



Solar DEMON

Dimming and EUV wave Monitor

**Near real-time dimming and EUV wave
detection on SDO-AIA**

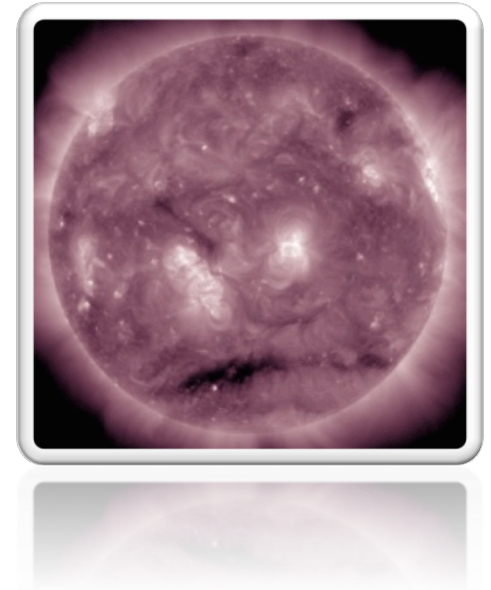
Presentation by Emil Kraaikamp (ROB)





Outline Solar DEMON

- Objectives
 - Event detection
 - Event characterization
- Output
 - (flare detection)
 - Future work





Objectives

- Develop early warning system for earth-directed CMEs
- Create a catalog of dimming and EUV wave events for research purposes





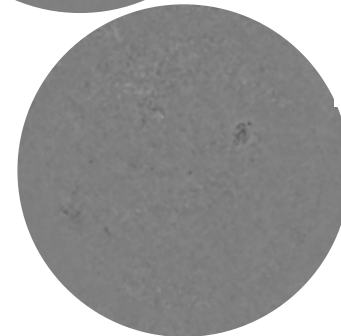
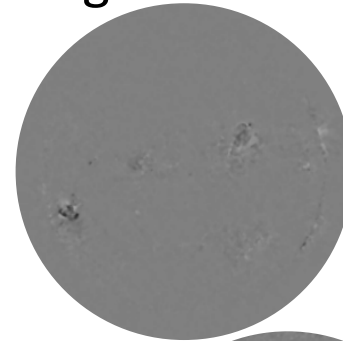
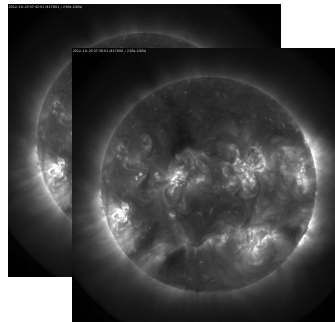




Event Detection

- Using **Running Difference** images

- Normal RD
 - Subtract 2 subsequent frames
- percentage based RD
 - RD divided by original image



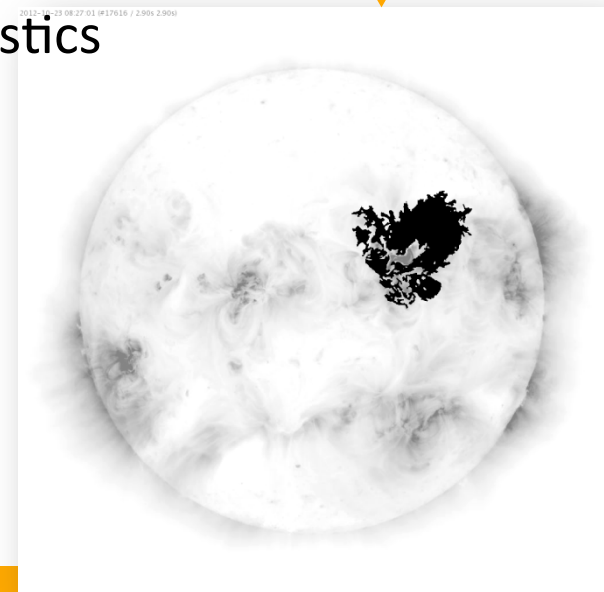
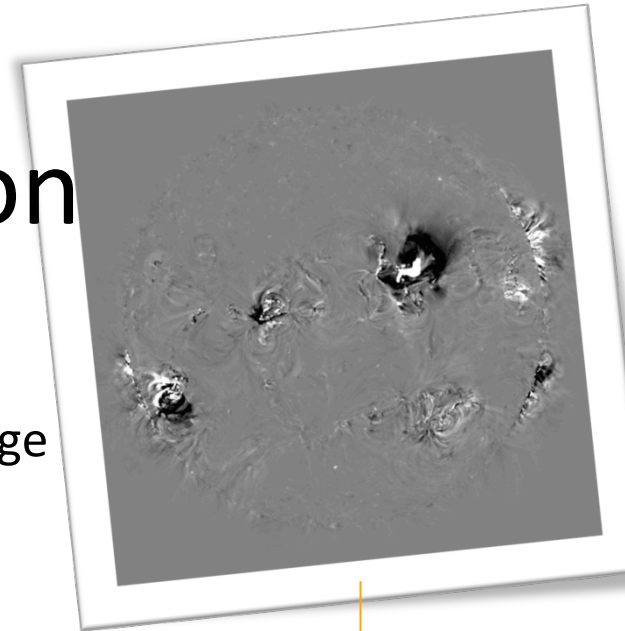
- Noise reduction
 - E.g. median filtering
- Basically detection of (large enough) growing/moving structures on the sun





Event Characterization

- Using **Base Difference** images
 - For each image subtract pre-event image
- Differential Derotation
 - Normalized limb-brightening
- Create dimming masks
 - Use these to extract dimming statistics
 - Overlay mask on BD
 - Location (near AR?), brightness, Area, Intensity, Volume.
 - Over time





Output

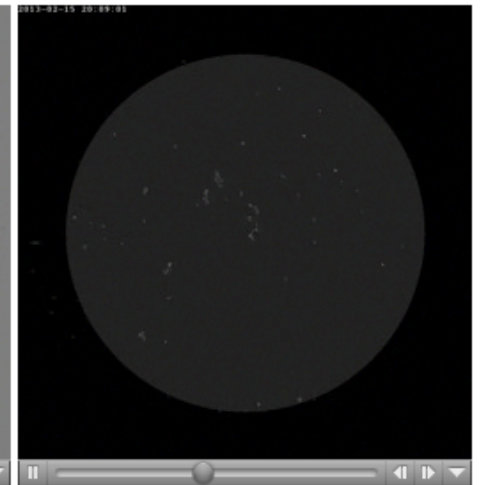
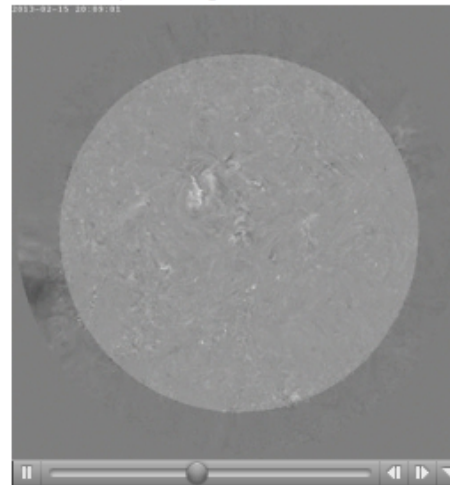
- List of characteristics
- Movies
 - Dimming mask
 - Dimming intensity (= mask * base difference)
 - (percentage) running differences
 - (percentage) base differences
 - EUV Wave
 - Best seen in running differences
- In the pipeline: graphs
 - Dimming intensity over time
 - Intensity profile per sector EUV Wave sector centered on eruption center



Solar DEMON

last event percentage base difference:

..EUV wave:



Last processed image:

2013-02-15 21:15:00, which is 138 hours and 11 minutes ago

Last detected dimming:

2013-02-15 20:33:01, which is 138 hours and 52 minutes ago

Last detected flare:

2013-02-06 01:03:01, which is 374 hours and 22 minutes ago

Overview of recent detections: (num pixels, area, intensity, and volume are averages for the detection duration!)

	start	end	#	images	detections	intensity * 10 ³	num pixels * 10 ³	area km ² * 10 ⁹	volume * 10 ⁹
February, 2013									
15	19:45	20:33	9	17	2	-92.6	4.1	0.0	0.0
12	22:12	22:57	8	16	1	-98.5	5.6	49.3	-789.1
9	05:30	06:45	7	26	11	-731.7	24.1	106.0	-2,782.5
6	02:24	03:15	6	17	1	-544.9	12.7	80.7	-2,748.2
5	23:57	01:00	5	22	6	-358.4	6.4	26.8	-1,324.5
3	17:36	18:36	10	21	5	-288.4	5.7	19.5	-896.2
January, 2013									
31	20:09	20:54	11	16	0	-67.5	2.5	8.5	-218.3
23	13:18	14:30	12	25	8	-170.0	12.0	74.3	-986.4
October, 2012									
23	07:33	07:51	14	7	1	-46.8	1.0	3.9	-166.2
23	03:09	03:57	13	17	1	-42.5	0.9	7.9	-342.9
March, 2012									
17	20:30	20:58	1	15	7	-74.6	2.8	11.6	-249.1
9	03:24	04:58	4	48	21	-480.8	15.7	63.1	-1,606.7
7	00:04	01:36	2	47	37	-1,370.5	37.3	206.6	-6,244.8
January, 2012									
23	03:30	04:44	3	38	17	-639.7	23.3	179.5	-3,993.5

Last processed image:

2013-02-15 21:15:00, which is 138 hours and 13 minutes ago

Last detected dimming:

2013-02-15 20:33:01, which is 138 hours and 55 minutes ago

Last detected flare:

2013-02-06 01:03:01, which is 374 hours and 25 minutes ago

Overview for dimming #:

2 [go back to overview](#)

Simultaneous flares:

id: 3 brightness: 193.5×10^6 lat: 18.4 lon: -30.6

Dimming animations

[dimming base difference](#)

[dimming percentage base difference](#)

[dimming mask](#)

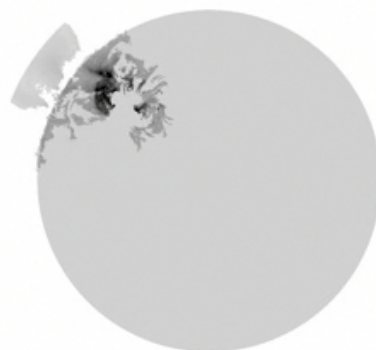
[dimming intensity](#)

[wave percentage running difference](#)

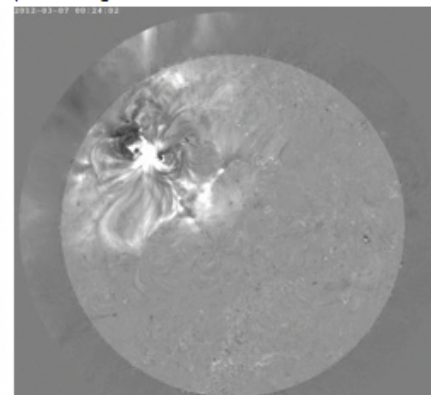
[wave percentage base difference](#)

[wave base difference](#)

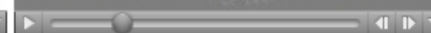
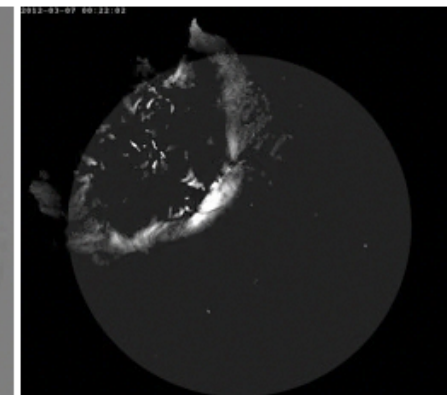
dimming intensity:



percentage base difference:



EUV wave:



time	seq #	intensity * 10^3	num pixels * 10^3	area km 2 * 10^9	volume * 10^9	lat	lon	AR	img	detection
2012-03-07 00:04:02	1	0.0	0.0	0.0	0.0			NaN	3503	0
2012-03-07 00:06:02	2	0.0	0.0	0.0	0.0			NaN	3504	0
2012-03-07 00:08:02	3	0.0	0.0	0.0	0.0			NaN	3505	0
2012-03-07 00:10:02	4	-1.4	0.1	0.3	-6.9	27.9	-43.2	AR 1429 (18, Beta-Gamma-Delta, 0)	3506	0
2012-03-07 00:12:02	5	-7.0	0.2	2.0	-40.4	32.6	-44.1	AR 1429 (22, Beta-Gamma-Delta, 0)	3507	0
2012-03-07 00:14:02	6	-56.7	1.9	12.6	-316.7	27.6	-45.1	AR 1429 (19, Beta-Gamma-Delta, 0)	3508	0
2012-03-07 00:16:02	7	-196.2	4.4	31.3	-1,030.6	25.9	-41.9	AR 1429 (16, Beta-Gamma-Delta, 0)	3509	1
2012-03-07 00:18:02	8	-276.1	5.0	43.8	-1,473.8	24.0	-42.2	AR 1429 (15, Beta-Gamma-Delta, 0)	3510	1
2012-03-07 00:20:02	9	-333.2	6.1	48.6	-1,757.3	24.7	-42.2	AR 1429 (15, Beta-Gamma-Delta, 0)	3511	1
2012-03-07 00:22:02	10	-410.3	8.3	52.9	-2,154.9	25.0	-41.3	AR 1429 (15, Beta-Gamma-Delta, 0)	3512	1
2012-03-07 00:24:02	11	-505.4	10.7	71.3	-2,655.0	25.1	-41.1	AR 1429 (15, Beta-Gamma-Delta, 0)	3513	1
2012-03-07 00:26:02	12	-563.7	9.5	84.3	-3,053.2	25.5	-41.7	AR 1429 (15, Beta-Gamma-Delta, 0)	3514	1
2012-03-07 00:28:02	13	-767.3	14.3	116.1	-3,999.7	24.6	-40.0	AR 1429 (13, Beta-Gamma-Delta, 0)	3515	1
2012-03-07 00:30:02	14	-856.4	15.3	110.1	-4,062.1	25.7	-42.1	AR 1429 (16, Beta-Gamma-Delta, 0)	3516	1
2012-03-07 00:32:02	15	-184.9	13.9	0.0	0.0			NaN	3517	1
2012-03-07 00:34:02	16	-979.4	15.1	151.8	-5,132.6	25.9	-42.2	AR 1429 (16, Beta-Gamma-Delta, 0)	3518	1
2012-03-07 00:36:02	17	-1,317.1	22.1	231.2	-6,985.5	25.5	-39.7	AR 1429 (14, Beta-Gamma-Delta, 0)	3519	1
2012-03-07 00:38:02	18	-1,430.0	31.9	259.0	-7,760.0	25.6	-39.3	AR 1429 (13, Beta-Gamma-Delta, 0)	3520	1
2012-03-07 00:40:02	19	-1,510.8	49.4	272.4	-8,296.7	25.6	-39.2	AR 1429 (13, Beta-Gamma-Delta, 0)	3521	1
2012-03-07 00:42:02	20	-1,560.1	45.1	276.1	-8,560.9	25.7	-39.0	AR 1429 (13, Beta-Gamma-Delta, 0)	3522	1
2012-03-07 00:44:02	21	-1,606.3	47.9	280.3	-8,727.4	25.9	-38.8	AR 1429 (13, Beta-Gamma-Delta, 0)	3523	1

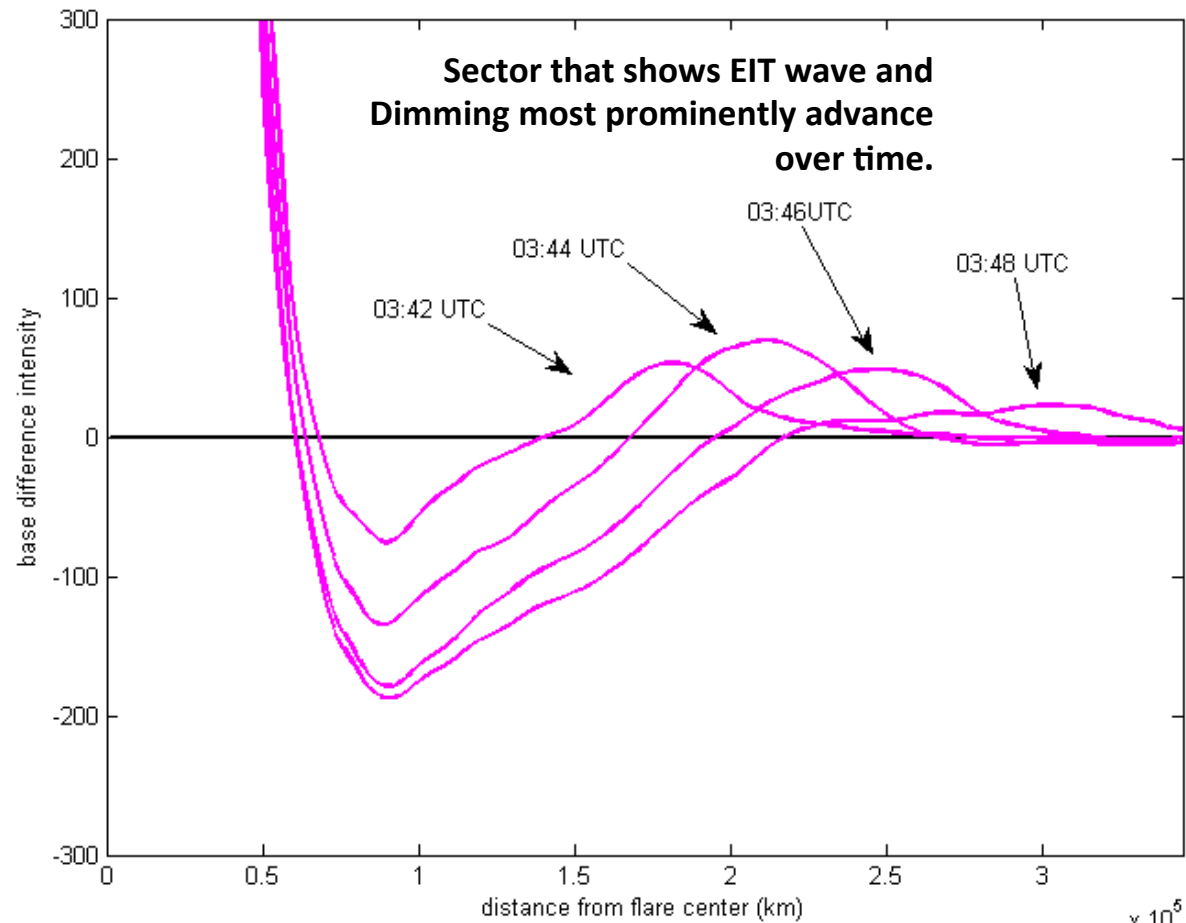
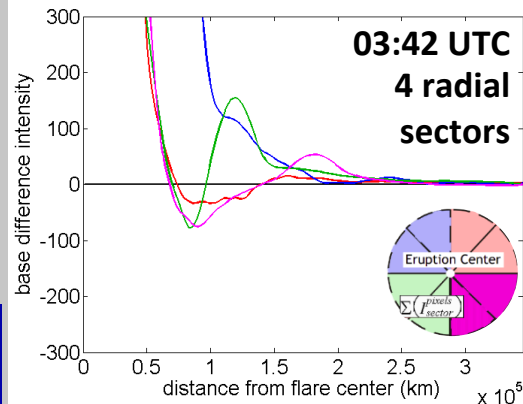
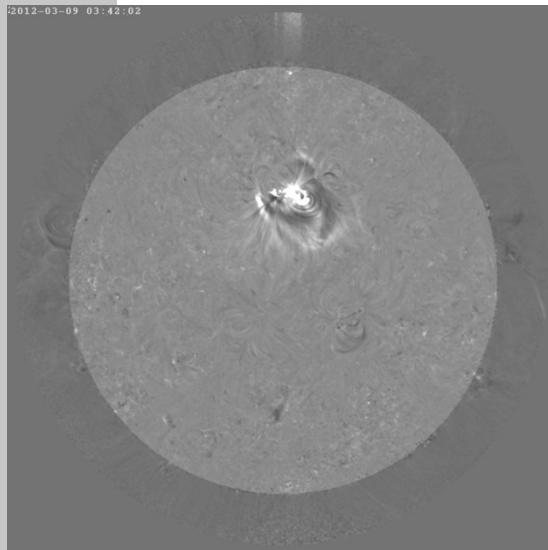






EUV wave plots

- Plot intensity from center outwards (March 9, 2012)





Spin-off: flare detection

- Detection operates on individual images
 - Thresholded images
 - Clustering of detections both in space and time
 - Flares very close by in time and spaces = one flare
- Detects
 - Brightness (sum of flare pixels DN)
 - Location
 - longitude, latitude, (distance to) associated active region
 - Duration





Future Work

- Automate EUV wave information extraction
 - Improve wave masks
 - Cross-correlation in radial vectors
 - Determine **speed**
 - (**Rotation?**)
- Reduce false alarms/misses
- Track dimming evolution longer
- Improve usability
 - searching/extracting information over longer time periods
 - annotations from (experienced) users
 - Both for false alarms and events that were missed
 - Improve system and usability!





Afternoon

- Solar DEMON demonstration
- Interesting events (e.g. February 6, 2013)
- Plenty of time to ask questions...
- and to give suggestions!
- Thanks!



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