A new ICMEs catalogue: Tracking a CME from Sun to the Earth

A.Ne.Mo.S
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FLARES, CORONAL MASS EJECTIONS AND SOLAR ENERGETIC PARTICLES: SPACE WEATHER IMPACT

Abstract: It is well known that the interplanetary coronal mass ejections (ICMEs) play the most important role on the interactions with the magnetosphere as they are the dominant drivers of intense geomagnetic storms. A number of 266 ICMEs associated with CMEs were spotted from SOHO-LASCO coronagraph and their characteristics were calculated by in situ observations from ACE data covering the years 1996–2009 are presented. The result of this study is a new ICME catalogue which contains all the available information. Especially, characteristics of a) the CME obtained from LASCO list which is responsible for the upcoming ICME, like the linear speed, the angular width and the coordinates on the Sun, the peak time and the active region of the associated solar flare, b) the initial/background solar wind plasma and magnetic field conditions before the arrival of the CME, such as the solar wind speed, the magnetic field B, the southward component Bz, the proton temperature and density, the ratio of alpha particles to protons and the plasma β, c) the sheath of the ICME, such as the presence or not of a shock wave, the arrival time of the ICME-driven shock and the solar wind plasma and magnetic field conditions of the sheath, d) the main part of the ICME, like the solar wind plasma and magnetic field conditions, the duration of the ICME with start/end time and the transit velocity from Sun to Earth, e) the geomagnetic conditions of the ICME's impact at Earth, such as Ap and Dst indices and the exact time of their maximum and minimum values, respectively and finally f) remarks on every event, are determined. Interesting results revealed from this study as the high correlation coefficient values of the magnetic field Bz component and the Ap index (r = 0.86), as well as the Dst index (r = 0.82), of the effective acceleration against the CME linear speed (r = 0.92) and of the transit velocity against the linear speed of the CME (r = 0.70). The amount of information makes this new catalogue the most comprehensive ICMEs catalogue for the solar cycle 23.

Introduction

Why ICMEs are so important?

ICMEs and high speed streams of solar wind emanating from coronal holes are the dominant factors for geomagnetic storms. Previous studies have shown that intense geomagnetic storms are mainly caused by ICMEs usually associated with halo CMEs (Gopalswamy *et al.*, 2007), while moderate and minor storms can be caused by both ICMEs or high speed streams of solar wind (Zhang *et al.*, 2007; Richardson and Cane, 2010)

A new ICMEs catalogue

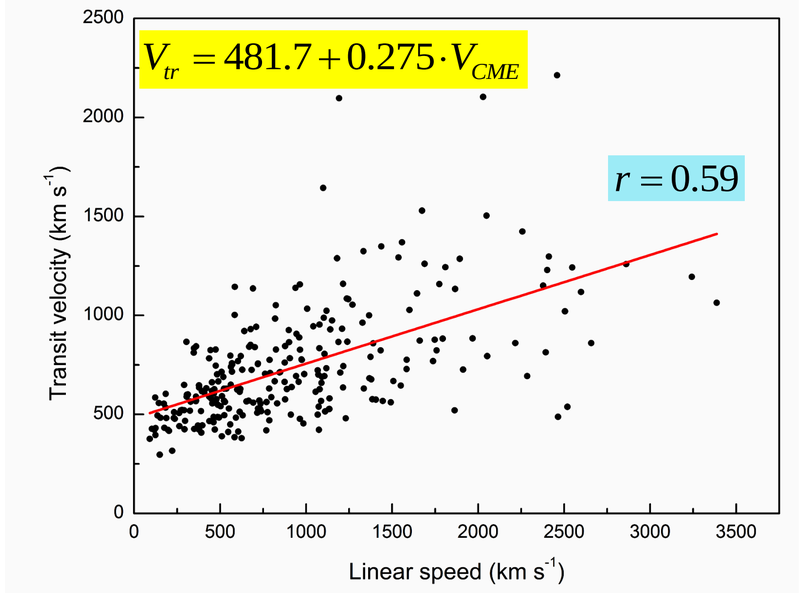
The new perspective of the present study could be divided in two major contributions. These ICMEs are events which are firstly spotted from SOHO/LASCO coronagraph and then examined using in situ measurements from the ACE spacecraft. Furthermore, it is the first time that as many as possible information per event is gathered in one catalogue.

Tracking from SOHO/LASCO and in situ observations from ACE satellites

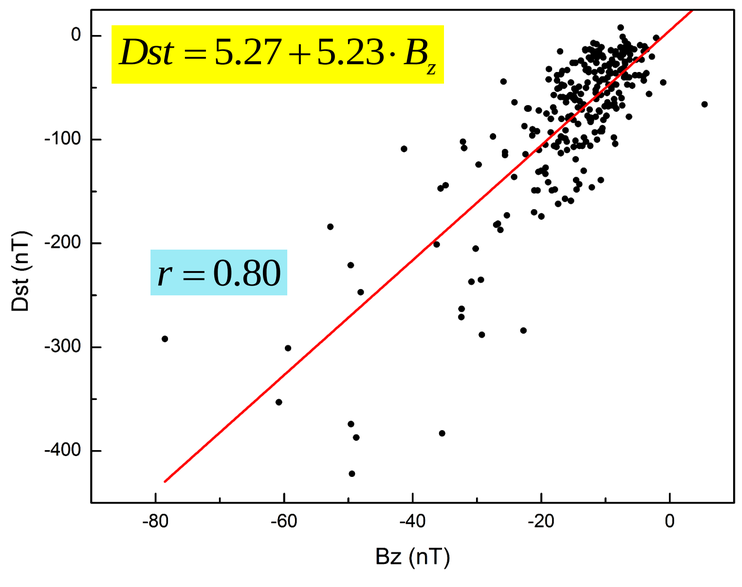
Study of each ICME using magnetic fields and solar wind plasma ACE 64-sec averages data for the CME at first spotted by SOHO/LASCO, was performed. This new catalogue contains also information for the associated solar flares and the geomagnetic conditions on Earth.

Statistical Analysis of ICMEs

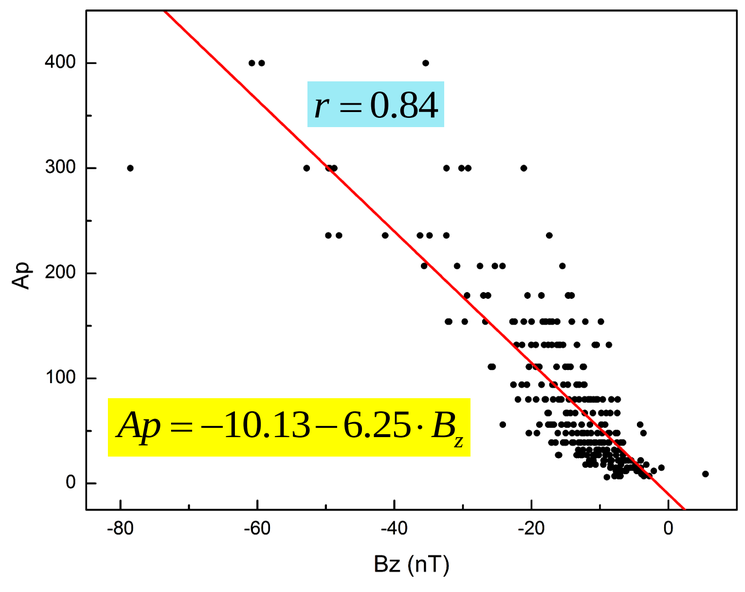
Transit velocity and CME linear speed



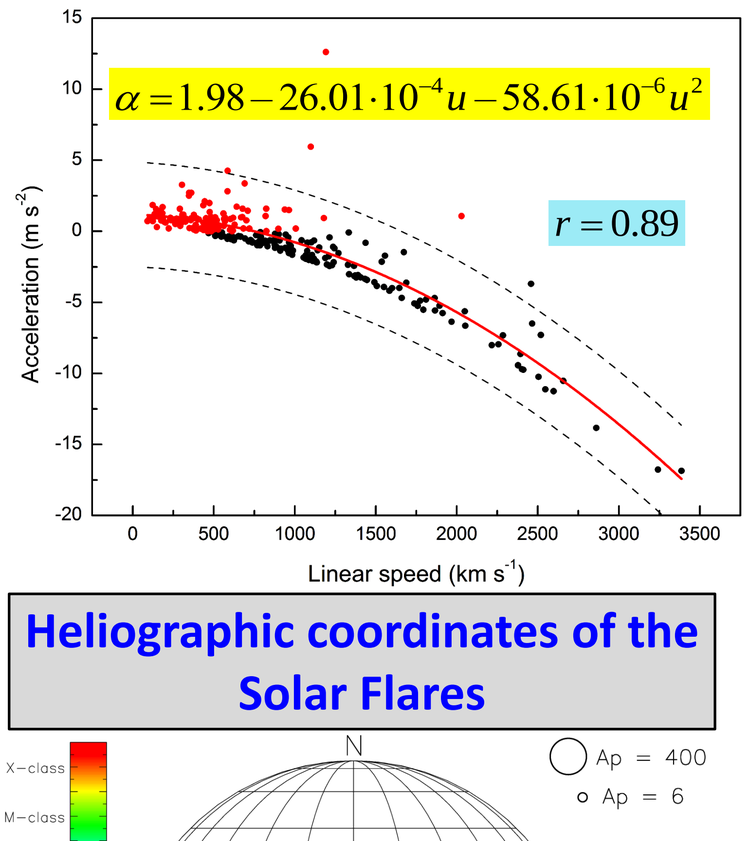
Dst index and Bz component



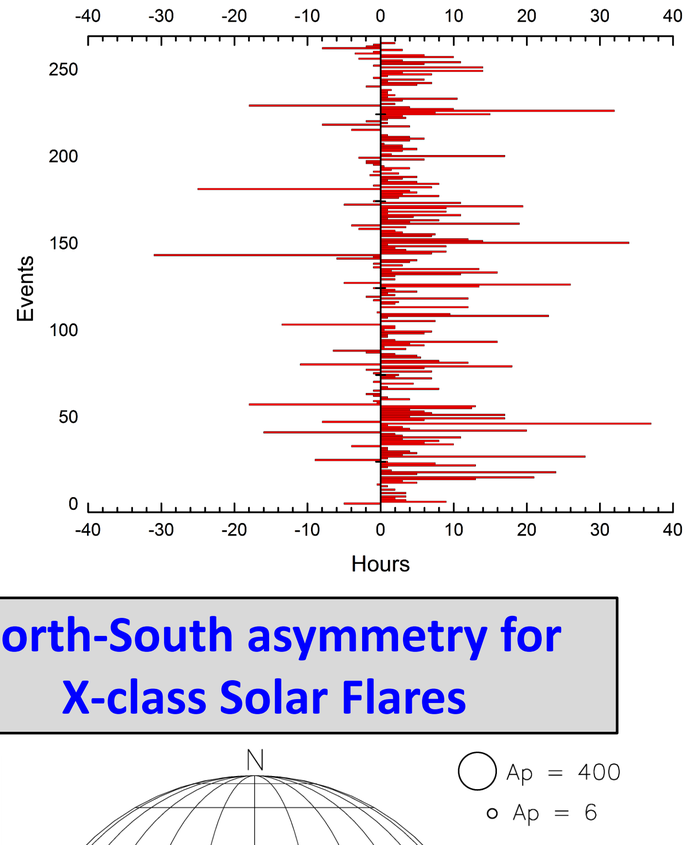
Ap index and Bz component



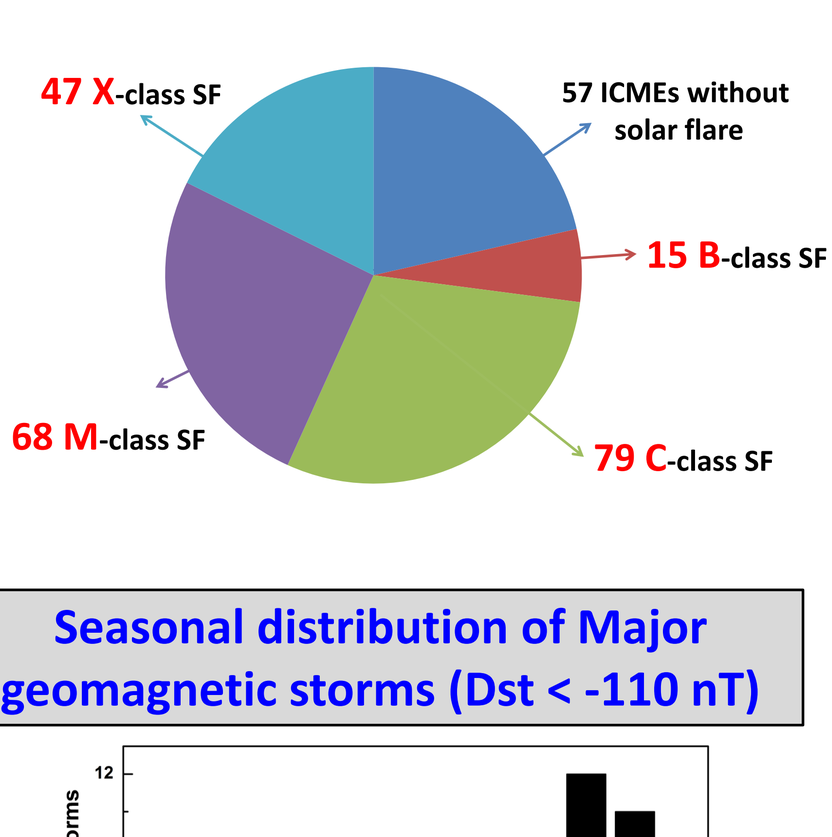
Effective acceleration and CME linear speed



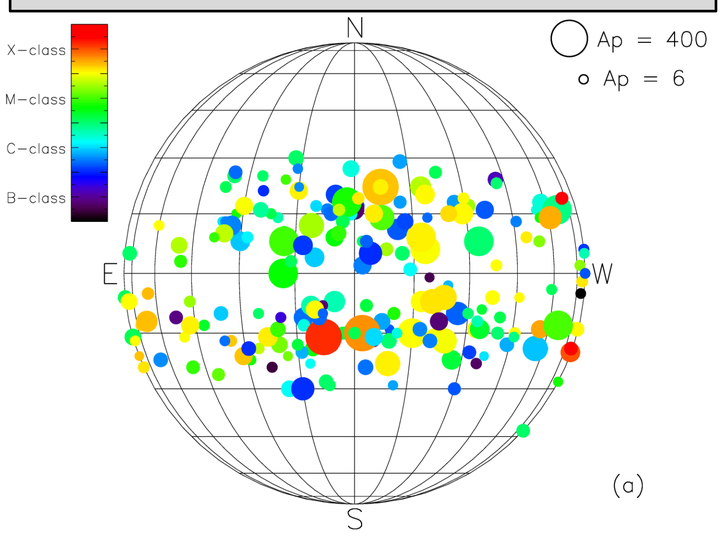
Dst minimum and Ap maximum occurrence times



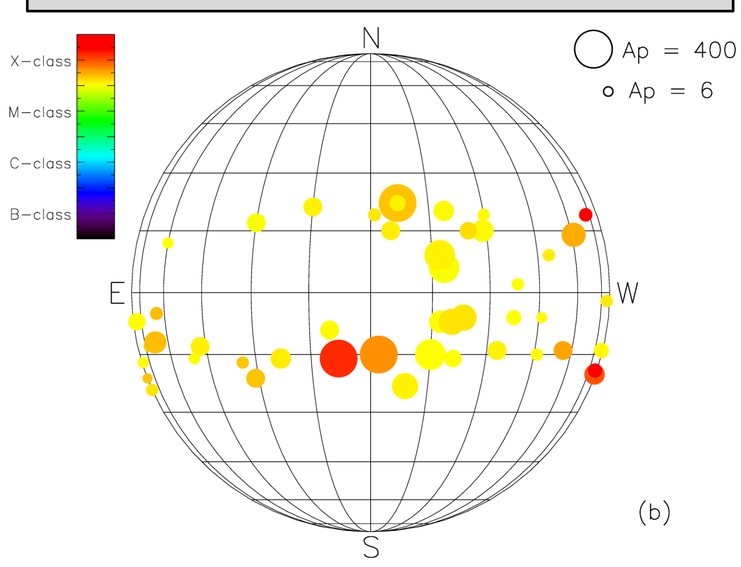
CMEs and associated Solar Flares



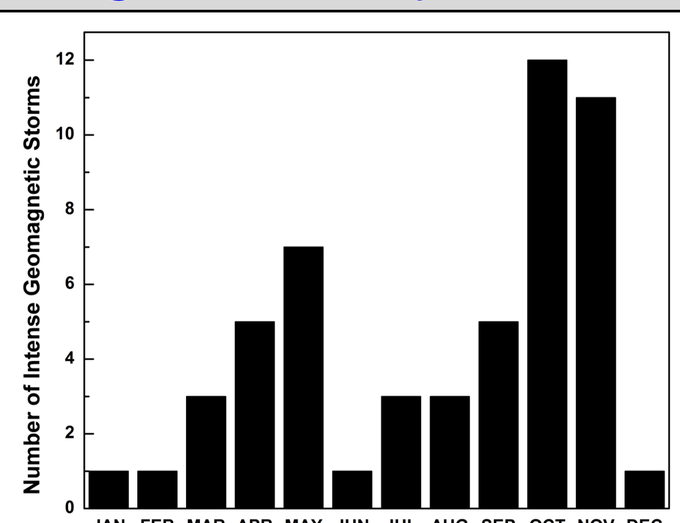
Heliographic coordinates of the Solar Flares



North-South asymmetry for X-class Solar Flares



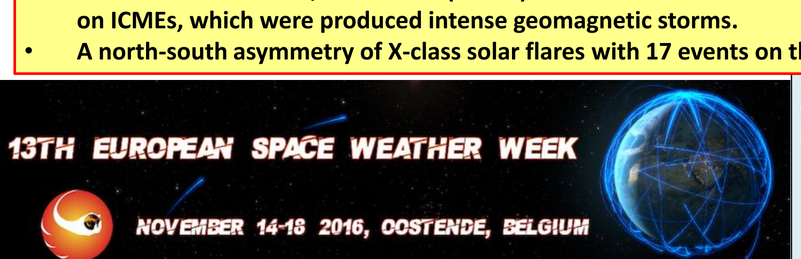
Seasonal distribution of Major geomagnetic storms (Dst < -110 nT)



Conclusions

From the study of a number of 266 ICMEs it was concluded that:

- The minimum value of the southward component of the magnetic field Bz during an ICME was very well correlated with the Dst minimum value of the geomagnetic storm with a correlation coefficient r = 0.80.
- The minimum Bz value (in the sheath or in the ICME) and the Ap-index maximum values are highly correlated to r = 0.84.
- The transit velocity of the CME and the calculated effective acceleration of all the examined events, gives a cross correlation coefficient r = 0.82.
- For strong geomagnetic storms (33 events with 179 < Ap < 400) the Ap maximum was recorded almost 4 hours before the Dst minimum.
- In a total of 266 CMEs, 209 events (78.6%) were associated with solar flares while 57 events (21.4%) were not associated. Moreover, larger and more energetic solar flares were associated with faster Earth-directed CMEs, resulting on ICMEs, which were produced intense geomagnetic storms.
- A north-south asymmetry of X-class solar flares with 17 events on the northern hemisphere and 30 events on the southern hemisphere, was revealed.



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