDO- HMI

ANALYSIS

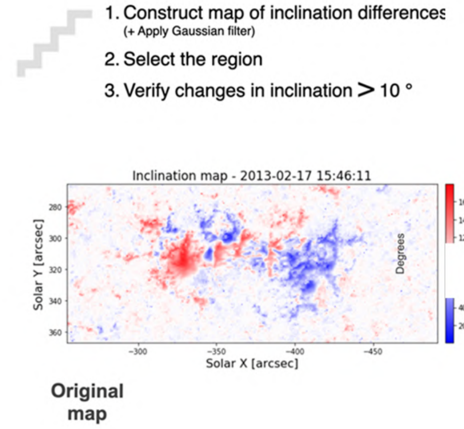
In order to probe the geometry of the magnetic field we applied the procedure sketched below and the steps 1,2,3 detailed in the right white box.

- Choose an appropriate time interval (2 hours before and after the impulsive phase of each flare)

Select the sample of flaring regions → Download Magnetic data → Identify Regions of interest → Look for changes in B inclination (>10º)

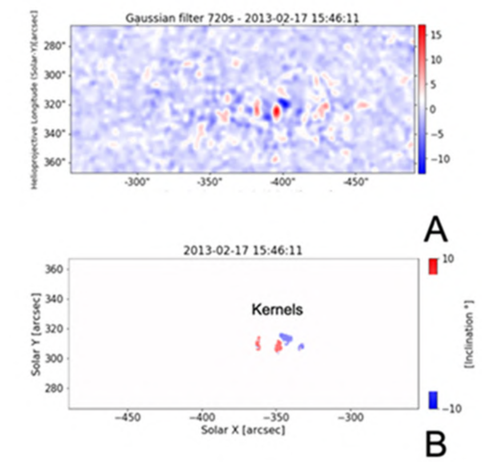
Steps

1. Construct map of inclination differences (+ Apply Gaussian filter)
2. Select the region
3. Verify changes in inclination > 10 °



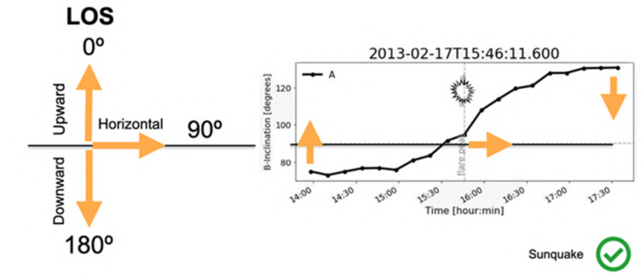
Steps 1-2

1. Construct map of inclination differences. (+ Apply Gaussian filter)
2. Select the region compact changes greater than 10º (-10º > inclination diff. > 10º)
3. Verify changes in inclination > 10 °



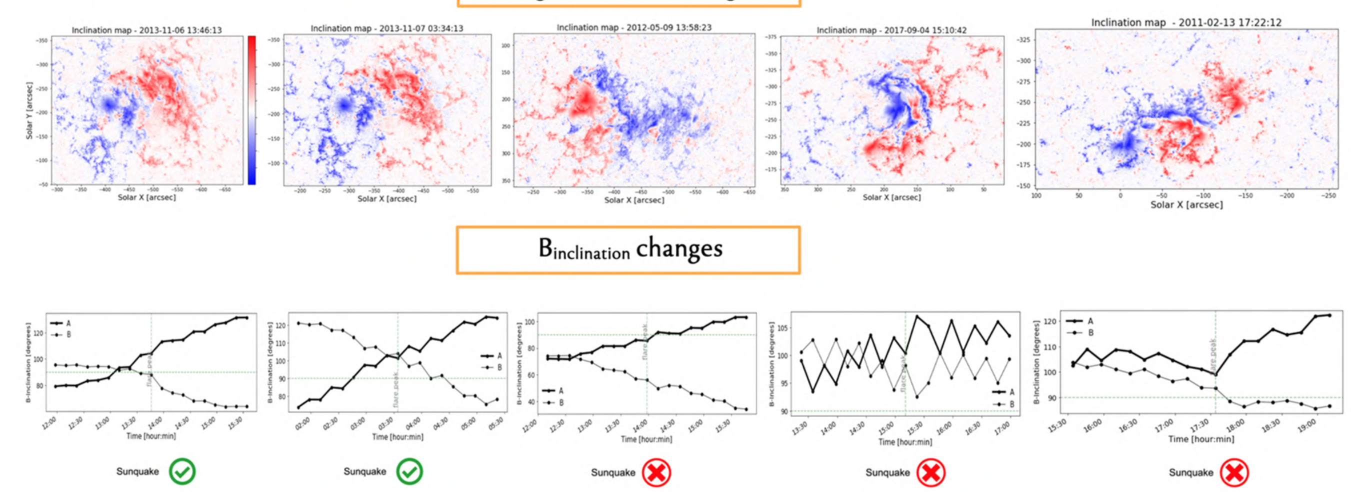
Steps 3:

1. Apply Gaussian filter
2. Select the region
3. Verify changes in inclination > 10 °



RESULTS

Changes of tens of degrees in the magnetic field inclination are preent in the flaring events displaying sunquakes. The acoustic wave is produced in the lower atmosphere by the ponderomotive force in the Alfvénic front associated with the magnetic variation.



TAKE-AWAY IDEAS

- Permanent changes in the magnetic field inclination with values greater than 10º in a kernel are likely to induce sunquake signatures
- Injection of particles can not take place if the field lines do not display the correct direction (downwards).
- Results are in agreement with theoretical approaches e.g. Russell et al. 2016
- Sunquakes offer an opportunity for studying the interaction of acoustic waves with magnetic fields and flows in flaring active regions.

The analysis carried out represents a crucial input for the investigation of sunquakes origin and dynamics.