SPACE WEATHER INTRODUCTORY COURSE



Collaboration of



Solar-Terrestrial Centre of Excellence



Koninklijke luchtmacht



Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu





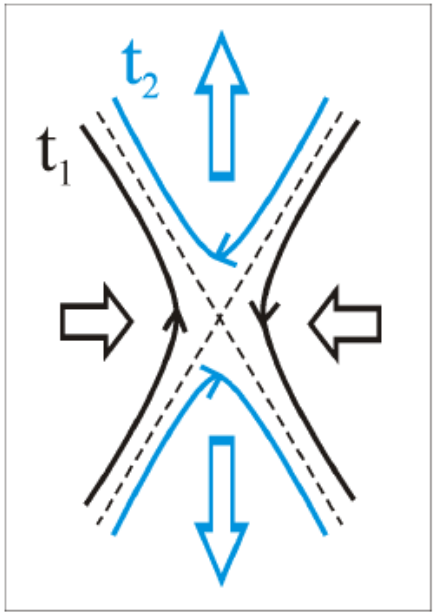
SPACE WEATHER

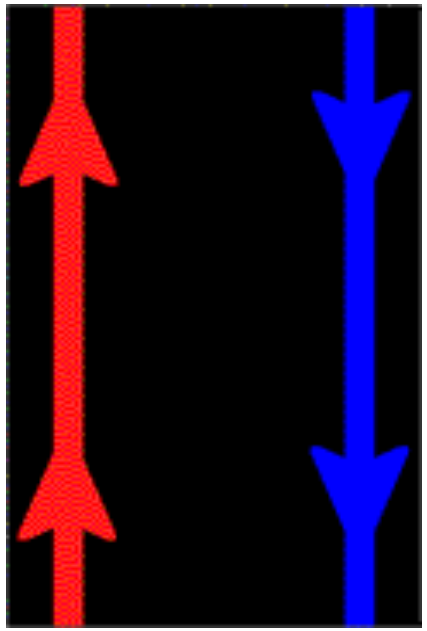
Drivers

Elke D'Huys, Jan Janssens & Petra Vanlommel

MAGNETIC RECONNECTION

- Conversion of magnetic energy into kinetic energy and radiation
- Where
  - Solar flares
  - CME release from the Sun
  - Geomagnetic storms at Earth





SOLAR ERUPTIONS

Magnetic Reconnection

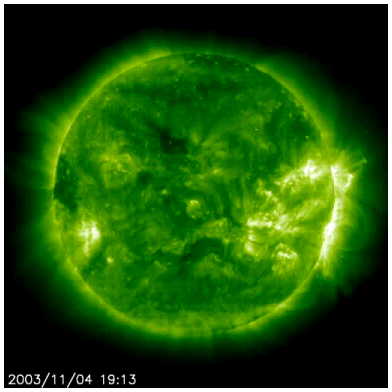
Radiation

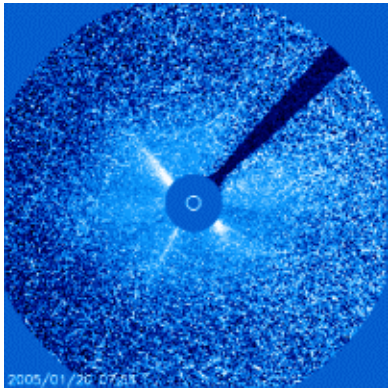
Particles

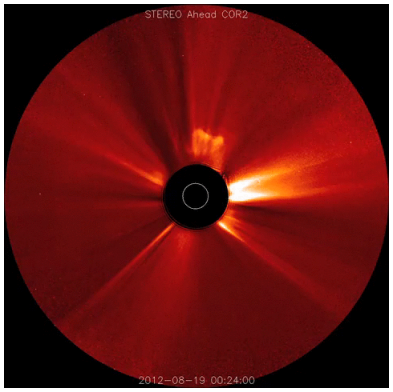
Solar flares

Proton events

Coronal Mass Ejections





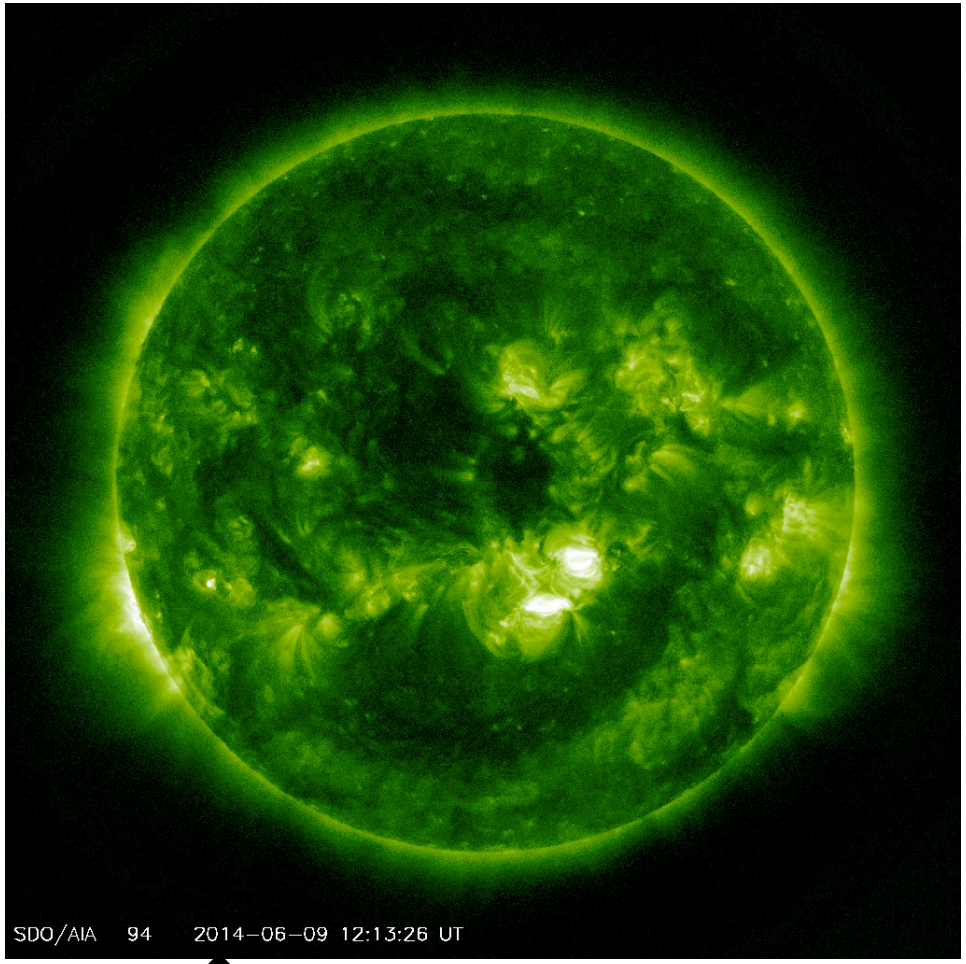


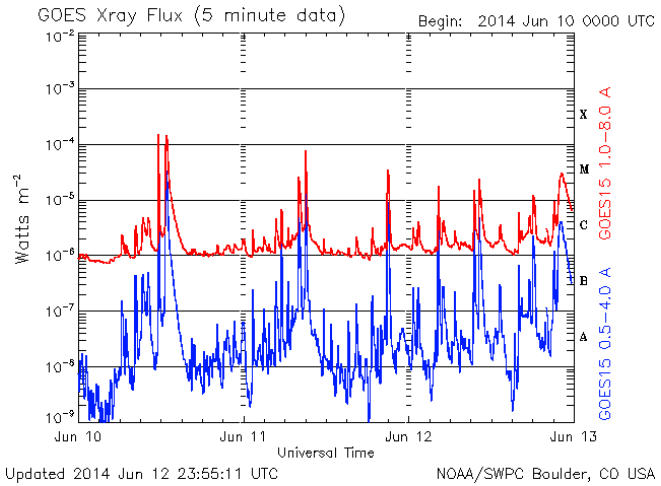
SOHO/EIT

SOHO/LASCO

SOHO/LASCO

FLARE OBSERVATION



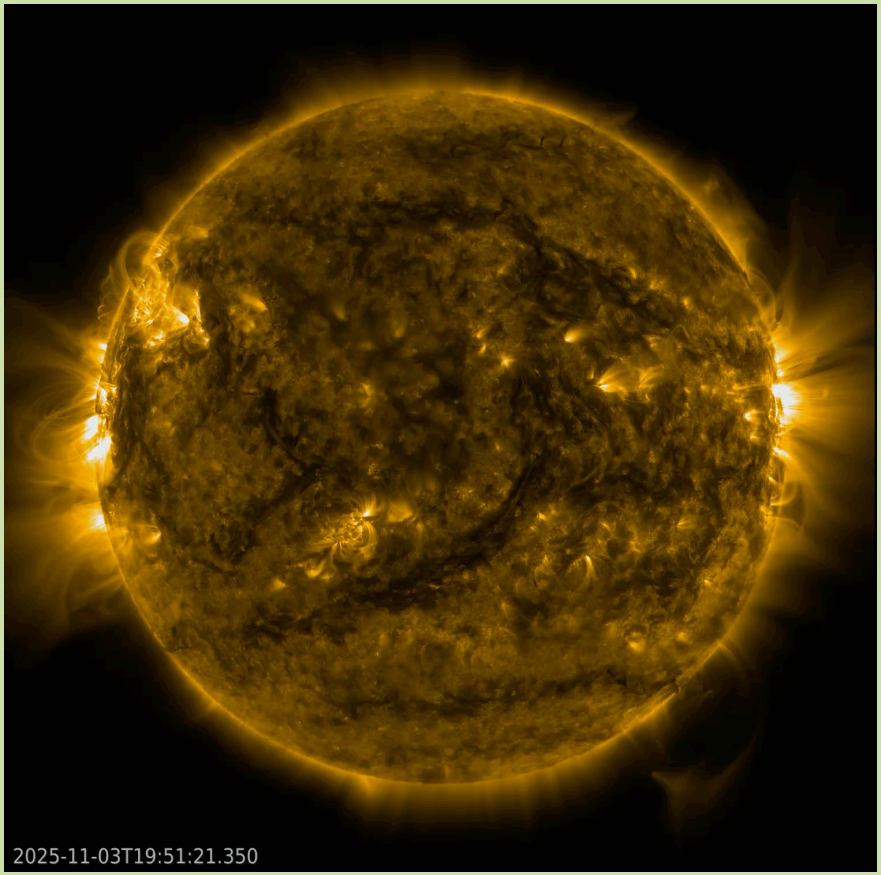


GOES

SDO/AIA

FLARES - OVERVIEW

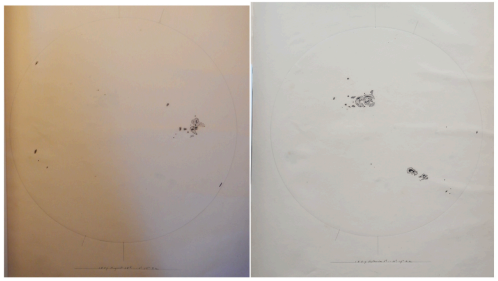
- **Flare Characteristics**
  - **Definition**
  - **Standard model**
  - **Flare triggers**
  - **Flare features**
- Flare Classification
- Flare Predictions

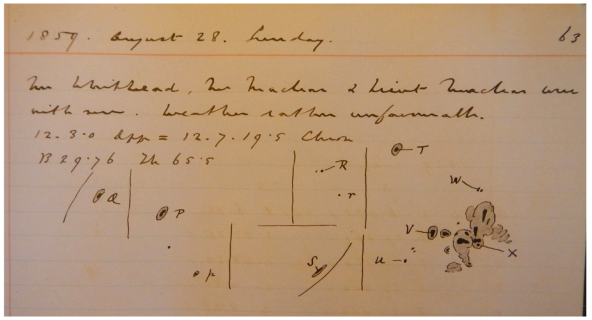


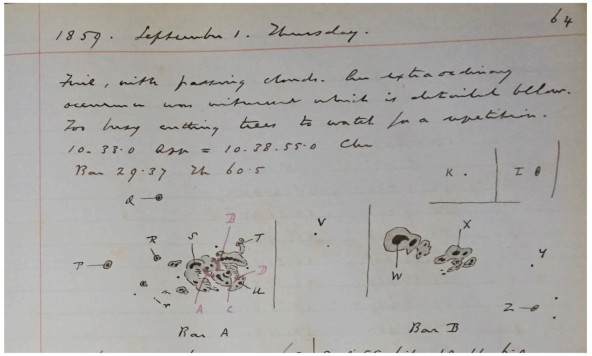
SDO/AIA

SOLAR FLARES - WHAT?

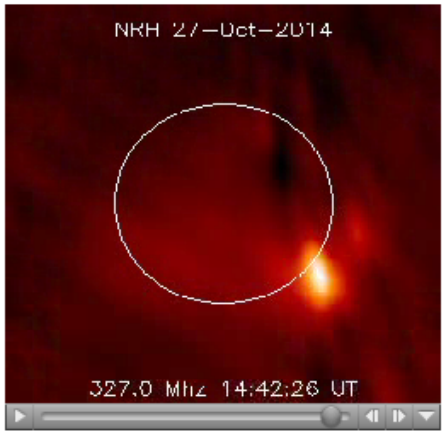
- Sudden burst of radiation
- First observation in 1859 (white light) by Carrington and Hodgson
- Large quantity of energy is released
  >10^20 Joule
- Required:
  A very rapid means of converting stored magnetic energy into particle energy and radiation – magnetic reconnection

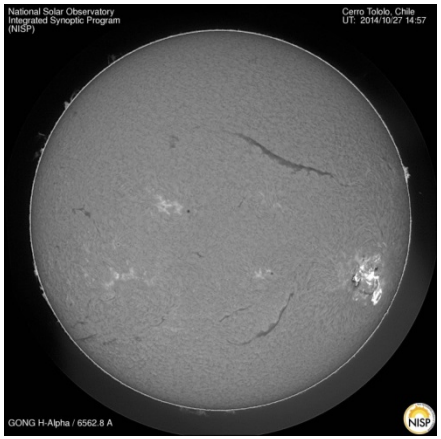


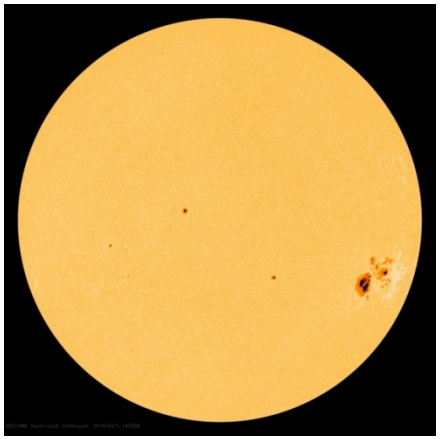




SOLAR FLARES - OBSERVATIONS

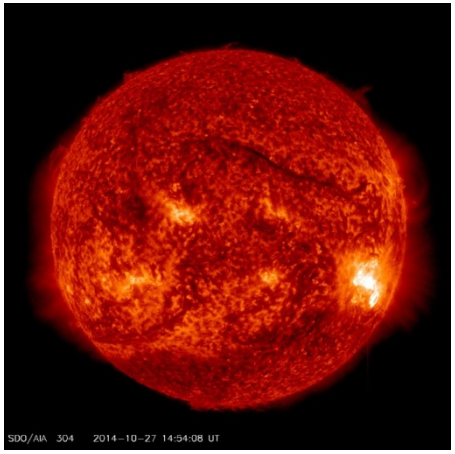


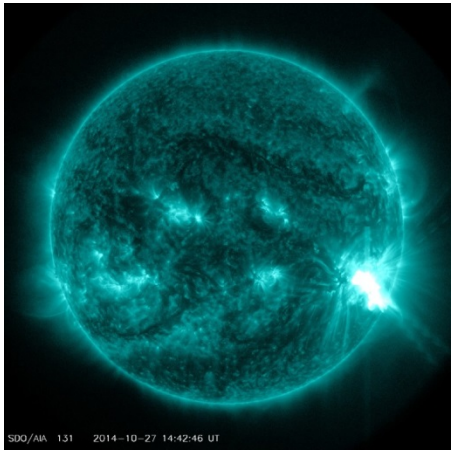


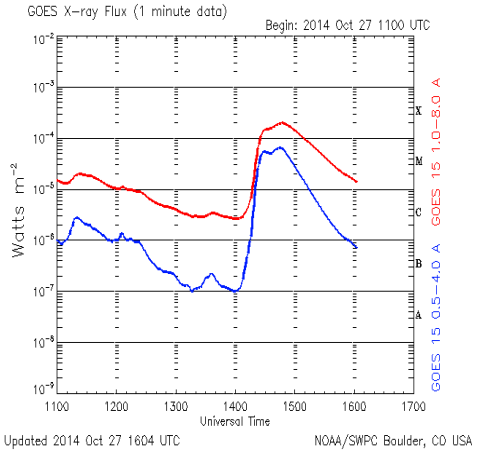




SDO/HMI







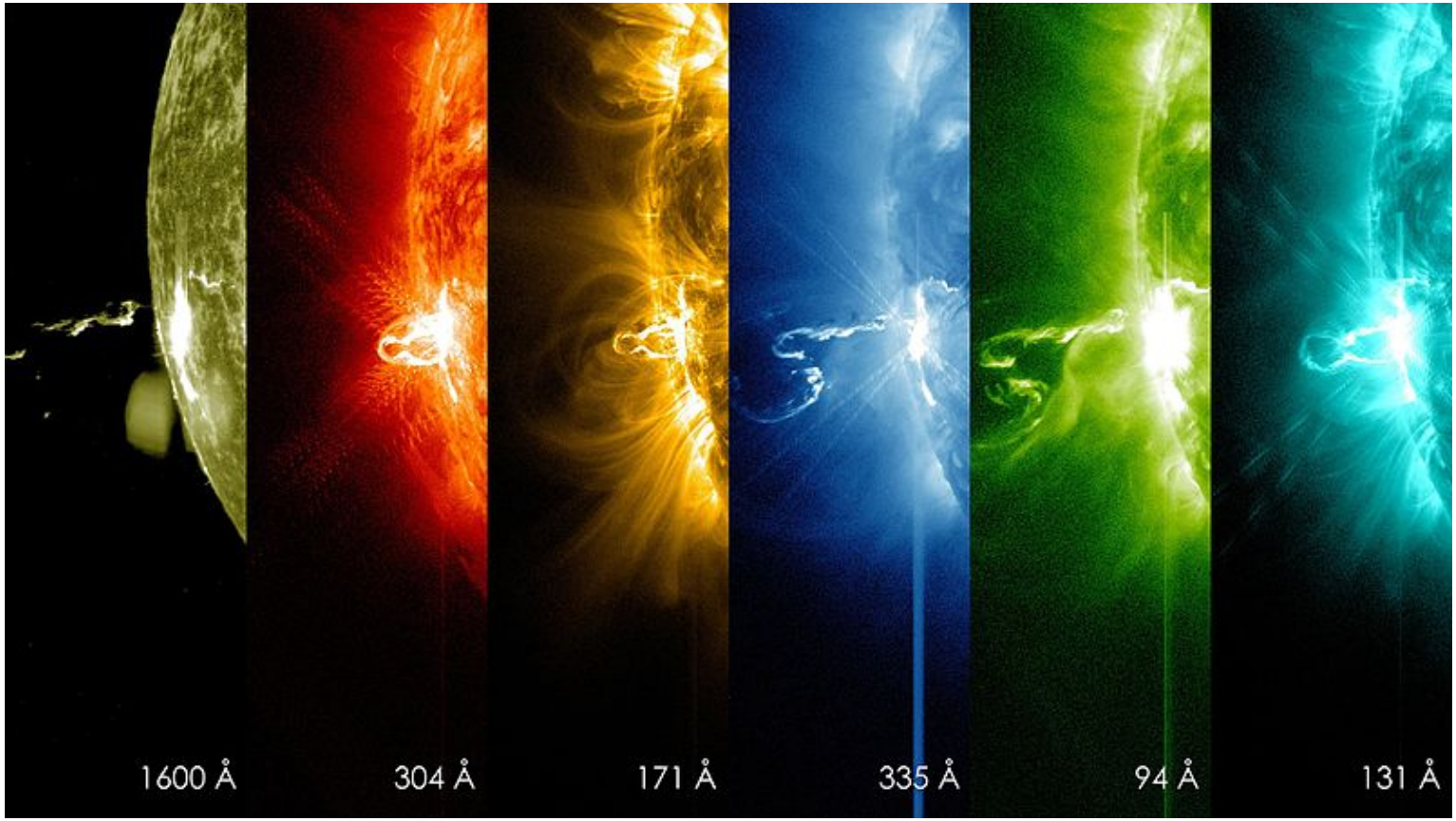


GOES



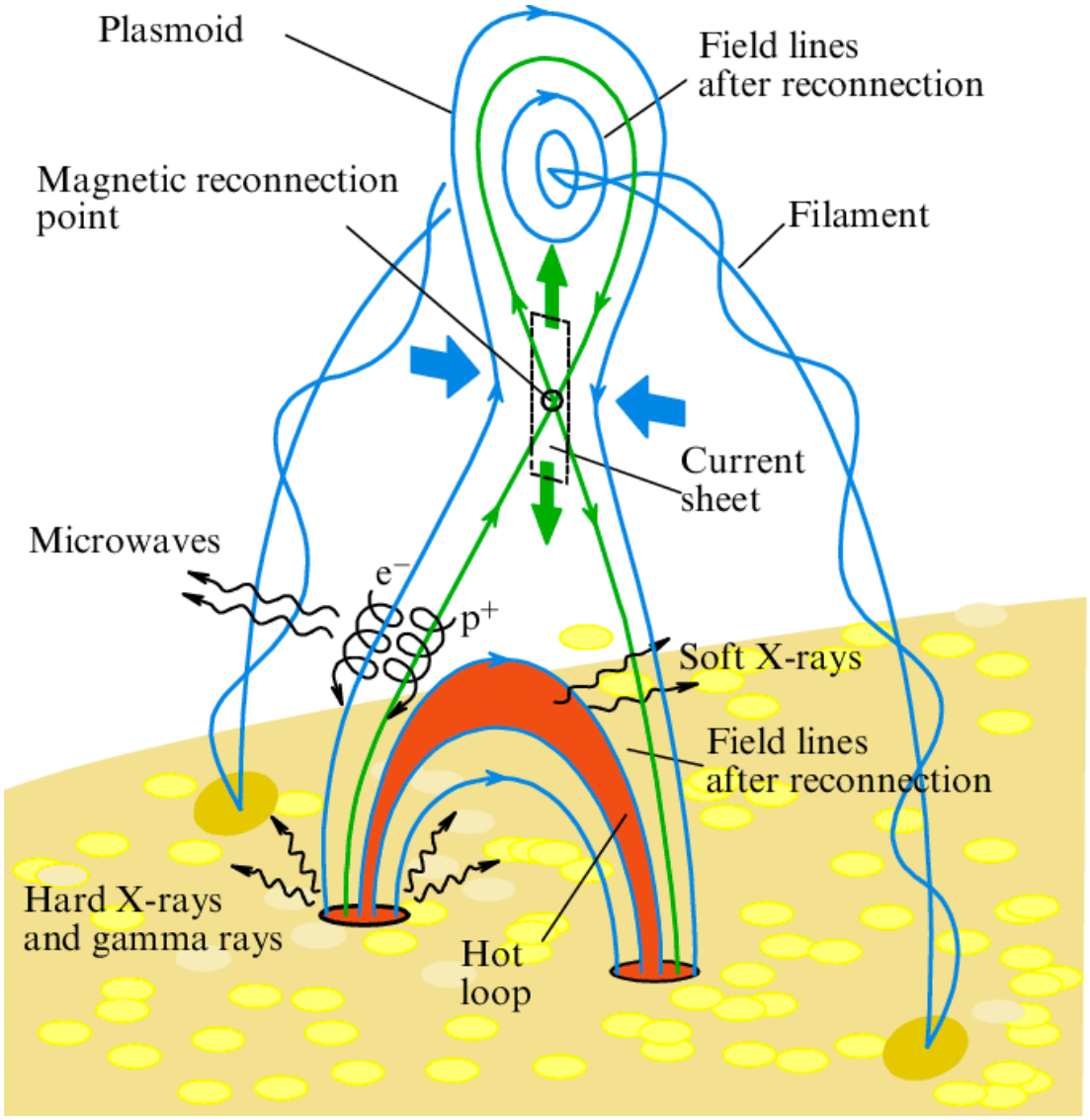
SDO/AIA

SOLAR FLARES - OBSERVATIONS



SDO/AIA

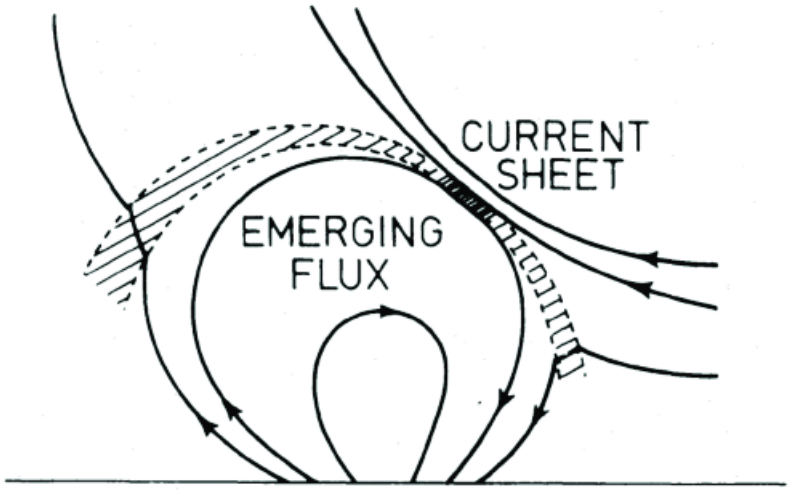
STANDARD FLARE MODEL



TRIGGERS OF SOLAR FLARES

Magnetic restructuring

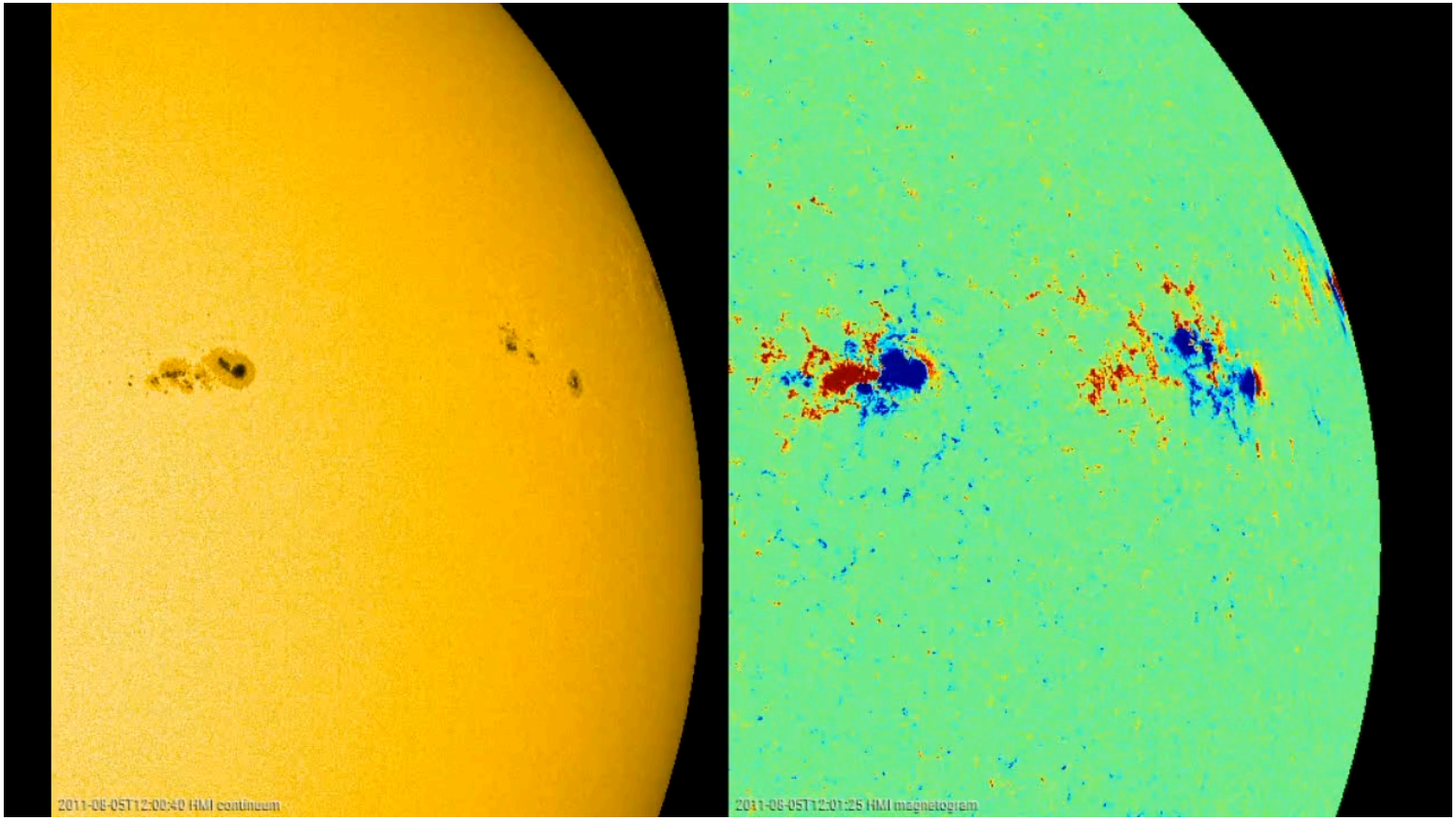
- Magnetic flux emergence
- Helical energy storage
- Instability surrounding fields
- Interaction with nearby CH
- …



TRIGGERS OF SOLAR FLARES

SDO/HMI

Magnetic flux emergence

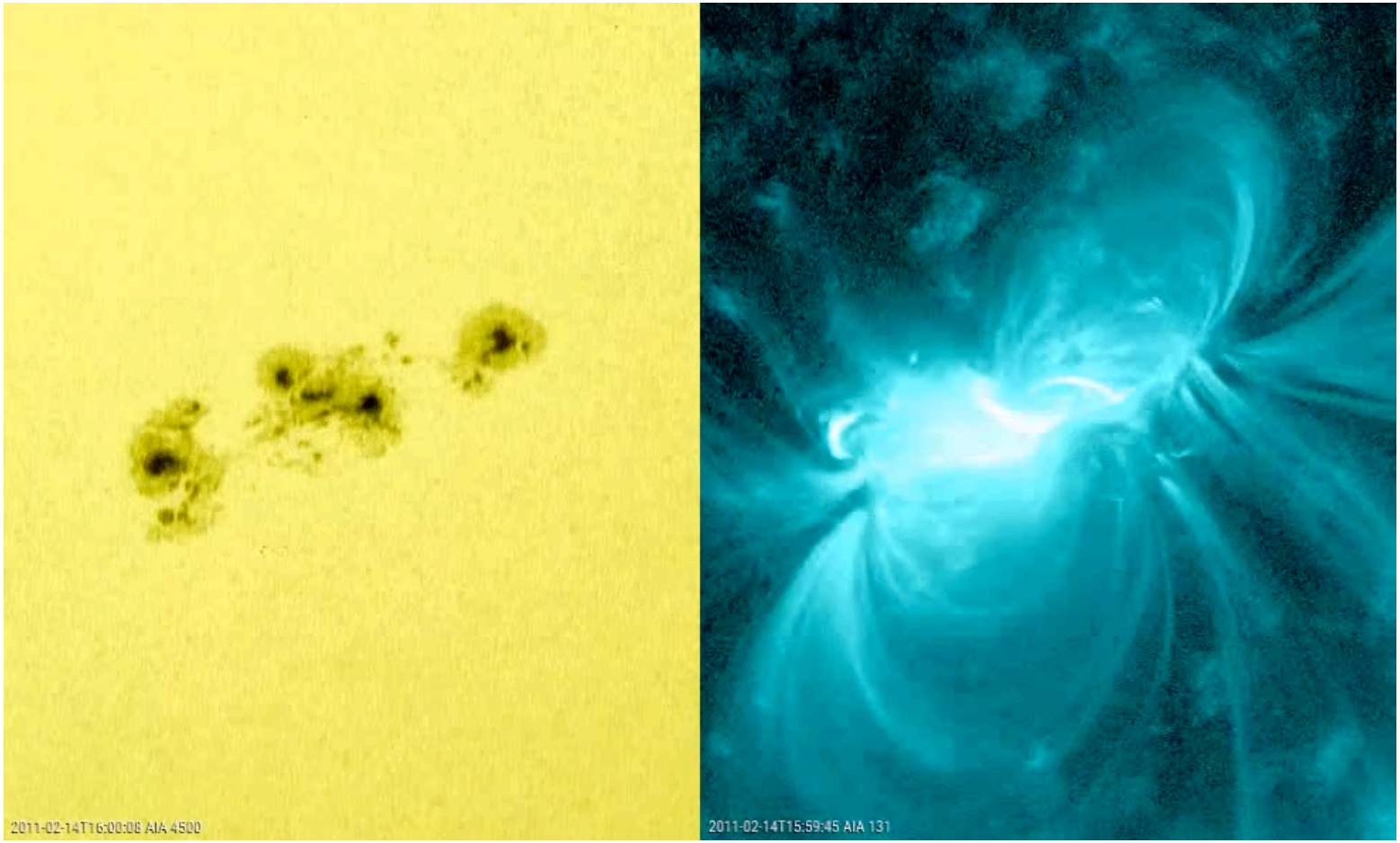


TRIGGERS OF SOLAR FLARES

Helical energy storage

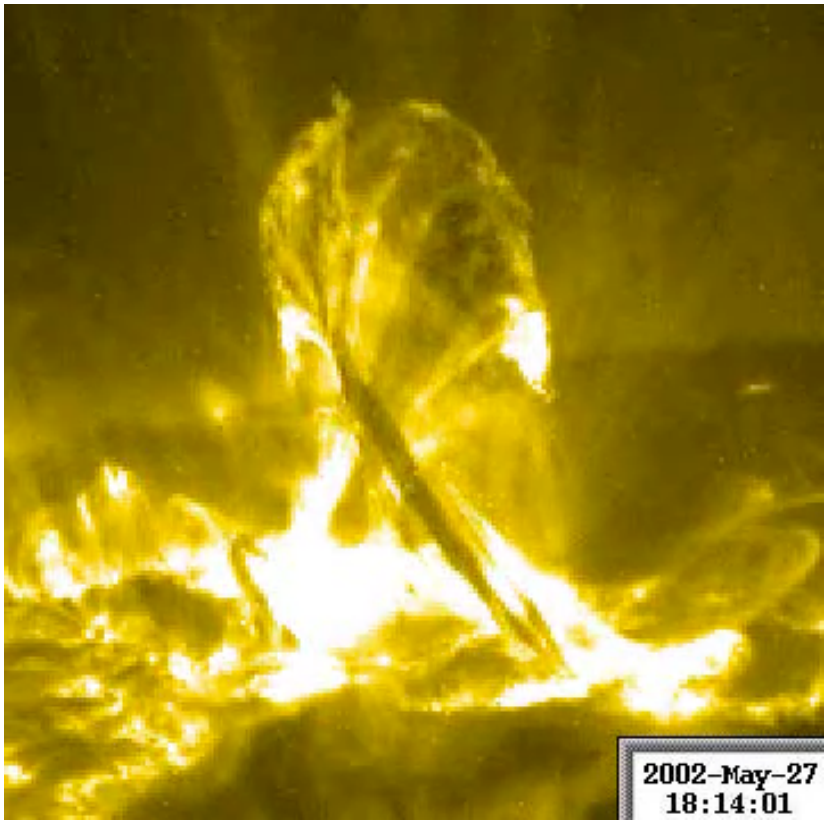


SDO/AIA

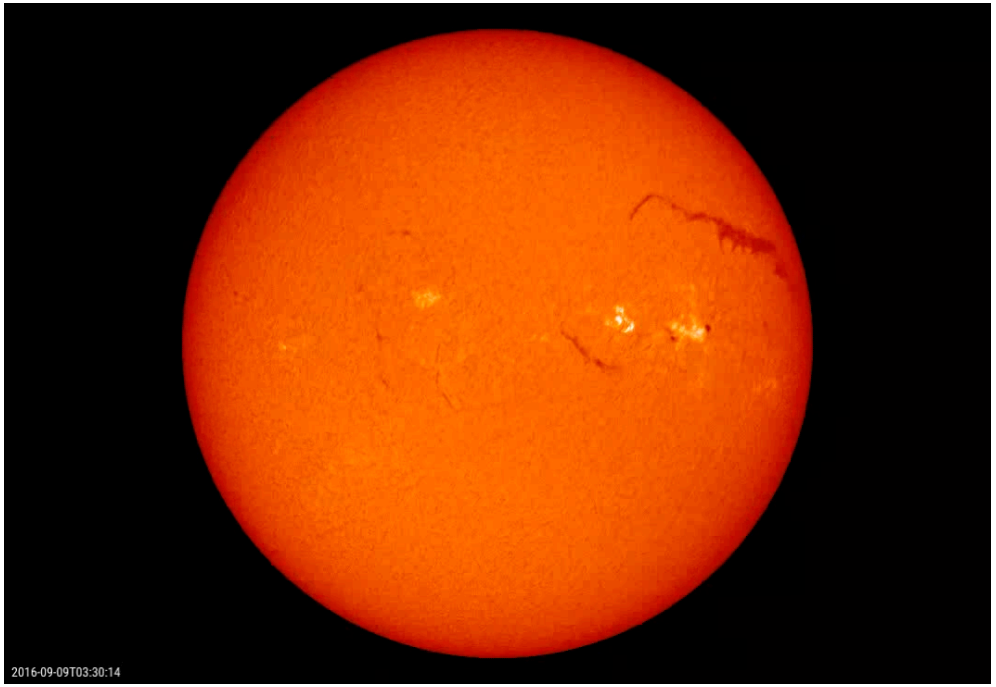


TRIGGERS OF SOLAR FLARES

Kink instability



Unstable magnetic fields



:Issued: 2026 Oct 09 1254 UTC
:Product: documentation at http://www.sidc.be/products/meu
#---#
DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC
(RWC Belgium)
#---#
SIDC URSIGRAM 61009
SIDC SOLAR BULLETIN 09 Oct 2026, 1253UT
SIDC FORECAST
SOLAR FLARES : M-class flares expected (probability >=50%)
GEOMAGNETISM : Minor storm expected (A>=30 or K=5)
SOLAR PROTONS : Warning condition (activity levels expected to increase, but no numeric forecast given)
PREDICTIONS FOR 09 Oct 2026 10CM FLUX: 122 / AP: 021
PREDICTIONS FOR 10 Oct 2026 10CM FLUX: 124 / AP: 022
PREDICTIONS FOR 11 Oct 2026 10CM FLUX: 126 / AP: 015



Finding your way in the URSIgram

Solar Active Regions and flaring: The solar flaring activity over the past 24 hours reached high levels with background C-class flaring and one registered M-flare. The strongest recorded activity was a M6.7 flare (SIDC Flare 8685) with peak time at 15:48 UTC on October 08. The flare was produced within SIDC Sunspot Group 976 (NOAA Active Region 4549) currently located at N10W31. A total of 5 numbered sunspot groups were identified on the visible solar disk with SIDC Sunspot Group 976 remaining the largest and most complex region. It continues to be classified as magnetic type beta-gamma-delta and was the main contributor to the observed flaring activity over the past 24 hours. SIDC Sunspot Group 973 (NOAA Active Region 4545), currently located at N18W37, has exhibited some decay. It is classified as magnetic type beta and remained quiet. A new region has emerged on disc SIDC Sunspot Group 979, currently located at N22W11, and another one, SIDC Sunspot Group 980, is rotating from behind the south-east limb. Both are classified as magnetic type beta and the latter one has exhibited some low flaring activity while behind the east limb. The solar flaring activity is expected to be at moderate over the next 24 hours with likely M-class flaring and chances for an X-class flare.

Coronal mass ejections: A wide coronal mass ejection (SIDC CME 727) was observed by LASCO/C2 to lift off the solar surface around 16:12 UTC on October 08 with a white-light shock and an estimated projected speed of around 500 km/s. The eruption is likely linked to the M6.7 flaring from SIDC Sunspot Group 976 (NOAA Active Region 4549) with an associated EUV dimming and a coronal wave detected in the SDO/AIA data around 16:33 UTC on October 08. Related type II and type IV solar radio emissions were detected at 15:42 UTC and 16:12 UTC on October 08 respectively. SIDC CME 727 is estimated to have an Earth-directed component and current analysis suggests a possible arrival time late UTC on October 11 to early UTC on October 12. Another EUV dimming and a small coronal wave were observed in the SDO/AIA imagery starting at 17:36 UTC on October 08, seemingly related to a filament eruption in the south-eastern quadrant triggered by the same event chain. A faint eastward eruption is visible in the LASCO/C2 around 17:00 UTC, but is expected to travel off the Sun-Earth line.

Coronal holes: SIDC Coronal Hole 149 (a recurrent mid-latitude coronal hole with a negative polarity) continues to reside on the central meridian. A high-speed stream related to it might be expected at Earth on October 09, possibly mixed with anticipated ICME arrival signatures related to SIDC CME 725.

Solar wind: Over the past 24 hours the solar wind parameters (as measured by ACE at L1) registered some enhancements, possibly the precursor of a high-speed stream arrival related to SIDC Coronal Hole 149. The solar wind speed remained slow, varying in the range of 333 to 390 km/s. The interplanetary magnetic field (B) registered a maximum value of 12.7 nT with a north-south (Bz) component down to - 7 nT. The B field phi angle switched from the positive to the negative sector (directed towards the Sun). The solar wind parameters are expected to be perturbed over the next 24 hours with an anticipated arrival of a high-speed stream possibly mixed with an ICME arrival related to SIDC CME 725. Perturbed solar wind conditions are expected to continue on October 10 with anticipated high- speed stream influence and possible waning ICME influence. A mild glancing blow arrival related to SIDC CME 726 could be expected on October 11 with the possibility of another ICME arrival late UTC on October 11 or early UTC on October 12 related to SIDC CME 727.

Geomagnetism: The geomagnetic conditions over the past 24 hours were locally (over Belgium) quiet to unsettled and globally quiet to active with NOAA Kp reaching 4 in the period 9-12 UTC on October 09. Unsettled conditions to minor storm levels are expected over the next 24 hours with chances for isolated moderate storms. Unsettled to active conditions with chances for more minor storm levels can continue on October 10, October 11 and October 12.

Proton flux levels: Over the past 24 hours the greater than 10 MeV GOES proton flux remained at close to nominal levels, while exhibiting some further enhancements related to activity from SIDC Sunspot Group 976 (NOAA Active Region 4549). The greater than 10 MeV GOES proton flux is expected to further increase over the next 24 hours with chances of reaching the 10 pfu proton event threshold.

Electron fluxes at GEO: The greater than 2 MeV electron flux as measured by GOES 18 and GOES 19 has exceeded the 1000 pfu threshold over the past 24 hours and is expected to be predominantly below the 1000 pfu threshold over the next 24 hours. The 24-hour electron fluence was at moderate levels and is expected to decrease to nominal levels over the next 24 hours.

TODAY'S ESTIMATED ISN : 086, BASED ON 07 STATIONS.

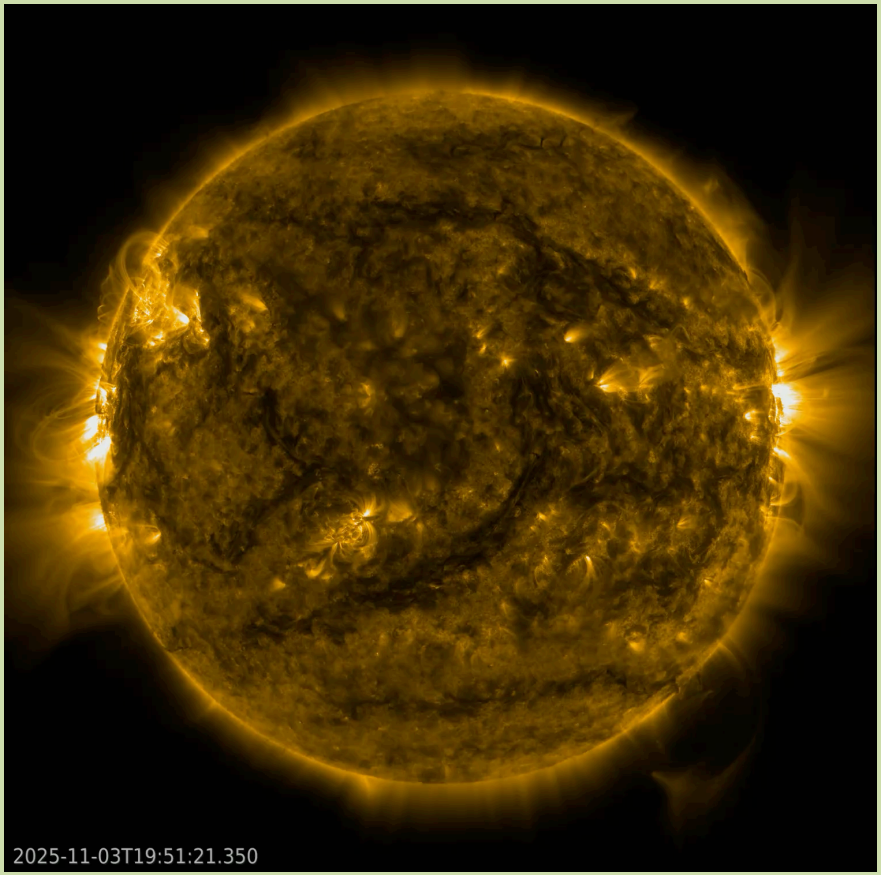
SOLAR INDICES FOR 08 Oct 2026
WOLF NUMBER CATANIA : 089
10CM SOLAR FLUX : ///
AK CHAMBON LA FORET : 017
AK WINGST : 006
ESTIMATED AP : 006
ESTIMATED ISN : 075, BASED ON 18 STATIONS.

NOTICEABLE EVENTS SUMMARY
DAY BEGIN MAX END LOC XRAY OP 10CM Catania/NOAA RADIO_BURST_TYPES
08 1529 1548 1558 N12W20 M6.7 2B 57/4549 I/3
END

Flare features

FLARES - OVERVIEW

- Flare Characteristics
- **Flare Classification**
  - **H-alpha**
  - **X-ray**
- Flare predictions



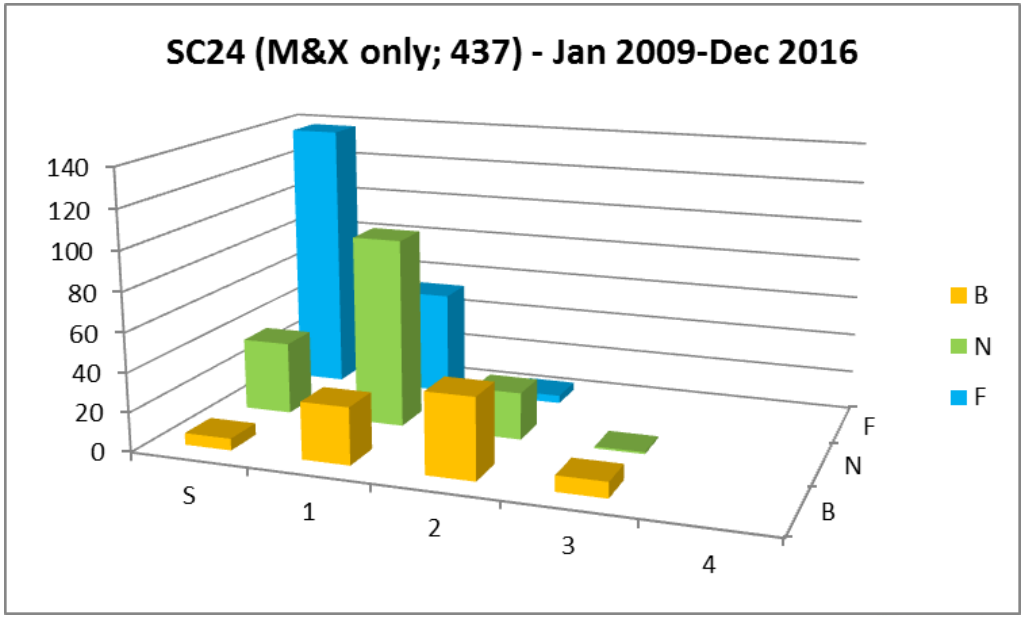
SDO/AIA

SOLAR FLARES CLASSIFICATION

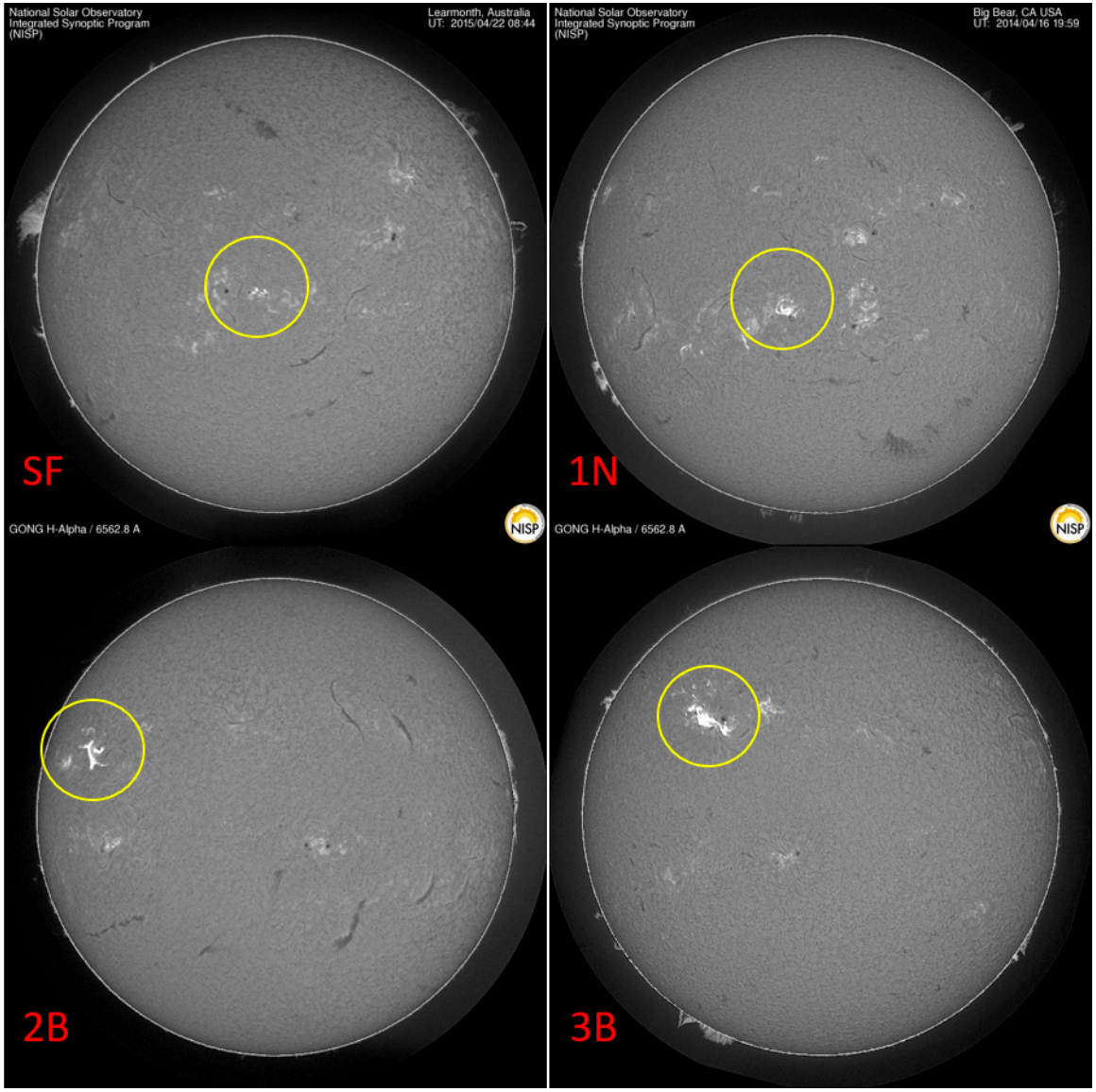
H-alpha

- Visual classification
- Importance
  - Area at max. brightness
- Brightness
  - Faint, Normal, Brilliant
- Optical class
  - E.g. SF, 3B,…
- Limited correlation with geophysical effects
- Depends strongly on seeing conditions

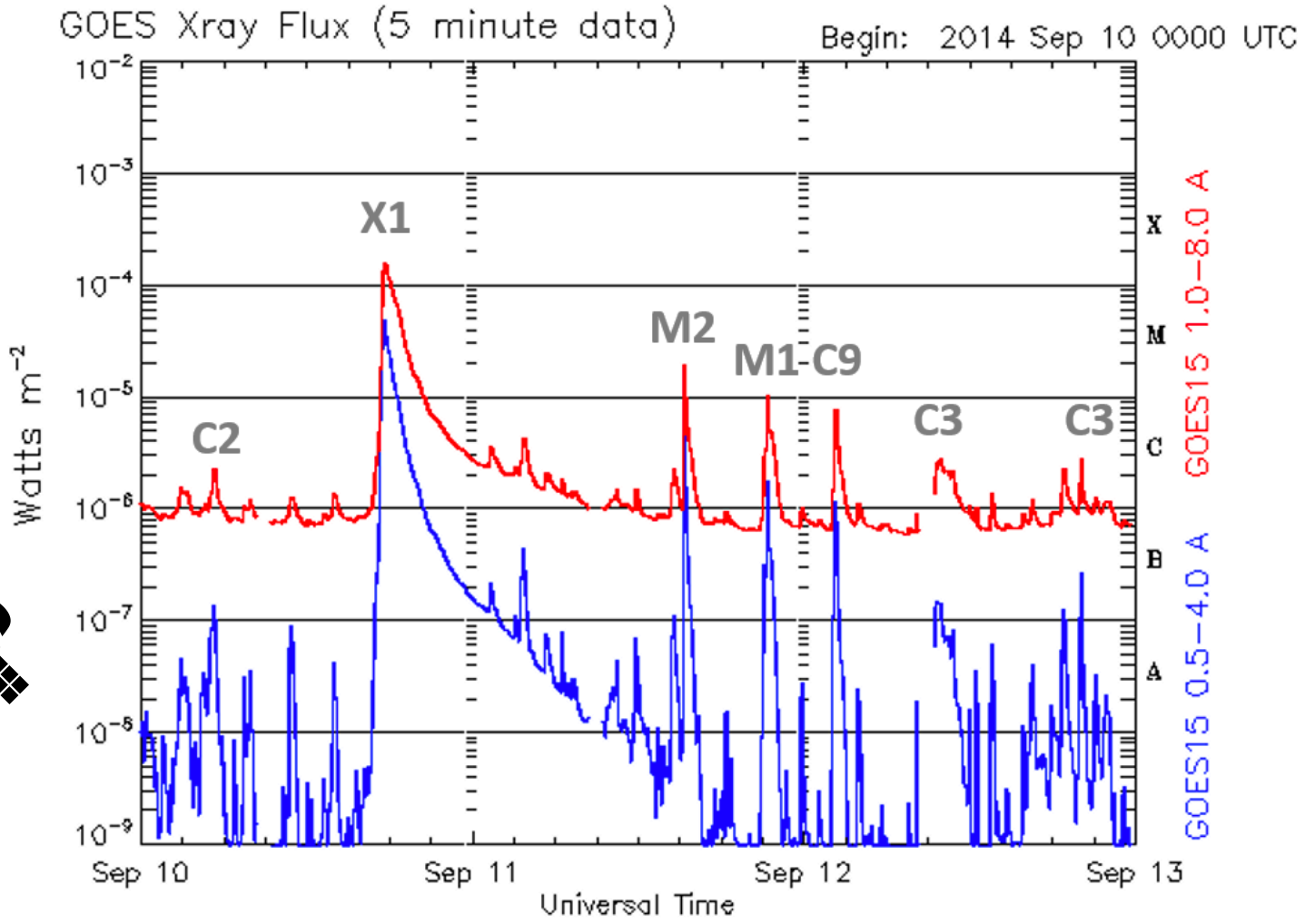
Importance	A_c (MH)	A_c ($^{\circ 2}$)
S	$10 \leq A_c < 100$	$0,2 \leq A_c < 2,1$
1	$100 \leq A_c < 250$	$2,1 \leq A_c < 5,2$
2	$250 \leq A_c < 600$	$5,2 \leq A_c < 12,4$
3	$600 \leq A_c < 1200$	$12,4 \leq A_c < 24,7$
4	$1200 \leq A_c$	$24,7 \leq A_c$



SOLAR FLARE CLASSIFICATION: H-ALPHA



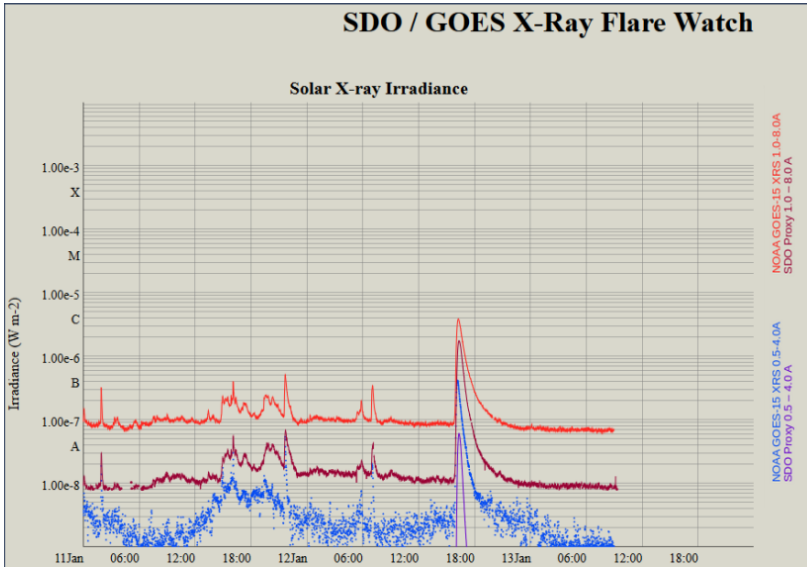
SOLAR FLARE CLASSIFICATION: X-RAY



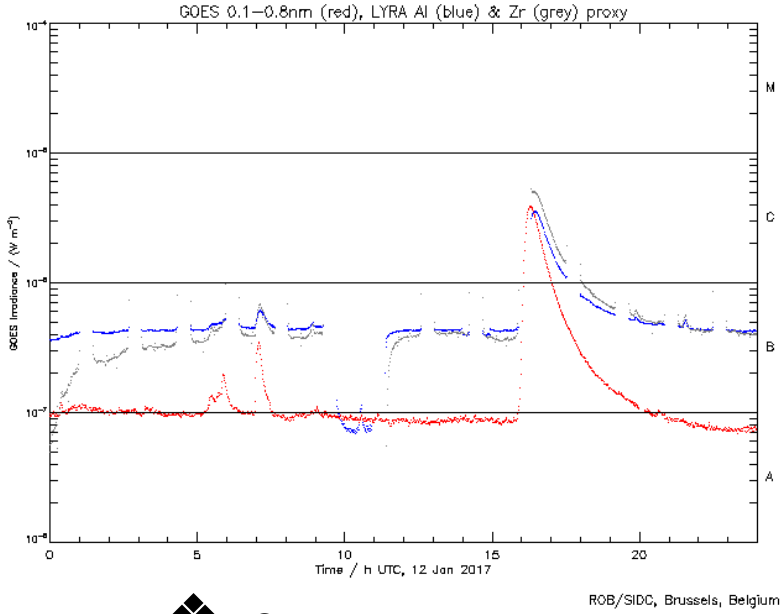
GOES

SOLAR FLARE CLASSIFICATION: X-RAY

Back-up for GOES x-ray



SDO/EVE

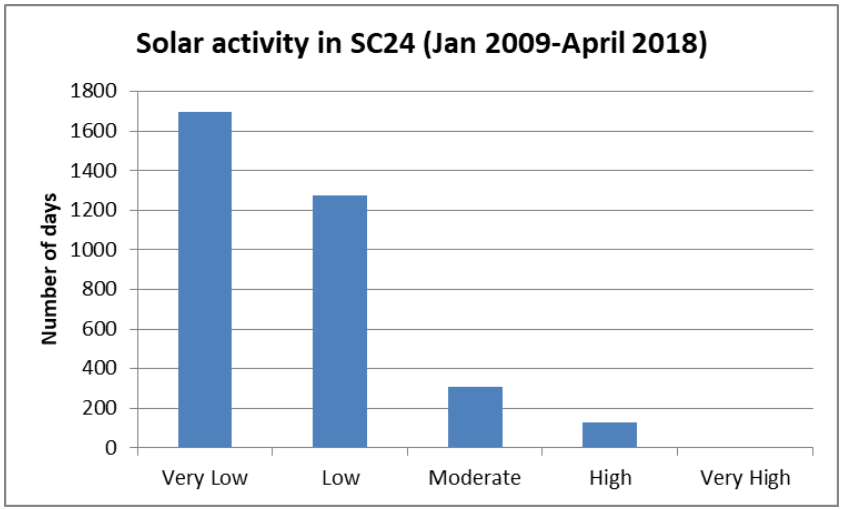


PROBA2/LYRA

SOLAR FLARE CLASSIFICATION: X-RAY

Frequency terminology

- Solar (flaring) activity
- For a 24 hour period



Terms Used to Describe Solar Activity

Very Low: x-ray events less than C-class.

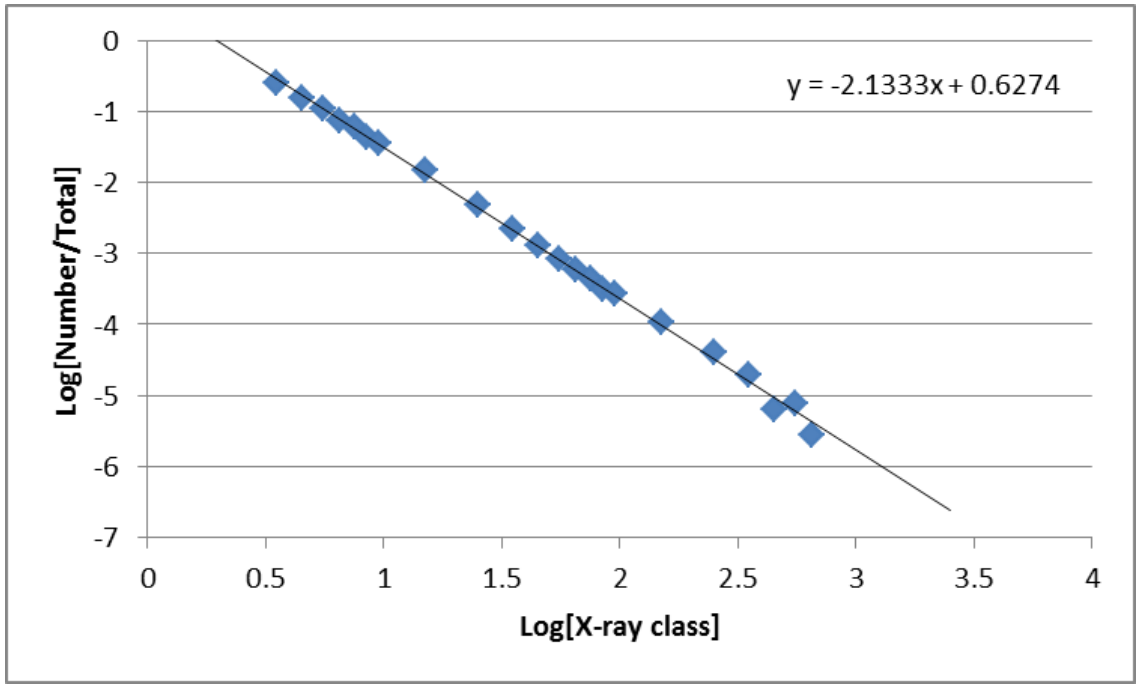
Low: C-class x-ray events.

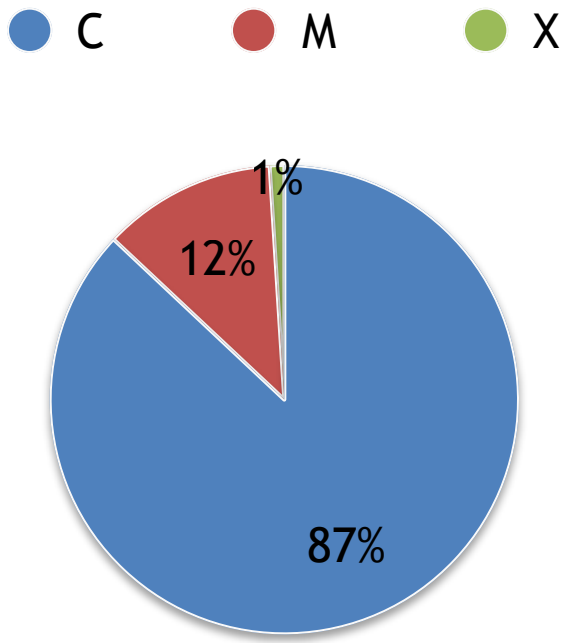
Moderate: isolated (one to four) M-class x-ray events.

High: several (5 or more) M-class x-ray events, or isolated (one to four) M5 or greater x-ray events.

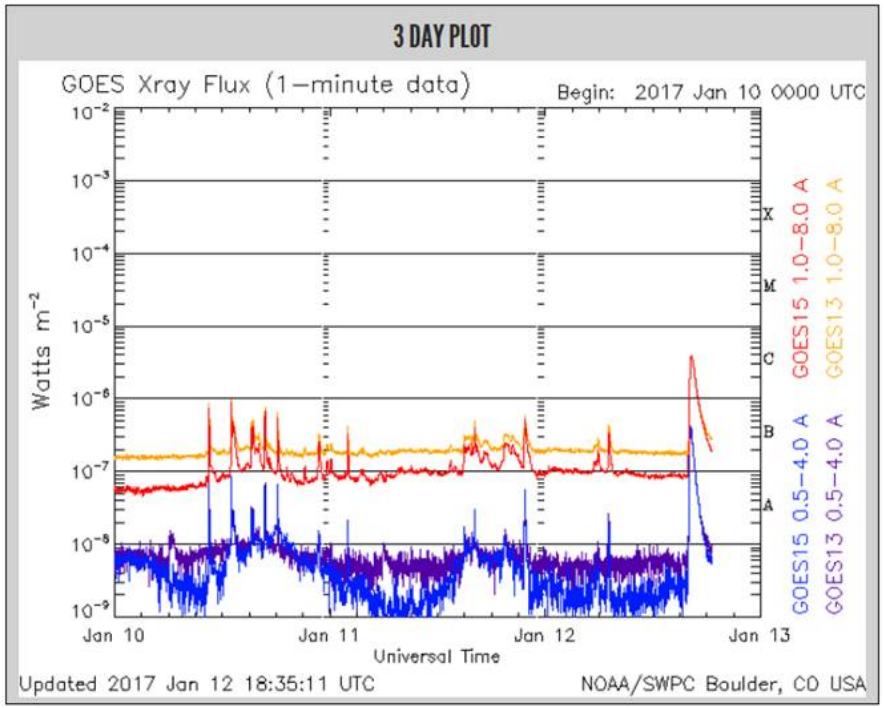
Very High: several (5 or more) M5 or greater x-ray events.

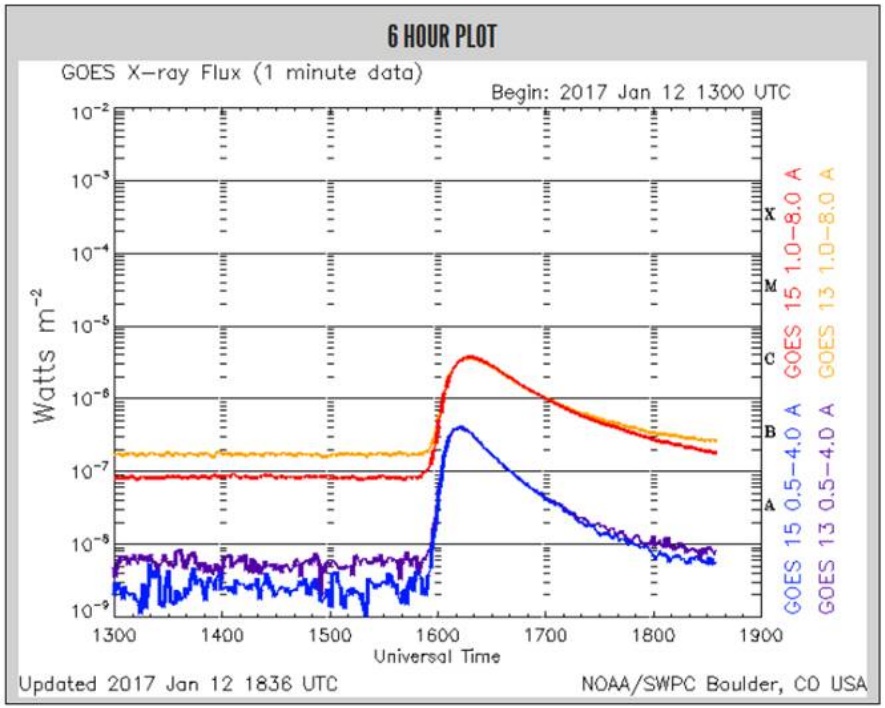
SOLAR FLARE STATISTICS: X-RAY





SOLAR FLARE DURATION



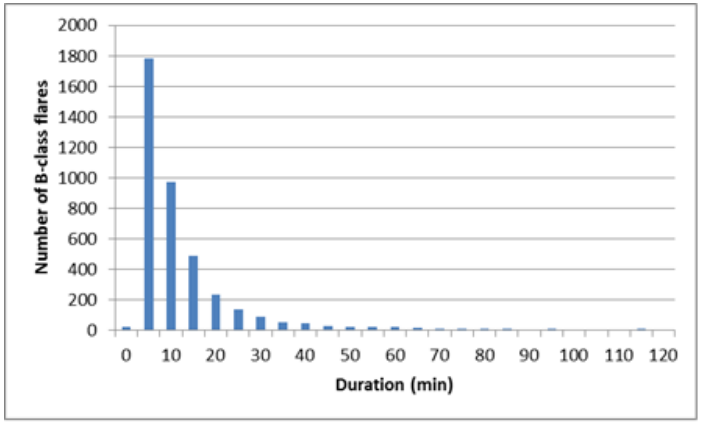


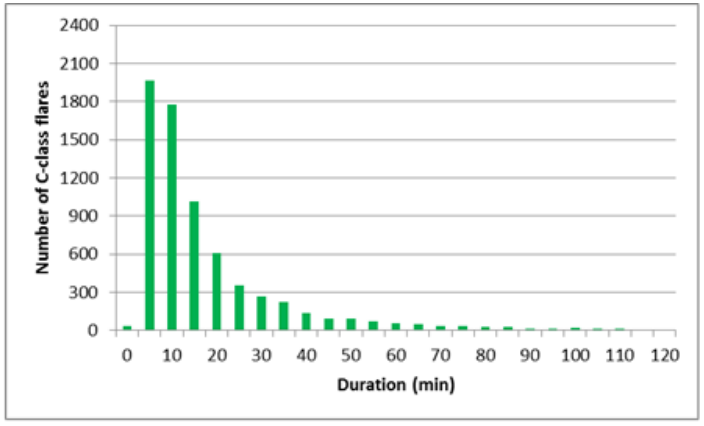


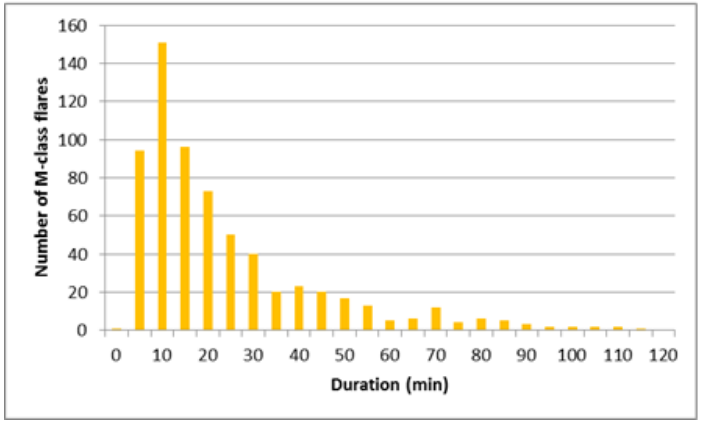
GOES

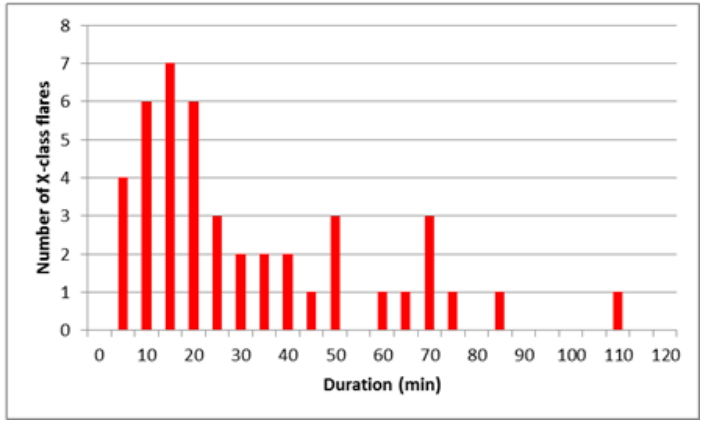
LATEST X-RAY EVENT (1-8Å)			
Current	2017-01-12 18:35:00 UTC	B1.8	Ratio: 0.031
Beginning	2017-01-12 15:54:00 UTC	B1.0	
Maximum	2017-01-12 16:18:00 UTC	C3.8	Integrated flux: 0.006896 J m^{-2}
End	2017-01-12 16:41:00 UTC	C1.9	

SOLAR FLARE DURATION









Jan 1976 - Dec 2000			Jan 2009 - Nov 2015		
Class	Number	Median	Class	Number	Median
B	8844	10	B	4041	10
C	16507	12	C	7015	14
M	1331	24	M	659	19
X	63	30	X	45	24
T	*26745*	*12*	*T*	*11760*	*13*

SOLAR FLARE DURATION

Impulsive flare

- M- and X-class only
- Duration
  - Total duration < 10 minutes
- Usually NOT associated with CMEs
- Compact

Long Duration Event

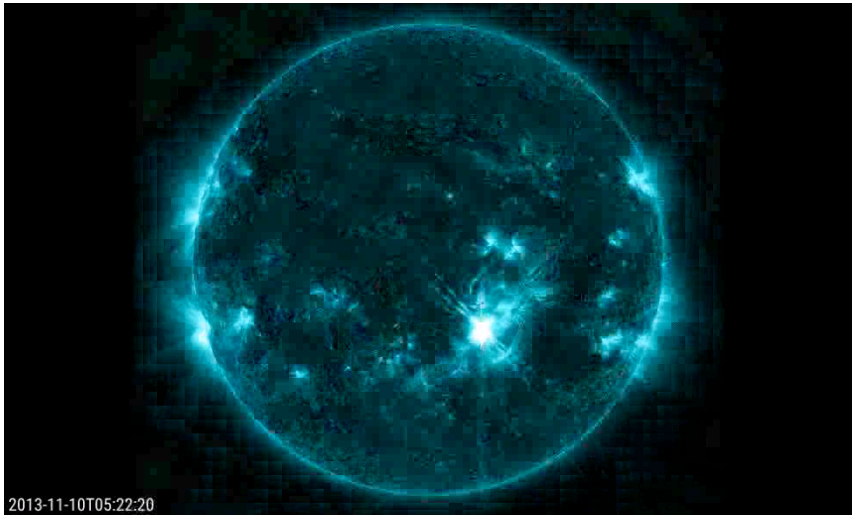
- All flare classes
- Duration
  - Total duration > 1 hour
  - Decay time > 30 minutes (SWPC)
- Association with CMEs increases with increased duration

SOLAR FLARE DURATION

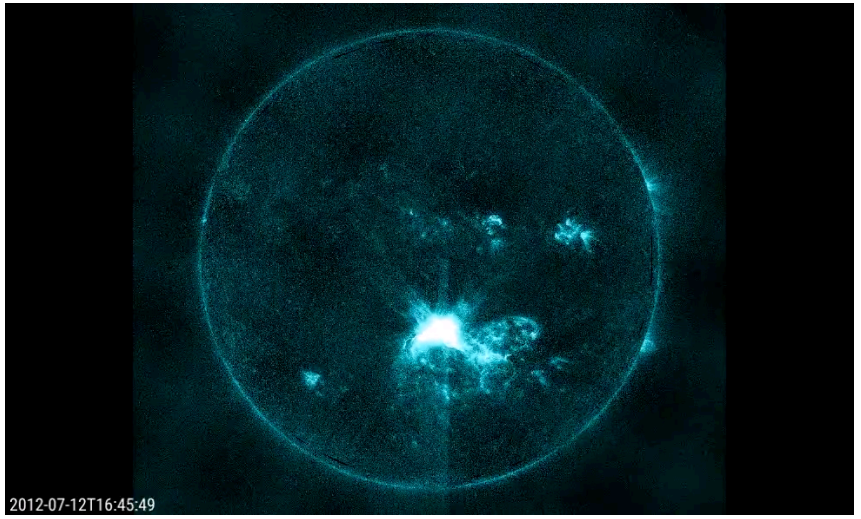
Impulsive flare

Long Duration Event

SDO/AIA



X1 - NOAA 1890 - 10 Nov 2013 (duration: 10 minutes)

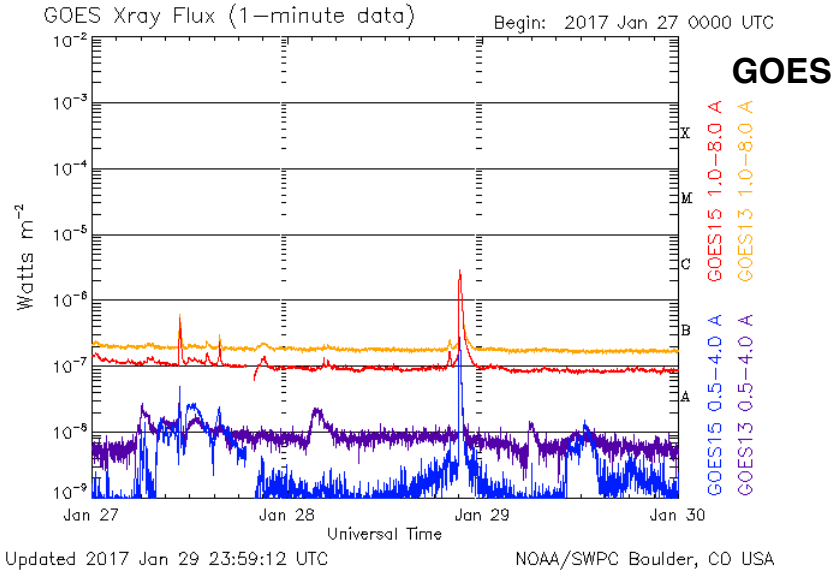


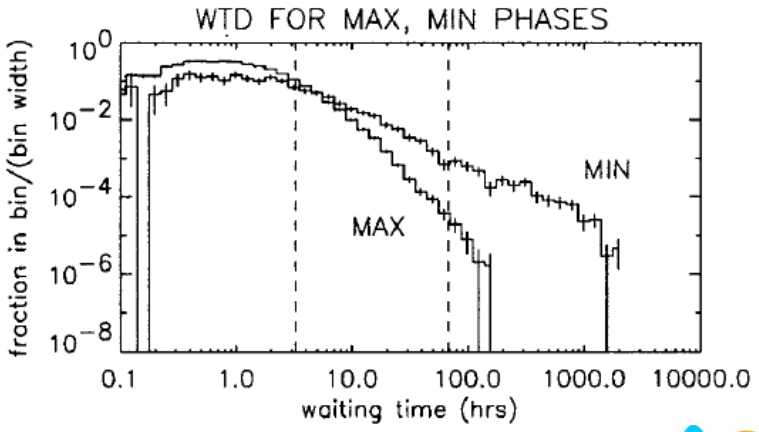
X1 - NOAA 1520 - 12 July 2012 (duration: 113 minutes)

SOLAR FLARE FREQUENCY

Isolated flare

- Usually specified per class (B, C, M, X)
- From entire Sun
  - 1-4 per day
- In practice
  - 1 event in 24 hours
- Average waiting time
  - 6.5 hours (≥ C1)
  - SCmax: 3 hours
  - SCmin: 3 days





:Issued: 2026 Oct 09 1254 UTC
:Product: documentation at http://www.sidc.be/products/meu
#---#
DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC
(RWC Belgium)
#---#
SIDC URSIGRAM 61009
SIDC SOLAR BULLETIN 09 Oct 2026, 1253UT
SIDC FORECAST
SOLAR FLARES : M-class flares expected (probability >=50%)
GEOMAGNETISM : Minor storm expected (A>=30 or K=5)
SOLAR PROTONS : Warning condition (activity levels expected to increase, but no numeric forecast given)
PREDICTIONS FOR 09 Oct 2026 10CM FLUX: 122 / AP: 021
PREDICTIONS FOR 10 Oct 2026 10CM FLUX: 124 / AP: 022
PREDICTIONS FOR 11 Oct 2026 10CM FLUX: 126 / AP: 015



Finding your way in the URSIgram

Solar Active Regions and flaring: The solar flaring activity over the past 24 hours reached high levels with background C-class flaring and one registered M-flare. The strongest recorded activity was a M6.7 flare (SIDC Flare 8685) with peak time at 15:48 UTC on October 08. The flare was produced within SIDC Sunspot Group 976 (NOAA Active Region 4549) currently located at N10W31. A total of 5 numbered sunspot groups were identified on the visible solar disk with SIDC Sunspot Group 976 remaining the largest and most complex region. It continues to be classified as magnetic type beta-gamma-delta and was the main contributor to the observed flaring activity over the past 24 hours. SIDC Sunspot Group 973 (NOAA Active Region 4545), currently located at N18W37, has exhibited some decay. It is classified as magnetic type beta and remained quiet. A new region has emerged on disc SIDC Sunspot Group 979, currently located at N22W11, and another one, SIDC Sunspot Group 980, is rotating from behind the south-east limb. Both are classified as magnetic type beta and the latter one has exhibited some low flaring activity while behind the east limb. The solar flaring activity is expected to be at moderate over the next 24 hours with likely M-class flaring and chances for an X-class flare.

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Coronal holes: SIDC Coronal Hole 149 (a recurrent mid-latitude coronal hole with a negative polarity) continues to reside on the central meridian. A high-speed stream related to it might be expected at Earth on October 09, possibly mixed with anticipated ICME arrival signatures related to SIDC CME 725.

Solar wind: Over the past 24 hours the solar wind parameters (as measured by ACE at L1) registered some enhancements, possibly the precursor of a high-speed stream arrival related to SIDC Coronal Hole 149. The solar wind speed remained slow, varying in the range of 333 to 390 km/s. The interplanetary magnetic field (B) registered a maximum value of 12.7 nT with a north-south (Bz) component down to - 7 nT. The B field phi angle switched from the positive to the negative sector (directed towards the Sun). The solar wind parameters are expected to be perturbed over the next 24 hours with an anticipated arrival of a high-speed stream possibly mixed with an ICME arrival related to SIDC CME 725. Perturbed solar wind conditions are expected to continue on October 10 with anticipated high- speed stream influence and possible waning ICME influence. A mild glancing blow arrival related to SIDC CME 726 could be expected on October 11 with the possibility of another ICME arrival late UTC on October 11 or early UTC on October 12 related to SIDC CME 727.

Geomagnetism: The geomagnetic conditions over the past 24 hours were locally (over Belgium) quiet to unsettled and globally quiet to active with NOAA Kp reaching 4 in the period 9-12 UTC on October 09. Unsettled conditions to minor storm levels are expected over the next 24 hours with chances for isolated moderate storms. Unsettled to active conditions with chances for more minor storm levels can continue on October 10, October 11 and October 12.

Proton flux levels: Over the past 24 hours the greater than 10 MeV GOES proton flux remained at close to nominal levels, while exhibiting some further enhancements related to activity from SIDC Sunspot Group 976 (NOAA Active Region 4549). The greater than 10 MeV GOES proton flux is expected to further increase over the next 24 hours with chances of reaching the 10 pfu proton event threshold.

Electron fluxes at GEO: The greater than 2 MeV electron flux as measured by GOES 18 and GOES 19 has exceeded the 1000 pfu threshold over the past 24 hours and is expected to be predominantly below the 1000 pfu threshold over the next 24 hours. The 24-hour electron fluence was at moderate levels and is expected to decrease to nominal levels over the next 24 hours.

TODAY'S ESTIMATED ISN : 086, BASED ON 07 STATIONS.

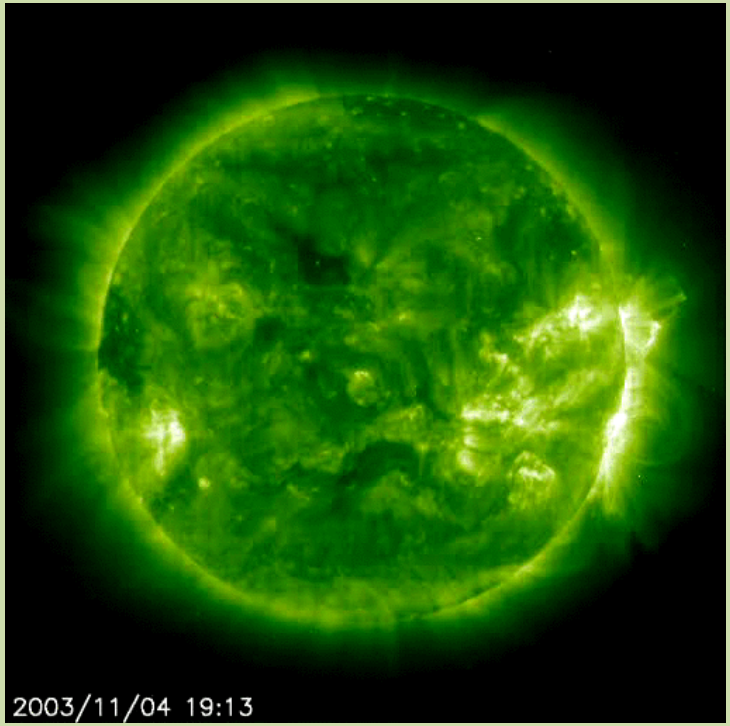
SOLAR INDICES FOR 08 Oct 2026
WOLF NUMBER CATANIA : 089
10CM SOLAR FLUX : ///
AK CHAMBON LA FORET : 017
AK WINGST : 006
ESTIMATED AP : 006
ESTIMATED ISN : 075, BASED ON 18 STATIONS.

Flare classification

NOTICEABLE EVENTS SUMMARY
DAY BEGIN MAX END LOC XRAY OP 10CM Catania/NOAA RADIO_BURST_TYPES
08 1529 1548 1558 N12W20 M6.7 2B 57/4549 I/3
END

FLARES - OVERVIEW

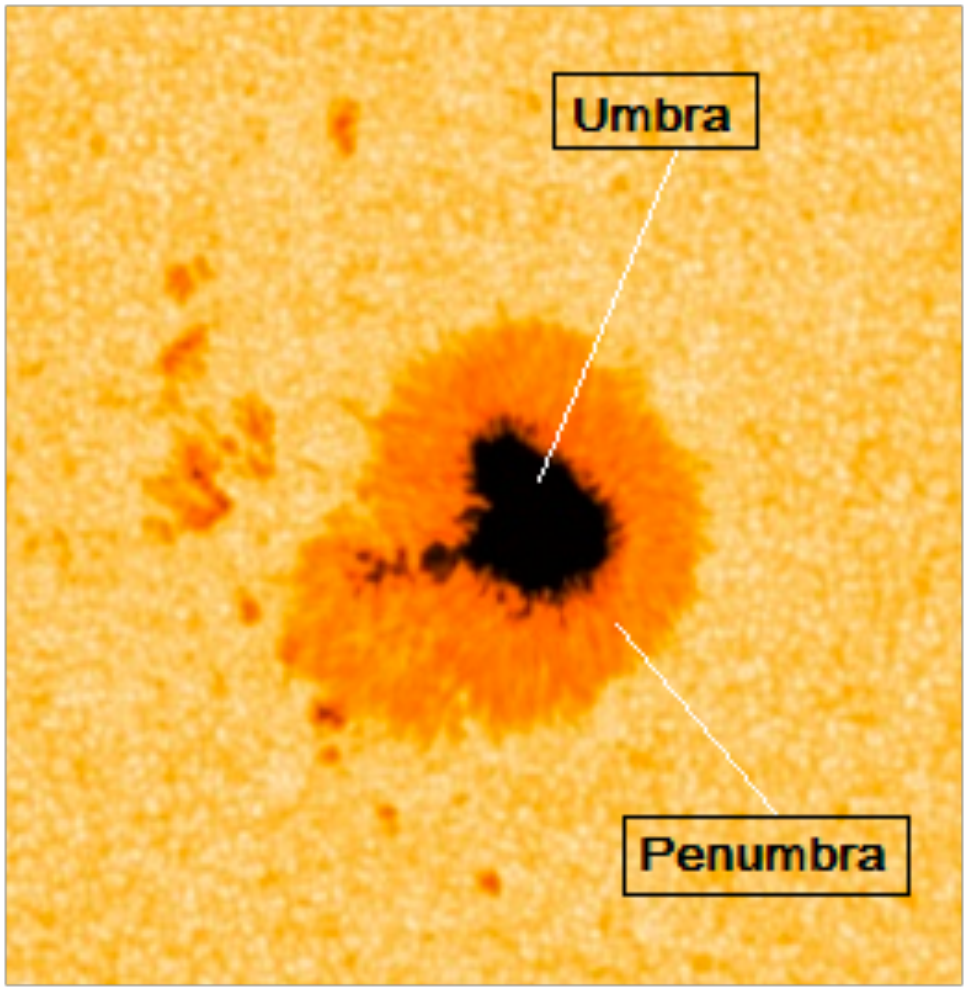
- Flare Characteristics
- Flare Classification
- **Flare predictions**
  - **McIntosh**
  - **Hale**





SOHO/EIT

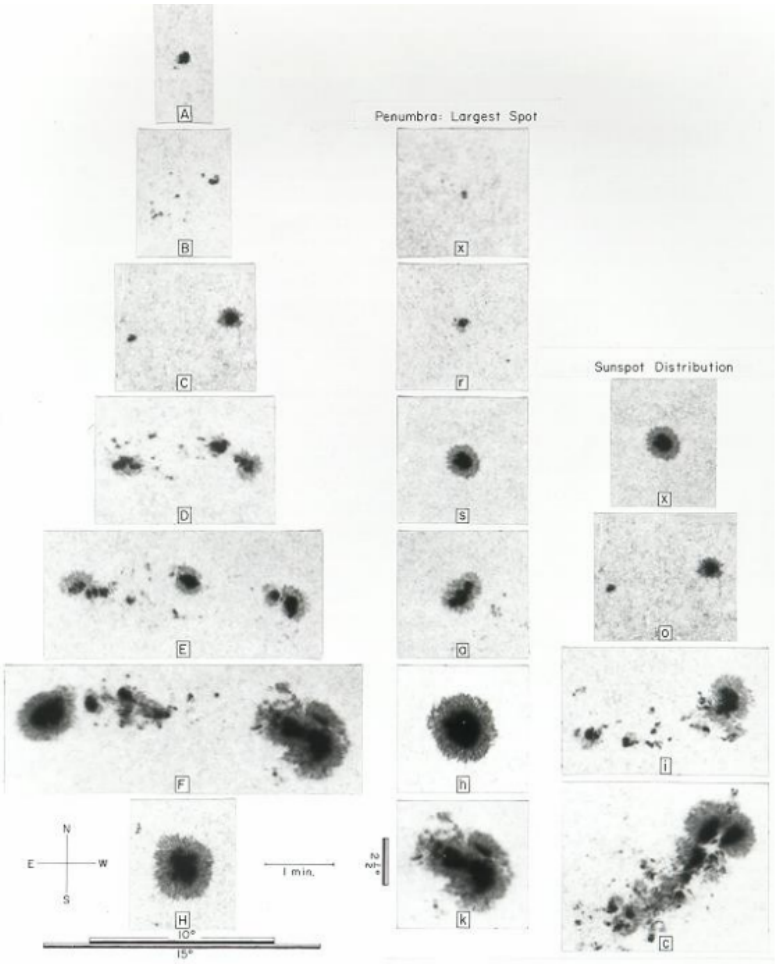
SUNSPOT NOMENCLATURE



FLARE PREDICTIONS

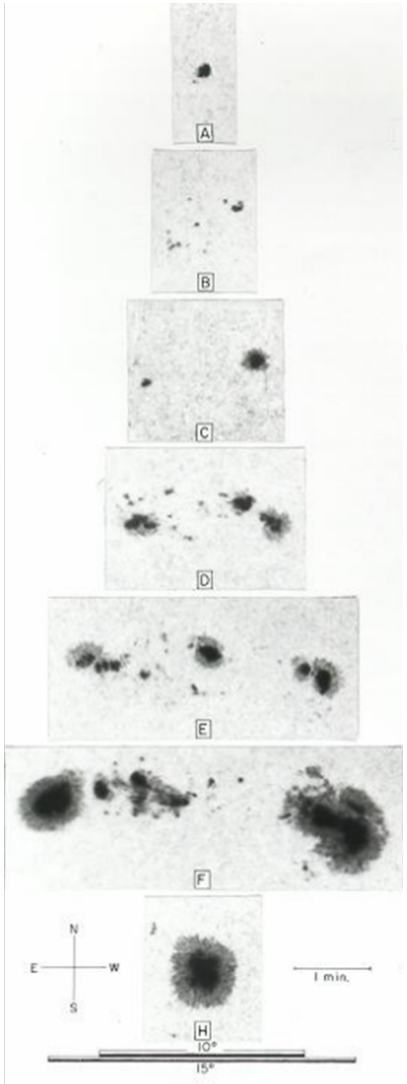
McIntosh classification

- Zpc ***(3-letter code)***
  - Z - Modified Zürich classification
  - p - Penumbra largest spot
  - c - Interior sunspot distribution
- 60 possible combinations
  - Linked to flare intensity
  - Rather large uncertainties
- Used worldwide



FLARE PREDICTIONS

A
B
C
D
E
F
H



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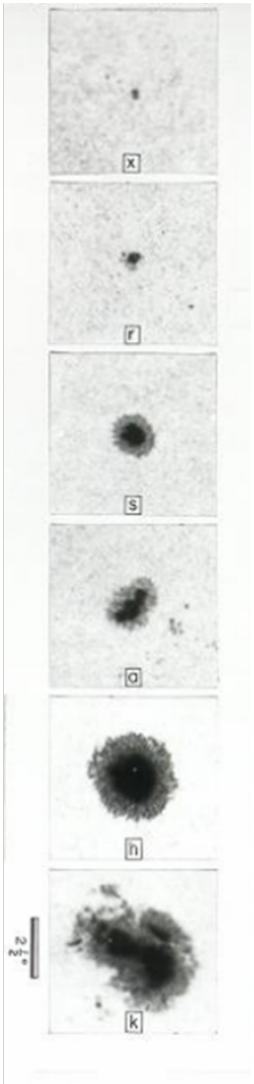

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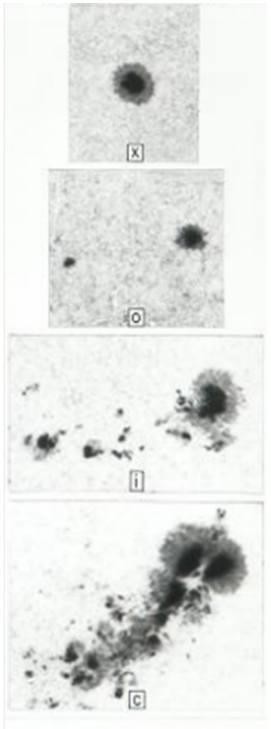


FLARE PREDICTIONS

Table 2
McIntosh Classification Flare Statistics

McIntosh	SWPC (1988–1996)				Kildahl (1969–1976)[b]				Combined Flare Rate (24 hr^{-1})				Poisson Flare Probability (%)				
Region	Region	Total Flares			Region	Total Flares			In *GOES* Class				In *GOES* Class			Above *GOES*[d]	
Classes[a]	Count	C	M	X	Count	C[c]	M	X	C	M	X	$\pm\sigma$	C	M	X	M1.0	C1.0
ESO	95	37	6	0	82	31.9	14	0	0.39	0.11	0.00	0.08	32	11	0	11	39
ESI	18	33	1	0	78	143.0	22	2	1.83	0.24	0.02	0.10	84	21	2	23	88
EAO	459	267	61	0	47	27.3	10	4	0.58	0.14	0.01	0.04	44	13	1	14	52
EAI	295	370	83	2	82	102.8	48	1	1.25	0.35	0.01	0.05	71	29	1	30	80
EAC	3	5	1	0	17	28.3	6	3	1.67	0.35	0.15	0.22	81	30	14	39	89
EHO	42	31	6	0	39	28.8	6	0	0.74	0.15	0.00	0.11	52	14	0	14	59
EHI	15	24	6	0	45	72.0	28	4	1.60	0.57	0.07	0.13	80	43	6	47	89
EHC	2	9	0	0	4	18.0	8	0	4.50	1.33	0.00	0.41	99	74	0	74	100
EKO	185	173	35	3	52	48.6	20	1	0.94	0.23	0.02	0.06	61	21	2	22	69
EKI	423	703	173	23	81	134.6	103	11	1.66	0.55	0.07	0.04	81	42	7	46	90
EKC	103	278	132	17	63	170.0	149	21	2.70	1.69	0.23	0.08	93	82	20	85	99
FRI	0	0	0	0	2	0.0	1	0	0.00	0.50	0.00	0.71	0	39	0	39	39
FSO	14	9	3	0	13	8.4	6	1	0.64	0.33	0.04	0.19	47	28	4	31	64
FSI	6	12	0	0	8	16.0	15	0	2.00	1.07	0.00	0.27	86	66	0	66	95
FAO	73	63	16	0	3	2.6	0	0	0.86	0.21	0.00	0.11	58	19	0	19	66
FAI	91	106	35	3	12	14.0	8	0	1.16	0.42	0.03	0.10	69	34	3	36	80
FHO	9	5	1	0	10	5.6	0	0	0.56	0.05	0.00	0.23	43	5	0	5	46
FHI	10	17	9	0	18	30.6	15	0	1.70	0.86	0.00	0.19	82	58	0	58	92
FHC	0	0	0	0	5	0.0	4	0	0.00	0.80	0.00	0.45	0	55	0	55	55
FKO	97	165	29	1	19	32.3	6	0	1.70	0.30	0.01	0.09	82	26	1	27	87
FKI	235	517	161	17	47	103.4	106	17	2.20	0.95	0.12	0.06	89	61	11	66	96
FKC	93	233	146	24	27	67.6	39	13	2.51	1.54	0.31	0.09	92	79	27	84	99

Notes.
[a] Only includes classifications producing $\geqslant$1 C-, M-, or X-class flare in either time range.
[b] From Kildahl (1980).
[c] Non-integer flare numbers result from use of observed C-class rates from SWPC (1988–1996).
[d] "Above *GOES* X1.0" is equivalent to "In *GOES* Class X."

FLARE PREDICTIONS

Likelihood (terminology)

RWC Belgium: Decision on use of scales and wording

Flare forecast

ISES
0 = Quiet (<50% probability of C-class flares) 1 = Eruptive (C-class flares expected, probability >=50%) 2 = Active (M-class flares expected, probability >=50%) 3 = Major flares expected (X-class flares expected, probability >=50%)

Activity level	wording for bulletin
<50% probability of C-class flares	Quiet solar conditions
C-class flares expected, probability >=50%	C-class flares expected C-class flaring activity/conditions expected we expect solar active conditions ([C,M,X]-class flares) with a high/small probability for a [C, M, X]-flare
M-class flares expected, probability >=50%	M-class flares expected / idem as above
X-class flares expected, probability >=50%	X-class flares expected / idem as above

Unofficial terminology deduced from various SWx reports/services

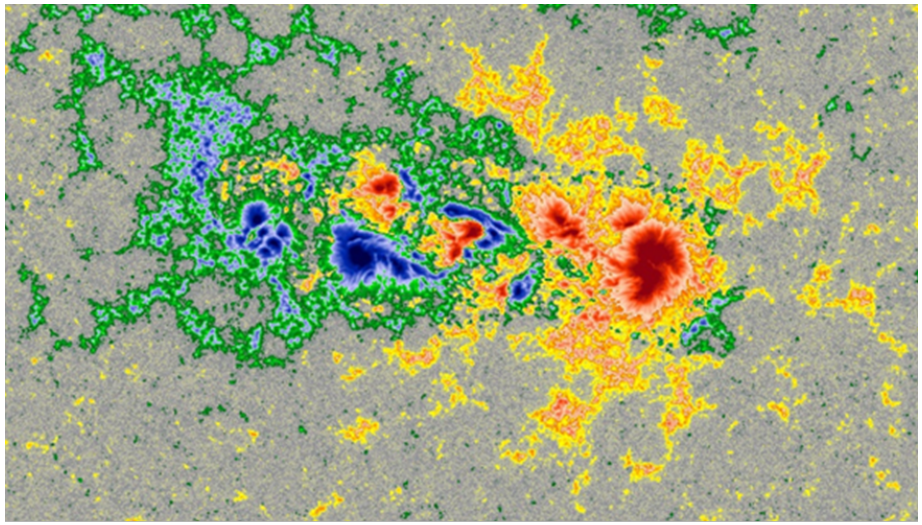
Probability (%)	Terminology
0-10	Unlikely
10-25	Small chance
25-50	A chance; Possible
50-75	Likely
75-100	Very likely; Expected

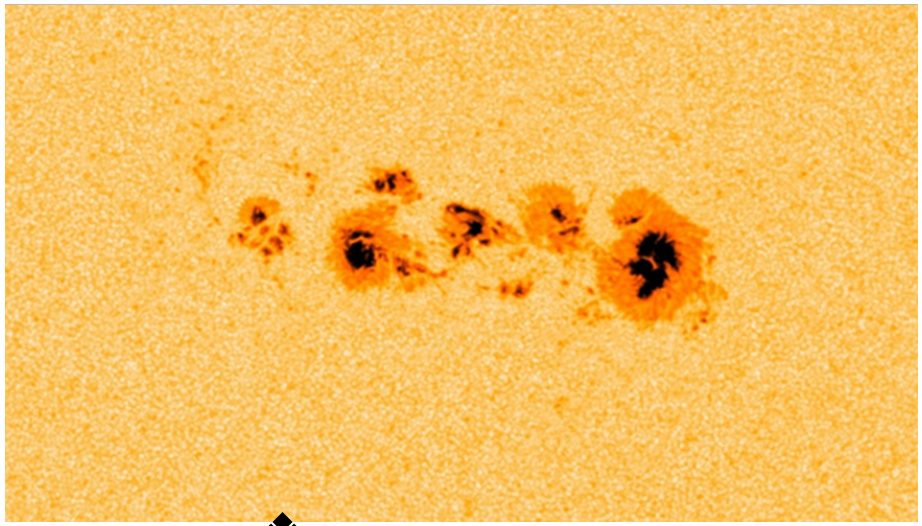
This is a topic under continued improvement / discussion….

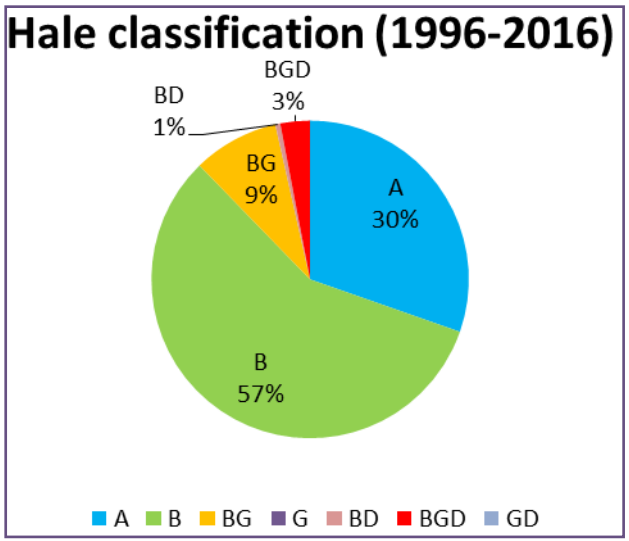
FLARE PREDICTIONS

Mount Wilson (Hale) classification

- Based on the magnetic properties of a sunspot group
- 7 options:
  - A (α)
  - B (β), BG (βγ), G (γ)
  - BD (βδ), BGD (βγδ), GD (γδ)



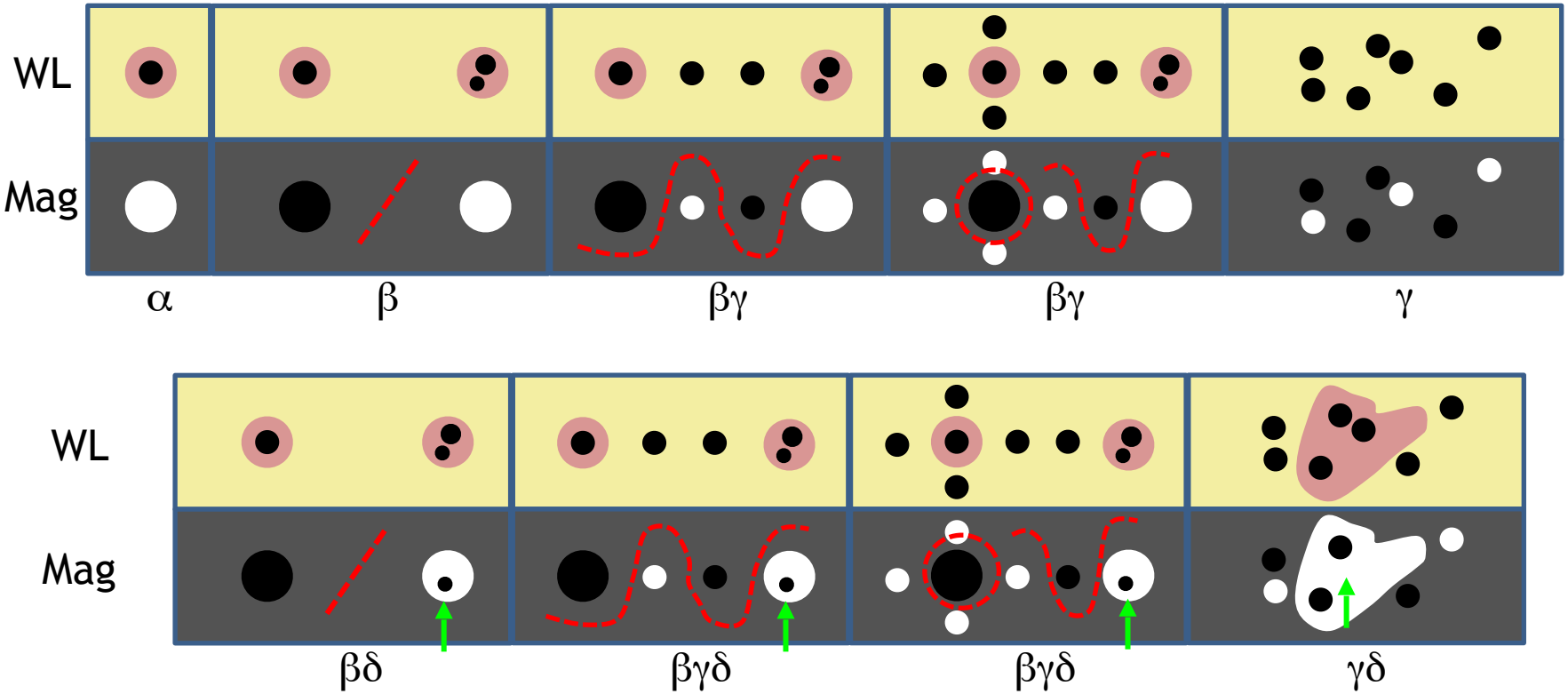




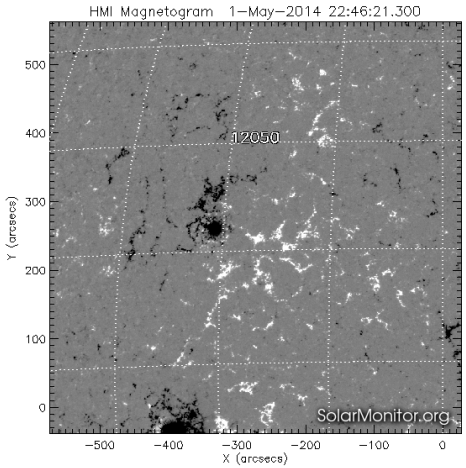
SDO/HMI

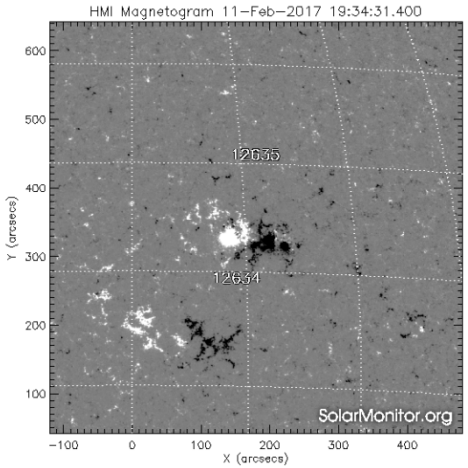
FLARE PREDICTIONS

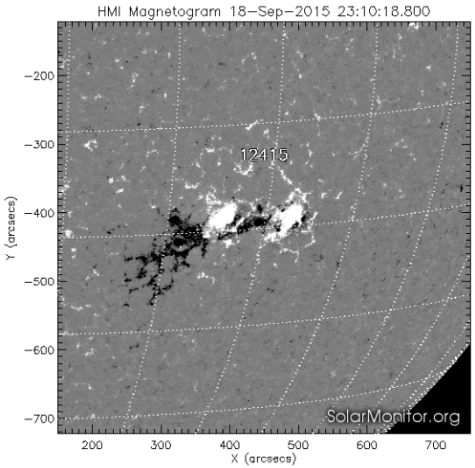
Mount Wilson (Hale) classification - Sketches

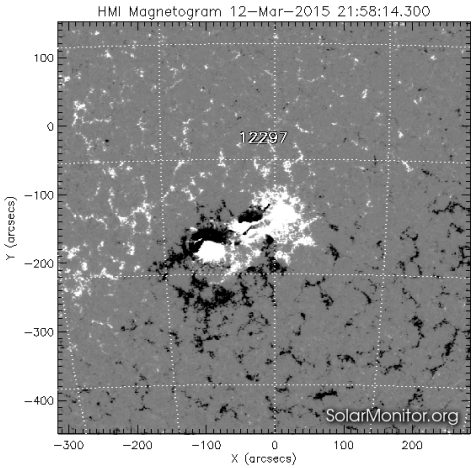


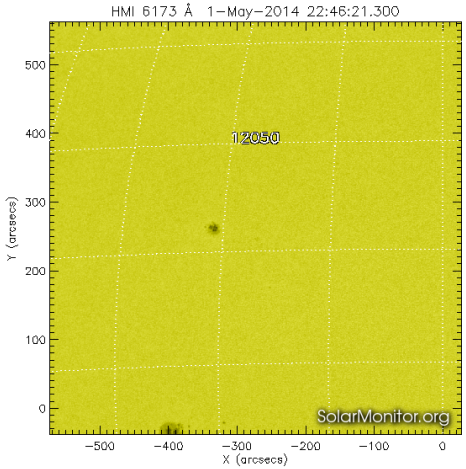
EXAMPLES OF HALE CLASSIFICATION

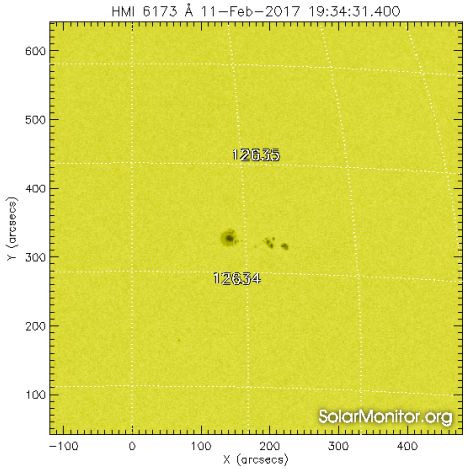


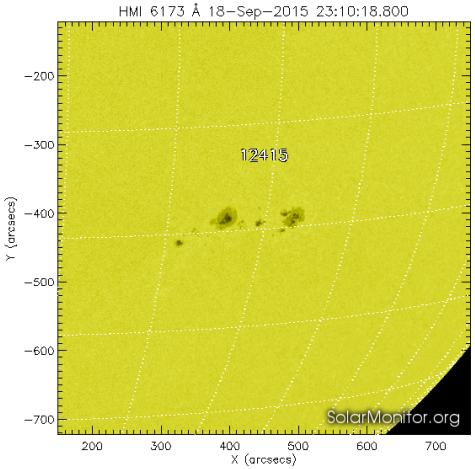


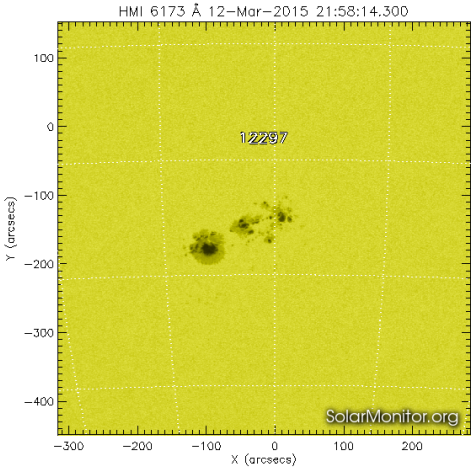








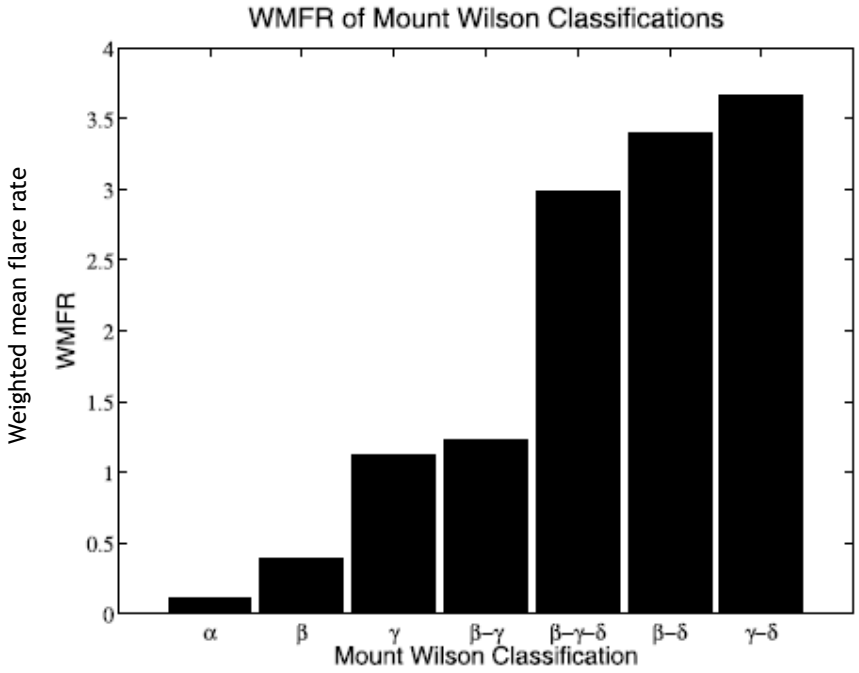


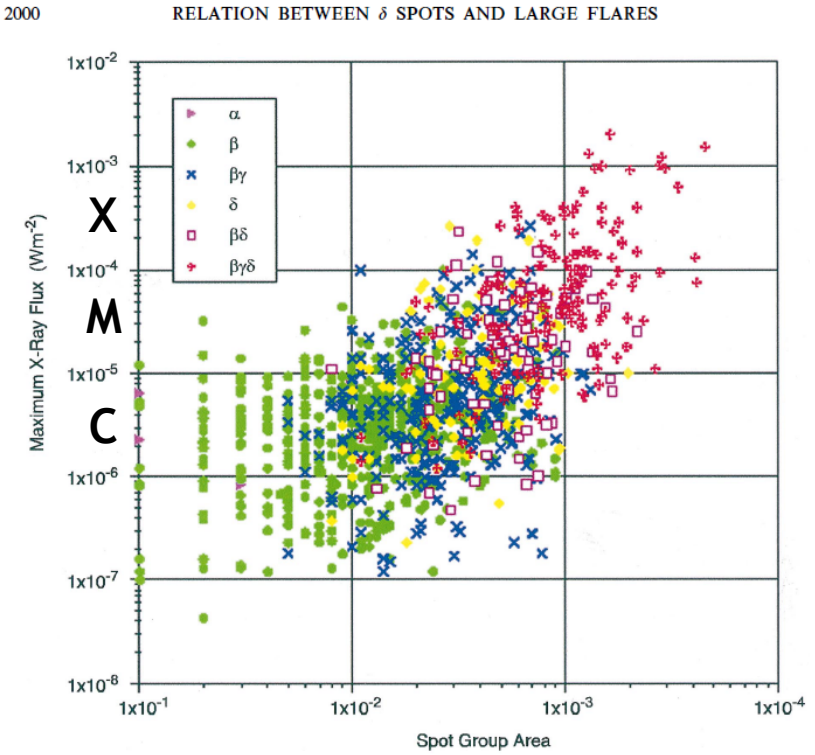


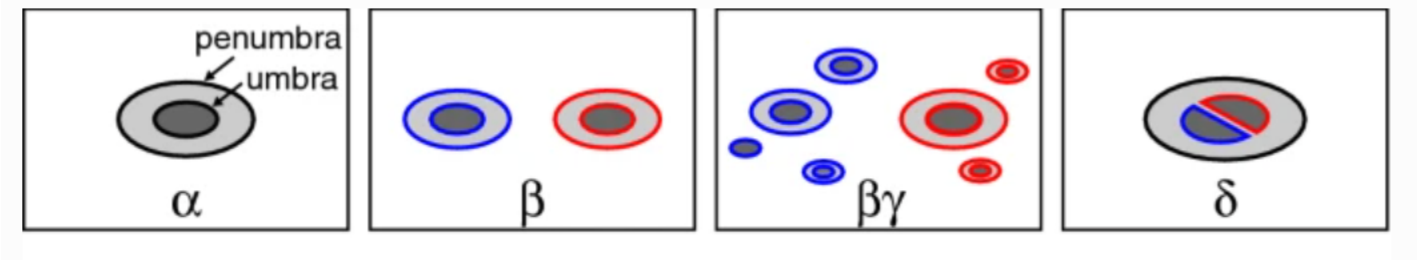
α β βγ βγδ

SDO/HMI

FLARE PREDICTIONS

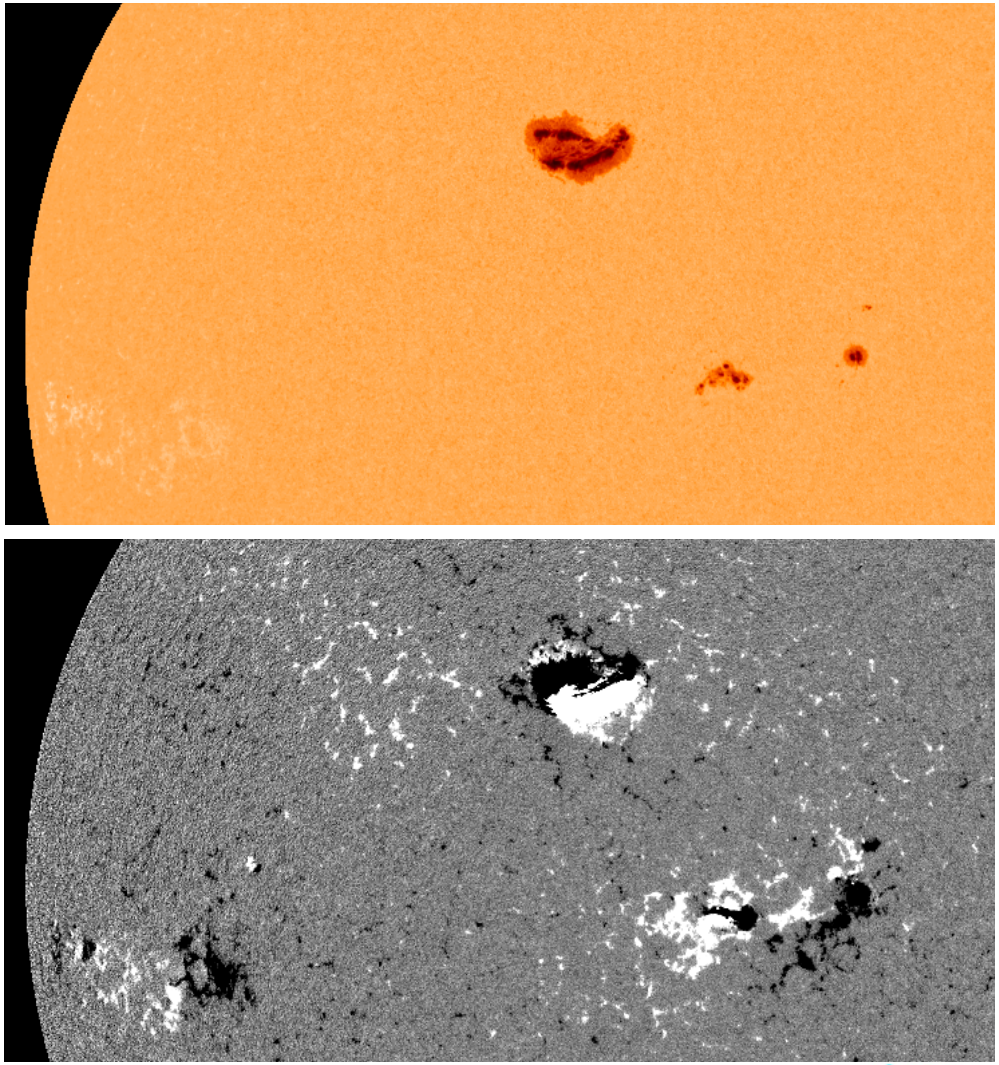






FLARE PREDICTIONS

- Magnetic shear
- Magnetic helicity
- Flaring history
- Evolution of group
- Size of the spots
- …



:Issued: 2026 Oct 09 1254 UTC
:Product: documentation at http://www.sidc.be/products/meu
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Solar wind: Over the past 24 hours the solar wind parameters (as measured by ACE at L1) registered some enhancements, possibly the precursor of a high-speed stream arrival related to SIDC Coronal Hole 149. The solar wind speed remained slow, varying in the range of 333 to 390 km/s. The interplanetary magnetic field (B) registered a maximum value of 12.7 nT with a north-south (Bz) component down to - 7 nT. The B field phi angle switched from the positive to the negative sector (directed towards the Sun). The solar wind parameters are expected to be perturbed over the next 24 hours with an anticipated arrival of a high-speed stream possibly mixed with an ICME arrival related to SIDC CME 725. Perturbed solar wind conditions are expected to continue on October 10 with anticipated high- speed stream influence and possible waning ICME influence. A mild glancing blow arrival related to SIDC CME 726 could be expected on October 11 with the possibility of another ICME arrival late UTC on October 11 or early UTC on October 12 related to SIDC CME 727.

Geomagnetism: The geomagnetic conditions over the past 24 hours were locally (over Belgium) quiet to unsettled and globally quiet to active with NOAA Kp reaching 4 in the period 9-12 UTC on October 09. Unsettled conditions to minor storm levels are expected over the next 24 hours with chances for isolated moderate storms. Unsettled to active conditions with chances for more minor storm levels can continue on October 10, October 11 and October 12.

Proton flux levels: Over the past 24 hours the greater than 10 MeV GOES proton flux remained at close to nominal levels, while exhibiting some further enhancements related to activity from SIDC Sunspot Group 976 (NOAA Active Region 4549). The greater than 10 MeV GOES proton flux is expected to further increase over the next 24 hours with chances of reaching the 10 pfu proton event threshold.

Electron fluxes at GEO: The greater than 2 MeV electron flux as measured by GOES 18 and GOES 19 has exceeded the 1000 pfu threshold over the past 24 hours and is expected to be predominantly below the 1000 pfu threshold over the next 24 hours. The 24-hour electron fluence was at moderate levels and is expected to decrease to nominal levels over the next 24 hours.

TODAY'S ESTIMATED ISN : 086, BASED ON 07 STATIONS.

SOLAR INDICES FOR 08 Oct 2026
WOLF NUMBER CATANIA : 089
10CM SOLAR FLUX : ///
AK CHAMBON LA FORET : 017
AK WINGST : 006
ESTIMATED AP : 006
ESTIMATED ISN : 075, BASED ON 18 STATIONS.

NOTICEABLE EVENTS SUMMARY
DAY BEGIN MAX END LOC XRAY OP 10CM Catania/NOAA RADIO_BURST_TYPES
08 1529 1548 1558 N12W20 M6.7 2B 57/4549 I/3
END

Flare prediction

SOLAR ERUPTIONS

Magnetic Reconnection

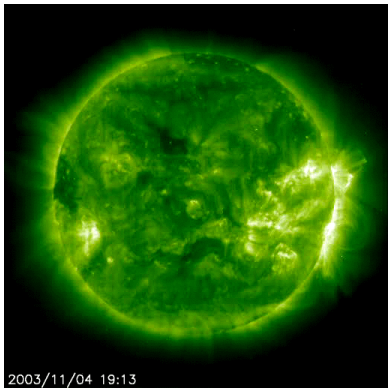
Radiation

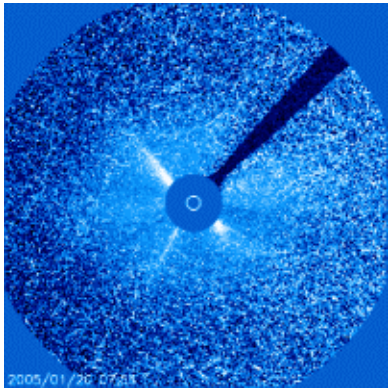
Particles

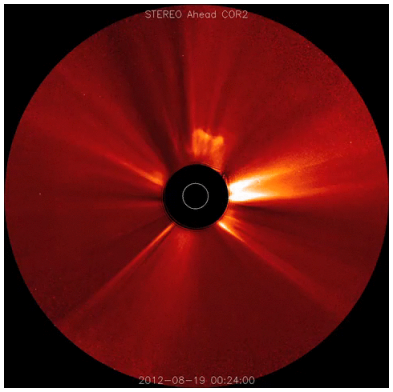
Solar flares

Proton events

Coronal Mass Ejections







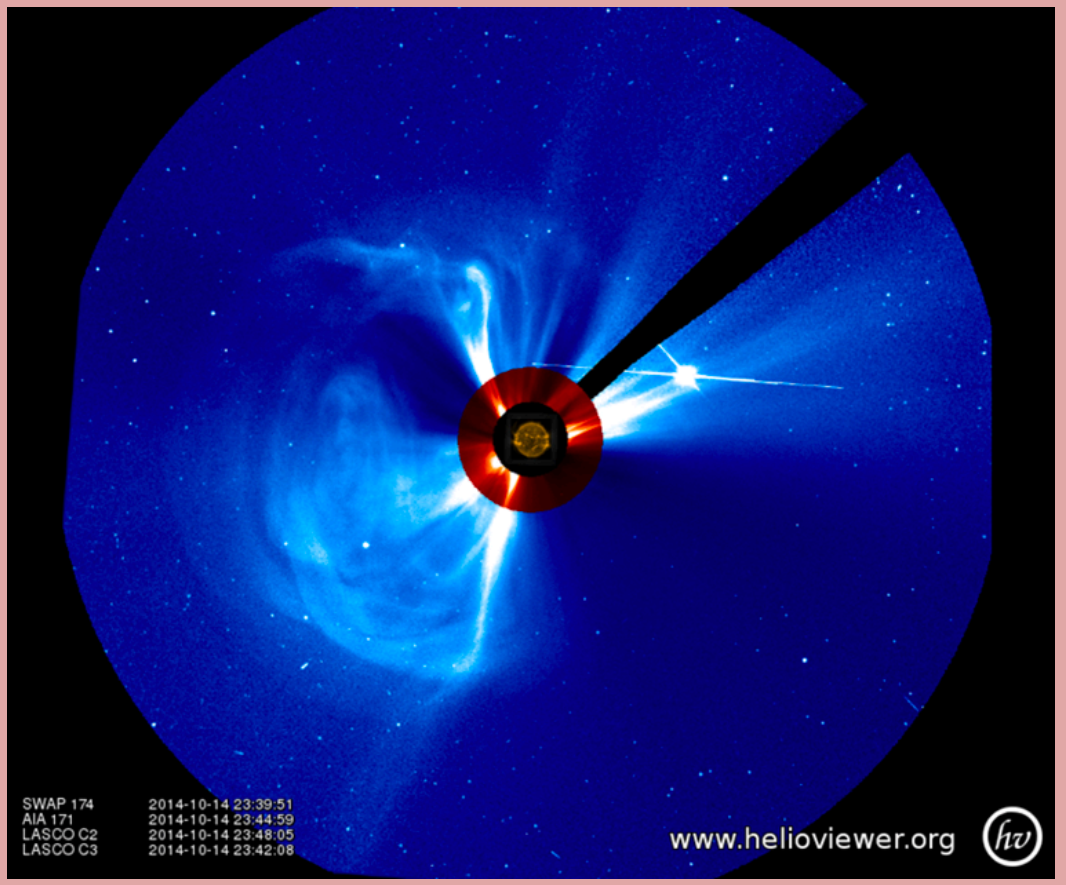
SOHO/EIT

SOHO/LASCO

SOHO/LASCO

CME - OVERVIEW

- **Model**
- On-disk signatures
  - Filaments
  - Waves
  - Dimming
  - Post-eruption arcade
- Characteristics



PROBA2/SWAP
SDO/AIA
SOHO/LASCO

CORONAL MASS EJECTION

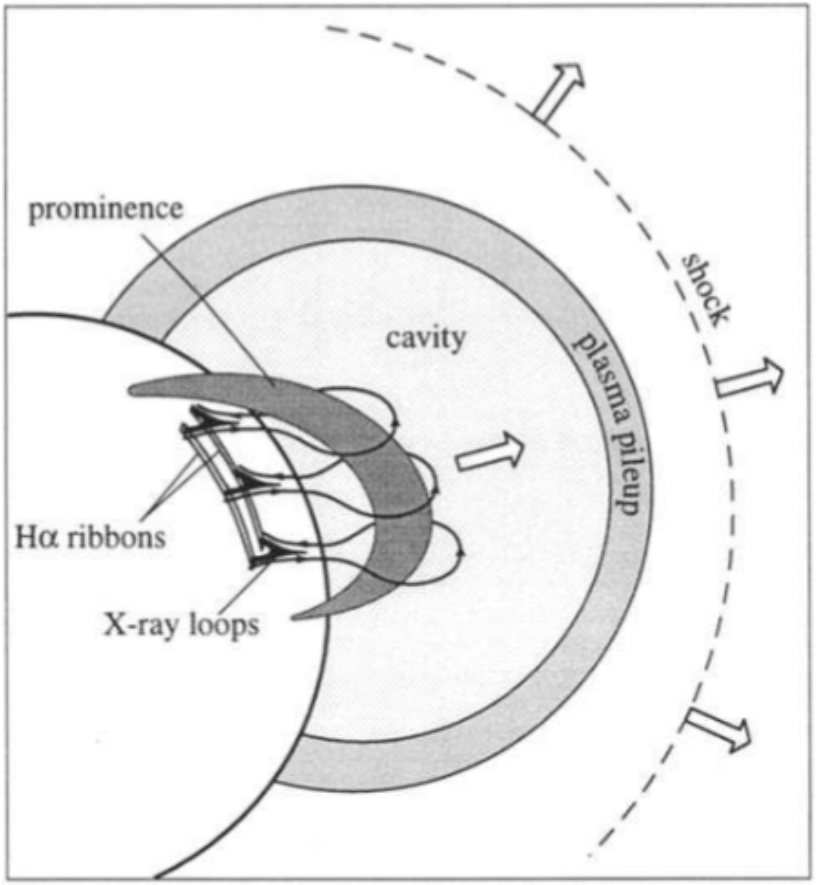
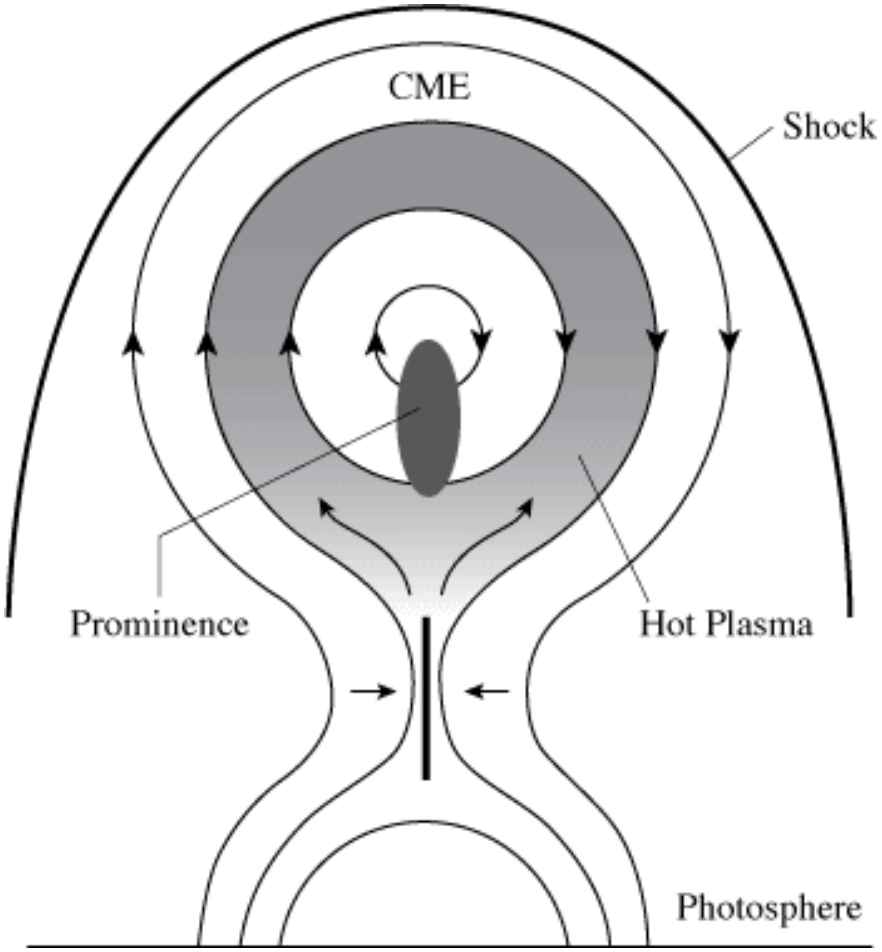


Figure 3. Schematic diagram showing the relationship between various features associated with a CME. The shaded region labeled "plasma pileup" refers to the outer circular arc seen in coronagraphs.



CME SKETCH

Shock

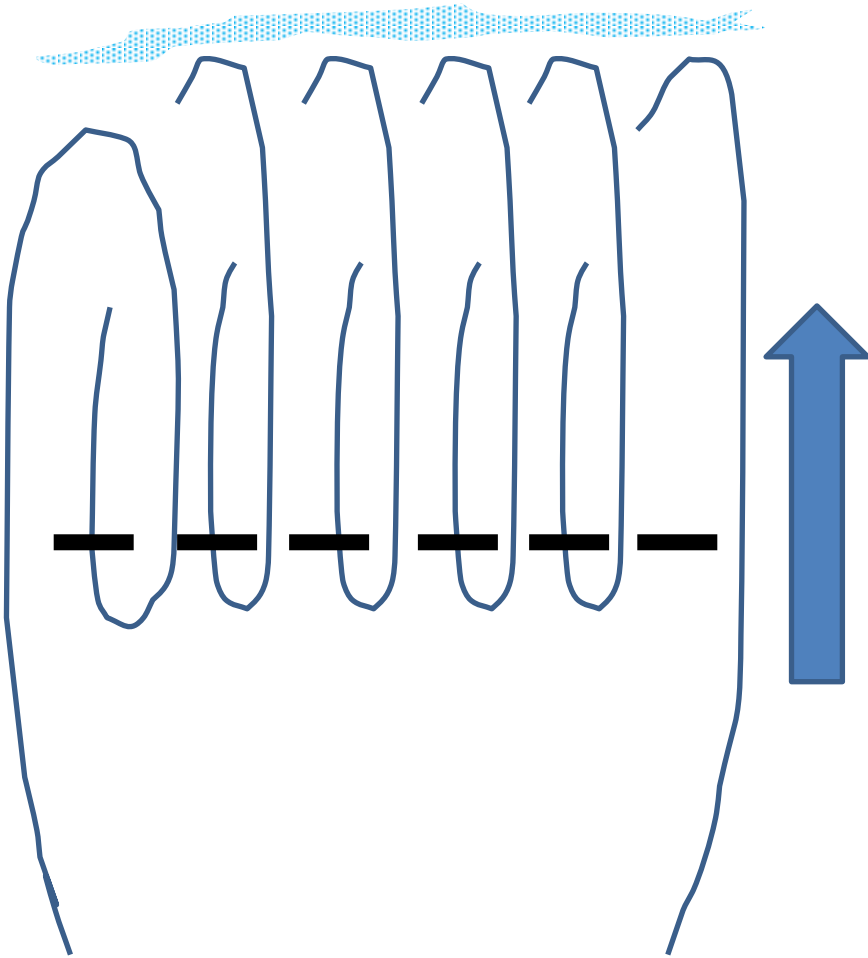
Plasma pile-up

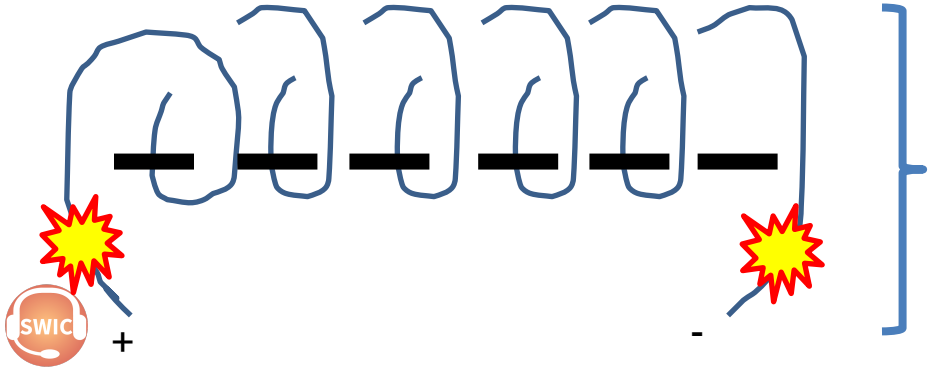
Cavity

Core filament

Flanks

Step 2: Expanding flux rope evolving into a CME





Step 1: Magnetic flux rope at magnetic reconnection

CME SKETCH

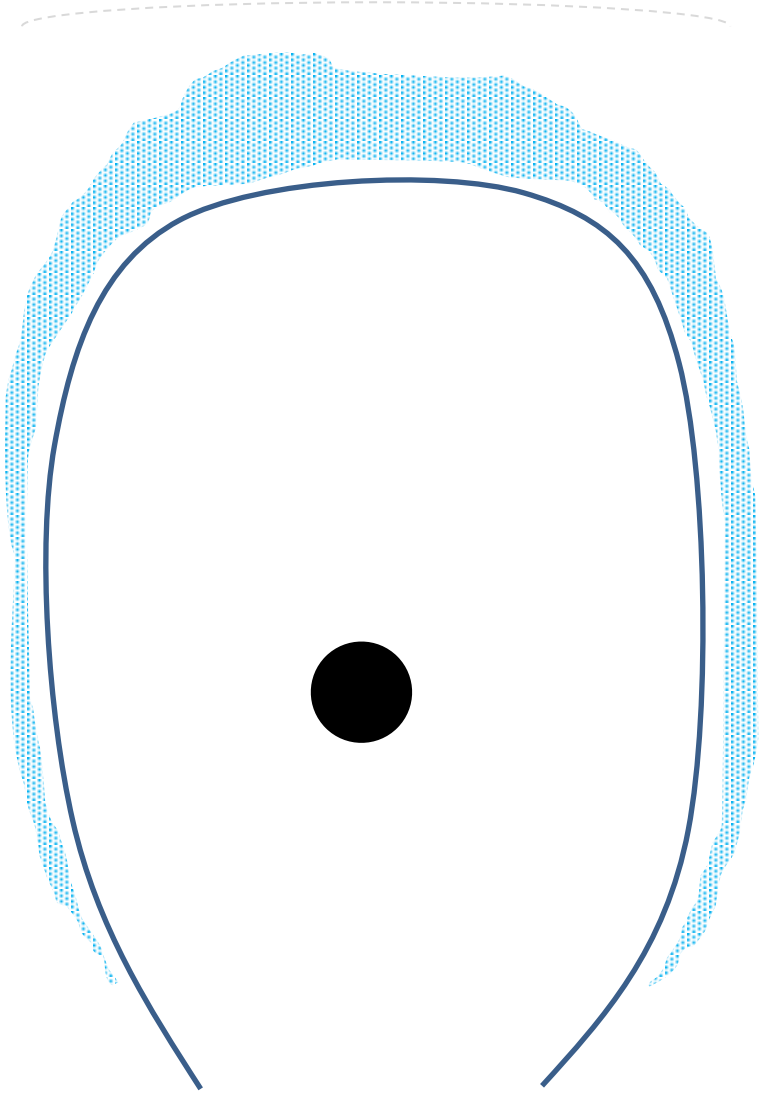
Shock

Plasma pile-up

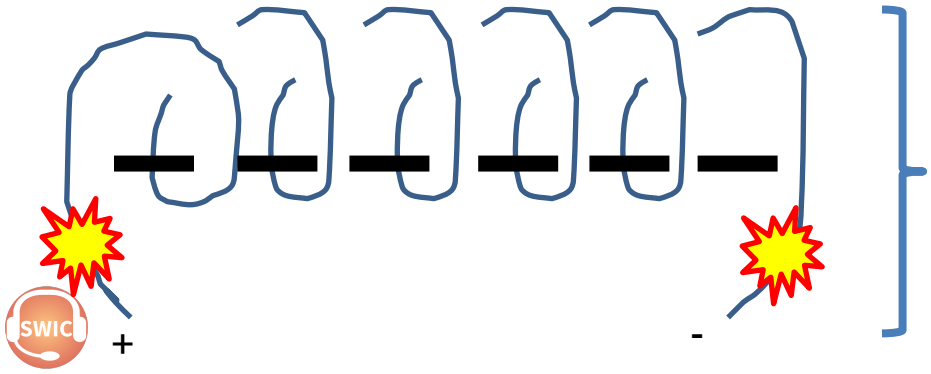
Cavity

Core filament

Flanks

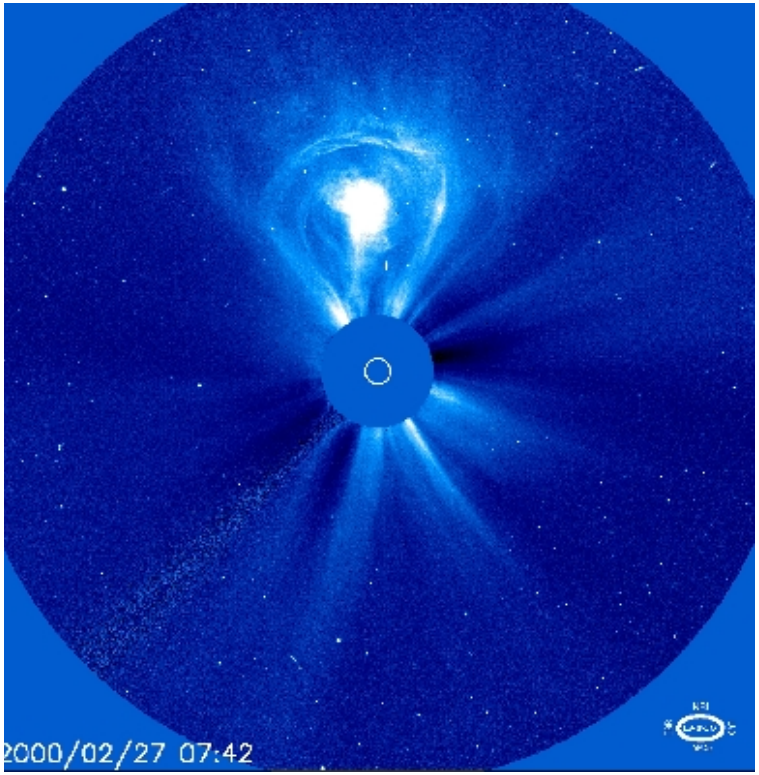


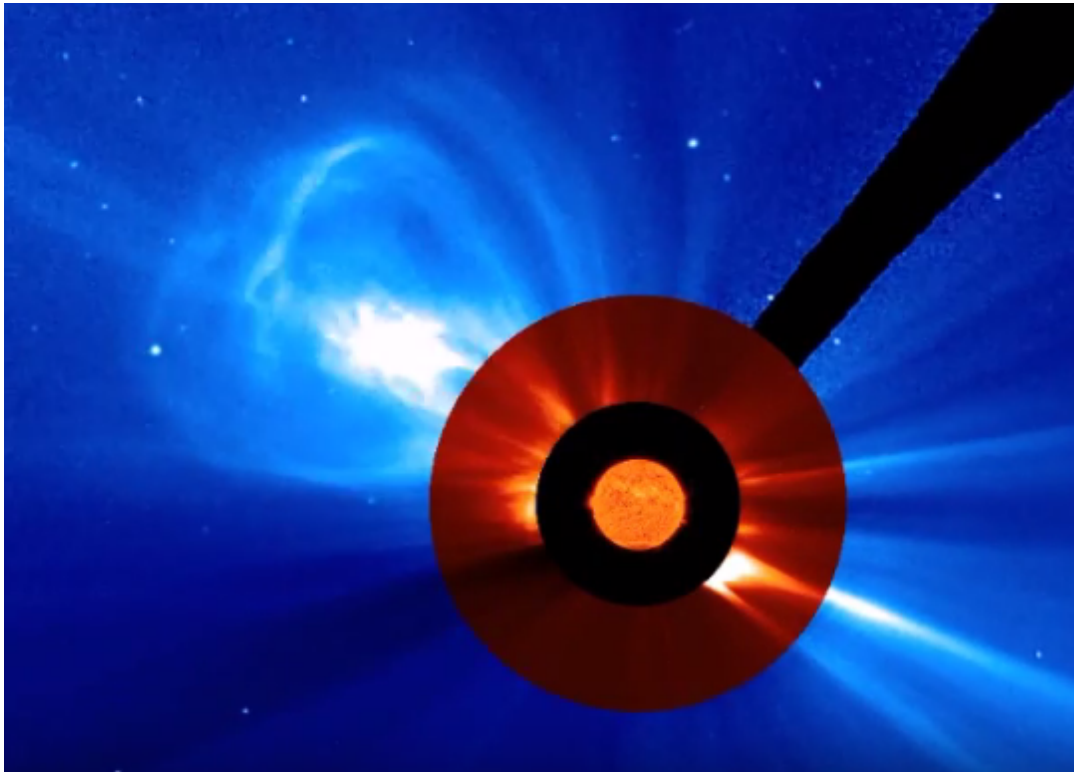
Step 2: Expanding flux rope evolving into a CME



Step 1: Magnetic flux rope at magnetic reconnection

CORONAL MASS EJECTION





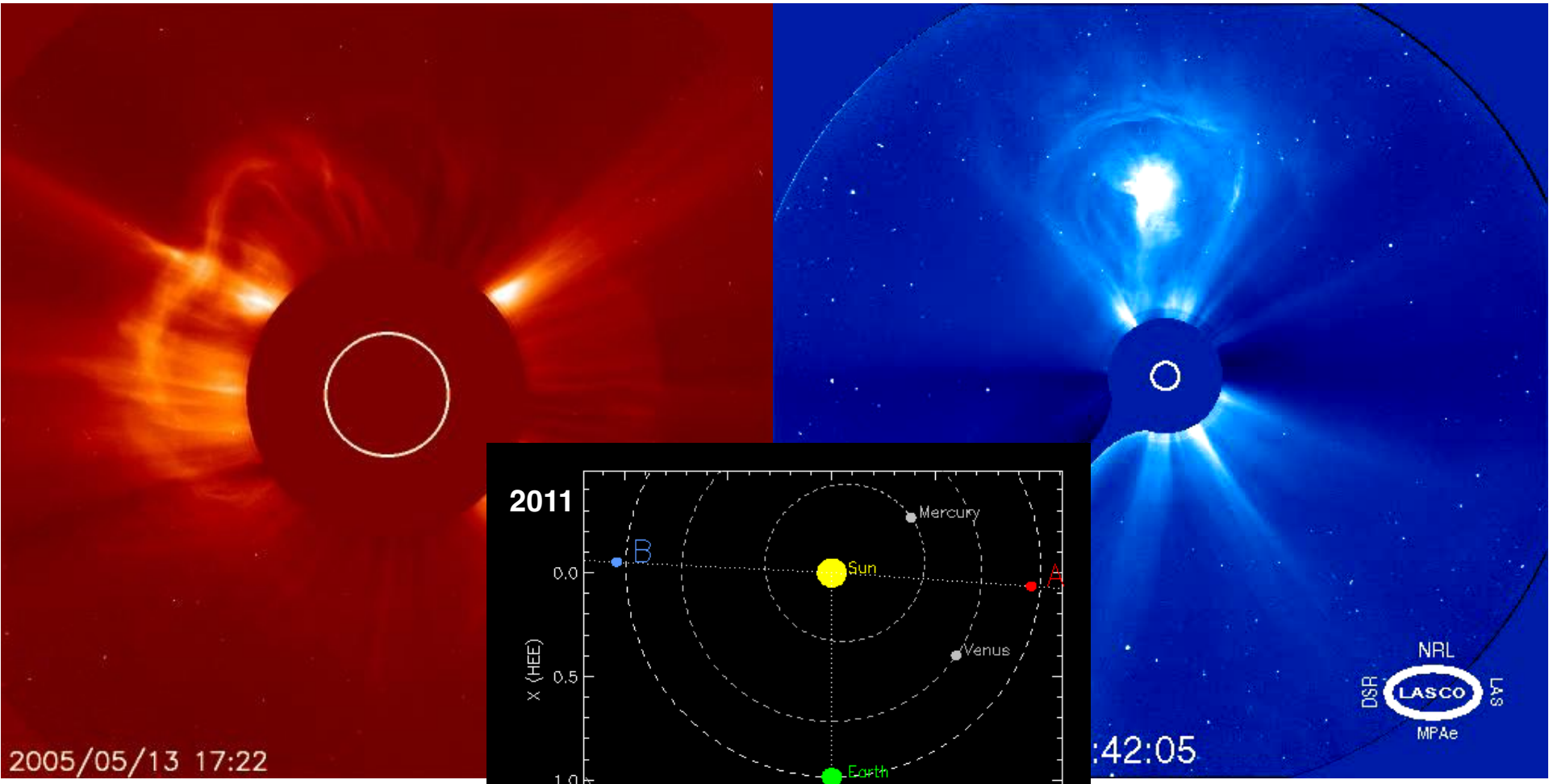
SOHO/LASCO

SDO/AIA
SOHO/LASCO

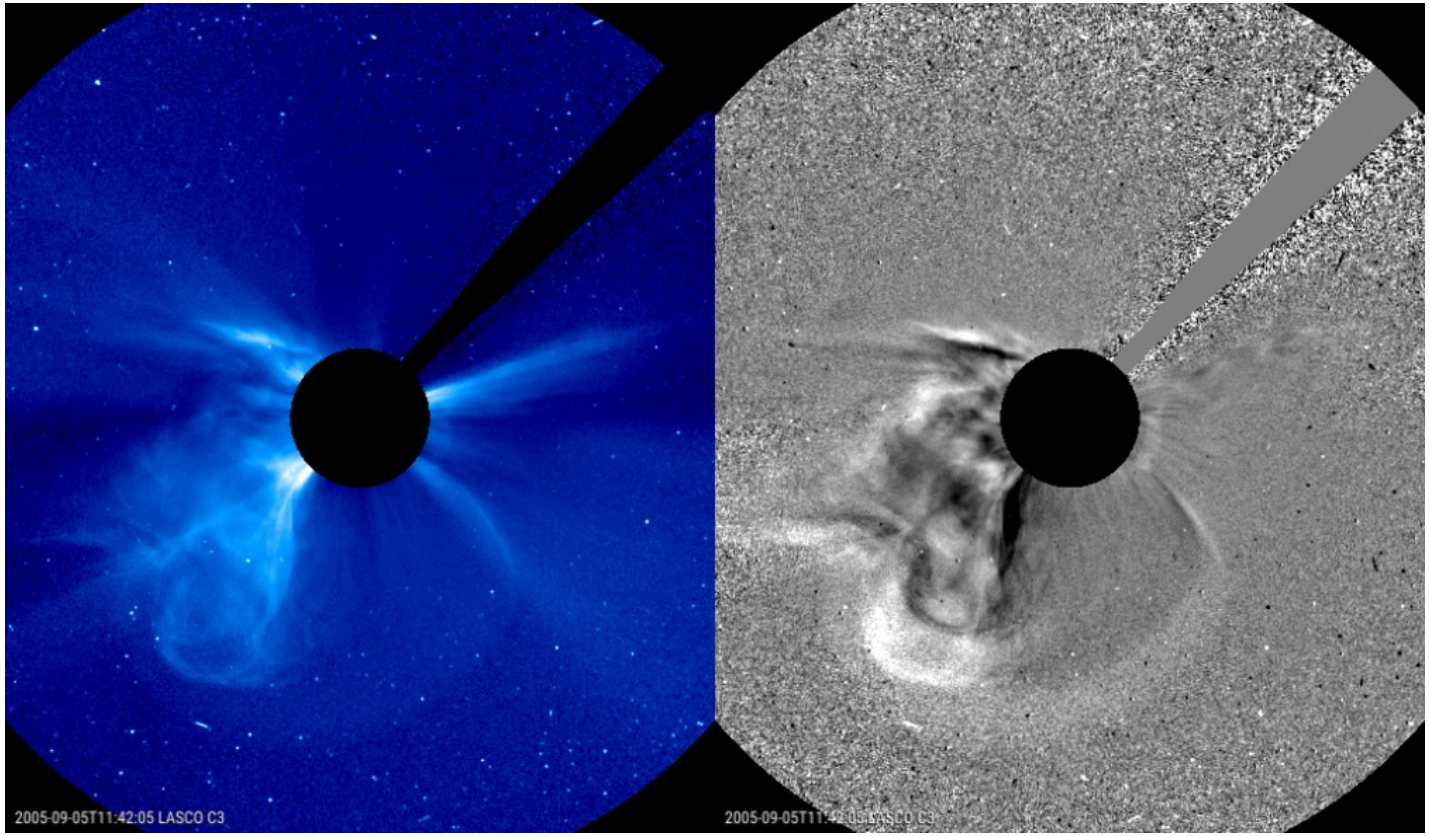
PLASMA CLOUDS

SOHO/LASCO C2

SOHO/LASCO C3



DIFFERENCE IMAGES





SOHO/LASCO

CME - OVERVIEW

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  - Filaments
  - Waves
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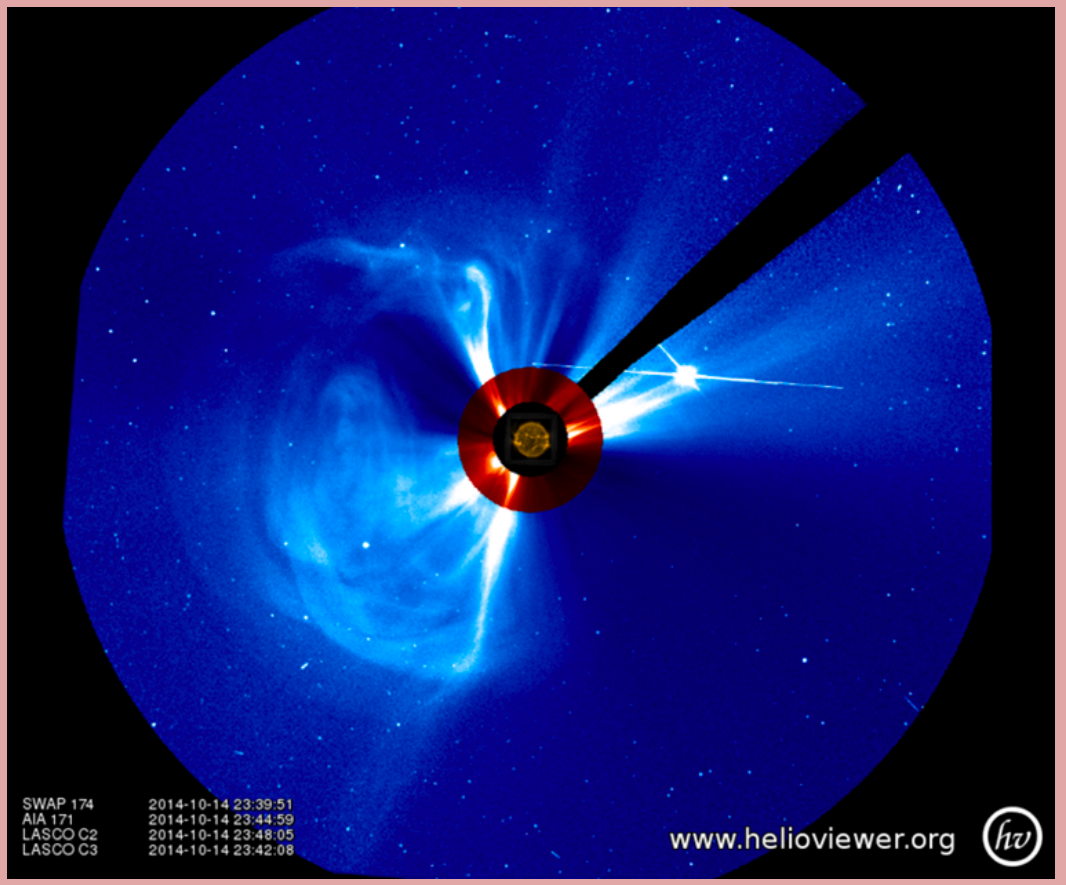




PROBA2/SWAP
SDO/AIA
SOHO/LASCO

FILAMENTS & PROMINENCES

Chromospheric features
- Protruding into corona
- H-alpha and EUV
- Relatively cool (10.000K)

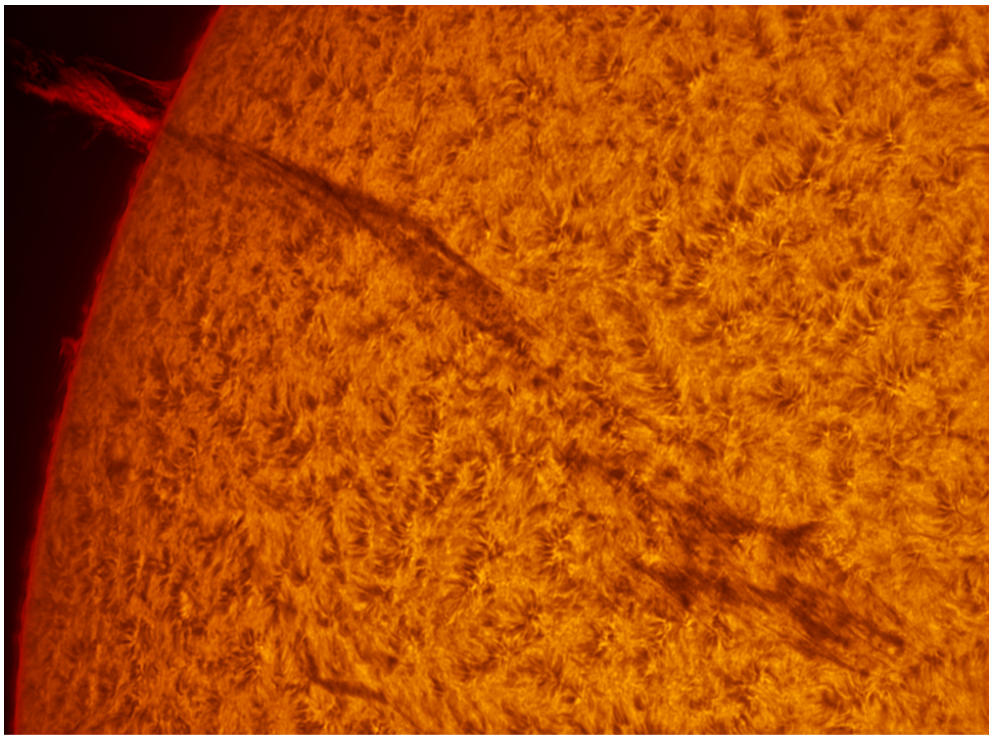
Mark the transition between positive and negative magnetic areas

Appear all over solar disk

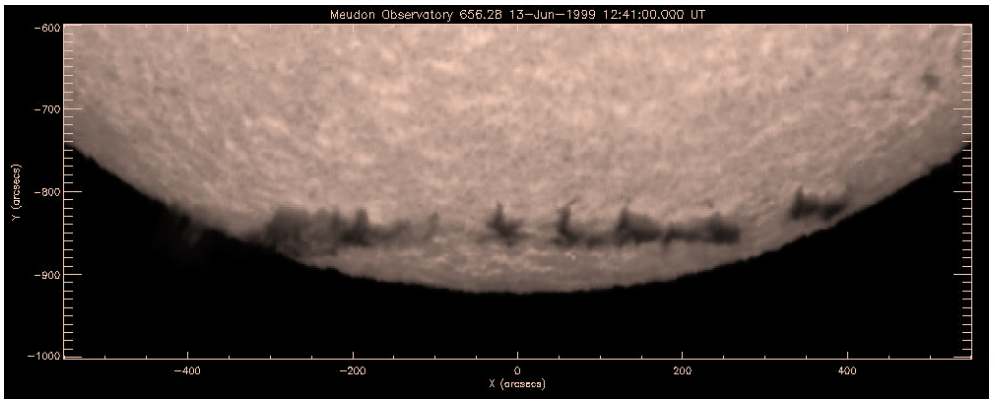
Location
- In active region

  Group filament
- Outside active region

  Quiescent filament
- Polar crown filament



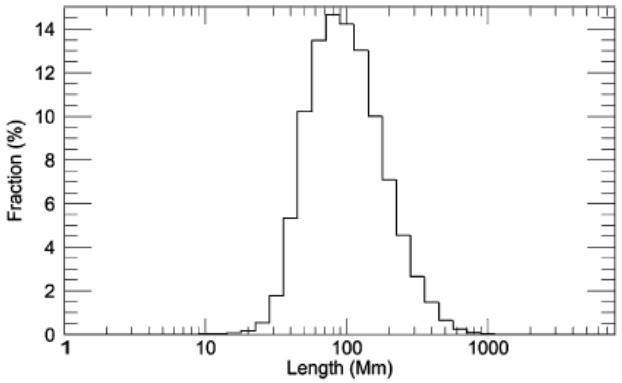
Large NE Solar Filaprom (Filament and Prominence) by Jett Aguilar, 01:45 UTC, April 28, 2015 , Quezon City, Philippines
Lunt 100 mm/BF1800 H-Alpha telescope, 2.5x Televue Powermate, DMK31AU03 camera



FILAMENTS & PROMINENCES

- Quiescent
  - Not associated to AR
  - Weeks to months
- Length
  - Long filaments (> 15°)
  - More prone to instabilities
    - Near (emerging) active regions
    - From chromospheric or coronal waves
    - Near coronal holes
  - Flaring
    - 38% result in at least 1 flare
    - Intensity : C1-M1

Figure 4 Distribution of the filament length in a logarithmic scale. The relative number of filaments is given as a function of their length in Mm.



R. Mawad et al. / Advances in Space Research 55 (2015) 696–704

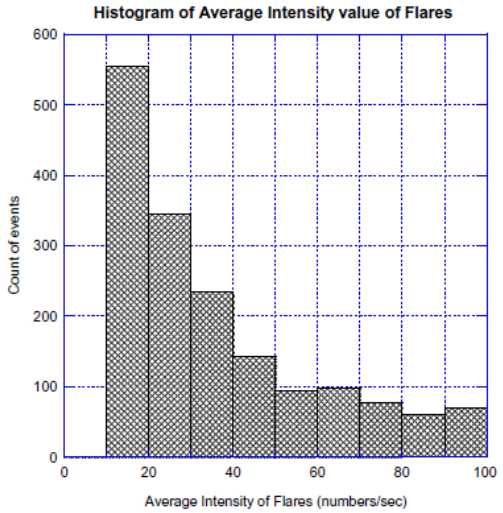


Fig. 6. Histogram of intensity of solar flares which are occurred during duration time of filament disappearance event during 1996–2010.

FILAMENT/PROMINENCE ERUPTIONS

Height

- Zirin (1988)
  - If > 50.000 km, eruption likely within next 48 hours
- Filippov (2008)
  - Height cannot exceed ciritical height
  - Related to strength of and change in magnetic field

Other signs

- Darkening filament
- Change in tilt or length

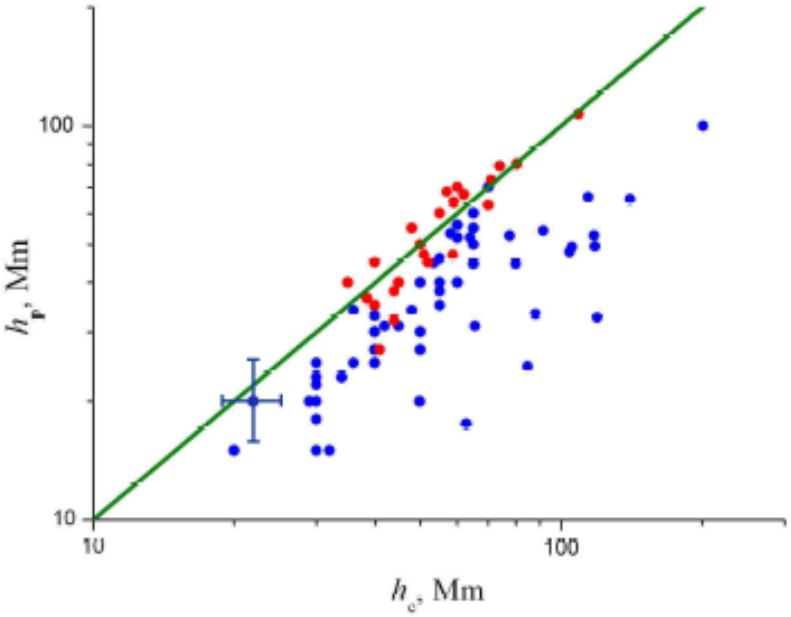
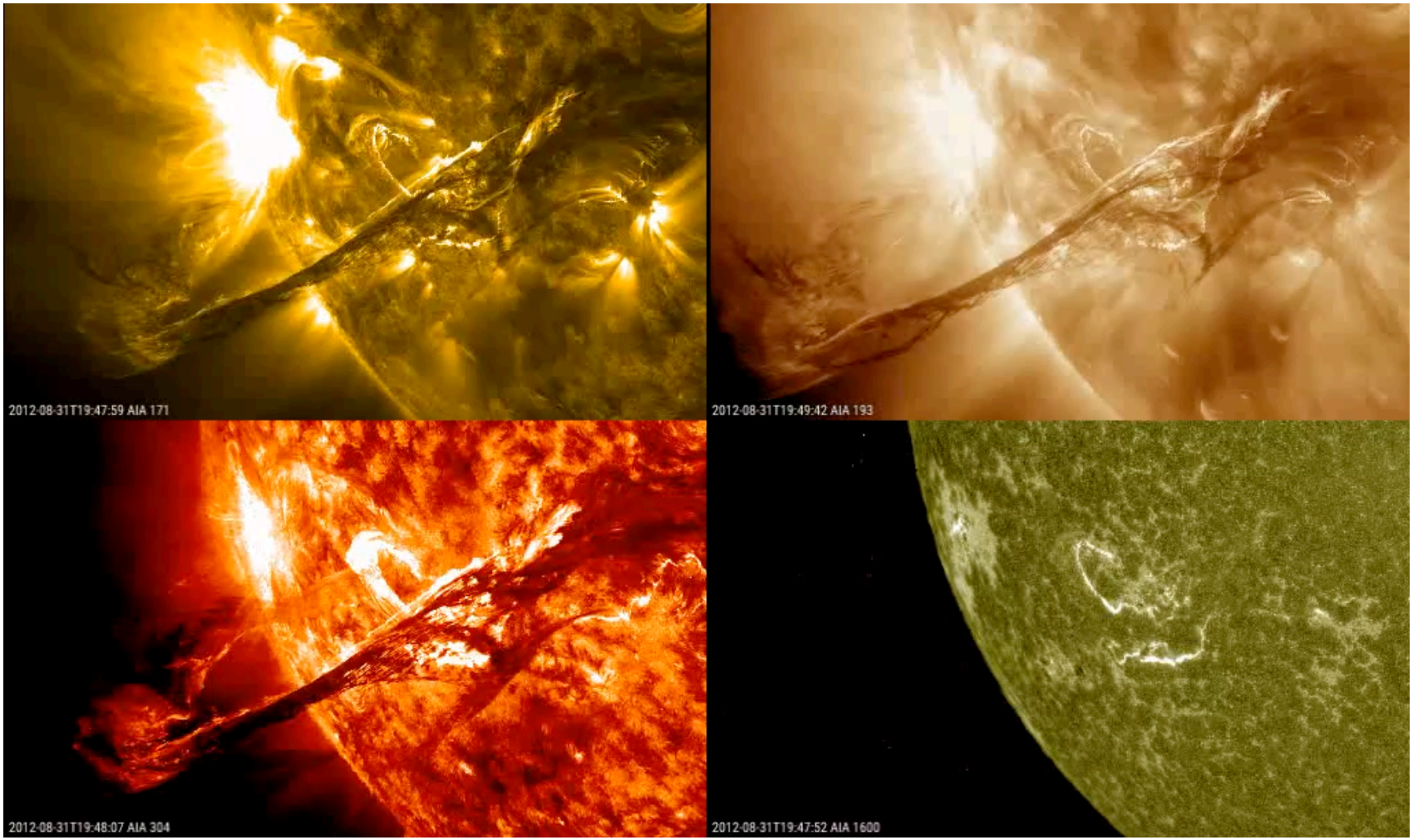


Fig. 7. The observed filament height above the chromosphere h_p versus the critical height of stable filament equilibrium h_c. The blue circles correspond to the filaments which safely passed the west limb. The red circles correspond to the filaments which disappeared from the disk. The straight green line corresponding to an equality of these quantities is the stability boundary.

FILAMENT ERUPTION



SDO/AIA

:Issued: 2026 Oct 09 1254 UTC
:Product: documentation at http://www.sidc.be/products/meu
#---#
DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC
(RWC Belgium)
#---#
SIDC URSIGRAM 61009
SIDC SOLAR BULLETIN 09 Oct 2026, 1253UT
SIDC FORECAST
SOLAR FLARES : M-class flares expected (probability >=50%)
GEOMAGNETISM : Minor storm expected (A>=30 or K=5)
SOLAR PROTONS : Warning condition (activity levels expected to increase, but no numeric forecast given)
PREDICTIONS FOR 09 Oct 2026 10CM FLUX: 122 / AP: 021
PREDICTIONS FOR 10 Oct 2026 10CM FLUX: 124 / AP: 022
PREDICTIONS FOR 11 Oct 2026 10CM FLUX: 126 / AP: 015



Finding your way in the URSIgram

Solar Active Regions and flaring: The solar flaring activity over the past 24 hours reached high levels with background C-class flaring and one registered M-flare. The strongest recorded activity was a M6.7 flare (SIDC Flare 8685) with peak time at 15:48 UTC on October 08. The flare was produced within SIDC Sunspot Group 976 (NOAA Active Region 4549) currently located at N10W31. A total of 5 numbered sunspot groups were identified on the visible solar disk with SIDC Sunspot Group 976 remaining the largest and most complex region. It continues to be classified as magnetic type beta-gamma-delta and was the main contributor to the observed flaring activity over the past 24 hours. SIDC Sunspot Group 973 (NOAA Active Region 4545), currently located at N18W37, has exhibited some decay. It is classified as magnetic type beta and remained quiet. A new region has emerged on disc SIDC Sunspot Group 979, currently located at N22W11, and another one, SIDC Sunspot Group 980, is rotating from behind the south-east limb. Both are classified as magnetic type beta and the latter one has exhibited some low flaring activity while behind the east limb. The solar flaring activity is expected to be at moderate over the next 24 hours with likely M-class flaring and chances for an X-class flare.

Coronal mass ejections: A wide coronal mass ejection (SIDC CME 727) was observed by LASCO/C2 to lift off the solar surface around 16:12 UTC on October 08 with a white-light shock and an estimated projected speed of around 500 km/s. The eruption is likely linked to the M6.7 flaring from SIDC Sunspot Group 976 (NOAA Active Region 4549) with an associated EUV dimming and a coronal wave detected in the SDO/AIA data around 16:33 UTC on October 08. Related type II and type IV solar radio emissions were detected at 15:42 UTC and 16:12 UTC on October 08 respectively. SIDC CME 727 is estimated to have an Earth-directed component and current analysis suggests a possible arrival time late UTC on October 11 to early UTC on October 12. Another EUV dimming and a small coronal wave were observed in the SDO/AIA imagery starting at 17:36 UTC on October 08, seemingly related to a filament eruption in the south-eastern quadrant triggered by the same event chain. A faint eastward eruption is visible in the LASCO/C2 around 17:00 UTC, but is expected to travel off the Sun-Earth line.

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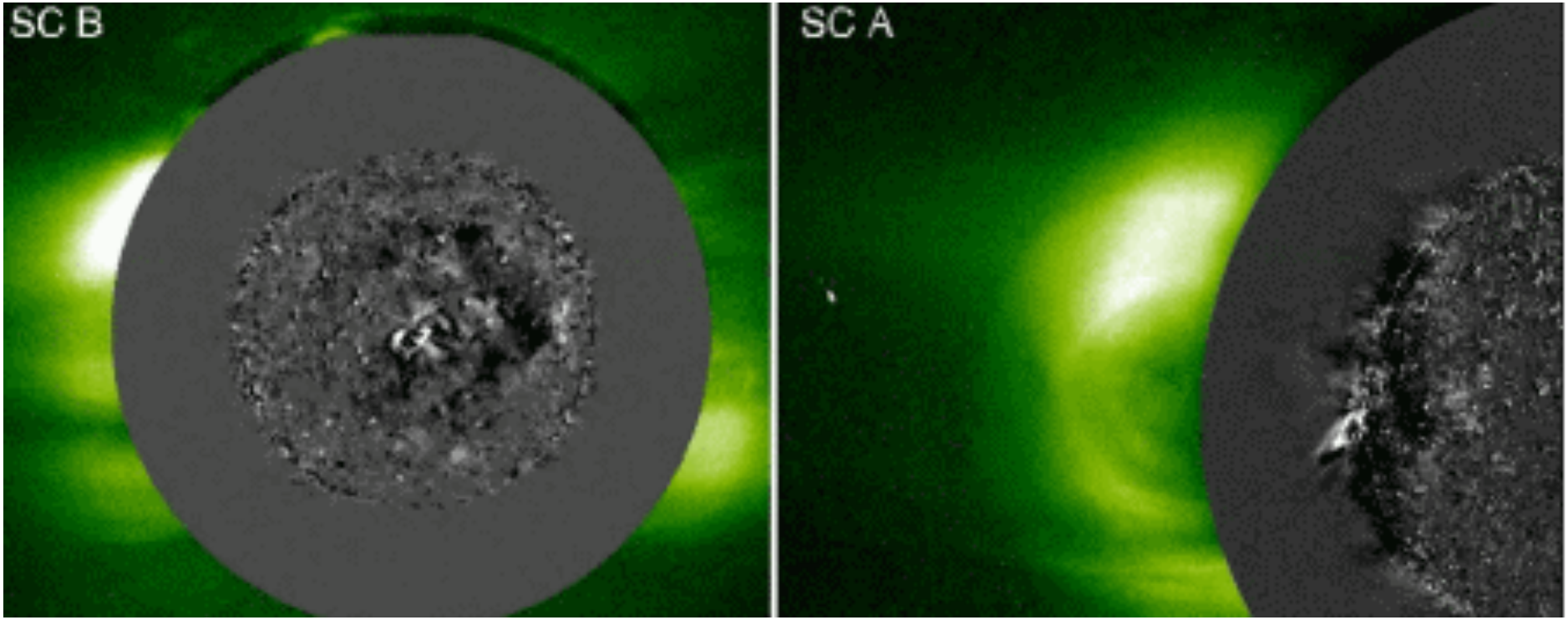
END

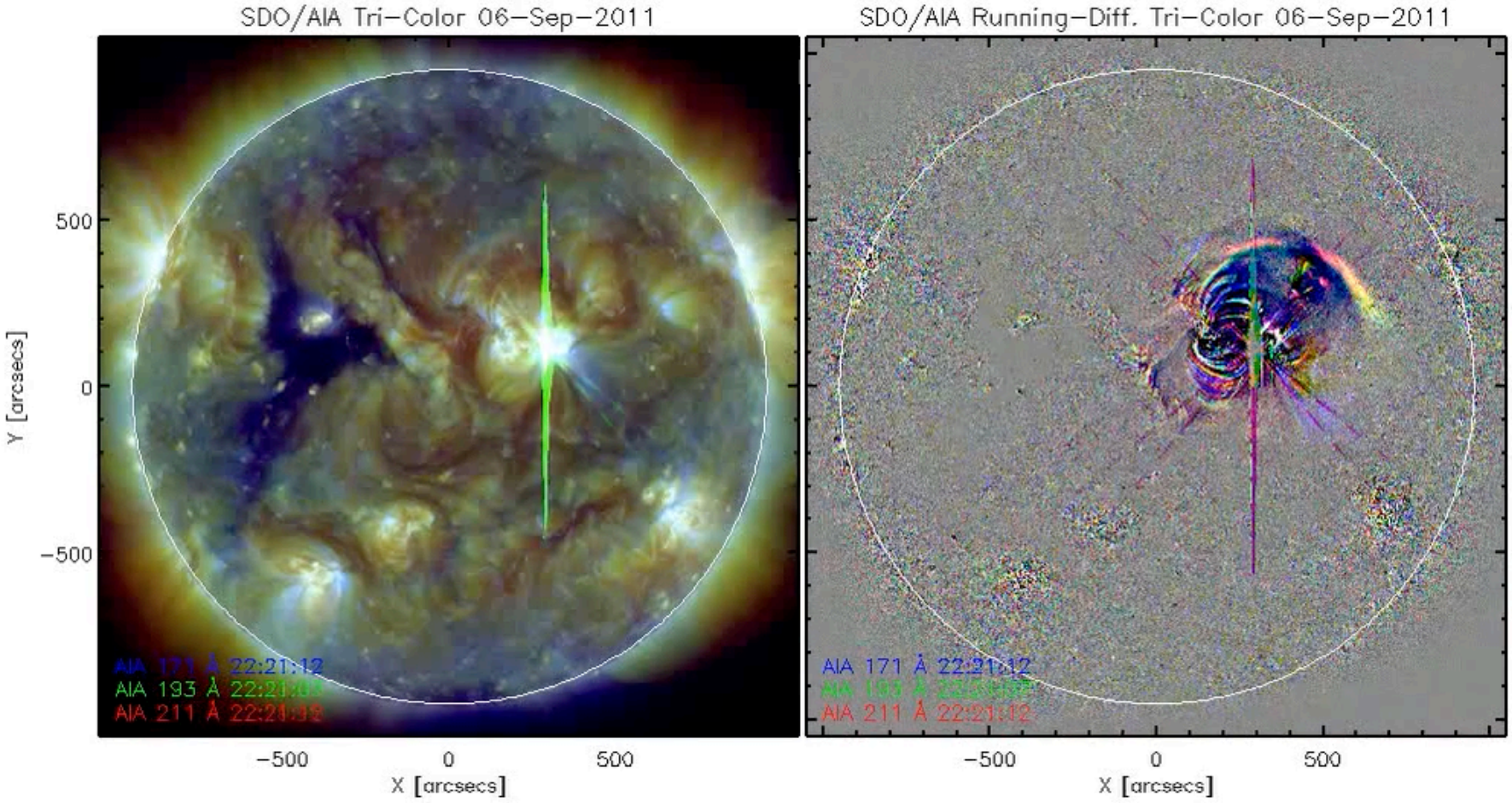
filaments / prominences

EIT WAVE



STEREO/EUVI & COR1

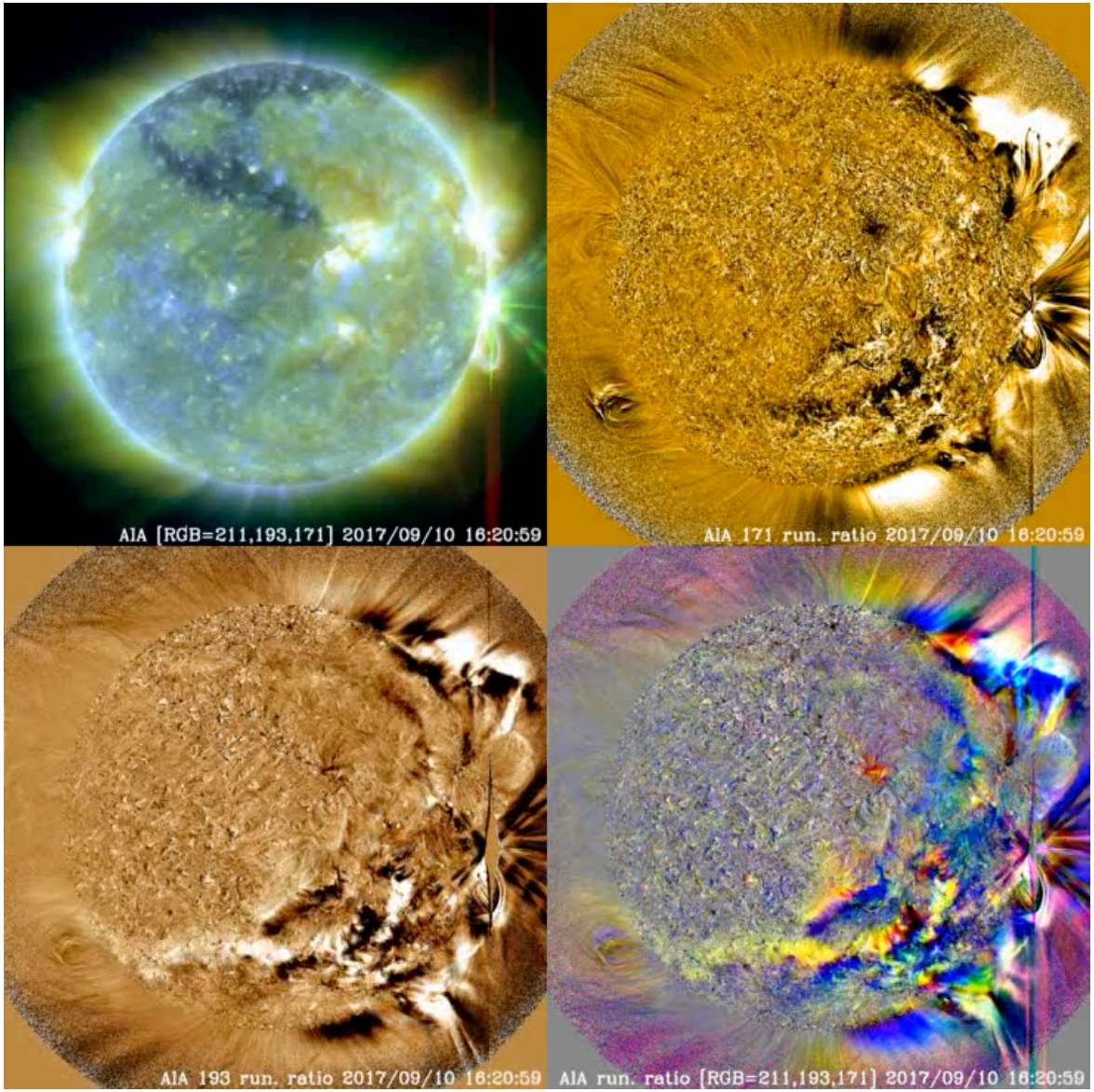
EUV WAVE



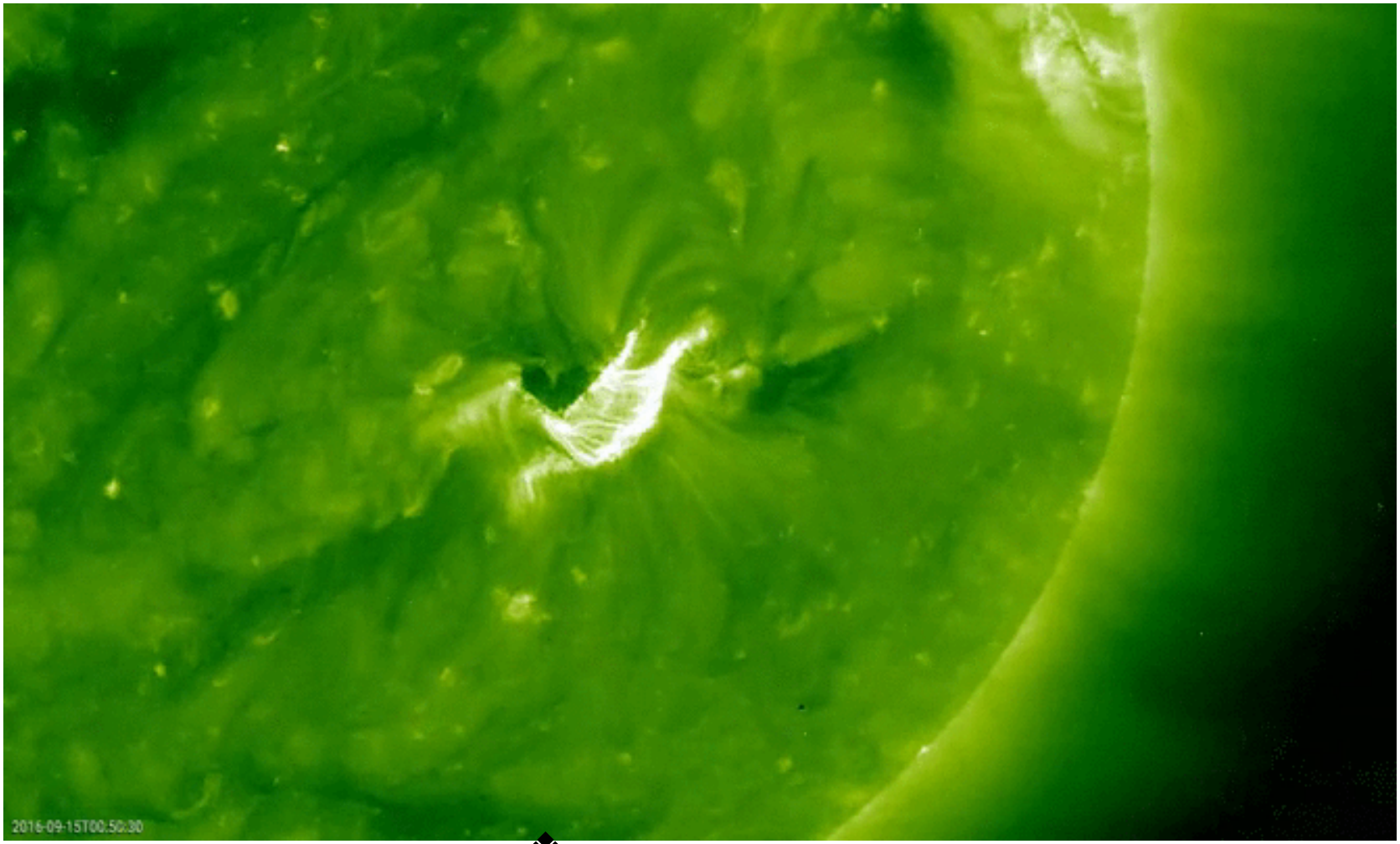
SDO/AIA

GLOBAL EUV WAVE

SDO/AIA

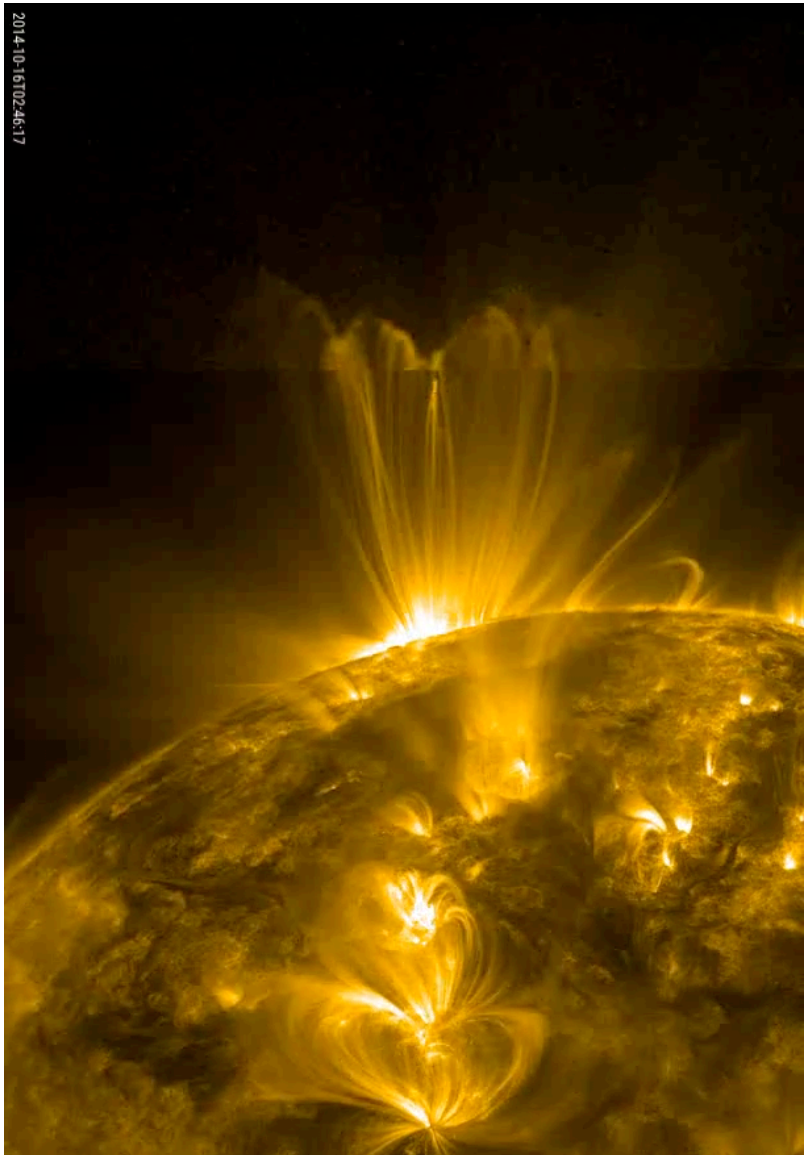


CORONAL DIMMING
~~(TRANSIENT CORONAL HOLE)~~



STEREO/EUVI

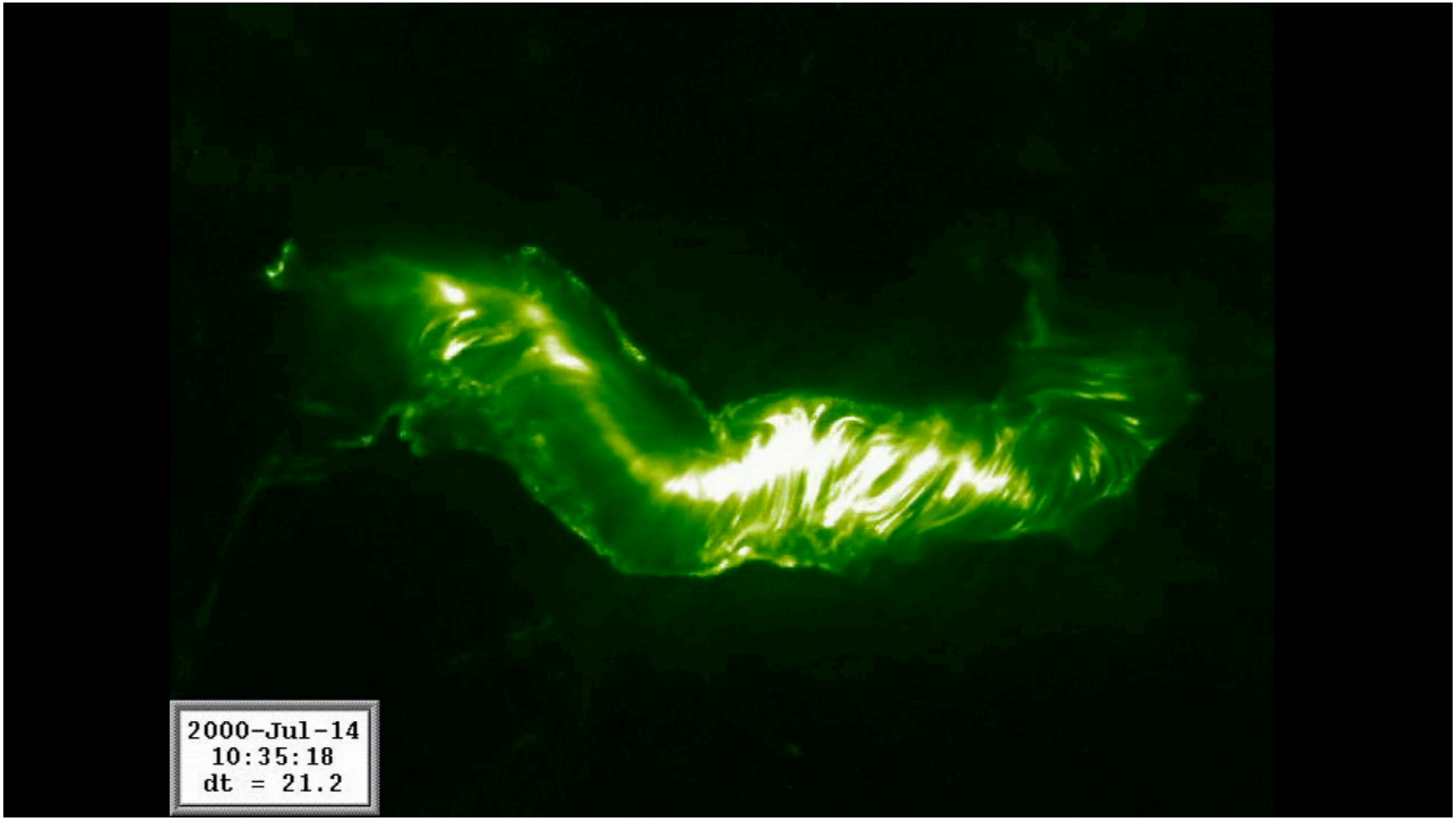
POST-ERUPTION CORONAL LOOPS



PROBA2/SWAP

SDO/AIA

POST-ERUPTION CORONAL LOOPS
POST-ERUPTION ARCADE



SOHO/EIT

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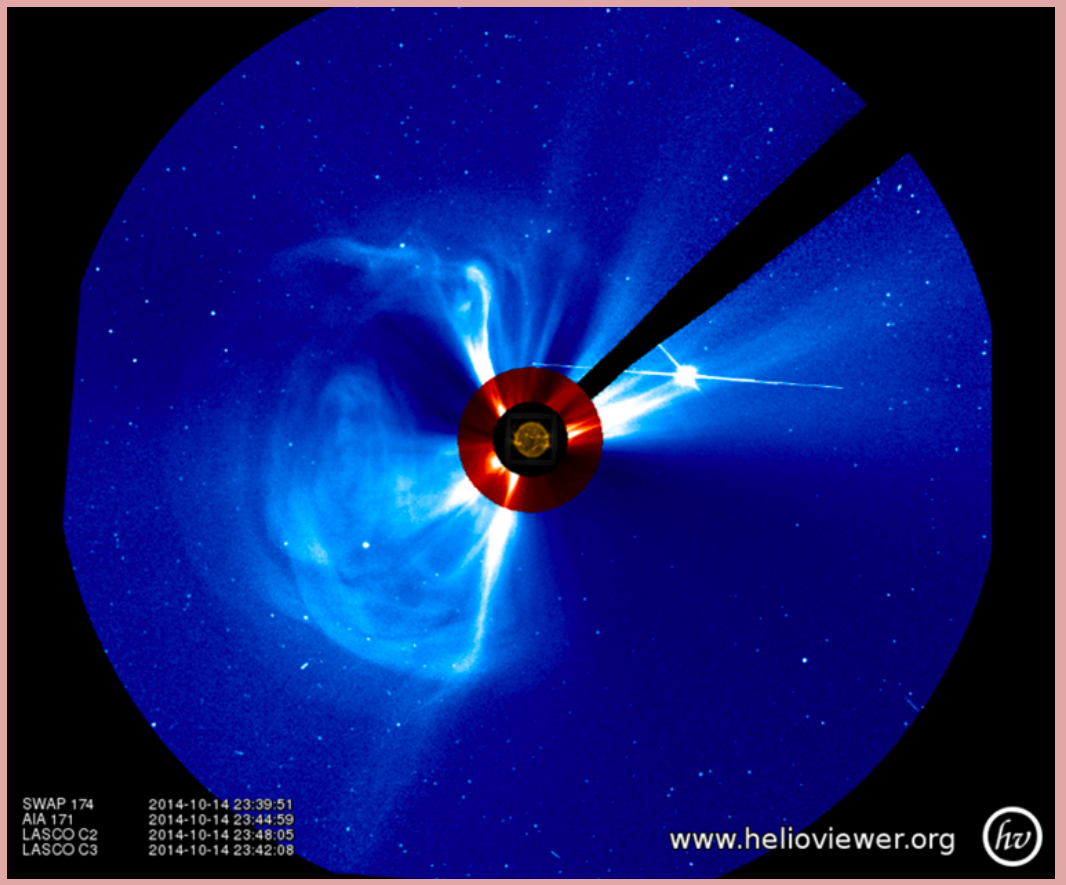
- **Characteristics**



PROBA2/SWAP
SDO/AIA
SOHO/LASCO

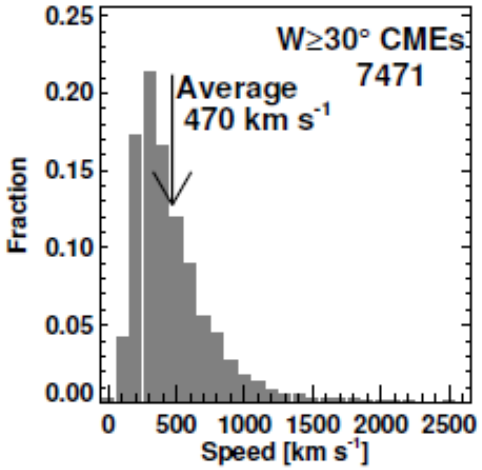
CORONAL MASS EJECTION

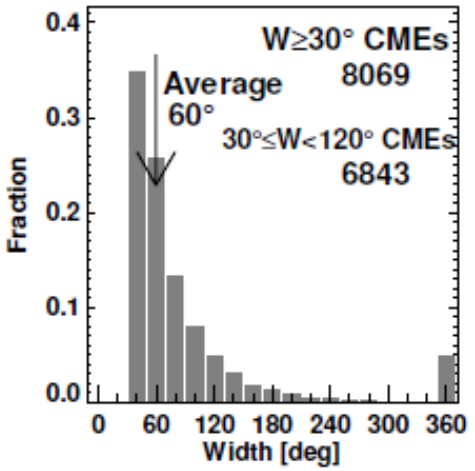
Characteristics

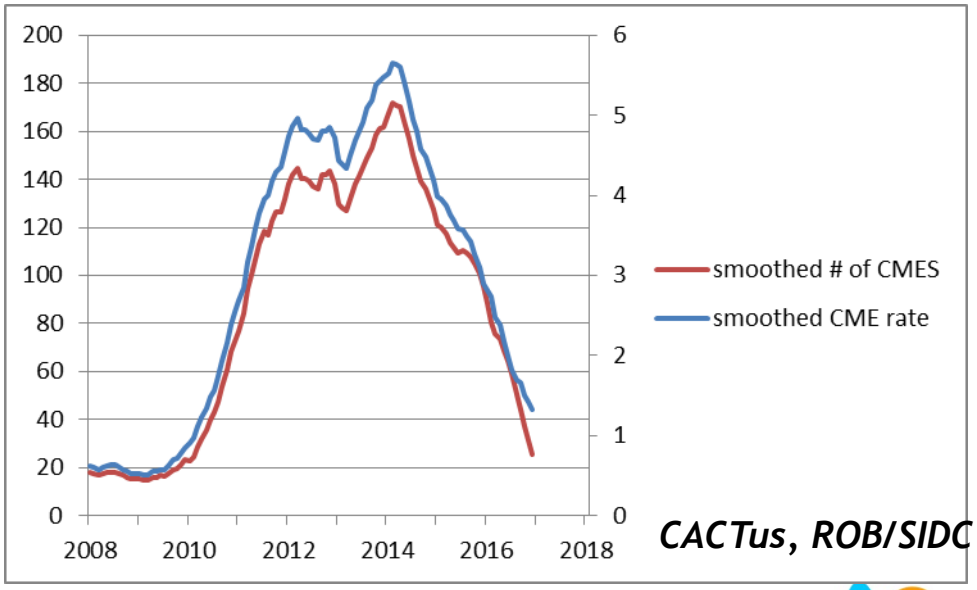
- Average speed
  - 470 km/s
  - Fast transit event (<24h)
- Average width

  60 degrees
- Average Mass
  - 10^{12} kg
  - ~ medium sized mountain
- Number per day

  1-6 / day







CORONAL MASS EJECTION

Terminology

- Width
  - Narrow: <20°
  - Partial halo: >120°
  - (Full) halo: 360°
- Shape halo
  - Symmetric
  - Asymmetric
- Origin

  Frontside/Farside
- De- & acceleration

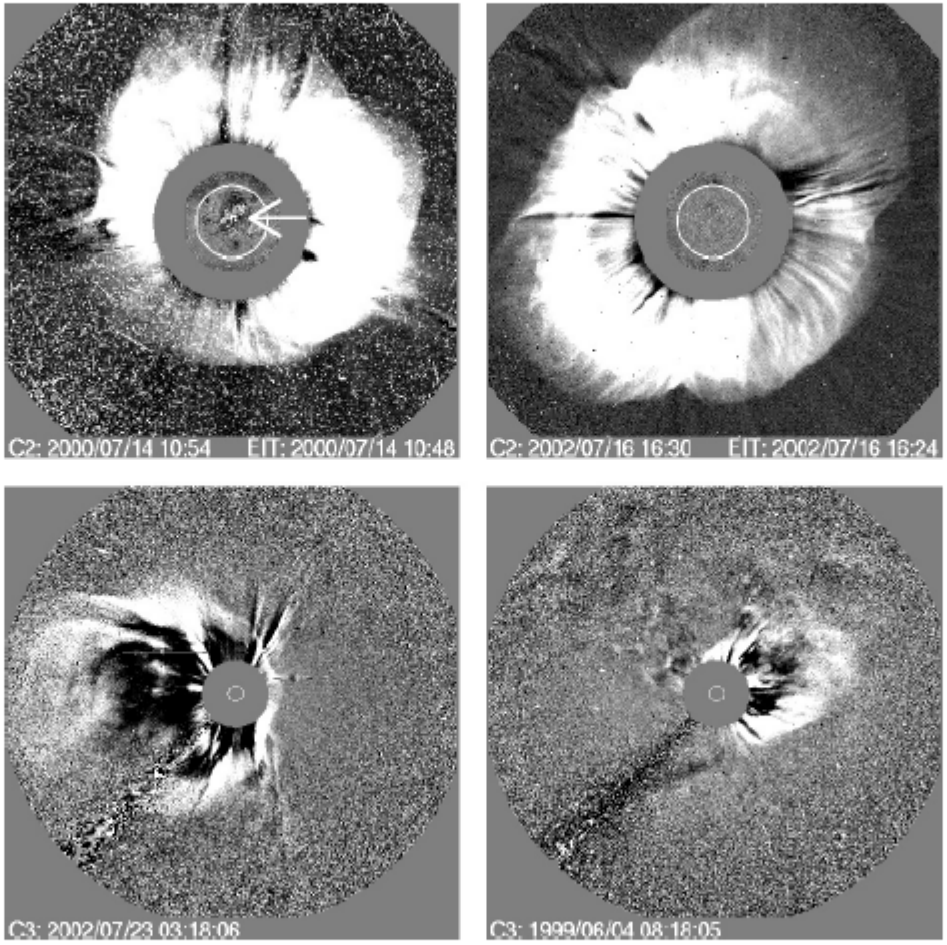
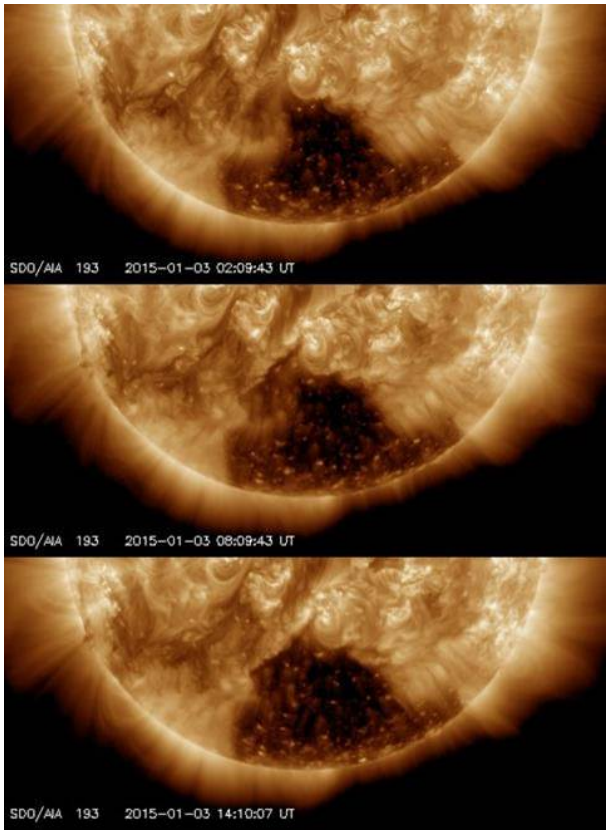


Figure 4: Examples of a variety of halo CME observations, clockwise: a frontside full halo (arrow shows likely source near Sun center); a backside full halo; a partial halo; and an asymmetric full halo. Image reproduced with permission from Gopalswamy *et al.* (2003a).

CORONAL MASS EJECTION

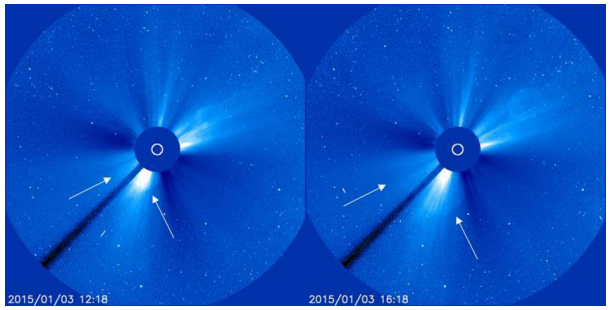
Terminology

- Stealth CME
  - No obvious surface signature
  - Rather slow (<300 km/s)
  - Rather faint
- CME cannibalism
  - 2nd CME overtakes 1st
  - Enhanced geomagnetic storms
- Deflection
  - By corona holes, CME,…



SDO/AIA

SOHO/LASCO



CORONAL MASS EJECTION

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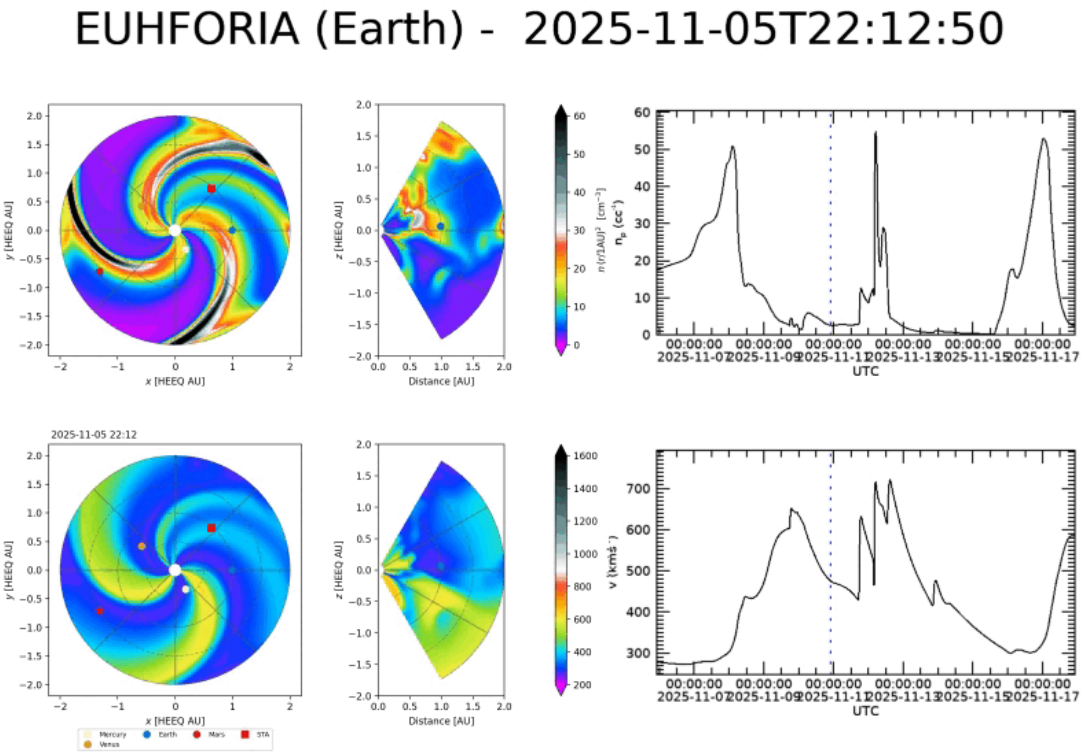

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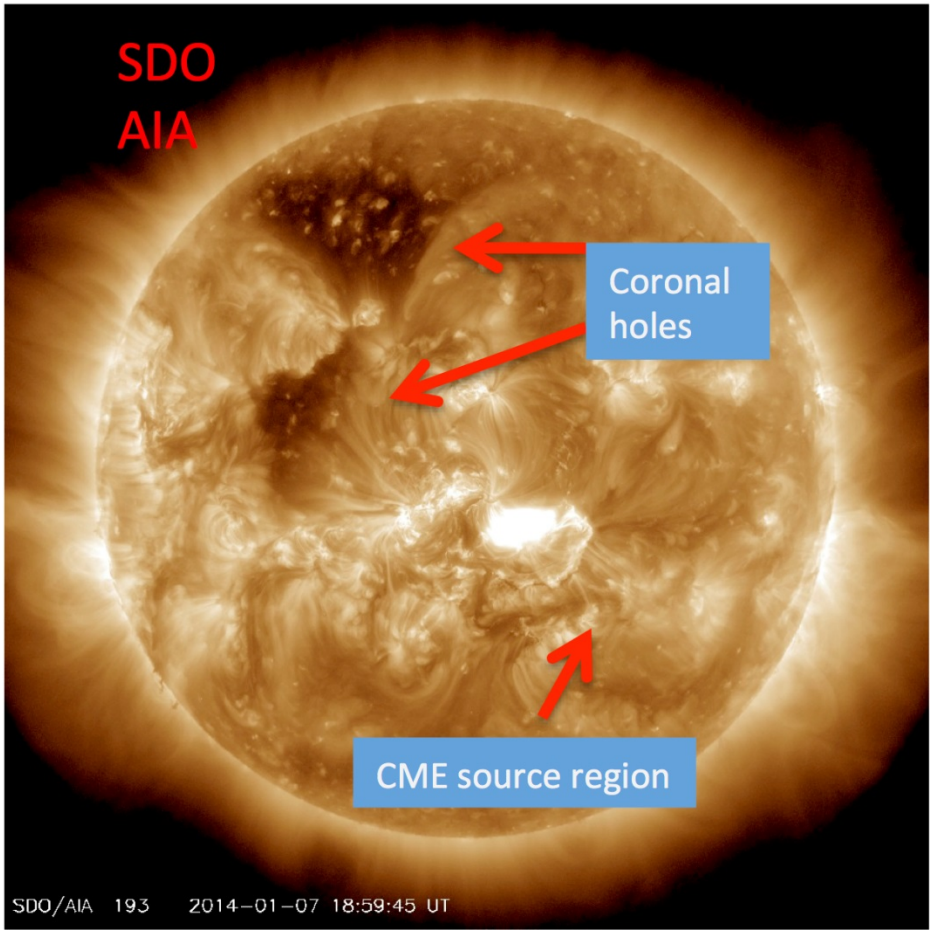


SDO/AIA

CORONAL MASS EJECTION

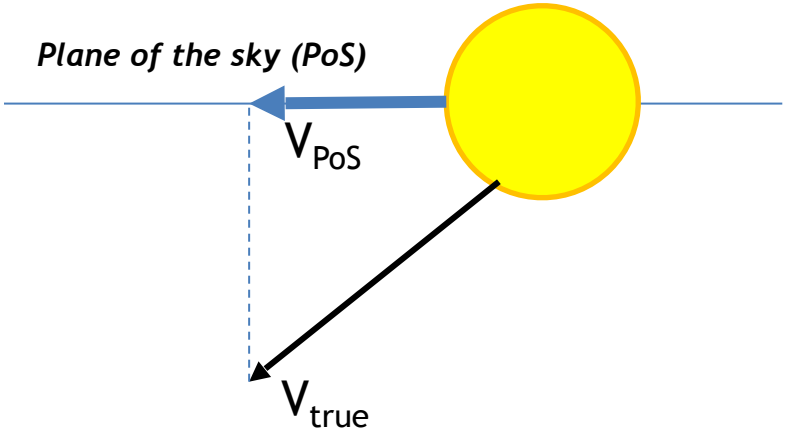
Speed

- We see the projected speed
  - Plane of the sky (PoS)
- We use the true speed
  - = Corrected PoS speed

$$V_{true} \geq V_{PoS}$$

  - From Type II radio bursts

    = shock speed

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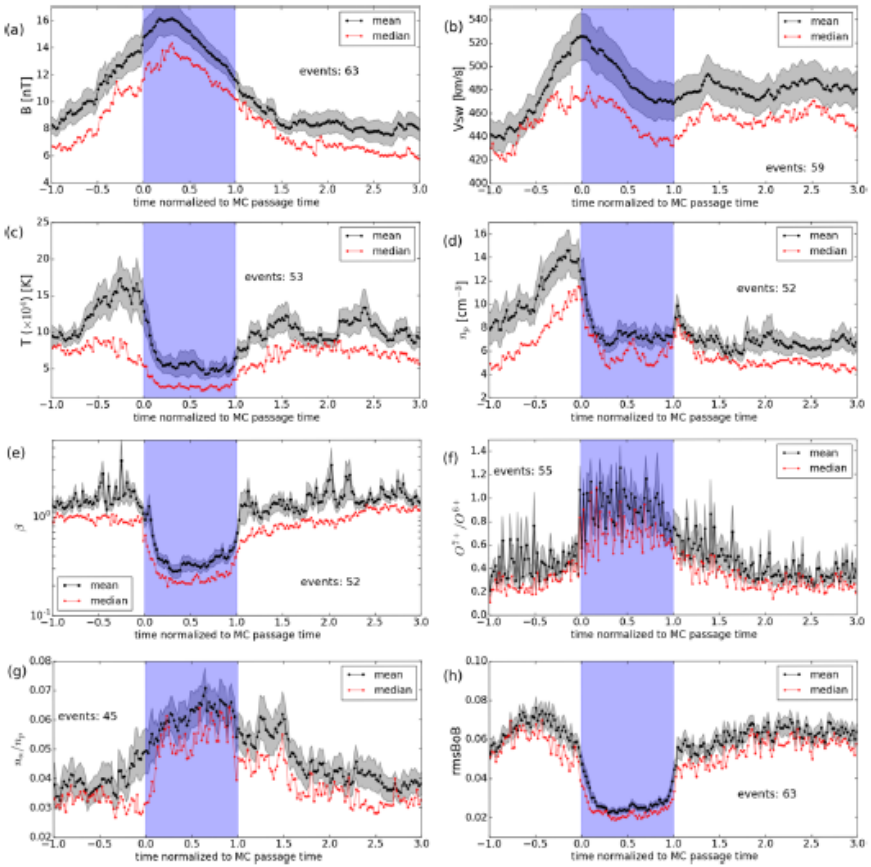
:Created: 2012 Jul 15 0332 UT
:Date: 2012 07 12
# Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center
# Please send comments and suggestions to SWPC.Webmaster@noaa.gov
#
# Missing data: ////
# Updated every 30 minutes.
#                          Edited Events for 2012 Jul 12
#
#Event    Begin    Max       End  Obs  Q  Type  Loc/Frq   Particulars        Reg#
#-------------------------------------------------------------------------------

9900 +     1537   1649      1730  G15  5   XRA  1-8A      X1.4      4.6E-01  1520
9900       1610   ////      1638  PAL  C   RSP  108-180   CTM/1               1520
9900 +     1614   1649      1732  SAG  G   RBR  410       6600                1520
9900 +     1614   1652      1706  SAG  G   RBR  1415      1100                1520
9900 +     1614   1653      1705  SAG  G   RBR  2695      800                 1520
9900 +     1614   1653      1714  SAG  G   RBR  4995      480                 1520
9900 +     1615   1653      1824  SAG  G   RBR  8800      430                 1520
9900       1615   1652      2010  SAG  G   RBR  245       3900                1520
9900       1620   1655      1814  SAG  G   RBR  610       2400                1520
9900 +     1621   1654      1815  SAG  G   RBR  15400     270                 1520
9900 +     1625   ////      1653  SAG  C   RSP  025-082   II/2      1268      1520
9900 +     1638   ////      2359  PAL  C   RSP  025-180   IV/2                1520
```

INTERPLANETARY CORONAL MASS EJECTION



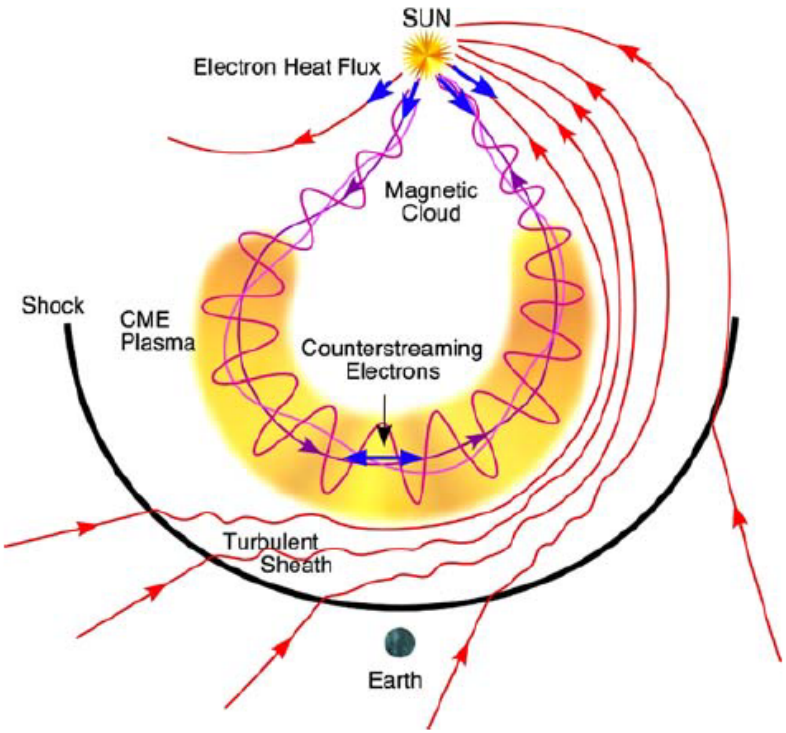
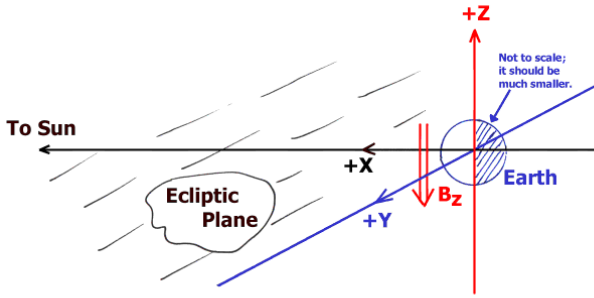


Figure 2. Schematic of the three-dimensional structure of an ICME and upstream shock, relating magnetic field, plasma, and BDE signatures.

CORONAL MASS EJECTION



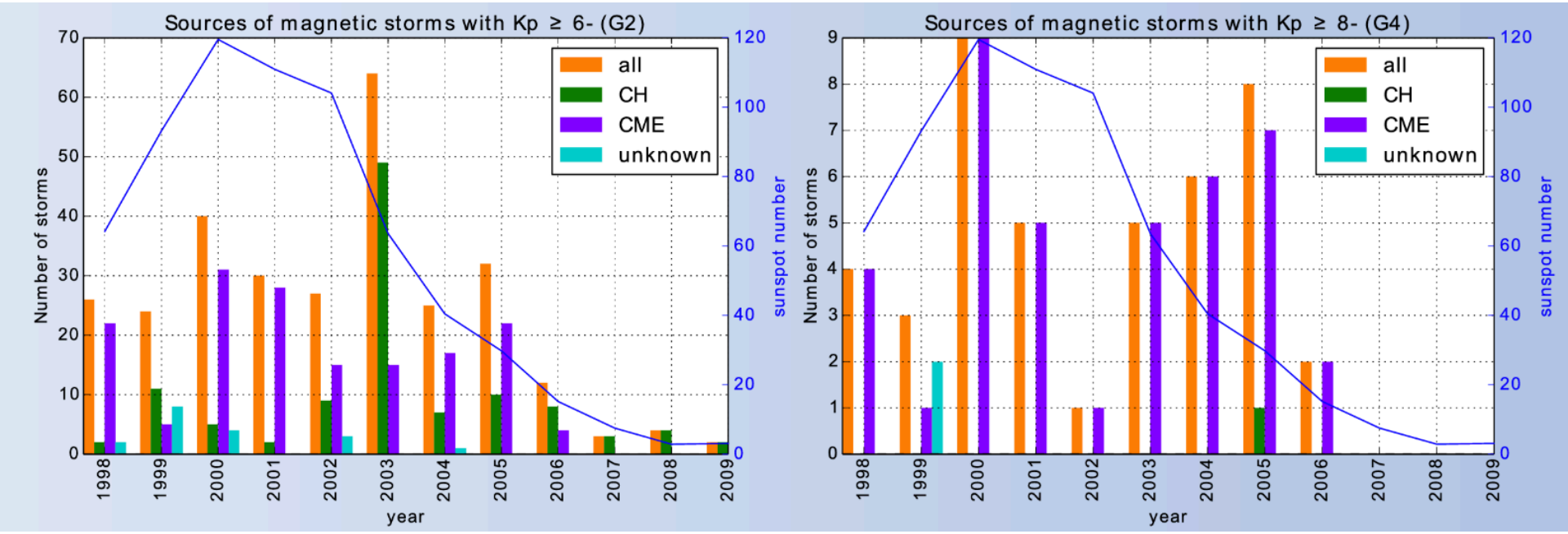
+Z is perpendicular to the Ecliptic Plane.

Bz

- North-South component of magnetic field (nT) perpendicular to the ecliptic
- Intensity varies much more than CME speed
- **Negative (south), strong and long-lasting Bz is necessary to get a strong geomagnetic storm**
- Need to predict both orientation and intensity

  Not easy and potentially changing during Sun-Earth transit!

CME STATISTICS - SOURCE



:Issued: 2026 Oct 09 1254 UTC
:Product: documentation at http://www.sidc.be/products/meu
#---#
DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC
(RWC Belgium)
#---#
SIDC URSIGRAM 61009
SIDC SOLAR BULLETIN 09 Oct 2026, 1253UT
SIDC FORECAST
SOLAR FLARES : M-class flares expected (probability >=50%)
GEOMAGNETISM : Minor storm expected (A>=30 or K=5)
SOLAR PROTONS : Warning condition (activity levels expected to increase, but no numeric forecast given)
PREDICTIONS FOR 09 Oct 2026 10CM FLUX: 122 / AP: 021
PREDICTIONS FOR 10 Oct 2026 10CM FLUX: 124 / AP: 022
PREDICTIONS FOR 11 Oct 2026 10CM FLUX: 126 / AP: 015



Solar Active Regions and flaring: The solar flaring activity over the past 24 hours reached high levels with background C-class flaring and one registered M-flare. The strongest recorded activity was a M6.7 flare (SIDC Flare 8685) with peak time at 15:48 UTC on October 08. The flare was produced within SIDC Sunspot Group 976 (NOAA Active Region 4549) currently located at N10W31. A total of 5 numbered sunspot groups were identified on the visible solar disk with SIDC Sunspot Group 976 remaining the largest and most complex region. It continues to be classified as magnetic type beta-gamma-delta and was the main contributor to the observed flaring activity over the past 24 hours. SIDC Sunspot Group 973 (NOAA Active Region 4545), currently located at N18W37, has exhibited some decay. It is classified as magnetic type beta and remained quiet. A new region has emerged on disc SIDC Sunspot Group 979, currently located at N22W11, and another one, SIDC Sunspot Group 980, is rotating from behind the south-east limb. Both are classified as magnetic type beta and the latter one has exhibited some low flaring activity while behind the east limb. The solar flaring activity is expected to be at moderate over the next 24 hours with likely M-class flaring and chances for an X-class flare.

Coronal mass ejections: A wide coronal mass ejection (SIDC CME 727) was observed by LASCO/C2 to lift off the solar surface around 16:12 UTC on October 08 with a white-light shock and an estimated projected speed of around 500 km/s. The eruption is likely linked to the M6.7 flaring from SIDC Sunspot Group 976 (NOAA Active Region 4549) with an associated EUV dimming and a coronal wave detected in the SDO/AIA data around 16:33 UTC on October 08. Related type II and type IV solar radio emissions were detected at 15:42 UTC and 16:12 UTC on October 08 respectively. SIDC CME 727 is estimated to have an Earth-directed component and current analysis suggests a possible arrival time late UTC on October 11 to early UTC on October 12. Another EUV dimming and a small coronal wave were observed in the SDO/AIA imagery starting at 17:36 UTC on October 08, seemingly related to a filament eruption in the south-eastern quadrant triggered by the same event chain. A faint eastward eruption is visible in the LASCO/C2 around 17:00 UTC, but is expected to travel off the Sun-Earth line.

Coronal holes: SIDC Coronal Hole 149 (a recurrent mid-latitude coronal hole with a negative polarity) continues to reside on the central meridian. A high-speed stream related to it might be expected at Earth on October 09, possibly mixed with anticipated ICME arrival signatures related to SIDC CME 725.

Solar wind: Over the past 24 hours the solar wind parameters (as measured by ACE at L1) registered some enhancements, possibly the precursor of a high-speed stream arrival related to SIDC Coronal Hole 149. The solar wind speed remained slow, varying in the range of 333 to 390 km/s. The interplanetary magnetic field (B) registered a maximum value of 12.7 nT with a north-south (Bz) component down to - 7 nT. The B field phi angle switched from the positive to the negative sector (directed towards the Sun). The solar wind parameters are expected to be perturbed over the next 24 hours with an anticipated arrival of a high-speed stream possibly mixed with an ICME arrival related to SIDC CME 725. Perturbed solar wind conditions are expected to continue on October 10 with anticipated high- speed stream influence and possible waning ICME influence. A mild glancing blow arrival related to SIDC CME 726 could be expected on October 11 with the possibility of another ICME arrival late UTC on October 11 or early UTC on October 12 related to SIDC CME 727.

Geomagnetism: The geomagnetic conditions over the past 24 hours were locally (over Belgium) quiet to unsettled and globally quiet to active with NOAA Kp reaching 4 in the period 9-12 UTC on October 09. Unsettled conditions to minor storm levels are expected over the next 24 hours with chances for isolated moderate storms. Unsettled to active conditions with chances for more minor storm levels can continue on October 10, October 11 and October 12.

Proton flux levels: Over the past 24 hours the greater than 10 MeV GOES proton flux remained at close to nominal levels, while exhibiting some further enhancements related to activity from SIDC Sunspot Group 976 (NOAA Active Region 4549). The greater than 10 MeV GOES proton flux is expected to further increase over the next 24 hours with chances of reaching the 10 pfu proton event threshold.

Electron fluxes at GEO: The greater than 2 MeV electron flux as measured by GOES 18 and GOES 19 has exceeded the 1000 pfu threshold over the past 24 hours and is expected to be predominantly below the 1000 pfu threshold over the next 24 hours. The 24-hour electron fluence was at moderate levels and is expected to decrease to nominal levels over the next 24 hours.

TODAY'S ESTIMATED ISN : 086, BASED ON 07 STATIONS.

SOLAR INDICES FOR 08 Oct 2026
WOLF NUMBER CATANIA : 089
10CM SOLAR FLUX : ///
AK CHAMBON LA FORET : 017
AK WINGST : 006
ESTIMATED AP : 006
ESTIMATED ISN : 075, BASED ON 18 STATIONS.

NOTICEABLE EVENTS SUMMARY
DAY BEGIN MAX END LOC XRAY OP 10CM Catania/NOAA RADIO_BURST_TYPES
08 1529 1548 1558 N12W20 M6.7 2B 57/4549 I/3
END

CME/ICME