Active Region Magnetic Parameters as Proxies for CME Velocity Prediction

S. Aswin Amirtha Raj, A. Shanmugaraju, P. Vijayalakshmi
Arul Anandar College, Madurai – 625514, India.

Purpose of the Research

To find the relationship between the CME velocity and Sunspot Magnetic properties

Check whether those relations are constant for all types of CMEs(in our case Slow and fast CMEs)

To explore the possibility of using SHARP parameters as a proxy to predict near-sun CME velocity

Introduction

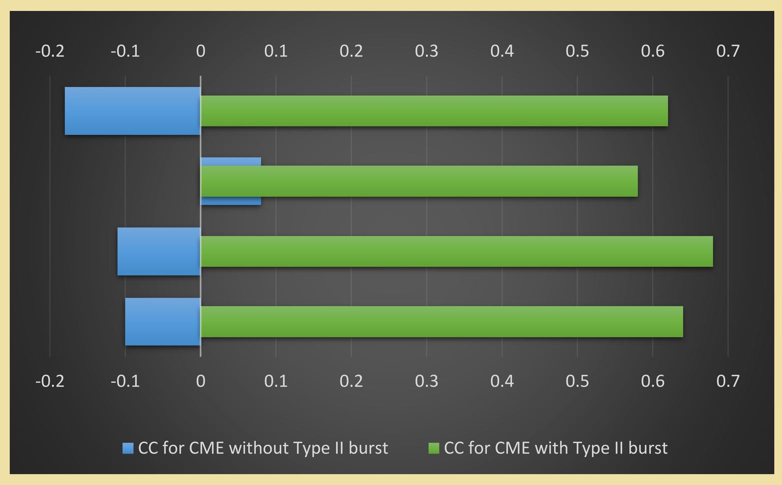
Coronal Mass Ejection (CME) plays a vital role in shaping the space weather. Most of the intense CMEs mainly originate from sunspots. Hence comparing their properties is useful for predicting and mitigating their effects Especially, predicting CME Velocity will aid in

- Predicting SEP properties and their arrival time prediction.
- To Estimate the geo effectiveness of the CME before reaching earth

The recent trend in using ML for predictions also demands us to find the best proxies to train and test the ML models for better prediction hence studying the correlation between the source

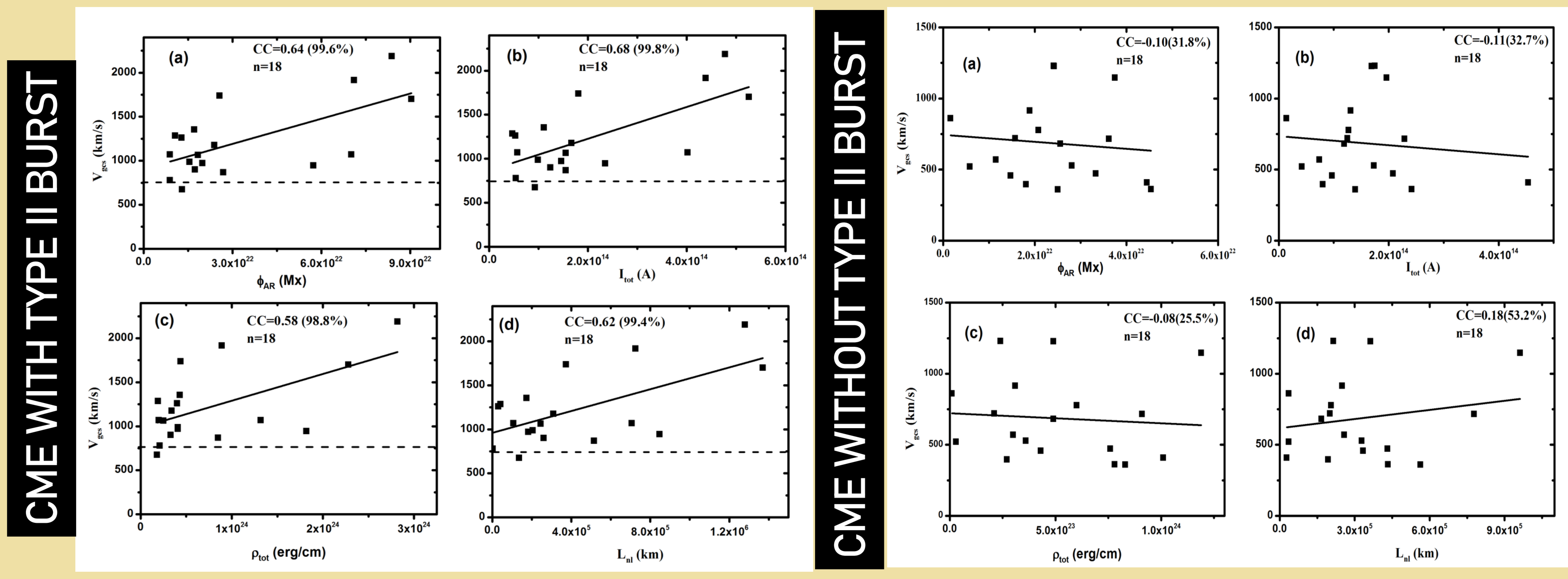
In our case, AR properties with CME velocity are essential to predict CME velocity

Motivation



In our previous study, "Magnetic Properties of Source Regions of CMEs and DH Type II Radio Bursts", we observed intriguing correlations between CME velocities and sunspot properties for CMEs with and without associated Type II radio bursts. Our findings revealed that CMEs accompanied by Type II bursts showed strong correlations with certain sunspot magnetic properties such as **total unsigned magnetic flux, vertical current, magnetic free energy density, and the length of the strong-field neutral line. As shown below in the figures**

While the correlations were weak in the latter case, this prompted a further investigation to understand why these properties differ across CME types, forming the basis of our current research.



Approach

Event Selection

We used CME events from **Solar Cycle 24** and studied **36 events** they were selected based on the following Criteria

- CMEs with a well-defined three-part structure.
- CMEs that appeared as a single event in the coronagraphs of the SECCHI on board STEREO spacecraft A and B.
- Events that originated on the Earth-facing side of the Sun within ±45° longitude from the disk center.
- CMEs with their source regions identified by NOAA and vector magnetograms available from the HMI.

Classification

The Selected CMEs are classified into two groups based on the GCS CME velocity (near the sun)

CMEs

- Group I: CME Speed ≥ 700 Km/s
- Group II: CME Speed ≤ 700 Km/s

Data

CME velocity

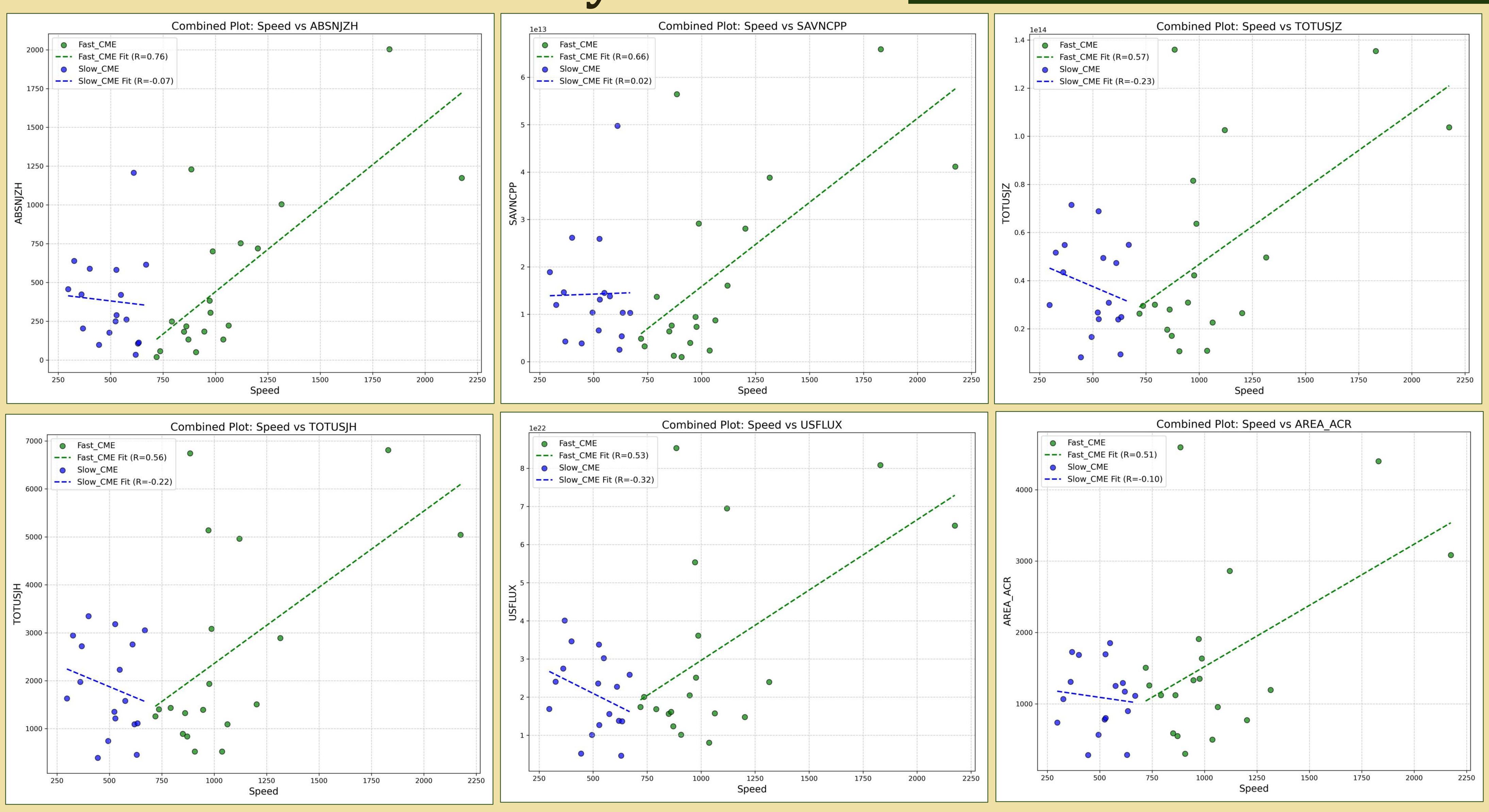
Using the Graduated Cylindrical Shell (GCS) forward modeling technique, we calculated deprojected speeds for 36 selected CMEs by integrating data from SOHO LASCO and STEREO coronagraphs.

Sunspot properties - SHARP Parameters

The SHARP parameters are 18 standardized metrics derived from solar magnetic field data, focused on active regions. They assess magnetic properties like flux, shear, and current density, aiding in solar activity prediction and space weather analysis. In this poster, we provide a list of the first 5 well correlated SHARP parameters wrt CME Velocity which are

- **ABSNJZH** (Absolute value of the Net Current Helicity) $=|\sum J_z B_z|$
- **SAVNCPP** (Sum of the Absolute Value of the Net Current Per Polarity) $=\sum|J_{z+}+J_{z-}|$
- **TOTUSJZ** Total Unsigned Current Helicity)$=\sum|B_z \cdot J_z|$
- **TOTUSJH** (Total Unsigned Current Helicity)$=\sum|J_z|$
- **AREA_ACR** (Area of Strongest Magnetic Field)
- **USFLUX** (Total Unsigned Magnetic Flux):(Φ) $=\sum|B_z \cdot dA|$

SHARP Vs CME velocity



Result And Discussion

The scatter plots for both Group I and Group II With their CME velocity on the x-axis and corresponding SHARP parameters on the y-axis is shown on the figures on the right. the linear regression fit for each parameter, with correlation coefficient (R) is mentioned on the the top left corner of each plot.

The Key observations from the plot include:

Group I (Fast CMEs): (in green Color ●)

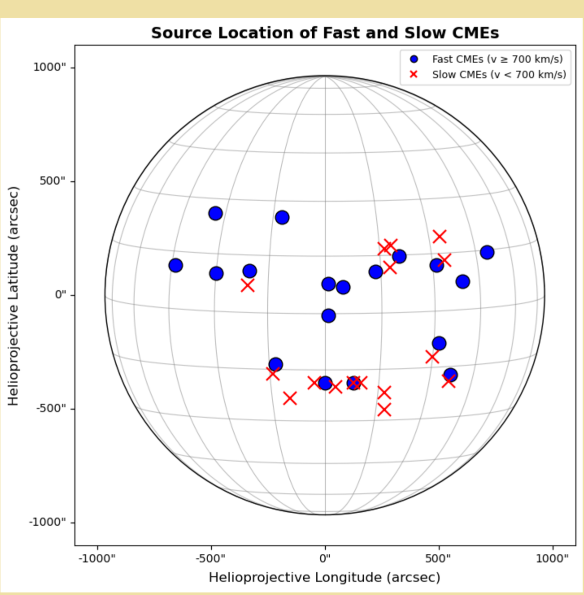
Good Correlation indicating that the SHARP parameters MENTIONED are effective predictors for fast CMEs.

Group II (Slow CMEs): (in Blue Color ●)

Weak or negligible correlations, suggesting that SHARP parameters may not be adequate for predicting Slow CME speeds.

These results indicate that - SHARP parameters are valuable for predicting fast CME velocities, they fall short for slow CMEs.

Event's Location



We didn't filter the events based on the location but from event location plot we can see many Group I events are in Northern hemisphere and Group II are in southern hemisphere

Does location have any influence on this speed-based Correlation? is still a question

We are working

Conclusion

Our findings suggest that SHARP parameters can be used to predict fast CME velocities effectively. However, for slow CMEs, these parameters lack predictive power. The real time prediction of CME velocity will be accurate if and only if we can able to separate the Fast CME from the slow

This discrepancy emphasizes the need for additional research to identify or develop new proxies that can improve prediction models for slow CMEs.

our Ongoing work aims to uncover the underlying causes of this variation, potentially enhancing the predictive capacity of space weather forecasting models for all CME types.