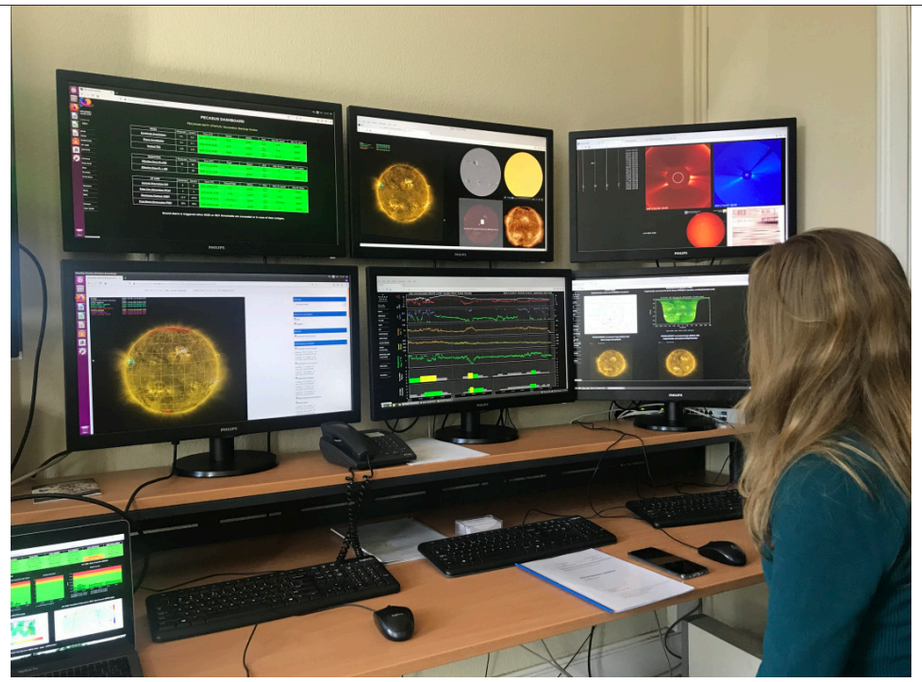
SPACE WEATHER INTRODUCTORY COURSE

Collaboration of

Solar-Terrestrial Centre of Excellence

Koninklijke luchtmacht

Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu



Space Weather Forecasting at the STCE

Elke D'Huys and the STCE team

SIDC Webpage

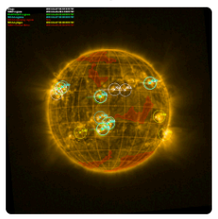
Space Weather Services

Detections

Solardemon
2023-04-27 02:51 B8 flare

CACTus
2023-04-21 18:12
844km/s

Solar Map



Latest Alerts

Presto 2023-04-24

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

Forecasts

Flare:	Quiet conditions (<50% C-class flares)
Protons:	Quiet
Geomagnetic:	Quiet (A<20 and K<4)
All quiet:	False
Provisional SSN:	127

Solar Activity

URSIgram 2023-04-26

Solar flaring activity was low and infrequent with two C1 flares detected during the past 24 hours. NOAA Active Region (AR) 3285 (Catania group 65) produced one of them, while a yet unnamed AR turning into Earth's view produced the second flare. More C-class flare activity is expected in the next 24 hours, most probably from the unnamed AR mentioned above. No Earth-directed Coronal Mass Ejections

Solar Wind

URSIgram 2023-04-26

The Solar Wind (SW) conditions were stable during the last 24 hours. The SW speed ranged between 490 and 570 km/s in the last 24 hours. The total interplanetary magnetic field (Bt) varied between 2 and 6 nT and its North-South component (Bz) ranged between -5 and 5 nT. The interplanetary magnetic field phi angle was directed away from the Sun until yesterday 19:00 UT and has turned

www.sidc.be

RWC belgium bestaat sinds 2000, eerste ursigram verzonden in October 2000
2029: PECASUS
The website gives an overview of all the products we have: daily bulletins, but also automatic detections and alerts

Forecaster tasks

Forecasters
- One week duty cycle
- Daily ursigram
- Alerts when needed
- Briefing/handover on Monday
- 24/7 with automated alerts
- PECASUS operator during day (9-17h)
- Tailored bulletins (BepiColombo, Mars Express)

PECASUS Operator
- 17h-9h (except weekends)
- Night shifts
- On call with support from MeteoWing
- ICAO Advisories when needed + follow-up

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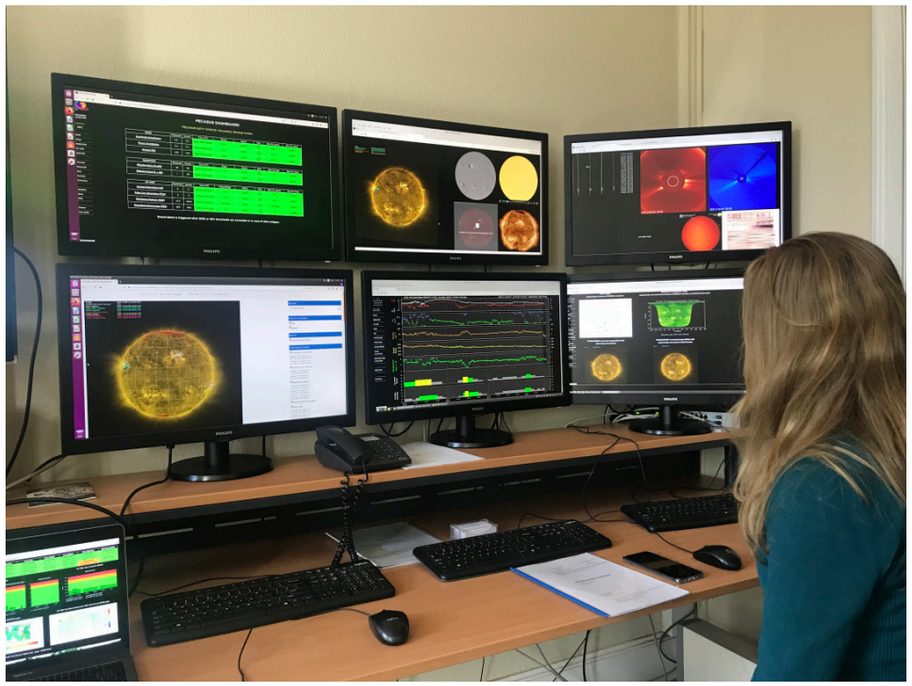
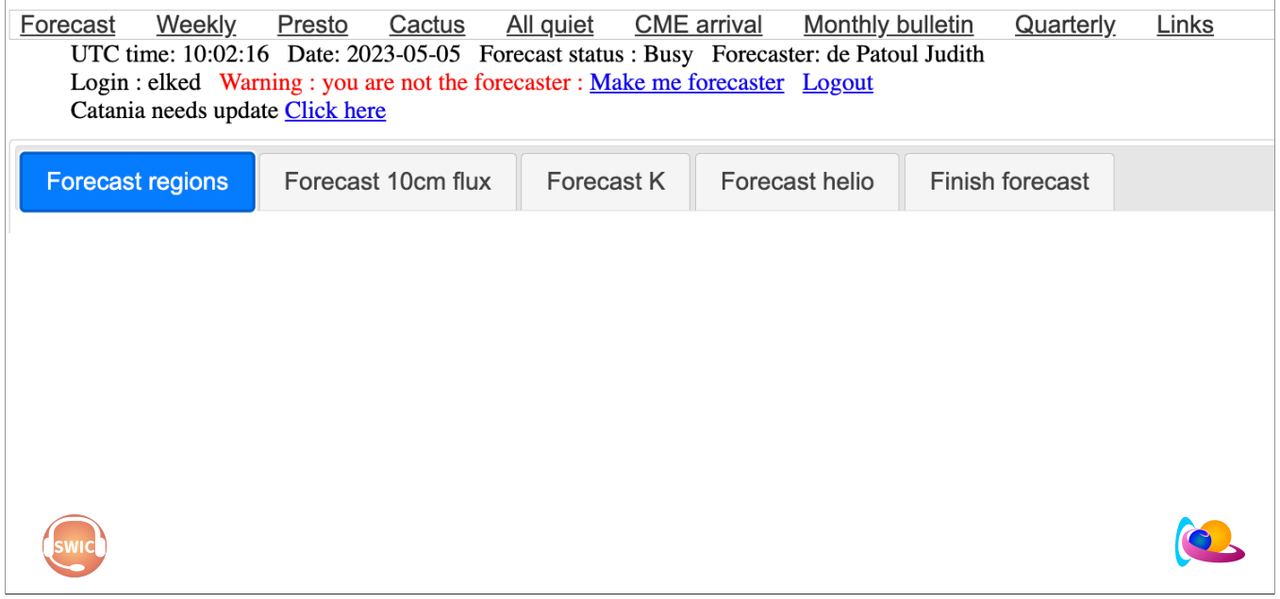
Forecaster tasks: monitoring



satellite and ground-based data
data processing & modelling software

Previweb - Forecaster page



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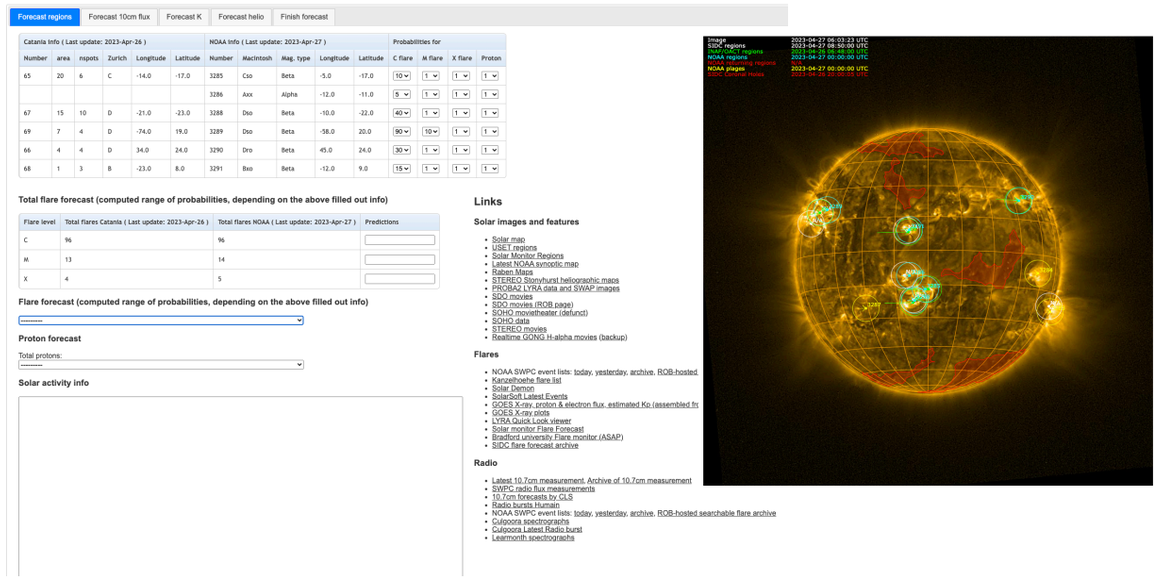
Solar Flares - Regions



Going back to our forecasting tool.
When the forecaster loads this page, it is automatically filled with the regions that are on the solar disk that day.
We use the numbering by the Catania Observatory as a baseline, which is based on the sunspots only (so no magnetic observations), and we thus link it to McIntosh classifications. We have a classification for each Catania group. We also use the NOAA group numbering and as you can see there is not always a one-to-one correspondence between both. For each region, the tool suggest the probability for each type of flare. This is based on a statistical look-up table (that we built internally) linked to the Macintosh classification. The probabilities can be adapted by the forecaster based on their observations, eg. Did the region show increased activity in the past hours, was there flaring observed already, what did this region do during its previous rotation, is the region decaying Etc.
Its position is also important, as for forecasting we are interested in regions that will produce an event that will impact Earth. Therefore, a region on the Eastern side that is approaching Central Meridian should probably be reported

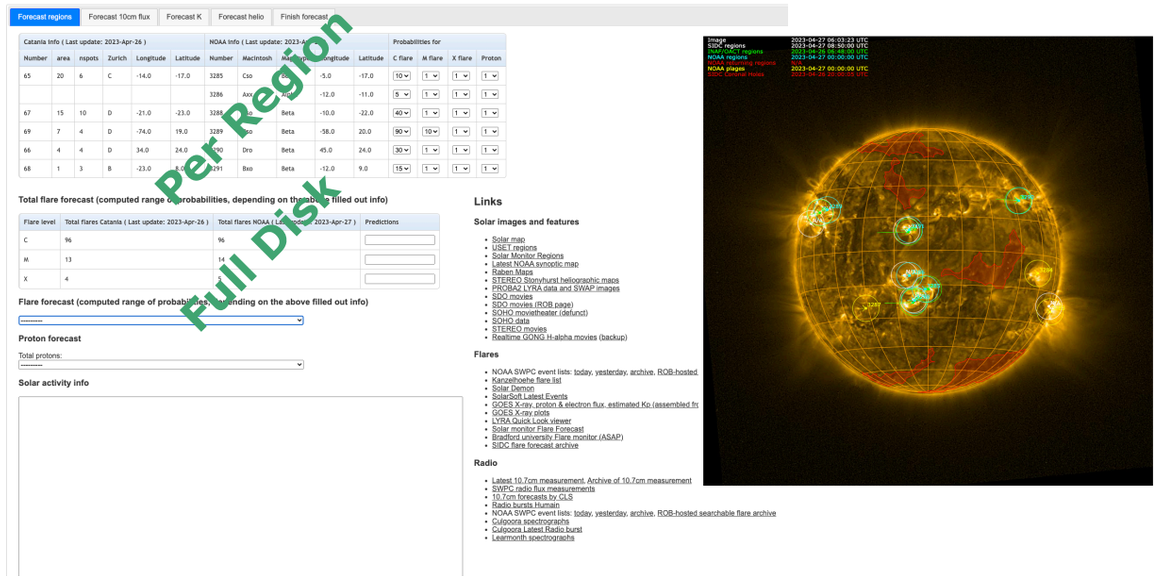
Region data are collected from two sources: Catania Observatory and NOAA.
By convention, we report the regions reported by Catania. SIDC uses NOAA for crossexamination.

A probability here means: “The probability of a flare of a certain magnitude or higher occurring over a certain time period”.
The magnitude bins are interpreted to be unbound at the upper end: e.i. C means C or above, M means M or above, etc.
The time period of prediction covers a period of 24 hours, from 12:30UT of that day until 12:30UT of the next day.

If a region has a complex magnetic configuration it is more likely to flare. Does this region seem to be decaying, or will it develop further the next days? Its position is also important, as for forecasting we are interested in regions that will produce an event that will impact Earth. Therefore, a region on the Eastern side that is approaching Central Meridian should probably be reported. On the other hand, one that has crossed Central Meridian and is moving to the Western limb may be of less significance and therefore not mentioned in the Ursigram.
For each identified region on the visible Earth side of the Sun, fill in your estimated flaring probability for C, M and X Flares from 1 to 99%.

The prediction of the full disc probability corresponds in principle to the sum of all probabilities. However, you might want to increase or decrease your prediction to take into accounted **additional regions expected** to rotate from behind the East solar limb or developing on disc.

Solar Flares - Forecast



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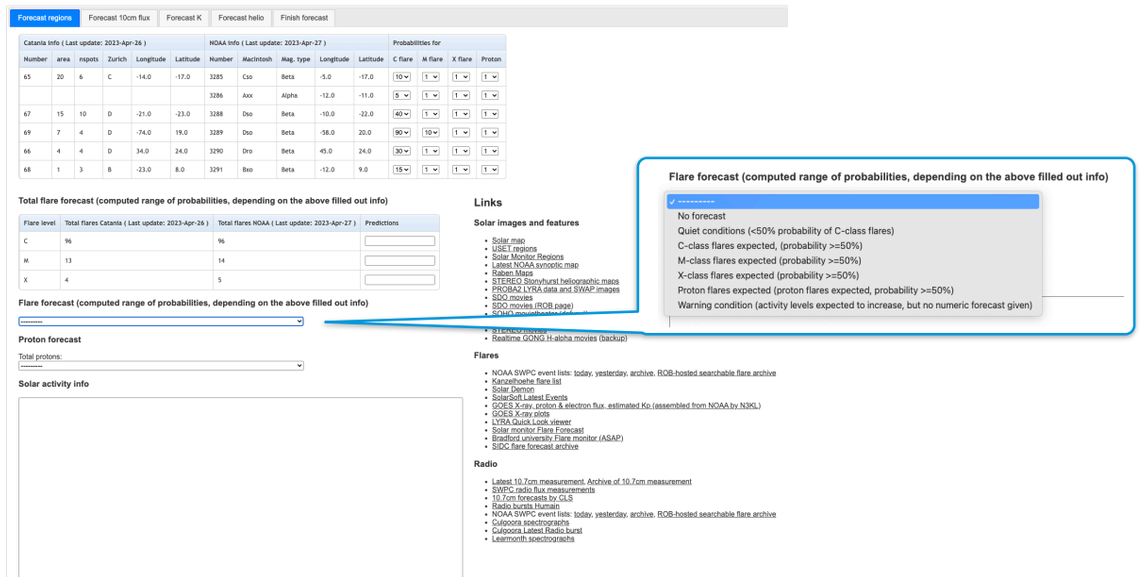
Solar Flares - Forecast Disk



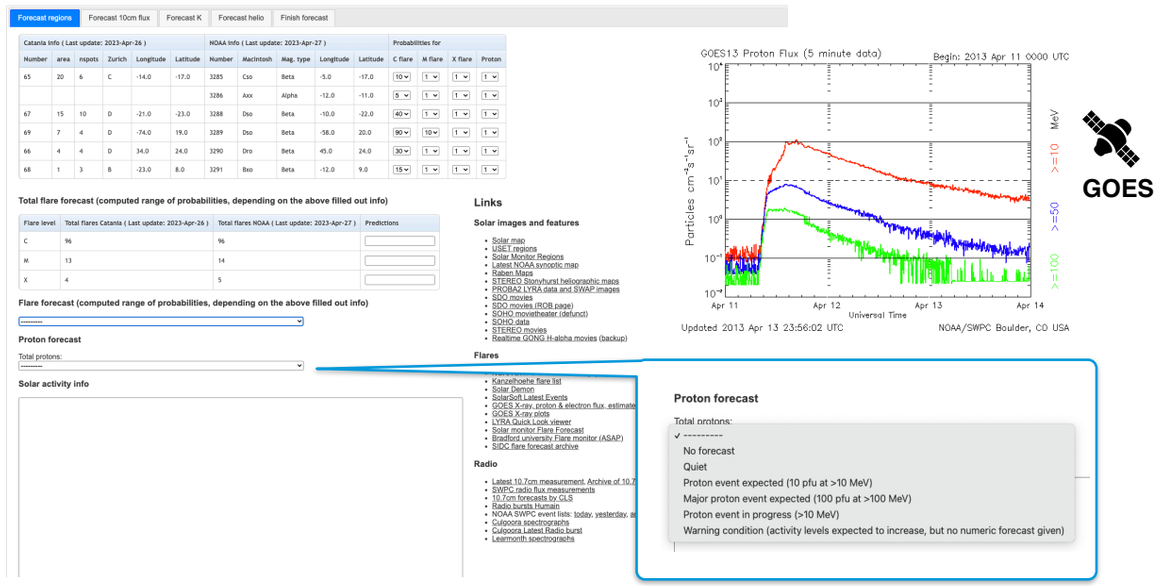
The Total flare forecast table is automatically computed based on your flare probabilities provided for every active region. Use your judgment to decide and eventually update the full disc probabilities.

Forecasts of categorical variables may be either categorical or probabilistic. The former is definitive – one of the categories is predicted to occur. A probabilistic forecast gives the estimated probability of occurrence of the categories of the variable. -> we do a probabilistic forecast of the flare categories

Flare predictions refer to the full disc but only in the **International Space Environment Service (ISES) categories**: classes according to 50% threshold exceeded for C, M or X flares

Based on the regional probabilities that are inserted, previweb shows the computed full disc probabilities for C, M, X flares once based on the Catania regions and once based on the NOAA regions. These probabilities are themselves not distributed in the URSIgram. They are intended as a guidance to the forecaster to be consistent with the individual region forecasts, when choosing the full disc prediction. The forecaster must use his/her judgement to decide and enter the full disc probabilities. He/she can take into account additional regions expected to appear from behind the East limb or developing on disc. Based on the full disc probabilities the forecaster chooses the applicable ISES category based on passing the 50 percent threshold for the C/M/X flares.

Protons - Forecast

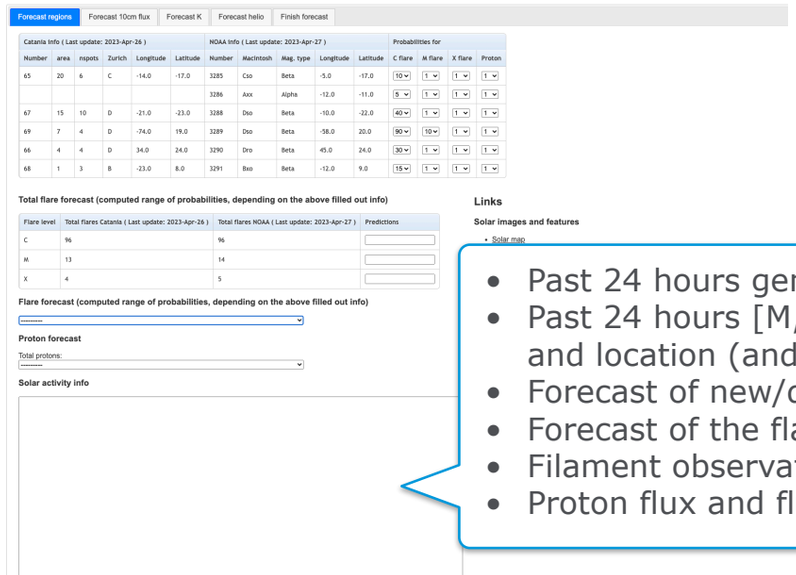


The forecaster also predicts proton events. These occur when the greater than 10 MeV proton flux exceeds the threshold of 10 particles.
Proton events can be associated with flares (impulsive, particles are accelerated) or CMEs (from shock, gradual event)
There's a higher likelihood for SEP events from the western hemisphere as they travel on magnetic field lines that are connected to the earth's magnetosphere. (Parker spiral)
The stronger gradual events are associated to wider and faster CMEs

Look for active regions & filaments that can:
- Produce strong x-ray flares
- Fast CMEs (~1000 km/s or more)
- Wide CMEs (partial or full halo CMEs)
- Preferably on the western solar hemisphere

Finetune from history on farside/eastern hemisphere
- Proton flux enhancements,…
- Observations by STEREO spacecraft

Solar Activity - Forecast

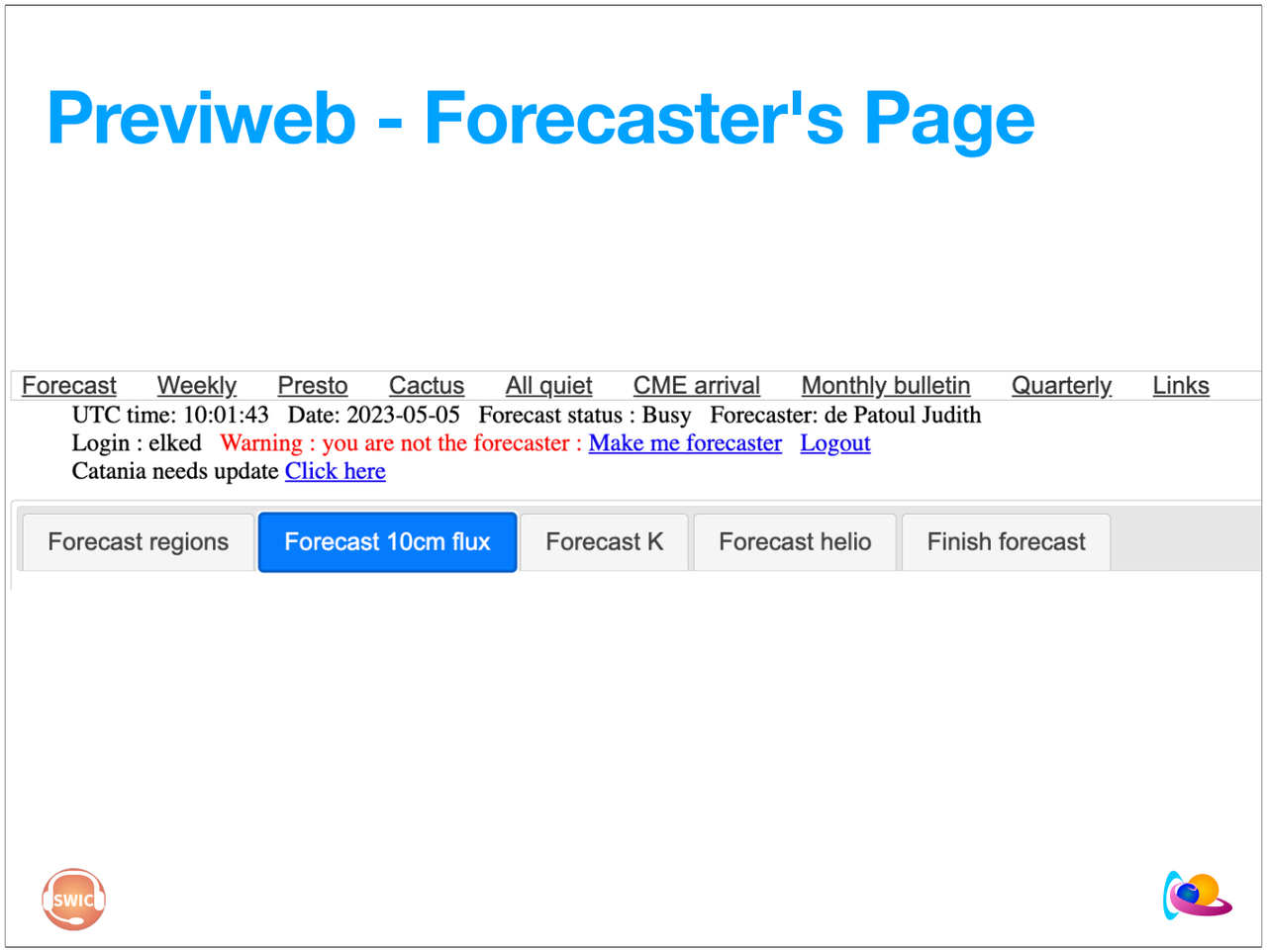


- Past 24 hours general solar activity
- Past 24 hours [M,X]-class flares peak time and location (and optionally C-Flare).
- Forecast of new/decaying active regions
- Forecast of the flare activity level
- Filament observations and eruptions
- Proton flux and fluence

In the info box, the forecaster describes the solar activity that was observed in the past 24h (since the last bulletin). Here also the Hale classifications is used to describe the magnetic complexity of the regions.

When reporting flares, write the biggest flare in the latest 24 hours and those associated with Earth-directed CMEs.

fluence = flux accumulation over 24 hours



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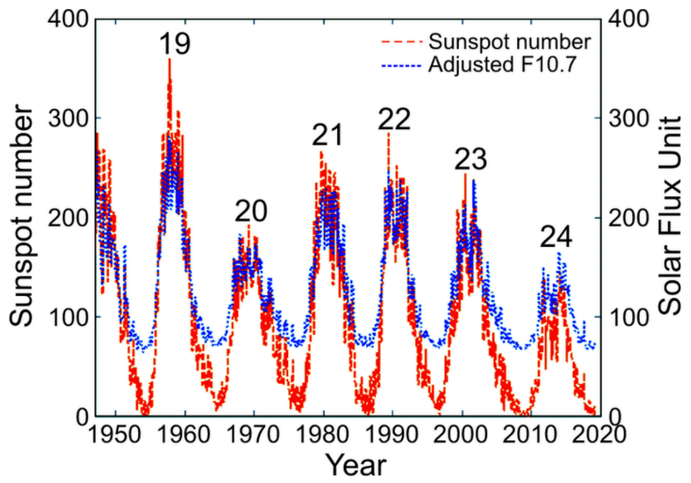
F10.7 - Observation



The sunspot numbers (red curve) and the 10.7 cm solar flux (F10.7, blue curve) from the middle of the 20th century [69-71]. The F10.7 values are in solar flux units (sfu), 1 sfu is equal to 10 -22 W m -2 ·Hz -1 . The observed F10.7 is presented on the right axis.

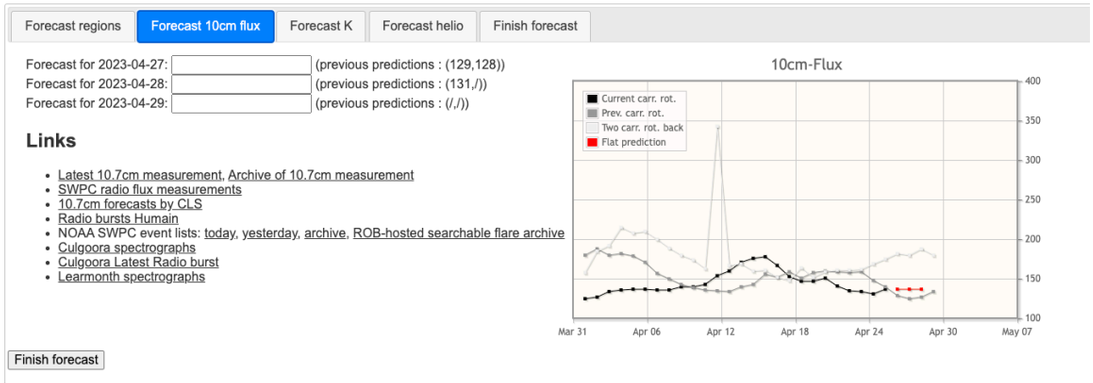
(Grytsai et al., 2020)

A 10.7 cm solar flux measurement is a determination of the strength of solar radio emission in a 100 MHz-wide band centered on 2800 MHz (a wavelength of 10.7 cm), averaged over an hour. It is expressed in solar flux units (sfu), where 1 sfu = 10–22 W m–2 Hz–1.
The F10.7 is well correlated with the sunspot number, and thus a good indicator of the level of solar activity

Note that the baseline F10.7 flux is not at 0, but at ~65 sfu

Three flux determinations are made each day, at 1700, 2000, and 2300 UT, except during the winter months, where the low elevation of the Sun (the Dominion Radio Astrophysical Observatory, DRAO, lies at +50° latitude) and the hilly terrain, forces the times to be changed to 1800, 2000, and 2200 UT. Each flux determination takes 1 h and takes no account of the solar radio emissions recorded outside the intervals covered by the measurements. Since the active region emissions contributing to the slowly varying emission (and F10.7) may vary over hours or less, there may be a significant degree of undersampling. In addition, there could be a contribution by a burst. The undersampling means there is a possible error if one uses a flux value in an application involving a different time from that at which the flux measurement is made.

F10.7 - Forecast

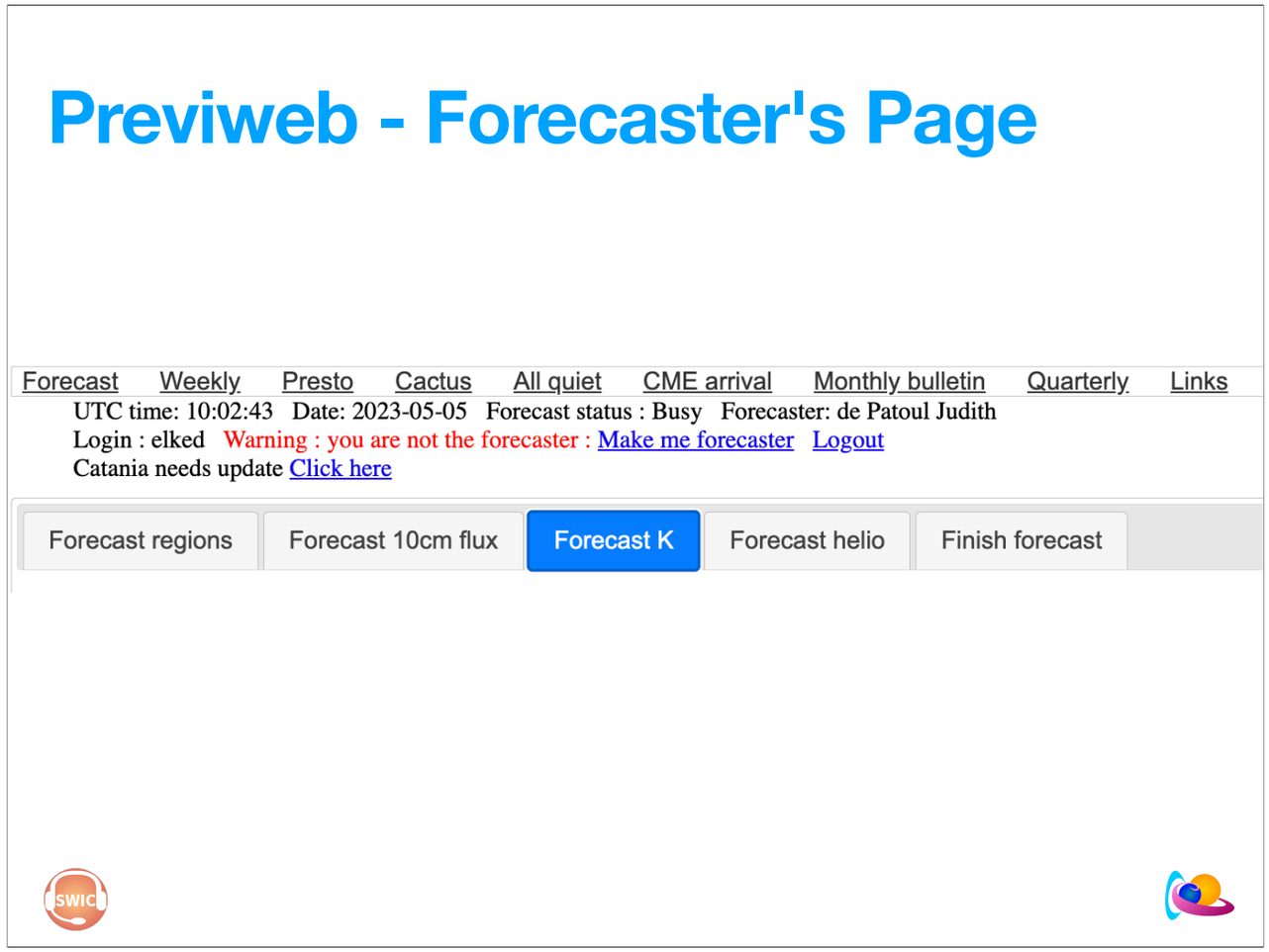


The 10.7cm radio flux has **contributions from three sources**. Firstly, it can be impacted by **radio bursts** (associated with eruptive phenomena), causing a changes to its values ranging from minutes to hours. Secondly, the **presence of active regions, dimmings or bright loops** will lead to an increase of its values, lasting from days to years. Finally, there is always present the contribution from the **background emission** of the Sun. As a result, **the bottom threshold for the 10.7cm flux is about 65 sfu.**

F10.7 is a continuous variable to forecast

Recurrence is a very good predictor for the background emission. What was the value during the previous cycle? Take that again and adjust for bursts or brighter regions.
We predict the F10.7 cm flux for the coming 3 days.

For the time already passed, we report the 10.7cm flux measurements reported by Natural Resources Canada recorded on 20:00:00UT. For any other time, we estimate how much the flux could be.
There are a number of models available to for 10.7cm flux prediction. One available on the links is by CLS, which you can use to have an idea of the future values. There is also the model created and used by Jan. In any case, the conditions on the Sun should also be taken into account:
• eruptive phenomena, bright loops, rising sunspots on solar surface? Increase the prediction by 1 or 2
• decaying sunspots on solar surfaces? Increase the prediction by 1 wing-periods



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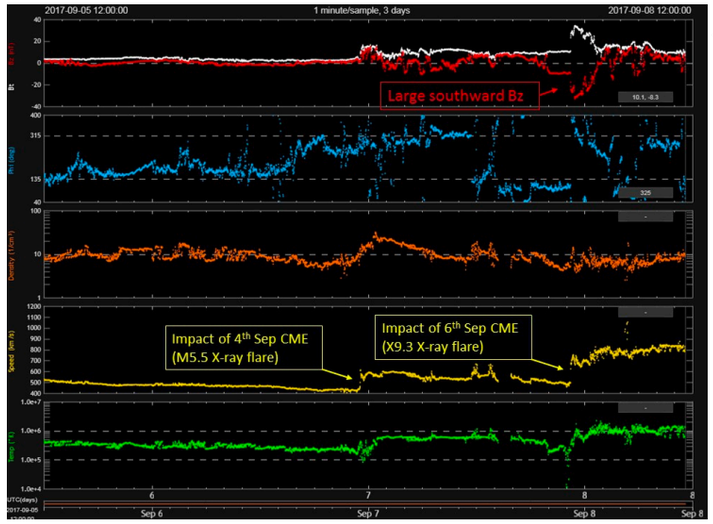
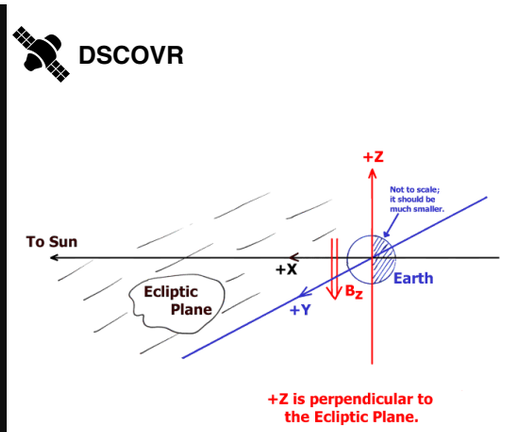
Solar Wind - Observations





To forecast the geomagnetic index K, we need to look at disturbances of the solar wind which will provoke disturbances in the Earth's magnetic field.

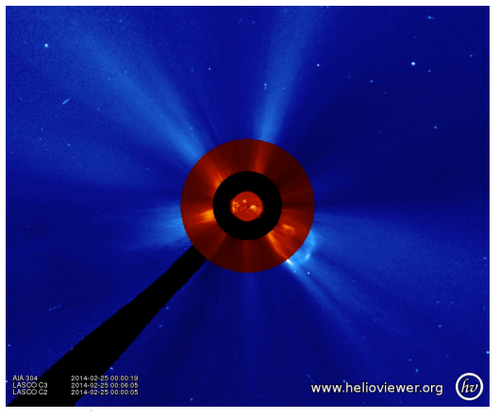
Solar wind disturbances that provoke strong geomagnetic storms are usually linked to either a CME (eruptive) or a coronal hole (non-eruptive)
Eruptive events (CMEs) typically have a stronger impact compared with CH because CME is a magnetic structure with a Bz component

When we monitor the magnetic field, we look at these parameters. These measurements are made by the DSCOVR satellite. They characterise the solar wind. From top to bottom there are measurements of: the magnetic field, the phi angle, the density, the speed, and the temperature.

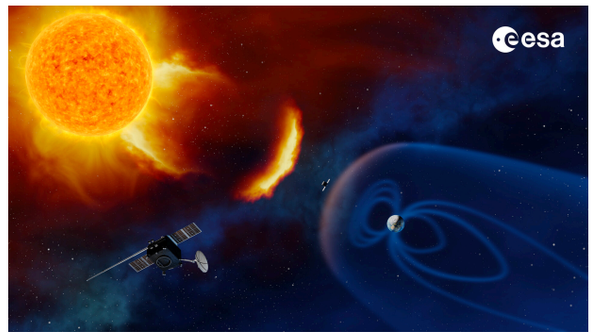
These measurements show the impact of two coronal mass ejections on the solar wind parameters: we see e.g. a clear rise in the speed of the solar wind, and a strong southward component of the magnetic field for the second coronal mass ejection.

Why is the southward component of the magnetic field so important: because a strongly southward oriented magnetic field allows reconnection with the magnetic field of the earth. (See coordinate frame used for the solar wind).

SW Disturbance - Coronal Mass Ejection



SDO/AIA and SOHO/LASCO



CME - coronagraph - front or back - low coronal signatures - geomagnetic storm

Solar wind disturbances that provoke strong geomagnetic storms are usually linked to either a CME (eruptive) or a coronal hole (non-eruptive)
Eruptive events (CMEs) typically have a stronger impact compared with CH because CME is a magnetic structure with a Bz component

CMEs originate from active regions with a complex (sheared and twisted) magnetic field structure or high/old filaments. A filament that in imaging data (SDO/AIA) seems to develop and suddenly disappear indicates a CME eruption. Another feature associated with CMEs are coronal dimmings. If you track one at the AIA data, search for a possible associated CME that took place about time of its appearance.

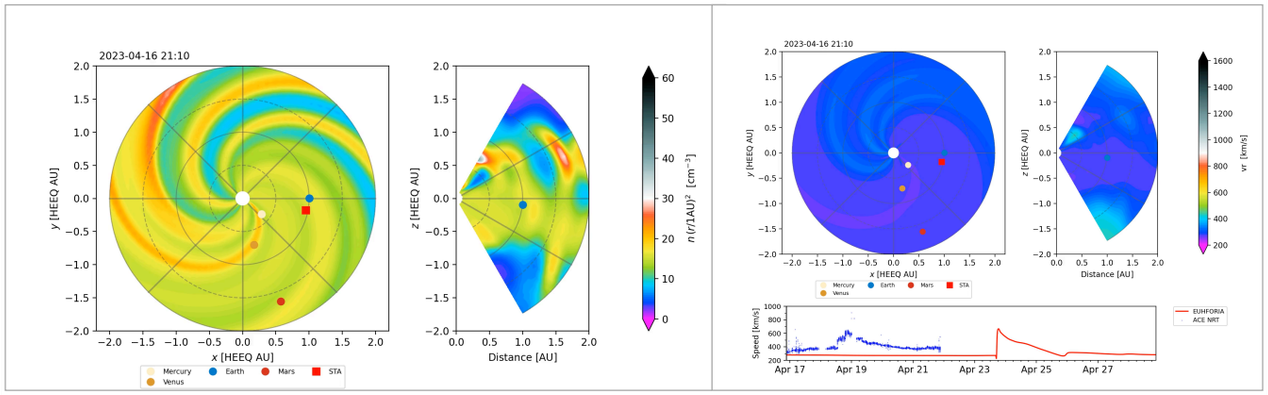
Check the position of STEREO on that date to understand the orientation of the CME. LASCO provides coronagraphic images of the CMEs, giving information on its structure, but not of its origin. It is therefore not possible to identify whether the eruption was **front or back-sided**. For forecasting purposes, we are interested in reporting either front-sided or Halo-CMES only, as those can have an impact on Earth.

As coronagraphic observations cannot distinguish between front side and backside halos, a forecaster thus has to look for low-coronal CME signatures like coronal dimming, EITwaves, post-eruption arcades and eruptive prominences. In order to understand whether the CME is front or back-side, use SDO/AIA or STEREO/EUVI 195A data. If a CME was seen by STEREO, you can additionally use the SIDC tool cor2speed to get a crude estimate of the CME speed. You will still need to calculate the inclination angle.

SW Disturbance - CME Arrival Prediction

Density

Velocity



euhforia

EUHFORIA - cactus as input to EUHFORIA

The picture below is the output of a simulation by EUHFORIA of the cloud propagation in the heliosphere. Left is a 'top' view of the sun (white dot) and the earth (blue dot). The black structure is the front of the magnetic cloud (purple) that reaches the earth. On the right is a side view of space. At the bottom, you see that the curve goes through the roof at the arrival.

EUHFORIA (EUropean Heliospheric FORecasting Information Asset) is a space weather modeling tool that computes the time-evolution of the inner heliospheric plasma environment using a combination of empirical and physics-based modeling approaches. EUHFORIA consists of two major components: A coronal model and a heliosphere model including several types of coronal mass ejections. The coronal model provides data-driven solar wind plasma parameters at 0.1 AU by constructing a magnetic field model of the coronal large-scale magnetic field and employing empirical relations to determine the plasma state such as the solar wind speed and mass density. These are then used as boundary conditions to drive a three-dimensional time-dependent magnetohydrodynamics model of the inner heliosphere up to 2 AU.

EUHFORIA (EUropean Heliospheric FORecasting Information Asset) aims to **model the propagation of CMEs** in the **inner heliosphere**. The model consists of two main parts: 1. The **semi-empirical WSA model**, which determines the solar wind conditions at the **inner radial boundary (near the Sun)** for the second part 2. The **heliospheric model**, which models the solar wind, with a possibility to insert CMEs.

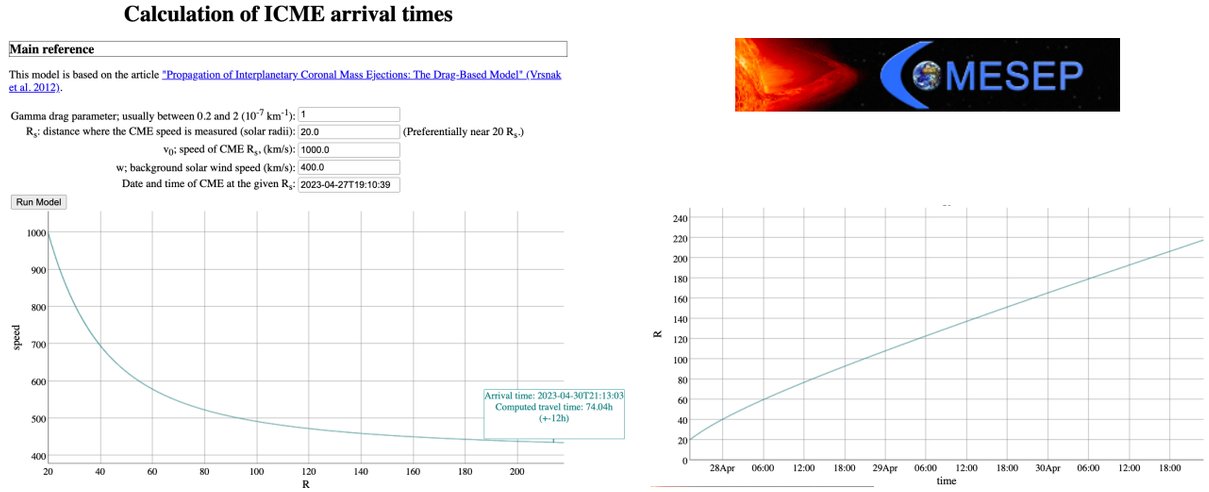
WSA model
Input: GONG synpotic map. Euhforia expects the information as a timestamp. If you want a specific time, you can look in the synoptic map database and give EUHFORIA this timestamp. The empirical model typically takes about 10-15 minutes to run.

Heliospheric Model:
The inner heliospheric model consists of the following phases (see figure): 1. Relaxation phase: As the Sun rotates, the solar wind is twisted into a spiral (similar to a a lawn sprinkler that is rotating, where the stream of water is representing the solar wind originating at a given point on the surface of the Sun). The inital conditions (based on the WSA-model above) of EUHFORIA do not start with a spiral and as such a relaxation phase is needed to propagate this spiral structure from the inner radial boundary to the outer radial boundary. This simulation phase does not represent a physical evolution in time but serves to build up the proper initial conditions for the remainder of the simulation. 2. CME insertion phase: From this phase onwards it is possible to insert CMEs. Any CMEs submitted that are launched before this date are not taking into account by the model (as they would have propagated out of the simulation domain anyway). 3. Forecasting phase: The forecasting phase starts at the timestamp of the GONG magnetogram (considered t=0) that was chosen by the user and the end of this phase denotes the end of an EUHFORIA simulation.

The inner radial boundary conditions are based on: 1. A **GONG standard synoptic map** 2. **CME kinematic (and magnetic) parameters** The model runs from **0.1au to 2au** with a **latitudional extent of 60deg and longitudinal extent of 360 deg**. This means that in practice it does not make sense to inject CMEs with an very strong up- or downward direction.

CME parameters: **Furthermore, information on the CME(s) should be provided**. This can be done in two types of models: The cone CME (using no magnetic field) and the LFFS CME (using internal magnetic field).
Note: Typically **any CMEs preceding the CME of interest (about 2-3 days before), should be included as well as they can influence the propagation of the CME by having cleared the solar wind in front of it or even interact with it**.

SW Disturbance - CME Arrival Prediction



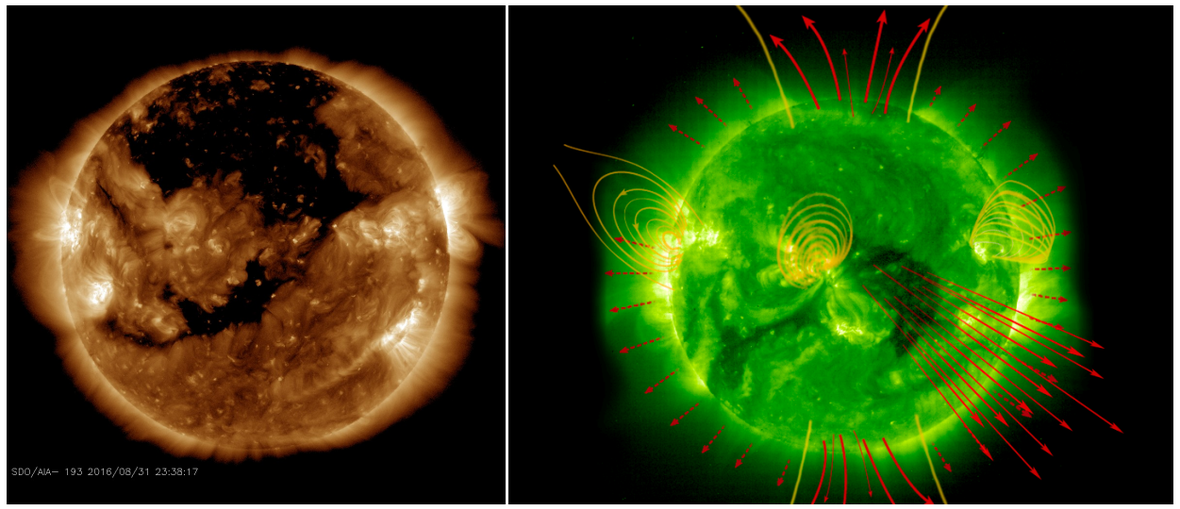
Drag based models

- Simple propagation only influenced by MHD drag
  - Constant drag (Vršnak et al., 2013, Dumbovicet al, 2021)
  - Height dependent drag coefficient (Goettingen dynamic drag model)
- **Simple and easy to do ensemble runs**

When a CME is observed in coronagraph images and is heading toward Earth:
1. Use the Stereo CAT tool to determine the 3D speed (not only the projected speed) to estimate the 3D speed and arrival time at about 20 solar radii
2. Use the drag model to estimate the arrival time
3. Send a Presto alert via Previweb
4. Report your data in the CME arrival tab on Previweb.

Estimation of the arrival time/How to:
Use the Drag-based Model (DBM). We consider here the basic DBM. Write the values (takeoff date/time, radial distance, and speed) according to what you have estimated using StereoCAT tool. The background or asymptotic solar wind speed (ranging here from 200 to 800 km/s) need to be estimated by looking at ACE and DSCOVR real-time solar wind data as well as the EUHFORIA and ENLIL models. The drag parameter defines the velocity change-rate. It is proportional to the solar wind density and the mass of the CME. Leave this parameter as is on the webpage.
Finally, you might want to slightly increase or decrease the speed depending on the general context: If the CME follows a first CME, its speed might be higher by up to ... %as the first CME has in somewhat cleared the path; As CMEs tends to converge their own speed to the background solar wind speed, its speed might increase or decrease slightly, etc.

SW Disturbance - Coronal Hole



SDO/AIA SOHO/EIT

Second type: Non-eruptive disturbance of the solar wind
RECURRENCE is important here

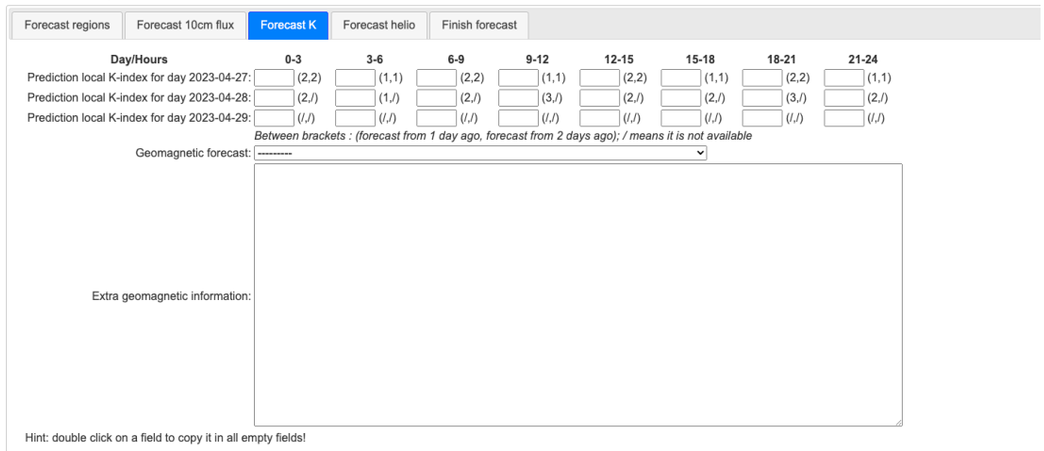
A coronal hole is a structure in the solar corona that you see as a black area in the EUV. In these regions, the magnetic field is less strong and the magnetic field lines are open, which allows plasma to escape. There is thus less plasma present to radiate and the region appears black in images.
The magnetic field lines of a coronal hole fan out into space, there are no closed magnetic loops above. This gives rise to a solar wind that is faster (~800 km/s) than the regular solar wind (~450 km/s).

In determining how strong the impact of a coronal hole will be, the **latitude of the coronal hole on the solar disk is important**. It is the plasma that leaves at the **central meridian** that will reach Earth. Polar coronal holes only have an impact when they extend to lower latitudes.

Less impactful: Earth near equatorial plane where Bz = 0 if the solar wind would not deviate from its definition

Recurrent - STEREO for preview - evolution

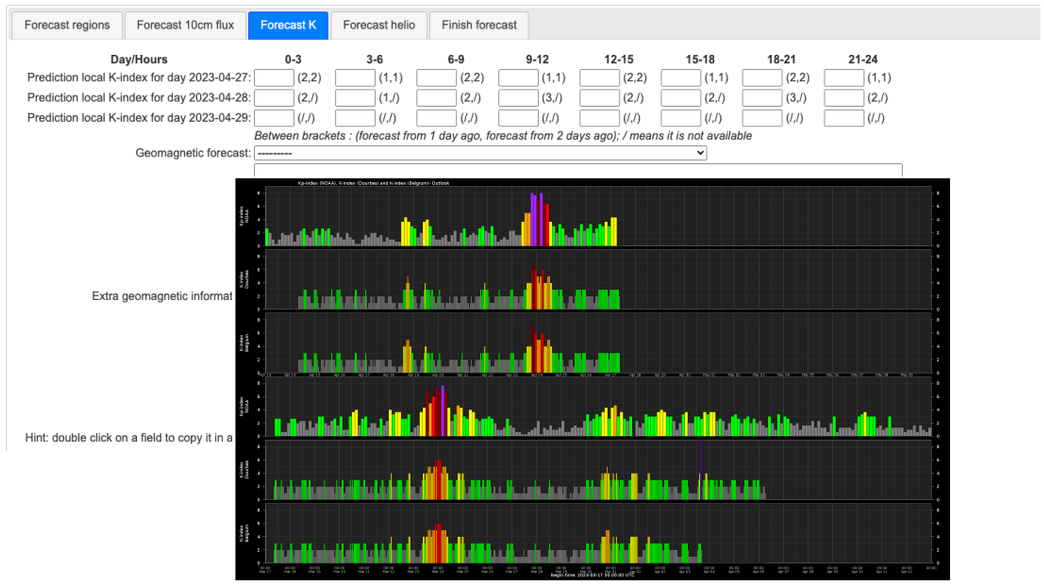
K index - Forecast



Recurrence!
But also CME arrival, HSS arrival from CH and orientation of the magnetic field
We predict local K, not Kp!
The K index is a categorical variable to forecast

Recurrence (27 day rotation) + Coronal hole evolution (from EUV) + STEREO in situ measurements
Competitive with physics based models like ENLIL and EUHFORIA
Verification of these forecasts is an ongoing activity

K index - Forecast



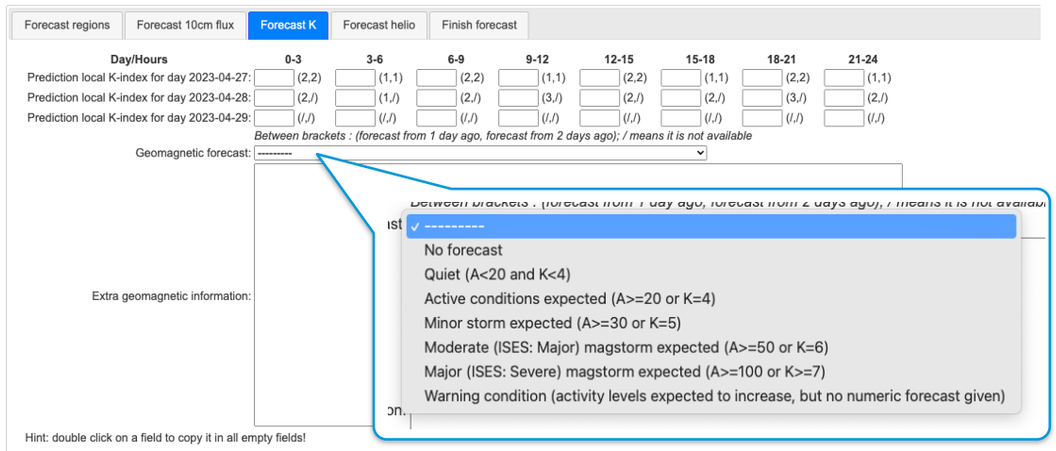
A K-index value is a local measurement over a three hour period.
In Dourbes, K-index values are produced every hour, but traditionally this was done only once every three hours. Therefore, the only Dourbes measurements that have relevance in comparison with most other stations are those at the 3UT,6UT,9UT,12UT,15UT,18UT,21UT,24UT. The indices calculated for the mornings and evenings are usually lower than for the rest of the day.

Look at the latest K-index from Dourbes. Then check the solar wind speed, as well as the Bz and the phi angle. The speed will tell you if you have a fast or slow solar wind, the phi angle if the solar wind crossed a sector boundary and the Bz if the solar magnetic field is pointing towards Earth or Sun.

Look at the phi angle. If there was a Coronal Hole, the phi angle will indicate change in polarity. The effects of a Coronal Hole on the solar wind data show in about 3 days, depending on the solar wind speed. Therefore, look at the solar wind data 3 days after CH first appearance.

Enter the values for the K-index for every three hour period in the coming 3 days. Since our bulletin is produced at UT noon we effectively know the first three local K values. Make sure to use those at the 3UT,6UT,9UT marks and discard the intermediate measurements.
As far as the forecasted values are concerned, the interpretation of the ISES scales is that K is to be interpreted as the **maximum K**. So, even if you expect K to become 4 for only a short period and the A-index is still below 20, you should still predict active conditions.
If in doubt, it is better to over-estimate the K indices than underestimating, as long as it is not happening frequently.

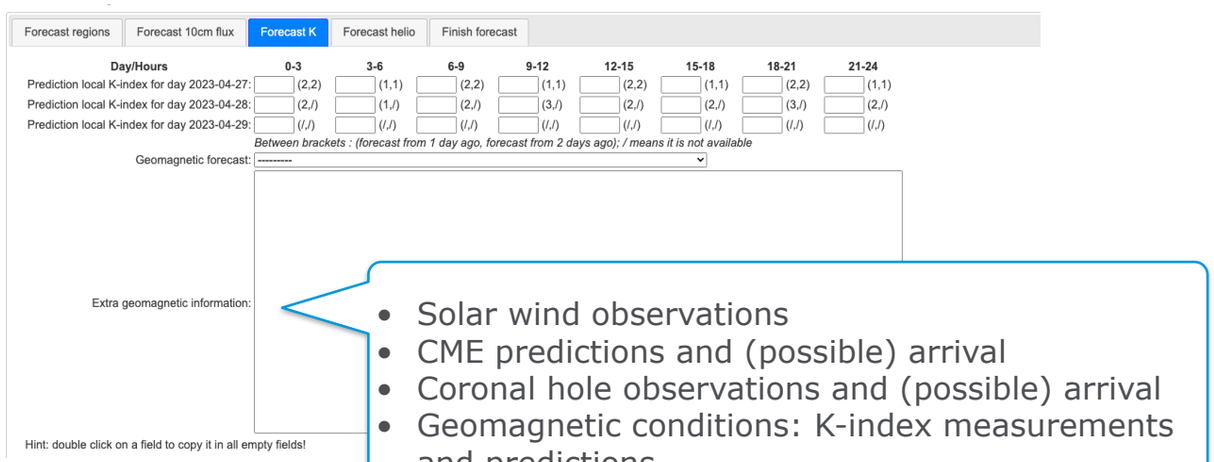
K index - Forecast



A K-index can be translated in an equivalent a-index value (quasi-logarithmic scale). The average of the a-indices over a day is called an A-index value. Since K-index values are interpreted locally, the computed A-index is also local.
Careful!: The ISES scales are based on thresholds both in A-index and K-index values while one is a daily value and the other a 3 hourly value. This is ambiguous.

ak index - The local K index is a quasi-logaritmic index, and as such averages cannot be taken. This poses a problem when one wants to express geomagnetic activity over e.g. a day or a month. To this aim, a 3-hourly "equivalent amplitude" index of local geomagnetic activity was established, with "ak" related to the 3-hourly K index according to the scale underneath

K index - Forecast



- Solar wind observations
- CME predictions and (possible) arrival
- Coronal hole observations and (possible) arrival
- Geomagnetic conditions: K-index measurements and predictions

If you believe a Coronal Hole will be geoeffective in the next 24 hours, report it in the Ursigram. Report minimum and maximum speed, B and Bz.

Riley et al (Sp. Weather, 2018)
CME arrival time mean forecast error small but under and over predictions can be large (> 12 hrs)
Simple models often perform comparably
Note: datasets on this plot are not pure model outputs, forecaster generated after consulting models

Daily Forecast - URSIgram

```
:Issued: 2022 Sep 07 1232 UTC
:Product: documentation at http://www.sidc.be/products/meu
#-----------------------------------------------------------------------#
# DAILY BULLETIN ON SOLAR AND GEOMAGNETIC ACTIVITY from the SIDC        #
# (RWC Belgium)                                                         #
#-----------------------------------------------------------------------#
SIDC URSIGRAM 20907
SIDC SOLAR BULLETIN 07 Sep 2022, 1230UT
SIDC FORECAST (valid from 1230UT, 07 Sep 2022 until 09 Sep 2022)
SOLAR FLARES  : C-class flares expected, (probability >=50%)
GEOMAGNETISM  : Active conditions expected (A>=20 or K=4)
SOLAR PROTONS : Quiet
PREDICTIONS FOR 07 Sep 2022  10CM FLUX: 123 / AP: 010
PREDICTIONS FOR 08 Sep 2022  10CM FLUX: 122 / AP: 010
PREDICTIONS FOR 09 Sep 2022  10CM FLUX: 120 / AP: 010
COMMENT: Solar flaring activity was low during the last 24 hours, with six C-class flares detected, the brightest being an C3 at 18:42 UTC
yesterday. However, all but one of those flares originated from NOAA Active Region (AR) 3088 that is now invisible from Earth. NOAA AR 3092
produced a C1 flare in the previous 24 hours and it is likely to produce some more C-class activity in the next 24 hours.

No Earth directed CMEs observed in the last 24 hours.

The greater than 10 MeV proton flux was at nominal levels over the past 24 hours and is expected to remain so for the next 24 hours. The greater
than 2 MeV electron flux was above the 1000 pfu alert threshold during the last 24 hours and is expected to remain above this level for the next
24 hours.
The 24h electron fluence was at moderate levels in the past 24 hours and is
expected to remain at these levels during the next 24 hours.

The Solar Wind (SW) conditions remained affected by the High Speed Stream (HSS) that arrived on 3 Sep. The SW speed ranged between 530 and 630
km/s over the last 24 hours. The total magnetic field (Bt) varied between 3 and 6 nT, while its Bz component ranged between -6 and 6 nT. The
interplanetary
magnetic field (phi) angle was directed away from the Sun during the last 24 hours. The SW conditions are expected to continue in the same
pattern in the next 24 hours.

Geomagnetic conditions reached globally active (Kp 2-4) and locally unsettled (K-Belgium 2-3) levels over the last 24 hours. Unsettled conditions
are expected for the next 24 hours with intervals of active conditions.

TODAY'S ESTIMATED ISN  : 095, BASED ON 19 STATIONS.

SOLAR INDICES FOR 06 Sep 2022
WOLF NUMBER CATANIA    : ///
10CM SOLAR FLUX        : ///
AK CHAMBON LA FORET    : ///
AK WINGST              : 022
ESTIMATED AP           : 019
ESTIMATED ISN          : 078, BASED ON 28 STATIONS.
```

Flaring Activity

CMEs

Particles

Solar Wind

Geomagnetic

The result of all this is a daily forecast bulletin sent to all registered users
Learn about a bulletin, what are the different sections and info
This bulletin was before the event, those are our background conditions

SIDC Webpage - Predictions

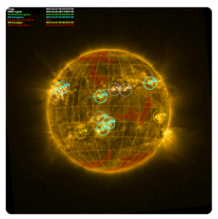
Space Weather Services

Detections

Solardemon
2023-04-27 02:51 B8 flare

CACTus
2023-04-21 18:12
844km/s

Solar Map



Latest Alerts

Presto 2023-04-24

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

Forecasts

Flare:	Quiet conditions (<50% C-class flares)
Protons:	Quiet
Geomagnetic:	Quiet (A<20 and K<4)
All quiet:	False
Provisional SSN:	127

Solar Activity

URSIgram 2023-04-26

Solar flaring activity was low and infrequent with two C1 flares detected during the past 24 hours. NOAA Active Region (AR) 3285 (Catania group 65) produced one of them, while a yet unnamed AR turning into Earth's view produced the second flare. More C-class flare activity is expected in the next 24 hours, most probably from the unnamed AR mentioned above. No Earth-directed Coronal Mass Ejections

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URSIgram 2023-04-26

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SIDC Webpage - Detections

Space Weather Services

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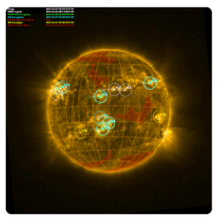

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CACTUS - CME Detection

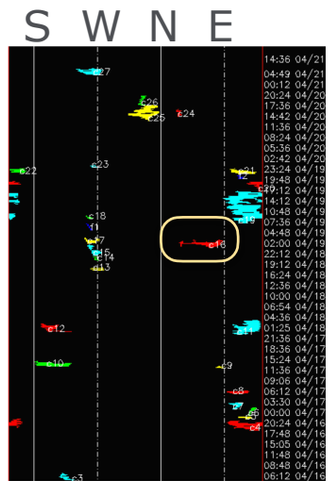
CACTUS

A software package for 'Computer Aided CME Tracking'

```
# CME |          t0     | dt0| pa | da |  v   |  dv  | minv| maxv| halo?
  0027|2023/04/21 06:24| 02 | 259| 036| 0669| 0057| 0549| 0753|
  0026|2023/04/20 18:36| 03 | 334| 010| 0422| 0169| 0157| 0659|
  0025|2023/04/20 15:36| 04 | 336| 042| 0452| 0064| 0359| 0624|
  0024|2023/04/20 15:24| 02 | 026| 006| 0520| 0190| 0466| 0892|
  0023|2023/04/20 00:36| 01 | 265| 008| 0306| 0056| 0224| 0390|
  0022|2023/04/19 23:36| 02 | 158| 022| 0255| 0074| 0186| 0452|
  0021|2023/04/19 23:24| 02 | 117| 036| 0355| 0147| 0160| 0664|
  0020|2023/04/19 18:36| 03 | 142| 038| 0199| 0064| 0112| 0300|
  0019|2023/04/19 11:48| 10 | 124| 070| 0374| 0343| 0104| 1420|
  0018|2023/04/19 10:00| 01 | 259| 008| 0466| 0084| 0312| 0538|
  0017|2023/04/19 02:36| 02 | 263| 020| 0477| 0775| 0176| 1953|
  0016|2023/04/19 02:24| 02 | 057| 060| 0268| 0089| 0203| 0504|
  0015|2023/04/18 23:12| 04 | 266| 018| 0425| 0049| 0315| 0480|
  0014|2023/04/18 21:12| 01 | 268| 006| 0548| 0060| 0534| 0651|
  0013|2023/04/18 19:36| 01 | 270| 018| 0428| 0218| 0130| 0801|
  0012|2023/04/18 01:25| 03 | 212| 042| 0470| 0092| 0284| 0568|
  0011|2023/04/18 00:48| 05 | 122| 038| 0359| 0118| 0128| 0569|
  0010|2023/04/17 13:36| 02 | 207| 052| 0398| 0086| 0237| 0558|
  0009|2023/04/17 13:36| 01 | 084| 010| 0435| 0030| 0400| 0473|
  0008|2023/04/17 07:12| 01 | 110| 030| 0396| 0045| 0318| 0466|
  0007|2023/04/17 03:12| 02 | 106| 018| 0434| 0072| 0318| 0589|
  0006|2023/04/16 23:24| 03 | 130| 010| 0600| 0297| 0315| 1077|
  0005|2023/04/16 20:12| 01 | 120| 018| 0819| 0273| 0558| 1361|
  0004|2023/04/16 20:12| 03 | 129| 068| 0470| 0252| 0220| 1116|
  0003|2023/04/16 06:48| 02 | 227| 020| 0264| 0031| 0238| 0318|
  0002|2023/04/16 00:48| 02 | 219| 020| 0488| 0214| 0220| 0804|
  0001|2023/04/16 00:48| 02 | 000| 062| 0269| 0028| 0217| 0332|

# Flow|          t0     | dt0| pa | da |  v   |  dv  | minv| maxv| halo?
  0002|2023/04/19 21:24| 01 | 113| 008| 0345| 0068| 0284| 0466|
  0001|2023/04/19 06:12| 02 | 259| 008| 1247| 0076| 1114| 1250|
#EOF
```

cmecat.txt



One tool to use to track CMEs is Cactus, which is a SIDC product. In Cactus, the orientation on the solar disk is indicated by vertical lines, while **horizontal lines indicate the CME presence and orientation**. As a result, **the longer the CME line is, the further it can be found in the solar Corona. The thicker the CME line is, the longer its lifetime**. If a CME is faint, it cannot be tracked by Cactus. In that case, you can check images from Stereo A/COR2.

CACTUS - CME Detection

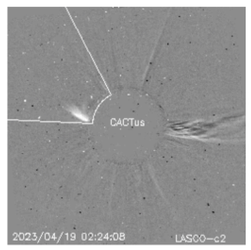
CACTUS

A software package for 'Computer Aided CME Tracking'

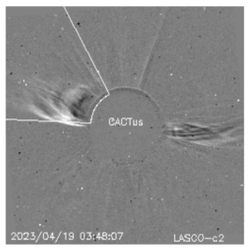
Details and graphs for CME0016

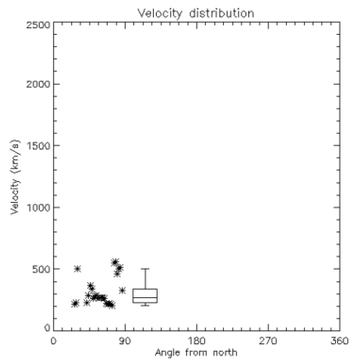
```
# CME |          t0     | dt0| pa | da |  v   |  dv  | minv| maxv| halo?
  0016|2023/04/19 02:24| 02 | 057| 060| 0268| 0089| 0203| 0504|
```

CME Movie :: Download ::



Sample Image





Projected speed (3D object projected on 2D plane), so speed is underestimation and only gives a very rough estimate of the arrival time of the CME. How can we do better?

Solar Demon

Solar Demon Flare Detection (qlk)

Quick-look! running in real time on SDO/AIA 94 QKL data
3 minute cadence, typical delay 15 minutes
(detection version 1.00)
(view all Solar Demon detection tools)

Detector 24h operating status:

Last processed image:
0 hours and 34 minutes ago (2023-11-09 13:33 UTC)

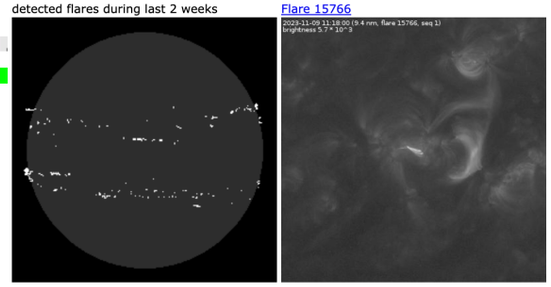
Last detected flare:
2 hours and 46 minutes ago (2023-11-09 11:21 UTC)

Filters (category)
-- *All classes*
Only C class flares and above
Only M class flares and above
Only X class flares and above

Filters (time)
Last 7 days
-- *Last 14 days*

detected flares during last 2 weeks

Flare 15766



Overview of flares

	est. class	start	peak	end	#	lat	lon	dist. R⊙	AR	est. flux	GOES flux	GOES peak time	COMESEP	# det.	dimming
November, 2023															
9	B3	11:18	11:21	11:21	15766	-10	4	0.25	AR 3480	2.6	**N/A**	N/A	0	2	-1,899
9	B1	10:48	10:51	10:51	15765	25	15	0.44		1.4	**N/A**	N/A	0	2	
9	A8	08:30	08:33	08:33	15764	8	16	0.29	AR 3483	0.8	**N/A**	N/A	0	2	
9	B2	01:15	01:15	01:21	15763	7	14	0.26	AR 3483	1.8	**N/A**	N/A	0	3	-19
9	B2	00:51	00:51	00:51	15762	23	70	0.95	AR 3479	1.6	**N/A**	N/A	0	1	
8	C2	20:09	20:18	21:00	15761	9	7	0.16	AR 3483	20.1	**N/A**	N/A	0	18	-44
8	B3	14:48	14:48	14:54	15760	8	4	0.11	AR 3483	2.8	**N/A**	N/A	0	3	-29
8	C3	08:30	08:51	09:36	15759	9	0	0.09	AR 3483	28.3	**N/A**	N/A	0	20	
8	B6	07:06	07:24	08:03	15756			1.01		5.8	**N/A**	N/A	0	19	-266
8	A7	07:24	07:24	07:24	15757	23	59	0.88	AR 3479	0.7	**N/A**	N/A	0	1	-266
8	B5	06:15	06:18	06:33	15755	9	-3	0.10	AR 3483	4.6	**N/A**	N/A	0	7	
8	B7	05:00	05:09	05:30	15754	9	-2	0.10	AR 3483	7.0	**N/A**	N/A	0	11	-41
8	C2	02:54	03:12	04:09	15751	9	-3	0.11	AR 3483	18.0	**N/A**	N/A	0	24	
8	B7	03:06	03:12	03:18	15753			1.01		7.2	**N/A**	N/A	0	5	-5

SIDC Webpage - Alerts

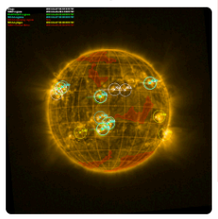
Space Weather Services

Detections

Solardemon
2023-04-27 02:51 B8 flare

CACTus
2023-04-21 18:12
844km/s

Solar Map



Latest Alerts

Presto 2023-04-24

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Forecasts

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Protons:	Quiet
Geomagnetic:	Quiet (A<20 and K<4)
All quiet:	False
Provisional SSN:	127

Solar Activity

URSIgram 2023-04-26

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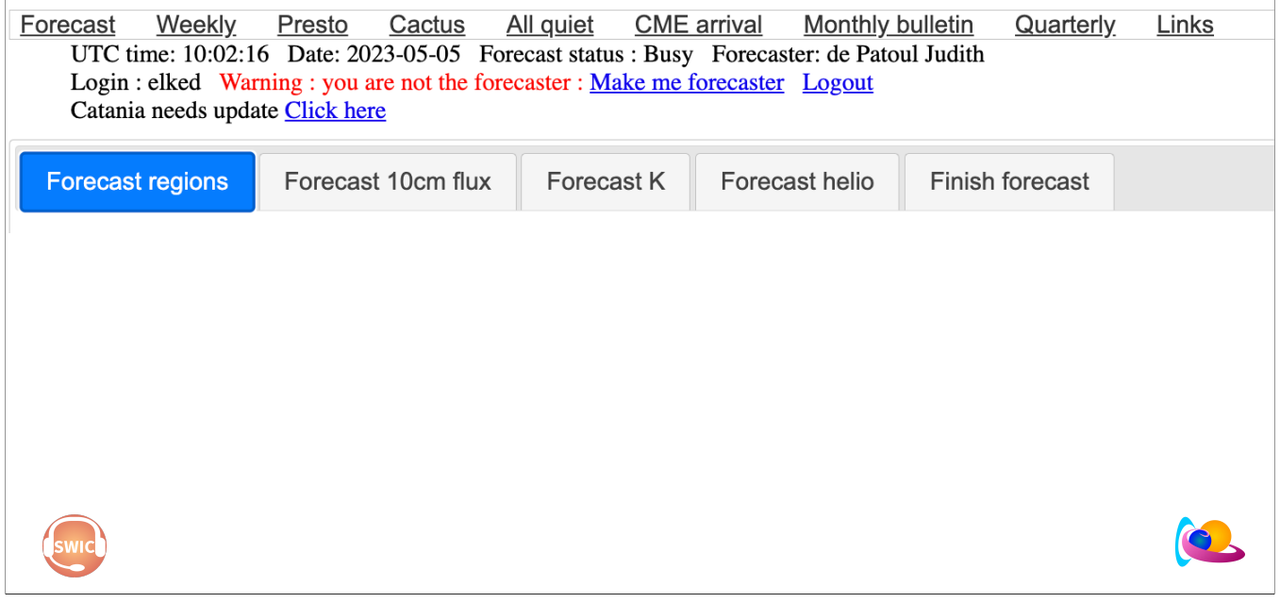
Previweb - Forecaster page



This is the top of our forecaster prediction page. You can see that besides the preparation of the daily bulletin, the forecaster also makes a weekly overview.
We will focus on the three tabs at the Bottom: forecasting of flares based on the active regions that are present on the disk, forecasting of the 10.7cm flux and forecasting of the geomagnetic index K

Types of Alerts

Automated
- Halo CME by CACTus
- Flaremail

Manual
- Presto
- CACTus Correction
- CME Arrival
- All quiet - End of all quiet

Automated Alerts

Automated: Halo CME

```
:Issued: 2023 Sep 24 2326 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|
2023-09-24T09:36:07.402 | 4.0 | 296 | 150 | 367 | 133 | 123 | 710


     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
  mindv: lowest velocity detected within the CME
  maxdv: highest velocity detected within the CME
#-----------------------------------------------------------------#
# Solar Influences Data analysis Center - RWC Belgium             #
# Royal Observatory of Belgium                                    #
```

Partial or full halo detected, i.e. da >180

This message is of the Fast Alert type.
The CACTUS software package scans through the images produced by the SOHO/LASCO coronagraph. When it detects a partial or full halo CME (a halo CME with an angular width of more than 180°), this warning message is generated.

Automated: flaremail

```
:Issued: 2014 Sep 10 1926 UTC
:Product: documentation at http://www.sidc.be/products/flaremail
#-----------------------------------------------------------------#
# Large flare alerts from the SIDC (RWC-Belgium), detected in GOES  #
# X-ray data                                                      #
#-----------------------------------------------------------------#
A class X1.6 solar X-ray flare occurred on 2014/09/10 with peak time 17:45 UT

#-----------------------------------------------------------------#
# Solar Influences Data analysis Center - RWC Belgium             #
# Royal Observatory of Belgium                                    #
# Fax : 32 (0) 2 373 0 224                                        #
# Tel.: 32 (0) 2 373 0 491                                        #
#                                                                 #
# For more information, see http://www.sidc.be.  Please do not reply #
# directly to this message, but send comments and suggestions to  #
# 'sidctech@oma.be'. If you are unable to use that address, use   #
# 'rvdlinden@spd.aas.org' instead.                                #
# To unsubscribe, visit http://sidc.be/registration/unsub.php     #
#-----------------------------------------------------------------#
```

GOES X-ray > M5

This message is of the fast alert type.
It is sent out when SIDC software detects in the GOES data a flare with an X-ray radiation flux stronger than M5.

Presto Alert

A presto alert needs to be sent ASAP:

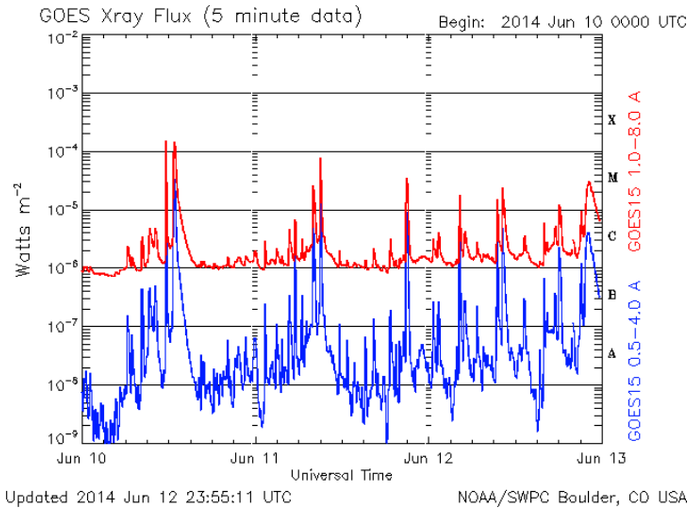
- During or just after an **X-flare** (high level of flaring activity)
- In case of a **proton event**, i.e., Flux >= 10 pfu (10 MeV particles)
- When a (either front or back-sided) (partial) **halo CME** or a strong westward directed CME occurred.
- In case we observe a **fast forward shock** in the solar wind speed at 1 AU
- When **Kp > 5** or K > 5.
- In case you observe **enhanced solar wind conditions** which will likely lead to geomagnetic storm conditions K or Kp > 5.

What does this indicate? Storm conditions (K=5 Minor storm)

PRESTO

A presto alert needs to be sent ASAP:

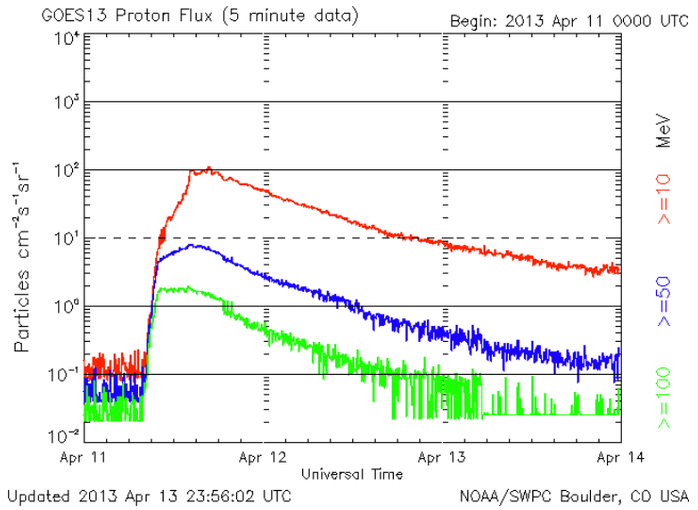
- During or just after an **X-flare**



PRESTO

A presto alert needs to be sent ASAP:

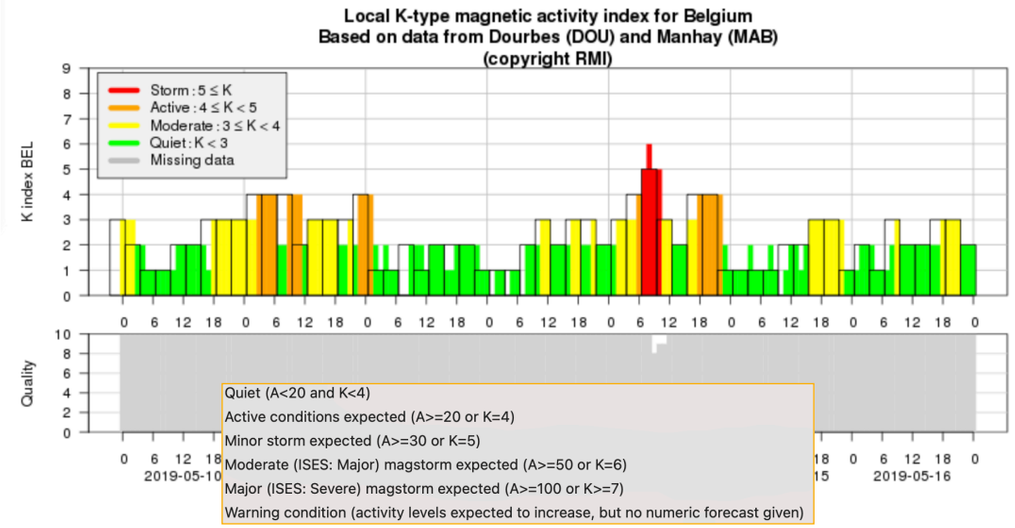
- In case of a **proton event**, i.e., proton flux >= 10 pfu (10 MeV particles)



PRESTO

A presto alert needs to be sent ASAP:

- When **Kp > 5** or K > 5.

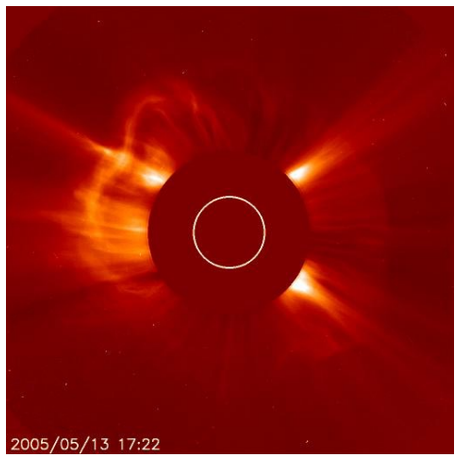


https://www.stce.be/news/638/welcome.html
Kp eventually reached severe storming levels (Kp = 8-)
ICME arrival, no shock
What does this indicate? Storm conditions (K=5 Minor storm)

PRESTO

A presto alert needs to be sent ASAP:

- When a (either front or back-side) (partial) **halo CME** or a strong westward directed CME occurred.
  Try to find out whether the halo CME is front-sided or not, by locating the source.

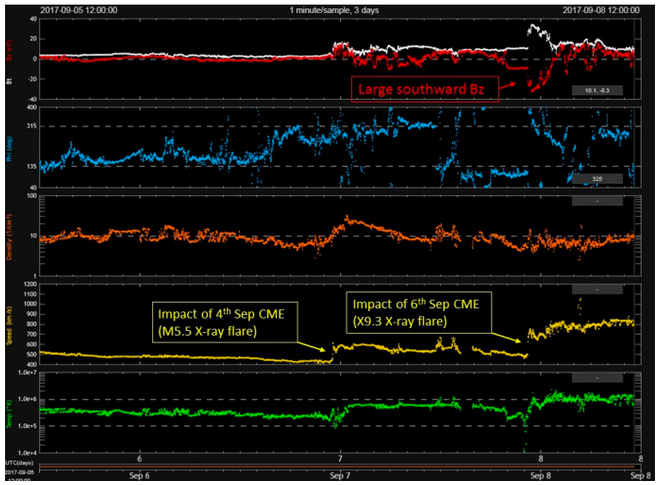


How do you know if a halo CME is front-sided?
Why the westward CMEs?

PRESTO

A presto alert needs to be sent ASAP:

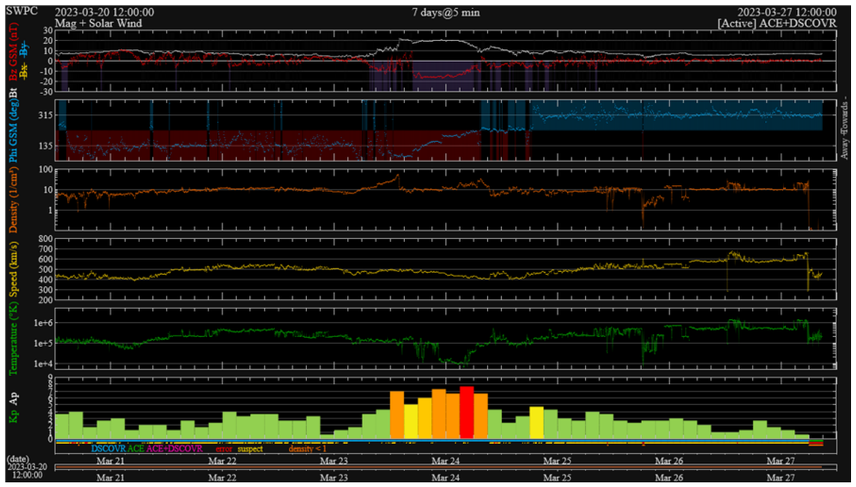
- In case you observe a **fast forward shock** in the solar wind speed. (delta_v>20km/s, ratio_n>1.2 and ratio_B>1.2)



PRESTO

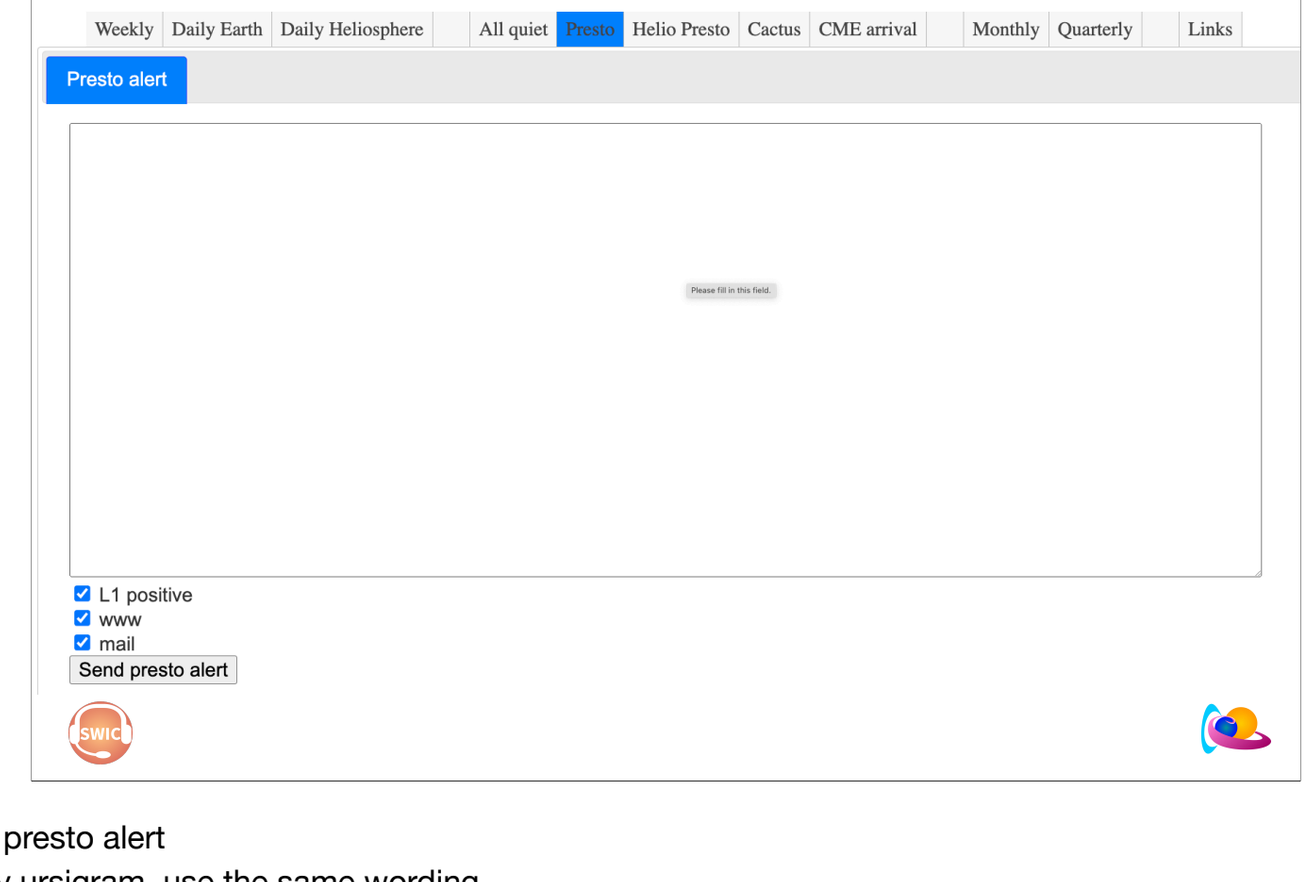
A presto alert needs to be sent ASAP:

- In case you observe **enhanced solar wind conditions** which will likely lead to geomagnetic storm conditions K or Kp > 5.



https://www.stce.be/news/638/welcome.html
ICME arrival, no shock

PRESTO: How?



Description of event that triggered the presto alert
Very similar to what you put in the daily ursigram, use the same wording

PRESTO: example

:Issued: 2023 Mar 07 1343 UTC
:Product: documentation at http://www.sidc.be/products/presto
#---#
FAST WARNING 'PRESTO' MESSAGE from the SIDC (RWC-Belgium)
#---#
A halo Coronal Cass Ejection (CME) was observed in SOHO/LASCO-C2 from yesterday 03:12 UT. Although the bulk of the plasma is directed towards the West and South-West, a very faint asymmetric halo can be seen when the data are closely inspected. The speed of the CME is estimated to be 840 km/s and although the bulk of the CME is expected to miss Earth, a glancing blow is likely to arrive on the second half of 8 Mar or early on 9 Mar.

Another partial halo CME was automatically detected by the CACTUS software as launched yesterday 10:36 UT. However, close inspection revealed CACTUS took into account unrelated plasma ejecta and this is a marginally partial halo CME with only a weak component towards Earth's general direction. The speed of the CME is estimated to also be 840 km/s the bulk of the plasma is expected to miss Earth. A glancing blow might arrive on Earth's magnetosphere but if so it is expected to merge with the earlier CME mentioned above.
#---#
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

PRESTo: More examples

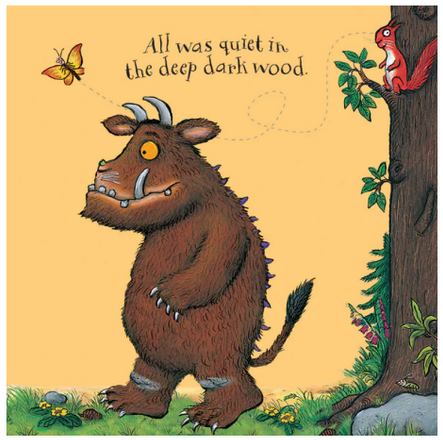
A **shock** in the solar wind at 19:54 UTC on 24 September marks the **arrival** of the ICME from 21 September (and probably that of the 22 September too). The **speed** jumped from 315 km/s to 440 km/s and the interplanetary **magnetic field** from 7 to 19 nT. The speed later reached 470 km/s and the magnetic field 28 nT with Bz down to -27 nT. This created moderate **geomagnetic storms** globally (Kp 6) and minor storms locally (K_Bel 5). The Earth is still inside the ICME (or ICMEs, to be confirmed as more data becomes available) and the corresponding geomagnetic storm is still ongoing.

Geomagnetic conditions have reached **moderate storm** levels globally (Kp 6) and minor storm levels locally (K_Bel 5), due to the ICME that arrived yesterday (**solar wind** speed up to 600 km/s and interplanetary magnetic field up to 22 nT and Bz down to -17 nT) and probably also some effects from a high speed solar wind stream. More disturbed conditions can be expected in the next 24 hours.

A **partial halo CME** with angular width around 150 degrees was first seen by LASCO-C2 at 13:36 UTC on 21 September. The CME was related to the M8.7 **flare** from NOAA **AR** 3435. The CME **speed** was estimated to be around 500 km/s, with the bulk of the material directed to the south. Since the source is located close to disk center, an **impact** at Earth can be expected on 25 September.

An **X1.5 class flare** was observed on August 07 peaking at 20:46 UTC. The flare was produced by the NOAA Active Region (**AR**) 3386 (Catania sunspot group 01), which was located at the west limb. Following this flare, the greater than 10 MeV **proton flux** started to rise at 21:46 UTC and crossed the 10 MeV warning **threshold** at 01:10 UTC on August 08 as measured by GOES. The 10 MeV proton flux remains currently above the threshold.

All Quiet Alert



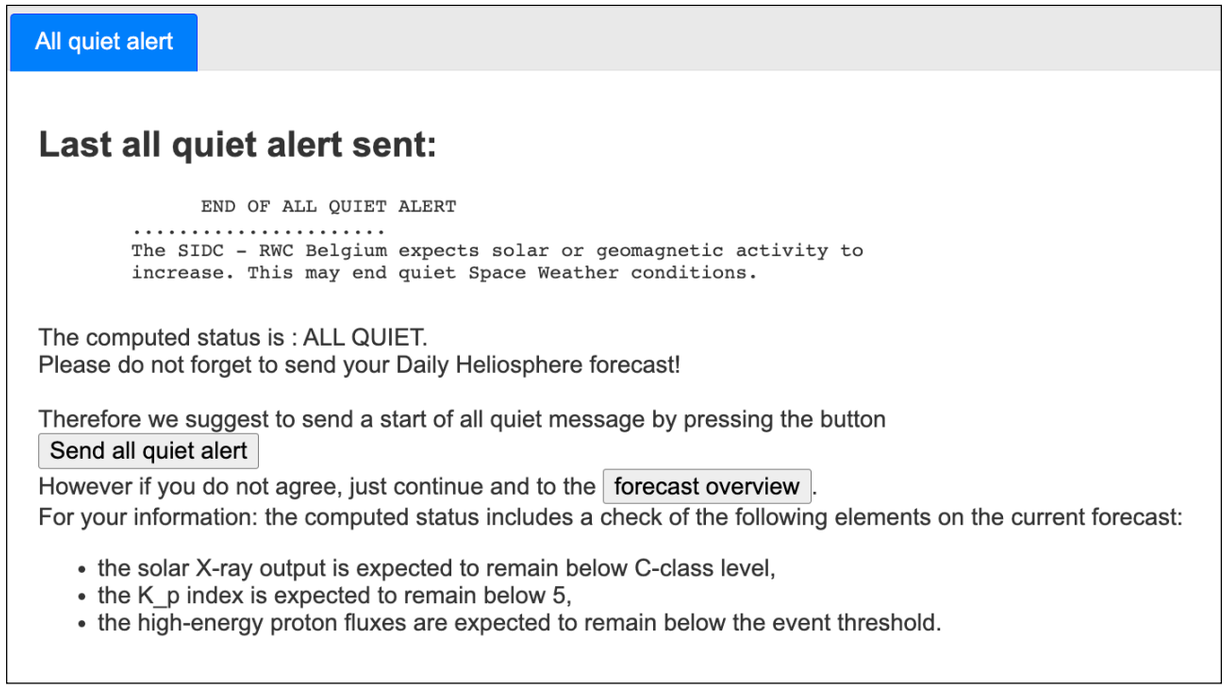
All quiet

Send all quiet alert if **for the next 48 hours** you are forecasting that:

- the solar **X-ray** flux is expected to remain **below C-class level**
  (probability of C-flares on a daily basis should remain below 20% for the next two days),
- the **Kp** (and **K?)** indices are expected to remain **below 5**,
- **AND** the high-energy **proton** fluxes are expected to remain **below the event threshold**
  (10 pfu)

All conditions need to be met!

All quiet



Don’t forget the end of all quiet/all quiet alert, as you can see the system will warn you for this, based on the forecasts you have entered in the other tabs

All quiet

UTC time: 2023-10-04T12:48:04Z

Weekly | Daily Earth | Daily Heliosphere | All quiet | Presto | Helio Presto | Cactus | CME arrival | Monthly | Quarterly | Links

All quiet alert

Last all quiet alert sent:

```
            END OF ALL QUIET ALERT
.....................
The SIDC - RWC Belgium expects solar or geomagnetic activity to
increase. This may end quiet Space Weather conditions.
```

The computed status is : NOT QUIET.
Please do not forget to send your Daily Heliosphere forecast!

Therefore nothing needs to be done and you can just continue to the forecast overview.

However if you do not agree you can still decide to send a start of all quiet message by pressing the button

Send all quiet alert
For your information: the computed status includes a check of the following elements on the current forecast:

- the solar X-ray output is expected to remain below C-class level,
- the K_p index is expected to remain below 5,
- the high-energy proton fluxes are expected to remain below the event threshold.

All quiet: example

:Issued: 2019 May 30 1214 UTC
:Product: documentation at http://www.sidc.be/products/quieta
#---#
From the SIDC (RWC-Belgium): "ALL QUIET" ALERT
#---#
START OF ALL QUIET ALERT
.....
The SIDC - RWC Belgium expects quiet Space Weather conditions for the next 48 hours or until further notice.
This implies that:
* the solar X-ray output is expected to remain below C-class level,
* the K_p index is expected to remain below 5,
* the high-energy proton fluxes are expected to remain below the event threshold.
#---#
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
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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
#---#

All quiet alert email message

End of All quiet

```
:Issued: 2023 Jan 30 1608 UTC
:Product: documentation at http://www.sidc.be/products/quieta
#-----------------------------------------------------------------#
# From the SIDC (RWC-Belgium): "ALL QUIET" ALERT                  #
#-----------------------------------------------------------------#
END OF ALL QUIET ALERT
        ......................
        The SIDC - RWC Belgium expects solar or geomagnetic activity to
        increase. This may end quiet Space Weather conditions.
#-----------------------------------------------------------------#
# Solar Influences Data analysis Center - RWC Belgium             #
# Royal Observatory of Belgium                                    #
#                                                                 #
# Website         http://www.sidc.be.                             #
# E-mail          sidc-support@oma.be                             #
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# - Use and processing of your personal information:              #
#   http://www.astro.oma.be/common/internet/en/privacy-policy-en.pdf #
#-----------------------------------------------------------------#
```
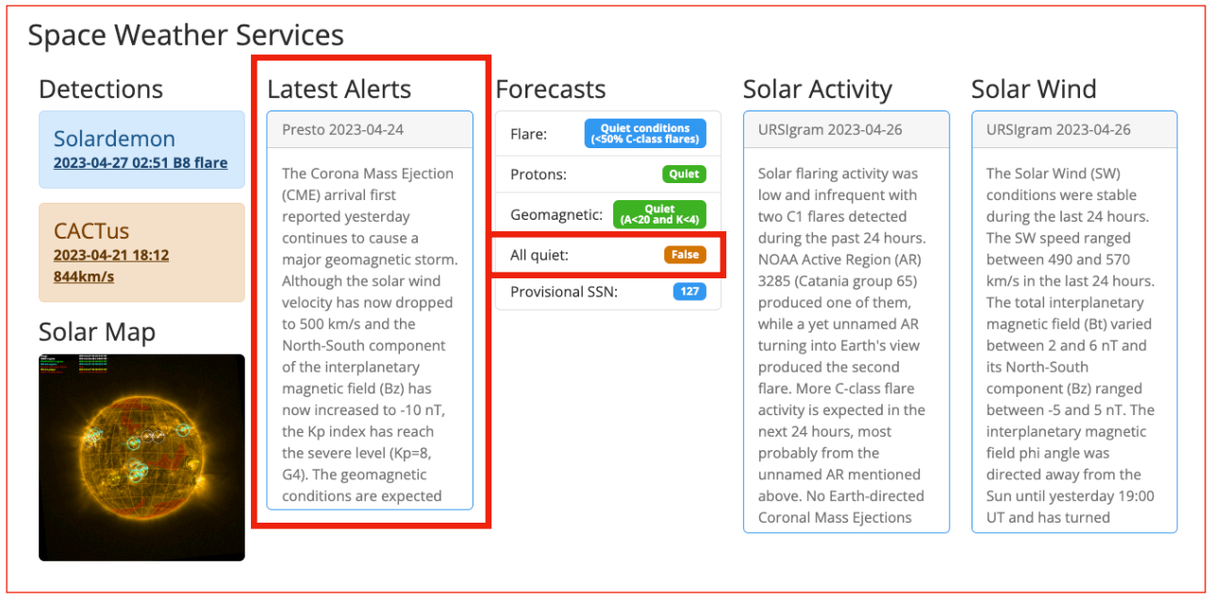

End of all quiet message

SIDC Webpage - Alerts



The CACTus correction alert does not appear on the website, only distributed by email

STCE Newsletter

NEWSLETTER

STCE Newsletter

SOLAR-TERRESTRIAL CENTRE OF EXCELLENCE

STCE Newsletter

19 Feb 2024 - 25 Feb 2024

Published by the STCE - this issue : 1 Mar 2024.
The Solar-Terrestrial Centre of Excellence (STCE) is a collaborative network of the Belgian Institute for Space Aeronomy, the Royal Observatory of Belgium and the Royal Meteorological Institute of Belgium.

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Registration through old webpage for now
Lists differ for each sort of alert!

Registration

E-mail lists - register!

https://www.sidc.be/

Registration through old webpage for now
Lists differ for each sort of alert!