The New CORIMP Coronal Mass Ejection Catalog
Automatically Detecting & Tracking CMEs in Coronagraph Data

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1. Abstract

Coronal mass ejections (CMEs) tend to be faint, transient phenomena, observed in white-light images that are prone to noise and user-dependent biases in their interpretation. A wealth of image processing techniques have been explored to characterise CME structure in coronagraph data from observatories like SOHO and STEREO. The increasing volume of data available has made it necessary to automate such techniques for detecting and tracking CMEs, and cataloging their kinematics and morphologies[1,2,3]. A new such catalog has been developed, called CORIMP, that overcomes many of the limitations of current catalogs in operation. An online database has so far been produced for the SOHO/LASCO observations, providing information on CME onset time, position angle, angular width, mass, speed and acceleration. A realtime version of the algorithm has been implemented to provide CME detection alerts to the interested space weather community. Furthermore, STEREO data provides the ability to perform 3D reconstructions of CMEs that are observed in image pairs. This work will lead to an improved understanding of the dynamics of CMEs.

2. Detecting & Tracking CMEs

CORIMP[4,5] Cataloging Technique:

1. A normalising radial graded filter (NRGF[6]) is applied to LASCO/C2 and C3 images, and the quiescent background subtracted[7], as in Fig. 1(a) and (b).
2. The images are convolved with high and low pass filters[8,9].
   ➘Multiple scales result from multiple filter sizes (dyadic: 2^s).
3. The resulting magnitude of edge strengths is shown in Fig. 1(c) and (d), and the corresponding angular information in Fig. 1(e) and (f).
4. Bright curvilinear features are flagged as CMEs.
   ➘Regions-of-interest, as in Fig. 1(g) and (h).
5. A pixel chaining algorithm details the structure along the detected CMEs, as shown in yellow in Fig. 1(i) and (j).
6. A stack of CME detections is generated, showing 'Time' against 'Position Angle', with a colourbar intensity corresponding to the measured heights from Sun-centre (Fig. 2).

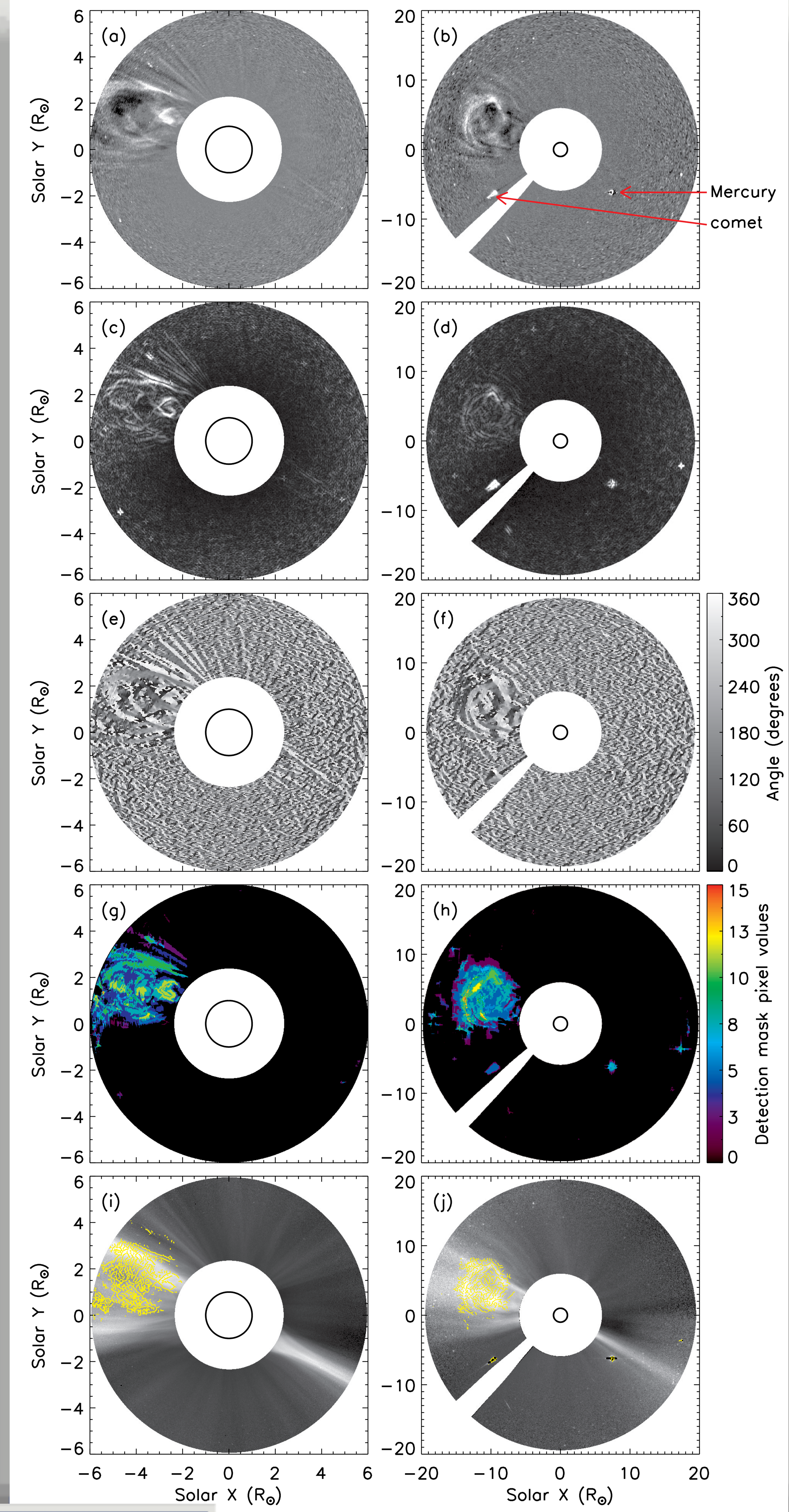


Figure 1

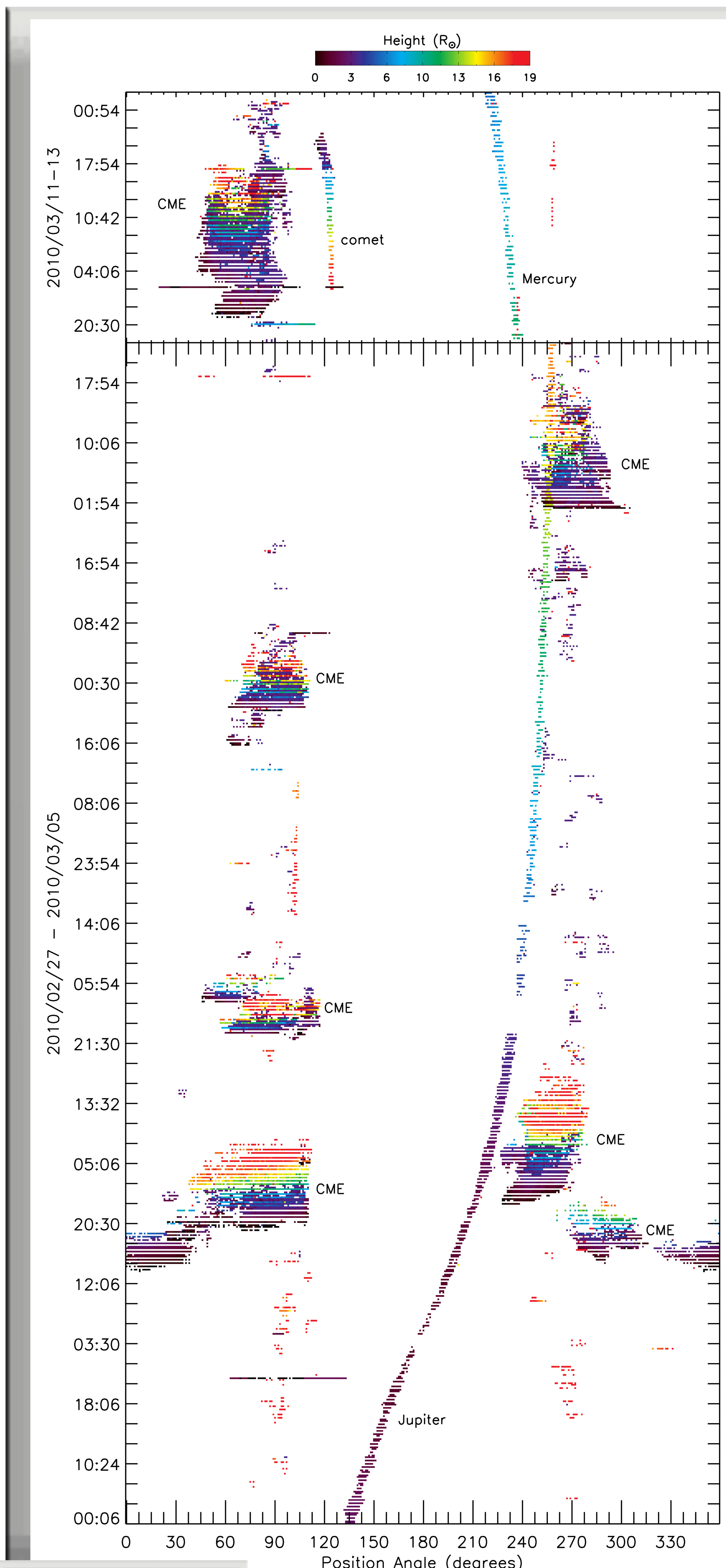
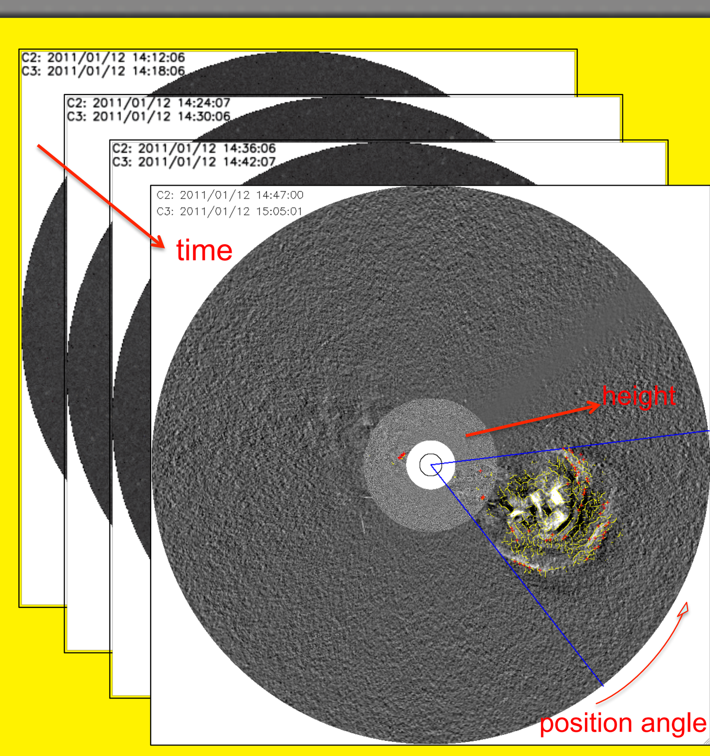


Figure 2

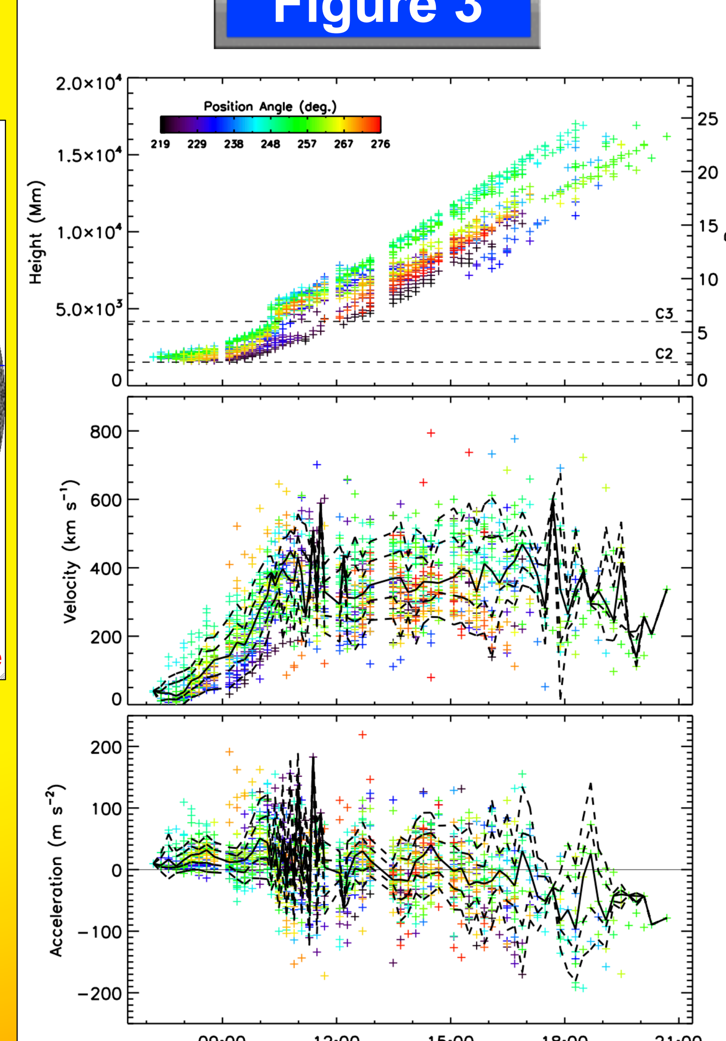
3. CME Kinematics & Morphology

A threshold on the edges is used to define the CME front: calculated from one median-absolute-deviation above the median strength of the edges[5] (resulting from the magnitude information of the multiscale filtering). The CME front is highlighted in red, on the overall structure traced in yellow (see right image).



CME height-time profiles are extracted along the angular span of the detections. Figure 3 shows an example of CME height-time measurements across position angles; and the resulting kinematics of the CME derived using a Savitzky-Golay filter. The median velocity (and acceleration) is determined from the angular distribution, along with the interquartile range and upper & lower fences.

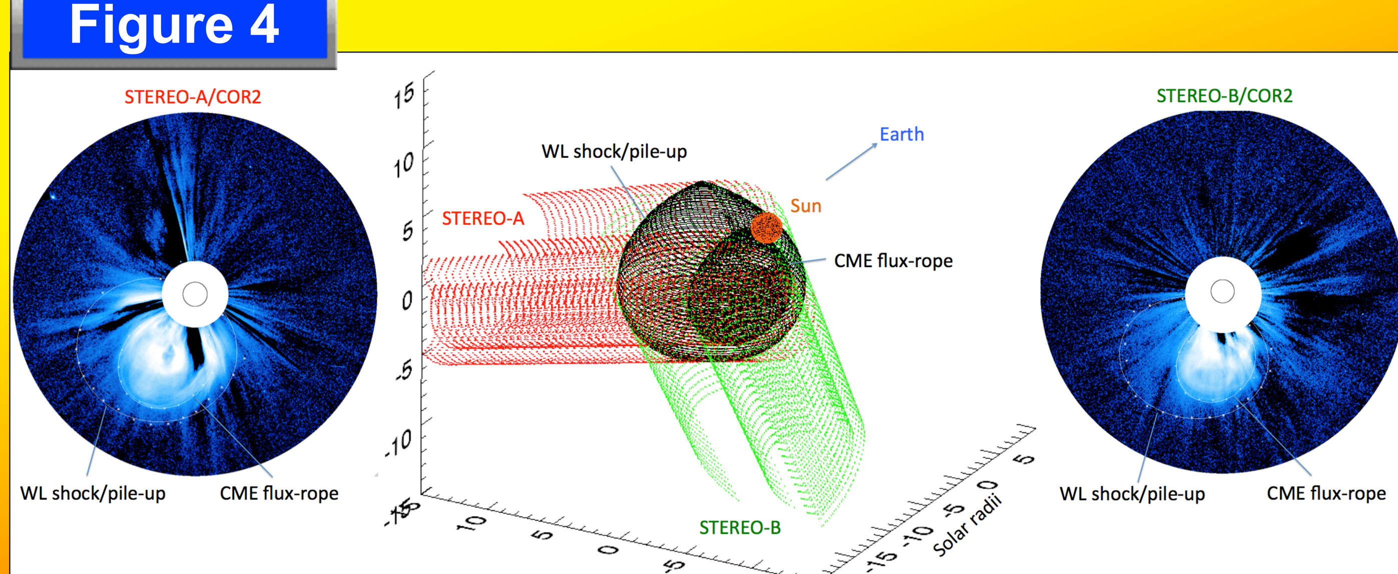
Figure 3



Byrne et al. (2013) highlight improved methods for determining the kinematics of CMEs and coronal waves, using appropriate fitting and bootstrapping techniques.

Byrne et al. (2014) investigate the initiation phase of a 'two-stage' eruptive event by applying these methods to observations from LASCO, Mk4, Proba2/SWAP and SDO/AIA.

Figure 4



Overcome plane-of-sky bias using 3D reconstructions of CME detections.

Figure 4 shows a 3D reconstruction of both the 'flux-rope' and 'WL shock/pile-up' components of a CME observed by STEREO on 2013/07/13; when the spacecrafts were in quadrature on the far-side of the Sun. This was done manually with the elliptical tie-pointing technique of Byrne et al. (2010), to demonstrate the future goals of this form of CME analysis with the available stereoscopic viewpoints (and the additional 'third-eye' of SOHO as in Carley et al. 2013).

4. Summary

We have described here the new CORIMP CME Catalog[4,5], that overcomes some of the issues of current cataloguing packages[1,2,3]. The CORIMP radial filtering[6] and quiescent background separation techniques[7] allow high-fidelity processing of coronagraph data, upon which a multiscale filter[8] is used to suppress the noise and characterise the complex CME structure across the entire field-of-view[9]. Thus the height-time profiles of the CMEs are determined across their full angular span. These allow a determination of CME velocity and acceleration[10], while the angular width provides a measure of plane-of-sky expansion. The filters implemented here also provide a method of characterising the internal CME structure, indicative of the underlying magnetic field[11]. Finally, STEREO observations allow for 3D reconstructions of CMEs to better determine their true kinematics and morphology[12,13].

@CMEcatalog

http://alshamess.ifa.hawaii.edu/CORIMP

5. References

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This work is supported by NASA grant NNX13AG11G & NSF grant AGS1358239.