

STCE Newsletter

24 Mar 2025 - 30 Mar 2025



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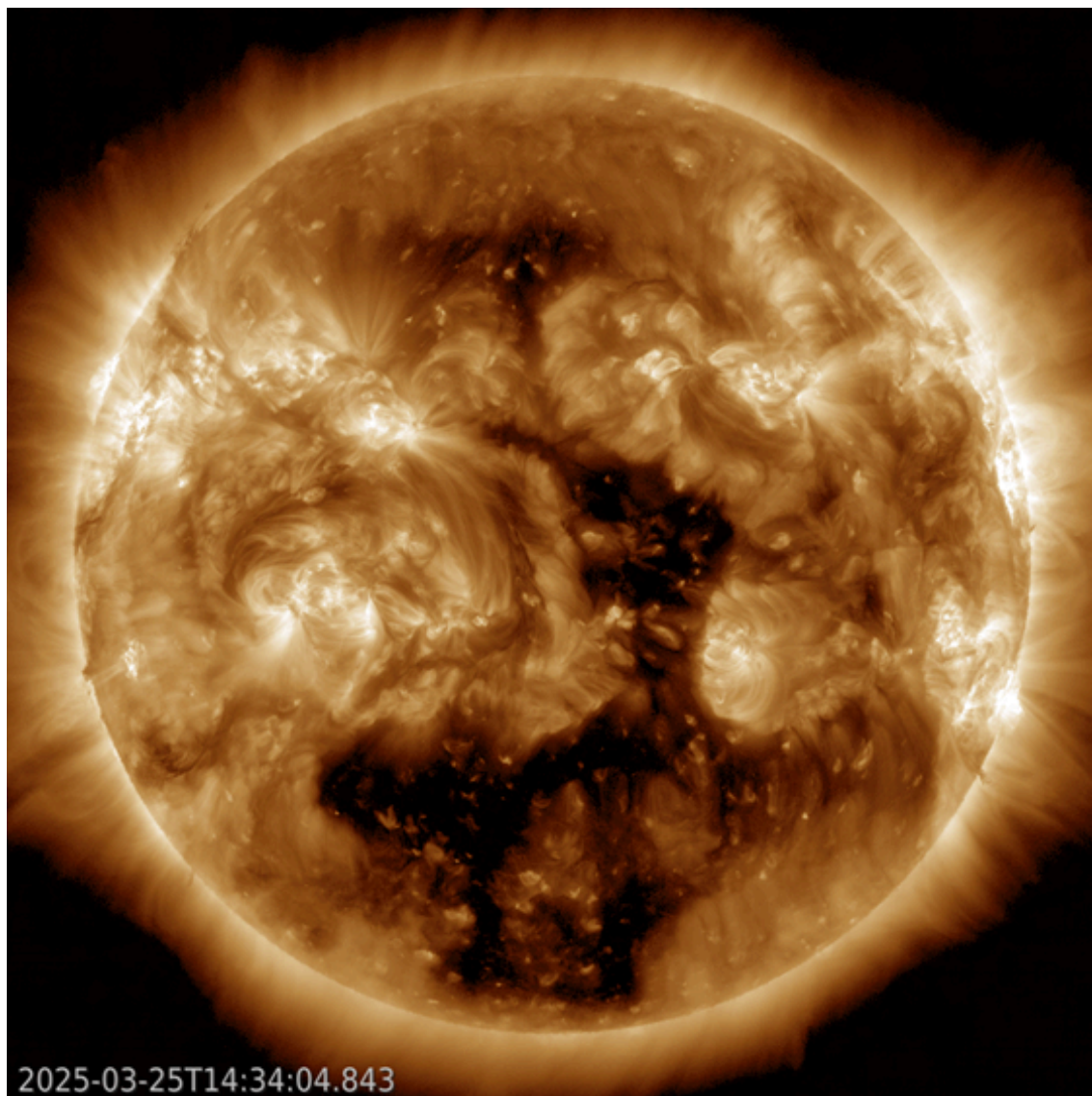
The Solar-Terrestrial Centre of Excellence (STCE) is a collaborative network of the Belgian Institute for Space Aeronomy, the Royal Observatory of Belgium and the Royal Meteorological Institute of Belgium.

Content	Page
1. Large coronal hole	2
2. Proba-3's first autonomous formation flight	4
3. The next generation of space weather experts visiting	5
4. The STCE in 2023	6
5. Review of solar and geomagnetic activity	7
6. International Sunspot Number by SILSO	9
7. PROBA2 Observations	9
8. Noticeable Solar Events	12
9. Geomagnetic Observations in Belgium	13
10. Review of Ionospheric Activity	14
11. The SIDC Space Weather Briefing	16
12. Upcoming Activities	16

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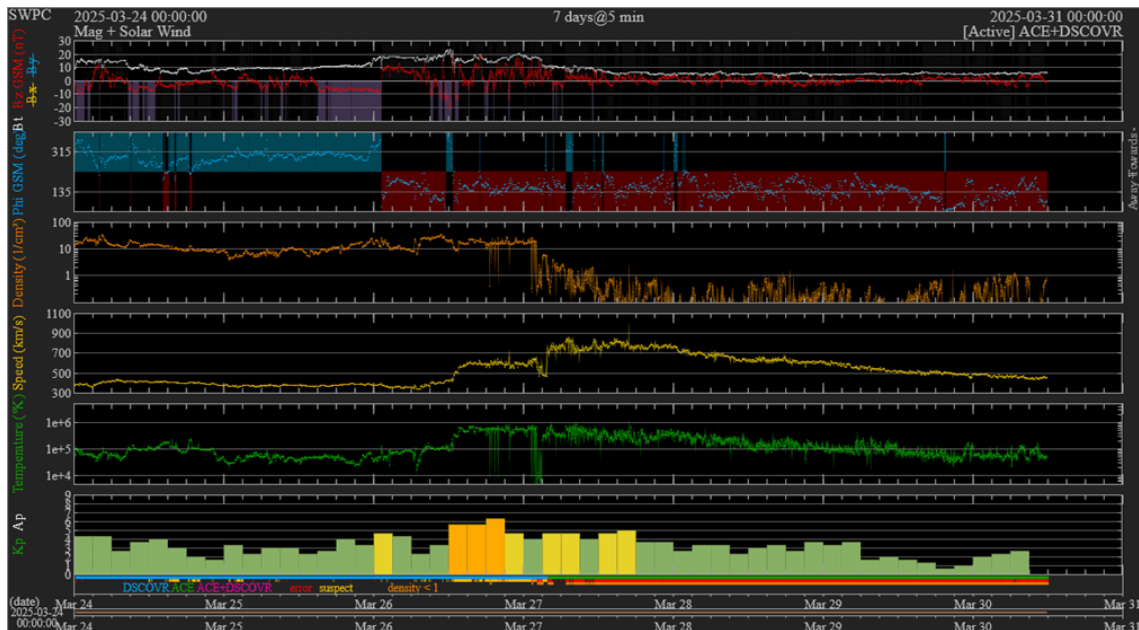
1. Large coronal hole

Coronal holes are regions in the hot solar atmosphere ("corona") where the plasma density at that temperature is very low compared to its surroundings, and thus they look like dark shapes in the corona. Linked to unipolar, open magnetic fields stretching into space, they are the source of the high-speed solar wind which can create geomagnetic disturbances. A large CH, emanating from the southern solar pole and reaching out all the way to the solar equator, started transiting the Sun's central meridian on 23 March. The CH had a positive magnetic polarity, i.e. the magnetic fields were pointing away from the Sun. The impressive size of the CH can be gauged from the SDO/AIA image underneath, showing the Sun in extreme ultraviolet (EUV) at temperatures of more than 1 million degrees. The coronal hole is the irregular, dark shape in the lower portion of the solar image.

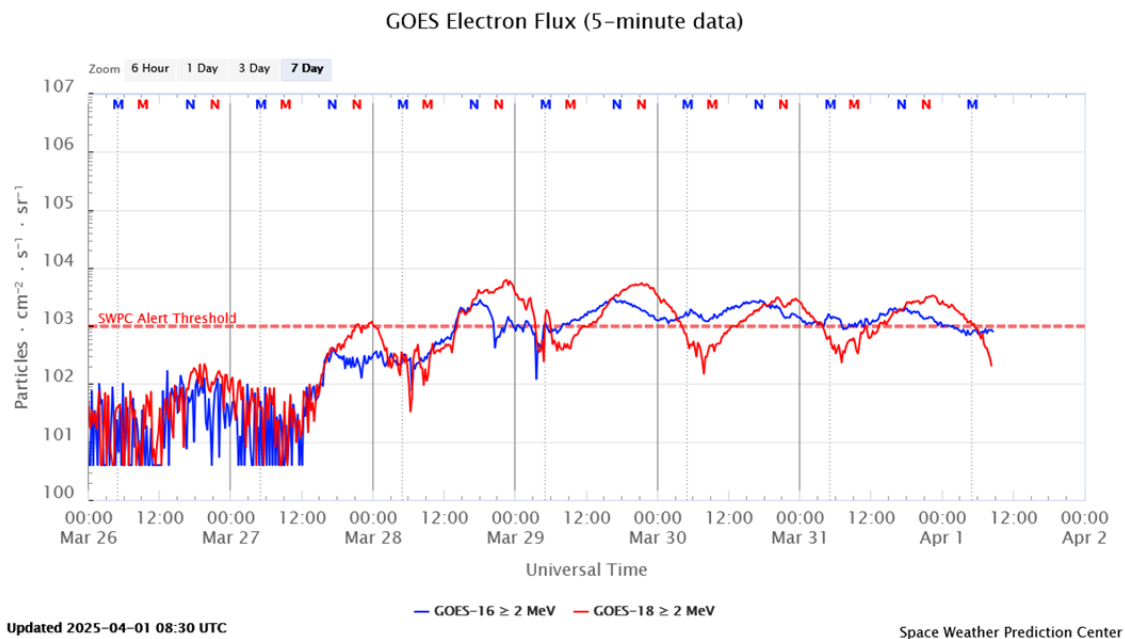


The associated high speed stream (HSS), preceded by a compression region (CIR - see the STCE newsitem at <https://www.stce.be/news/269/welcome.html>), started to influence the earth environment from 26 March onwards. Moderate geomagnetic storming was observed during the second half of 26 March. The solar wind speed gradually increased from about 350 km/s to values around 830 km/s (yellow

curve in the DSCOVR graph of solar wind data underneath). Such a high velocity -from a CH- has not been since the declining phase of the previous solar cycle.



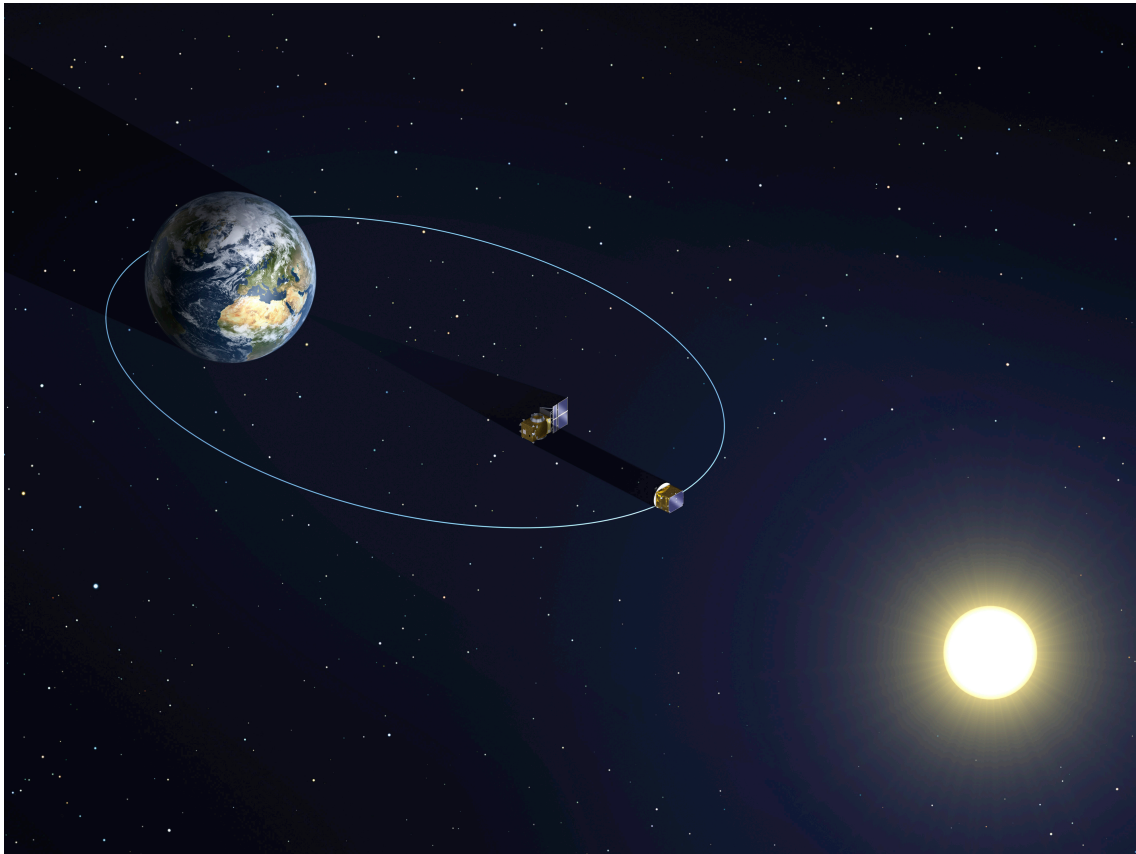
The wind speed stayed above the critical threshold of about 500 km/s from 26 March to late on 29 March. This drove the greater than 2 MeV electron flux over the 1000 pfu alert threshold from 28 March onwards (GOES graph underneath; "M" = local midnight, "N" = local noon). Satellite operators keep an eye on the number of these particles, because these energetic electrons can penetrate into spacecraft components and result in a build-up of charge within the material. When the accumulated charge becomes sufficiently high, an electrostatic discharge (ESD) or arcing can occur. This discharge can cause anomalous behaviour in spacecraft systems and can result in temporary or permanent loss of functionality. A notable example of satellite damage due to ESD is the consecutive outage of Telesat Canada's Anik-E1 and Anik-E2 geostationary communication satellites on 20 January 1994 that interrupted telecommunication and data transmission services across Canada (Lam, 2017 - <https://doi.org/10.1002/2016SW001492>). A view on the evolution of these highly energetic electrons during this solar cycle is at the STCE's SC25 Tracking page at <https://www.stce.be/content/sc25-tracking#electron>



2. Proba-3's first autonomous formation flight

Two spacecraft flying as one: that is the goal of European Space Agency's Proba-3 mission. Earlier this week, the eclipse-maker moved a step closer to achieving that goal, as both spacecraft aligned with the Sun, maintaining their relative position for several hours without any control from the ground.

More info: https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Proba-3/Proba-3_s_first_autonomous_formation_flight



3. The next generation of space weather experts visiting

On March 26, 30 students that were selected for the 2025 edition of ESA's Space Weather Training Course visited the STCE. Together, we explored ground-based solar and radio observations, various solar space instruments and different space weather services. This is how we lay the foundations for the next generation of space weather researchers and operators.



4. The STCE in 2023

The STCE Annual Report 2023 is now available at <https://www.stce.be/annualReport>

It is a compilation of the activities done in 2023 within the frame of the Solar-Terrestrial Centre of Excellence (STCE). This report continues the style from the previous editions. Hence, as it is targeting a more general public, it presents only a selection of the 2023-activities in easy-to-digest summaries.

These bite-sized articles emphasize the intense collaboration between the institutes at the Space Pole, as well as with our external partners. Aside the usual topics such as the space weather highlights, public outreach, and listings with conference talks and science papers, it covers also contributions on e.g. the Open Doors at the Huma radioastronomy station, the effects of Solar Energetic Particle (SEP) events on the radiation belts, auroral research from Skibotn (Sweden), the Earth radiation balance dataset (2018 to 2023), deep dielectric spacecraft charging, the classification of sunspot groups,... and much more.

We wish you an enjoyable reading experience!



5. Review of solar and geomagnetic activity

WEEK 1265 from 2025 Mar 24

Solar Active Regions and flares

Over the past week, the solar flaring activity was low at the beginning and increased to moderate to high levels later. There were 14 numbered active regions (ARs) on the visible solar disk throughout the week which produced 13 M-class flares and 1 X-class flare. The largest flare was an X1.1 flare (SIDC Flare 3932) peaking at 15:21 UTC on March 28, which was produced by SIDC Sunspot Group 459 (NOAA Active Region 4046). SIDC Sunspot Groups 455, 459, and 461 (NOAA Active Regions 4043, 4046, and 4048) were the regions which produced several C-class and M-class flares at the end of week.

Coronal mass ejections

A partial halo coronal mass ejection (CME) was observed in the SOHO/LASCO-C2 images around 15:24 on Mar 28. This CME was associated with an X1.1 flare (peak: 15:21 UTC, N06 E83, SIDC Flare 3932)

produced by SIDC Sunspot Group 459 (NOAA Active Region 4046) and a nearby possible filament eruption. It had a speed of about 1150 km/s. Associated type IV radio emission was detected starting from 15:14 UTC on Mar 28. A glancing blow was expected at Earth around 00:00 UTC on Mar 31 and it possibly arrived at 10:16 UTC on March 31.

Coronal Holes

During the last week, three positive polarity coronal holes (SIDC Coronal Holes 60, 82, and 96) crossed the central meridian. These coronal holes were the extension of southern polar coronal hole extending all across the solar equator. A CIR and following high speed streams related to these coronal holes enhanced the solar wind parameters near Earth during Mar 26-30.

Proton flux levels

The greater than 10 MeV GOES proton flux remained below the 10 pfu threshold level over the past week. It started to increase at 02:00 UTC on Mar 30 which was possibly associated with flaring activity from SIDC Sunspot Group 461 (NOAA Active Region 4048), but it still remained below the threshold level.

Electron fluxes at GEO

The greater than 2 MeV electron flux, as measured by the GOES-18 satellite, was above the threshold level for few hours on Mar 23 and during 27-30. The greater than 2 MeV electron flux measured by the GOES-16 satellite remained below the 1000 pfu threshold level until 14:00 UTC on Mar 28. Later it remained above the threshold level almost continuously until the end of the week.

The 24h electron fluence was at normal level till Mar 28 and it was at moderate level during Mar 28-30.

Solar wind

At the beginning of the past week, the solar wind parameters were disturbed under the influence of an interplanetary coronal mass ejection (ICME) associated to a CME that departed the Sun on Mar 21. The solar wind speed was as high as 450 km/s and the interplanetary magnetic field (IMF) reaching 17 nT and North-South component (Bz) down to -9 nT.

The solar wind parameters were slightly enhanced during the midnight of Mar 25-26 which was possibly associated to the arrival of a weak ICME.

A CIR and following high speed streams (HSSs), related to the three positive-polarity coronal holes (SIDC Coronal Holes 60, 82, and 96) that crossed the central meridian during Mar 22-28, enhanced the solar wind parameters near Earth during Mar 26-30. Following the arrival of HSSs, the solar wind speed was as high as 870 km/s with the IMF reaching 29 nT and Bz down to -28 nT.

At the end of the week, solar wind parameters transitioned from fast to slow solar wind regime.

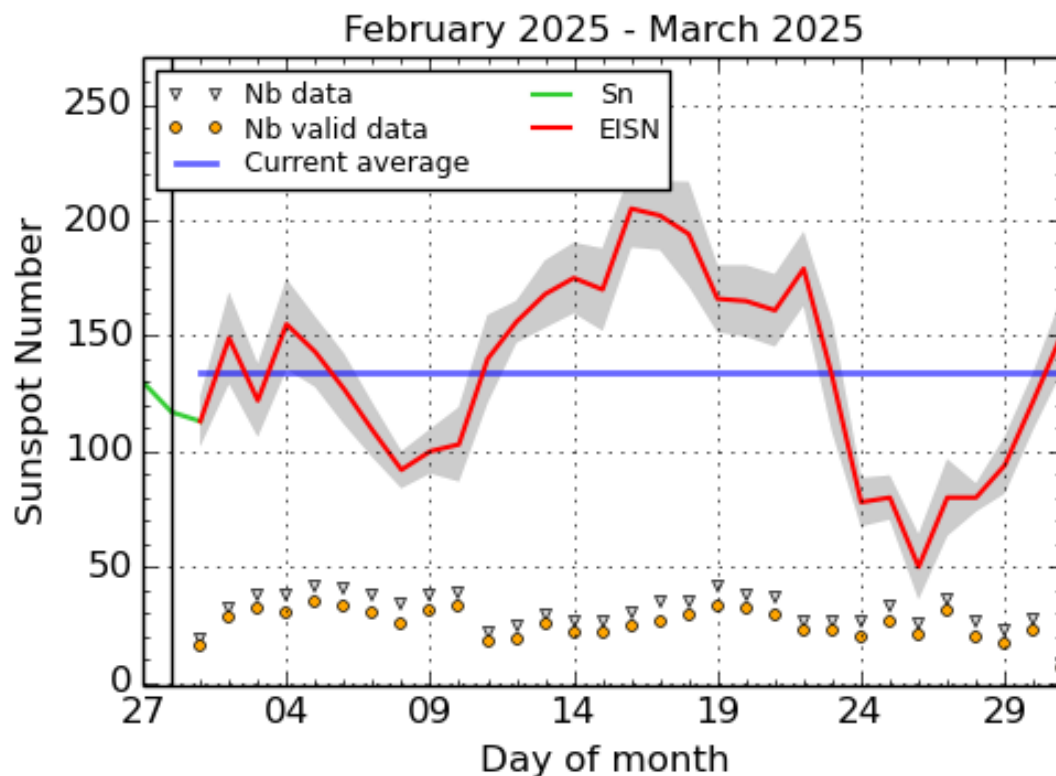
Geomagnetism

At the start of the past week, geomagnetic conditions reached active conditions (NOAA Kp and K_{BEL} 1 to 4) both globally and locally, due to the impact of an interplanetary coronal mass ejection (ICME) associated to a CME that departed the Sun on Mar 21.

During the midnight of Mar 25-26, geomagnetic conditions reached minor storm levels (NOAA Kp=5) globally and active conditions (K_{BEL}=4) locally, possibly due to the arrival of a weak ICME.

The geomagnetic conditions were further disturbed during Mar 26-29 due to a CIR followed by high speed streams (HSSs), which were related to the three positive-polarity coronal holes (SIDC Coronal Holes 60, 82, and 96) that crossed the central meridian during Mar 22-28. With the arrival of HSSs, geomagnetic conditions reached moderate storm levels (NOAA Kp=6) globally and minor storm levels (K_{BEL}=5) locally on Mar 26, and it returned to quiet levels on Mar 29.

6. International Sunspot Number by SILSO



SILSO graphics (<http://sidc.be/silso>) Royal Observatory of Belgium, 2025 March 31

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.

7. PROBA2 Observations

Solar Activity

Solar flare activity fluctuated from low to high during the week.

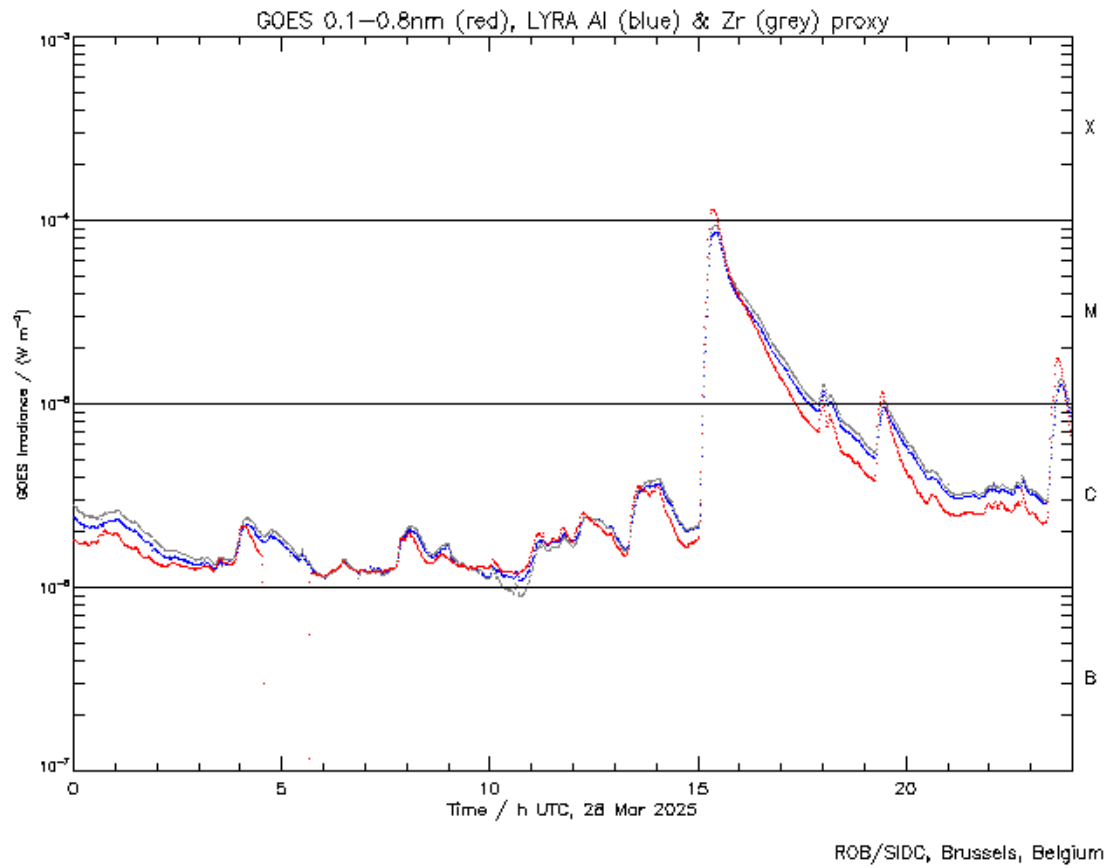
In order to view the activity of this week in more detail, we suggest to go to the following website from which all the daily (normal and difference) movies can be accessed: <https://proba2.oma.be/ssa>
This page also lists the recorded flaring events.

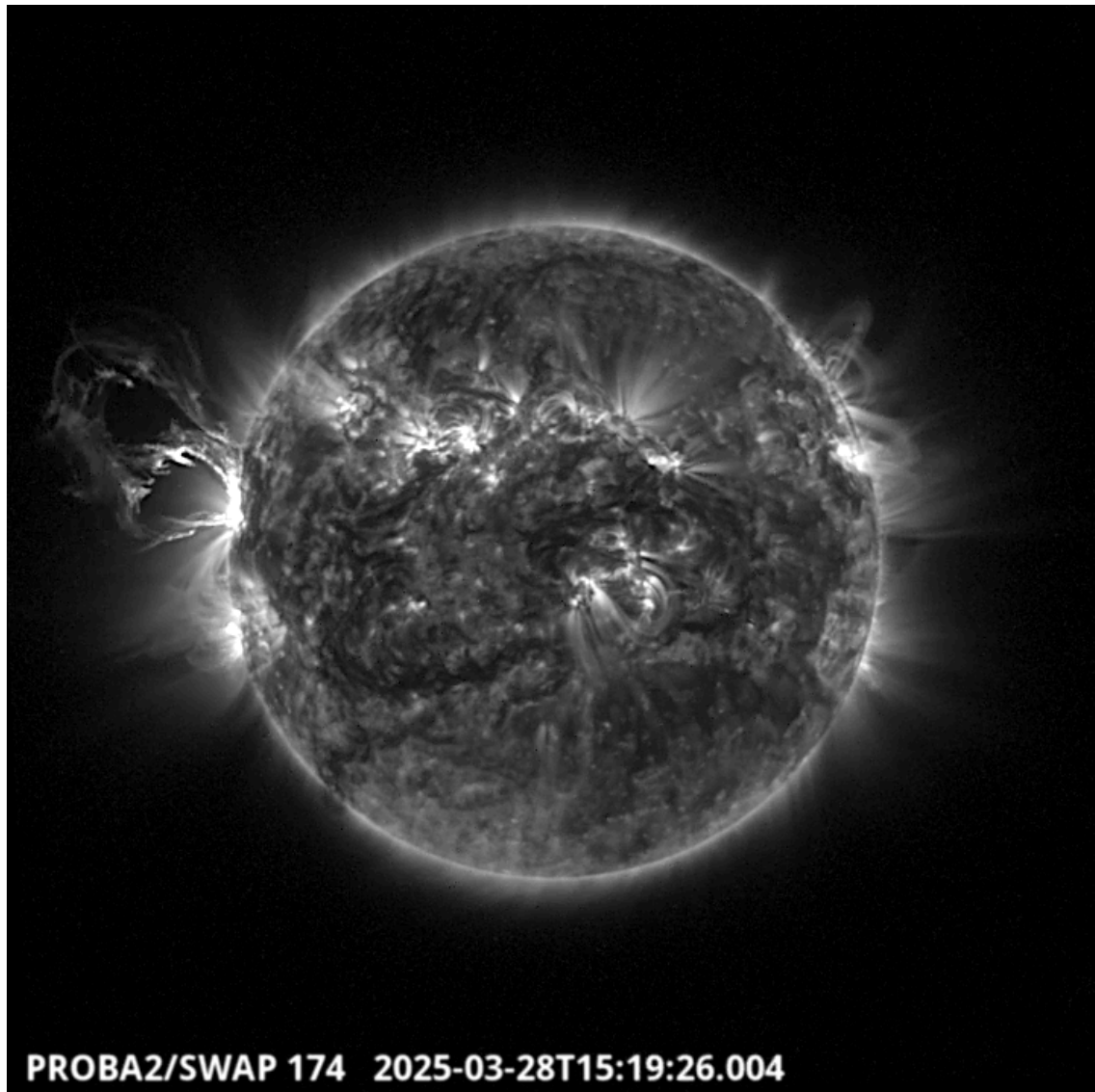
A weekly overview movie (SWAP week 783) can be found here: https://proba2.sidc.be/swap/data/mpg/movies/weekly_movies/weekly_movie_2025_03_24.mp4.

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/>.

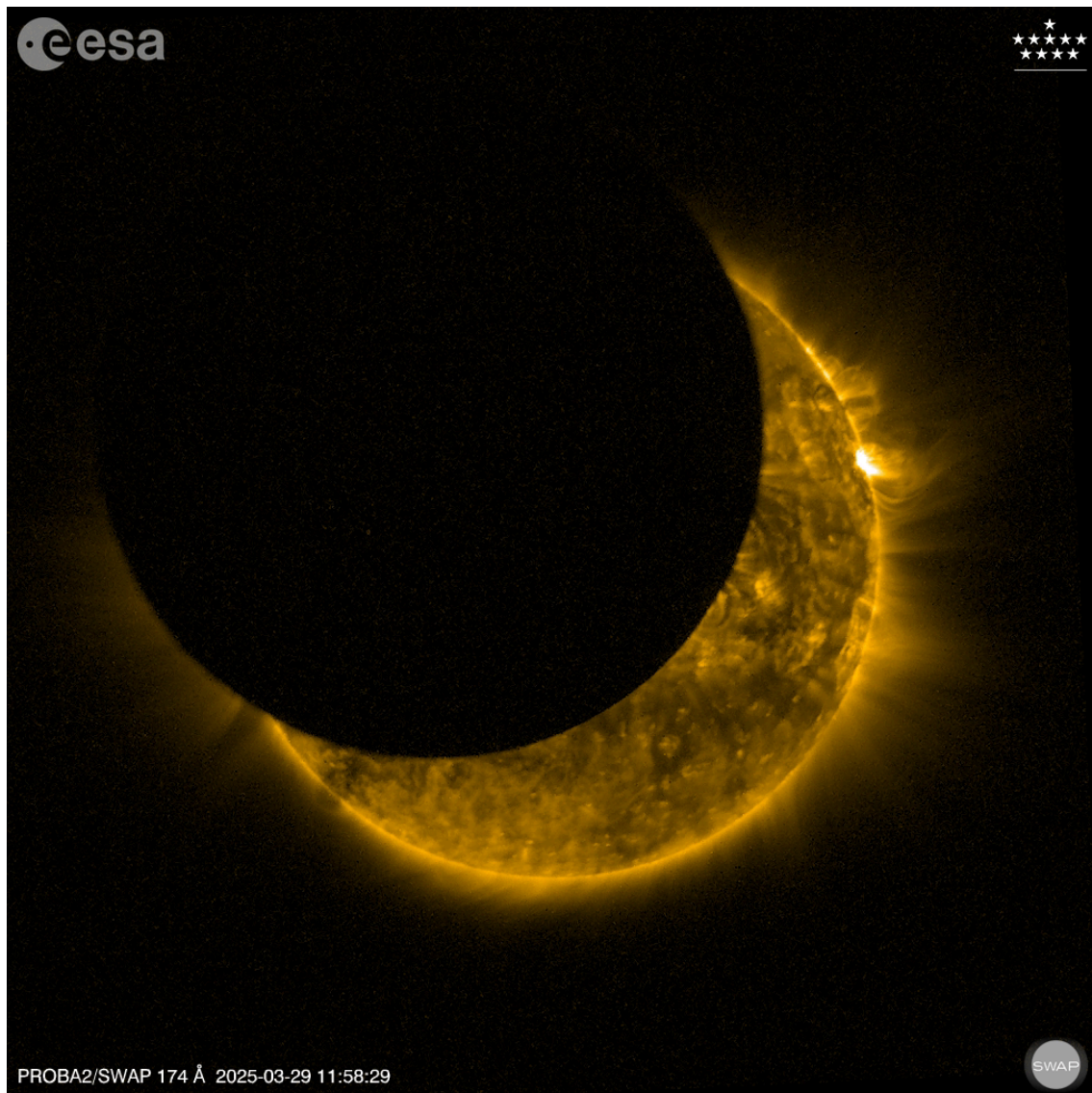
Friday March 28





The largest flare of this week was an X1.1, and it was observed by LYRA (top panel) and SWAP (bottom panel). The flare peaked on 2025-Mar-28 at 15:21 UT and it was associated with a large prominence eruption. It occurred at the eastern limb of the Sun, originating from active region NOAA4046. Find a SWAP movie of the event here: https://proba2.sidc.be/swap/movies/20250328_swap_movie.mp4.

Saturday March 29



On March 29 a partial solar eclipse was primarily visible in North America, and parts of Asia, Africa and Europe. Given the satellite's orbit, PROBA2 passed twice through the shadow of the Moon, and the first pass had an almost 100% coverage. Sadly, due to a minor under-voltage issue, SWAP and LYRA turned off at the time of the greatest eclipse and the scientific data were lost. SWAP automatically turned back on following the commands issued for the second passage of the Moon, and observed a 70% eclipsed Sun. Here you can enjoy a movie of the SWAP observations taken during this pass: https://proba2.sidc.be/Events/2025-Mar-29-SolarEclipse/movies/swap_eclipse_2025_03_29_logos_lossless.mp4. Unfortunately, the LYRA instrument was unavailable for several hours, resulting in a lack of data for this event.

8. Noticeable Solar Events

DAY	BEGIN	MAX	END	LOC	XRAY	OP	10CM	TYPE	Cat	NOAA
26	0744	0809	0821		M1.0					4043
27	0018	0037	0051		M2.0					4043

28	1503	1521	1542		X1.1		IV/2	4046
28	1754	1801	1805	N2E76	M1.0	S		4046
28	1914	1926	1938		M1.1			
28	2320	2339	2353		M1.7			4048
29	2119	2138	2209		M1.4		10	4043
29	2238	2300	2321		M1.9			4048
30	0119	0148	0201		M1.5			4048
30	1627	1642	1700		M1.6			4048
30	1700	1707	1714		M1.4			4048
30	2243	2250	2256		M1.4			4048
30	2310	2319	2331		M1.5		III/2VI/2	4048
30	2341	2348	2352		M1.0			4048

LOC: approximate heliographic location

XRAY: X-ray flare class

OP: optical flare class

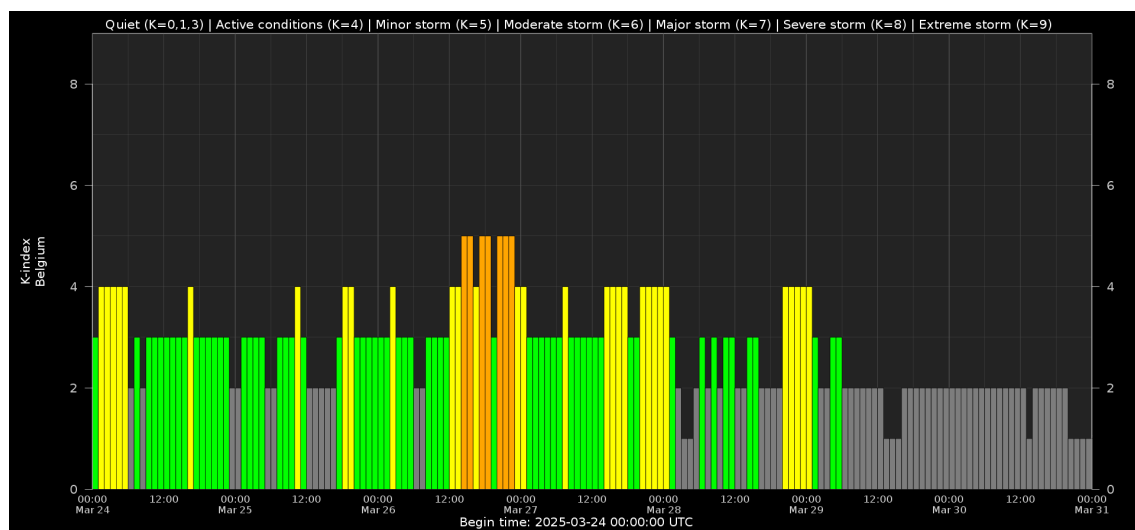
10CM: peak 10 cm radio flux

TYPE: radio burst type

Cat: Catania sunspot group number

NOAA: NOAA active region number

9. Geomagnetic Observations in Belgium

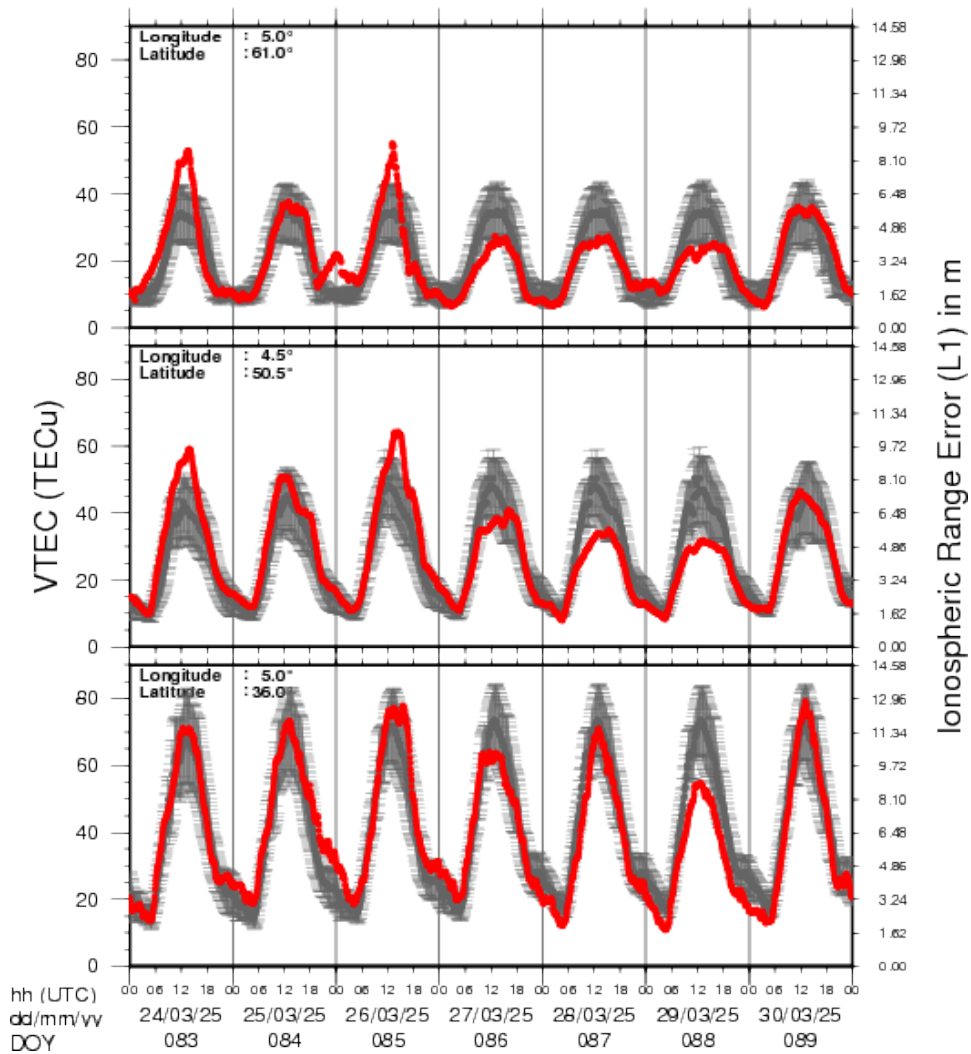


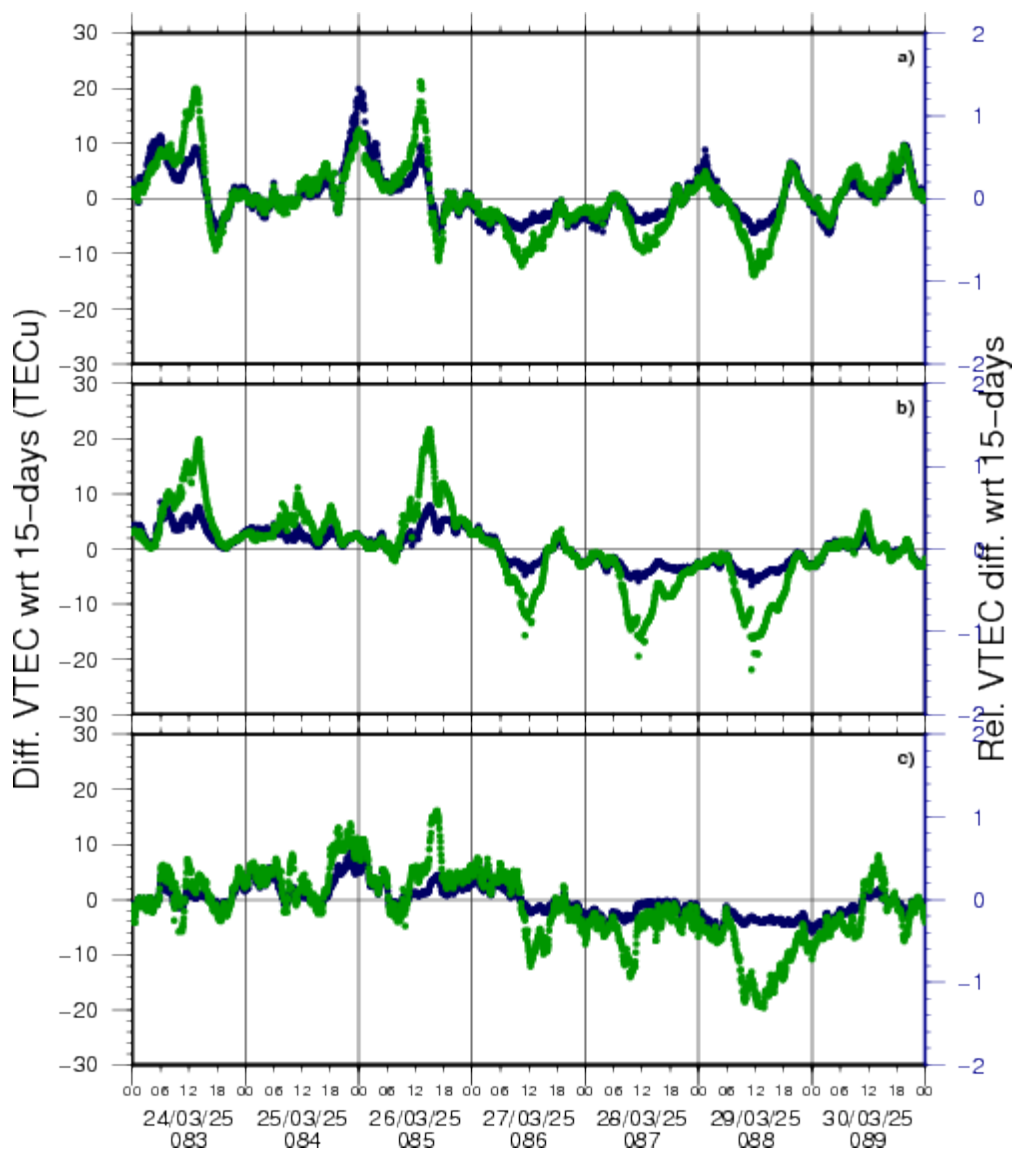
Local K-type magnetic activity index for Belgium based on data from Dourbes (DOU) and Manhay (MAB). Comparing the data from both measurement stations allows to reliably remove outliers from the magnetic data. At the same time the operational service availability is improved: whenever data from one observatory 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/

10. Review of Ionospheric Activity

VTEC Time Series





VTEC time series at 3 locations in Europe from 24 Mar 2025 till 30 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 $\text{TECu} = 10^{16}$ electrons per square meter) and is directly related to the signal propagation delay due to the ionosphere (in figure: delay on GPS L1 frequency).

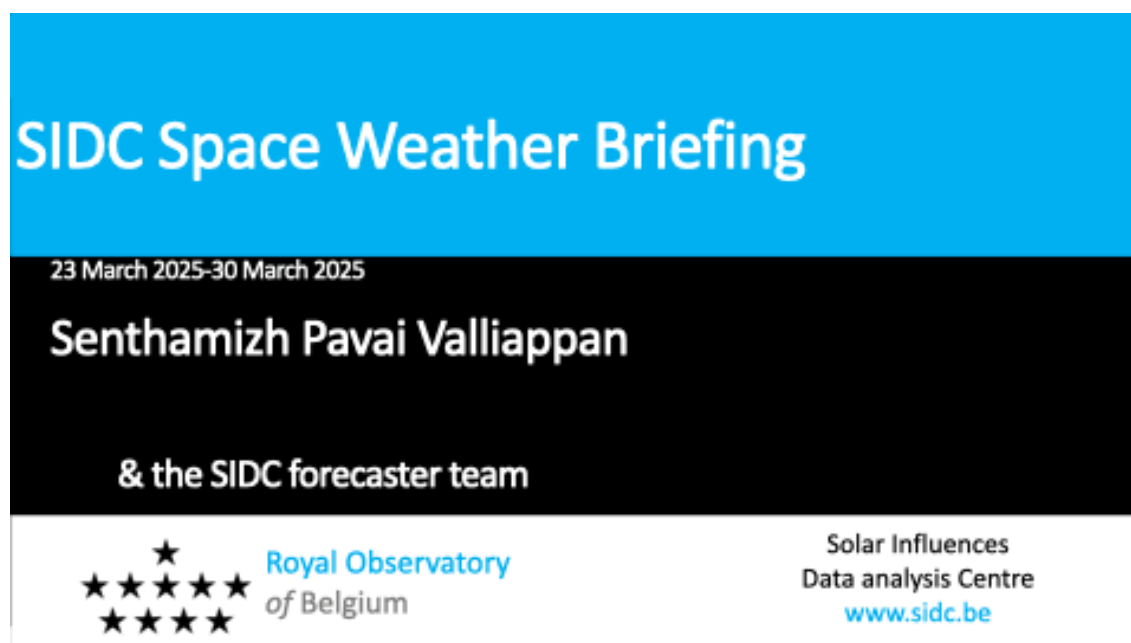
The Sun's radiation ionizes the Earth's upper atmosphere, the ionosphere, located from about 60km to 1000km above the Earth's surface. The ionization process in the ionosphere produces ions and free electrons. These electrons perturb the propagation of the GNSS (Global Navigation Satellite System) signals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

11. The SIDC Space Weather Briefing

The forecaster on duty presented the SIDC briefing that gives an overview of space weather from March 23 to 30.

The pdf of the presentation can be found here: https://www.stce.be/briefings/20250331_SWbriefing.pdf



12. Upcoming Activities

Courses, seminars, presentations and events 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.

- * 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](mailto:stce_coordination@stce.be) at [stce.be](mailto:stce_coordination@stce.be)



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