Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310010380

Eruptive Signatures in the Solar Atmosphere During the WHI Campaign (20 March–16 April 2008)

Alphonse C. Sterling†
Space Science Office, VP62, NASA Marshall Space Flight Center,
Huntsville, AL 35812 USA
email: alphonse.sterling@nasa.gov

Abstract. We examined EUV movies of the Sun during the period of the Whole Heliospheric Interval (WHI) campaign of 20 March–16 April 2008, searching for indications of eruptive events. Our data set was obtained from EIT on SOHO, using its 195 Å filter, and from EUVI on the two STEREO satellites, using their 171 Å, 195 Å, 284 Å, and 304 Å filters. Here we present a table showing results from our preliminary search.

Keywords. Sun: activity, Sun: corona, Sun: coronal mass ejections (CMEs), Sun: flares, Sun: UV radiation

1. Introduction

Positive identification of the source regions on the solar disk of solar eruptions is, in many cases, a difficult problem. Of course there are frequently cases where there are obvious features on the solar disk, such as solar flares or strong intensity dimming regions, that occur in tandem with the launch of a coronal mass ejection (CME). There are other cases however where CMEs occur with only very weak solar-disk signatures, or even no signature at all - see, for example, (Hudson *et al.* (1998), Webb *et al.* (1998), Robbrecht *et al.* (2009)). During the Whole Heliospheric Interval (WHI) campaign of 20 March–16 April 2008, several satellites and ground-based observatories performed coordinated observations of the Sun and heliosphere, and therefore this period is an appropriate one for revisiting the connection between CMEs and their solar source regions. We have initiated such an investigation, and here we summarize some early results of an initial survey. Our focus was to identify visually what appear to be eruptive events in the lower solar atmosphere during the WHI period. This initial investigation can serve as a basis for more detailed studies to follow. Future investigations will make comparisons between our list with lists of observed CME eruptions.

2. Analysis Procedure

We first examined movies from the EUV Imaging Telescope (EIT) on the SOHO spacecraft over the WHI period for indications of eruptions, usually in the form of intensity dimmings (e.g., Hudson *et al.* (1998)), filament eruptions, or transient brightenings coupled with rapid changes in the local coronal structure (cf. Canfield *et al.* (1999)). From EIT we used images in the 195 Å filter, as it had the highest cadence during the period (∼12 min). After composing an initial list of low-coronal eruptive-like signatures with

† Present address: JAXA/Institute of Space and Astronautical Science, Hinode Group, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan

EIT 195 Å images, we supplemented the list using movies from the EUVI imagers on the STEREO spacecraft. EUVI has better spatial resolution than EIT ($\sim$ 1.6"/pixel vs. 2.6″/pixel), and higher time cadence ($\sim$ 3—6 min for EUVI). We examined EUVI images taken with their 171 Å, 195 Å, 284 Å, and 304 Å filters.

3. Results

During the WHI period, four active regions (ARs) appeared on the solar disk: NOAO ARs 10987, 10988, and 10989 appeared early in the WHI period, and 10990 began developing at the end of the WHI period. Many of the events we identified as "eruptive looking" emanated from or near the ARs. Table 1 presents an overview of our results. Seven of the events (events 3, 7, 10, 12, 15, 16, and 17) originated from an active region, while three of the events (events 4, 6, and 14), while near the limb, almost certainly had no direct connection to an active region. The connection between the remaining events and active regions was marginal or uncertain, as indicated in the Table 1 notes.

4. Discussion

We identified nearly 20 features that appeared eruptive, but not necessarily all were "ejective," i.e., an eruption that produced an ejection that left the Sun (e.g., Moore *et al.* (2001)). Some eruptions do not produce ejections into the heliosphere, sometimes even when the eruptions are accompanied by large flares (e.g., Green *et al.* (2002), Wang & Zhang (2007)), but instead the material is confined by strong overlying magnetic field. Such "confined eruptions" often will not produce a CME (e.g., Moore *et al.* (2001), Török & Kliem (2005)), or could result in a weak secondary CME or outflow (Bemporad *et al.* (2005)). To identify ejective eruptions we look for persistent dimmings, an expelled prominence, etc. Confined eruptions generally produce relatively transient dimmings or brightenings, and sometimes a filament can be seen to have its upward movement thwarted (e.g., Ji *et al.* (2003)). In marginal cases however it can be difficult to determine whether an eruption is confined or ejective, and so for several events in Table 1 we indicate the connection is uncertain. AR 10989 erupted several times, and some of these were clearly ejective. AR 10987 probably produced at least one ejective eruption (event 11), but overall ARs 10987 and 10988 displayed fewer eruptive signatures than AR 10989, according to our visual survey results.

In several cases we initially missed events in movies taken with the EIT and EUVI 195 Å filter, but could identify them readily in movies from a different EUVI filter. This could be an important consideration when attempting to identify disk sources of CMEs.

Acknowledgements

A.C.S. was supported by funding from NASA's Office of Space Science through the Solar Physics Supporting Research and Technology Program and the Sun-Earth Connection Guest Investigator Program. The author thanks D. Webb and H. Cremades for valuable discussions.

References

Bemporad, A., Sterling, A. C., Moore, R. L., & Poletto, G. 2005, *ApJ*, 635, L189

Canfield, R. C., Hudson, H. S., & McKenzie, D. E. 1999, *Geophys. Res. Lett.*, 26, 627

Green, L. M., Matthews, S. A., van Driel-Gesztelyi, L., Harra, L. K., & Culhane, J. L. 2002, *Solar Physics*, 205, 325

Hudson, H. S., Lemen, J. R., St. Cyr, O. C., Sterling, A. C., & Webb, D. F. 1998, *Geophys. Res. Lett.*, 25, 2481
Ji, H., Wang, H., Schmahl, E. J., Moon, Y.-J., & Jiang, Y. 2003, *ApJ*, 595, L135
Moore, R. L., Sterling, A. C., Hudson, H. S., & Lemen, J. R. 2001, *ApJ*, 552, 833
Robbrecht, E., Patsourakos, S., & Vourlidas, A. 2009, *ApJ*, 701, 283
Török, T., & Kliem, B. 2005, *ApJ*, 630, L97
Wang, Y., & Zhang, J. 2007, *ApJ*, 665, 1428
Webb, D. F., Cliver, E. W., Gopalswamy, N., Hudson, H. S., & St. Cyr, O. C. 1998, *Geophys. Res. Lett.*, 25, 2469

Table 1. "Eruptive-Looking" Coronal Events Over WHI Period: 20-Mar - 16 Apr 2008

Event	Date (M/DD)	UT	First Instrument[1]	Location	Comments:
1	3/22	11:45	EUVI-B 195	At E limb.	Weak coronal opening or ejection. Possible precursor to 14:05 UT event.
2	3/22	14:05	EUVI-B 195	At E limb.	Coronal opening, and ejection. Behind the limb for EIT. Probably from AR 10989 during its early stages.
3	3/25	18:34	EIT 195	AR 10989 at E limb.	Coronal opening and dimming, bright transient flare.
—	3/26	—	EUVI-B 195	—	Extensive activity between ARs 10987 and 10988, but no obvious ejections. Maybe a failed eruption visible in EUVI-B 284 from about 16:26 UT between those two ARs, perhaps producing a weak ejection (cf. Bemporad *et al.* (2005)).
4	3/27	c16:06	EUVI-B 304, etc.	NE limb in STEREO B.	Slowly-erupting prominence in 304 Å; faint in other EUVI filters. Probably ejective, but not certain.
5	3/27	17:26	EUVI-B 284	S of AR 10988.	Filament erupts, but probably not ejective. Source region rooted adjacent to but not in the AR, but AR magnetic field may have triggered onset.
6	3/29	07:47 onward.	EIT 195	Along E limb.	Large-scale flows seen in 195 Å filters and EUVI-B 171 Å; continues until next day. Slowly-evolving prominence in EUVI-B 304 Å; may eject from Sun at $\gtrsim$11 UT.
7	3/30	05:22	EIT 195	AR 10989.	Eruptive flare, removing corona (dimming) to SE. Also well seen in EUVI-B 284.
8	3/30	>7:46	EUVI-B 304	S of ARs 10988 & 10989.	Large filament eruption, faint in non-304 filters. From EUVI-A 304 however, it may not be ejective.
9	4/01	04:26	EUVI-B 284	N of AR 10989.	Eruption with source outside of AR, but with remote connections to the AR. Prominent in 284 Å but weak in 195 Å. May be confined.
10	4/05	05:34	EIT 195	AR 10989 SE side.	Eruption with dimming. From EUVI-B 284 Å there may be a partial ejection, but uncertain; EUVI 171 Å shows dimming that suggests an ejection however.
11	4/05	15:35	EUVI-A	W limb, probably from AR 10987	Coronal opening and dimming.
12	4/05	19:34	EIT 195	AR 10989, SE side.	Same location as event at 05:34 UT on same day. Filament eruption clear in 304 Å; probably ejective, but uncertain.
13	4/09	09:58	EIT 195	W limb, probably from AR 10989.	Filament and cavity clearly erupting in EUVI-A. In EUVI-B 284 appears as very fast ejection.
14	4/11	16:06-24:00	EUVI-B 304	NE limb.	Very slow filament eruption; seen in 304 Å but not noticed in other filters. Faint and behind the limb in EIT 195 Å.
15	4/16	06:46	EUVI-B 284	AR 10990.	Eruption from AR; possibly ejective, but uncertain.
16	4/16	10:06	EUVI-B 284	AR 10990.	Relatively strong eruption from AR, likely ejective.
17	4/16	18:06	EUVI-B 284	AR 10990.	Eruption from AR, likely ejective.

Notes:

[1] Instrument in which feature was first noticed.

https://doi.org/10.1017/S1743921310010380 Published online by Cambridge University Press