The Lower Solar Atmosphere During The WHI Campaign (20 Apr - 16 May 2008)

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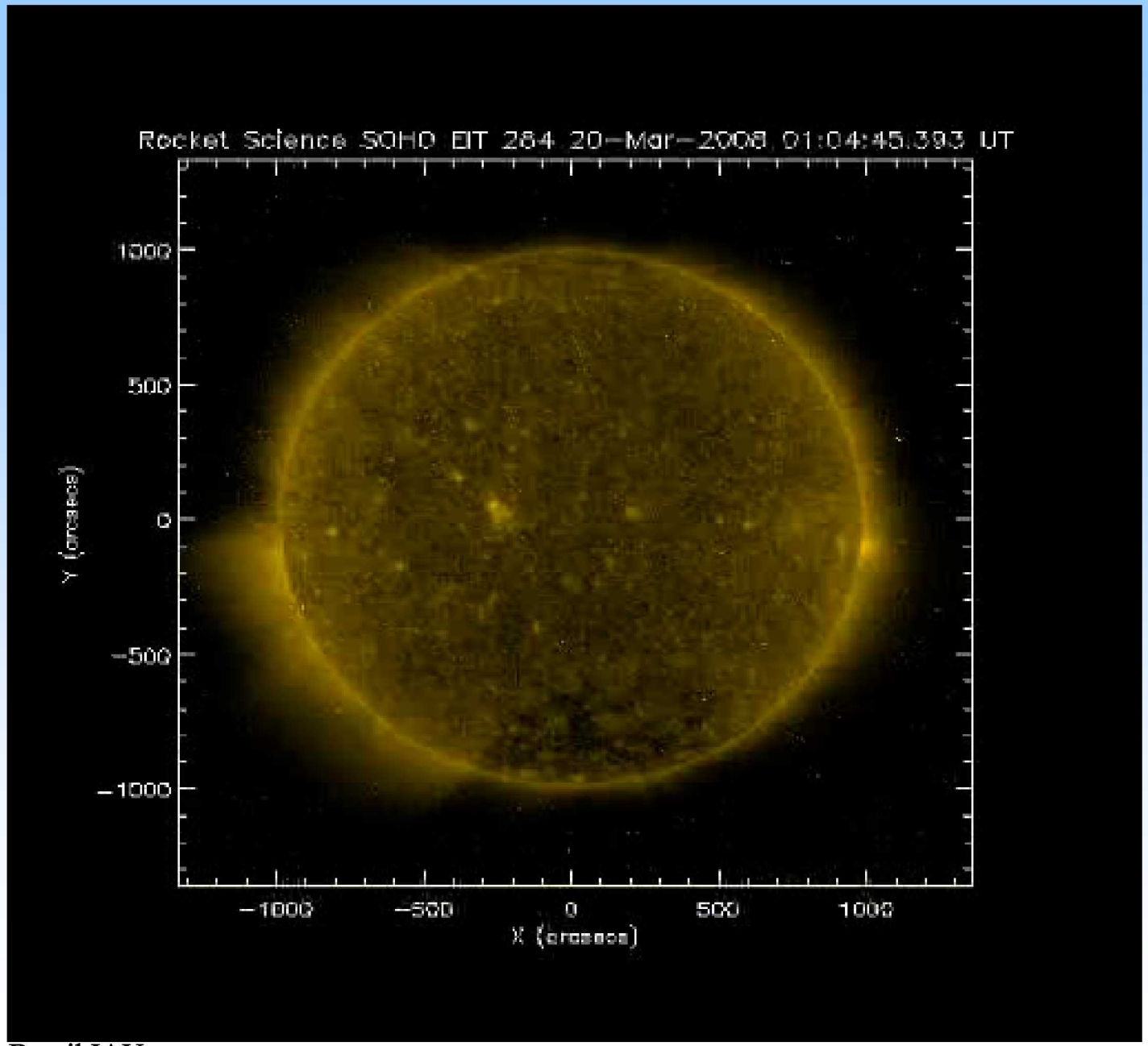
WHI @ Brazil IAU
2009

Introduction

- The WHI period covered 20 March - 16 April 2008.
- My focus is on the solar disk events.
- Overview of what's to follow:
  - Begin with overview of the Sun over the period.
  - Present a list of "eruptive type" of events seen on the disk.
  - Consider some specific eruptions in more detail.
  - Consider (briefly) the eruption dynamics in a particularly active region (AR 10989).
  - Compare my list of disk events with a list of CMEs (courtesy D. Webb).
  - Outstanding questions and summary.

The Sun Over the WHI Period

- Four ARs, otherwise quiet.
- ARs 10987, 10988, 10989 in a group.
- AR 10990.
- SXR images and EUV images show this well.
- GOES for the period reflects this too.


Rocket Science SOHO EIT 284 20-Mar-2008 01:04:45.393 UT
1000
500
0
-500
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Y (arcsecs)
-1000
-500
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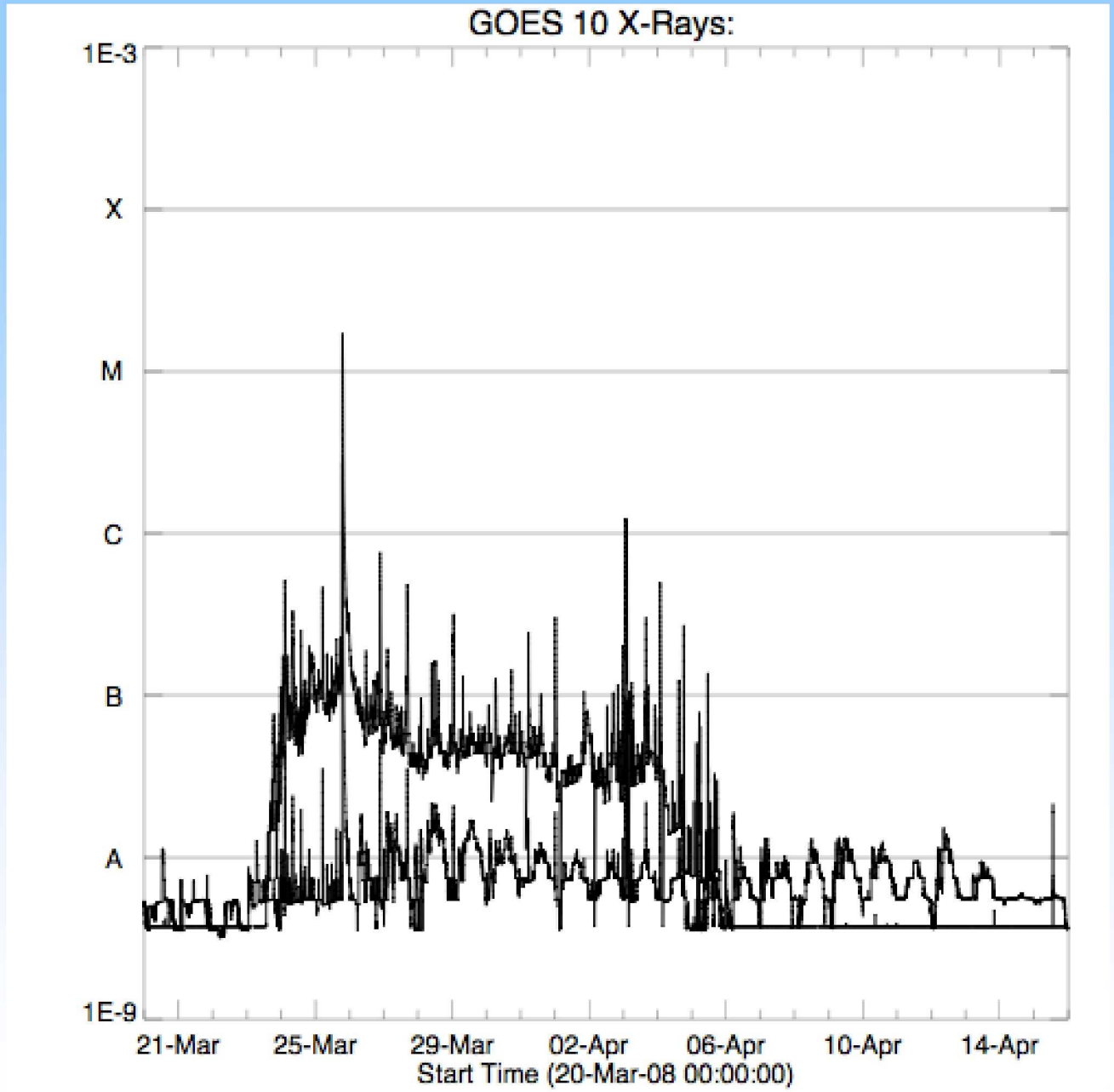
500
1000
X (arcsecs)


GOES 10 X-Rays:
1E-3
X
M
C
B
A
1E-9
21-Mar
25-Mar
29-Mar
02-Apr
06-Apr
10-Apr
14-Apr
Start Time (20-Mar-08 00:00:00)

Eruption-Like Events During the WHI Period

- Concentrated on surface phenomena.
- Examined EIT 195 images first (full disk, ~12 min cadence). Tried to identify events that looked eruptive.
- Supplemented this by examining STEREO EUVI 195, 284, and 304 images.
- Most eruptive-appearing events were from the ARs, or from activity near them.
- "Eruptive appearing" does not mean necessarily "ejective"!

Some of Events in EIT

Most of the events can be seen in the EIT movies for March and April 2008.

"Eruptive-Looking" Coronal Events, During WHI 20-Mar - 16 Apr 2008: EIT 195

Date	Time	"First" Instr	Location	Comments:
3/22	11:45	s195-B	At E limb.	Precursor to 14:05 event (same location).
3/22	14:05	s195-B	At E limb.	BTL for EIT, but nice eruption. Probably from early 989.
3/22	---		s195-B	ARs starting to grow, but no obvious ejections.
3/25	18:34	e195	10989 @ E limb.	Ejective eruption, with wide span, especially to S. Appears as huge eruption in s195-B, etc.
3/26	---		s195-B	Lots of activity between 987 and 988, but no obvious ejections. In s284-B between 987 and 988 there may be a failed-eruption (puffs?).
3/27	c16:06	s-B284, etc.	E limb in s-B.	Faint feature, maybe best in 171. In s284-B NE events looks like "pulled-out flare" from overlying leaving loop. Some channels may miss this event due to scaling (high-altitude event).
3/27	17:06	s284-B, etc.	AR 988	Rapid ejection off to SE; not clear if it leaves Sun. Not noticed in 195. Visible nicely in 304.
3/27	17:26	s284-B	S of AR 988	Filament erupts, but may have failed. Seen faintly in 284, didn't check 171.
3/29	07:47 +	e195	Along E limb.	Large-scale flows that may or may not erupt. May be two events, one in NE, and jet in S, perhaps converging toward equator. Continues until >= 3/30 eruption. Better seen in s-B [check].
3/30	06:22	e195	989 (furthest E)	Eruptive flare, removing corona (dimming) to SE. Well seen in s284-B too.
3/30	>7:46	s304-B	S of 988 and 989	Large filament eruption, initially not noticed in the non-304 filters. From 304-A however, it may not leave Sun. [Not explicitly checking s195-B beyond this day.]

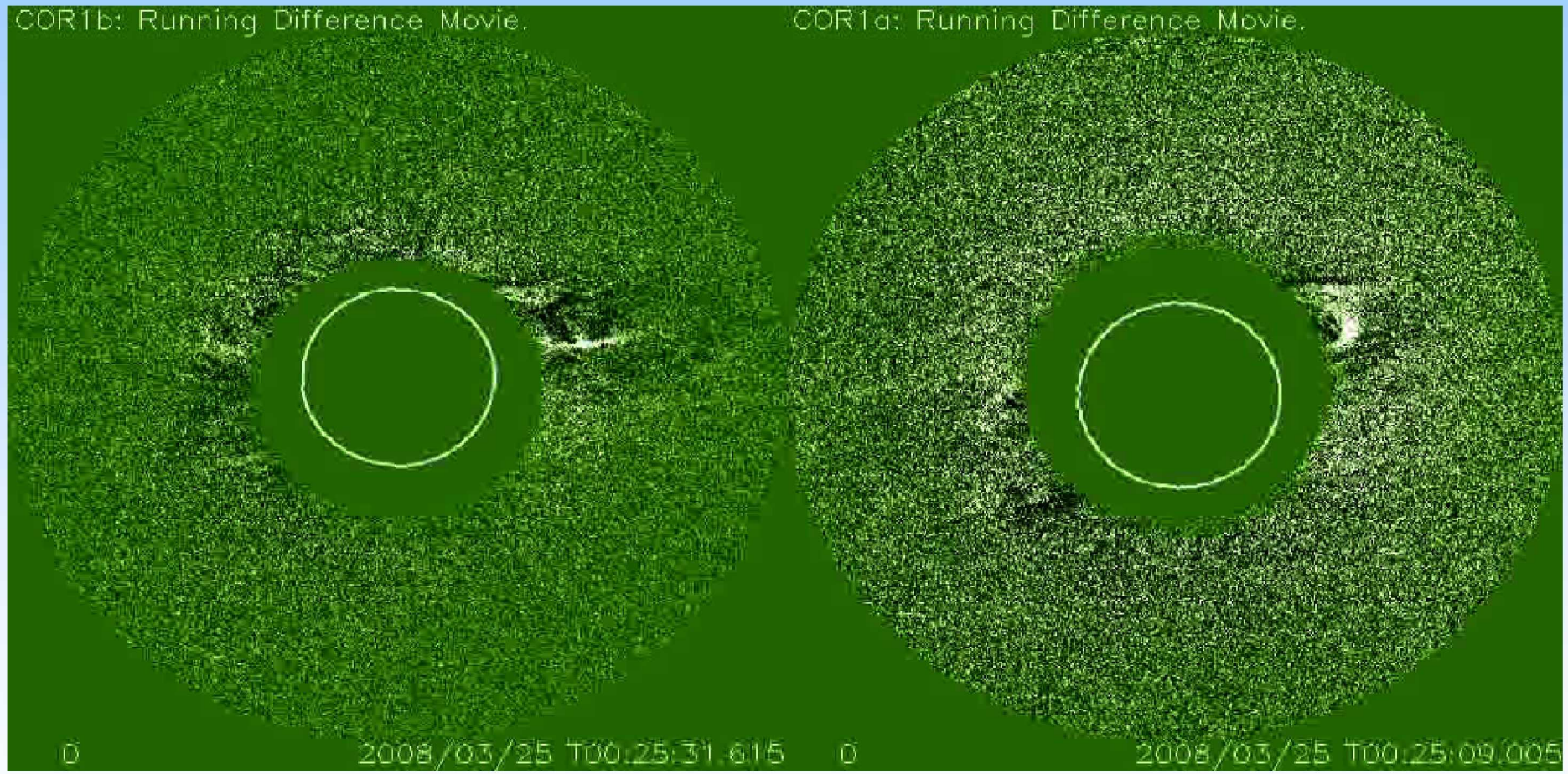
"Eruptive-Looking" Coronal Events, During WHI 20-Mar - 16 Apr 2008: EIT 195 (cont.)

Date	Time	"First" Instr	Location	Comments:
4/01	04:26	s284-B	N of 989.	Eruption of some sort, with wide effects but maybe confined.
4/02	02:26	s284-B	QR near disk cent.	Not clear if this is ejective.
4/05	05:34	e195	E of 989, nearing W limb.	Eruptive, dimming off to the SE. In s284-B appears as a burp that may eject some, but not clear. 171 shows dimming that suggests a real eruption. 304 didn't observe during the burp.
4/05	19:34	e195	989, SE side.	Filament eruption (failed?). But in s284-B appears as a very nice filament eruption.
4/09	09:58	e195	989(?), at W limb.	At latitude of 989. Nice filament w/ cavity fully erupting. In s284-B appears as very fast ejection.
4/11	16:06-24:00	s304-B	NE limb.	Seen in 304, not noticed in others maybe because too high?). Very slow filament ejection. BTL for EIT, where it is faintly visible when searching for it.
4/16	06:26	s284-B	AR 10990	Possible eruption from AR, but uncertain.
4/16	10:06	s284-B	AR 990	Relatively strong eruption from AR, looks like material expelled..
4/16	18:06	s284-B	AR 990	Same as previous.

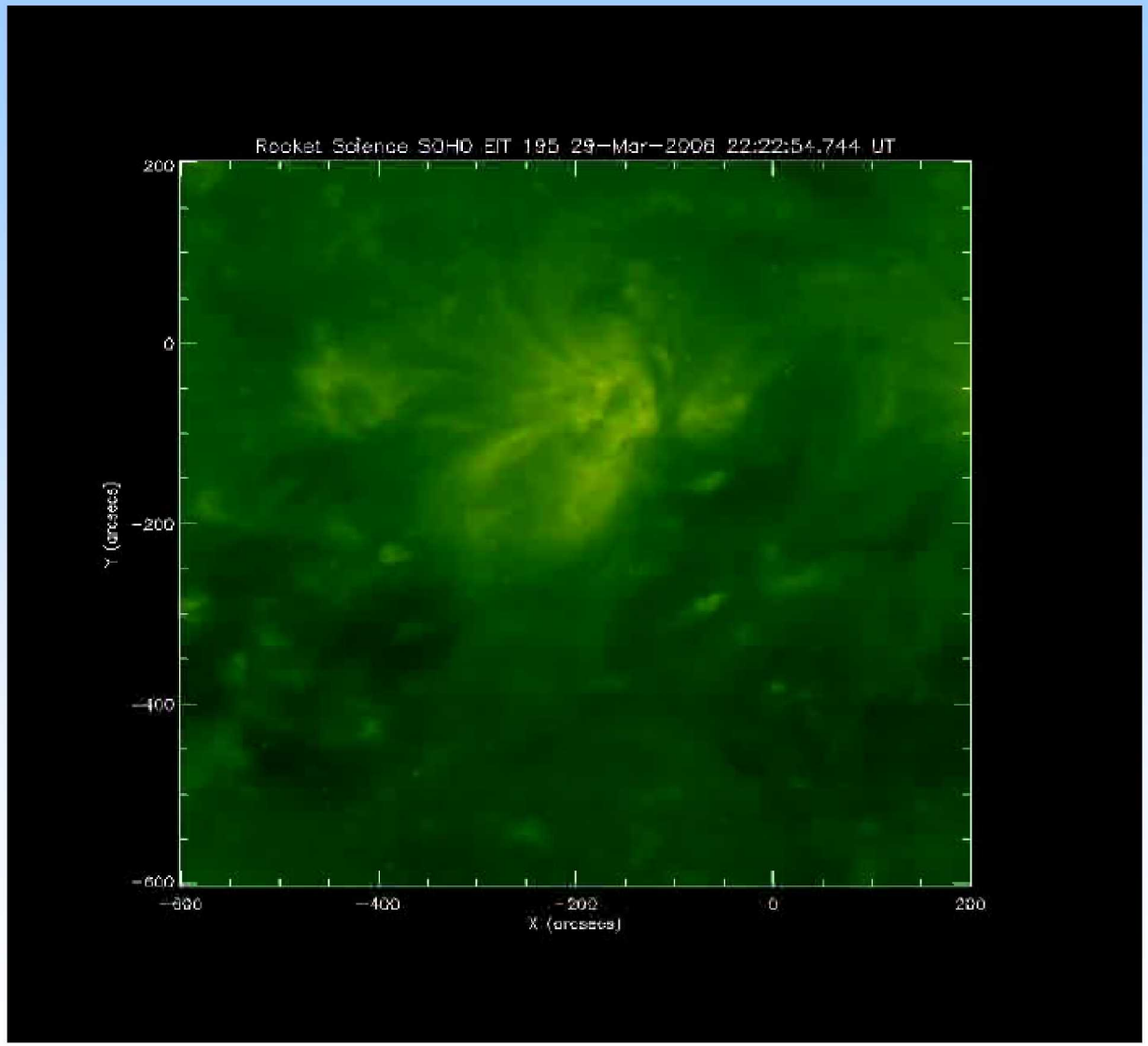
Activity in AR 10989 and Friends

- AR 10989 (furthest to east of the triplet) erupted several times. At least two times were clearly ejective.
- AR 10987 (furthest west of triplet) erupted for sure on 5 April.
- ARs 10987 and 988 less eruptive than 989 overall.
- Activity between the ARs also may be a source of activity.

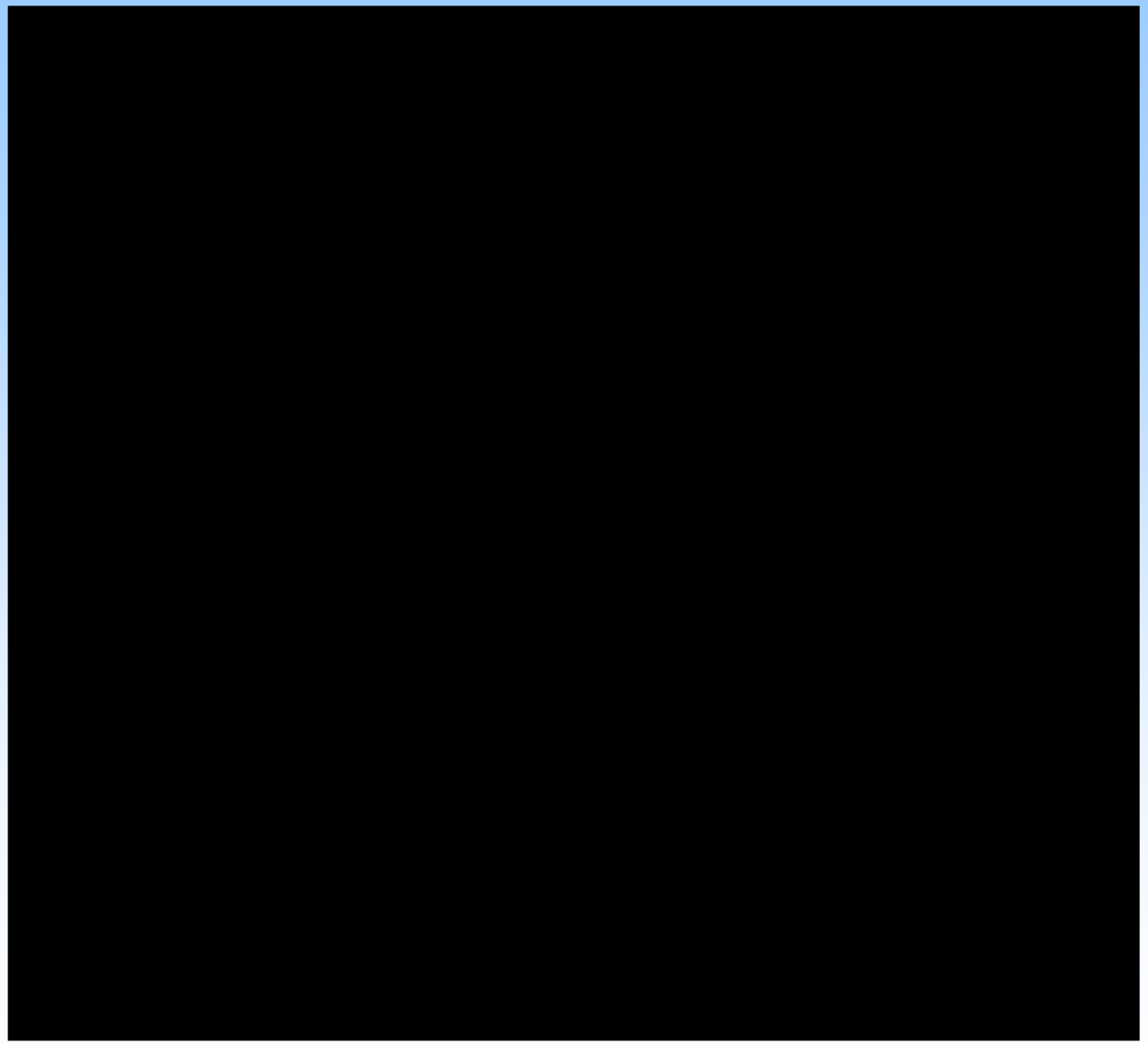
COR1 Movie: Big CME from 989 on 25 March



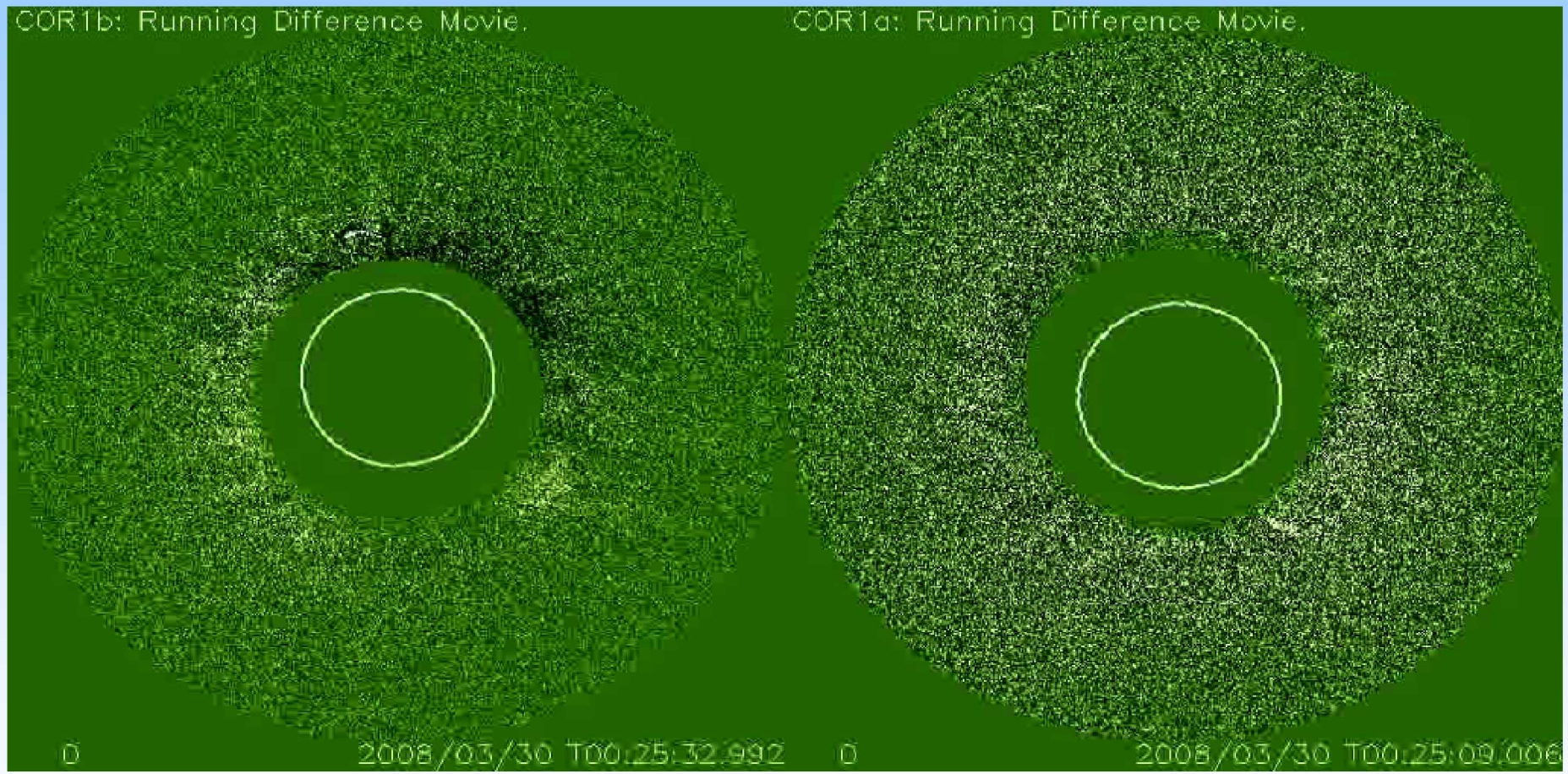
EIT 195: Weaker event from same region on 20 March



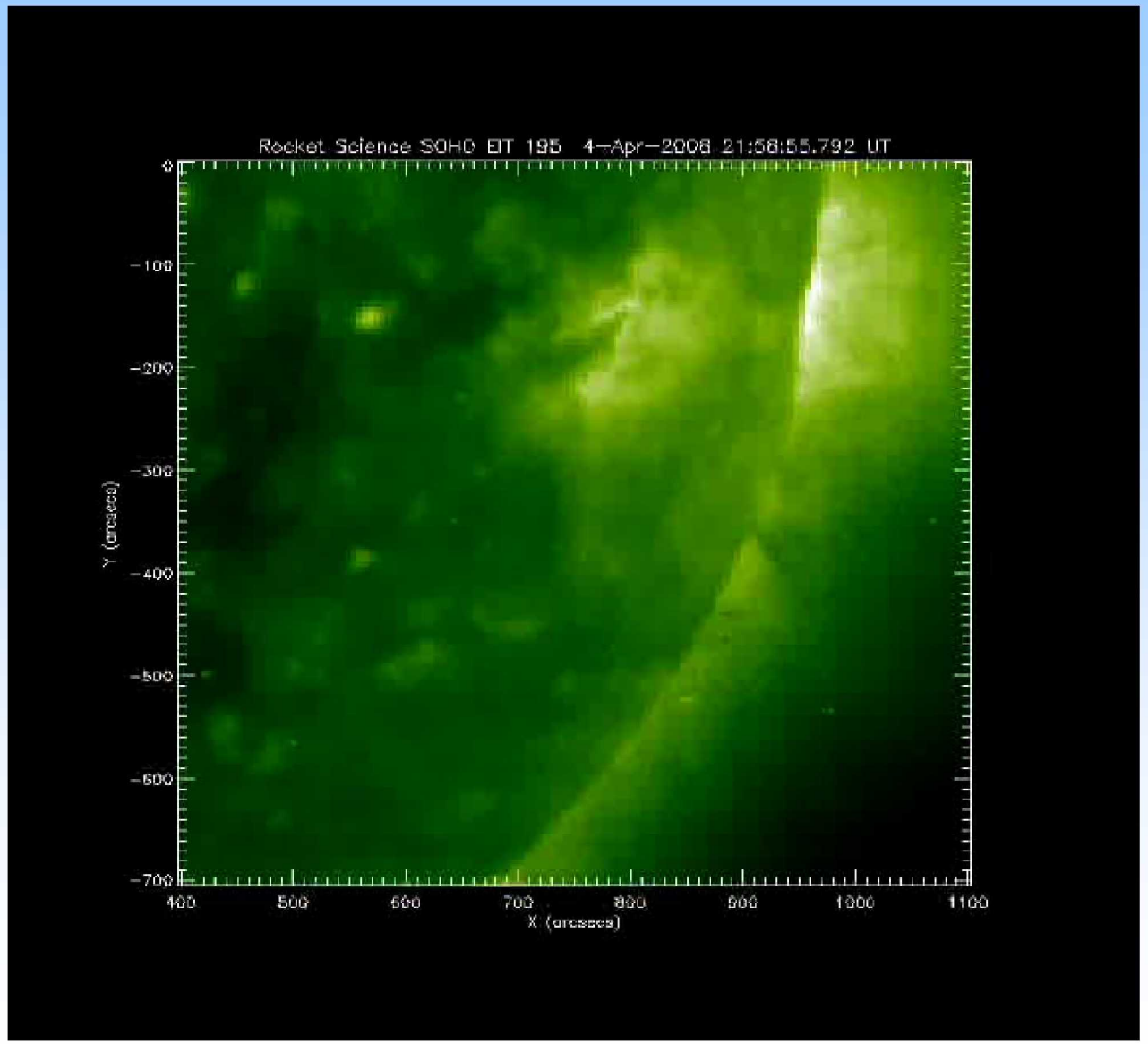
Same event, EIT difference (“percentage”) movie



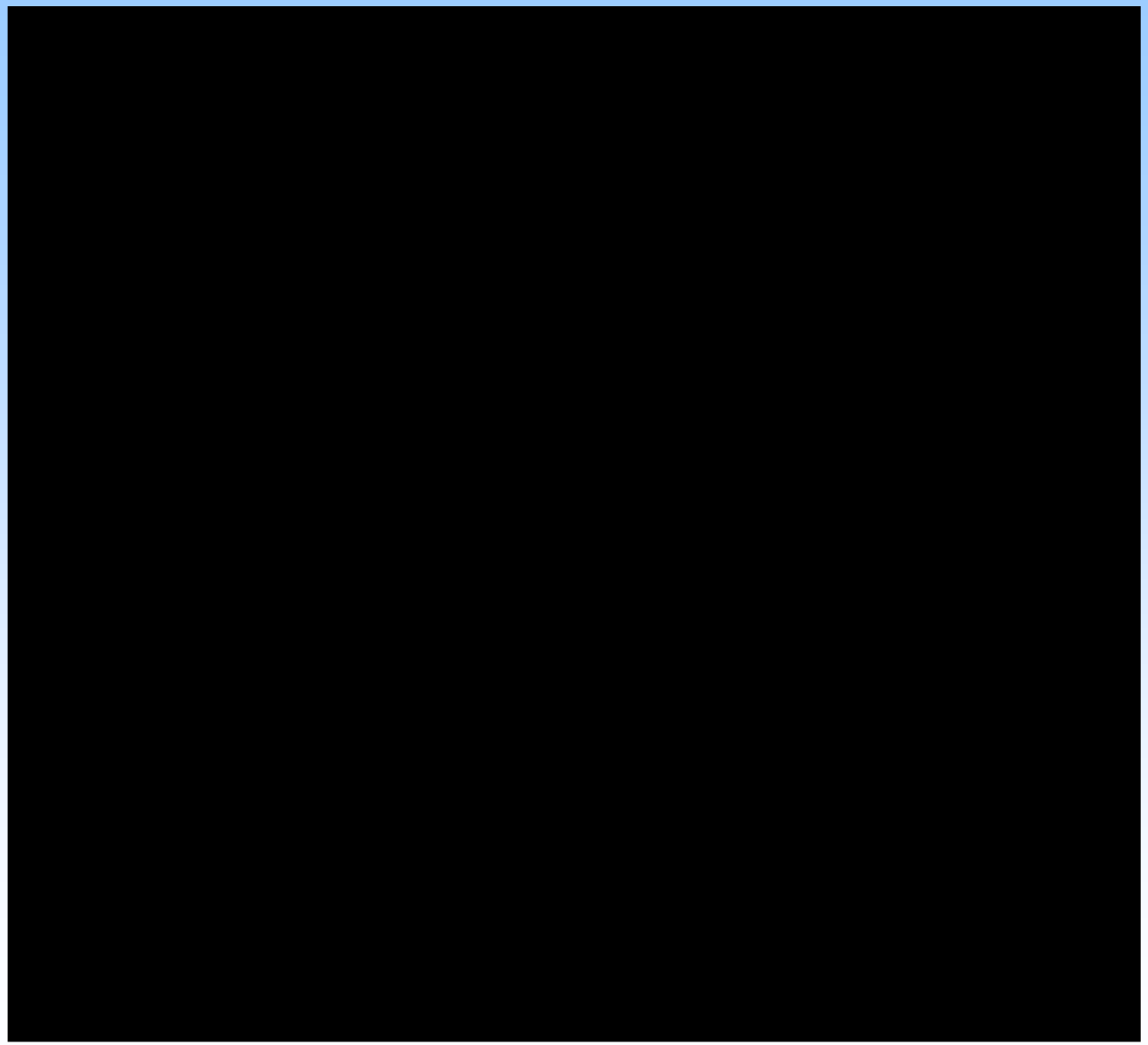
Alas, no obvious CME (but could there be a weak halo?)



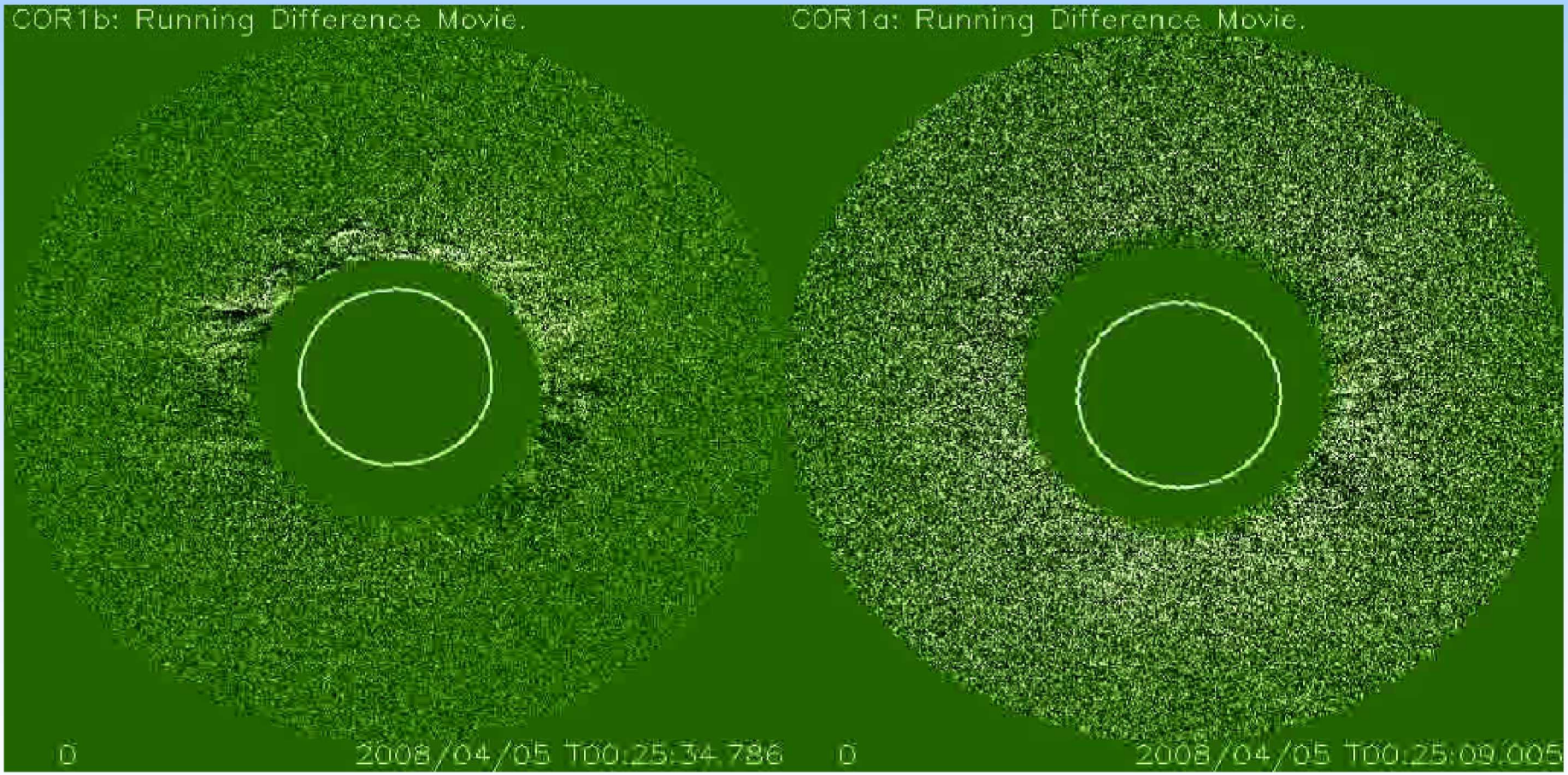
EIT 195: AR 989 eruption at W limb



Difference (percentage) movie of 05 April eruption



Makes a weak CME on 5 April, but overwhelmed by one from 987!



On the Cause and Nature of the Eruptions in AR 10989

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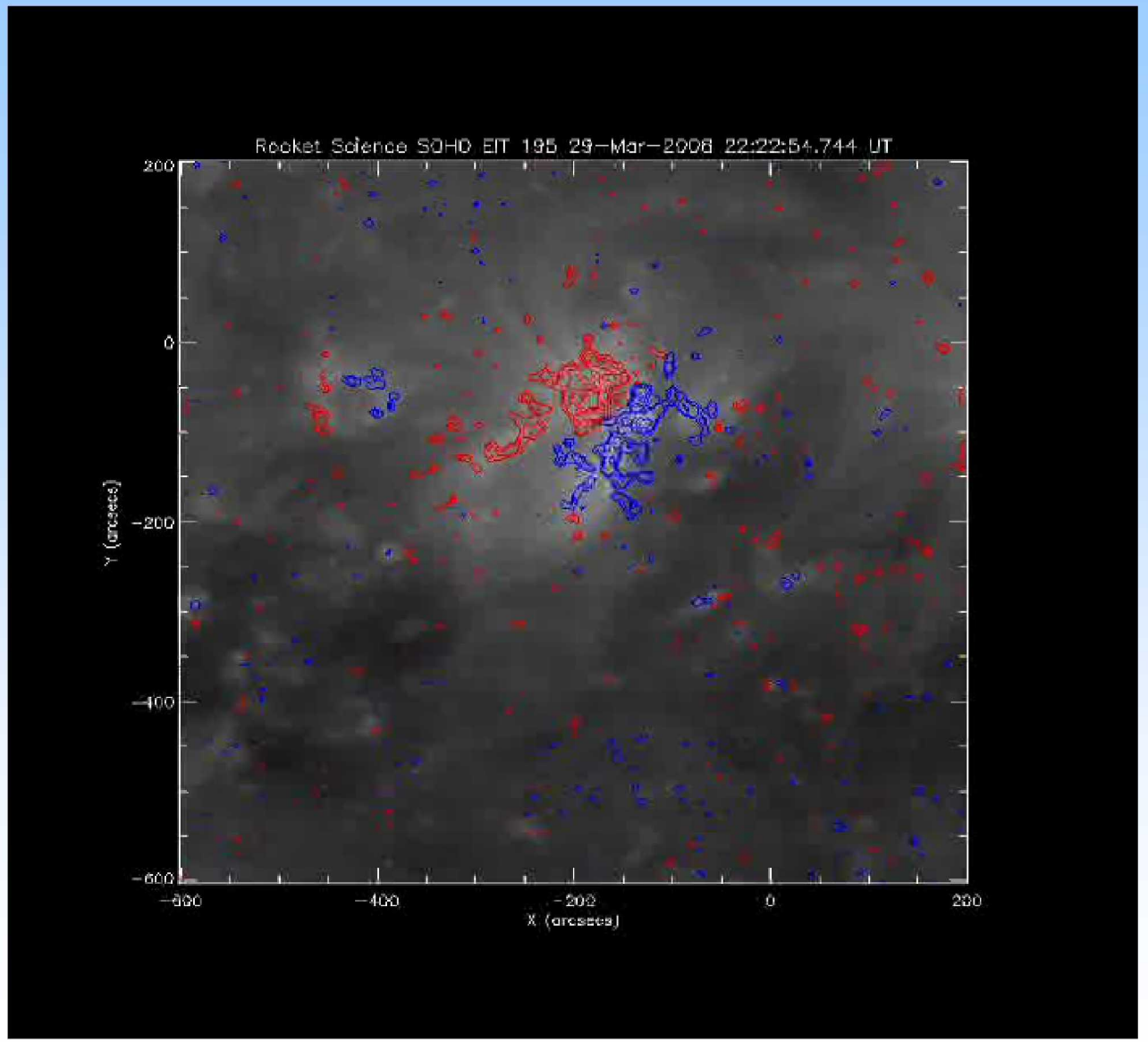
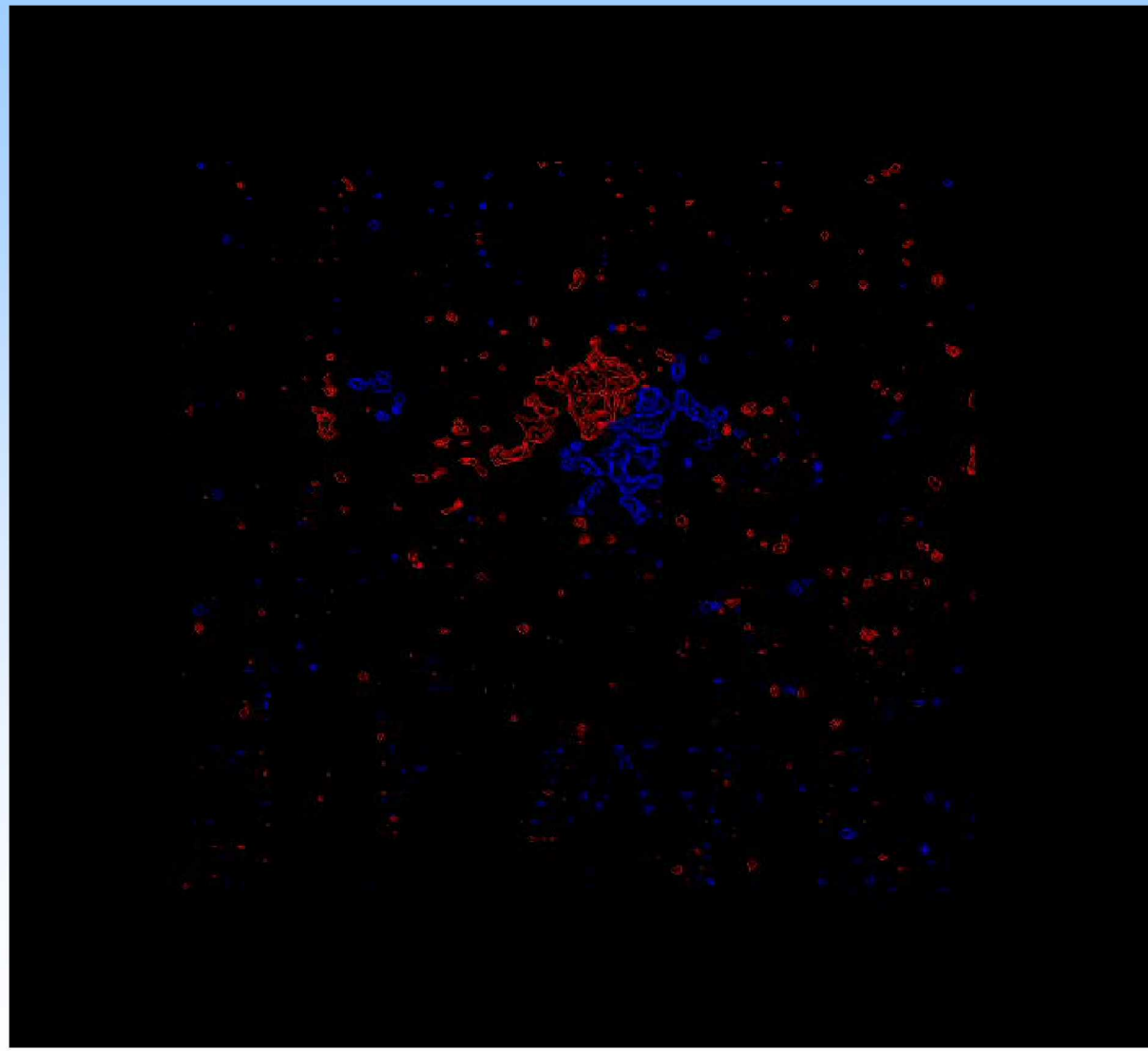
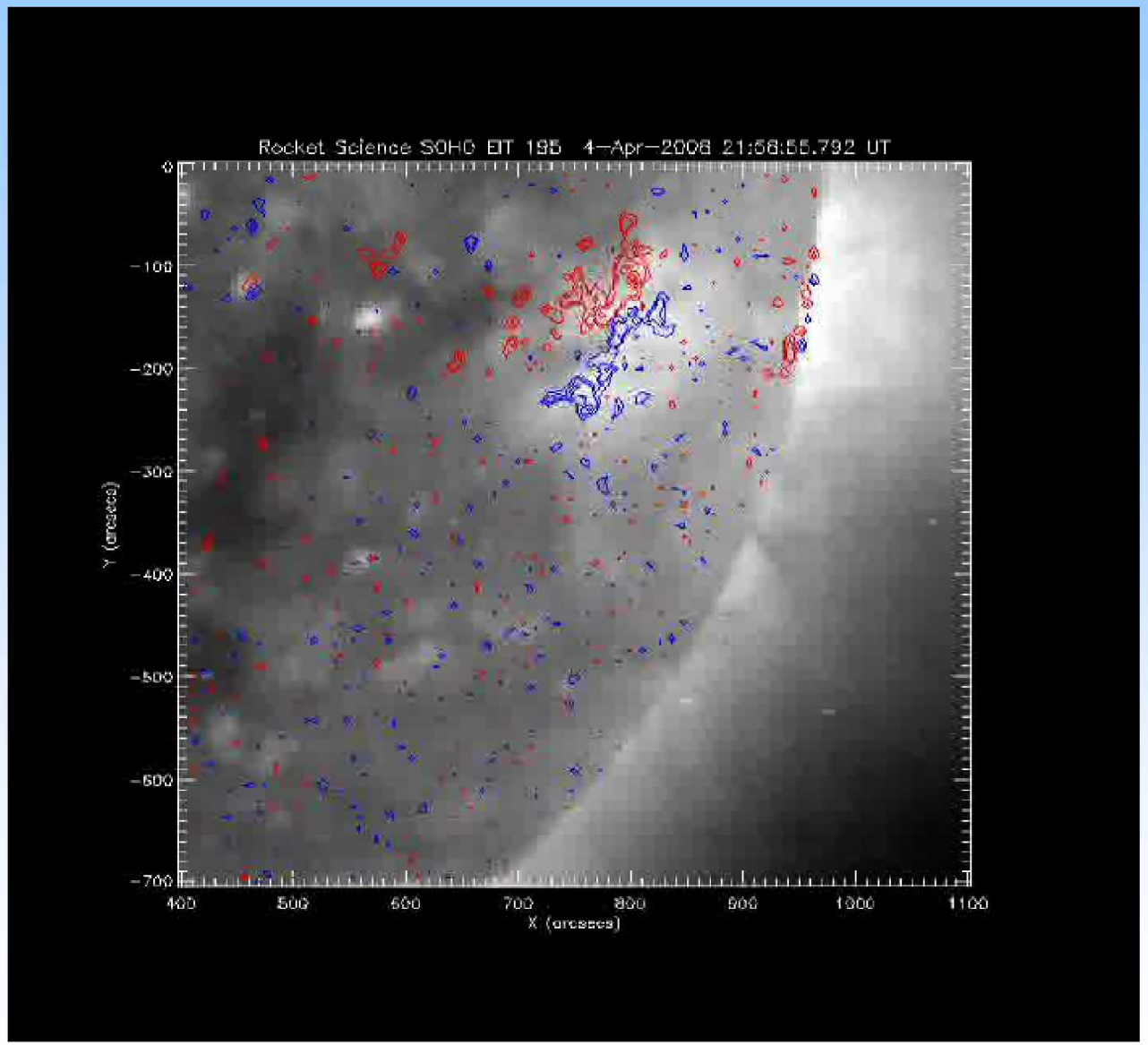
MDI on EIT: 30 March Eruption



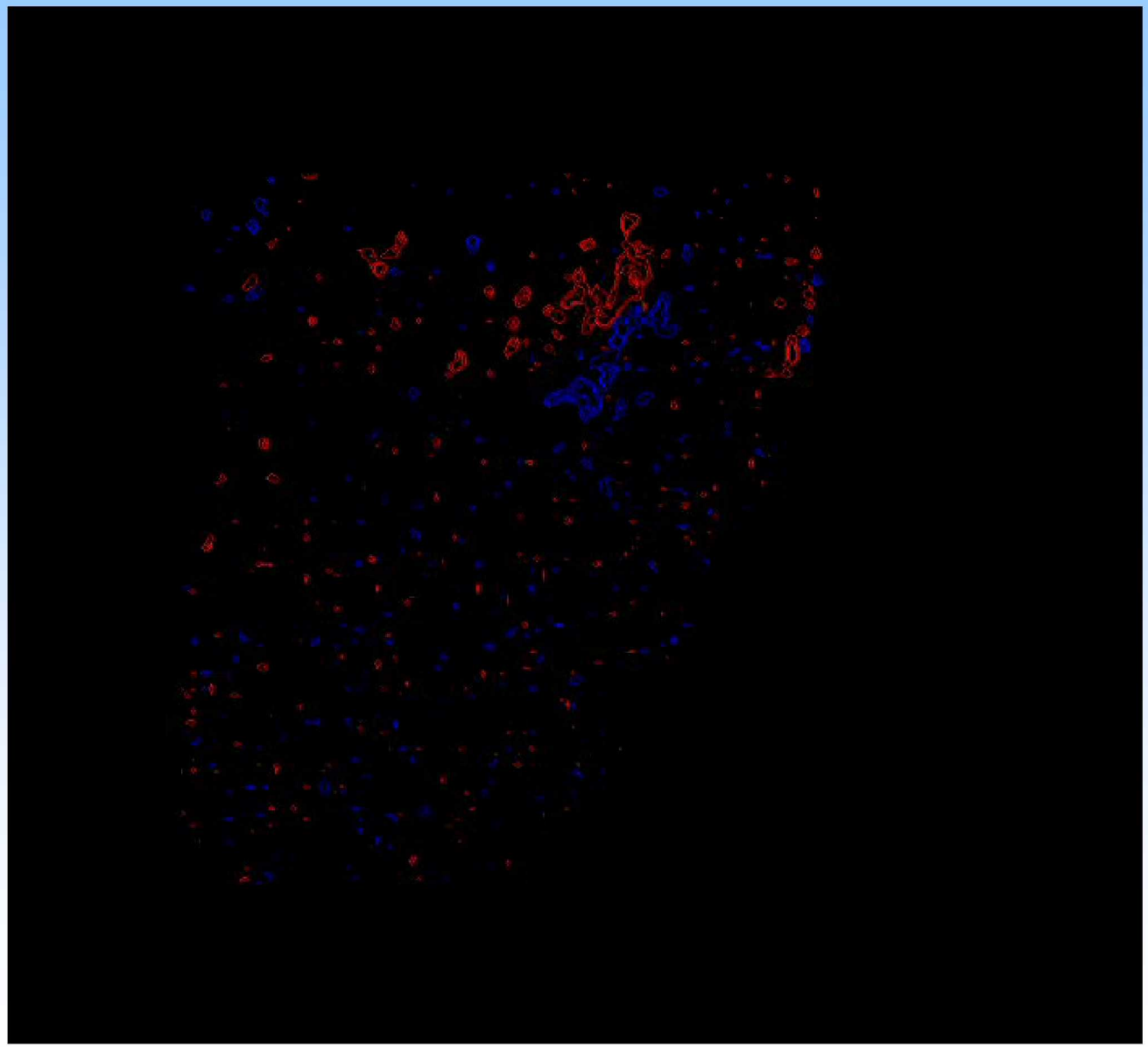
MDI on EIT Difference: 30 March Eruption



MDI on EIT: 05 April Eruption



MDI on EIT Difference: 05 April Eruption



Comparing source eruptions with observed CMEs

- Use list from Dave Webb (et al.), of observed CMEs from the period.
- Dave's list includes disk events; most overlap with mine, but not 100%.
- In the following, brown indicates where Dave has no disk source listed, but I have a candidate or suspicion for the source.
- Red indicates where neither Dave nor I have a candidate disk source for the CME event.

Dave Webb's List

CMEs During the WHI: March 20 - April 16, 2008
D. Webb; Last updated 20 August 2008

Date	DOY	First Obs. (U.T.)	P.A. (deg.)	Width (deg.)	Speed km/s	Accel.	Instrument	Surface Association	Comments
22-Mar	81	8:45	NW	Narrow			COR1 A,B		Narrow slow loop
23-Mar	82	5:07	277	22	1388		COR2 A		
*		14:05	E 75-101	~40-50	287-390		COR1 A,B; COR2 A,B; LASCO	EIT;14:12; ESE L Dmg. EUVI-B;13:55	Brg ragged loop front. Narrow struc. Follows.
		2:20	85	>30			SMEI		Faint arc only in Cam2. 67-73 deg. elong.
24-Mar	83	early	SE		slow		COR1 A,B		Faint, slow c-o front
		2:20	ENE	>30			SMEI		Ft, arc in Cam2- 67-73 deg.E; Cam3 shutt.
		~04:30	NE				COR2 A,B; LASCO		Series of faint ragged fronts that shift NP-ward.
			36-49	10,-30	~350				
		8:08	336	36	240		COR2 B		
		8:37	273	10	233		COR2 B		
25-Mar	84	14:25	NW				COR1 B		Loop front w/twisted core
		20:30	WNW	~ 30			COR1 A; LASCO		Same but later. Slow dev.
* 25-Mar	85	00:52-03:08	275	14-112	150-1560		COR2 A,B		
		18:40	82-94	70-112	750		COR1 A,B; COR2 A,B; LASCO HI1, 2 A	M2 flare; 18:56; S13E78 EIT,EUVI, RHESSI dimming, wave	Brg, wide loop, brg inner core. RHESSI nugget at: http://sprg.ssl.berkeley.edu/~tohban/nuggets/?page=article&article_id=7 EPL, EUVI304-B; 18:46-19:46
27-Mar	86	6:05	W; SW	~40			COR1 A,B; LASCO		Loop front w/fast twisted core
		15:07	269	30	213		COR2 A		
28-Mar	87	2:07	262	12	185		COR2 A		
		15:36	NE				EIT		Ft. brief ejection in NE
29-Mar	88	13:48	S10E60				EIT		AR 989 brg., slight dimming Chec othor poss. source
		22:08	349	30	863		COR2 B		
30-Mar	89	2:38	301	210	1041		COR2 B		Lg-scale NE L act./EPL 01-10 UT in EIT, EUVI304-B. Prom active on 28t
		6:38	358	16	961		COR2 B		
		10:08	358	12	961		COR2 B		
		13:08	357	14	1001		COR2 B		
31-Mar	90	6:24	S10E30				EIT		Flare, diming, aracde to S of AR989.
		14:38	45	10	211		COR2 B		

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Dave Webb's List (Cont.)

2-Apr	92	0:37	154	8	1136		COR2 A		
		5:45	NW	Narrow			COR1 A		Narrow ejection deflects eq-ward
3-Apr	93	15:37; 19:54	W; 347	~45	1041		COR2 A; LASCO		Faint, slow, complex event.
		20:08	220	64	1250		COR2 B		
		21:08	304	72	1562		COR2 B		
		21:08	84	176	1562		COR2 B		
4-Apr	94	1:38	S10W30				EIT		Brg., dimming over AR 989
		19:05; 21:05	SW; 268	28	446		COR1 A,B; COR2 B; EIT; EUVI-A		Fanlike; wider in A. EIT, EUVI-A: SW brg. In AR989 & ejection? to WNW;20 UT
* 4-Apr	96	6:00	S30W35				EIT, EUVI-A		DSB S from AR 989
		16:06	W; 270	~180	890	No	COR1 A,B; COR2 A,B; LASCO HI1-B 5-6th	EIT, EUVI-A limb:15:45; AR987. DB:19:30;S from	Brg, fast, wide loop front w/faint extensions. Continues thru Apr. 6. Whole event well obs. in EUVI-A,CORs-A,HI1-B. 19:30-fil. ejected to S.
		16:07; 22:38	~250	~40	340		COR2 A,B	AR 989	Same event?
7-Apr	97	0:08	266	12	337		COR2 B		
		20:37	297	6	483		COR2 B		
8-Apr	98	15:45	NE; ENE	Narrow			COR1 A,B		Narrow, slow loop deflects toward Eq. Continues thru Apr. 8.
9-Apr	99	4:25	SE				COR1 A,B		Small loop, slow; hard to see in A.
		16:25	NW	Wide			COR1 A,B		Wide ragged front, ff by narrow twisted loop. Faint in B.
10-Apr	100	1:05	NE				COR1 A,B		Loop w/C-O front, faint and slow. Faint in B. Brg ragged loop front w/twisted brg.
*		9:05; 10:26	WSW;SW	~55	~400		COR1 A,B; COR2 A,B; LASCO EIT; EUVI A,B; XRT		core (unwinding prominence). Full XRT evt; current sheet. CFA Focus event
		13:37; 14:26	ENE	18	179		COR2 A; LASCO		Small, gradual brg. C2 data gaps. Fades in C3.
		20:37	223	14	237		COR2 A		
11-Apr	101	20:05	NE				COR1 B		Narrow cusp loop with core. Slow. Continues into Apr. 12.
12-Apr	102	00:07; 1:25	W; 272	36	338		COR1 A,B; COR2 A		Wide, faint eruption
		23:37	60	26	~520		COR2 A,B		Expansion/extension of 11 April event?
13-Apr	103	09:45; 11:50; 15:07	S; 200	>90	152		COR1 A,B; COR2 A; LASCO		Slow outflow develops into loop front. Faint and wide. Continues into Apr. 13.
		19:08	132	11	160;320		COR2 B		
		18:37	226	12	164		COR2 B		
14-Apr	104	10:07	201	10	156		COR2 A		
15-Apr	105	6:25	NE	Wide			COR1 B		Wide eruption, no distinct front.
		5:38	120	23	330		COR2 A,B		same event?
		6:25	W; NW				COR1 A,B		Cont. outflow w.faint loop front. Faint in B.
		14:07	225	14	513		COR2 A		I see several events this day from AR 990.
16-Apr	106	19:53	40	60	625		COR2 B		
17-Apr	107	07:45; 8:50; 9:08	E; 83	30	353		COR1 A,B; COR2 B; LASCO		Diffuse brg develops loop front w/core. C-O front. Faint in A.
		10:24	N4500				EIT		Ft. dimming to NW of AR

COR1 CME list courtesy Hong Xie
COR 2 CME list is from CACTus program; courtesy Eva Robbrecht
LASCO CME list is preliminary; courtesy G. Stenborg
HI CME list not yet available for Mar and Apr 2008
EIT searched for dimmings/events by DW

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Why Are Some Events Not Id-ed? Some Possibilities:

- Behind the limb.
- “Hidden” events from ARs. (Several cases?)
- Not searched for carefully enough yet.
- “Problem events.”

Summary

- The Whole Heliospheric Interval (WHI) period of 20 March - 16 April had a “quiet side” of the Sun, and an “active side,” with three ARs.
- At least two of the ARs produced CMEs, but there were several events that may have been “confined eruptions” from these regions too.
- Examining the magnetic environment of the erupting regions gives insight into the onset and dynamics of the eruptions.
- Several of the CMEs can be traced back to likely disk sources, but several unmatched cases still remain.
- More work is needed to sort through these points.

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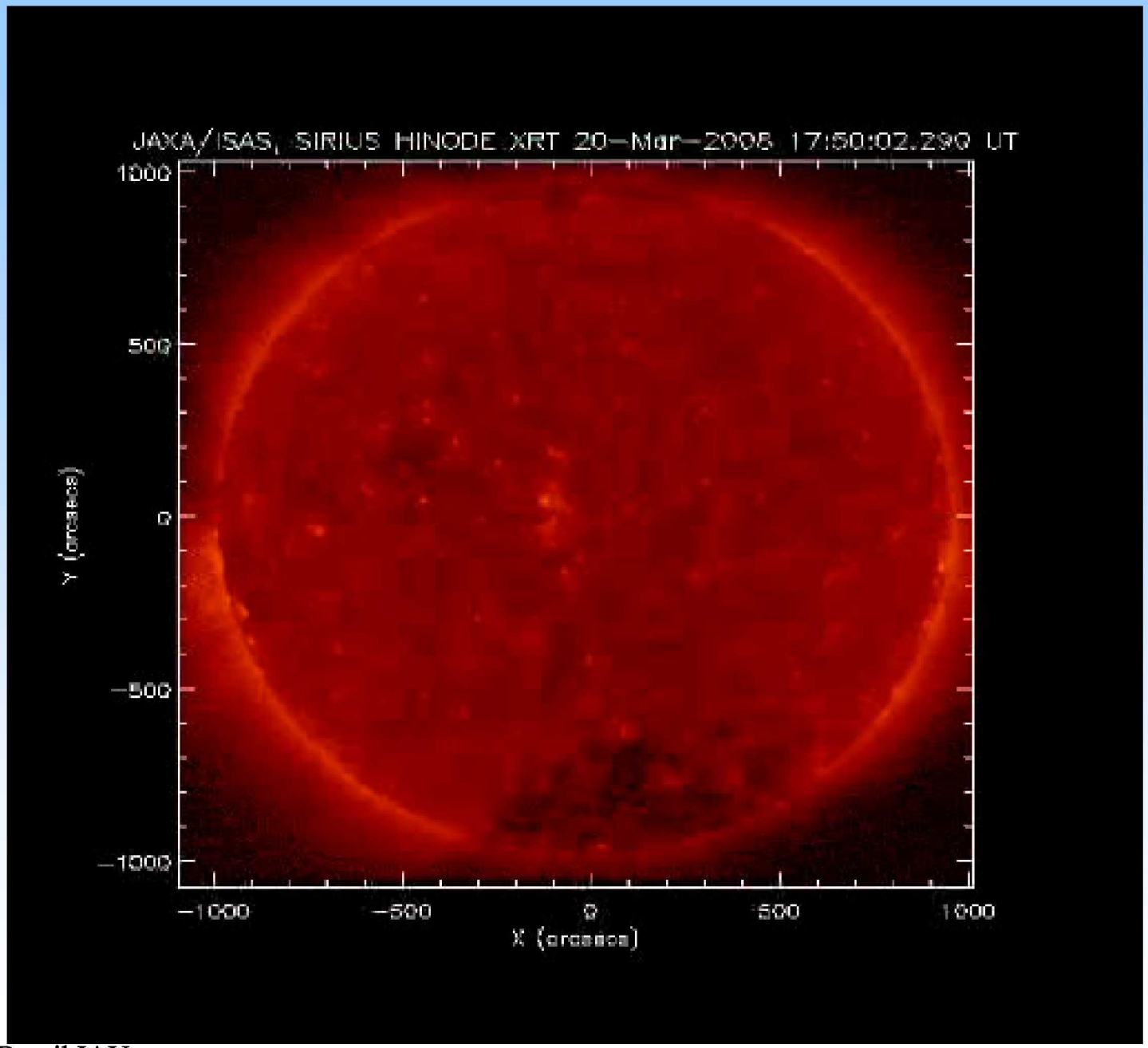

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