Nonlinear force-free field extrapolation calculation for inferring solar colona magnetic fields

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Abstract

Our study focuses on understanding of the mechanism responsible for the occurrence of the solar flares. We derive 3D magnetic field structure in the corona by performing a 3D magnetohydrodynamics simulation using vector magnetic field maps mainly acquired with the Hinode spacecraft. We investigate 3D magnetic field structure formed in the solar atmosphere responsible for the occurrence of solar flares.

Ref. URL: http://www.isas.jaxa.jp/home/solar/solarPlasma/whatsSolarPlasma.html

Reasons and benefits of using JAXA Supercomputer System

The aim to use JAXA supercomputer is to estimate chromospheric and colonal 3D magnetic fields from the spatial distribution of magnetic field vectors observed at the solar surface (photosphere). We use force-free field modeling based on three-dimensional magnetohydrodynamics simulations, requiring computer resource. Usage of calculation results is to search 3D magnetic fields distribution before flare and the area where energetic magnetic fields easy to expand explosively. Thanks to high-spec supercompution resource, we can investigate a variety of magentic fields data with different time siries in a short time.

Achievements of the Year

There are two types of solar flares: eruptive flares (flares with plasma ejections) and confined flares (flares without plasma ejections). Especially, eruptive flares are related to the generation of magnetic storms on the earth. In this year's study, the similarities and differences between the two flares were investigated observationally using the parameters of the coronal magnetic field, i.e., twist number, decay index, and magnetic field line height, for the analysis of a set of confined and eruptive flares that occurred on September 6, 2017 at the same magnetic neutral line with a time interval of 3 h. The coronal magnetic field structure is derived by the non-linear force-free field modeling with the photospheric magnetic flux density maps derived by the HMI instrument onboard the SDO

satellite. Our study focuses on the magnetic field lines contributing to the energy release, which can be identified by the photospheric locations of chromospheric flare ribbons (Figure 1). We found that the eruptive flare has a twist number larger than the confined flare and that the interquartile range (central 50 % data) of the twist number can separate the eruptive flare from the confined flare. The decay index shows no difference between the flares. And, only magnetic field lines of the eruptive flare exist in the region where both the twist number and decay index are over 0.8. These results may derive the following three interpretations; 1) a part of the magnetic field lines that has a large twist number may make a difiference in eruptivity, although the majority of the magnetic field lines contributing to the energy release show no significant difference between the two flares, 2) the decay index distribution shows no difference between the confined and eruptive flares, but the difference might be made by several magnetic field lines of the eruptive flare that the height is larger than all of the magnetic field lines of the confined flare, 3) a limited number of the magnetic field lines having a large twist number and decay index may be sufficient to develop flares toward eruptive flares.

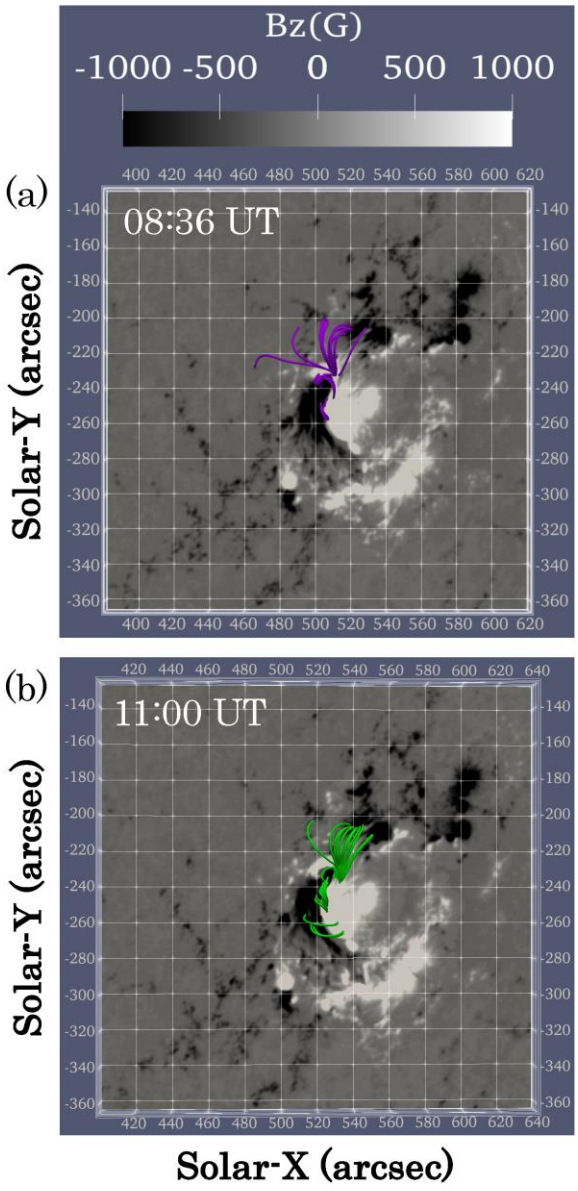

Fig. 1: Nonlinear force-free field extrapolation and (a) energy-release-related magnetic field lines on the confined flare, (b) energy-release-related magnetic field lines on the eruptive flare.

Publications

- Oral Presentations

Kouhei Teraoka, Toshifumi Shimizu, Daiki Yamasaki, Yusuke Kawabata, and Shinsuke Imada, "CME onset mechanism searched from the confined and Eruptive in AR 12673", The Astronomical Society of Japan, M21a, Nagoya, September, 2023

- Poster Presentations

Kouhei Teraoka, Toshifumi Shimizu, Daiki Yamasaki, Yusuke Kawabata, and Shinsuke Imada, "Comparison of 3D coronal magnetic field structure between eruptive and confined flares observed in AR 12673 on September 6, 2017", Hinode-16/IRIS-13 meeting, P-83, Niigata, Japan, September, 2023

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	16
Elapsed Time per Case	3.5 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources[*1](%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	83,294.51	0.00
TOKI-ST	0.00	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	0.00	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	10.00	0.01
/data and /data2	2,450.00	0.02
/ssd	0.00	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage*2 (%)
ISV Software Licenses (Total)	0.00	0.00

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.