Combining sparsity DEM inversions with event tracking for AIA data

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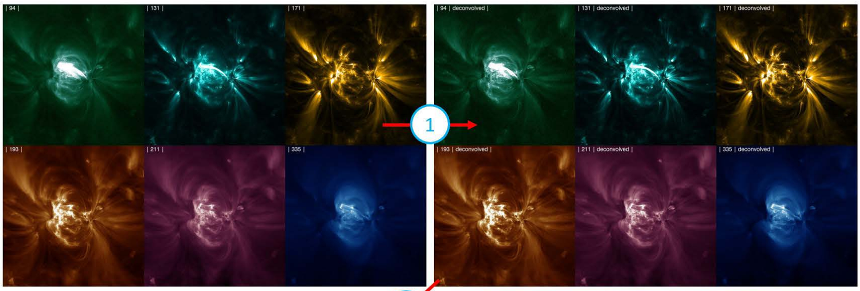
Introduction

We introduce a modified version of the ASGARD code *(Automated Selection and Grouping of events in AIA Regional Data)*. Originally written to detect and group brightenings ("events") in the AIA EUV channels, it now includes the sparsity DEM inversion method *(Cheung et al. 2015)*[1] and instead detects emission measure enhancements in different temperature bins. Ultimately, the goal is to automatically determine heating and cooling rates in different coronal structures.

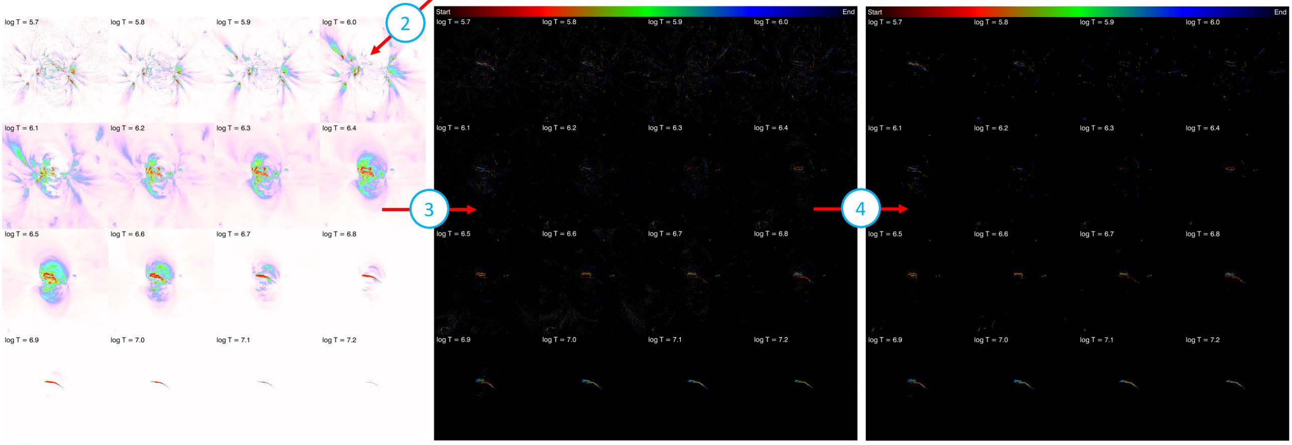
Procedure



Input: AIA regions of interest in the EUV that are tracked, co-registered, and limited in time (typically 12 hours). This sample dataset shows AR11339 at 19:41:02 UT on 8 Nov 2011.

① **Deconvolution, normalization, and interpolation:** We perform a Richardson-Lucy deconvolution to enhance contrast and remove diffraction patterns, normalize the data to a 1 second exposure time, and interpolate missing/bad quality frames.

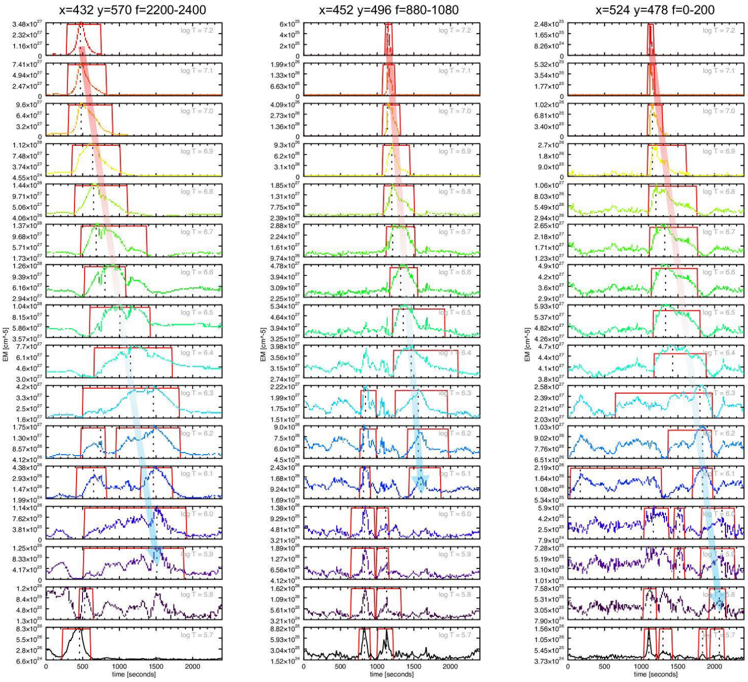
② **DEM inversion:** The sparsity DEM inversion method is used to find the emission measure in different temperature bins (typically from about log T = 5.7 to 7.2 and with dlogT = 0.1).



③ **Event detection:** Pixel-by-pixel and for each temperature bin separately, we run the ASGARD code to detect emission measure enhancements ("events"). An event progress parameter Start End is assigned to each event, i.e. a linear ramp from start to end.

④ **Selecting/discarding events:** The detected events are then clustered into 3-D event groups based on spatial and temporal proximity. Only groups above a selected size threshold (= "total number of pixels involved" or "biggest X percent") are kept, the rest is discarded.

Sample events: cooling plasma



The above plots show the emission measure (EM) from the sparsity DEM inversions vs. time and temperature, averaged over a region of 3x3 pixels in AIA. The red boxes indicate events picked up by the ASGARD code, the dotted black lines mark the position of highest EM during the event. The overplotted arrows in these examples illustrate coronal plasma cooling over different temperature ranges and at different rates.

Future work

Grouping algorithm: We are currently working on an algorithm to automatically select sequential event groups over adjacent temperature bins, and, as an alternative, on extending the selection/grouping described in ④ to 4-D, with the fourth dimension being the temperature. This would enable us to automatically determine heating and cooling rates in the corona from AIA data.

Validation: The grouping algorithm will then have to be validated against several datasets where the heating and cooling rates in different structures have been determined manually from the emission measure maps.

Choosing a set of general parameters: The event detection takes several input parameters to allow the user to optimize what is considered an event by the code. In order to pipeline the code (see next item), a set of general parameters that works for various scenarios needs to be chosen and validated.

Pipelining to increase statistics: Despite the sparsity DEM inversion being comparatively fast with about 10000 pixels/s on an off-the-shelf laptop, the entire procedure is still computationally expensive. However, with most of the code being parallelized and therefore scalable, and with everything in place to pipeline the entire data stream from AIA images to DEM inversions to grouped events, this could significantly increase statistics about heat exchange rates in the corona.

[1] Cheung, M. C. M., Boerner, P., Schrijver, C. J., et al., "Thermal Diagnostics with the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory: A Validated Method for Differential Emission Measure Inversions", 2015, ApJ, 807, 143