AUTOMATED DETECTION OF FILAMENTS IN SDO DATA

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Abstract. Solar eruption can eject billions of tons of plasma to the interplanetary space, with geophysical effects and impacts on human activities. The time constraints for space weather application as well as the huge volume of data that needs to be analyzed, especially since the launch of SDO, imply that the detection of solar filaments and their eruptions must be automated. Most current detection codes use Hα data, which are not available frequently enough for these applications. We present a new detection code that we have developed at IAS and that uses the high spatial and temporal-resolution SDO/AIA He II 30.4 nm data.

Keywords: Sun: filaments, Sun: solar-terrestrial relations, techniques: image processing

1 Introduction

Instabilities of the magnetic field can cause the ejection of plasma to the interplanetary space, producing a Coronal Mass Ejection (CME), which can strongly perturb the solar wind. If directed towards the Earth, a CME can put some human activities at risk. However, its effects can be mitigated if it is detected well enough before arriving on the Earth. This is one of the main stakes of space weather.

In this process, filaments (or prominences when seen in emission at the solar limb), which are made of plasma maintained in suspension in the corona by the magnetic field, play a major role, as they provide the material (about 100 times denser and colder than the surrounding corona) that can be ejected to the CME. The detection of a filament and its subsequent disappearance thus provides a signature for the start of a potential CME.

Filament detection is usually performed from images taken in the Hα 656.3nm line (e.g. Bernasconi et al. 2005; Fuller et al. 2005; Gao et al. 2002; Jing et al. 2004; Scholl & Habbal 2007; Zharkova & Schetinin 2005). For example, the Bernasconi et al. (2005) code is based on a threshold, region growing to a second, higher threshold, and a morphological filter for the selection of elongated structures. This code produces a list of filaments (with size, position, and chirality), and it tracks them as a function of time.

The interest of Hα images lies in the fact that in these images filaments are easily seen as dark, elongated structures on a brighter background. However, these data come from ground-based observatories only*, and despite current improvements to the capabilities of these observatories, high-cadence observations during all day, every day, cannot be done. At the moment a few tens of images per day are available at most, and this is not enough to detect filament eruptions in near real-time.

For this reason we developed a new filament detection code that can use data which is continuously available at high cadence. The 30.4nm channel, routinely observed by space instruments like SoHO/EIT, STEREO/SECCHI and now SDO/AIA would be one of the main components of such a detection system. The He II 30.4nm line shares indeed some of its emission properties with the Hα line, and filaments are also visible as dark structures in this channel, although the separation from the background is more difficult than for Hα. In particular, the data from SDO/AIA, with their high resolution (4096^2 pixels at 0.6 arcsec resolution) and high cadence (10s for the 30.4nm channel) offer a new opportunity for such an enterprise.

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*For example from the global Hα network: Mauna Loa, Big Bear, Meudon, Kanzelhöhe, Catania, Yunnan, and Huairou solar observatories.

2 Development of a new filament detection code

Methods used to detect filaments in Hα cannot generally be used for the 30.4nm channel, mainly because at 30.4nm the background contains features from the chromospheric network, which have a high contrast. For this reason we rather choose to start with a filtering in curvelets space, in order to select dark elongated structures against this contrasted background. Curvelets (Starck et al. 2002) are orthogonal functions analogous to wavelets in 2D, characterized by a position, scale, and orientation (Fig. 1). Then we use a threshold to obtain clusters of pixels, and we give a score to these clusters according to their size, shape, position, and intensity. The clusters of pixels with the best scores, or scores above some threshold, are considered as filaments. Then their spine is computed and the resulting filaments can be tracked as a function of time.

3 Current status and perspectives

The filament detection is now working, but a proper assessment of its results remains to be done. Improvements are still needed in order to be able to rely on tracking of detected filaments for the near-real-time detection of filament eruptions. Such improvements could come for example from adding to the computation of scores a criterion of proximity to a magnetic field polarity inversion line. We are also currently working on including this code in the SDO/AIA data pipeline, first at MEDOC in IAS, with the aim of producing a catalog of filaments and their eruptions than can be sent to the Heliophysics Events Knowledge Base (`http://www.lmsal.com/hek`).

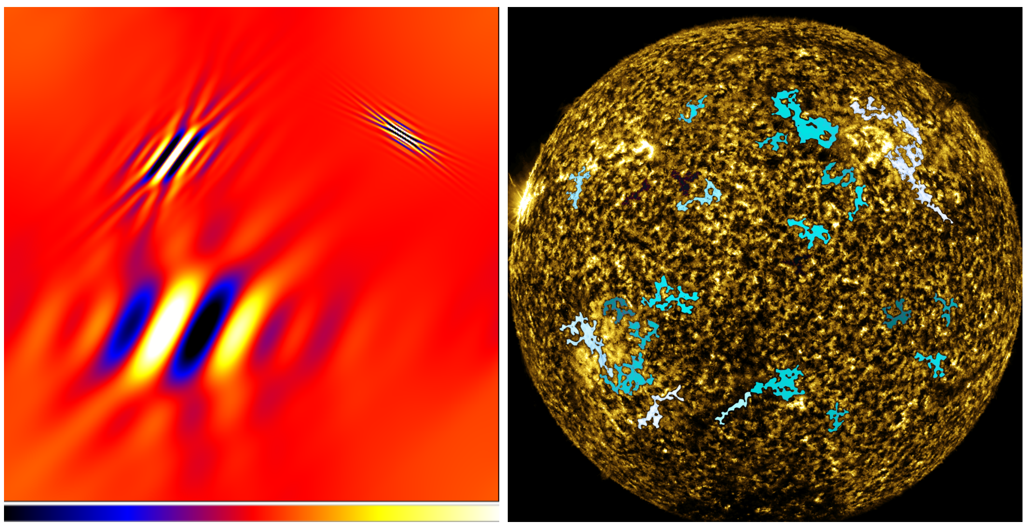

Fig. 1. Example curvelet functions (real part), and detected filaments in a SDO/AIA image (blue/white pixels, brighter blue means better score).

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