

Flare, Dimming, and EUV wave Monitor on SDO-AIA

E. Kraaikamp¹, C. Verbeeck¹, and the AFFECTS team

¹Royal Observatory of Belgium



Introduction

What? Solar Demon is a collection of tools to automatically detect and characterize solar flares, dimmings, and EUV waves in near real-time.

Why? Aid space weather applications by providing extra information on front sided eruptive events, and gain better understanding of underlying physical mechanisms.

How? Automatically analyzing SDO/AIA 94Å and 211Å synoptic and quick-look images.

Where? Solar Demon results are available at www.solardemon.oma.be

Here: We provide details of the algorithm and present and overview of several Solar Demon results.

For additional questions or suggestions: emil.kraaikamp@observatoire.be

Pre-processing

Solar Demon is operating on SDO/AIA level 1.5 quick-look and synoptic data. Even though this data is calibrated, (image) pre-processing remains a crucial step especially for automated detection algorithms. To reduce the risk of false detections, each image has been:

- normalized by exposure time
- tested for a wide range of image defects (e.g. caused by satellite rotation, miss-aligned solar discs, or brightness changes caused by lunar eclipses)

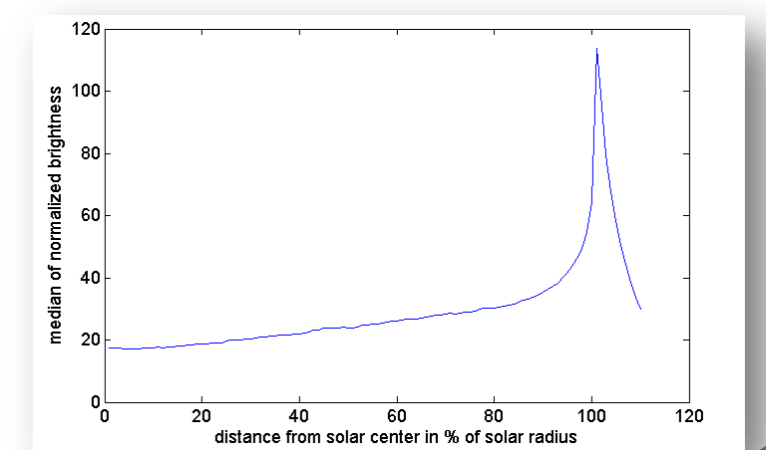


Where possible, FITS meta-data is used to perform these tests, but other tests are directly based on image data. Additionally, Solar Demon can deal with either temporarily or permanently missing data, to ensure real-time operation is maintained.

For Dimming and EUV detection, each image has been corrected for:

- (differential) rotation effects
- limb brightening

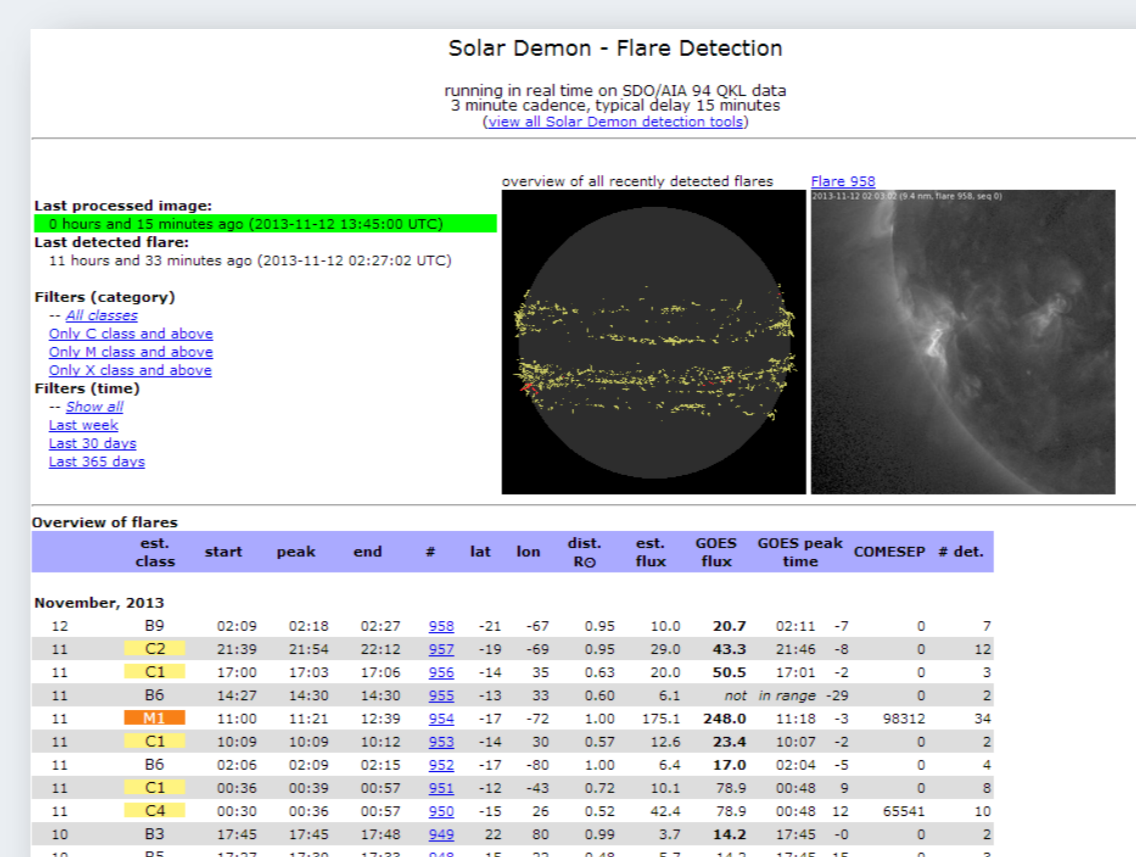
Brightness curve sampled from SDO/AIA 211Å images taken between July 2010 and March 2011.



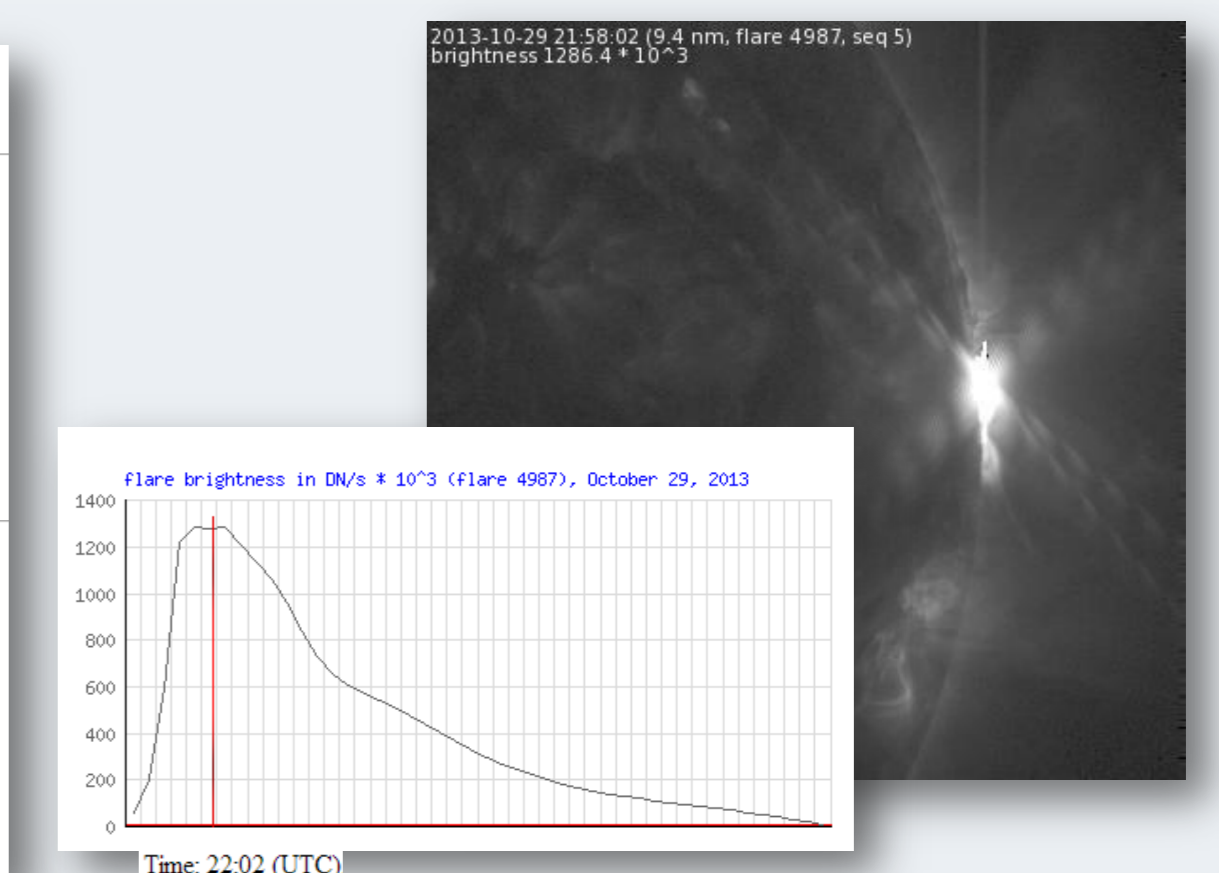
Detecting Flares

Flares are detected using running difference and original SDO/AIA 94Å images. For each detected flare the location and brightness is tracked and displayed on the Solar Demon website in real-time. Multiple flares can be tracked simultaneously, and for each flare the GOES X-ray flux 1.0-8.0Å is estimated using the flare intensity in the 94Å images. Using the STAFF database, the actual GOES flux values are also displayed on the Solar Demon website.

Alerts for flares with an estimated class of at least C5 are automatically sent to the COMESEP space weather impact forecasting system.



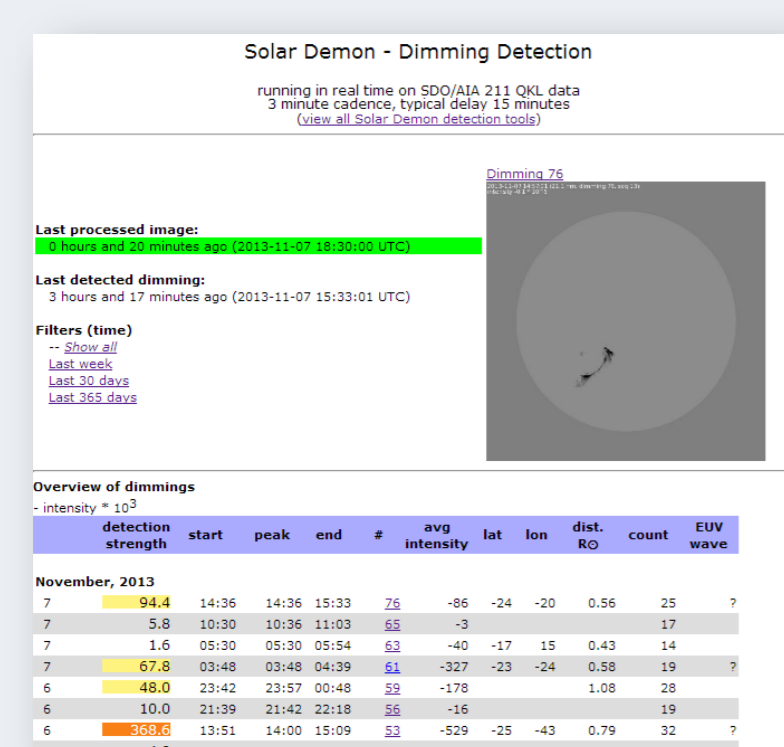
The location, brightness, and start and end time of each flare is displayed on the front page of Solar Demon.



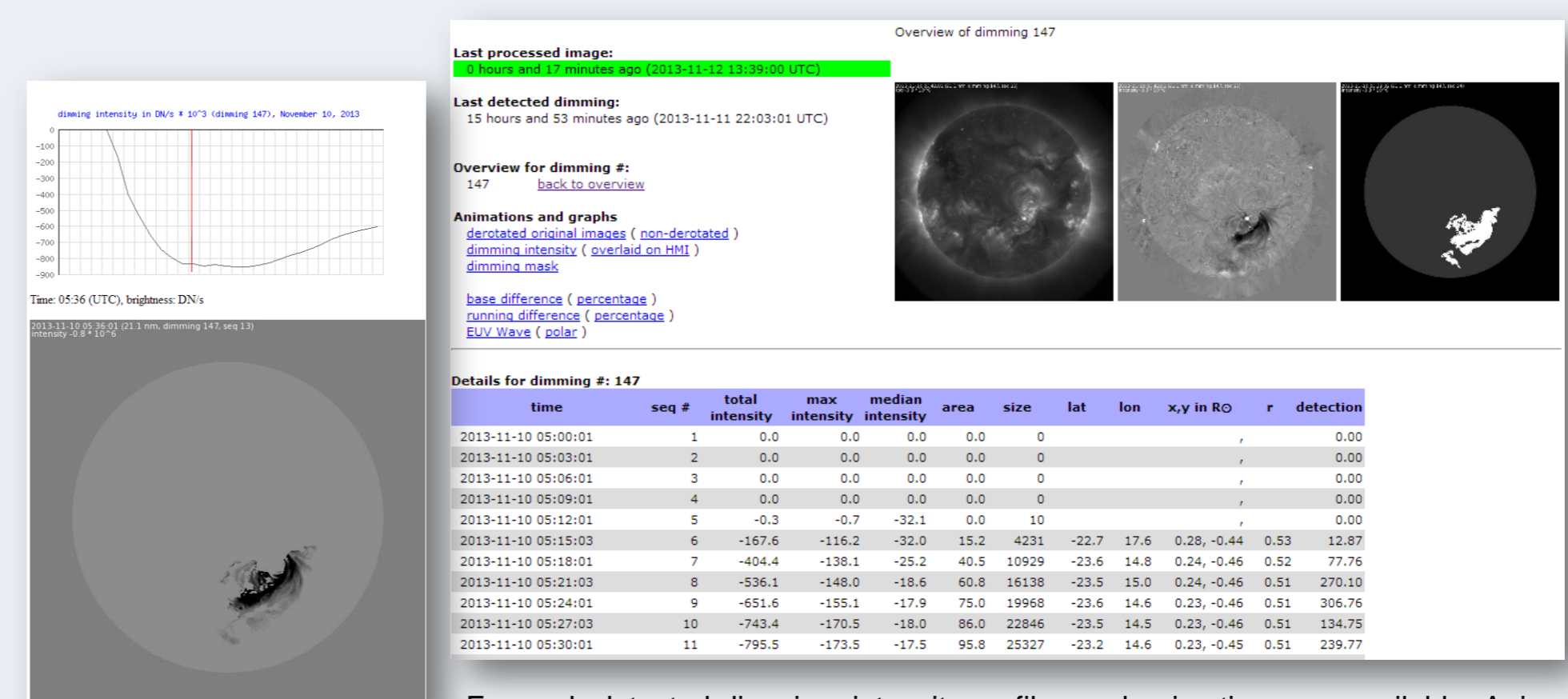
For each detected flare intensity profiles and animations are available. Solar Demon detected this X2.3 flare on October 20, 2013 with peak brightness at 22:02 UTC.

Detecting Dimmings

Transient coronal holes, or dimmings, are detected in real-time using SDO/AIA 211Å images. They are detected both on- and off-disc using a combination of running and base difference images. The intensity of the dimmings is tracked with derotated, limb brightness corrected, base difference images.



The locations, intensities, and start, peak and end times of recently detected dimmings are displayed on the front page of Solar Demon.

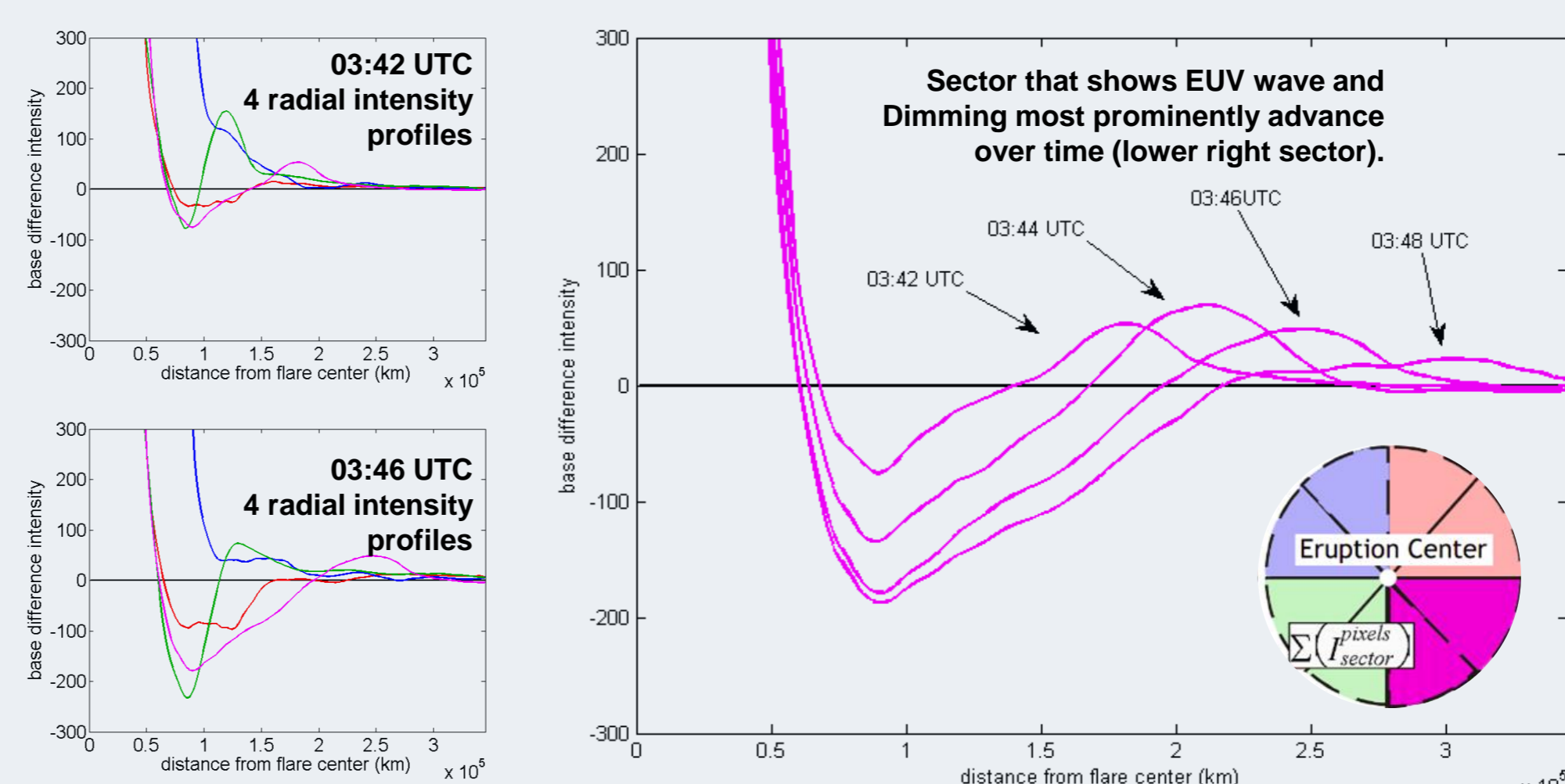


For each detected dimming, intensity profiles and animations include (percentage) running difference, (percentage) base difference, dimming mask, dimming intensity, as well as the original SDO/AIA 211Å images. This dimming was detected on November 10, 2013 with peak intensity drop at 05:24 UTC.

Detecting EUV waves

For each of the dimmings detected on the solar disc, radial intensity profiles emanating from the eruption center outwards are generated for both running difference and base difference images. The solar disc in the images has been derotated such that the events are seen head-on and an estimation of the speed of a possible EUV wave following the surface of the sun can be made.

The images are also used to generate animations that can be viewed - along with the intensity profiles - on the Solar Demon website. The intensity profiles will be used to automatically define EUV wave fronts (under development).

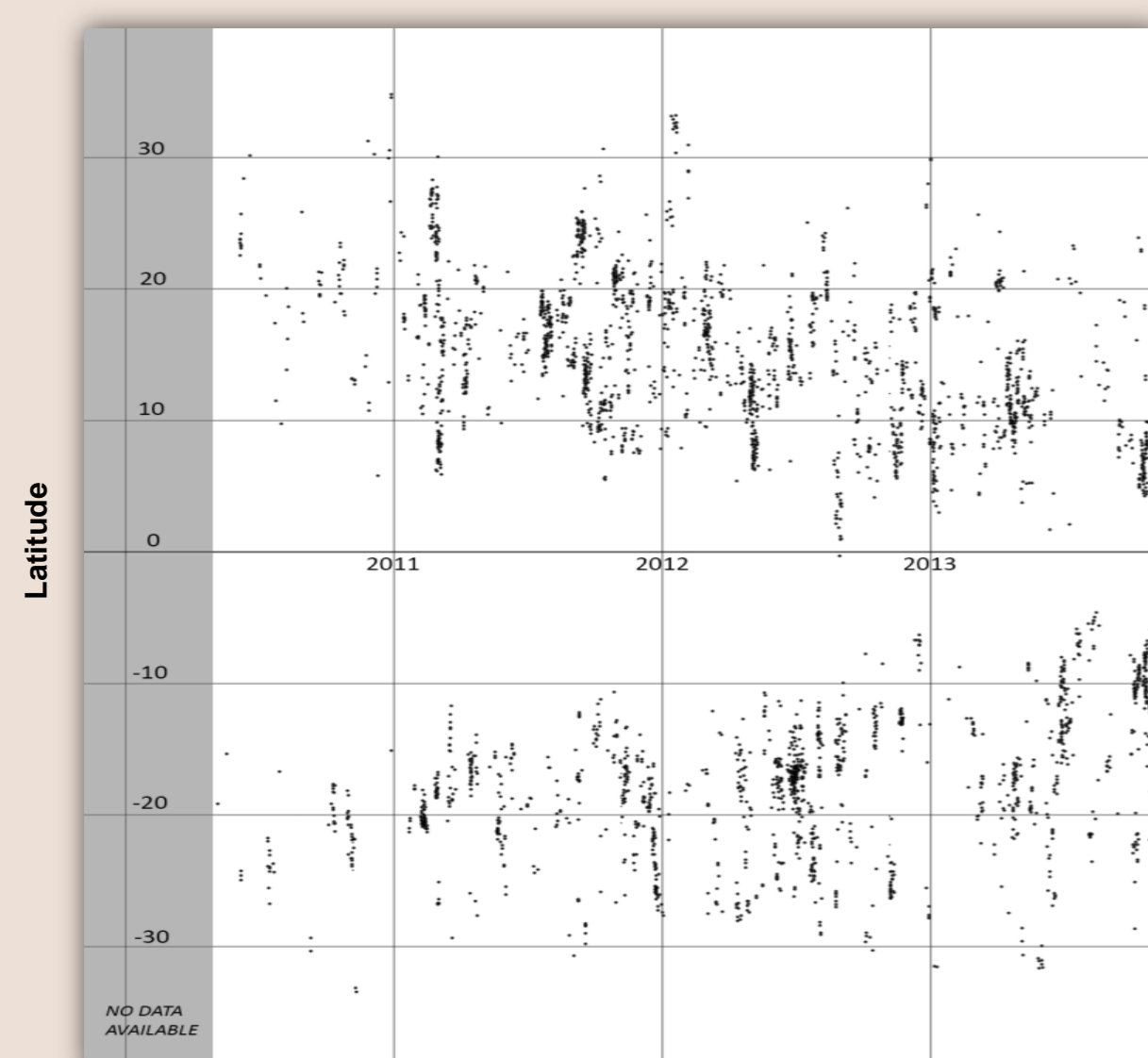


Far left, radial intensity profiles per quadrant centered on the eruption. The dimming and EUV wave are asymmetrical. Left, progression of the EUV wave and dimming over time for the quadrant at the lower right. March 9, 2012. An accompanying M6.4 flare with peak brightness at 04:00 UTC was also detected by Solar Demon (below).

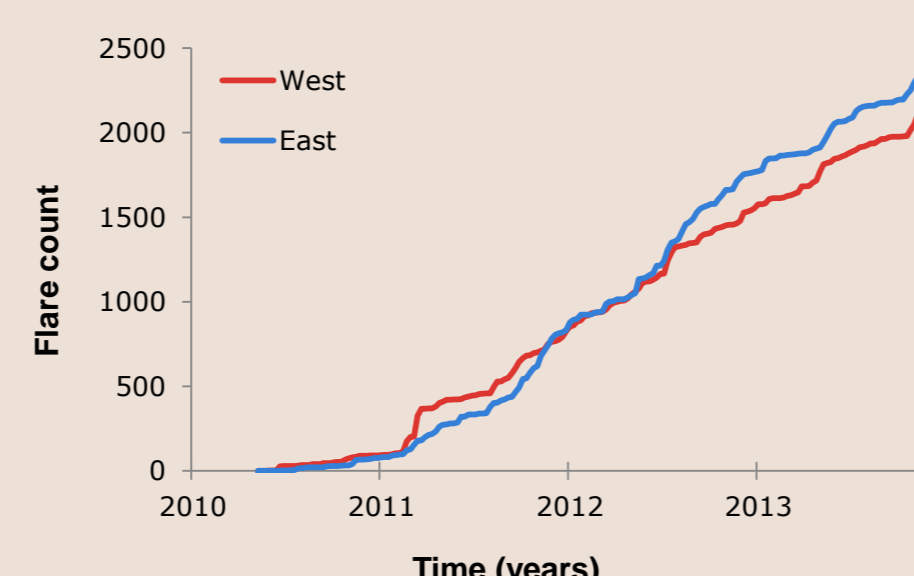


Monitoring Solar Cycle 24

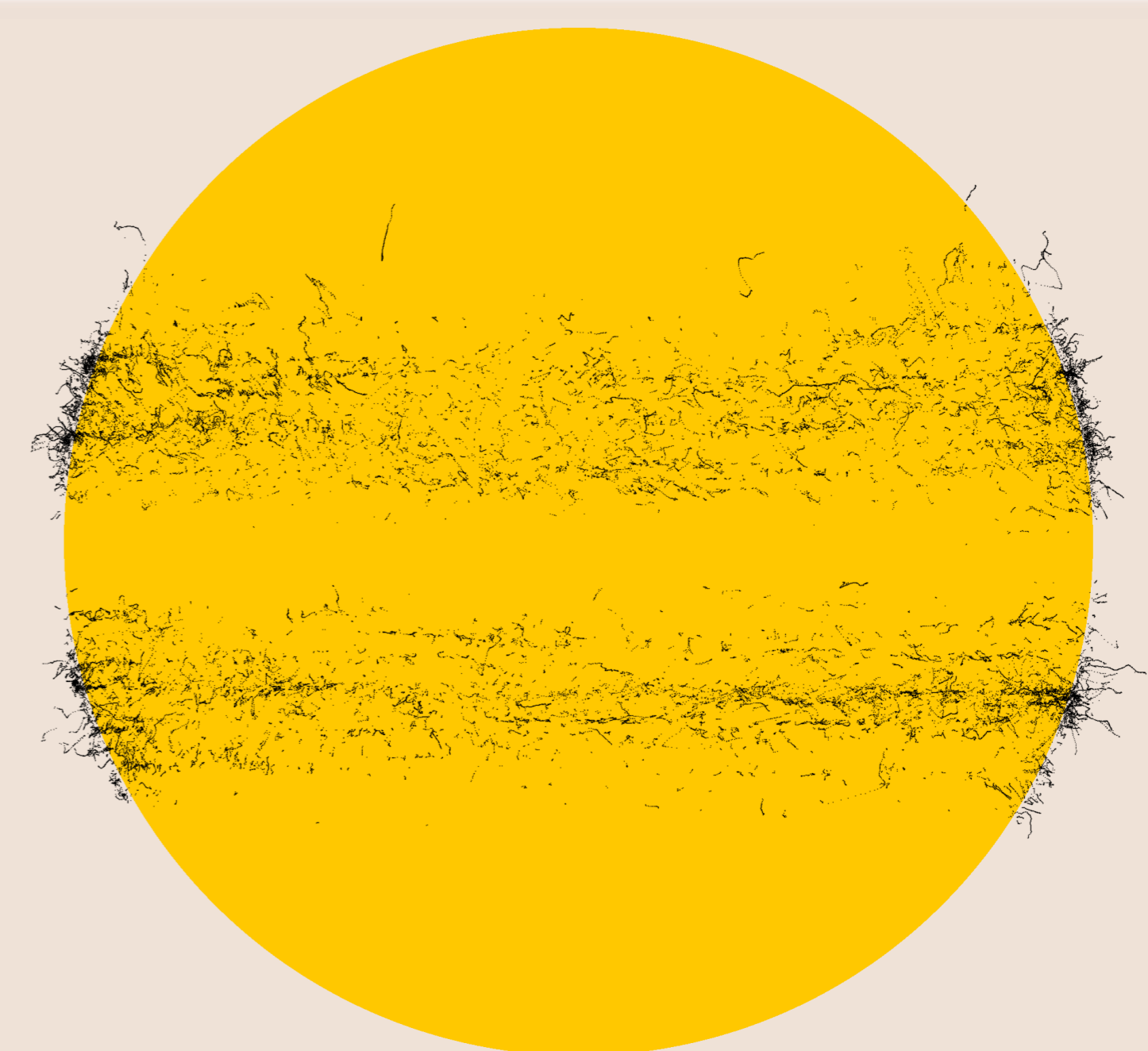
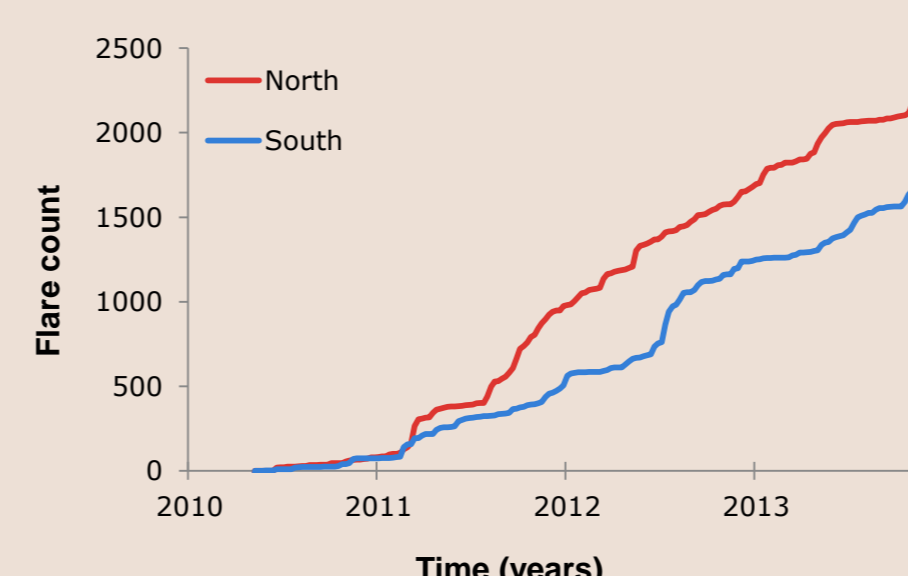
The Solar Demon flare detector has processed all SDO/AIA 94Å synoptic images from May 2010 up to November 2013. The resulting catalog allows us to, for example, generate interesting plots showing the distribution of flares for Solar Cycle 24.



"Butterfly" diagram displaying the Stonyhurst latitude of all detected flares since May 2010.



Cumulative count of flares detected in the eastern and western hemisphere (left), and northern and southern hemisphere (right). The northern hemisphere shows an increased flaring activity earlier than the southern hemisphere.



An overview of all flares detected by Solar Demon in Stonyhurst heliographic coordinates.

Acknowledgment

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