Identification Method of Coronal Mass Ejection and Its Propagation

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ABSTRACT
We use a geometrical model to detect the propagation and the velocity of Coronal Mass Ejection, then using the data of STEREO (Solar Terrestrial Relations Observatory), we reconstruct the CME in space. By using this model we can detect the occurence of the CME and its propagation in space. On August 4, 2011 a strong M9.3 flare is erupted from active region NOAA 1261 which was located on 15°North and 49°West of solar hemisphere. This flare was accompanied with a Coronal Mass Ejection (CME). We can derive the variation of this CME speed and its propagation by analyzing the COR2 SECCHI STEREO data.

Keywords: Coronal mass ejection, velocity, propagation

8 INTRODUCTION

Coronal Mass Ejection (CME) is a phenomena released from the Sun which bring huge amount of energetic particles and magnetic field. Such phenomena, when it is headed to the Earth will lead to a significant effect to Earth's environment, therefore it is very important to observe and analyze the phenomena soon and then predict the propagation of the event for the early warning purpose.

The understanding of the propagation of Coronal Mass Ejection (CME) in space is very important to see its effect if the propagation directed toward the Earth. SOHO (Solar and Heliospheric Observatory) is a satellite which used to observe the phenomena on the Sun, one of them is CME. The CME is observed by LASCO (Large Angle and Spectrometric Coronagraph). It observes photospheric light dispersion emitted by free electrons in solar corona and gives information about the integrated density along the line of sight, therefore it does not give the information of the real propagation direction of CME.

To have better understanding, the twin satellites STEREO (Solar Terrestrial Relations Observatory) observes the stereoscopic images of the Sun. It can detect the occurrence of CME and define the propagation of CME in 3 dimensions as well [1] [2]. We reconstruct the CME event of the August

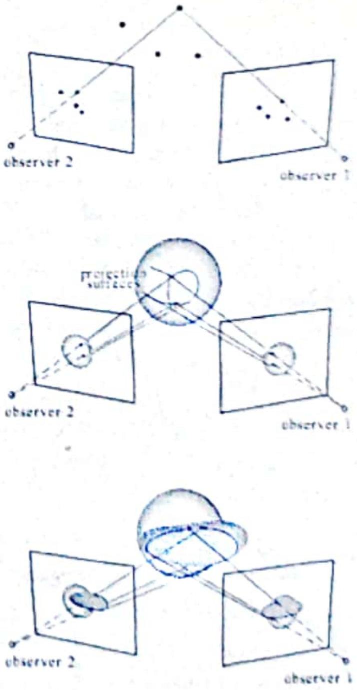

Figure 1. Reconstruction of point sources (top), curve (middle), and surface (bottom), which explain the different situations which have to be reconstructed [4].

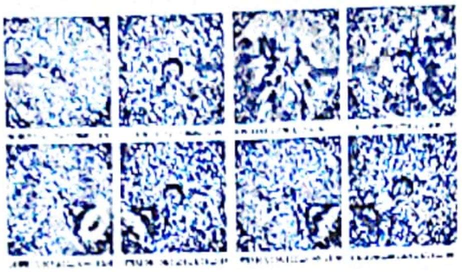

Figure 2. The arrows mark of the feature of CME, from the start of the occurences of the CME and the subsequences pictures show the evolution of the features. The pictures from 06:39 UT show the new emergence, while the previous one still developing.

4, 2011 CME by analyzing the data of STEREO COR2, based on quick detection method of [3].

9 DATA AND METHOD

STEREO observation is conducted from two observation points, by STEREO A and B, which orbits on the preceding and following Earth's orbit with identical instruments. It allows the instruments to observe the Sun from different angles. The images can be used to reconstruct the images in space.

The two observer positions and any object point to be reconstructed exactly define a plane. For many object points there are many planes but all have in common that they contain the two observer positions. Any of this set of planes which contains the two observer positions is called an *epipolar* plane and these planes form a natural geometrical basis for our reconstruction coordinate system (see Figure. 1)[4], while the mathematic description described in [3].

We analyze the sequences from COR2 STEREO images using difference imaging between subsequence images to follow the evolution of the features from the Sun, and calculate the propagation in the interplanetary space, as described in the several pictures in Figure 2. Two features identified as possible CME occurrences (marked with arrows).

As have seen in Figure 2, the first occurrence observed on the 1st data on 04:39 UT, marked with the red arrow on the pair STEREO A and B of the plate 04:39 UT (upper left picture).

While the the first occurence still develop, the second event occurs on the opposite side of the Solar disk, marked with the red arrow on the second picture on the Figure 2 for the pair of STEREO A and B (picture on the upper right, observed on 06:39 UT).

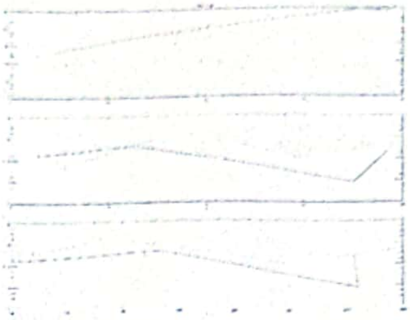

Figure 3. The cartesian transformation of the two CMEs to describe how the CMEs propagate in space. The solid line represents the first, while the d dotted line represents the second CME

The method discussed above is used to identify possible CME propagation of the event on August, 4th 2011. An M9.3 flare associated with a CME blasted out from the Sun. This flare located on Active Region 1261.

During the period of the observation, the Earth is situated at the separate angle (γ = 166°.763) between STEREO A and B. We can obtain the difference Δλ in ecliptic longitude of the object (detected features from CME) from the Earth, by the method described in [3].

10 RESULT AND ANALYSIS

Table 1 shows the measured features from the CME as the difference of the ecliptic longitude from the Earth, and the longitude column describe the possibilities of the CME will hit the earth. From the result shows that only the first occurrence, with average speed of 1705.75 km/s directed toward the earth (on the longitude range of [0,π/2]), while the following event with average speed 1436.89 km/s is unlikely propagating toward the earth, due to longitude range of [-π,-π/2].

We also try to transform the information into the Cartesian coordinate to see how those CMEs propagate, as shown in Figure 3. The cartesian transformation shows that the two occurrences are similar in nature (the solid line is the first and the dashed for the second occurrence), but only the earlier CME that directed toward the Earth.

Table 1. The calculated difference of the ecliptic longitude from the Earth and the longitude of CME occurrences.

Time Observed (UT)	Δλ (°)	longitude
04:39	87.93	[0,π/2]
05:39	88.26	
06:39	89.57	Average speed:
07:39	88.89	1705.75 km/s
10:39	88.32	[-π,-π/2]
11:39	87.59	
12:39	88.96	Average speed:
13:39	88.82	1436.89 km/s

11 CONCLUSION AND DISCUSSION

The information of the occurence of CME is very useful in the space weather information system. The information should include the velocity and the propagation of the CME in the space in order to predict the geoeffectiveness. We use the identification method developed in [3] to identify the velocity and the propagation of CME.

From our analysis, we found that for two occurences on August, 4th 2011, only one event, (04:39 UT) that most propability has the geo-effectiveness. Our calculation estimates the average speed of the CME 1705.75 km/s. The CME with this typical speed will impact the Earth approximated in around one day.

In using this identification method, both of the STEREO spacecraft have to be in ecliptic plane, and the object(s) have to be located near enough from the Sun. Unfortunately , this method has a sistematical error, it can not be applied for the feature(s) that located less than 2 solar radii.

The information described above shows the propagation of CMEs in the Space derived from the STEREO observations. From the two events observed, only one occurence that likely propagate toward the Earth.

The method is sufficiently good to approximate the propagation of CME since the occurrence, during the propagation in interplanetary space, and the possibility to impact the Earth environment.

However, in order to have a better picture of geo-effectiveness and better accuracy to estimate the probability of an event, there is the need for more spatial and temporal data.

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