

First E-SWAN school

Space Weather Data, Models and Services



Collaboration of



Solar-Terrestrial Centre of
Excellence



European Space Weather and Space
Climate Association

CASE STUDY - April 21, 2023

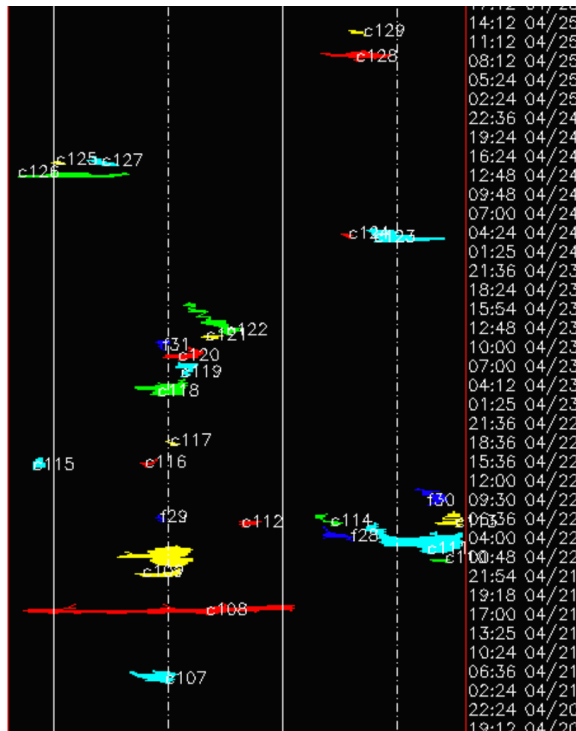
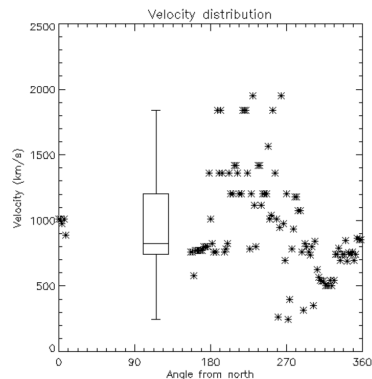
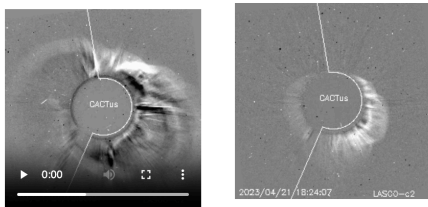
April 21/22 - CACTus detection

Details and graphs for CME0108

```
# CME | t0 | dt0 | pa | da | v | dv | minv | maxv | halo?
0108 | 2023/04/21 18:12 | 01 | 263 | 212 | 0821 | 0375 | 0248 | 1838 | III
```

CME Movie :: [Download](#) ::

Sample Image



```
:Issued: 2023 Apr 22 0202 UTC
:Product: documentation at http://www.sidc.be/products/cactus
#-----#
# HALO CME ALERTS from the SIDC (RWC-Belgium), generated by CACTUS #
#-----#
```

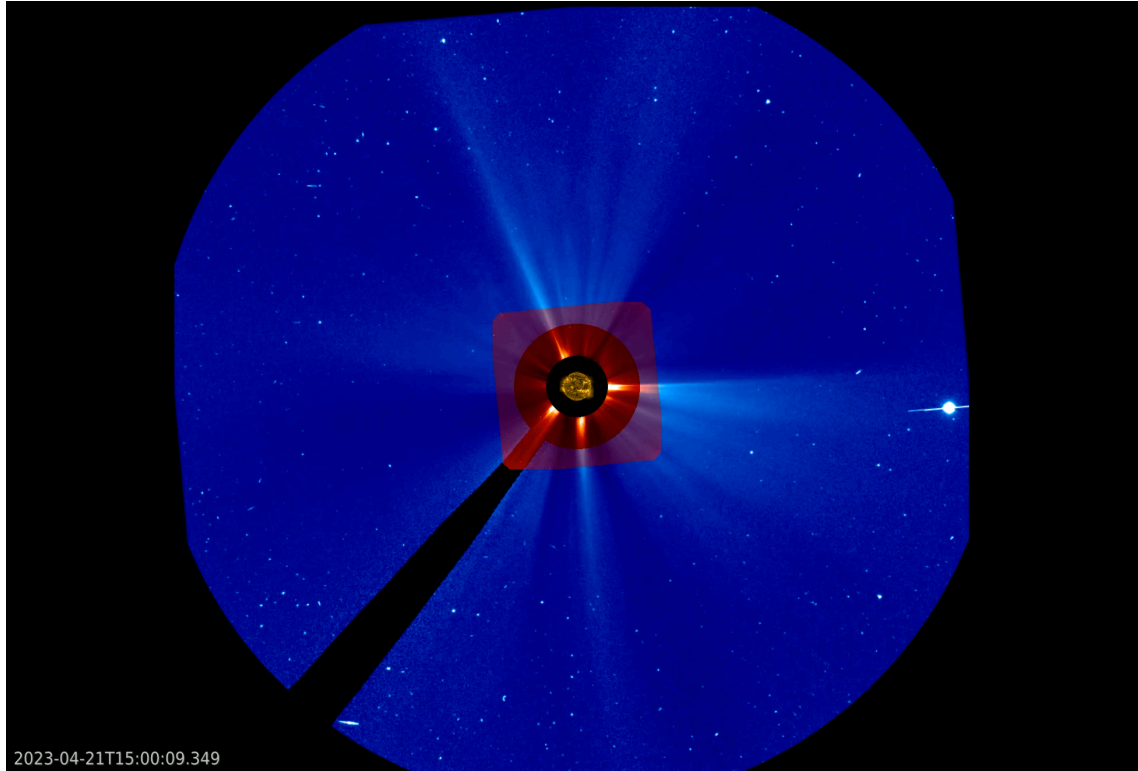
A halo or partial-halo CME was detected with the following characteristics:

```
t0 | dt0 | pa | da | v | dv | minv | maxv |
2023-04-21T18:12:08.030 | 1.0 | 267 | 220 | 844 | 334 | 194 | 1838
```

t0: onset time, earliest indication of liftoff
dt0: duration of liftoff (hours)
pa: principal angle, counterclockwise from North (degrees)
da: angular width of the CME (degrees),
v: median velocity (km/s)
dv: variation (1 sigma) of velocity over the width of the CME
minv: lowest velocity detected within the CME
maxv: highest velocity detected within the CME

```
#-----#
# Solar Influences Data analysis Center - RWC Belgium #
# Royal Observatory of Belgium #
# Website http://www.sidc.be #
# E-mail sidc-support@oma.be #
# To unsubscribe http://www.sidc.be/registration/unsub.php #
# # #
# Legal notices: #
# - Intellectual Property Rights: #
# http://www.astro.oma.be/common/internet/en/data-policy-en.pdf #
# - Liability Disclaimer: #
# http://www.astro.oma.be/common/internet/en/disclaimer-en.pdf #
# - Use and processing of your personal information: #
# http://www.astro.oma.be/common/internet/en/privacy-policy-en.pdf #
#-----#
```

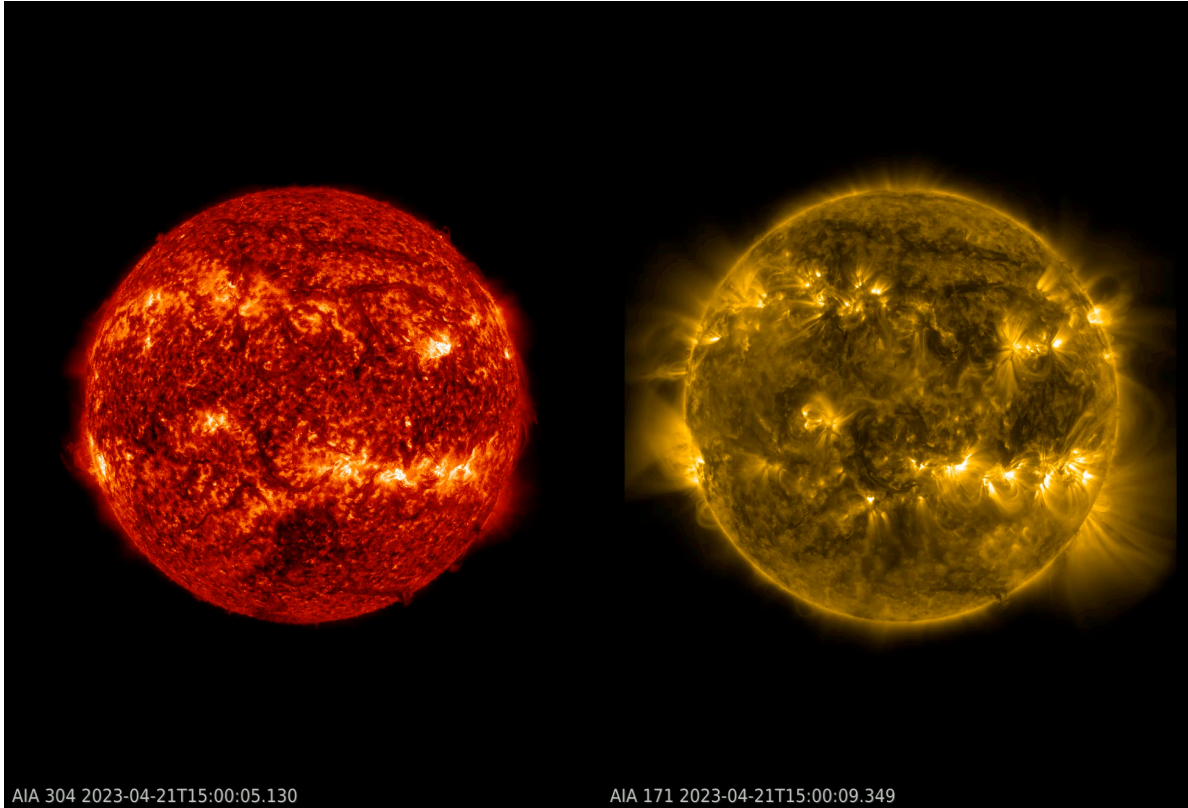
April 21 - Coronagraph observations



2023-04-21T15:00:09.349



April 21 - Solar Observations



April 21- Solar Demon Flare detection

Detector 24h operating status:



Last processed image:

0 hours and 42 minutes ago (2023-04-27 12:36 UTC)

Last detected flare:

1 hours and 3 minutes ago (2023-04-27 12:15 UTC)

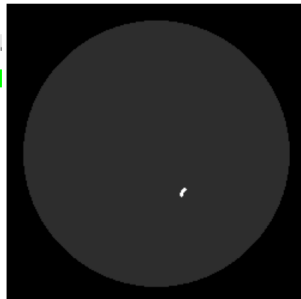
Animations and brightness graph

[fixed brightness](#)
[adaptive brightness](#)

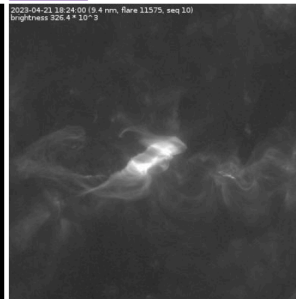
Navigation

Please send me [back](#).

location of flare 11575



Flare 11575



Details for flare #: 11575

time	seq #	brightness	size	lat	lon	X,Y in R☉	dist. R☉	Blooming	Img ID
2023-04-21 17:54:00	1	10.2	68	-20.4	12.8	0.21, -0.27	0.34		0 2763782
2023-04-21 18:00:00	2	123.9	631	-20.3	13.0	0.21, -0.27	0.34		0 2763787
2023-04-21 18:03:00	3	178.2	824	-20.4	12.9	0.21, -0.27	0.34		0 2763788
2023-04-21 18:06:00	4	211.8	933	-20.6	12.7	0.21, -0.27	0.34		0 2763789
2023-04-21 18:09:00	5	238.9	999	-20.7	12.7	0.21, -0.27	0.34		0 2763790
2023-04-21 18:12:24	6	278.7	1085	-20.9	12.5	0.20, -0.28	0.34		0 2763791
2023-04-21 18:15:00	7	310.6	1103	-21.0	12.4	0.20, -0.28	0.34		0 2763792
2023-04-21 18:18:00	8	337.0	1126	-21.1	12.4	0.20, -0.28	0.35		0 2763793
2023-04-21 18:21:00	9	340.6	1149	-21.3	12.3	0.20, -0.28	0.35		0 2763802
2023-04-21 18:24:00	10	326.4	1176	-21.5	12.2	0.20, -0.29	0.35		0 2763803
2023-04-21 18:27:00	11	304.0	1198	-21.8	12.0	0.20, -0.29	0.35		0 2763804
2023-04-21 18:30:00	12	272.8	1157	-22.0	11.9	0.19, -0.30	0.35		0 2763805
2023-04-21 18:33:00	13	241.4	1075	-22.3	11.8	0.19, -0.30	0.36		0 2763806
2023-04-21 18:36:00	14	217.6	998	-22.6	11.7	0.19, -0.31	0.36		0 2763807
2023-04-21 18:39:00	15	198.4	921	-22.8	11.7	0.19, -0.31	0.36		0 2763808
2023-04-21 18:42:00	16	192.9	932	-23.0	11.7	0.19, -0.31	0.36		0 2763809

Solar Demon estimated flare class:

M1

April 21 - PRESTO

#-----#

:Issued: 2023 Apr 21 2235 UTC

:Product: documentation at <http://www.sidc.be/products/presto>

#-----#

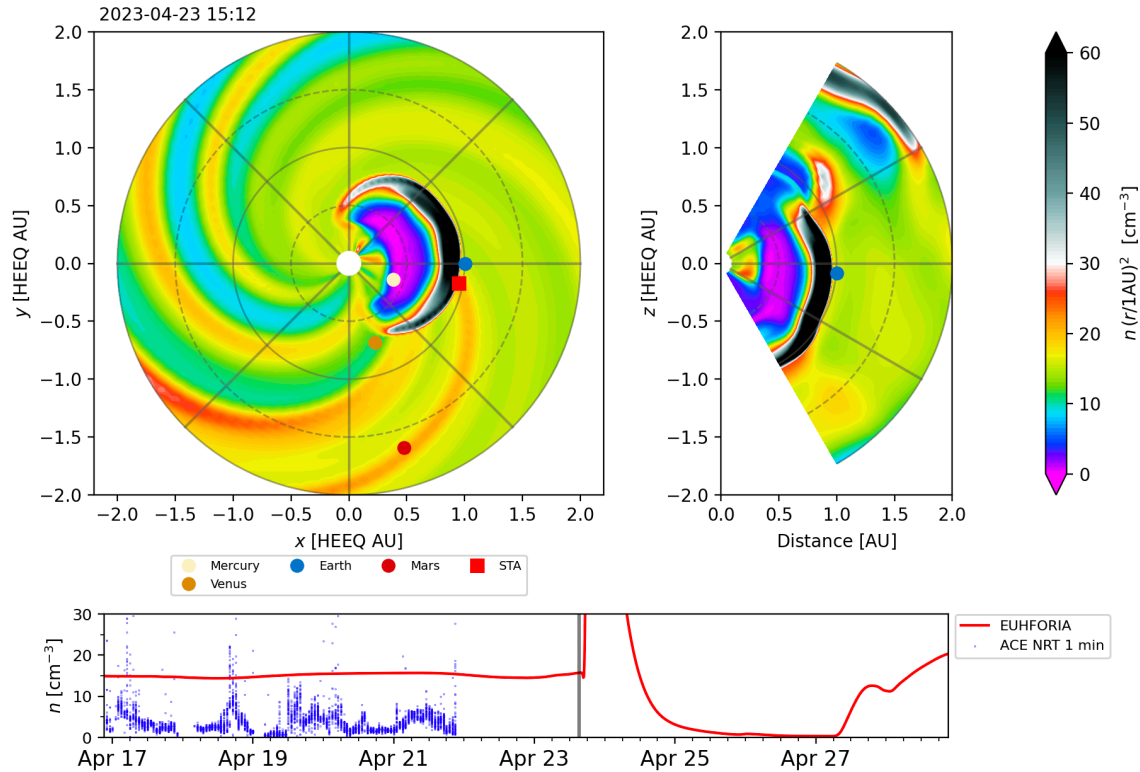
FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)

#-----#

A fast **full halo** coronal mass ejection (CME) was first observed in the LASCO/C2 chronograph imagery around 18 UTC on April 21st. The CME was driven by a **long-duration M-class flare** from NOAA AR 3283 (beta): an M1.7 flare with start time 17:44 UTC, peak time 18:12 UTC, end time 18:37 UTC on April 21st, and related **filament eruption** on the central meridian close to the disc centre. The estimated projected velocity of the CME is above 1100 km/s and preliminary analysis suggests an estimated **arrival at Earth on April 24th**. Due to the fast nature and location of the CME, moderate to major **geomagnetic storms** could be anticipated during the arrival with chances of reaching severe storm levels. The greater than 10 MeV GOES **proton flux might also be enhanced** in the next days due to particle acceleration at the CME front shock.

#-----#

April 21 - EUHFORIA CME modeling



Case Study - April 21 event

SIDC **URSIGRAM** 30422

SIDC SOLAR BULLETIN 22 Apr 2023, 1234UT

SIDC FORECAST (valid from 1230UT, 22 Apr 2023 until 24 Apr 2023)

SOLAR FLARES : C-class flares expected, (probability >=50%)

GEOMAGNETISM : **Active conditions** expected (A>=20 or K=4)

SOLAR PROTONS : **Warning** condition (activity levels expected to increase, but no numeric forecast given)

PREDICTIONS FOR 22 Apr 2023 10CM FLUX: 148 / AP: 010

PREDICTIONS FOR 23 Apr 2023 10CM FLUX: 148 / AP: 018

PREDICTIONS FOR 24 Apr 2023 10CM FLUX: 148 / AP: 065

COMMENT: Solar flaring activity reached moderate levels in the past 24 hours with an isolated low M-class flaring from NOAA AR 3283 (beta), namely a **long duration M1.7 flare**, start time 17:44 UTC, peak time 18:12 UTC, end time 18:37 UTC on April 21st. This flaring activity was driven by a nearby filament eruption and no other significant flaring was observed from NOAA AR 3283. NOAA AR 3279 (alpha) was also triggered by the magnetic field reconfiguration during the previous eruptions and has produced multiple C-class flaring, the most significant one being a C4.8 flare, peak time 01:48 UTC on April 22nd. NOAA AR 3285 (beta) was numbered and has produced isolated low C-class flaring. NOAA AR 3282 (beta-gamma) remains the largest and most complex region on the visible solar disc, but has been quiet and inactive. The remaining active regions are relatively simple and have shown no significant flaring. The solar flaring activity is expected to be at low levels over the next 24 hours with **chances for further isolated M-class flaring**.

A **fast full halo coronal mass ejection** (CME) was first observed in the LASCO/C2 chronograph imagery at 18:12 UTC on April 21st. The CME was driven by a long-duration M-class flaring from NOAA AR 3283 and a related filament eruption on the central meridian close to the disc centre. The estimated projected velocity of the CME is close to 1100 km/s and current analysis suggests an estimated arrival at Earth late April 23rd to early April 24th. **The nature and location of the CME suggest strong impact on Earth**. No other Earth-directed CMEs have been detected in the available coronagraph imagery.

Over the past 24 hours the greater than 10 MeV GOES proton flux was at nominal levels and is expected to register gradual enhancements over the next 24 hours with the **possibility of reaching minor radiation storm levels**. The greater than 2 MeV electron flux has been below the 1000 pfu threshold and is expected to remain so. The 24h electron fluence was at nominal levels and is expected to remain so over the next 24 hours.

Over the past 24 hours the solar wind parameters (ACE and DSCOVR) were mainly at background slow solar wind levels with an indication of a sector boundary crossing in the evening of April 21st. The solar wind velocity varied around 400 km/s and is currently reaching 450 km/s. The interplanetary magnetic field was weak with a maximum value of 6.6 nT and a minimum Bz of -6.5 nT. The B field was switching orientation between the positive and the negative sector (directed away from and towards the Sun). The solar wind conditions are expected to remain mostly at background slow solar wind regime over the next 24 hours with possible slight enhancements later today pending a mild high speed stream arrival from a narrow patchy negative polarity coronal hole, which crossed the central meridian on April 18th. **Strong solar wind disturbances are expected on April 24th** with the anticipated arrival of the full halo CME related to the M1.7-flaring from NOAA 3283 (beta) and a nearby filament eruption around 18:00 UTC on April 21st. **The CME-related shock might arrive late on April 23rd**.

The geomagnetic conditions over the past 24 hours were globally quiet to unsettled and locally registered an isolated active period over Belgium in the interval of 21-22 UTC after prolonged periods of negative Bz. Quiet to unsettled geomagnetic conditions are expected over the next 24 hours with probable active periods pending an anticipated mild high speed stream arrival. **Moderate to major geomagnetic storms might be expected in the night of April 23rd** with chances for severe storm levels on April 24th due to an expected ICME arrival.

TODAY'S ESTIMATED ISN : 109, BASED ON 15 STATIONS.

SOLAR INDICES FOR 21 Apr 2023

WOLF NUMBER CATANIA : 136

10CM SOLAR FLUX : 151

AK CHAMBON LA FORET : 014

AK WINGST : ///

ESTIMATED AP : 012

ESTIMATED ISN : 110, BASED ON 19 STATIONS.

NOTICEABLE EVENTS SUMMARY

DAY BEGIN MAX END LOC XRAY OP 10CM Catania/NOAA RADIO_BURST_TYPES

21 1744 1812 1844 S22W11 M1.7 2N 110 61/3283 II/3V/3IV/2



Apr 25, 2023
08:40:01 UTC

MAIN

REGIONS

FLARE

CME

SW

PARTICLE

PROTONS

ELECTRO

MARS

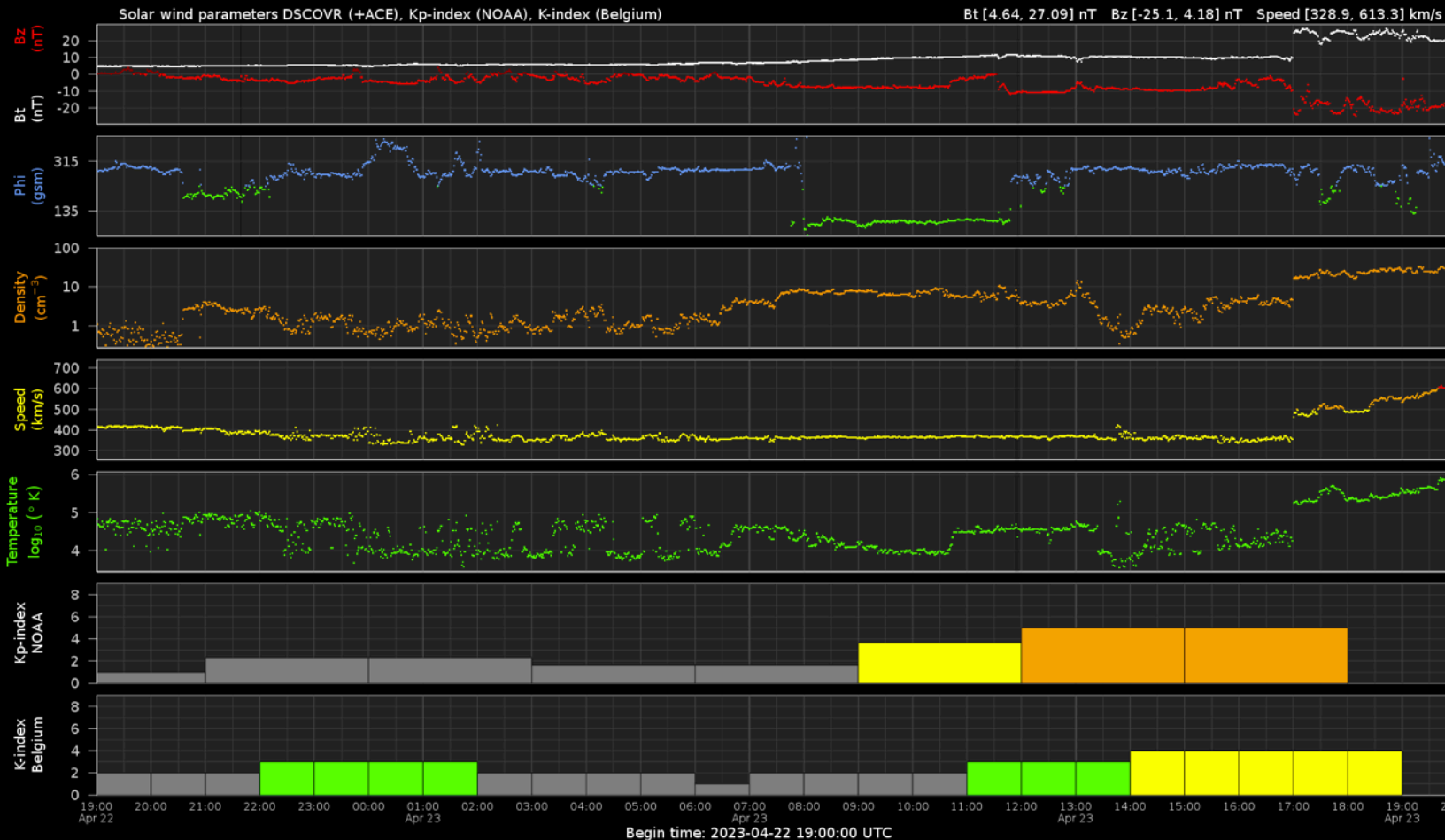
LOCATION

BEPICOLC

LOCATION

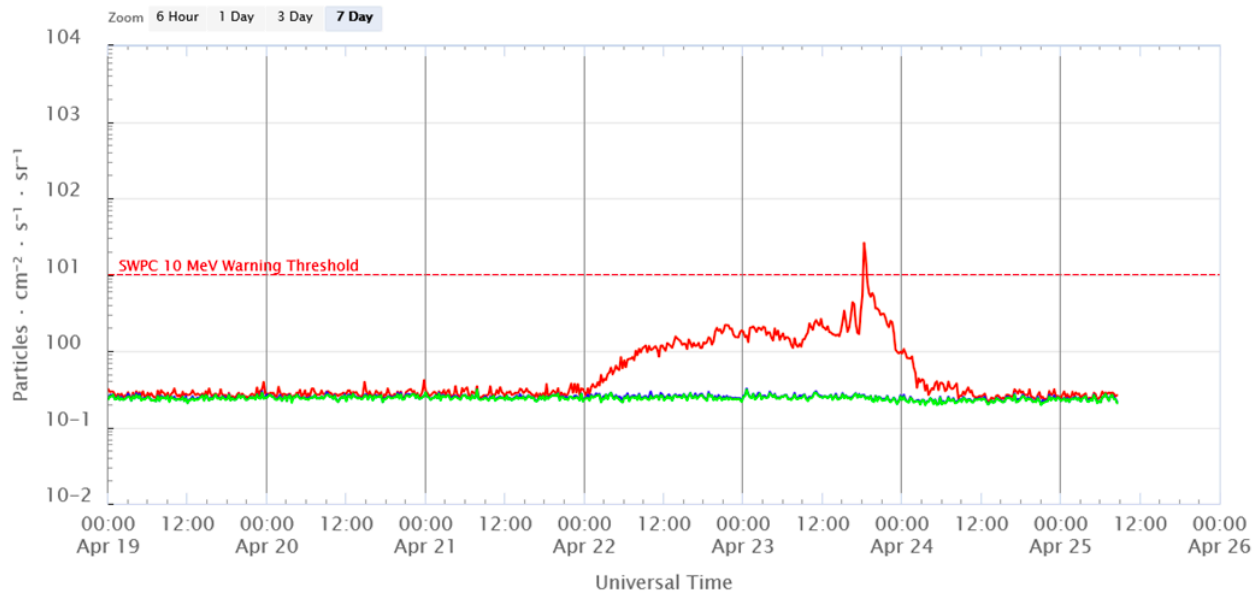
PECASUS

Workflow



April 23 - Proton Event

GOES Proton Flux (5-minute data)



Updated 2023-04-25 08:40 UTC

— GOES-16 ≥ 10 MeV — GOES-16 ≥ 50 MeV — GOES-16 ≥ 100 MeV

Space Weather Prediction Center

April 23 - PRESTO

#-----#

:Issued: 2023 Apr 23 1833 UTC

:Product: documentation at <http://www.sidc.be/products/presto>

#-----#

FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)

#-----#

A fast forward **shock** was observed in the solar wind at 17:00 UTC on April 23rd marking the expected arrival of a fast CME, which lifted off the solar surface on April 21st as a result of long duration M-class flaring triggered by a neighbouring filament eruption. The interplanetary magnetic field jumped from 9 nT to 26 nT with Bz reaching -24 nT. The solar wind velocity increased from 360 km/s to 480 km/s and the density jumped from 4.8 ppcc to 16.8 ppcc. The solar wind speed around 17:45 UTC has reached 527 km/s. The current **geomagnetic conditions** are active over Belgium and globally at minor storm levels. Moderate to major **storms** are expected in the upcoming hours with the ongoing ICME arrival. The greater than 10 MeV GOES **proton flux** has reached minor radiation storm levels and is expected to continue to increase, possibly reaching moderate radiation storm levels.

#-----#



Apr 25, 2023
08:48:32 UTC

MAIN

REGIONS

FLARE

CME

SW

PARTICLE

PROTONS

ELECTRO

MARS

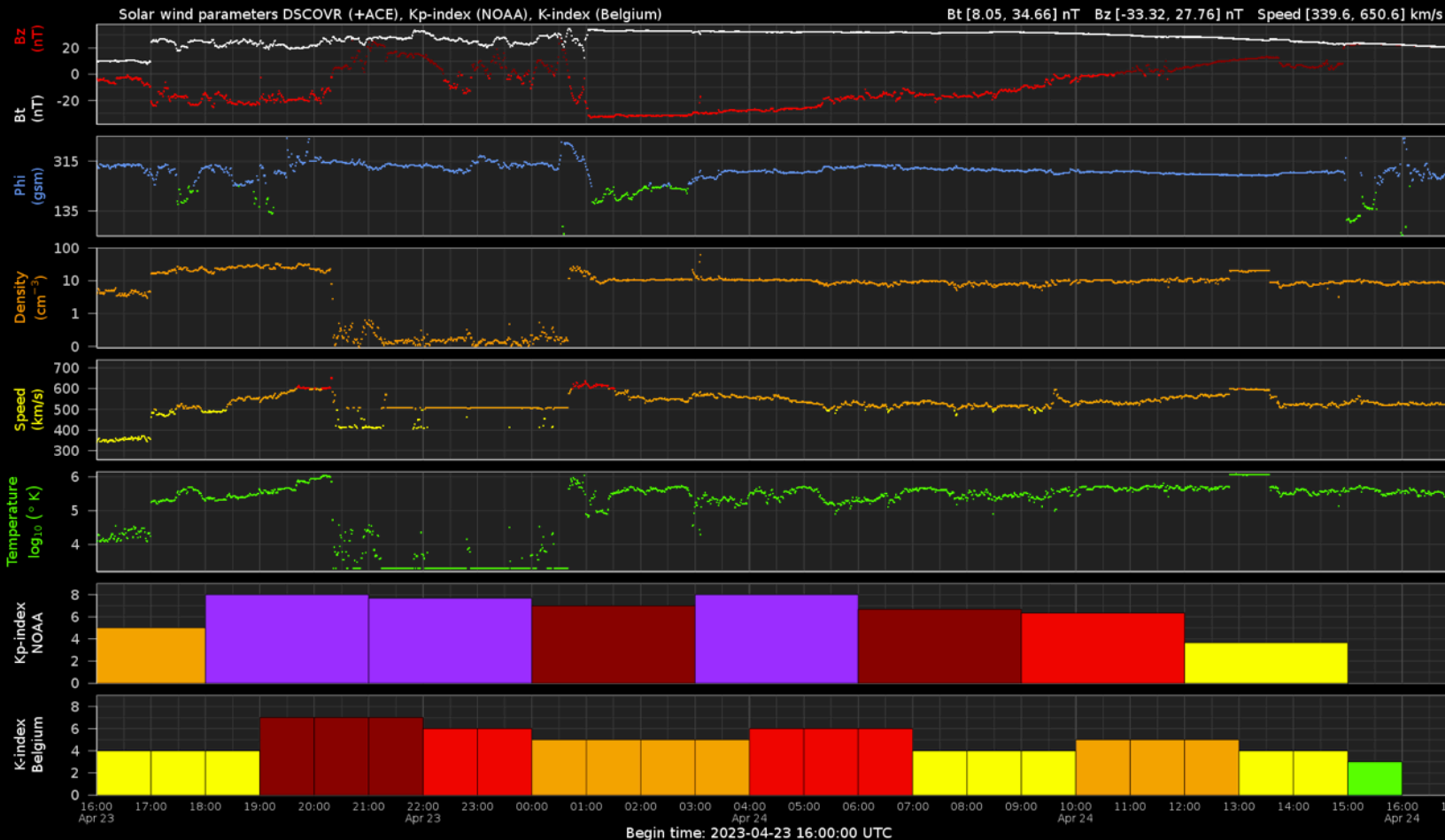
LOCATION

BEPICOLC

LOCATION

PECASUS

Workflow



April 23 - Another PRESTO

#-----#

:Issued: 2023 Apr 23 2026 UTC

:Product: documentation at <http://www.sidc.be/products/presto>

#-----#

FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)

#-----#

A **major geomagnetic storm** has been registered over Belgium due to an ongoing ICME arrival. The solar wind velocity has exceeded 610 km/s with interplanetary magnetic field values of 27 nT and a minimum BZ component of -25 nT. The solar wind density has exceeded 32 ppcc and the temperature is above 1 MK. The geomagnetic conditions are expected to remain at moderate to major storm levels in the upcoming hours. The greater than 10 MeV GOES proton flux remains enhanced, but has decreased to below minor storm radiation levels. Related to the storm there are ongoing strong ionospheric scintillations and post storm depressions, as well as some polar cap and auroral absorptions.

#-----#

April 24 - Yet another PRESTO

:Issued: 2023 Apr 24 0909 UTC

:Product: documentation at <http://www.sidc.be/products/presto>

#-----#

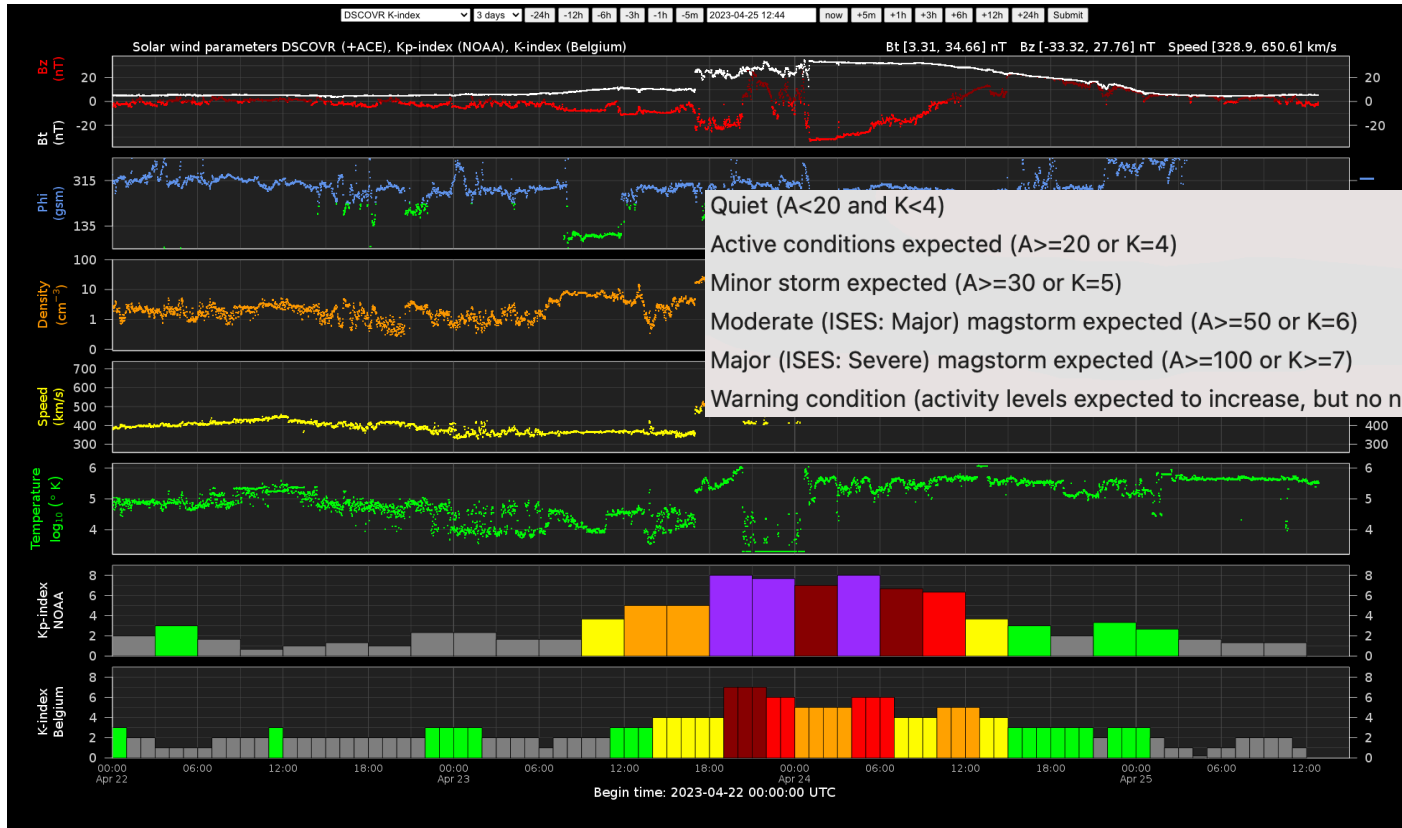
FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)

#-----#

The Corona Mass Ejection (CME) arrival first reported yesterday continues to cause a major geomagnetic storm. Although the solar wind velocity has now dropped to 500 km/s and the North-South component of the interplanetary magnetic field (Bz) has now increased to -10 nT, the Kp index has reach the **severe level** (Kp=8, G4). The geomagnetic conditions are expected to gradually decrease in the next several hours. Currently severe post storm depressions have been observed in various locations, and high auroral absorption.

#-----#

April 23 - CME arrival



Case Study - April 21 event

COMMENT: Solar flaring activity was low and infrequent during the last 24 hours. Three C-class flares were detected, all from NOAA Active Region (AR) 3282 (magnetic type Beta-Gamma, Catania group 61). Further C-class activity is likely in the next 24 hours, either from NOAA AR 3282 or NOAA AR 3285 (magnetic type Beta, Catania group 65).

No Earth-directed Coronal Mass Ejections (CME) were observed in the last 24 hours.

The greater than 10 MeV proton flux exceeded the 10 pfsu level yesterday between 18:15 and 18:40 UT and stayed at nominal levels for the rest of the past 24 hours. In the next 24 hours it is expected to remain below the 10 pfsu level. The greater than 2 MeV electron flux remained below the 1000 pfu alert threshold and is expected to remain below this threshold during the next 24 hours. The 24h electron fluence was at nominal levels and is expected to remain so.

A small equatorial coronal hole of negative polarity started crossing the central meridian today. An associated high speed stream in in-situ solar wind measurements is expected for 28 April.

The Solar Wind (SW) conditions are strongly affected by the arrival of a Corona Mass Ejection (CME) as previously forecasted. The SW speed increased from 340 to km/h before the arrival of the CME to 650 km/h by today 01:00 UT. The total interplanetary magnetic field (Btot) increased to 35 nT yesterday at 17:00 UT, while its North-South component (Bz) dropped as low as -33 nT. The interplanetary magnetic field phi angle was predominantly directed towards the Sun over the last 24 hours. For the next 24 hours the SW speed and the Btot are expected to remain high, however the Bz has already increased above zero and is not expected to drop to such low values in the next 24 hours.

Geomagnetic conditions reached globally severe storm (Kp 8 between 18:00-21:00 UT yesterday and 03:00-06:00 UT today, Kp 8- between 21:00-00:00 yesterday) and strong storm (Kp 7 between 00:00-03:00 and Kp 7- between 06:00-09:00 today), while the rest of the time they were at minor to moderate storm levels. Locally the situation was rather similar, with K BEL at storm level (K BEL 5 or more) since yesterday 21:00 UT. Storm levels are expected for the next several hours and a significant decrease for the rest of the next 24 hours, both globally and locally.