Solar Physics
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THE HELIO 100 CME CHALLENGE

I.

Abstract

Studying the propagation and impact of solar eruptive events and their various manifestations is of great importance for understanding and predicting space weather conditions in the heliosphere. The Heliophysics Integrated Observatory (HELIO) was generated out of a need to robustly link the detections of solar-driven events at different locations in space, via remote-sensing and in-situ instruments onboard various spacecrafts. Under development since 2009, HELIO is now at a stage of great scientific benefit for large-scale studies of solar and heliospheric phenomena, through the generation of workflows that use HELIO to access and cross-correlate event lists and their measured properties.

The fourth HELIO coordinated data analysis workshop (HELIO CDAW-4) held in Trinity College Dublin in September 2012 outlined three challenges to be addressed by working groups comprising solar physicists and computer scientists. The challenges were titled: (1) "Heliospheric variability over the solar cycle"; (2) "The 100 CME challenge"; and (3) "HELIO as a tool for space weather". In this paper we outline the success of challenge (2), that focused on using HELIO to study the origin, propagation and impacts of a large number of coronal mass ejections (CMEs) in the heliosphere. HELIO provides an interface that allows researchers to track active regions as they evolve and produce solar flares and CMEs. Once launched, CMEs can be tracked in coronagraph and heliospheric images. Their impacts throughout the heliosphere can then be measured using in-situ instruments from a number of spacecraft throughout the solar system. The aim of this challenge was to use HELIO to track a large number of CMEs that had an associated type II radio burst from their source region on the surface of the Sun, and possible flare occurrence, to their effects through interplanetary space. This was achieved through the generation of a workflow that accessed the corresponding event lists and used a ballistic CME propagation model to predict each event's arrival time at Earth and elsewhere in the solar system. This provides a timeframe for determining the in-situ parameters measured at the different spacecraft locations where a CME impact was detected, and thus allows us to combine the data across multiple spacecrafts on a per-event basis for comprehensive analysis of the physics of their propagation and evolution.

Poster:

Studying the propagation and impact of solar eruptive events and their various manifestations is of great importance for understanding and predicting space

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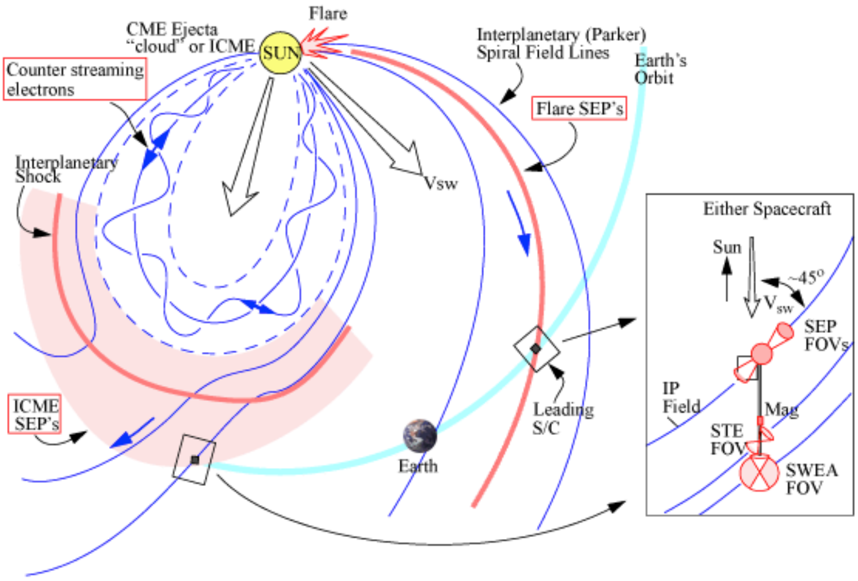

Figure 1.

weather conditions in the heliosphere. The Heliophysics Integrated Observatory (HELIO) provides an interface that allows researchers to track coronal mass ejections (CMEs) from their source region on the Sun, to their effects in interplanetary space. The aim of this challenge was to use HELIO to track a large number of CMEs having an associated type II radio burst and possible flare site on disk, through interplanetary space via their detected impacts at various spacecrafts. This was achieved by generating a workflow that accessed the corresponding event lists and used a ballistic CME propagation model to predict each event's arrival time at the expected impact sites (e.g. L1 near Earth). This provided a timeframe for determining the in-situ parameters measured at the different spacecraft locations along the CME trajectory, and thus allowed us to combine the remote-sensing and in-situ data across multiple spacecrafts on a per-event basis for comprehensive analysis of the physics of their propagation and evolution.

1. Introduction

2. Building a workflow

The challenge group began by choosing a 'test case' CME for tracking through the HELIO interface, and building a model workflow to be ultimately extended for a large scale study of many events. The CME chosen was a fast event associated with a flare and type II radio burst, as listed in the "Wind/WAVES type II bursts and CMEs" list [1]. The radio burst was detected at 04:20 UT on 11 April 2004, with an associated NOAA C 9.6 flare at disk location S 14 W 47, and CME observed in LASCO at 04:30 UT with central position angle 203°, angular width 314°, and speed $1645\,\mathrm{km\,s^{-1}}$.

The workflow was built in the following manner:

i) A time interval is specified and input to the "Wind/WAVES type II bursts and CMEs" list to retrieve a list of events within the given time-range of interest.

ii) From the list of candidate events, those having the fastest velocity CMEs were isolated and the top 100 chosen for the purposes of this challenge.

iii) The GOES X-ray flare list was then inspected for any associated flaring activity on the disk, within a specified window of ±1 hour on each event time-range.

iv) Since the "Wind/WAVES type II bursts and CMEs" list is compiled manually, the automated CACTus CME catalogue is inspected in order to associate CME parameters that carry a robust determination of their parameters (i.e. the automated detections output CME speeds, position angles, widths, etc.).

v)

[1] http://cdaw.gsfc.nasa.gov/CME_list/radio/waves_type2.html