STCE Newsletter

24 Feb 2025 - 2 Mar 2025

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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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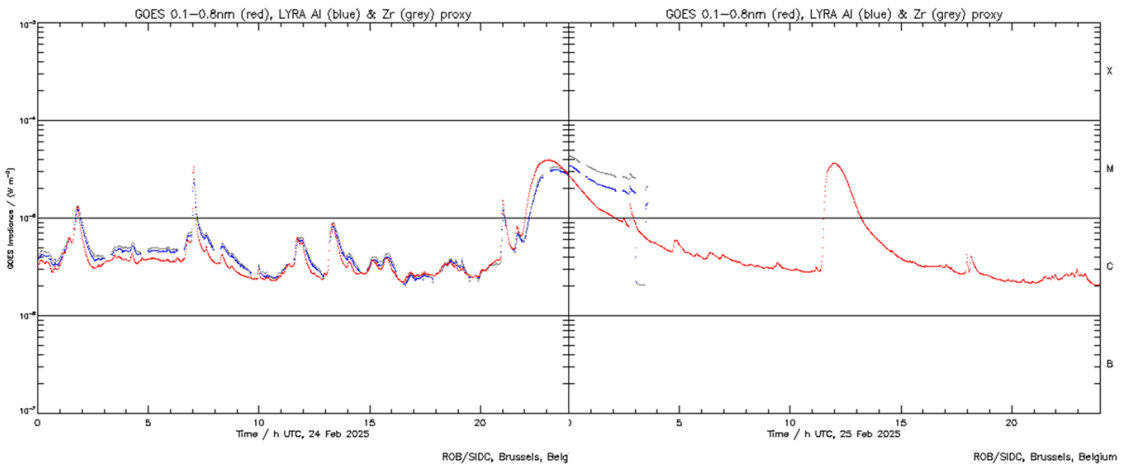
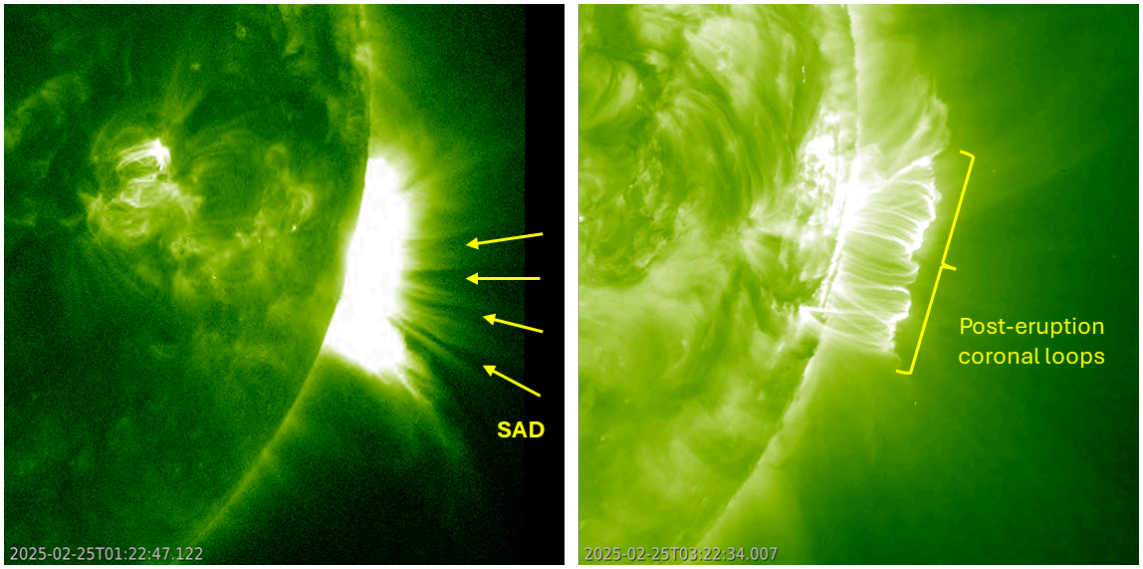
1. And the Oscar for best CME goes to...

Solar filaments are clouds of charged particles ("plasma") above the solar surface squeezed between regions of opposite magnetic polarity. Being cooler and denser than the plasma underneath and their surroundings, they appear as dark lines when seen on the solar disk. Special filters are required to observe these features, such as in the Hydrogen-alpha (H-alpha) line in the red part of the solar spectrum at a wavelength of 656.3 nm, or in some extreme ultraviolet (EUV) filters. The annotated H-alpha image underneath (GONG) shows a 15-degrees long filament anchored on one side to the leading sunspot of NOAA 13990. Late on 22 February, it was at the solar limb as seen from Earth. Two days later, it was also close to the southwest solar limb as seen from STEREO-A (EUVI 195). Indeed, that spacecraft is currently preceding the Earth by about 30 degrees, and so it takes the Sun -with its average rotation rate of about 13 degrees per day- 2 days to bring the feature in about the same position as seen from STEREO-A. The H-alpha image is in red and overlaid on the greenish EUV image from STEREO-A. The portion that is not overlapped, shows actually that part of the Sun that cannot be seen from Earth, but only by STEREO-A.

Long filaments are known for their potential to erupt, and so this one was no exception. Starting around 20:00UTC on 24 February, the surrounding magnetic fields became unstable and the filament got ejected into space. The image to the right in the above comparison actually shows the top portion of the filament at the start of its lift-off. It took about 1.5 hours for the complete ejection of the filament, and at that point the post-eruption coronal loops ("arcade") started to rise. As soon as they towered over the solar limb, the GOES soft x-ray flux started to rise with the onset of the associated flare at 21:50UTC. This eventually would become a long duration M3.9 flare, peaking at 23:02UTC and lasting no less than 2 hours and 29 minutes - as shown by the GOES and PROBA2/LYRA curves underneath.

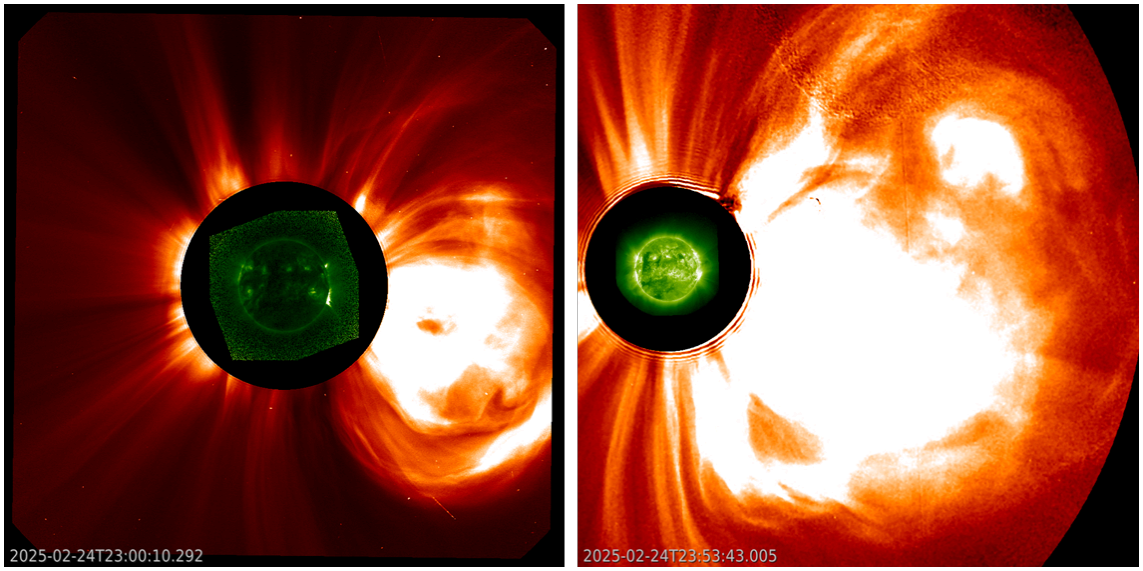


The imagery underneath shows the eruption in extreme ultraviolet, with on the left SDO/AIA 094 giving a multi-million degrees view of the eruption (as seen from Earth), and on the right STEREO-A/EUVI 195 showing the eruption at about 1.5 million degrees. The STEREO-A images give a better view on the filament eruption and the "arcade", whereas the significantly hotter SDO channel provides a good view on the supra-arcade downflows (SAD, discussed in this STCE newsitem at https://www.stce.be/news/630/welcome.html), which are the dark streaks flowing over and down towards the rising coronal loops. Note the 2-hours difference between the stills. Clips are in the online version of this newsitem at https://www.stce.be/news/753/welcome.html



The violent eruption was most likely the source of a minor proton event, which started on 25 February at 00:20UTC and reached a peak of 37 pfu at 02:40UTC. The higher energy proton fluxes (greater than 100 and 500 MeV) remained at their background levels, so except for the increased noise in the EUV images, the impact was all-in-all limited. The eruption was also associated with a solid and fast partial halo coronal mass ejection (CME), which was obviously not directed to Earth in view of the location of the source (behind the solar limb). The CME had a speed near 1100 km/s, reaching "O" ("occasional") on the SCORE-scale for CME speeds (Evans et al. 2013 - https://doi.org/10.1002/swe.20058). The stills underneath show the white light coronagraphic imagery from SOHO/LASCO (left) and STEREO-A/COR2 (right) overlaid on respectively EUV-imagery from GOES/SUVI 094 (wider field than SDO/AIA) and from

STEREO-A/EUVI 195. Note that in the stills, there's an hour difference between the two and they are not on the same size. In both cases though, no annotations are needed to indicate the associated CME... It really has a good chance to make it into the Top 10 of most spectacular CMEs of 2025!



2. Review of solar and geomagnetic activity

WEEK 1261 from 2025 Feb 24

Solar Active Regions and flares

The solar flaring activity over the past week started at high levels with an X2.0 flare, peak time 19:27 UTC on Feb 23, produced by SIDC Sunspot Group 410 (NOAA Active Region 4001) from behind the west limb. The solar flaring activity was at moderate levels on Feb 25th and decreased to low levels for the remaining of the week.
More than twenty active regions (ARs) were identified on the visible solar disc throughout the week. The largest and most complex regions were SIDC Sunspot Group 408 (NOAA Active Region 3998) and SIDC Sunspot Group 409 (NOAA Active Region 4000), both classified as beta-gamma-delta at the beginning of week and beta-gamma later on. Other notable regions growing later in the week were SIDC Sunspot Group 368 (NOAA Active Region 4006) and SIDC Sunspot Group 416 (NOAA Active Region 4007), as well as SIDC Sunspot Group 424, which emerged near the south-east limb towards the end of the week.

Coronal mass ejections

Multiple fast large-scale coronal mass ejections (CMEs) were detected in the LASCO/C2 coronagraph data throughout the week, all of them being back-sided. Several other CMEs were estimated to potentially have small Earth-directed components.
A fast partial-halo coronal mass ejection (CME) with a projected velocity close to 1900 km/s was first detected in the LASCO/C2 data at 19:48 UTC on Feb 23. The eruption was related to an X2.0 flare with peak time 19:27 UTC, produced by SIDC Sunspot Group 410 (NOAA Active Region 4001) from behind the west limb. The CME was estimated to be back-sided and was not expected to arrive at Earth.
Another wide westward CME was visible in LASCO/C2 data at 06:12 UTC on Feb 24, accompanied by activity at the west limb as well as an on-disc dimming, an associated M3.3 flare and related filament eruption in the north-west quadrant. Simulation analysis of the CME propagation (modelled with Eufhoria) suggested a possible low-impact shock arrival on Feb 27th.
A filament located between 15 and 30 degrees west from the central meridian erupted around 06:00 UTC on Feb 26. An associated narrow westward CME was detected in the LASCO/C2 coronagraph imagery

around 06:48 UTC. The CME was estimated to have a small Earth-directed component and a glancing blow from it was expected to arrive on Feb 28 mixed within an expected ongoing high speed stream.
Finally a long filament in the south-east quadrant erupted in the UTC afternoon on Mar 01. A possibly related south-east coronal mass ejection (CME) was visible in the LASCO/C2 coronagraph data around 18:12 UTC on Mar 01. The CME was estimated to have a projected velocity around 500 km/s. Analysis suggested a small glancing blow arrival on Mar 05.

Coronal Holes

Three positive-polarity coronal holes have crossed the central meridian throughout the week. The first crossing was observed on Feb 25th. A corotating interaction region (CIR) and following high speed stream related to the geo-effective coronal holes were observed in situ in the near-Earth solar wind data late on Feb 26th.

Proton flux levels

The greater than 10 MeV GOES proton flux registered slightly enhanced levels on Feb 24 possibly related to the fast coronal mass ejection first detected in the LASCO/C2 data at 06:12 UTC the same day.
The greater than 10 MeV GOES has exceeded the 10 pfu minor radiation storm threshold around 00:45 UTC on Feb 25th related to a long duration M3.9-flare, peaking at 23:06 UTC on Feb 24, and an associated halo coronal mass ejection.
The > 50 MeV proton flux showed only minor enhancements and the higher energy proton fluxes have remained at background level.
The proton flux decreased below the 10 pfu minor radiation storm threshold within the day. It returned to nominal levels by Feb 28 and remained there for the remaining of the week.

Electron fluxes at GEO

The greater than 2 MeV electron flux as measured by GOES 16 was below the 1000 pfu threshold throughout the entire week. The greater than 2 MeV electron flux as measured by GOES 18 briefly exceeded the 1000 pfu threshold on Mar 01. The corresponding electron fluence was at nominal levels throughout the entire week.

Solar wind

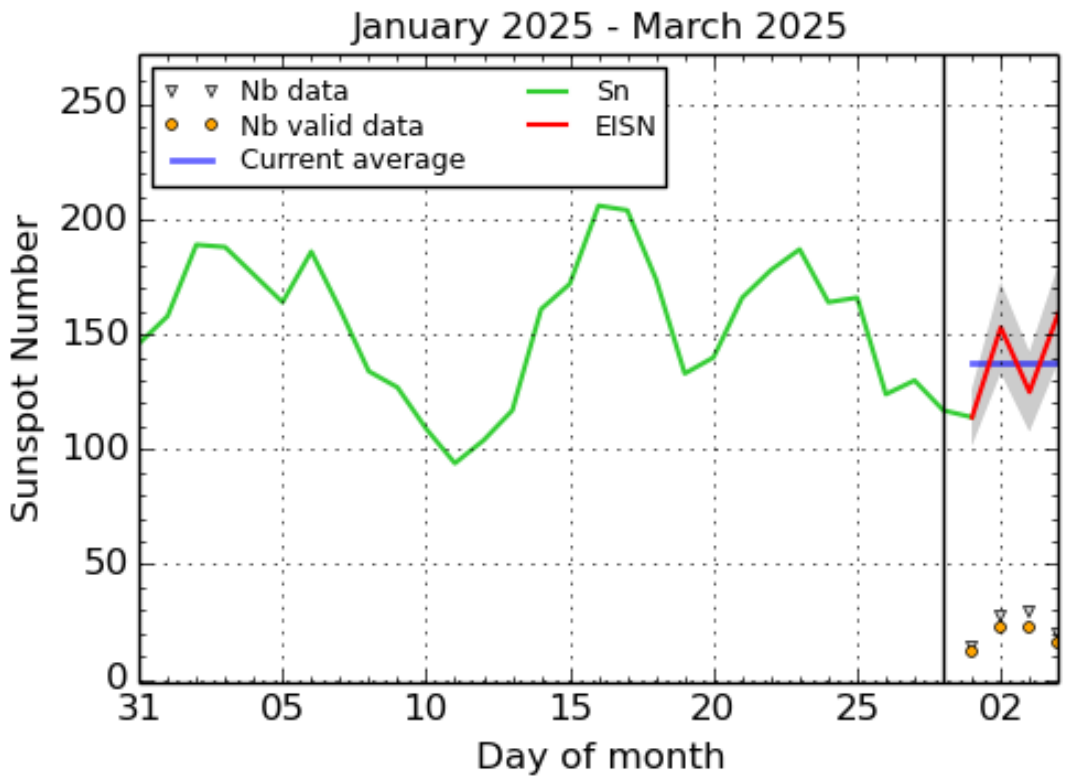
The solar wind conditions at the beginning of the week reflected slightly disturbed conditions possible related to a minor glancing blow ICME arrival and the crossing of a heliospheric current sheet. A reverse solar wind shock was observed in the solar wind around 12:45 UTC on Feb 26 possible related to an earlier arrival of a CIR and associated high speed stream or possibly due to a glancing blow from the Feb 24 CME.
A high speed stream related to the geo-effective positive polarity coronal holes was registered from Feb 26 throughout the rest of the week. The solar wind velocity throughout the week ranged from around 300 km/s to above 800 km/s. The interplanetary magnetic field (B) had a maximum of 20 nT and a minimum Bz of -13 nT. The magnetic field phi angle switched orientation from positive to negative at the beginning of the week and remained in the positive sector (directed away from the Sun) towards the end of the week, in agreement with the polarity of the geo-effective coronal hole, whose high speed stream was influencing the Earth.

Geomagnetism

The geomagnetic conditions started at quiet to unsettled levels on Feb 23. Isolated active levels were registered globally with two isolated minor storm periods over Belgium on Feb 24 related to a possible ICME arrival of the Feb 20 CME and the crossing of the heliospheric current sheet. Quiet to active conditions were registered on Feb 25 and Feb 26 and moderately geomagnetic storm levels with NOAA Kp reaching 5.67 were observed on Feb 27 related to an expected high speed steam arrival. Only minor geomagnetic storms were observed locally over Belgium continuing over Feb 28. Quiet to active

conditions were observed on Mar 01 and predominantly quiet conditions on Mar 02 with the waning influence of the ongoing high speed stream.

3. International Sunspot Number by SILSO



SILSO graphics (http://sidc.be/silso) Royal Observatory of Belgium, 2025 March 4

The daily Estimated International Sunspot Number (EISN, red curve with shaded error) derived by a simplified method from real-time data from the worldwide SILSO network. It extends the official Sunspot Number from the full processing of the preceding month (green line), a few days more than one solar rotation. The horizontal blue line shows the current monthly average. The yellow dots give the number of stations that provided valid data. Valid data are used to calculate the EISN. The triangle gives the number of stations providing data. When a triangle and a yellow dot coincide, it means that all the data is used to calculate the EISN of that day.

4. PROBA2 Observations

Solar Activity

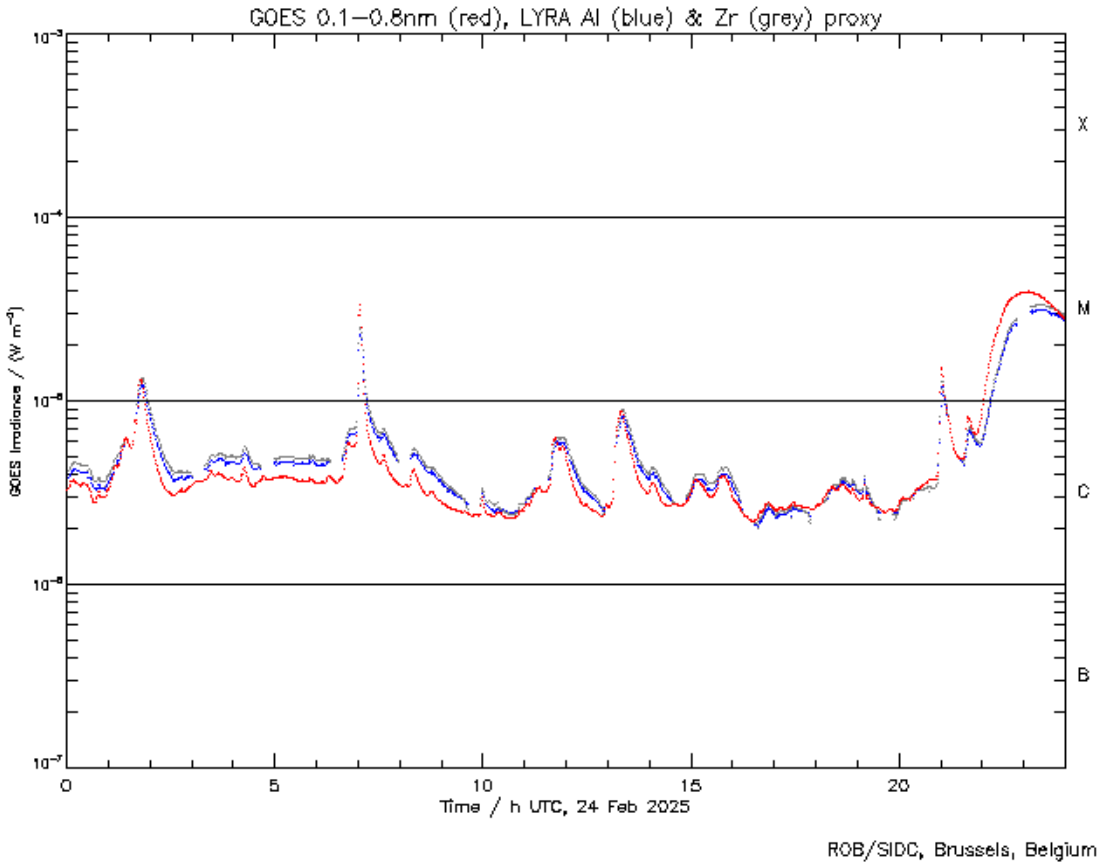
Solar flare activity fluctuated from low to moderate during the week.
In order to view the activity of this week in more detail, we suggest to go to the following website from which all the daily (normal and difference) movies can be accessed: https://proba2.oma.be/ssa
This page also lists the recorded flaring events.

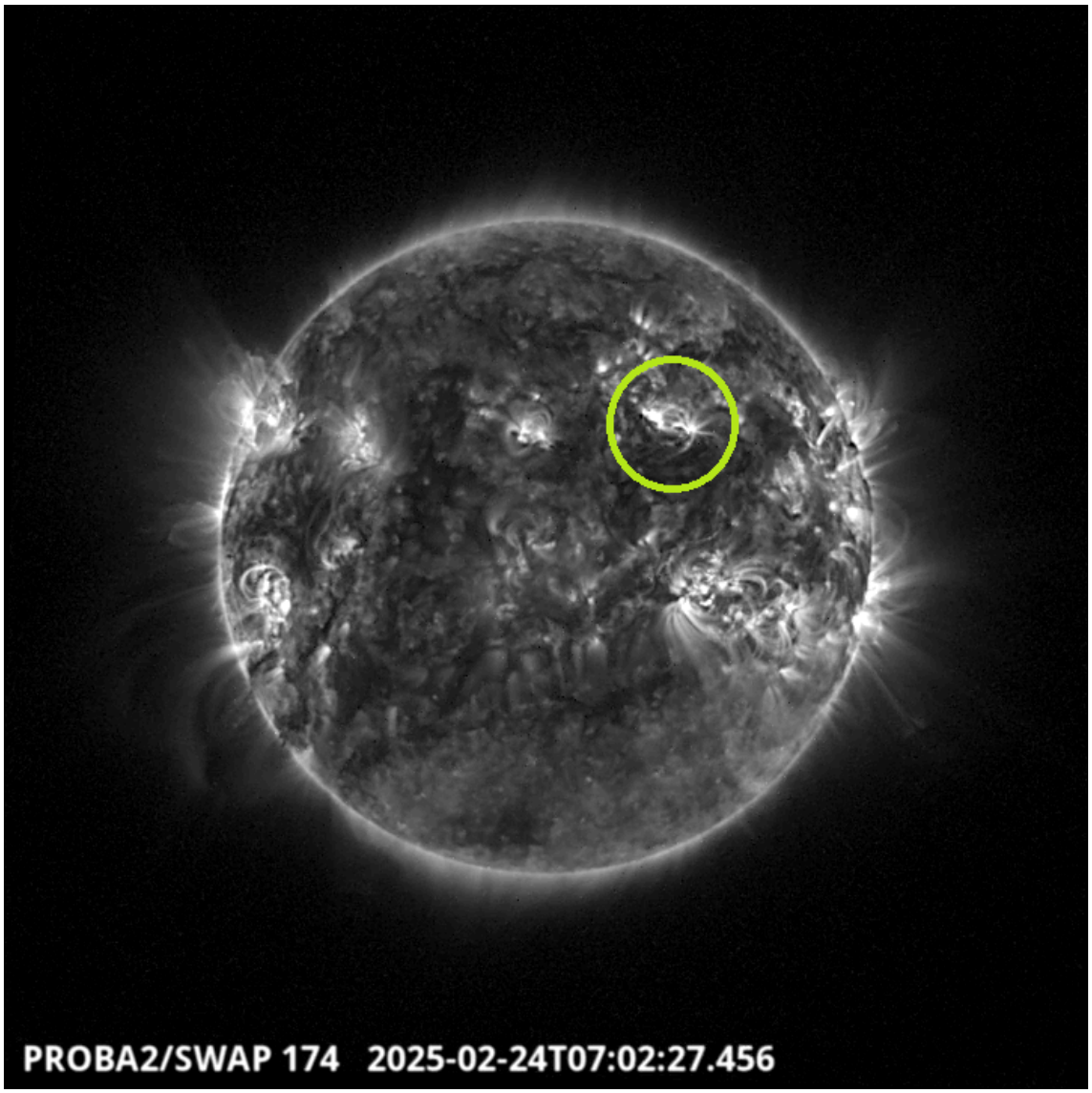
A weekly overview movie (SWAP week 779) can be found here: https://proba2.sidc.be/swap/data/mpg/movies/weekly_movies/weekly_movie_2025_02_24.mp4.

Details about some of this week's events can be found further below.

If any of the linked movies are unavailable they can be found in the P2SC movie repository here: https://proba2.oma.be/swap/data/mpg/movies/.

Monday February 24





The largest flare of this week was an M3.9 on 2025-Feb-24, but the largest one observed in its entirety by LYRA (top panel) and SWAP (bottom panel) was an M3.3. It occurred on the same day and peaked at 07:02 UT. It originated from active region NOAA4000 (see the green encircled region).
Find a SWAP movie of the event here: https://proba2.sidc.be/swap/movies/20250224_swap_movie.mp4.

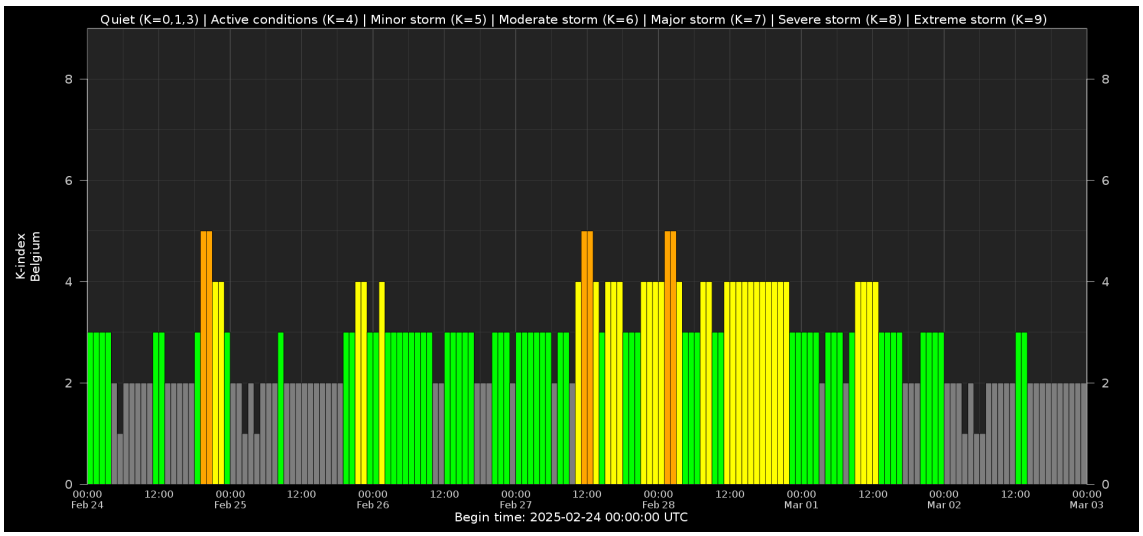
5. Noticeable Solar Events

DAY	BEGIN	MAX	END	LOC	XRAY	OP	10CM	TYPE	Cat	NOAA
24	0133	0146	0155		M1.3					4001
24	0653	0702	0708		M3.3			III/2II/2	51	4000
24	2051	2101	2109	N16W30	M1.5	1N		III/2	51	4000
24	2150	2302	0019		M3.9			II/2IV/2		
25	0243	0247	0254		M1.3				49	3998
25	1120	1159	1244	S13W51	M3.6	1F		IV/1II/2	49	3998

LOC: approximate heliographic location
XRAY: X-ray flare class
OP: optical flare class
10CM: peak 10 cm radio flux

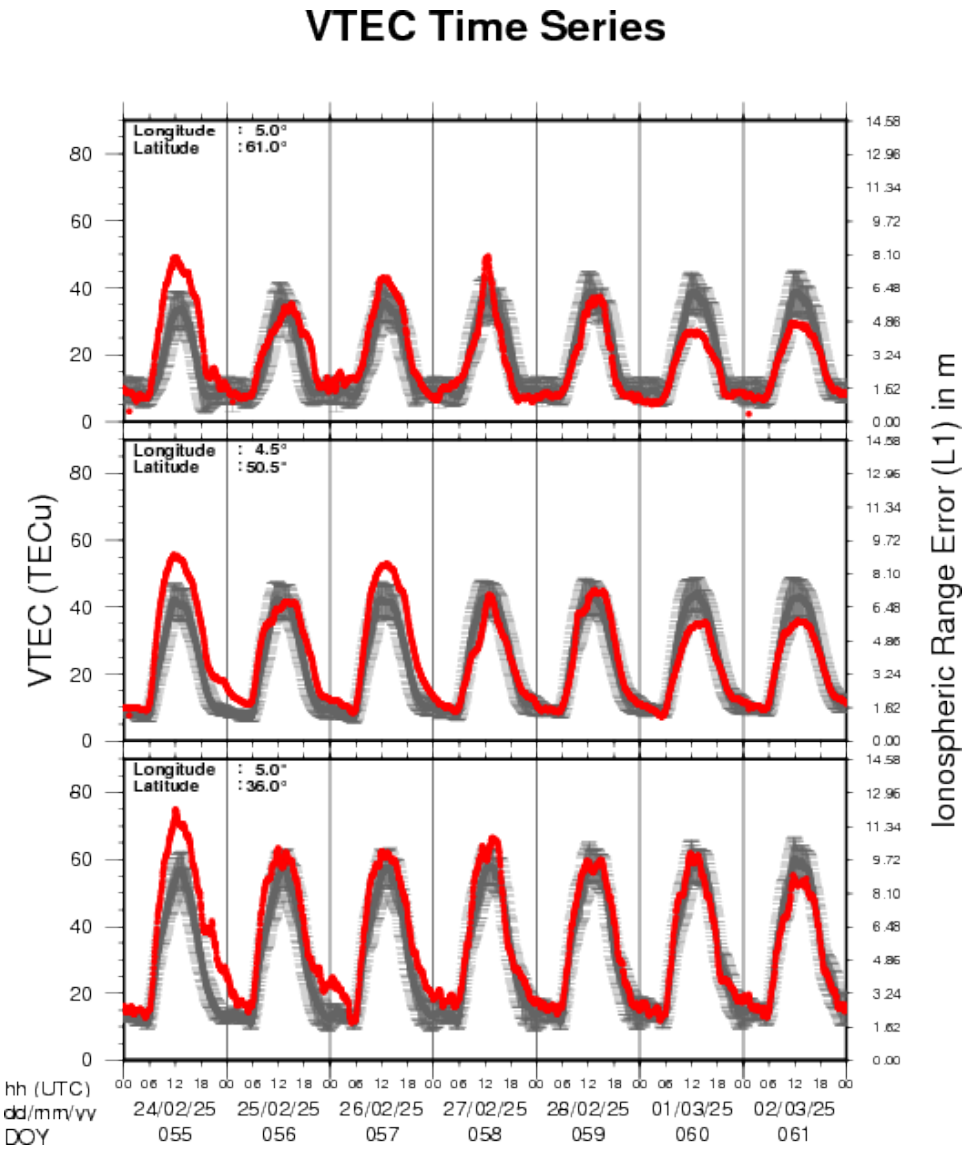
TYPE: radio burst type
Cat: Catania sunspot group number
NOAA: NOAA active region number

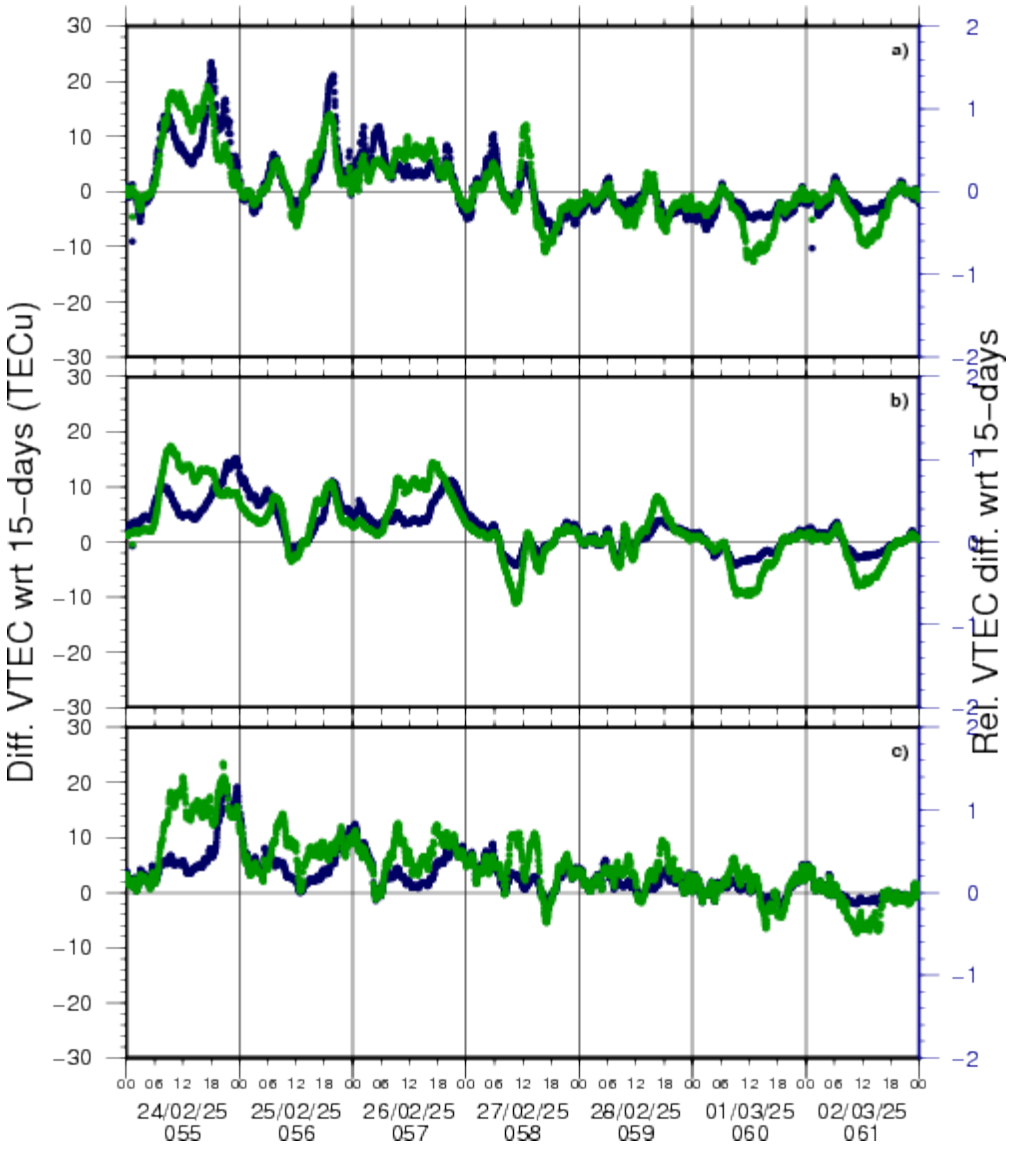
6. Geomagnetic Observations in Belgium



Local K-type magnetic activity index for Belgium based on data from Dourbes (DOU) and Manhay (MAB). Comparing the data from both measurement stations allows to reliably remove outliers from the magnetic data. At the same time the operational service availability is improved: whenever data from one observatory is not available, the single-station index obtained from the other can be used as a fallback system.
Both the two-station index and the single station indices are available here: http://ionosphere.meteo.be/geomagnetism/K_BEL/

7. Review of Ionospheric Activity





VTEC time series at 3 locations in Europe from 24 Feb 2025 till 2 Mar 2025

The top figure shows the time evolution of the Vertical Total Electron Content (VTEC) (in red) during the last week at three locations:
a) in the northern part of Europe(N 61deg E 5deg)
b) above Brussels(N 50.5deg, E 4.5 deg)
c) in the southern part of Europe(N 36 deg, E 5deg)
This top figure also shows (in grey) the normal ionospheric behaviour expected based on the median VTEC from the 15 previous days.

The time series below shows the VTEC difference (in green) and relative difference (in blue) with respect to the median of the last 15 days in the North, Mid (above Brussels) and South of Europe. It thus illustrates the VTEC deviation from normal quiet behaviour.

The VTEC is expressed in TECu (with TECu=10^16 electrons per square meter) and is directly related to the signal propagation delay due to the ionosphere (in figure: delay on GPS L1 frequency).

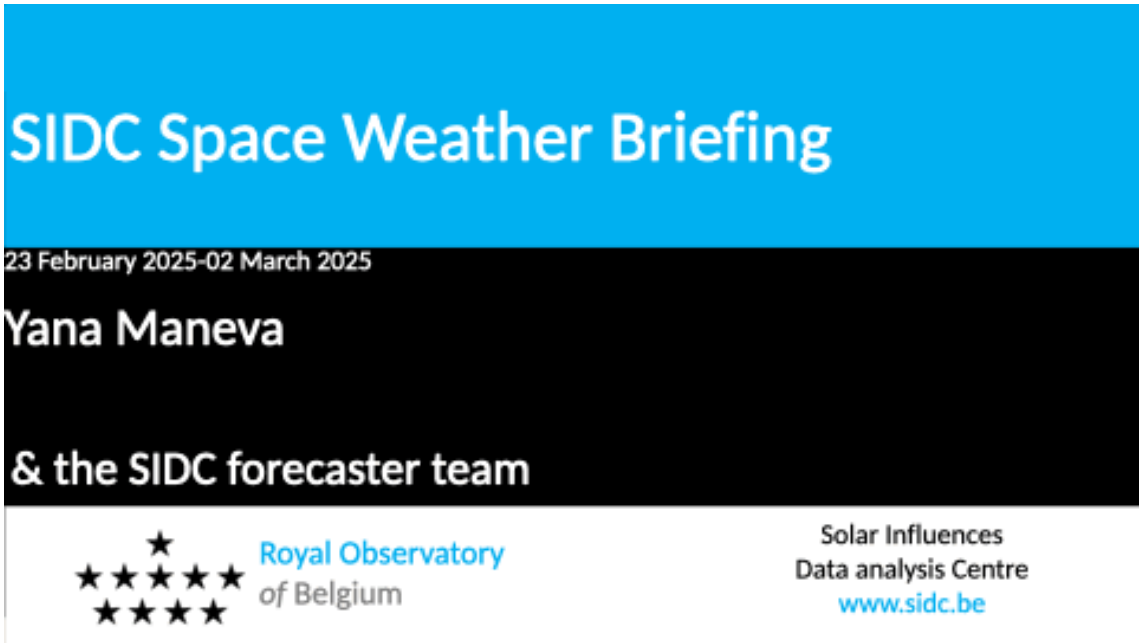
The Sun's radiation ionizes the Earth's upper atmosphere, the ionosphere, located from about 60km to 1000km above the Earth's surface.The ionization process in the ionosphere produces ions and free electrons. These electrons perturb the propagation of the GNSS (Global Navigation Satellite System) signals by inducing a so-called ionospheric delay.

See http://stce.be/newsletter/GNSS_final.pdf for some more explanations; for more information, see https://gnss.be/SpaceWeather

8. The SIDC Space Weather Briefing

The forecaster on duty presented the SIDC briefing that gives an overview of space weather from February 24 to March 2.

The pdf of the presentation can be found here: https://www.stce.be/briefings/20250303_SWbriefing.pdf



9. Upcoming Activities

Courses, seminars and presentations with the Sun-Space-Earth system and Space Weather as the main theme. We provide occasions to get submerged in our world through educational, informative and instructive activities.
* Mar 17-18, 2025, Inleiding tot het ruimteweer, enkel voor leden van volkssterrenwachten, Brussels, Belgium - register: https://events.spacepole.be/event/213/ - 1 stoel vrij
* Mar 24, 2025, STCE Lecture From Physics to Forecasting, ESA Academy's Space Weather Training Course
* April 28-30, 2025, STCE Space Weather Introductory Course, Brussels, Belgium - register: https://events.spacepole.be/event/214/
* May 26-27, 2025, STCE Course Space Weather impacts on aviation, online - register: https://events.spacepole.be/event/215/
* Jun 23-25, 2025, STCE Space Weather Introductory Course, Brussels, Belgium - register: https://events.spacepole.be/event/216/

* Sep 15-16, 2025, STCE Course Space Weather impacts on aviation, online - register: https://events.spacepole.be/event/218/
* Nov 17-19, 2025, STCE Space Weather Introductory Course, Brussels, Belgium - register: https://events.spacepole.be/event/217/

To register for a course and check the seminar details, navigate to the STCE Space Weather Education Center: https://www.stce.be/SWEC
If you want your event in the STCE newsletter, contact us: stce_coordination at stce.be

Website: https://www.stce.be/SWEC