CME flag for METIS

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OUTLINE

• Selected data and CME we wont identify with a flag

• Observed absolute and relative intensity evolutions (single polarized data, calibrated tB and pB)

• Implementation of a flag based on running differences

• Conclusions
Selected data

Data analyzed: STEREO-A/COR1 polarized images
Time interval: 2012/03/22,00:05:00 – 2012/03/24, 23:55:18
# of polarized images: 2580 (0°, 120°, and 240° acquired every 5 minutes)
Size (pix): 512 X 512 (262144 pix total)

FIRST TEST for a CME flag

Angular sectors: 8
Angular extension: 45°
Radial extension: 1.7 – 3.7 R\textsubscript{sun}
Pixel per sector: ~ 18900 pix
Image fraction covered: ~ 0.577

In what follows, angular sectors are identified by the lower value of polar angle edges (left).
Events in the selected 2 days period

<table>
<thead>
<tr>
<th>Date</th>
<th>Images/Event</th>
<th>UT</th>
<th>Comments</th>
<th>Flares/waves, EP &amp; Dimming</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012/03/23</td>
<td>286</td>
<td>00:05:00-23:55:18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012/03/23</td>
<td>CME</td>
<td>19:05</td>
<td>NNE, medium eruption</td>
<td>(EP/NE disk)</td>
</tr>
<tr>
<td>2012/03/24</td>
<td>286</td>
<td>00:05:00-23:55:18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012/03/24</td>
<td>CME</td>
<td>00:10</td>
<td>NW, bright and fast halo eruption</td>
<td>(Wave/NWlimb)</td>
</tr>
<tr>
<td>2012/03/24</td>
<td>CME</td>
<td>09:05</td>
<td>SSW, bright FR-like eruption</td>
<td>(~W162)</td>
</tr>
<tr>
<td>2012/03/24</td>
<td>CME</td>
<td>10:45</td>
<td>NW, narrow eruption</td>
<td>(EP and wave/NWlimb)</td>
</tr>
<tr>
<td>2012/03/24</td>
<td>CME</td>
<td>19:45</td>
<td>NW, narrow eruption</td>
<td></td>
</tr>
</tbody>
</table>

Cme events listed for the analyzed interval by the STEREO-A/COR1 catalog
Events in the selected 2 days period

Only one of these events is a significant CME!
The event to be identified by the flag
Remarks on variations observed in different angular sectors:

- Single polarized exposures (0 deg) and total WL brightness: almost constant
- Polarized brightness: more significant evolution
Remarks on relative variations observed in different angular sectors during the CME transit:

- Single polarized exposures (0 deg) and total WL brightness: less than 1%
- Polarized brightness: more than 20%
Explanation: given the geometry of Thomson scattering, the distribution along the LOS of polarized emission is much more concentrated on the plane of the sky, while total brightness is emitted by a thicker coronal layer → for CMEs crossing the plane of the sky (like the one reported here) the increase in pB emission is relatively much stronger than the increase in tB.
**First test: running differences in 8 angular sectors**

![Diagram with graphs showing running differences forUncalibrated exp. and Calibrated exp., Total brightness, and Polarized brightness.](image)

**Exp. #575**

**Remarks:** **absolute variations** (running differences) in different angular sectors in the whole interval
- Allows to unambiguously identify the “big” CME with respect to smaller scale events (dashed lines)
- Running difference peak values are comparable for single polarized exposures, tB and pB.
Remarks:

- Simple running difference seems already a fast and quick proxy for the determination of CME arrival time (significant increase of running difference already 3 exp. before the CME intensity peak exposure, i.e. 15 minutes before)
- Given the sector where the CME signal is maximum, the amplitude of the running difference signal strongly depends on the considered frames (i.e. on the angle of polarizer)
Remark: identification of a signal threshold value can be different depending on the considered polarization angle for each sequence of polarization triplets.
Orientation of polarization vector in corona

Examples: 2006 total solar eclipse data

Explanation: polarization angle always tangent to the limb

→ in single images acquired with a specific orientation of polarization angle the CME intensity will be more or less attenuated, depending on the angle between the CME and the orientation of the polarizer

→ for the same event peak value depends on that angle.
First test: simple geometrical average

Possible (computationally fast) solution: perform on-board averages over the three images acquired with different polarization angles (e.g. geometric average) → threshold definition for running difference not easy anyway.
**Remark:** implementation of a CME flag based on HI Lyman-α emission could avoid problems related with polarization angle, but the scattering in the HI Lyman-α peak for different events is broader than white light → hard flag definition.
Some comments in the literature about this problem...

**Robbrecht & Berghmans (2004):** “The CME signature is convolved with quasi-static K-corona streamer structures and with slowly moving stars, planets and comets as well as the instrumental stray light and F-corona backgrounds. (...) A typical CME is only a relatively weak variation in intensity and only visible in a few subsequent images. All this means that the signal on which we want to trigger, is only very weakly present in the huge amount of incoming data.

**Boursier et al. (2009):** “The automatic detection of CMEs faces two main problems. First, the radiance of a CME is highly variable so that a simple thresholding will not work for extraction. Second, the noise is complex and has two main components: i) the intrinsic noise of the images (e.g., photon noise) and ii) the background coronal structures which behave as noise for this detection problem. The global noise is neither Gaussian, nor stationary, nor ergodic.”

Sime and Hundhausen (1987) noted that the $\Delta B/B_{bg}$ ratio ranged from a few percent for the faintest CMEs up to unity for the brightest events. (...) In order to apply feature recognition techniques to detect coronal mass ejections, a clear definition of a “CME” is indispensable. Hundhausen et al. (1984; also Munro et al. 1979) defined a CME to be “an observable change in coronal structure that occurs on a time scale of a few minutes to several hours and involves the appearance of a new, discrete, bright, white-light feature in the coronagraph field-of-view”.”
SUMMARY

• 2 days of STEREO/COR1 WL data analyzed → first tests on a CME flag for METIS.

• Single polarized intensities (0 deg) and WL tB are almost constant (relative variation < 1%), while pB has more significant evolution (relative variation > 20%).

• Running differences allows to unambiguously identify the angular sector and the start time for the “big” CME with respect to smaller events.

• Identification of a signal threshold value can be difficult because:
  1) brightness of the same CME depends on the considered polarization angle for each sequence of polarization triplets,
  2) radiance of CMEs is highly variable from event to event.

• Moreover, the CME brightness contrast is expected to change during the mission, because CME plasma becomes more diluted at larger heliocentric distances → different flags for different spacecraft distances?

• Future: analyze more events on COR1 and COR2 data as well to define a good flag value at different heliocentric distances of the spacecraft, analyze halo CMEs to see whether METIS will be able to distinguish them with POS CMEs.