solardemon.oma.be

Solar Demon

Detecting Flares, Dimmings and EUV waves on SDO/AIA images

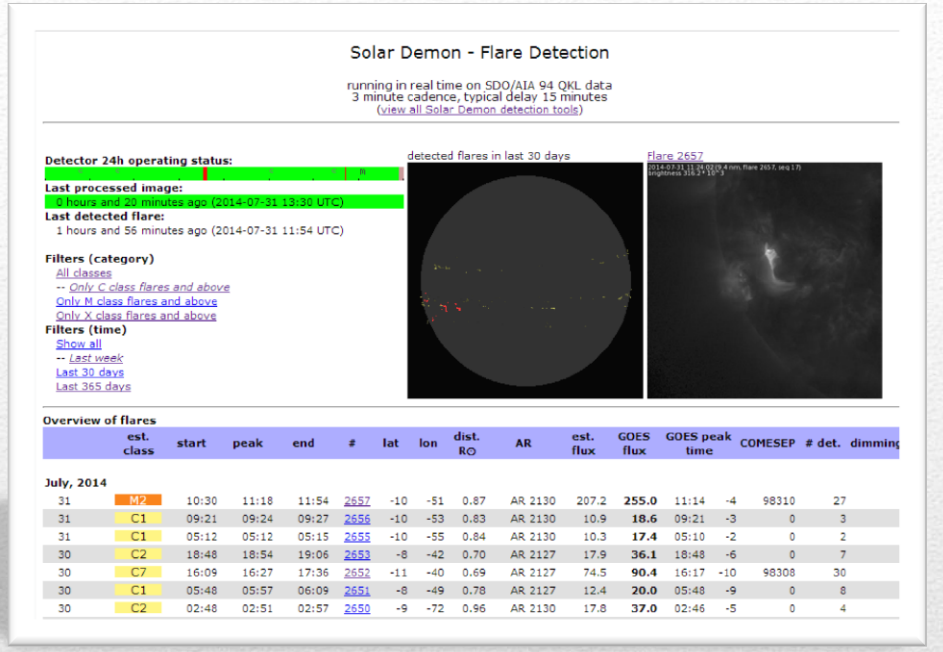
Dimming, Flare, and EUV wave Monitor

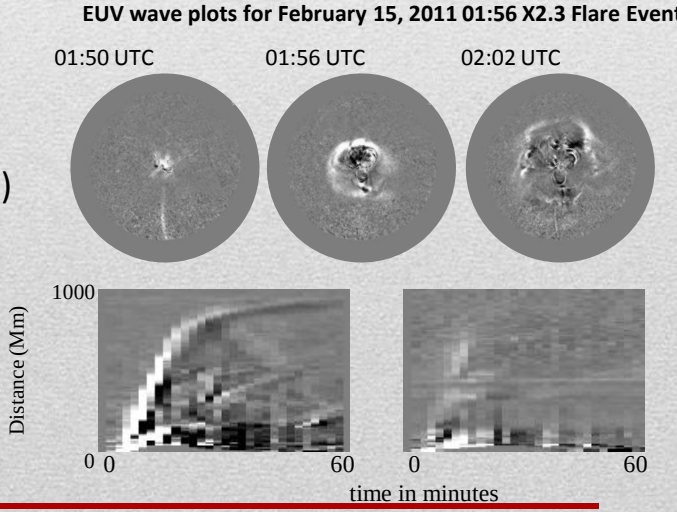
Emil Kraaikamp, Cis Verbeeck – Royal Observatory of Belgium

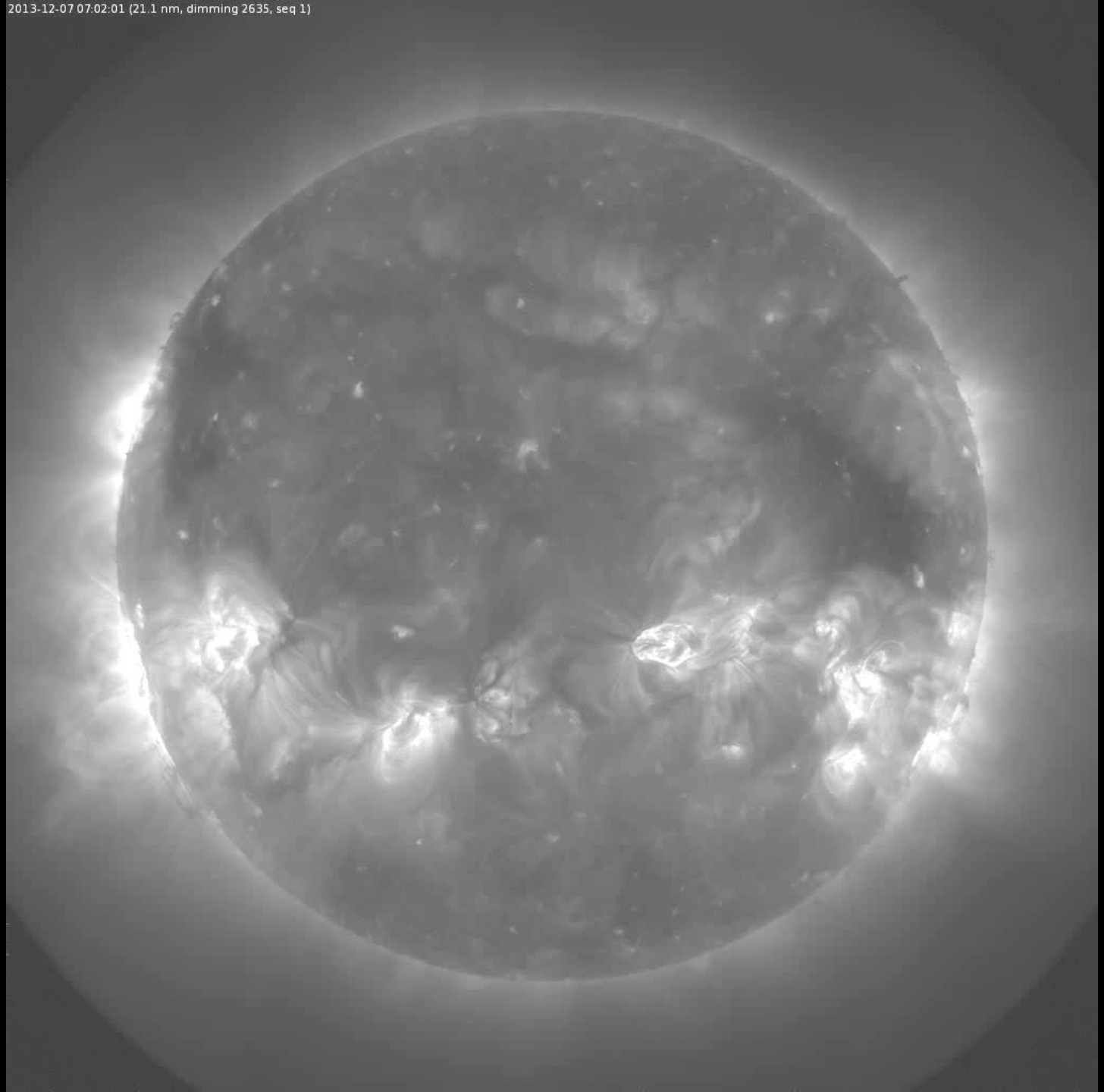
Seventh Solar Information Processing Workshop – August 20, 2014

Outline

- Objectives
- Solar Demon System
- Detection of
  - Flares
  - Dimmings (transient coronal holes)
  - EUV waves (EIT waves, large scale bright fronts)
- Future work






2013-12-07 07:02:01 (21.1 nm, dimming 2635, seq 1)

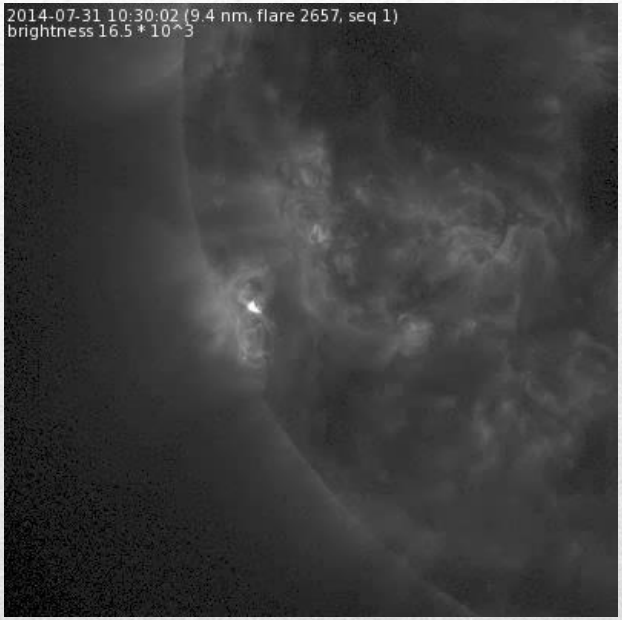

2013-12-07 07:02:01 (21.1 nm, dimming 2635, seq 1)
intensity 0.0 * 10^6

Objectives

Dimmings, Flares and EUV waves are closely related to CMEs

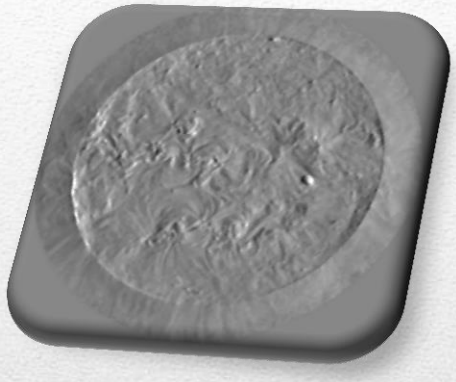
- Develop early warning system for earth-directed CMEs
  - Flares and dimmings detected typically within 20 minutes!
- Characterize flare, dimming and EUV wave events for research purposes
- Platform for future detectors
  - E.g. Filament eruption detector

Solar Demon System

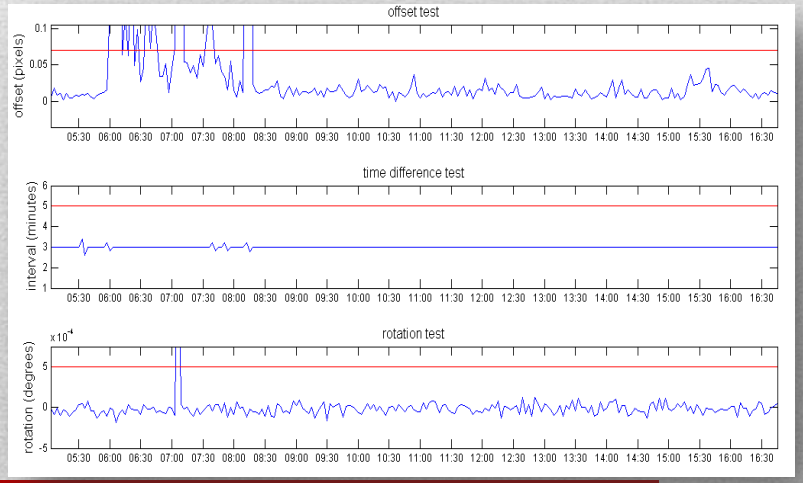


- **Automatic** detection of *flares*, *dimmings* and *EUV waves*
  - For Flares and Dimmings no human Intervention
  - Running in real-time
    - .. on *quick-look* data(SDO/AIA) – 15 minutes delay
  - And to create event catalogs
    - .. on *synoptic science* data (SDO/AIA) up to last week
  - EUV waves semi-automatic event characterization
- Modular approach
  - Input modules seeking new images online
    - for dimmings, flares, and waves, for both QLK and Synoptic
  - Detection modules working on the retrieved input
    - flare, dimming, EUV wave
  - Database used for storing events and communication between modules
  - Website shows events stored in database

Solar Demon System

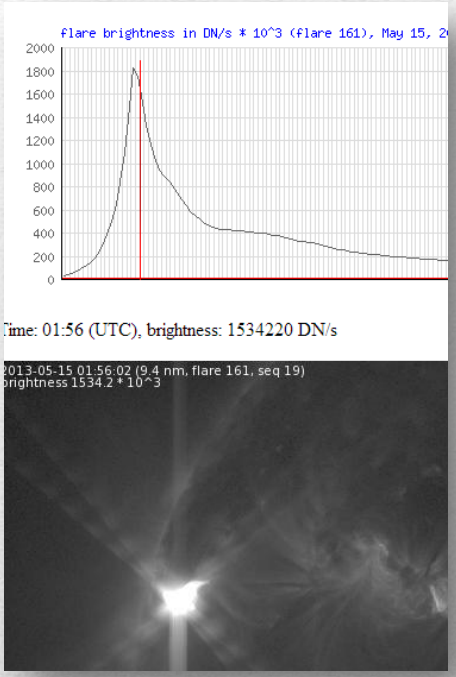


- One continuous run, no version of events
- Image tests to reduce false alarms
  - AIA quality keyword
    - This captures most events
  - Offset Sun position
  - SDO rotation
  - Time gaps
  - ..etc..
  - **Tests OK?**
    Only then process the images



Detecting Flares

…. ‘small’ regions on the sun that ‘suddenly’ gained quite a bit of intensity in for example 9.4 nm images



- Track (groups of) bright patches
  - On thresholded original images
  - Start at sudden brightness increase + over a threshold
  - Stop when they drop under threshold again
- Detects multiple flares occurring at the same time in separate locations
- No macro-pixels, accurate location
- Proxy for GOES flux
  - Flare class is estimated using the brightness of the flare
  - Also the original GOES 0.1-0.8nm flux is shown on the website

July, 2014																	
10	M2	22:32	22:36	22:52	6482	15	75	0.97	AR 2106	182.4	**155.0**	22:34	-2	98306	11		edge
8	M7	16:10	16:26	17:32	6470	10	-57	0.84		711.4	**652.0**	16:20	-6	98311	42	-584	wave
1	M1	11:08	11:42	12:56	6433	12	-58	0.84	AR 2106	116.3	**140.0**	11:22	-20	98316	55	-812	wave
June, 2014																	
14	M2	19:28	19:32	20:12	6367			1.02		170.9	**145.0**	19:29	-3	98306	23	-264	edge
13	M3	07:48	07:58	08:14	6346	-19	-39	0.69	AR 2087	348.2	**263.0**	07:56	-2	98307	14	-163	wave
12	M3	21:52	22:30	01:34	6339	-18	61	0.92	AR 2085	294.0	**315.0**	22:16	-14	98326	110	-607	wave
12	M2	10:18	10:24	11:12	6330	-19	-51	0.82	AR 2087	164.3	**274.0**	10:21	-3	98308	28	-211	wave
12	M3	09:34	09:40	09:54	6329	-18	48	0.78	AR 2085	333.1	**181.0**	09:37	-3	98307	11		wave
12	M1	04:18	04:24	04:52	6325	-18	-56	0.86	AR 2087	114.8	**208.0**	04:21	-3	98308	18	-174	wave
11	M2	20:56	21:06	21:30	6321	-19	-59	0.88	AR 2087	206.8	**392.0**	21:03	-3	98307	17	-71	wave
11	M4	09:04	09:08	09:42	6312	-18	-65	0.93	AR 2087	380.7	**1,000.0**	09:06	-2	98306	20	-100	wave
11	M1	08:04	08:12	09:02	6311	-18	-67	0.94	AR 2087	123.6	**302.0**	08:09	-3	98316	29	-31	wave
11	M2	05:32	05:36	05:44	6307	-11	35	0.60	AR 2080	186.2	**181.0**	05:34	-2	98306	7	-19	wave
10	X2	12:40	12:56	15:02	6300			1.02		1,986.0	**1,550.0**	12:52	-4	98311	72	-944	edge

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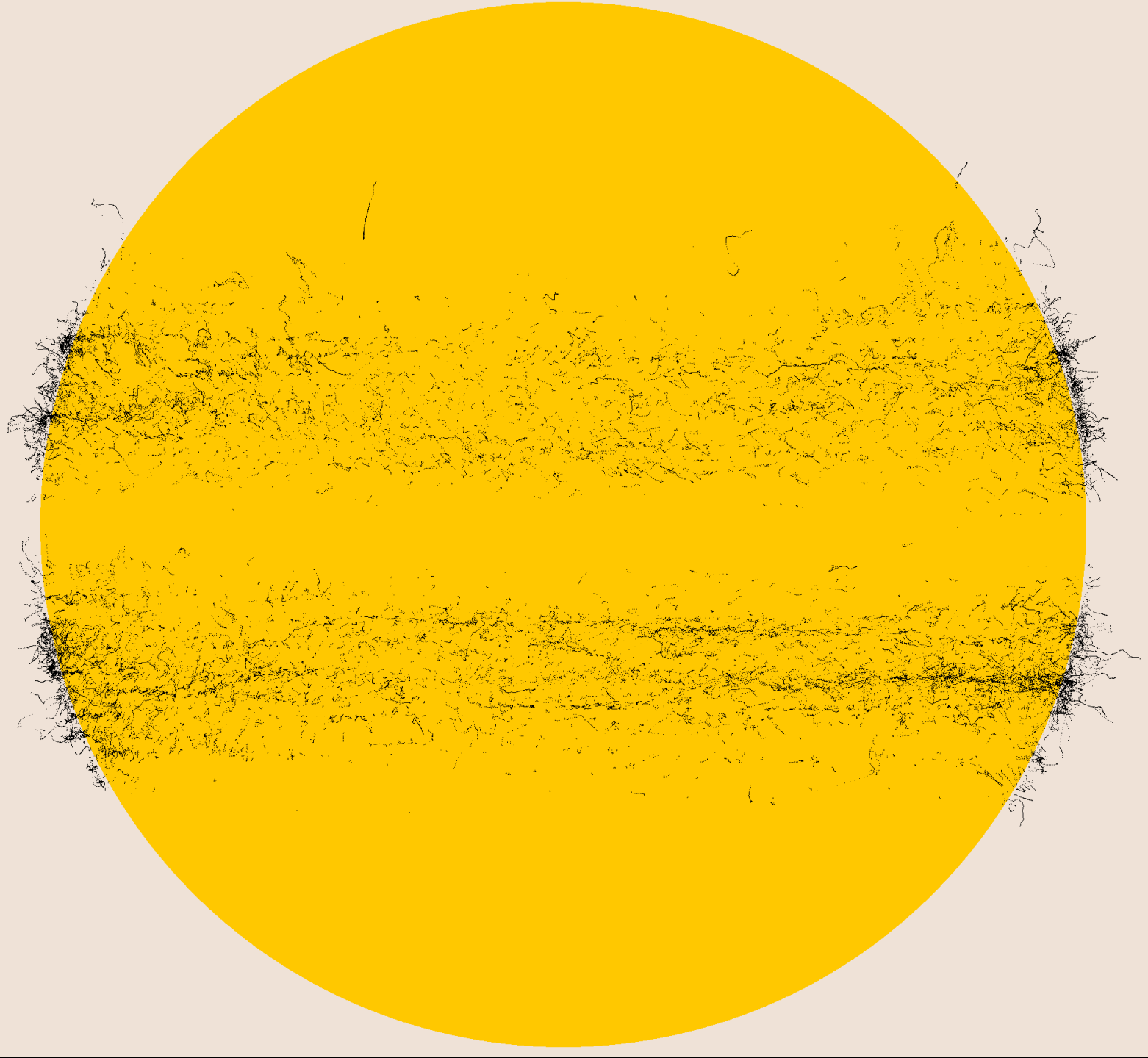
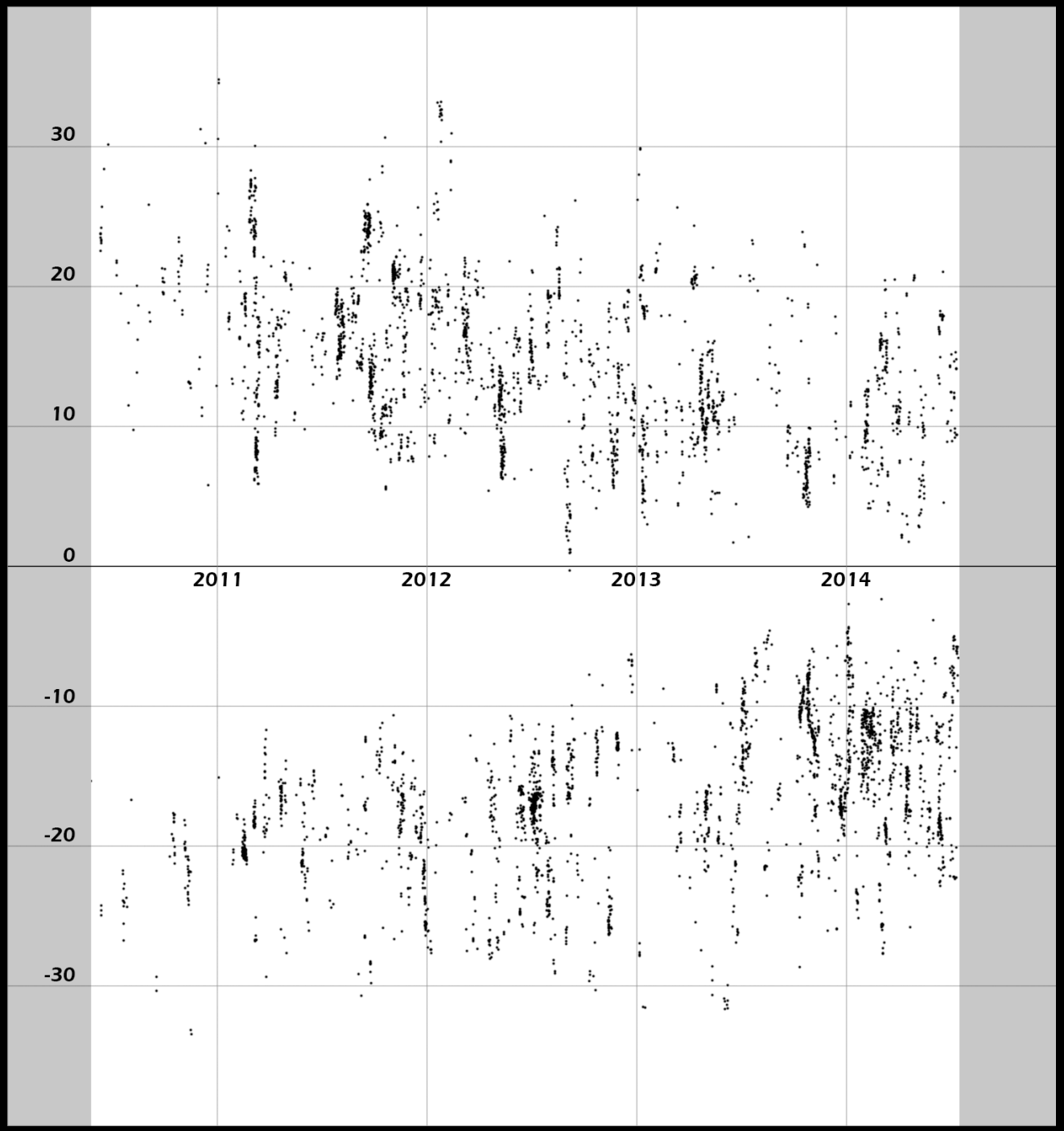


All flares detected by Solar Demon on synoptic science data.

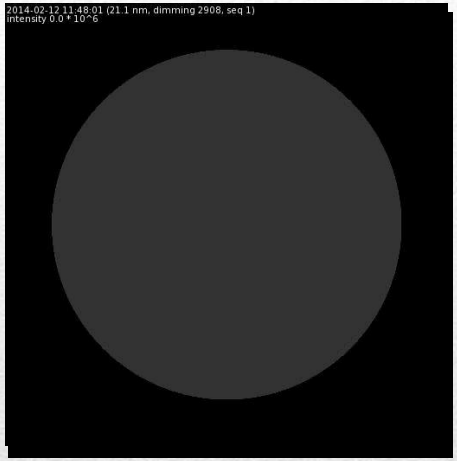
May 2010 up to June 2014



A ‘butterfly’ diagram generated from all flare detections since May 2010 up to June 2014

Detecting Dimmings

… 'large' regions on the sun that lost 'quite a bit of intensity' *(in 21.1nm)*



- Event detection on running difference images
  - Trigger on intensity drops on 6-minutes timescale
- Event characterization
  - Differential derotate and limb brightness correction
  - Create mask of regions that lost intensity (BD, pBD)
  - Track intensity changes and dimming size and shape during event
- Dimming masks become noisy over time
  - Difficult to track events accurately for a long amount of time

Solar Demon - Dimming Detection

running in real time on SDO/AIA 211 QLK data
3 minute cadence, typical delay 15 minutes
(view all Solar Demon detection tools)

Detector 24h operating status:

Last processed image:
0 hours and 16 minutes ago (2014-07-31 10:24 UTC)

Last detected dimming:
12 hours and 28 minutes ago (2014-07-30 22:12 UTC)

Filters (location)
-- *All locations*
On-disc
Off-disc

Filters (intensity)
-- *All intensities*
At least -100K
At least -300K
At least -900K

Filters (time)
Show all
-- *Last week*
Last 30 days
Last 365 days

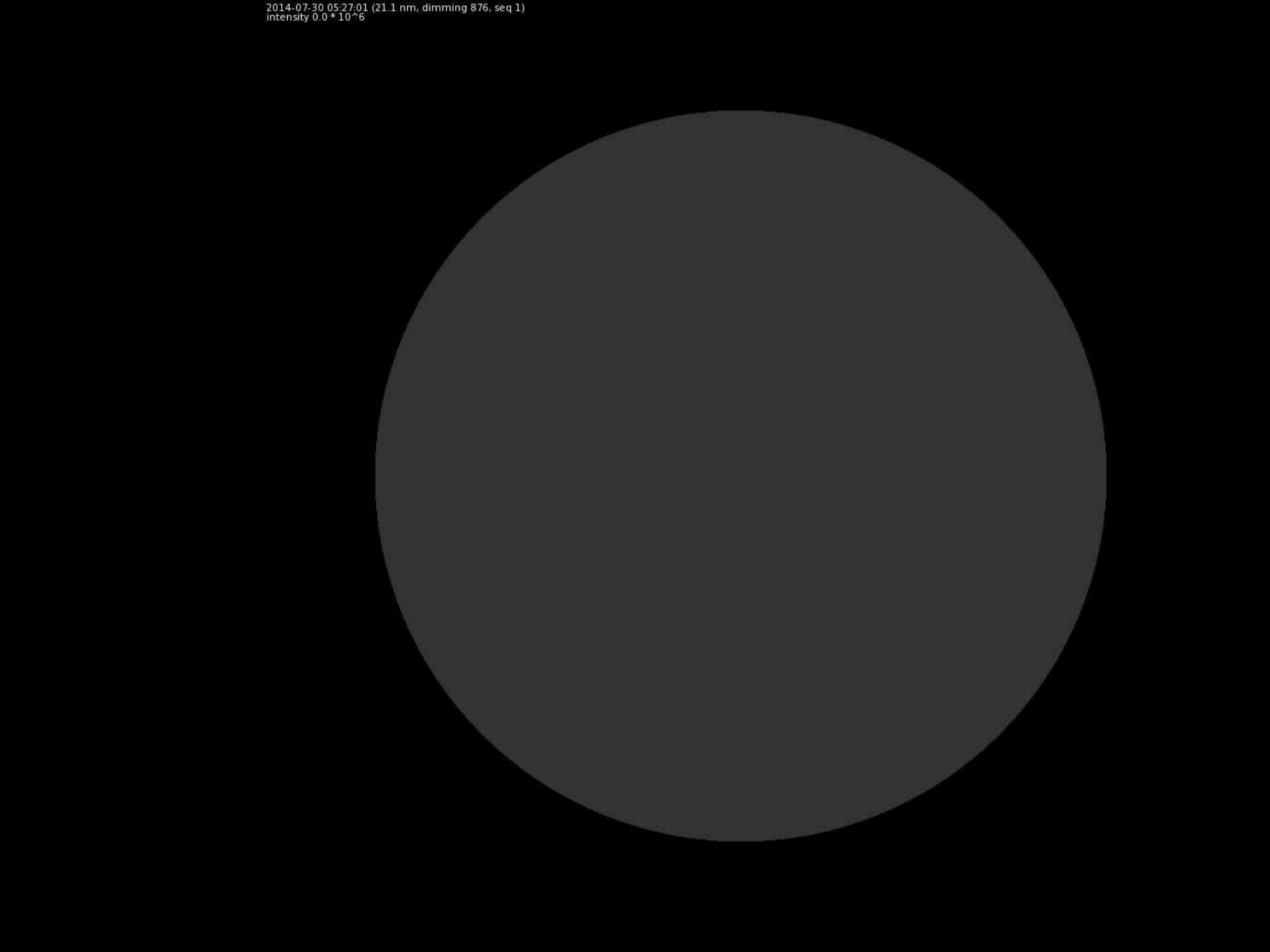
Dimming 881

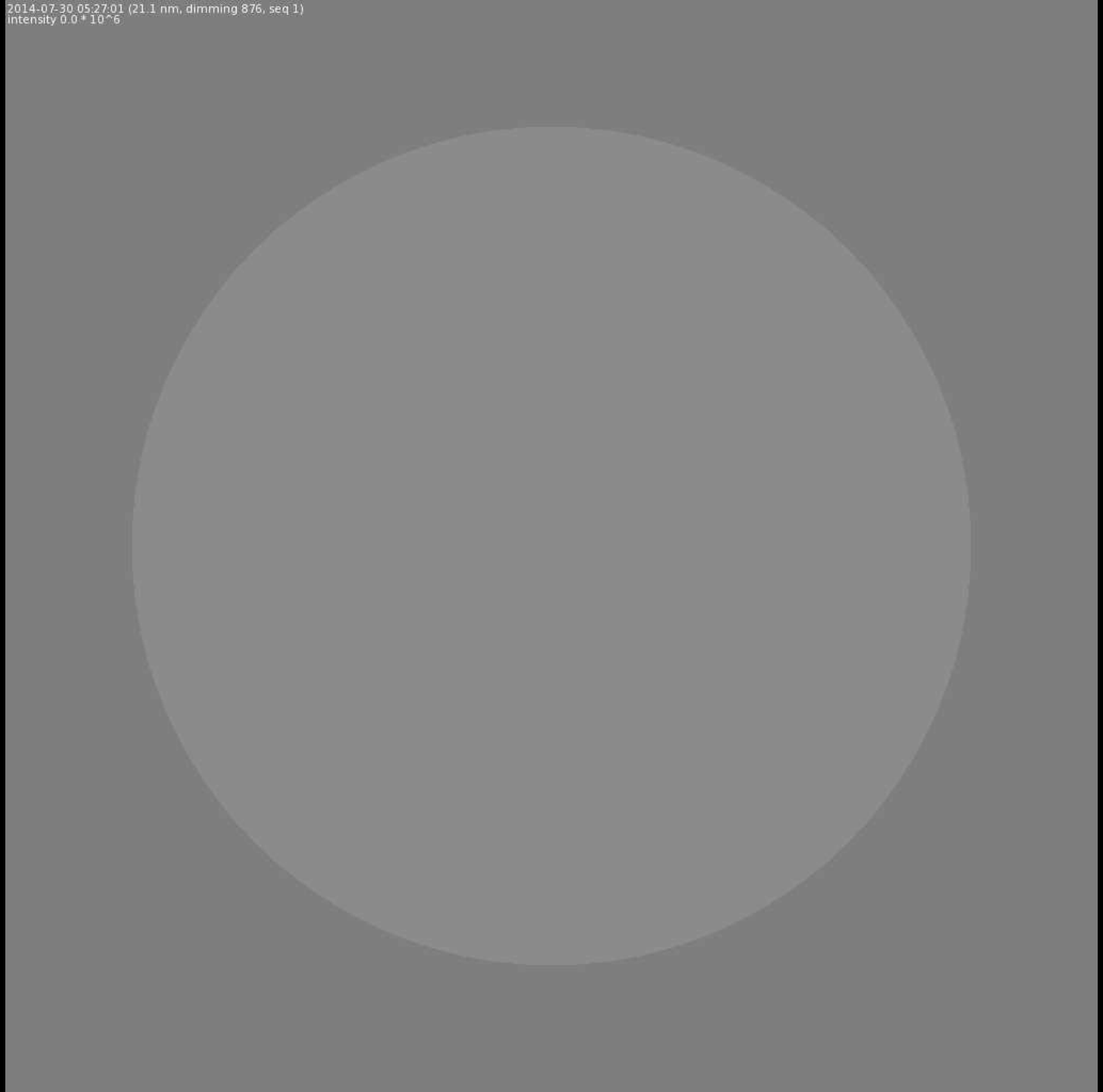
Overview of dimmings

	intensity	start	peak	end	#	max drop	lat	lon	dist. R⊙	AR	count	flare
July, 2014												
30	-82	21:30	21:36	22:12	881	80	16	30	0.53	AR 2121	20	
30	-217	17:42	18:18	18:57	880	104			1.05		31	
30	-5	16:21	16:21	16:48	879	5	-14	-47	0.78	AR 2131	13	C7
30	-54	12:24	12:24	12:48	878	23	15	-31	0.54	AR 2127	14	
30	-47	10:36	10:36	11:03	877	34	11	-30	0.50	AR 2127	15	
30	-921	05:42	07:09	07:48	876	[illegible]	15	-25	0.44	AR 2125	48	
30	-21	00:48	00:48	01:12	875	21			[illegible]		14	
29	-148	10:30	10:51	11:33	874	93	20	4	0.25	AR 2121	[illegible]	
29	-16	08:00	08:00	08:24	873	24				AR 2129	14	
28	-85	03:15	03:18	03:48	872	105	11	-55	0.82	AR 2125	17	
26	-98	19:24	19:27	20:00	871	41			1.15		18	
25	-55	07:15	07:18	07:42	870	71	13	-36	0.60	AR 2121	15	C2

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement nr. 263506 [AFFEC
263252 [COMESEP]
Solar Demon is still under construction.


2014-07-30 05:27:01 (21.1 nm, dimming 876, seq 1)
intensity 0.0 * 10^6


2014-07-30 05:27:01 (21.1 nm, dimming 876, seq 1)
intensity 0.0 * 10^6


2014-07-30 05:27:01 (21.1 nm, dimming 876, seq 1)
intensity 0.0 * 10^6

Solar Demon - Dimming Detection

running in real time on SDO/AIA 211 QLK data
3 minute cadence, typical delay 15 minutes
(view all Solar Demon detection tools)

Overview of dimming 876

Detector 24h operating status:

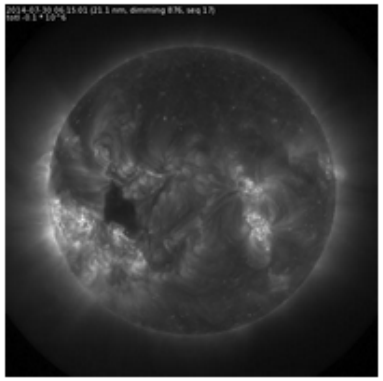
Last processed image:
0 hours and 17 minutes ago (2014-07-31 11:42 UTC)

Last detected dimming:
0 hours and 17 minutes ago (2014-07-31 11:42 UTC)

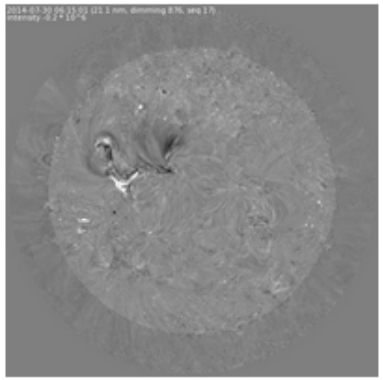
Overview for dimming #:
876 back to overview

Animations and graphs
derotated original images (non-derotated)
dimming intensity (overlaid on HMI)
dimming mask

base difference (percentage)
running difference (percentage)



more

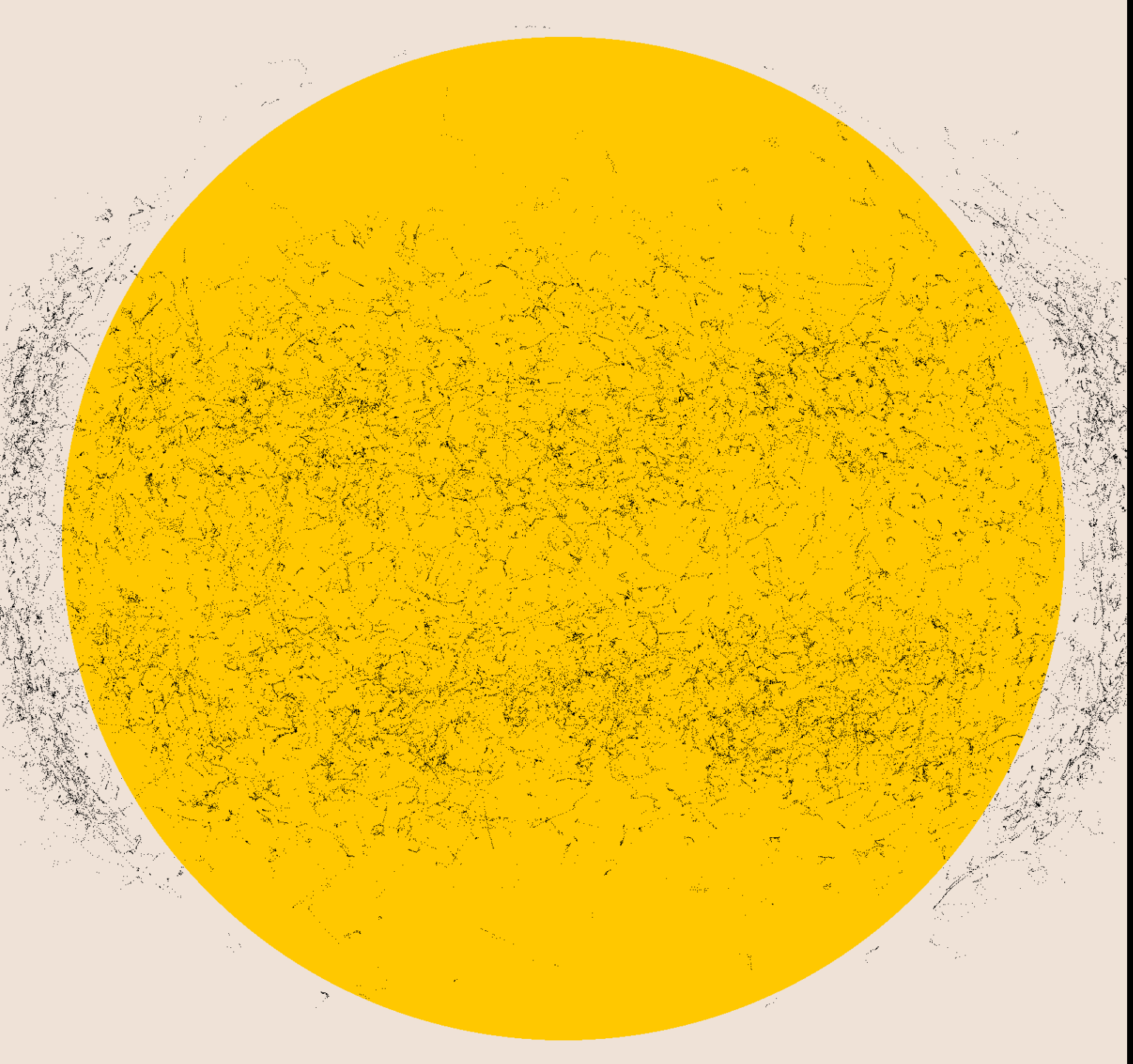


more

more

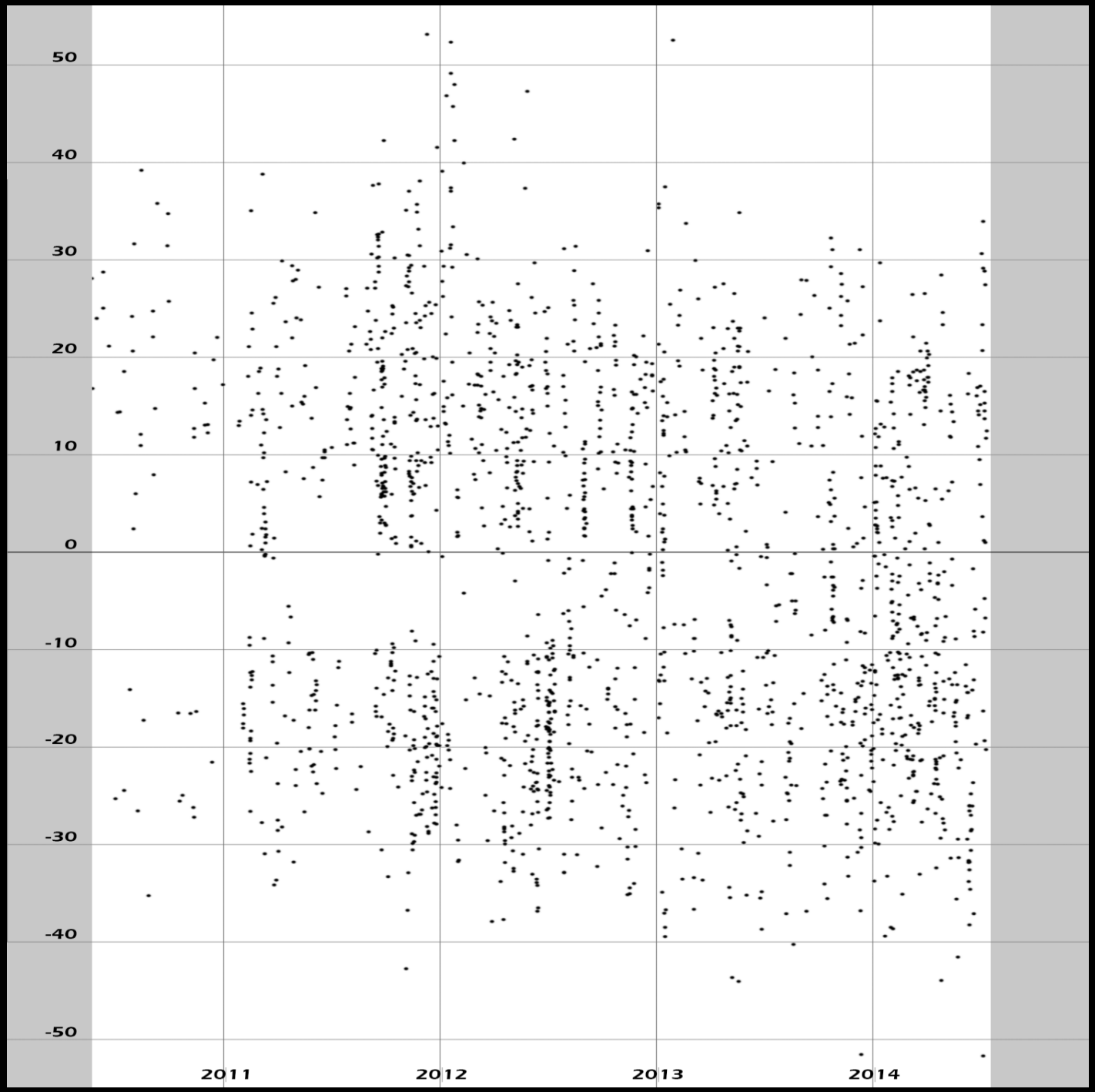
Details for dimming #: 876

time	seq #	total intensity	max intensity	median intensity	area	size	lat	lon	x,y in R⊙	dist. R⊙	detection
2014-07-30 05:27:01	1	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:30:01	2	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:33:13	3	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:36:01	4	-5.0	-16.0	-17.3	0.9	260			,		0.00
2014-07-30 05:39:01	5	-15.8	-21.2	-17.7	2.6	772	13.8	-10.0	-0.17, 0.14	0.22	0.00
2014-07-30 05:42:01	6	-26.2	-33.0	-16.0	4.4	1306	14.8	-10.1	-0.17, 0.16	0.24	2.03
2014-07-30 05:45:01	7	-38.2	-40.0	-16.4	6.4	1905	14.8	-12.2	-0.21, 0.16	0.26	1.78
2014-07-30 05:48:01	8	-49.3	-39.8	-15.5	8.9	2620	16.8	-10.8	-0.18, 0.20	0.27	0.00
2014-07-30 05:51:01	9	-64.1	-63.5	-15.1	11.2	3304	17.0	-10.2	-0.17, 0.20	0.26	0.00
2014-07-30 05:54:01	10	-79.8	-78.6	-15.2	13.6	3982	16.8	-10.6	-0.18, 0.20	0.27	2.50
2014-07-30 05:57:01	11	-92.6	-82.3	-15.2	15.5	4537	16.6	-11.9	-0.20, 0.19	0.28	2.03
2014-07-30 06:00:01	12	-101.1	-87.9	-15.0	16.9	4960	16.7	-11.8	-0.20, 0.20	0.28	1.66
2014-07-30 06:03:01	13	-112.0	-91.2	-15.2	18.4	5369	16.3	-13.1	-0.22, 0.19	0.29	0.91
2014-07-30 06:06:01	14	-120.9	-94.1	-14.9	20.0	5837	16.3	-13.3	-0.22, 0.19	0.29	0.91
2014-07-30 06:09:01	15	-127.2	-100.2	-14.7	21.3	6222	16.7	-13.1	-0.22, 0.20	0.30	0.92
2014-07-30 06:12:01	16	-142.5	-103.1	-14.9	23.5	6858	16.4	-14.2	-0.24, 0.19	0.31	1.36



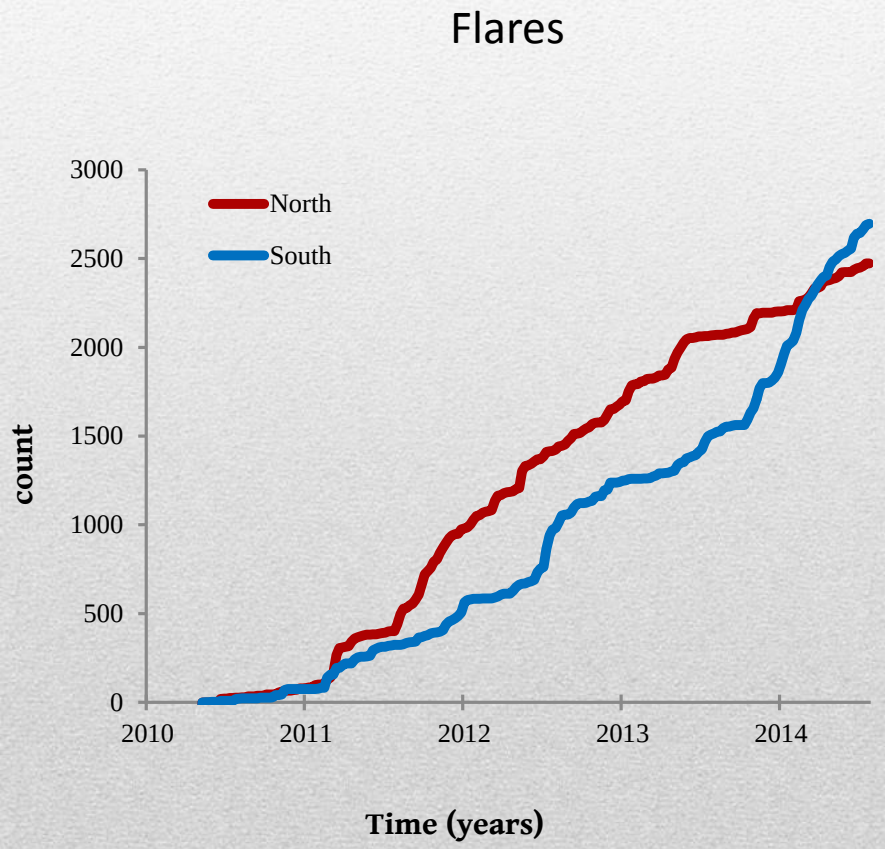
All dimmings detected by Solar Demon on synoptic science data.

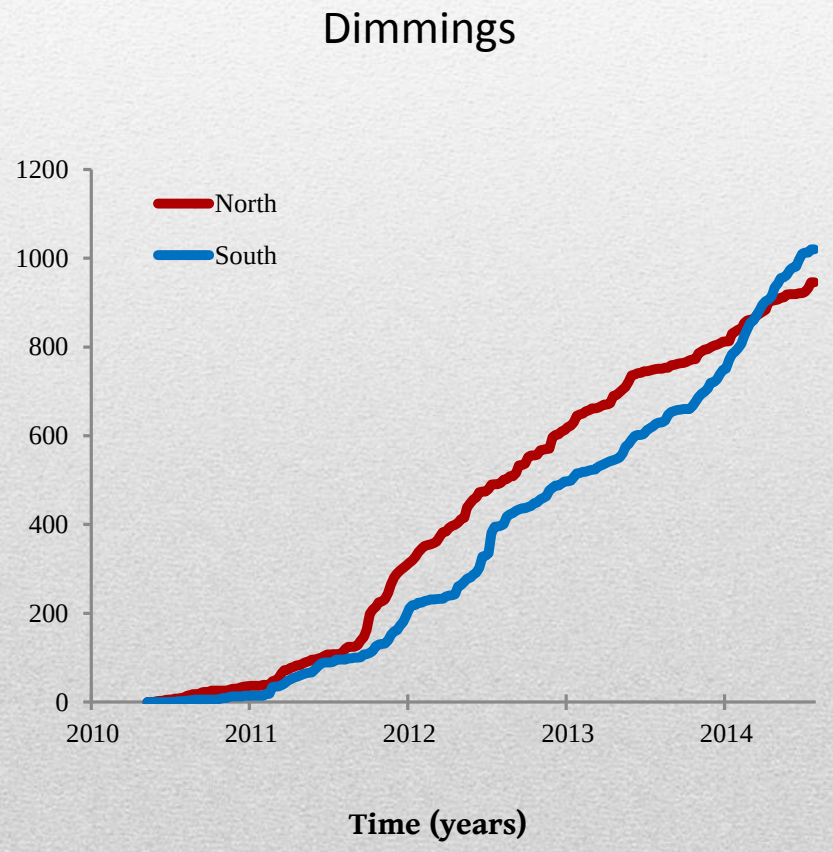
May 2010 up to June 2014



A ‘butterfly’ diagram generated from all dimming detections since May 2010 up to June 2014

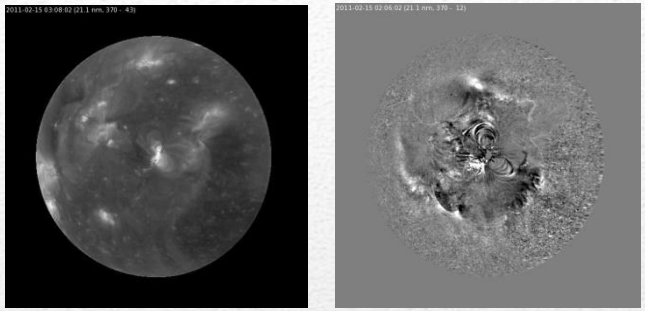
total number of detected events

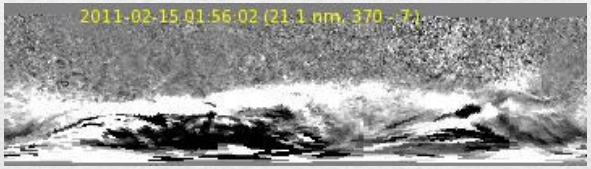


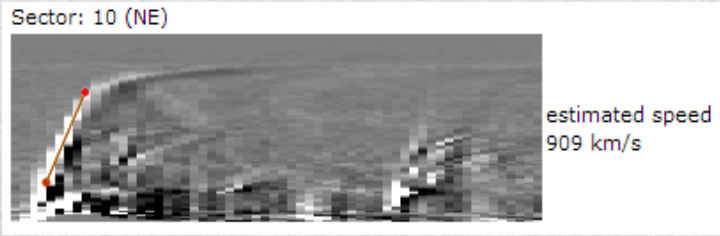


Detecting EUV waves

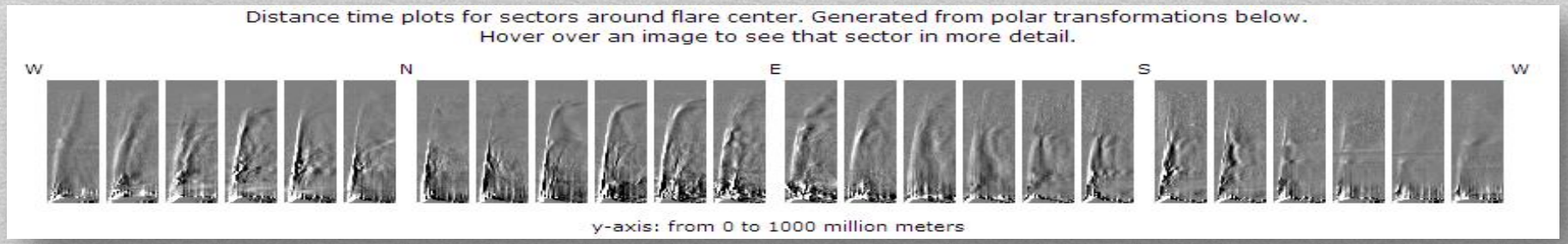
… detect and characterize a bright wave front moving radially outwards from some eruption center in 21.1nm







- Difficult to detect on their own
  - Mostly dim and noisy features, even in difference images
- Detection based on flares
  - Not every flare has an EUV wave, but most EUV waves are triggered by flares (Biesecker et al. 2002)
- Only on-disc events
  - Generate polar transformed running difference images
  - Centered on flare/EUV wave center
- Track EUV wave over 1000 Mm for at least 1 hour
- Distance-time plots to detect EUV waves

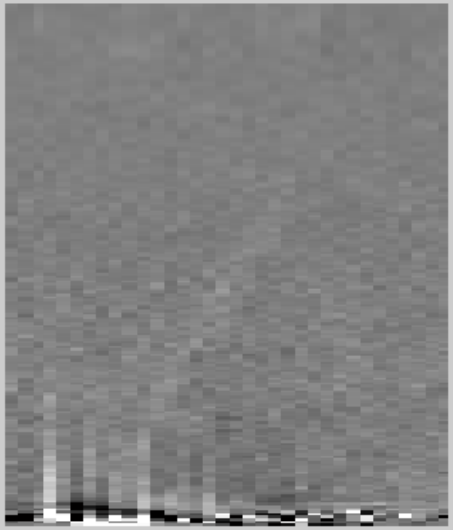


Automatic EUV wave detection

... detecting 'bright lines' in distance time plots.

- For several *distance regions* in the DT plots, search for 'straight lines'
  - The first region mostly contains flare artifacts, so ignore that
  - Hough transform
  - Detect brightest patch, and determine barycenter
    - So we get a speed, location, and intensity
  - The angles found correspond to speeds
  - Speed estimates for multiple locations
    - acceleration

- However, often there are still artifacts visible that get in the way of automatic detection methods....



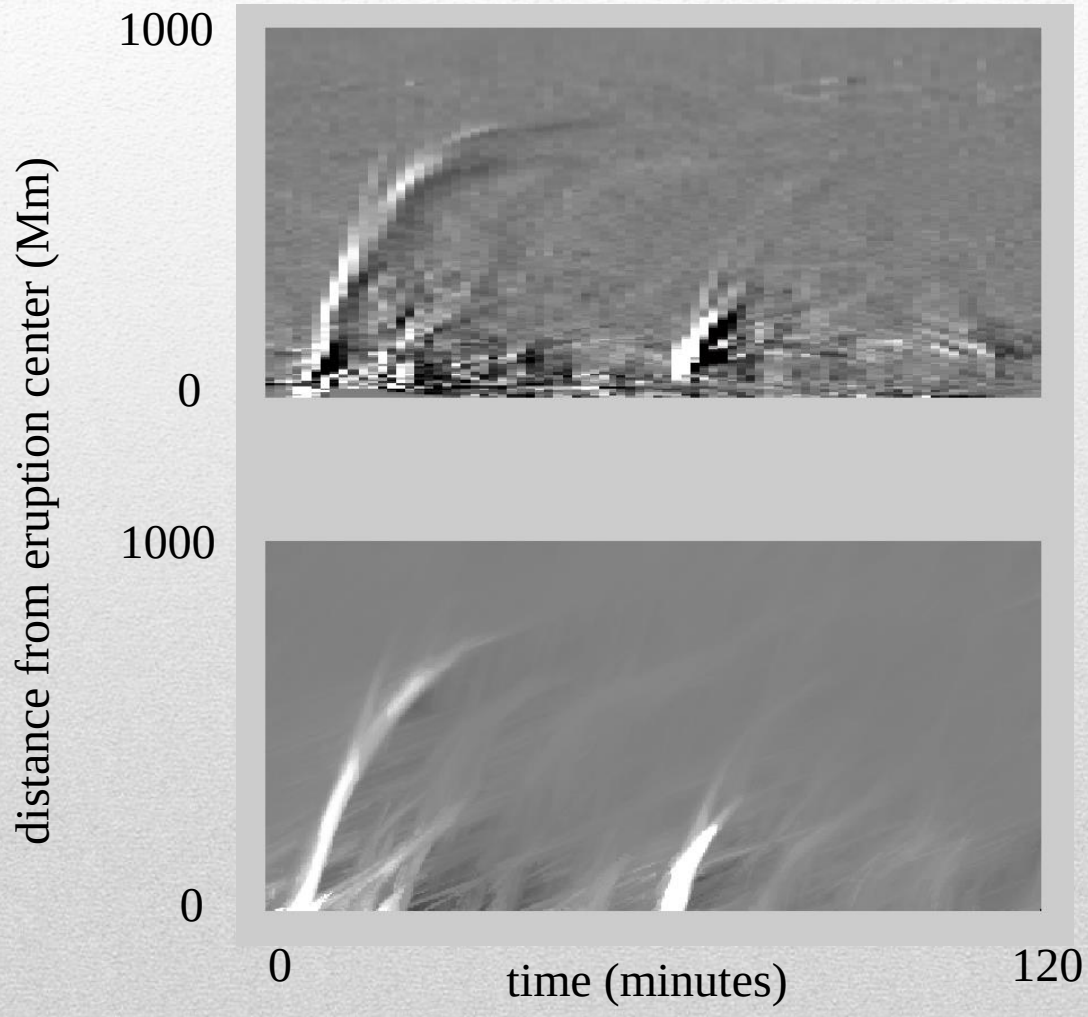
vertical spikes in DT plots corresponding to artifacts making it difficult to detect the faint EUV wave (diagonal line)

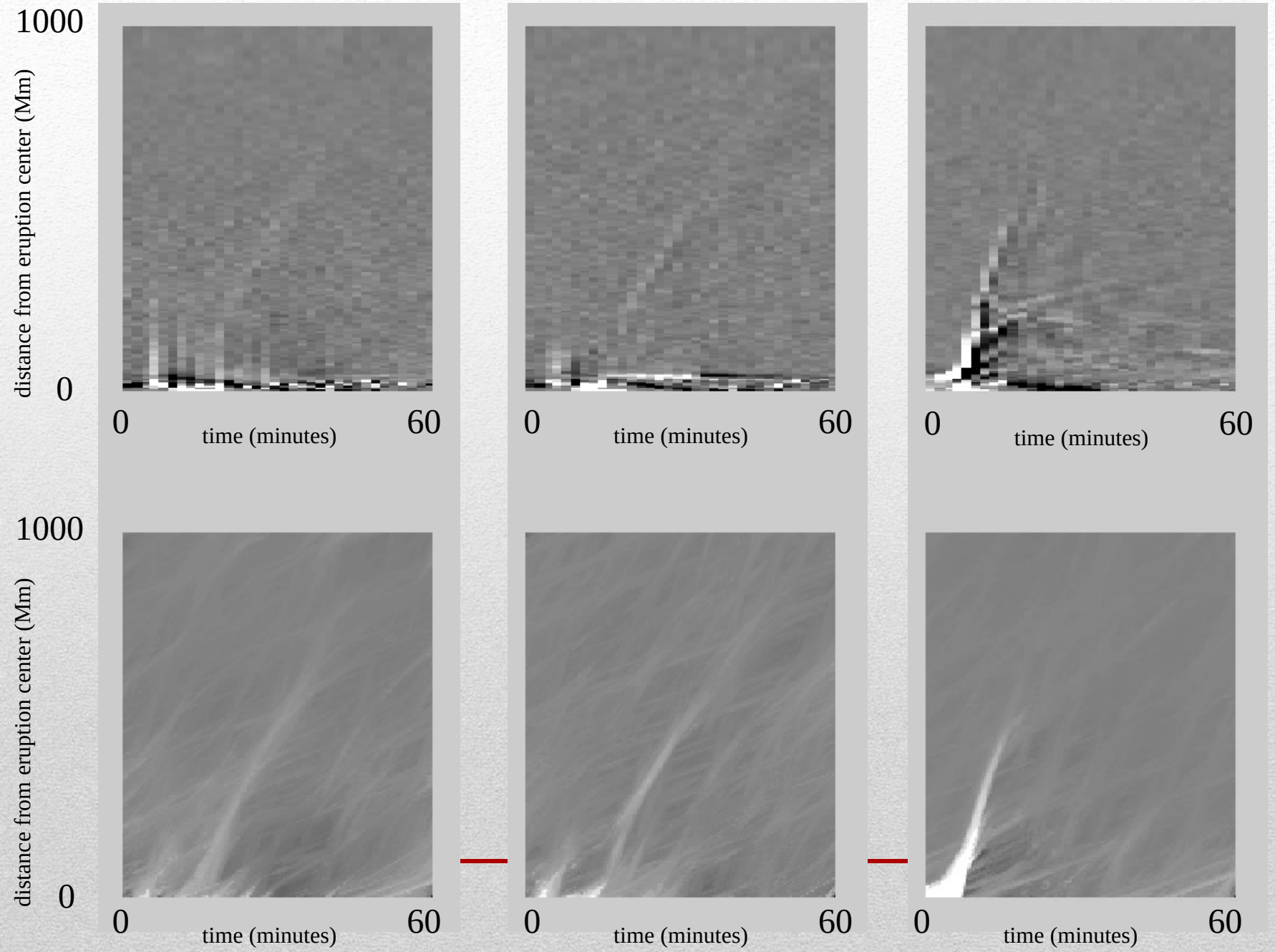
Line filtering DT plots

- Only keep line segments of a certain *length* and within a certain *angle* range
- This allows you to get rid of small unrelated features/artifacts, only keeping curves

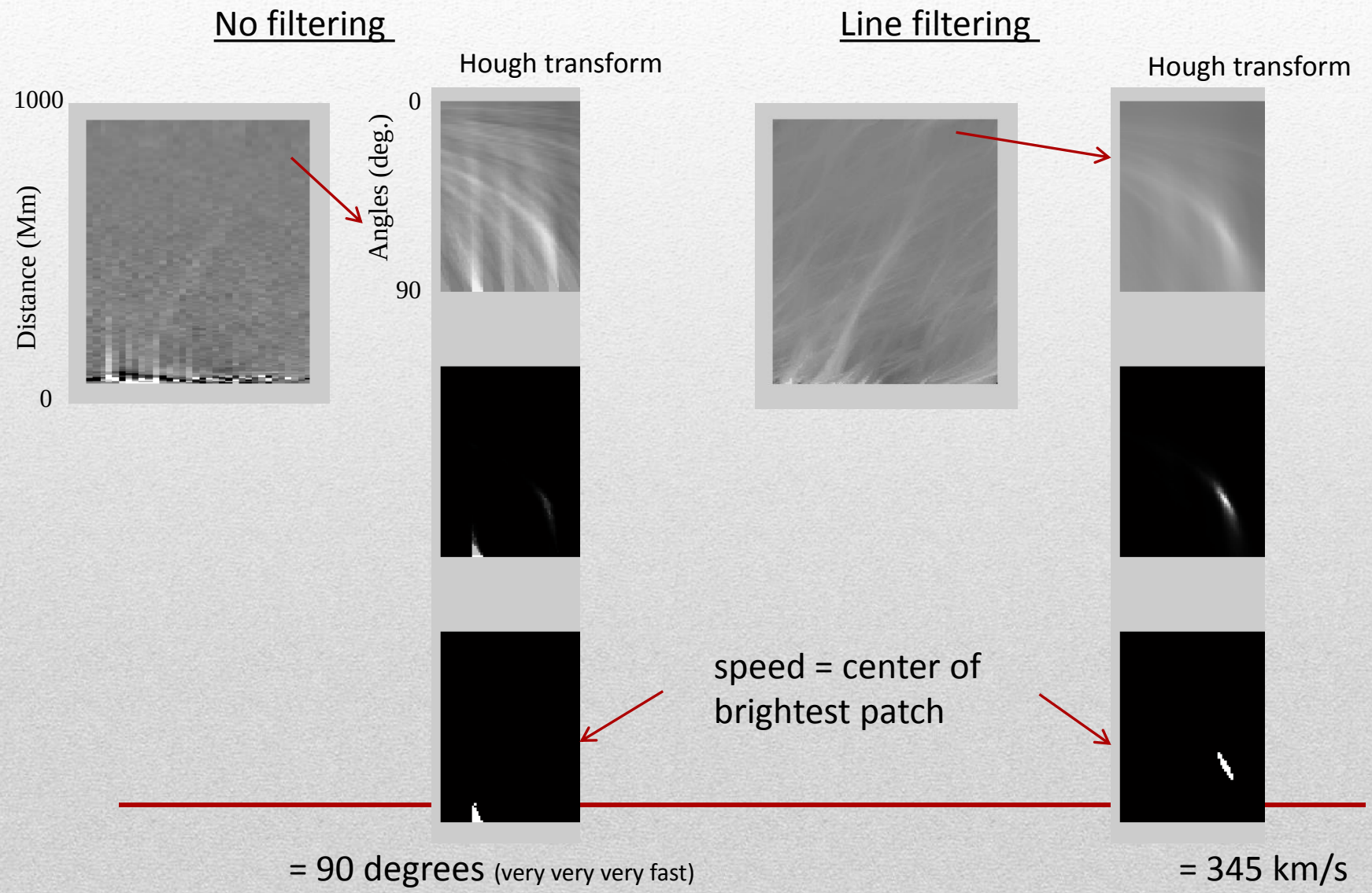
```
create new image all_filtered_angles

for every angle of lines you want to keep
   create new image filtered_angle
   for every pixel in the original image
      take the median value of the line segment (angle + length)
      ..and place this in filtered_angle
   end
   all_filtered_angles = max( all_filtered_angles, filtered_angle )
end
```

Line filtering DT plots



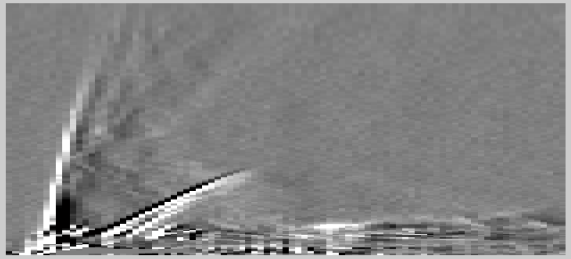

1000
distance from eruption center (Mm)
0
0
time (minutes)
60
0
time (minutes)
60
0
time (minutes)
60
1000
distance from eruption center (Mm)
0
0
time (minutes)
60
0
time (minutes)
60
0
time (minutes)
60

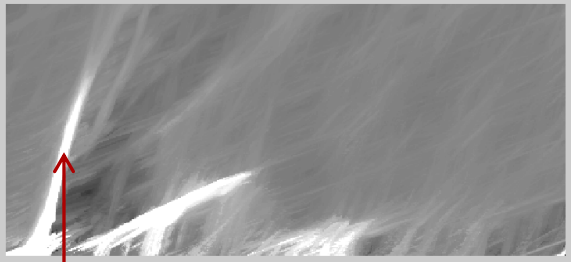
Line-filtering then hough transform...

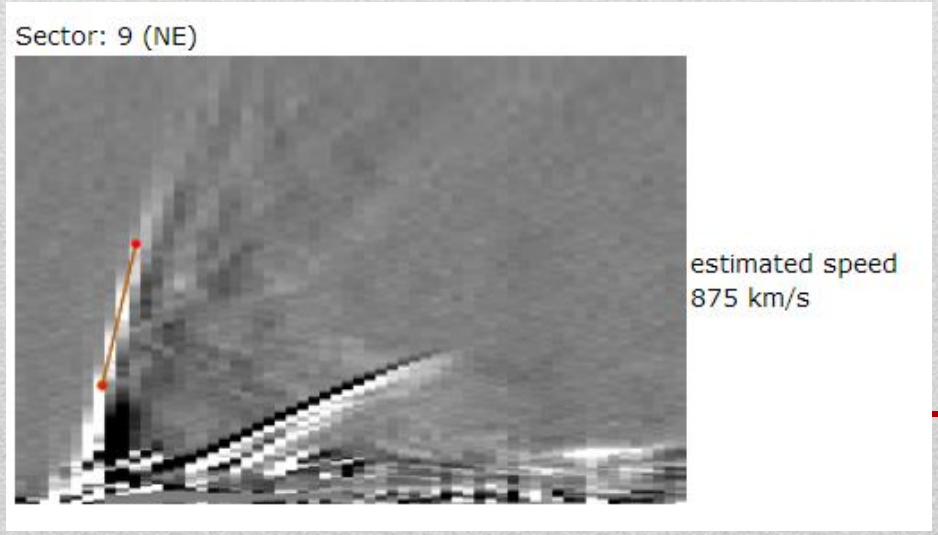


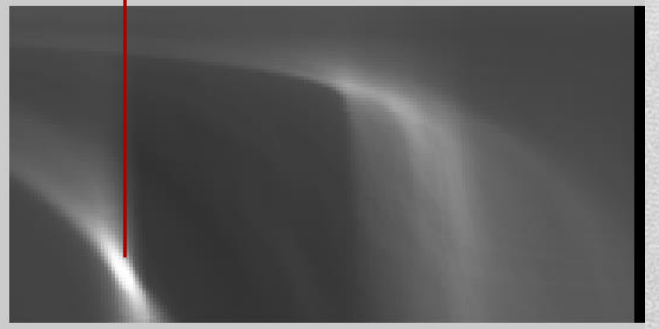
2011-08-04 03:46 - 04:00 - 06:36 (start - peak - end in UTC)

125 - 375 Mm	923 km/s	13.2 min	(19.3)
150 - 400 Mm	930 km/s	13.7 min	(19.1)
175 - 425 Mm	942 km/s	14.2 min	(18.9)
200 - 450 Mm	911 km/s	14.6 min	(18.6)
225 - 475 Mm	918 km/s	15.1 min	(18.3)
250 - 500 Mm	924 km/s	15.7 min	(17.9)
275 - 525 Mm	909 km/s	16.1 min	(17.5)
300 - 550 Mm	**875 km/s**	**16.6 min**	**(17.1)**
325 - 575 Mm	868 km/s	17.1 min	(16.7)
350 - 600 Mm	847 km/s	17.6 min	(16.2)
375 - 625 Mm	815 km/s	18.1 min	(15.8)
400 - 650 Mm	796 km/s	18.6 min	(15.3)
425 - 675 Mm	782 km/s	19.1 min	(14.9)
450 - 700 Mm	756 km/s	19.7 min	(14.5)
475 - 725 Mm	703 km/s	20.1 min	(14.1)
500 - 750 Mm	670 km/s	20.7 min	(13.6)



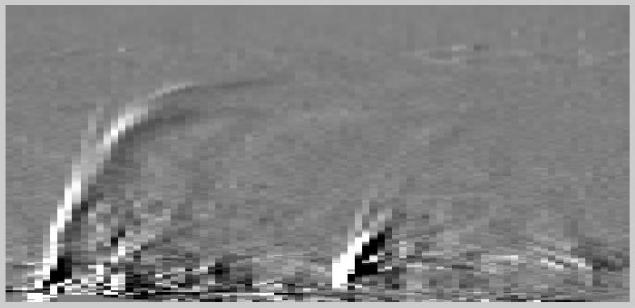


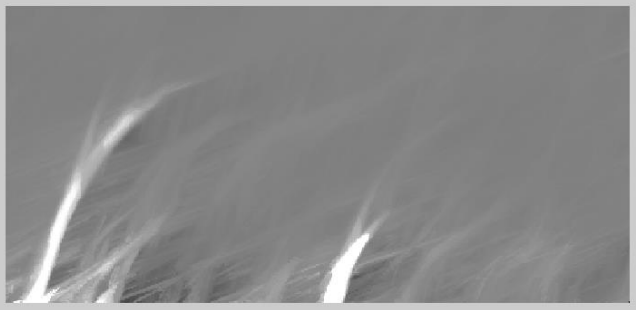


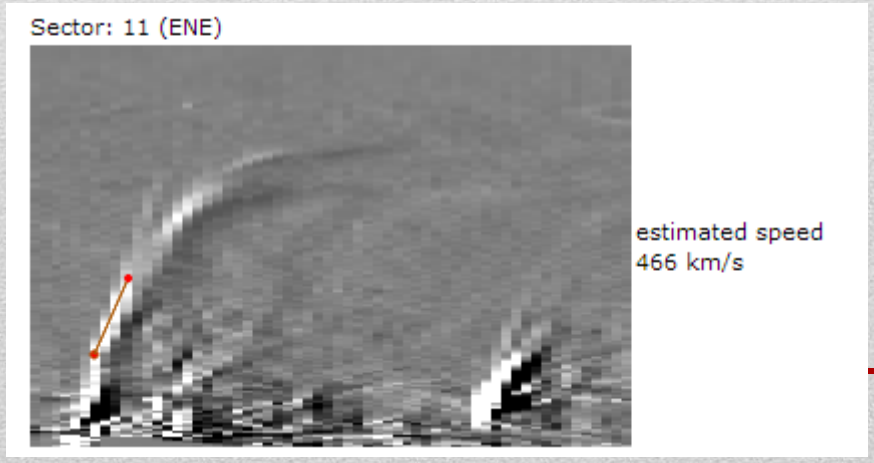


2011-02-15 01:48 - 02:02 - 04:28 (start - peak - end in UTC)

125 - 375 Mm	651 km/s	11.3 min	(18.7)
150 - 400 Mm	620 km/s	11.9 min	(18.6)
175 - 425 Mm	589 km/s	12.4 min	(18.3)
200 - 450 Mm	565 km/s	13.0 min	(17.9)
225 - 475 Mm	552 km/s	13.7 min	(17.5)
250 - 500 Mm	527 km/s	14.4 min	(16.9)
275 - 525 Mm	**494 km/s**	**15.0 min**	**(16.4)**
300 - 550 Mm	446 km/s	15.7 min	(15.8)
325 - 575 Mm	347 km/s	16.2 min	(13.0)
350 - 600 Mm	311 km/s	17.0 min	(15.0)
375 - 625 Mm	284 km/s	17.8 min	(14.9)
400 - 650 Mm	266 km/s	18.7 min	(14.7)
425 - 675 Mm	258 km/s	20.1 min	(14.4)
450 - 700 Mm	250 km/s	21.5 min	(14.1)
475 - 725 Mm	247 km/s	23.1 min	(13.9)
500 - 750 Mm	242 km/s	24.8 min	(13.5)

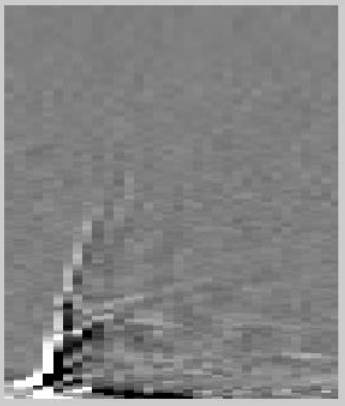


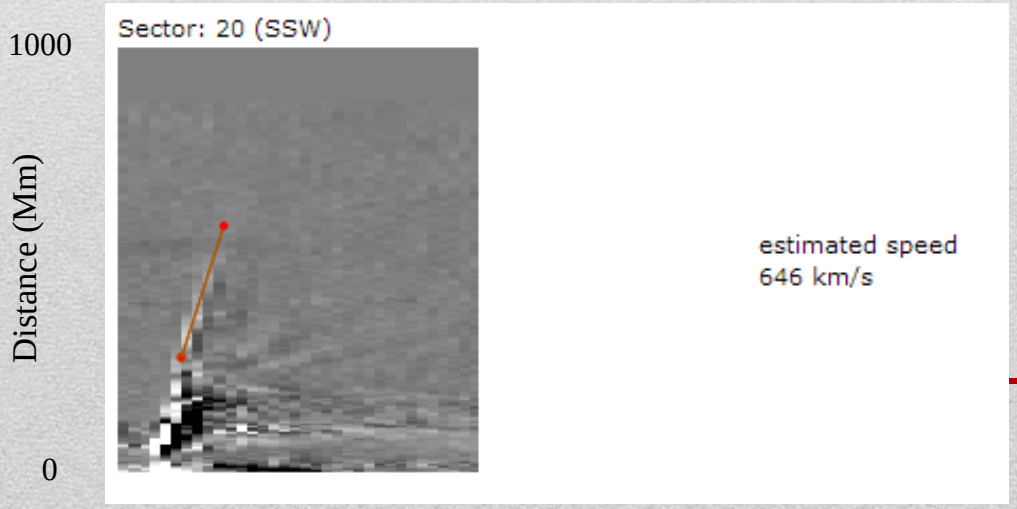




2011-03-12 04:36 - 04:44 - 04:56 (start - peak - end in UTC)

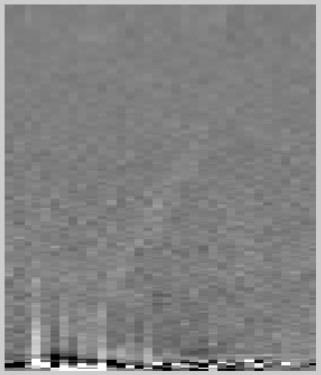
125 - 375 Mm	822 km/s 9.7 min	(5.5)
150 - 400 Mm	801 km/s 10.1 min	(5.3)
175 - 425 Mm	775 km/s 10.7 min	(5.2)
200 - 450 Mm	725 km/s 11.1 min	(5.1)
225 - 475 Mm	698 km/s 11.6 min	(4.9)
250 - 500 Mm	**659 km/s 12.1 min**	**(4.8)**
275 - 525 Mm	640 km/s 12.7 min	(4.7)
300 - 550 Mm	601 km/s 13.3 min	(4.6)
325 - 575 Mm	595 km/s 14.0 min	(4.5)
350 - 600 Mm	610 km/s 14.8 min	(4.1)
375 - 625 Mm	657 km/s 15.6 min	(3.8)
400 - 650 Mm	720 km/s 16.4 min	(3.8)
425 - 675 Mm	810 km/s 17.3 min	(4.2)
450 - 700 Mm	865 km/s 18.1 min	(4.1)
475 - 725 Mm	774 km/s 18.4 min	(4.1)
500 - 750 Mm	603 km/s 18.6 min	(4.5)

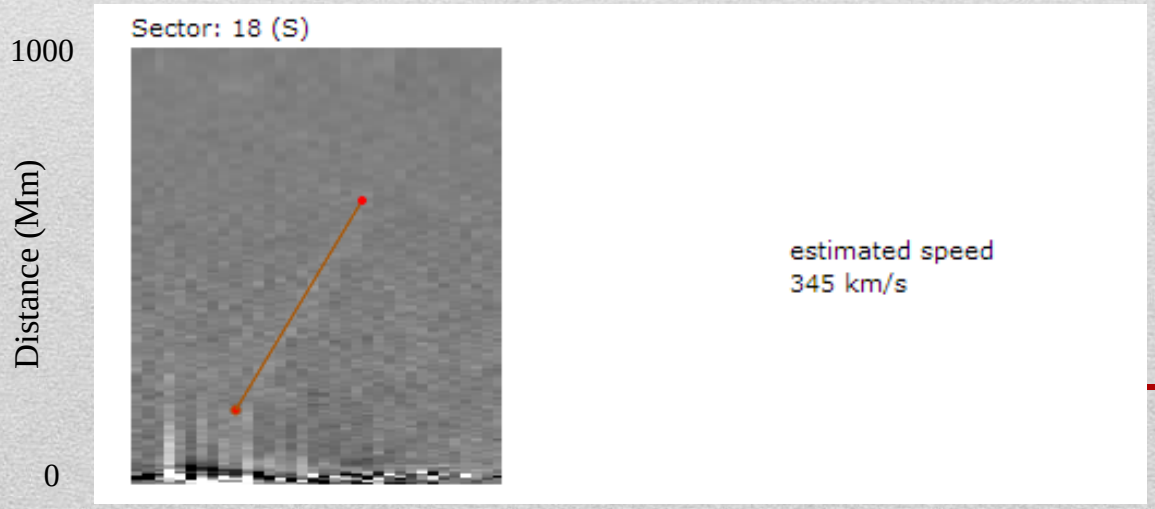




2010-06-12 09:08 - 09:20 - 09:36 (start - peak - end in UTC)

125 - 375 Mm	450 km/s	20.0 min	(4.3)
150 - 400 Mm	448 km/s	20.9 min	(4.3)
175 - 425 Mm	434 km/s	21.7 min	(4.3)
200 - 450 Mm	425 km/s	22.7 min	(4.3)
225 - 475 Mm	412 km/s	23.6 min	(4.3)
250 - 500 Mm	400 km/s	24.5 min	(4.3)
275 - 525 Mm	**379 km/s**	**25.4 min**	**(4.2)**
300 - 550 Mm	363 km/s	26.2 min	(4.2)
325 - 575 Mm	315 km/s	26.5 min	(4.2)
350 - 600 Mm	267 km/s	26.6 min	(4.2)
375 - 625 Mm	229 km/s	26.8 min	(4.1)
400 - 650 Mm	213 km/s	26.8 min	(4.1)
425 - 675 Mm	204 km/s	26.5 min	(3.0)
450 - 700 Mm	133 km/s	26.3 min	(2.1)
475 - 725 Mm	8 km/s	24.6 min	(2.3)
500 - 750 Mm	541 km/s	6.2 min	(1.7)





Future Work

- Provide fully automatic estimate of EUV wave speed in all directions
  - The prototype already provides estimates of speeds and acceleration in all directions (but not yet online..)
  - To increase accuracy this may require higher cadence images (e.g. 12 second cadence)
- Integrate user feedback (emil.kraaikamp@observatoire.be)
- Reduce false alarms/misses
  - Compare output to other event catalogs
- Adapt to different data sources
  - SWAP, EIT archive, Stereo EUVI
- Associate Solar Demon events using other catalogs (e.g. combine the dimming, flare, and EUV wave parameters with existing CME catalogs, or even with geomagnetic storms)
- Statistical study of flare, dimming and EUV wave properties

Thank you for your attention!

Questions?

http://www.solardemon.oma.be/

emil.kraaikamp@observatoire.be

Acknowledgment

The research leading to these results has received funding from the European Commission's Seventh Framework Programme (FP7/2007-2013) under the grant agreement nr. 263506 (AFFECTS project), and grant agreement nr. 263252 (COMESEP project).

Solar-Terrestrial
Centre of Excellence

for your eyes only

Loads of backup slides, mostly with Solar Demon image processing algorithms...

...containing surprisingly few images

EUV wave thoughts

- ‘Pretend’ waves are higher in the corona
  - Use a larger radius for drawing the great circles
- Detect waves not on-disc, but across the edge?
  - Also here you still have some LOS problems though
- Different wavelengths?
  - -> different temperatures -> wave features visible on different altitudes
  - So depending on the wavelength, it is likely (?) that the *estimated speed* DEPENDS on your assumptions about where these features occur
    - if you use the same detection algorithm to detect waves in different wavelengths, you can end up with speed estimates that are different ONLY because the EUV wave travels at a different height..
- Error-bars depending on LOS. The closer you get to the edge of the sun, the larger the impact of the physical height of the feature will be on the detected speed
  - E.g. It is easy to over-estimated wave speed moving TOWARDS the limb
    - Maybe even compensate for this...

image processing techniques for Solar Demon

- Difference Images
  - Detect changes from one time to the next
  - Running difference, percentage running difference, base difference, percentage base difference
    - Percentage variant or more robust against active regions (which are often MUCH brighter than anything else, so absolute differences are tricky). However, you probably want absolute intensity changes…
- Noise reduction
  - median filtering (3x3), Gaussian blurring, rebinning
- Differential Derotation
  - Limb brightness correction
- Creating masks
  - Thresholding images: only keep regions above or below certain intensities
- Connected-component labeling on masks
  - e.g. reject areas too small, but also keep areas that overlap with another mask!
- Growing/reducing masks
  - E.g. Gaussian blurring + thresholding
- Location determination
  - Barycenter (calculate center of darkest or brightest pixels within a mask)
- Detect offset changes to sub-pixel level
  - Find best ‘fit’ between two images (shifting one), and then use a Gaussian fit on this difference landscape.

1. Cut-off pixels near edge of the sun (noisy, most artifacts occur there)
2. Threshold image, keep only pixels that are potentially of ‘flare intensity’
3. Connected component labeling, discard smallest components
   - They might be part of (the outer regions of a) flare, we will retrieve them later
4. Enlarge the mask by blurring, and thresholding it
5. Connected component labeling
   - These are the ‘groups’ of flares (set of pixels within a small areas that turned brighter than they were before!), those are considered to be 1 flare!
6. Keep track of these groups.
   - Combine groups over time!
   - And close together
7. Compute statistics for each of these groups
   1. Overlay with original image
   2. Calculate barycenter of flare group
   3. Calculate brightness
8. If brightness decreases below threshold
   1. Discard flare (group)!
   2. If brightness didn’t increase enough the first detection, also discard the group!
9. Save all the flares in the database, and keep track of running flares. Multiple flares can be detected in multiple locations at the same time

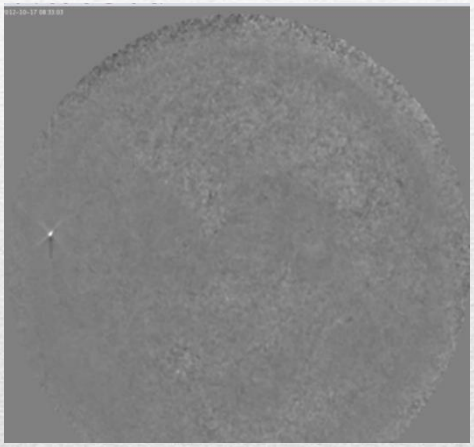


Image processing techniques

Flare Detection

1. Cut-off pixels near edge of the sun (noisy, most artifacts occur there)
2. Threshold running difference images (keep pixels that turned darker)
3. Threshold percentage based running difference images (keep pixels that turned darker)
4. Combine 2 & 3 mask
5. And overlay with original image running difference image
6. Increase size of mask (blur + thresholding)
7. Connected component labeling, exclude smallest changes
8. Overlay with 4, and if a large enough area turned darker by a certain intensity, a dimming was detected
9. Get a pre-event image (several images before), and use base-difference images to track the dimming event

- Dimming mask is created ONLY using the base difference images, the running difference images are only for event detection. Not characterization.
  - Basically repeating steps 1,2,3,4,5,6,7 and 8, but now for base difference images
- Only 1 event is active at a time
- There are (too) many thresholds??

Image processing techniques

Dimming Detection

1. For each flare, extract eruption center (barycenter)
2. Discard solar surface viewed almost edge on (unreliable detection)
3. Rotate solar images such that eruption is viewed face on.
4. Produce percentage running difference images
5. Sum intensities within 24 sectors around eruption center up to 1000 million meters (tracking the surface of the sun) using polar transformation.

6. Let user draw straight lines
7. Detect EUV wave and extract their speed:
8. … detect straight lines (constant speed) within parts of (5), for example from 250 to 500Mm to get a speed estimate of a bright wave front moving over the solar disc.
9. … detect curved lines (acceleration/deceleration) within (5), or, detect multiple straight lines according to (8).

10. Present output (store speeds in database, display animations, etc.).

Also interesting to detect EUV waves outside the surface of the Sun (e.g. floating just above 'tracking' the edge)

Image processing techniques

EUV wave Detection

Previous work

- Novel EIT wave Machine Observing (NEMO)

  (Podladchikova & Berghmans, 2005)

  - Automatically detect dimmings
  - 19.5nm SOHO-EIT (rebinned 256x256)
  - Event-detection based on image statistics (variance, kurtosis, skewness)
    - false alarms and misses

  - Does not run in real-time
  - Only detects on-disc events

  - Code difficult to adapt to AIA data

  - *Solar Demon uses ideas from NEMO, but built from scratch*

Solar Demon - Dimming Detection

running in real time on SDO/AIA 211 QLK data
3 minute cadence, typical delay 15 minutes
(view all Solar Demon detection tools)

Overview of dimming 876

Detector 24h operating status:

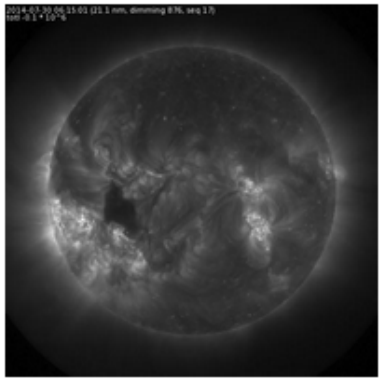
Last processed image:
0 hours and 17 minutes ago (2014-07-31 11:42 UTC)

Last detected dimming:
0 hours and 17 minutes ago (2014-07-31 11:42 UTC)

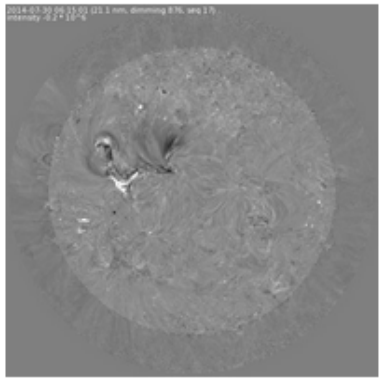
Overview for dimming #:
876 back to overview

Animations and graphs
derotated original images (non-derotated)
dimming intensity (overlaid on HMI)
dimming mask

base difference (percentage)
running difference (percentage)



more



more

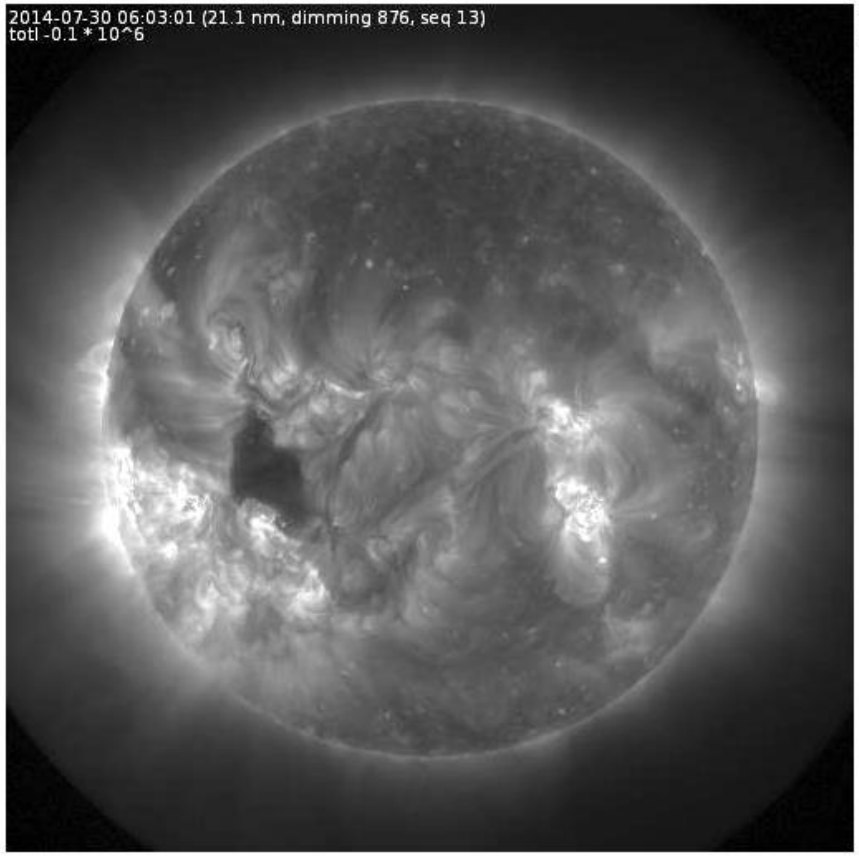
more

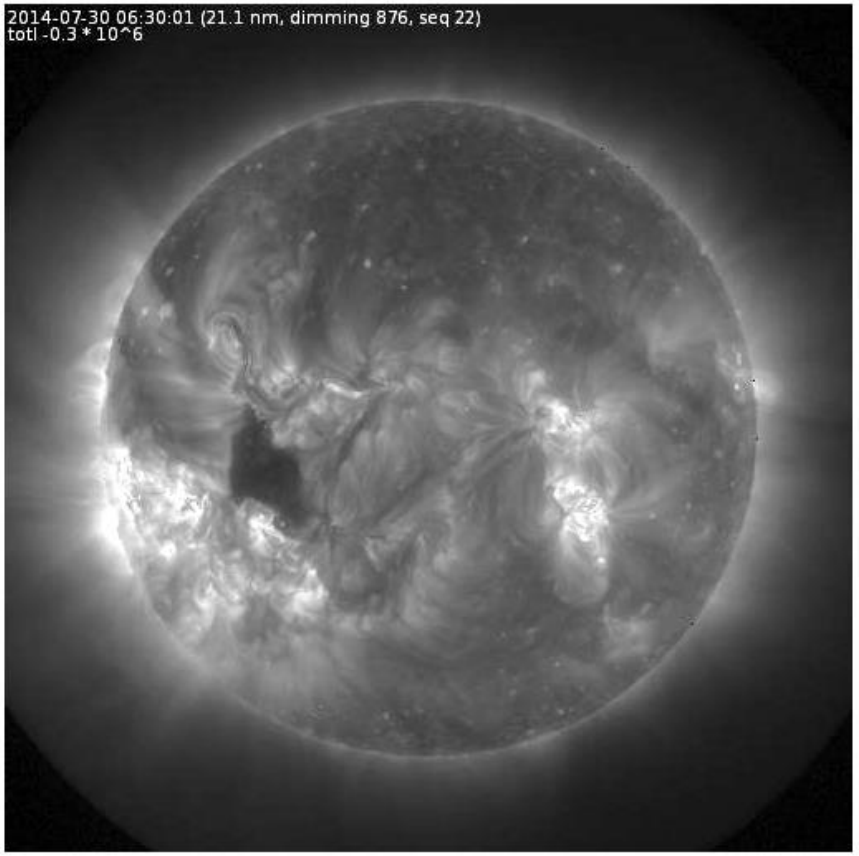
Details for dimming #: 876

time	seq #	total intensity	max intensity	median intensity	area	size	lat	lon	x,y in R⊙	dist. R⊙	detection
2014-07-30 05:27:01	1	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:30:01	2	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:33:13	3	0.0	0.0	0.0	0.0	0			,		0.00
2014-07-30 05:36:01	4	-5.0	-16.0	-17.3	0.9	260			,		0.00
2014-07-30 05:39:01	5	-15.8	-21.2	-17.7	2.6	772	13.8	-10.0	-0.17, 0.14	0.22	0.00
2014-07-30 05:42:01	6	-26.2	-33.0	-16.0	4.4	1306	14.8	-10.1	-0.17, 0.16	0.24	2.03
2014-07-30 05:45:01	7	-38.2	-40.0	-16.4	6.4	1905	14.8	-12.2	-0.21, 0.16	0.26	1.78
2014-07-30 05:48:01	8	-49.3	-39.8	-15.5	8.9	2620	16.8	-10.8	-0.18, 0.20	0.27	0.00
2014-07-30 05:51:01	9	-64.1	-63.5	-15.1	11.2	3304	17.0	-10.2	-0.17, 0.20	0.26	0.00
2014-07-30 05:54:01	10	-79.8	-78.6	-15.2	13.6	3982	16.8	-10.6	-0.18, 0.20	0.27	2.50
2014-07-30 05:57:01	11	-92.6	-82.3	-15.2	15.5	4537	16.6	-11.9	-0.20, 0.19	0.28	2.03
2014-07-30 06:00:01	12	-101.1	-87.9	-15.0	16.9	4960	16.7	-11.8	-0.20, 0.20	0.28	1.66
2014-07-30 06:03:01	13	-112.0	-91.2	-15.2	18.4	5369	16.3	-13.1	-0.22, 0.19	0.29	0.91
2014-07-30 06:06:01	14	-120.9	-94.1	-14.9	20.0	5837	16.3	-13.3	-0.22, 0.19	0.29	0.91
2014-07-30 06:09:01	15	-127.2	-100.2	-14.7	21.3	6222	16.7	-13.1	-0.22, 0.20	0.30	0.92
2014-07-30 06:12:01	16	-142.5	-103.1	-14.9	23.5	6858	16.4	-14.2	-0.24, 0.19	0.31	1.36

Time: 06:03 (UTC), brightness: DN/s

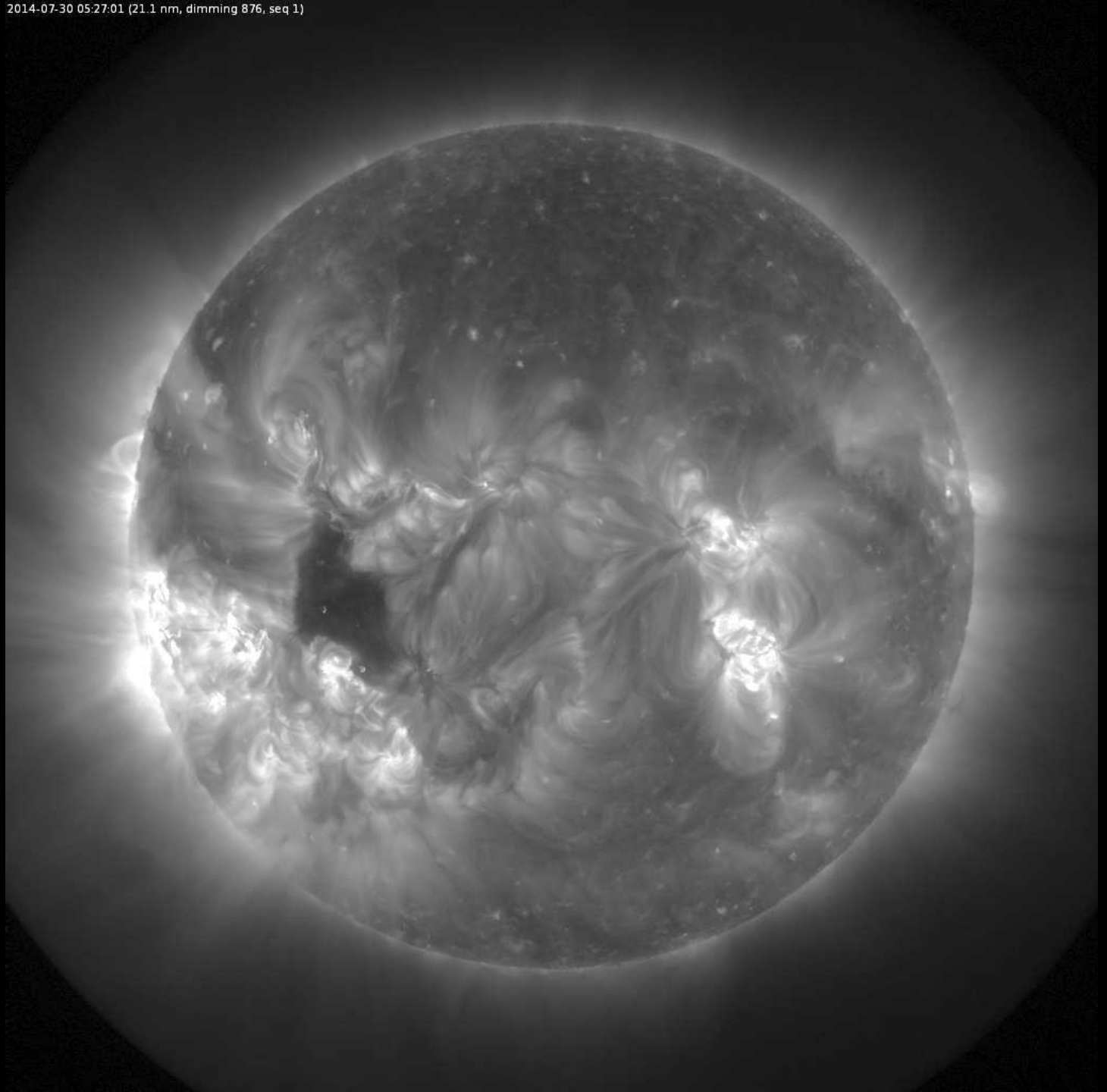
Animation

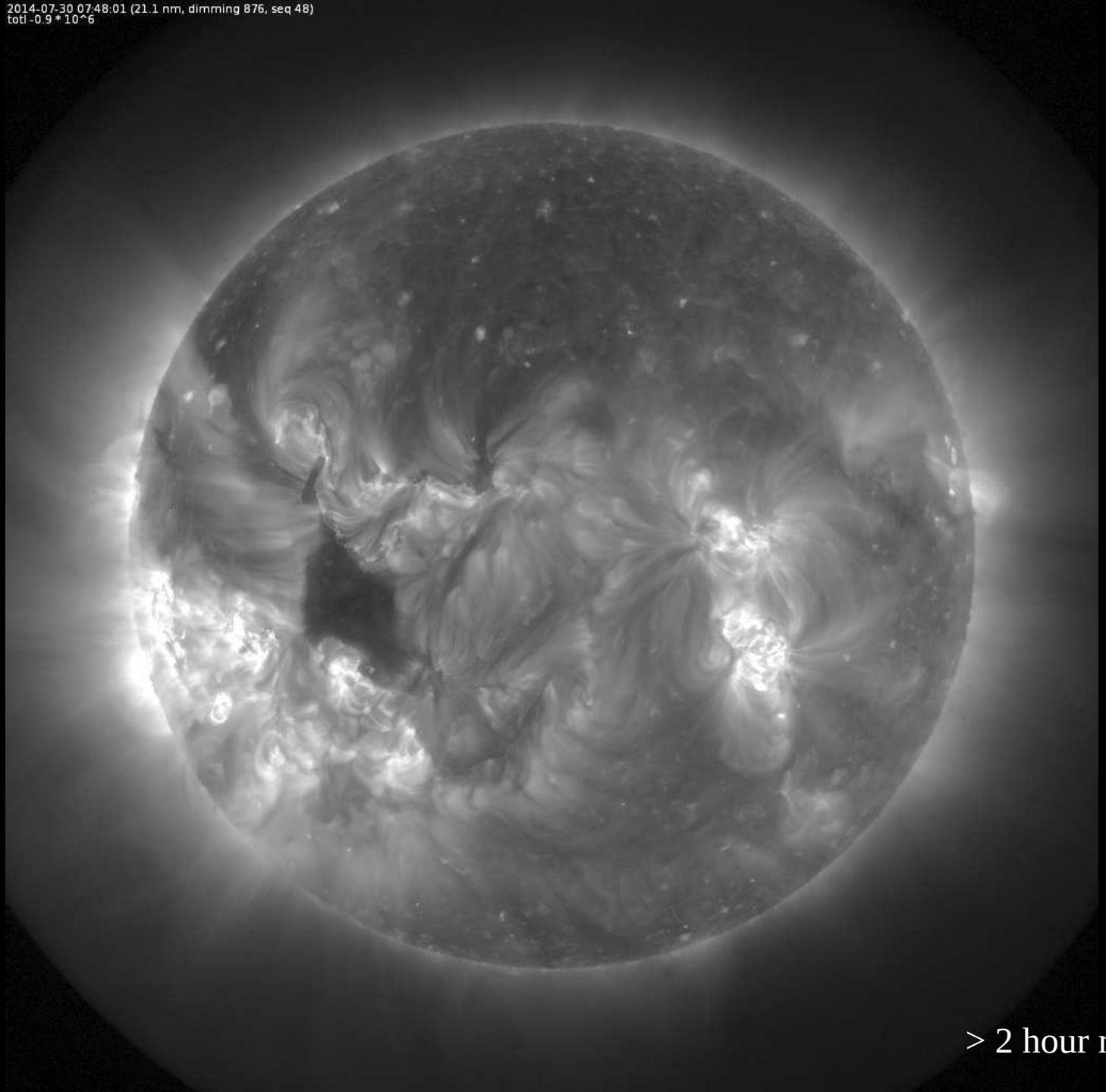




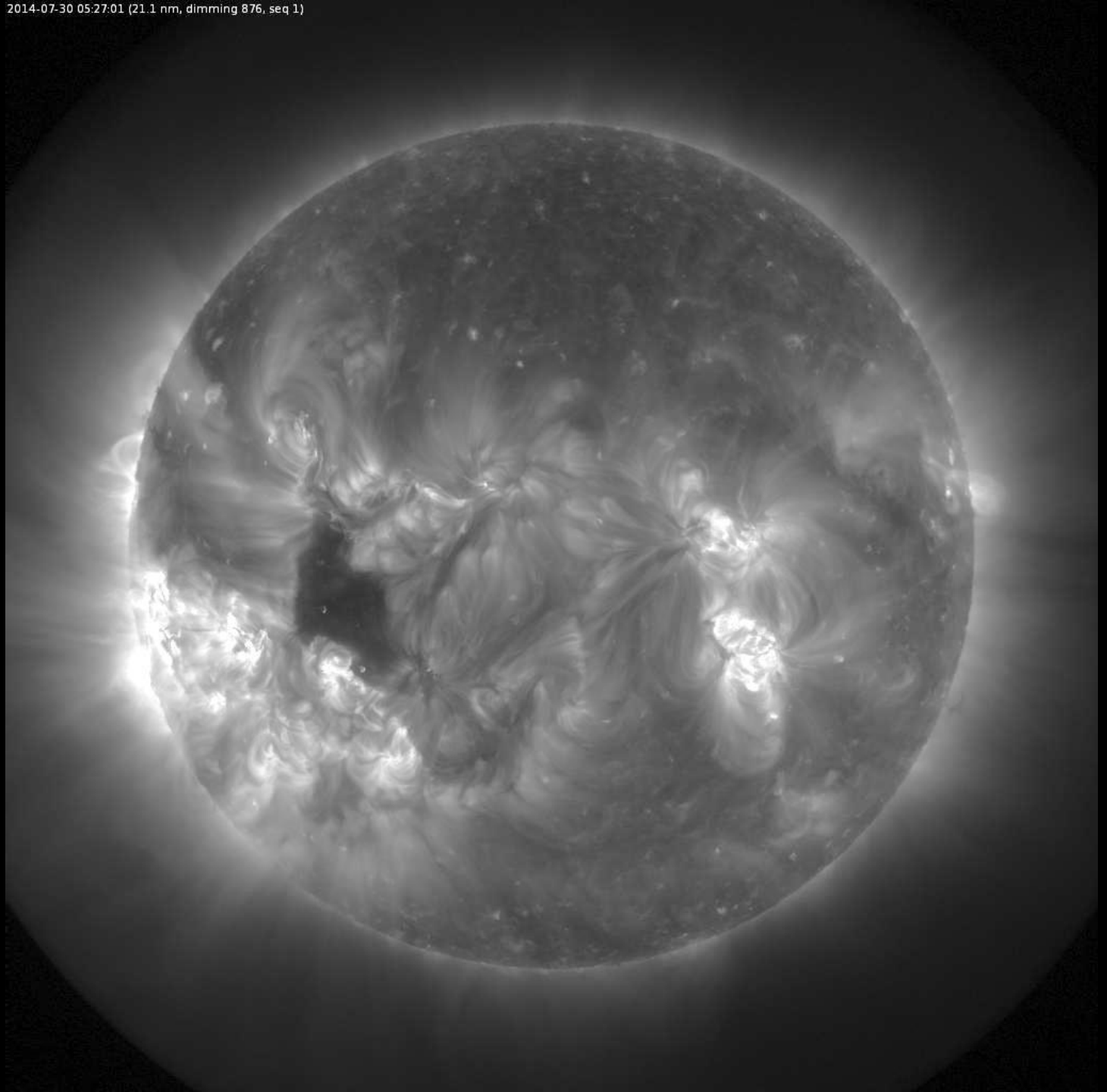
Choose your preferred format to download the flare movie as seen here at the top right: QuickTime (.mov) / FFMpeg MPEG-4 (.avi)

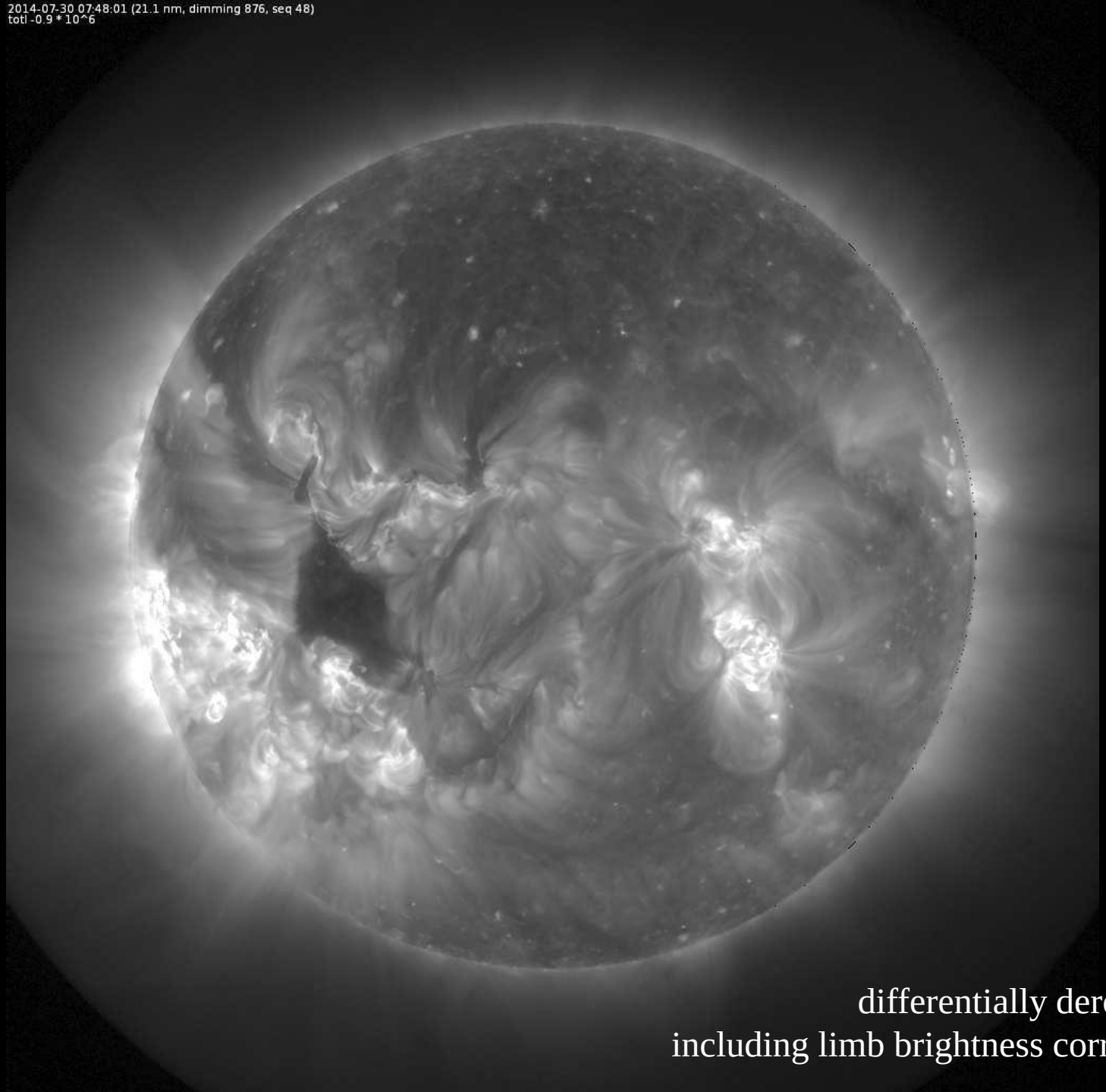
SDO/AIA 94Å images that have been differentially derotated to the time of the first image.


2014-07-30 05:27:01 (21.1 nm, dimming 876, seq 1)



> 2 hour rotation


2014-07-30 05:27:01 (21.1 nm, dimming 876, seq 1)



differentially derotated
including limb brightness correction