Comparison between Hinode/SOT and SDO/HMI, AIA data for the study of solar flare trigger processes

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1. Motivation & Introduction

Motivation: To elucidate the trigger mechanism of solar flares and advance the predictability of flare occurrence.

Kusano+[2012] proposed a new flare trigger model by numerical simulations.

1. The internal reconnection between large-scale sheared magnetic field and small magnetic field can trigger solar flares. The "flare trigger field" exist at the center of initial flare kernels appeared as sheared ribbon.
2. The conditions of flare occurrence are characterized by following two parameters:
   - The shared angle of global magnetic field of active region : θ
   - The azimuthal angle of small scale triggering flux : φ
3. The small magnetic fluxes appearing on the polarity inversion line (PIL) can trigger solar flares, if it forms either following types of magnetic structure.
   - **Opposite Polarity (OP) type**
     The polarity of small flux is opposite to the potential component of major field.
   - **Reversed Shear (RS) type**
     The polarity of small flux is reversed to the sheared component of major field.

Bamba+[2013] measured quantitative conditions of four flare events with Hinode/SOT data, and the results are well consistent with Kusano+'s model.

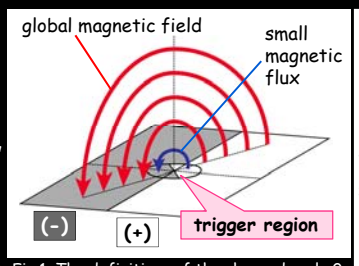


Fig.1: The definitions of the sheared angle θ and the azimuth φ in the simulation.

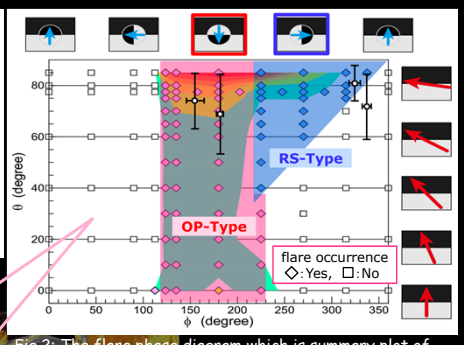


Fig.2: The flare phase diagram which is summary plot of numerical simulations in Kusano+[2012]. Solar flares occurred with the conditions represented by colored diamonds. Pink and blue indicate OP- and RS-types, respectively. The black crosses are the conditions of actual flare occurrences measured with Hinode/SOT data in Bamba+[2013].

Because of SOT's limited FOV, only four data sets were able to be utilized...

Use SDO data in order to increase the number of event analysis !!

2. Analysis

2-1. Data sets

* Hinode *

	NFI	BFI	SP
wavelength	6303Å (Fe I) 5896Å (Na D)	3928Å (Ca II H)	6301.5Å, 6302.5Å (Fe I) with a sampling 21.6mÅ
pixel size	0.16"	0.108"	0.32" (fast map mode)

* SDO *

	HMI	AIA	SHARP
wavelength	6173Å (Fe I)	1600Å (C IV, cont.)	6173Å (Fe I)
pixel size	0.5"	0.5"	0.5"

filter magnetograms pre-flare emissions vector magnetograms

2-2. Method

We superpose Ca-line or AIA 1600Å emission contour and PIL on filter magnetograms in order to investigate following issues:

- Where is the "flare trigger region" ?
- Which is flare trigger type ? (OP or RS ?)
- What degree the shear angle of θ and azimuth φ are?

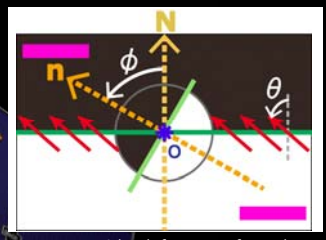


Fig.3: The definitions of θ and φ on the observational images. (positive helicity case)

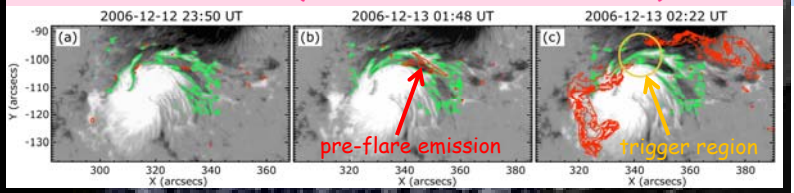
θ : The mean angle of the transverse magnetic field over the trigger region.
φ : The counterclockwise angle between vectors ***N*** and ***n***.
** The vectors N and n are normal to the PIL of the averaged magnetic field and the PIL on the flare-trigger field. (Fig. 3)

3. Results & Comparison

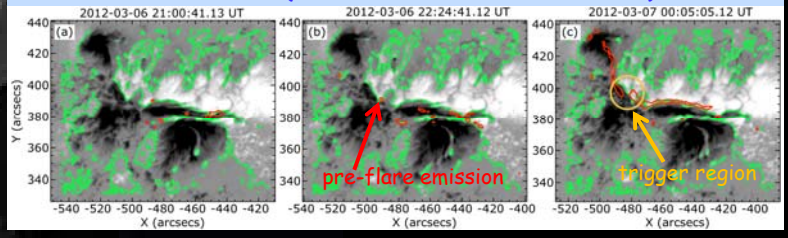
Background : Line-of-sight magnetic field (white = positive, black = negative)
Green lines : Polarity inversion line, **Red contour**: pre-flare emission

(1) Detection of the "flare trigger region" and classification (OP or RS ?)

*** Hinode *** (ex; X3.4 flare on 13th Dec. 2006)



*** SDO *** (ex; X5.4 flare on 06th Mar. 2012)

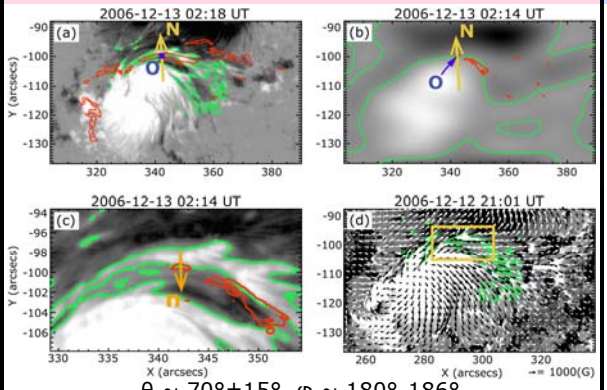


In our previous study with Hinode, we found that the initial flare kernel has sheared structure like the simulation results, and that the trigger region which satisfy the OP- or RS-types magnetic structure exist at the center of sheared ribbon. These results are also obtained by SDO data set.

→ Therefore, **it is confirmed that we can detect the flare trigger region with SDO data !!**

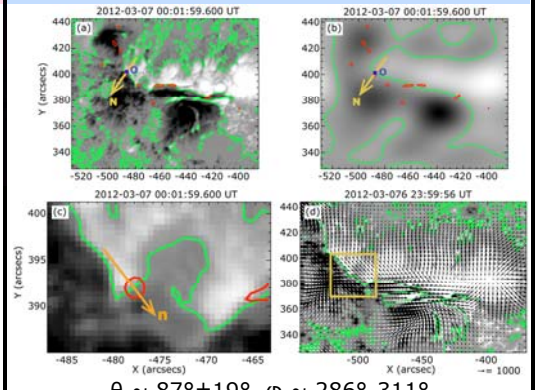
(2) Measurements of the shear angle θ and the azimuthal angle φ

*** Hinode ***(ex; X3.4 flare on 13th Dec. 2006)



θ ~ 70°±15°, φ ~ 180°-186°
OP-type

*** SDO ***(ex; X5.4 flare on 06th Mar. 2012)



θ ~ 87°±19°, φ ~ 286°-311°
RS-type

We applied the method for measurements of the angles θ and φ with Hinode to the SDO data via following processes.

1. To define the "trigger point ***O***" from smoothed LOS magnetic field.
2. To define the vector **N** normal to the smoothed PIL. (cf. panels (a) and (b))
3. To define the vector **n** orthogonal to the non-smoothed PIL. (cf. panels (c))
   → The azimuthal angle φ
4. To measure the angles between each transvers magnetic field vector and **N**.
   → The sheared angle θ (cf. panels (d))

In case of X5.4 flare in 2012, the conditions of θ and φ are consistent with RS-type.

→ **We can measure the angles θ and φ with SDO using previous method !!**

4. Summary

We confirm that the SDO data are able to be utilize for flare trigger study, and that we can apply the analysis method of our previous study with Hinode to the SDO data. It is also shown that if the size of trigger region is as large as ~10", they are detectable with HMI.

Next works:
- To increase the number of event analysis.
- To investigate the time variation of the angles θ and φ using high cadence and steady data sets obtained by SDO.