Royal Observatory of Belgium

Computer aided CME tracking: near-real-time reports produced by CACTus

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SIDC

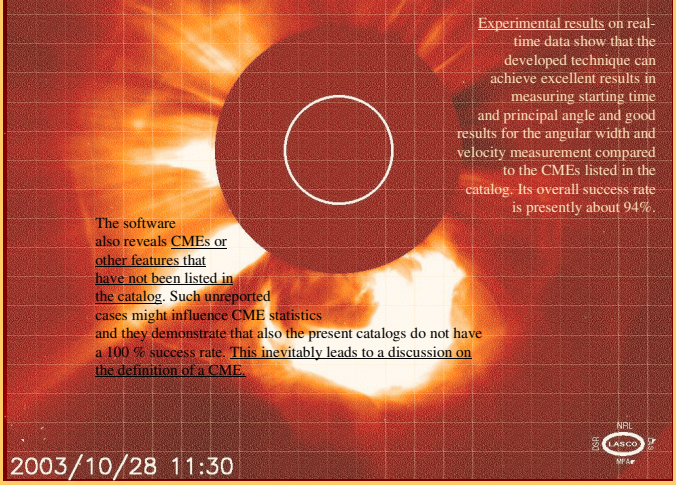
http://sidc.oma.be/cactus

Abstract:

We have developed software that autonomously detects CMEs in image sequences from LASCO. The output of our software is a list of events, similar to the classic catalogs, with starting time, principle angle, angular width and velocity estimation for each CME. In contrast to catalogs assembled by human operators, these CME detections by software can be faster, which is especially important in the context of space weather, and possibly also more objective, as the detection criterion is written explicitly in a program.

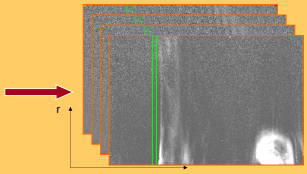
Experimental results on real-time data show that the developed technique can achieve excellent results in measuring starting time and principal angle and good results for the angular width and velocity measurement compared to the CMEs listed in the catalog. Its overall success rate is presently about 94%.

The software also reveals CMEs or other features that have not been listed in the catalog. Such unreported cases might influence CME statistics and they demonstrate that also the present catalogs do not have a 100 % success rate. This inevitably leads to a discussion on the definition of a CME.



Method

1. Data: c2/c3 images from LASCO
2. Cleaning
3. Polar transformation for each image: [x,y] → [θ,r]
4. Rebinning + Exposure time corrections
5. Enhance CMEs taking running difference

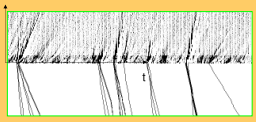


6. Combine c2 & c3
7. [time, height] slice for each angle (top):

   CMEs can be seen in [time, height] plots as inclined ridges with the inclination angle corresponding to the propagation speed. Time runs horizontally from 9 to 14 Nov 2003, the vertically height covers the combined C2/C3 FOV.

8. Extract the CMEs (bottom, upside down):

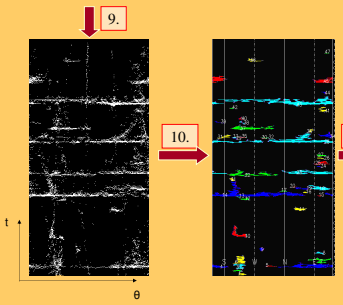
   The ridges are detected with the Hough transform.

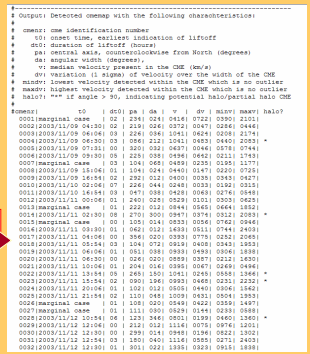


9. Combine detections in a [angle, time] map:

   By combining the ridges in [time, height] plots from all directions, we can reconstruct the CME front as it propagates outwards.

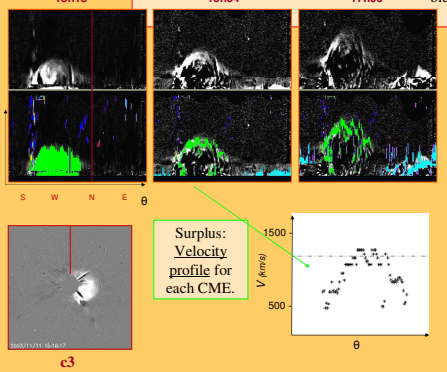
10. Cluster detections into different CMEs
11. Define characteristics of each CME





Output illustration

Sequence of 3 running difference polar images containing 2 CMEs, Cactus detections in green and blue.



Surplus: Velocity profile for each CME.

c3

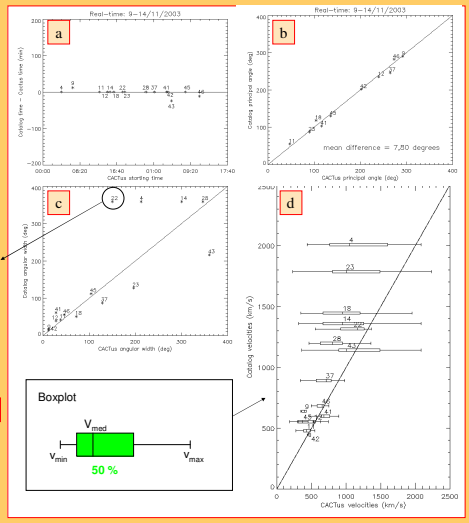
SWENET

esa

This activity is co-funded by ESA (16913/03/NL/LvH) as part of the SWENET/Space Weather Pilot Project Network

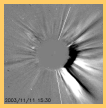
Evaluation

We have applied the above scheme to real-time data from a period from 9 to 14 November 2004 (See above for the output map). We compared our results with the SOHO LASCO CME Catalog available online.



15 of the 16 CMEs are reproduced with nearly identical starting time and principal angle. a b

c Good correspondence for small CMEs. Halo CMEs are often only detected as partial halos, the weaker part is sometimes difficult to retrieve. Also a discussion on CME definition is ongoing.

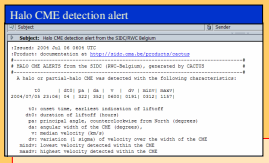


d CACTus measures a (linear) speed-profile per CME. The Catalog speed (fastest moving feature) is indeed mostly in the higher range of the profile.

Applications

CACTus is a program that runs continuously on a near-real-time basis. Its output can serve as input to diverse applications or other programs.

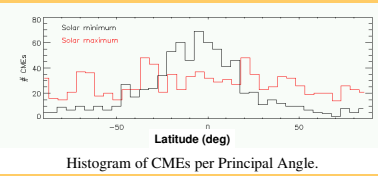
The CACTus output is used as an overlay for the Solar Weather Browser (**SWB** ~ see another poster at this conf.)



When a CME wider than 180° is detected, an automatic e-mail alert is sent.
Interested to receive these CME-alerts?
Send an email to
Ronald.Vanderlinden@oma.be

Large-scale application on the LASCO Archive

We have applied the software on a first sample of 29 months selected from archive data in the period July 1997 to December 2002. Results (e.g. see below) show that the overall characteristics of CMEs over the solar cycle are successfully recovered with the automated procedure. This proves that a completely automatically produced CME catalog is within reach.



Histogram of CMEs per Principal Angle.

CMEs are found to originate more from the centre during solar min as compared to solar max. This is in good agreement with earlier results (Howard, 1984, 1985; Hundhausen, 1993; Yashiro 2004)

Evaluation of 3 recent months (2004)

July: 16 events of which 12 detected by CACTus,

4 events were missed: 3 only partially detected and 1 missed (faint complex halo event, with geomag. cons.)

Alerts: 8 alerts were successfully issued of which 2 with major geomagnetic consequence

August: 9 events of which 6 well detected by CACTus,

3 events missed: 2 only partially detected and 1 missed (faint event)

Alerts: 2 alerts were successfully issued, one with major geomagnetic consequences.

This event was not reported elsewhere!

September: 10 events of which 9 detected by CACTus,

1 missed due to data gaps (EIT shutterless)

Alerts: 7 alerts were successfully issued, several events were not reported elsewhere

Visit our website at: www.sidc.oma.be/cactus for the latest output !