

Coronal dimmings associated with coronal mass ejections on the solar limb

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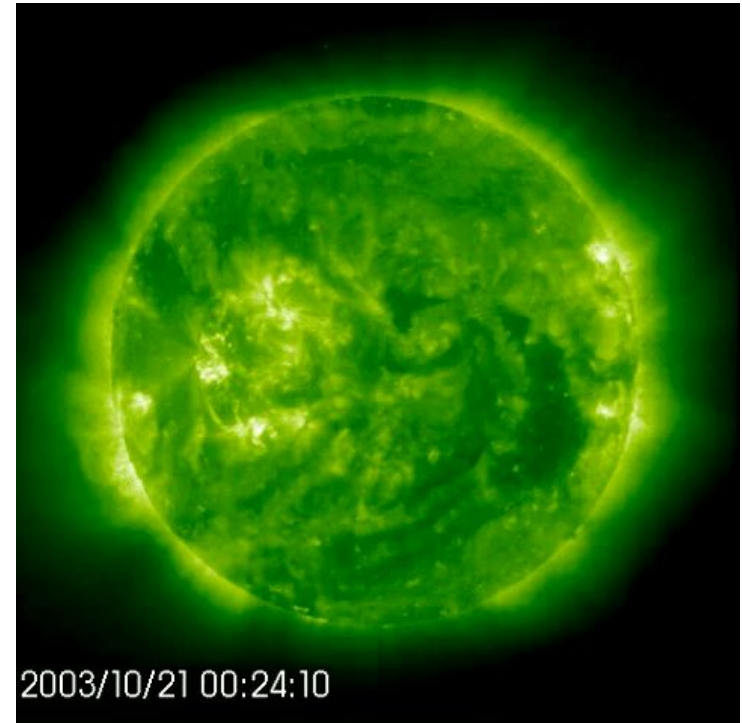


Introduction to the topic

Coronal Mass Ejections - huge clouds of magnetized plasma that are expelled from the Sun to interplanetary space.

Speed: 100-3500 [km/s]
Emitting billions tons of matter

Affects: Satellites,
Airplanes, Communication systems,
Navigation systems



CME on 28-Oct-2003 (SOHO):

47 satellites reported anomalies

1 satellite was lost

10 lost operational service for more than 1 day

Instruments for CME detection

Mostly CMEs are observed with coronagraphs:

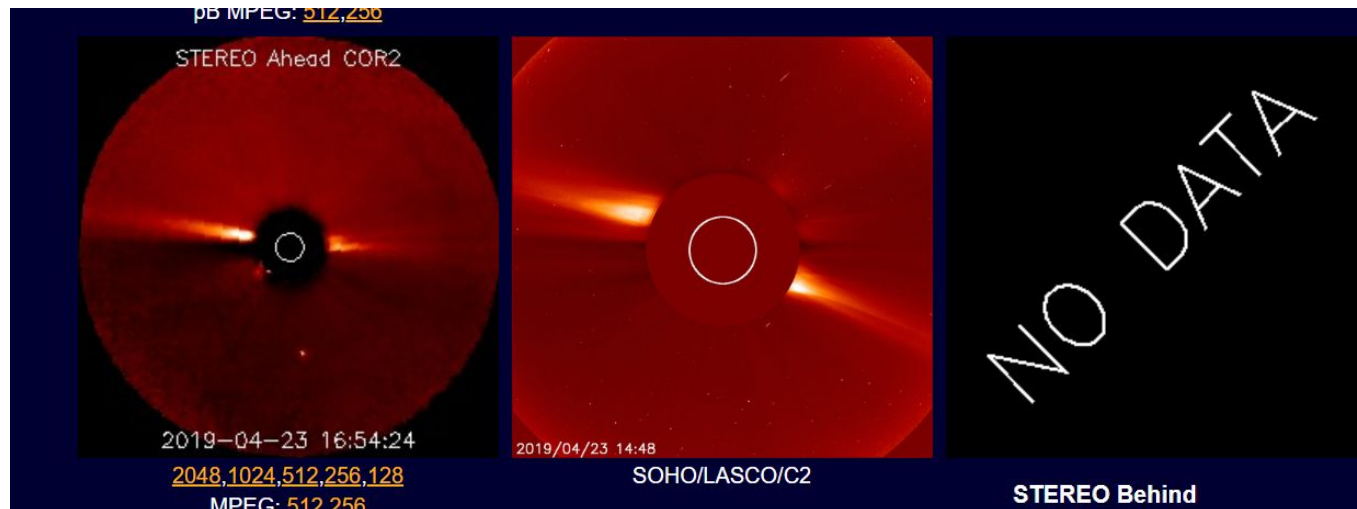
LASCO on SOHO's board (1995 -)

STEREO A (2006 -)

STEREO B (2006 - 2016)

satellites lifetime ~ 15 years

new missions with coronagraphs: only in 2024



screenshot from <https://stereo-ssc.nascom.nasa.gov>

Earth-directed CME

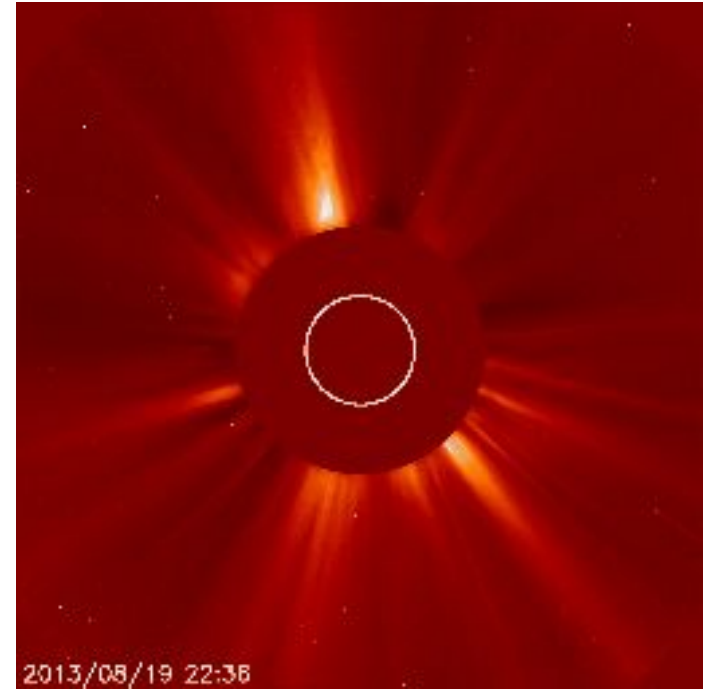
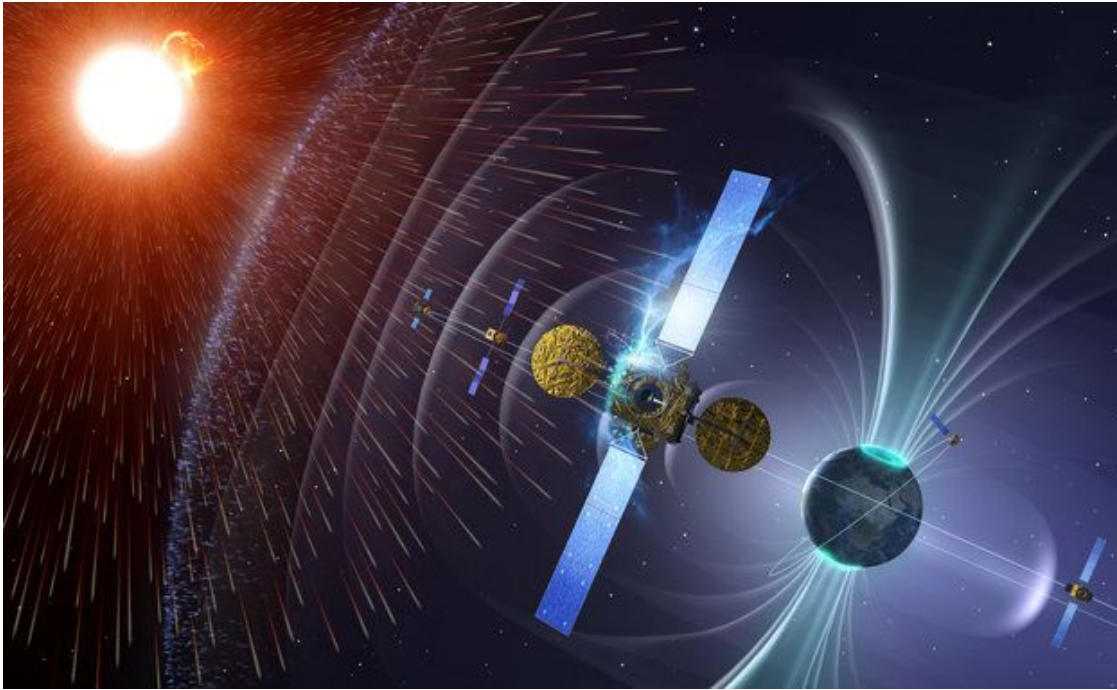
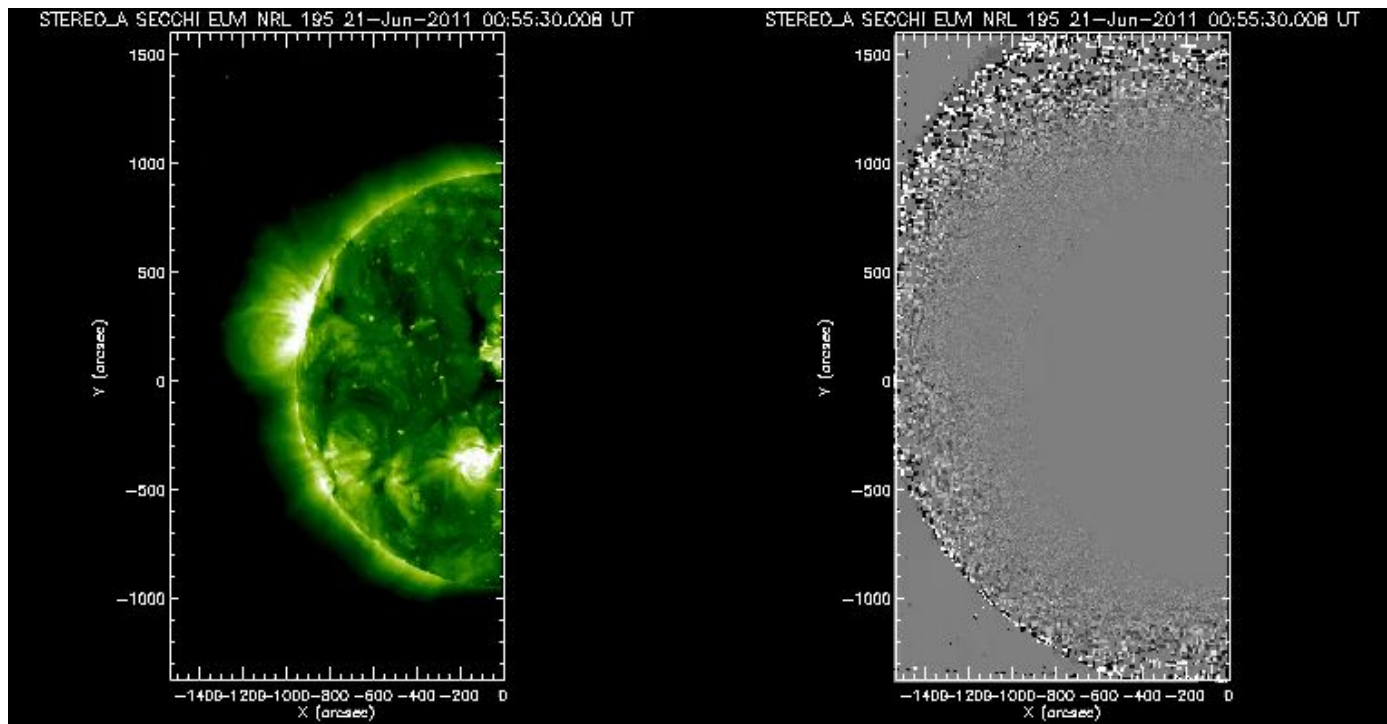


image source: LASCO

- the main drivers of space weather disturbances affecting near-Earth environment
- can be million times larger in volume than Earth
- allow the least accurate measurements due to projection effects

Coronal dimmings

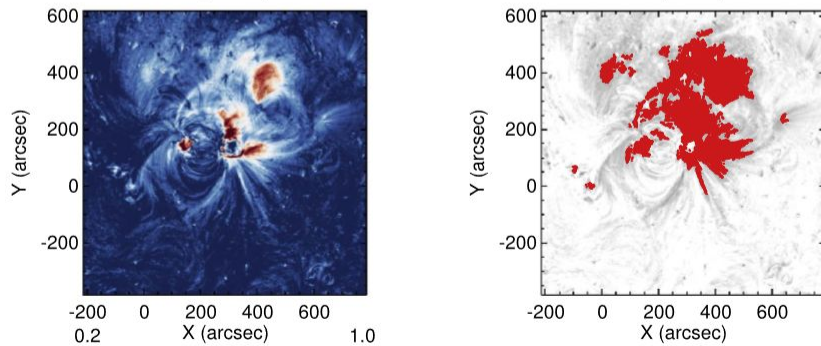
transient regions of strongly reduced emission in soft X-rays (SXR) and extreme-ultraviolet (EUV) emission that occur in association with CMEs in the low corona.



formation of the dimming: density depletion due to plasma evacuation

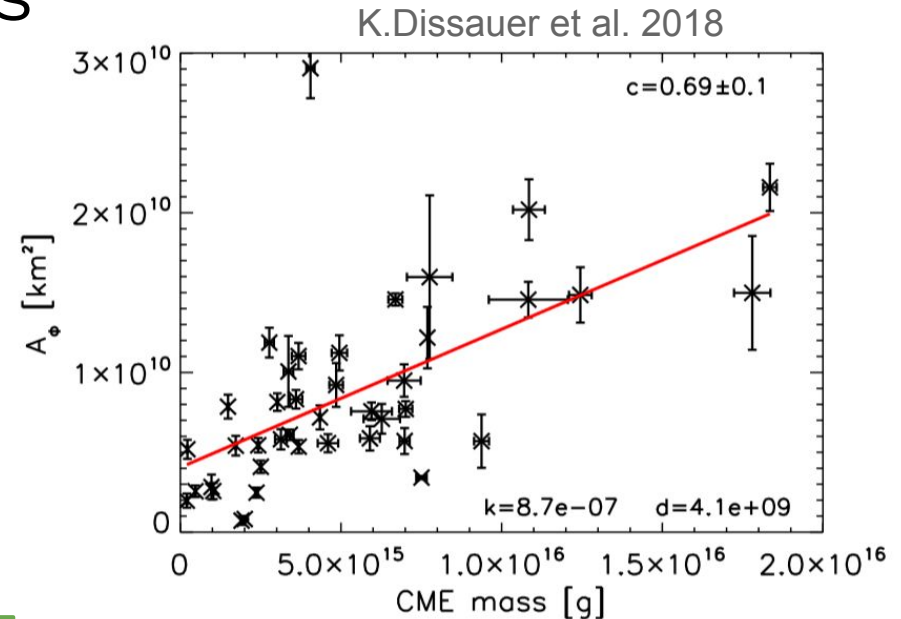
off-limb dimming on 21-Jun-2011

K.Dissauer's work - the 1st statistical analysis of the dimmings



Processed image and dimming mask

The CME mass shows the strongest correlations with first-order coronal dimming parameters; the maximal speed of the CME is strongly correlated with second-order dimming parameters

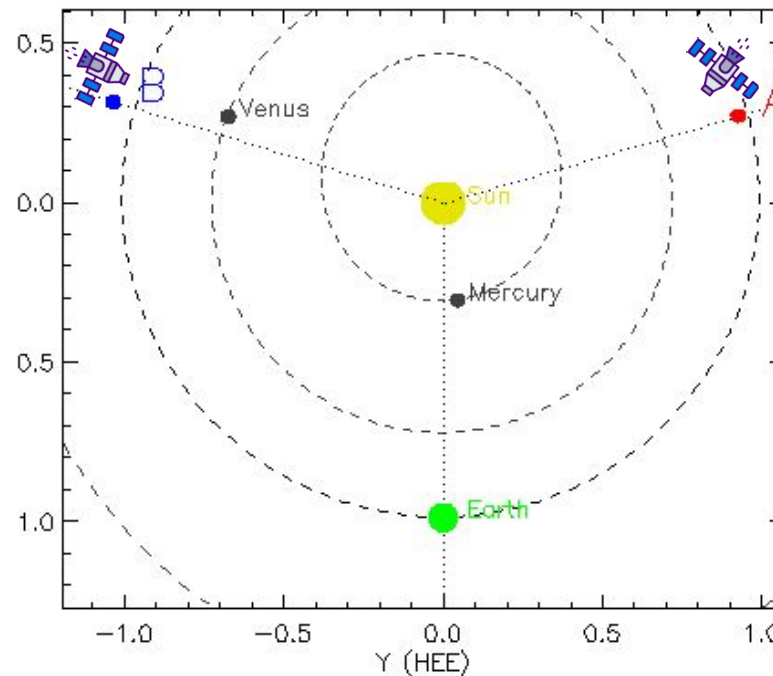


correlation between area of the dimming and mass of CME

- 62 events
- 7 EUV wavelengths from SDO AIA + LOS magnetograms

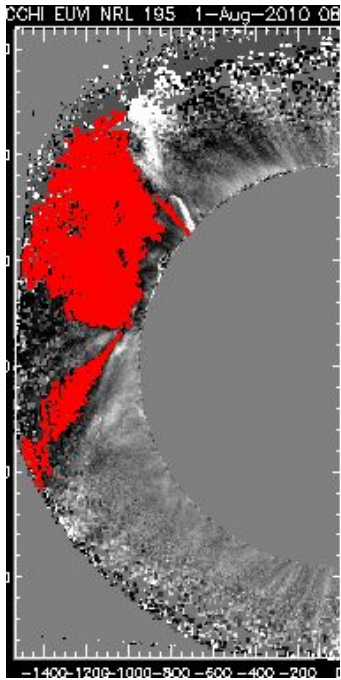
Current project

Aim of the project: to obtain relationships between the dimming parameters and the coronal mass ejections quantities in order to predict the CME parameters by using the associated phenomena

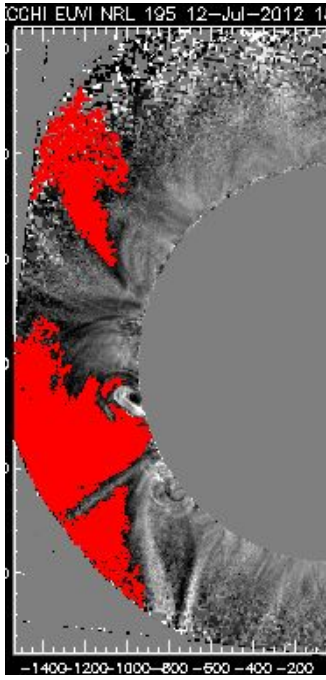


position of STEREO satellites
dataset of events for 2010-2012

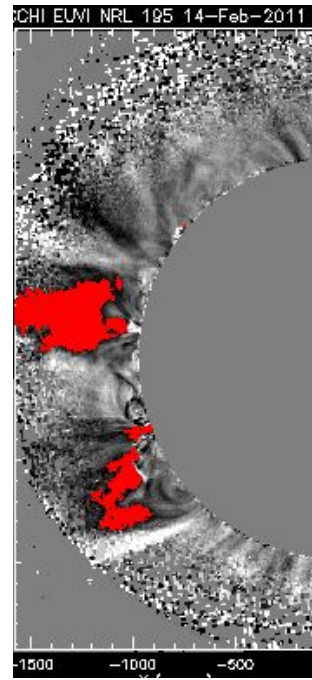
Examples of dimming extraction



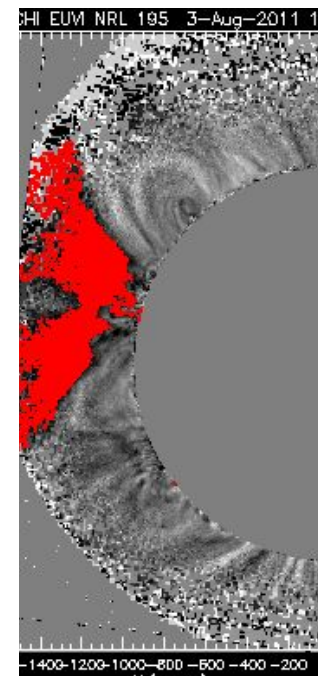
1-Aug-2010



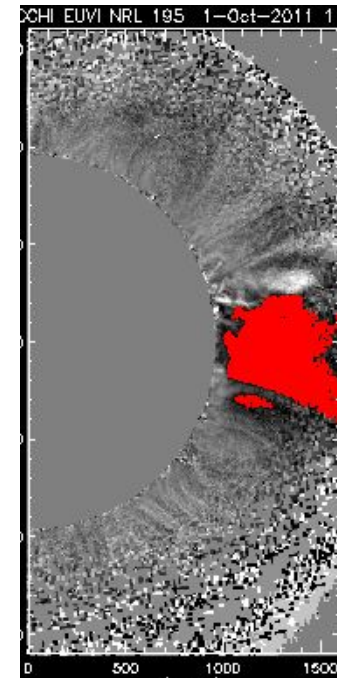
12-Jul-2012



14-Feb-2011



3-Aug-2011



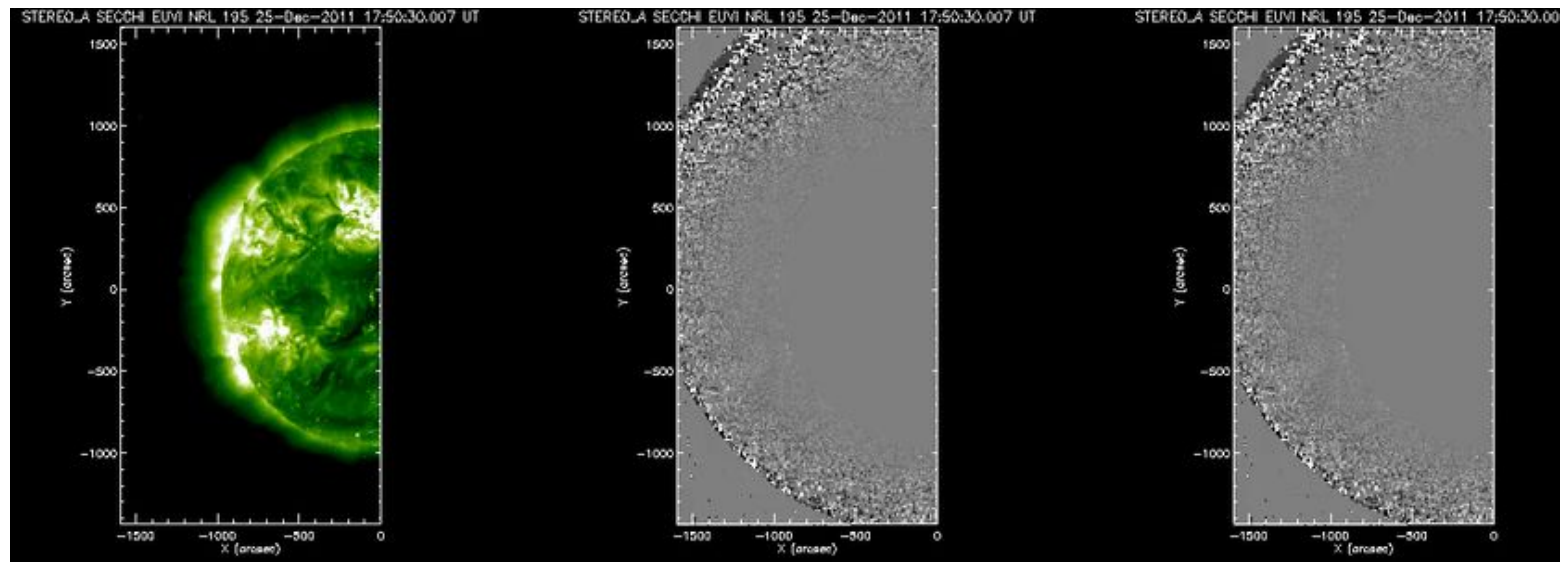
1-Oct-2011

1 set of parameters for all events: LBR/BD thresholding,
amount of the darkest pixels in BD,
filtering parameter

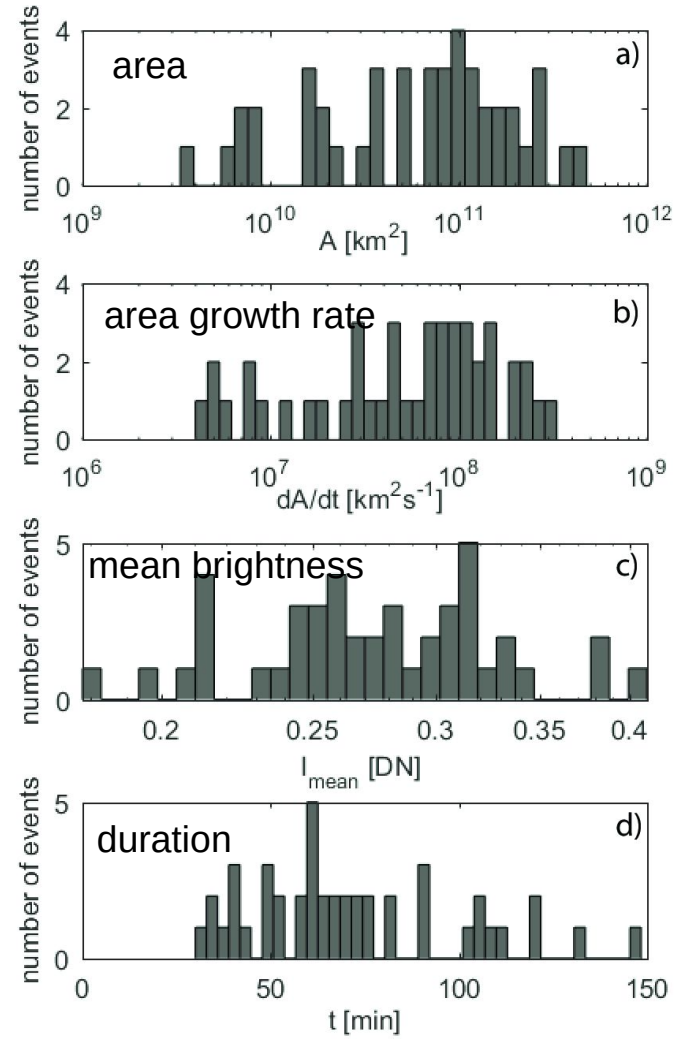
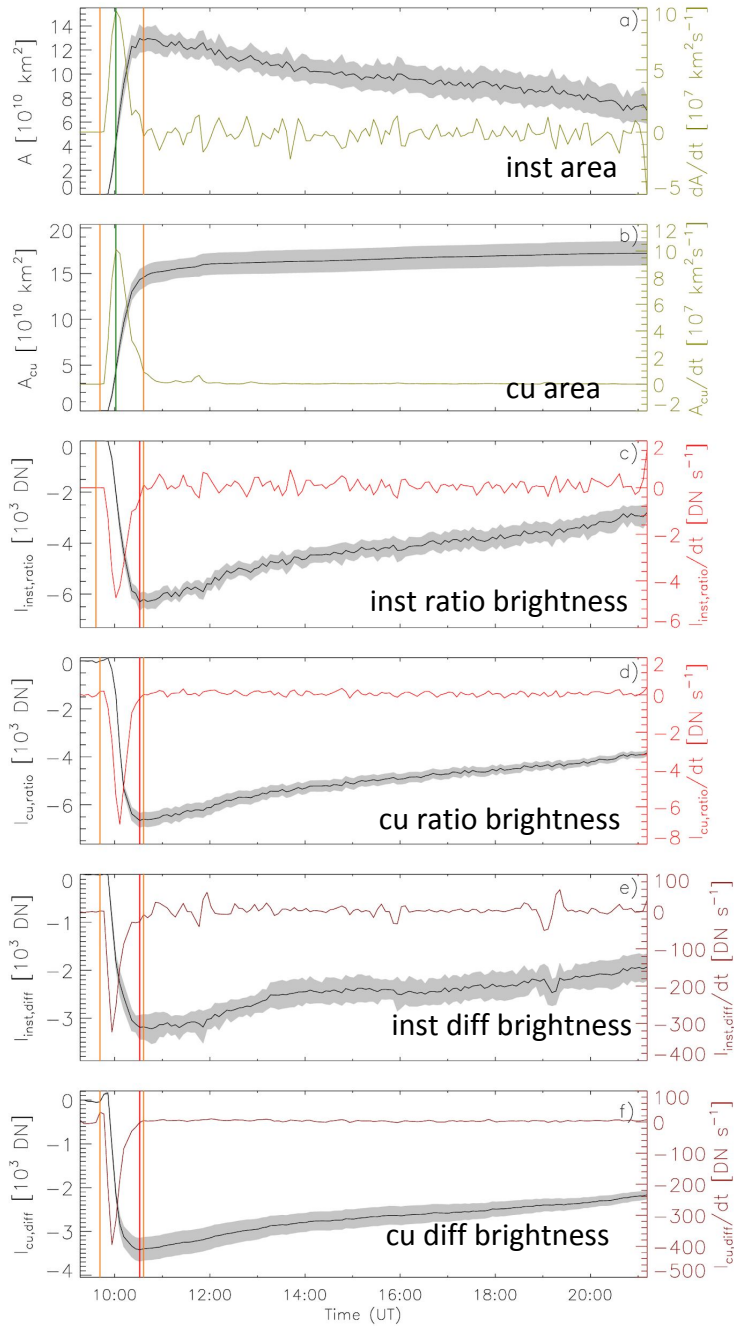
Results

The novel automatic algorithm for dimmings detection was created
Final set of 44 events was analyzed and compared with on-disk observations

together these works represent the 1st multi viewpoint analysis of coronal dimmings and CMEs

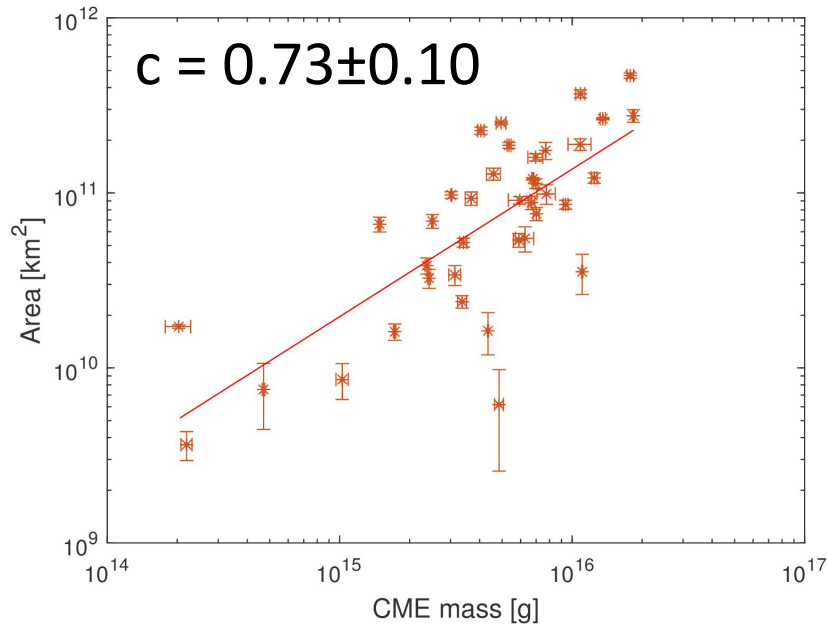


Evolution of dimming characteristics for 1 event

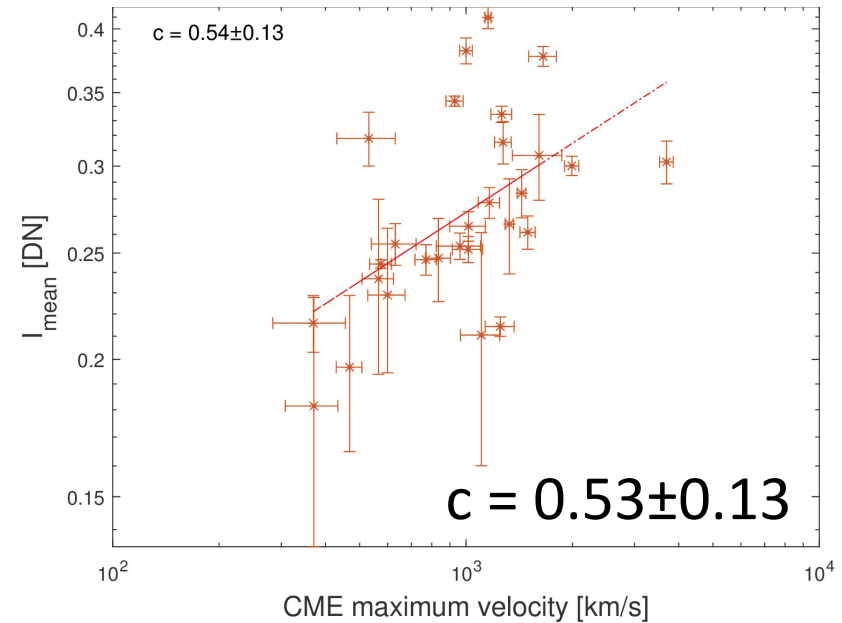


Distribution for the parameters for all events

Discussion of results



strong correlation between dimming area and CME mass



correlation between dimming brightness and maximal CME speed

The expected correlation of dimmings and CMEs parameters was established



Off-limb observations of the dimming allow us to predict the characteristics of Earth-directed CME, what is relevant for Space Weather applications

Project Innovation and Conclusions

- The novel automatic algorithm for dimming detection was developed and tested on a set of events using NASA STEREO/EUVI imagery and proved to be successful.
- A relationship between extracted properties of dimming and coronal mass ejections was established on the basis of regression analysis.
This will allow us to predict on advance the properties of coronal mass ejections using solar observations.
- **The developed detection algorithm can be recommended for future NASA/ESA L5 mission and real-time implementation.**

Future plans

- To publish a paper
Chikunova, Dissauer, Veronig, Podladchikova, Coronal dimmings associated with coronal mass ejections on the solar limb, Astrophysical Journal, 2019, in preparation
- To develop further the study:

Study how coronal dimmings may be used for space weather forecasting and to detect CMEs on solar-like stars.

Can we dimmings to identify a predominant direction of the CME already in the low corona?

Study the relevance of the coronal dimmings to the physics of CMEs by combining the high-quality multi-point observations with advanced coronal magnetic field modeling.

Thank you!

