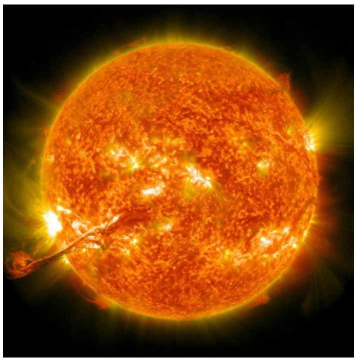
KA-Increasing Solar Activity

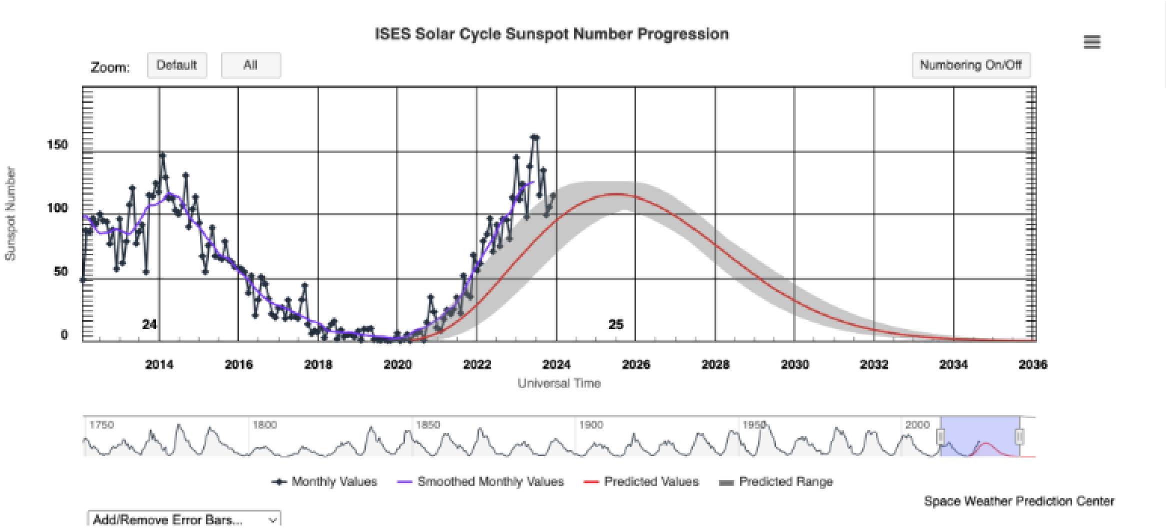


Scientists predict that the Sun is approaching a phase of heightened activity known as a "solar maximum." During this period, the Sun's magnetic poles flip, leading to increased sunspots, flares, and coronal mass ejections (CMEs).

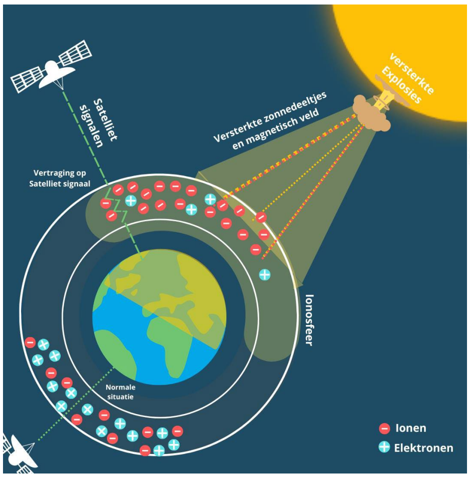
These phenomena, while visually stunning for astronomers, can have significant implications for life on Earth due to our reliance on electricity-dependent infrastructure. The solar maximum phase occurs roughly every decade, marking a period of intense solar surface activity driven by unstable convection processes within the Sun.

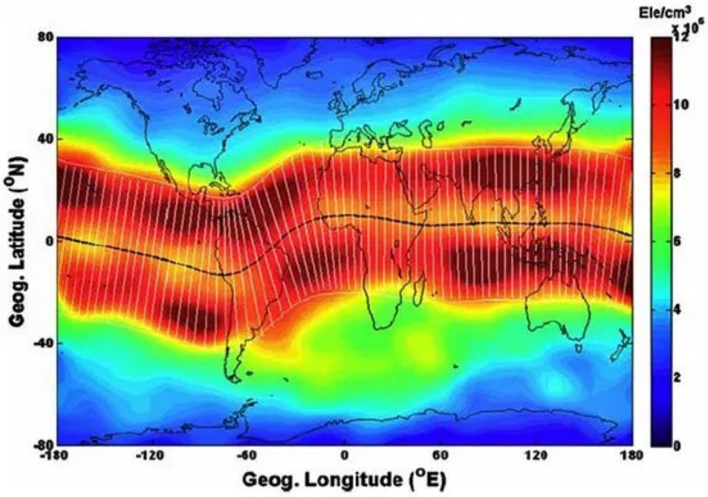
Solar activity changes through a 11-year cycle and is caused by flares emitted from the sun. The next cycle is underway and will last for 3 to 4 years (a few years either side of the peak). The peak of this cycle is due to be reached in 2025. This is proving to be a particularly active cycle which has already caused noticeable effects on receivers so early in the cycle period. The cause of this is the suns magnetic north and south poles flip every 11 years, this is known as the solar cycle. The emitted flares are caused by the suns magnetic field changing during this period.

The image below provides a prediction of when this current cycle is due to peak in 2024/2025, but is not due to completely end until around 2030. It also compares the current cycle with the previous cycle.



Source - https://www.almanac.com/solar-cycle-25-sun-heating





When a solar storm, such as a coronal mass ejection (CME) or a solar flare, impacts the Earth's ionosphere, it can trigger several significant effects:

The ionosphere affected is the area between 50-1000Km above the earth's surface.

Ionization Increase: Solar storms release a burst of charged particles, primarily electrons and protons, into space. When these particles reach the Earth's ionosphere, they collide with neutral atoms and molecules, causing them to ionize. This process increases the electron density in the ionosphere, particularly in the regions affected by the solar storm.

Scintillation: Solar storms can induce irregularities in the electron density of the ionosphere, leading to scintillation. Scintillation refers to rapid fluctuations in the amplitude and phase of radio signals passing through the ionosphere. These fluctuations can degrade the quality of GNSS (Global Navigation Satellite System) signals, leading to positioning errors and communication disruptions.

Radio Blackouts: Intense solar storms can cause radio blackouts by absorbing or scattering radio waves passing through the ionosphere. This can disrupt radio communications, particularly those relying on high-frequency (HF) bands, including aviation and maritime communications.

Geomagnetic Storms: Solar storms are often accompanied by disturbances in the Earth's magnetic field, known as geomagnetic storms. These storms can enhance the ionospheric effects of the solar storm, leading to more pronounced disruptions in GNSS signals, radio communications, and power grids.

Enhanced Aurora: Solar storms can also lead to enhanced auroral activity, particularly in high-latitude regions near the poles. Charged particles from the solar storm interact with the Earth's magnetic field, causing the characteristic auroral displays in the ionosphere.

Overall, when a solar storm hits the ionosphere, it can significantly impact various technologies and systems reliant on radio communication and satellite navigation.

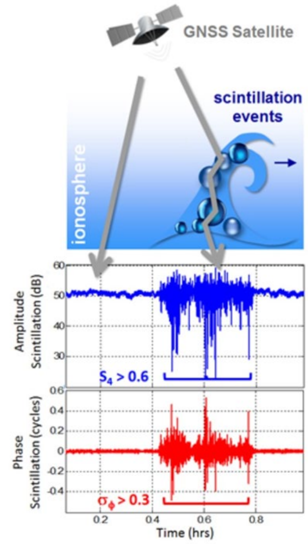
Understanding and monitoring solar activity and its effects on the ionosphere are crucial for mitigating the impact of solar storms on modern infrastructure and communication networks.

Its is not only GNSS receiver affected by these events but any technology which uses high-frequency radio signals may be impacted.

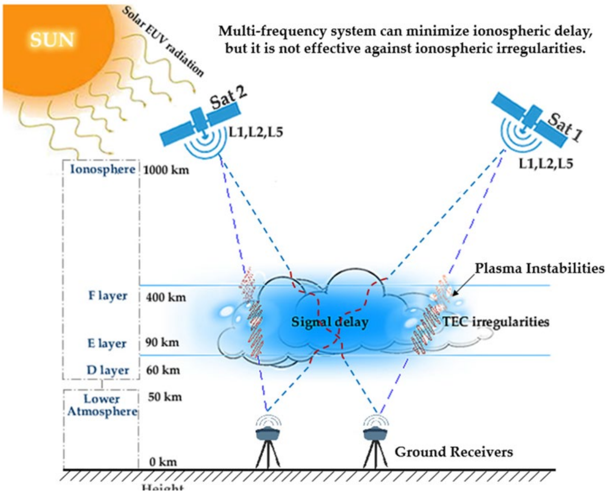
Solar activity can induce scintillation events in the ionosphere, degrading satellite signal quality.

Mild scintillation can reduce position accuracy by several meters, while severe cases may lead to cycle slips or complete loss of signal lock.

These disturbances can disrupt not only GNSS receivers but also radio communication. Solar maximum periods increase the likelihood of GNSS receivers being affected by solar scintillations worldwide.



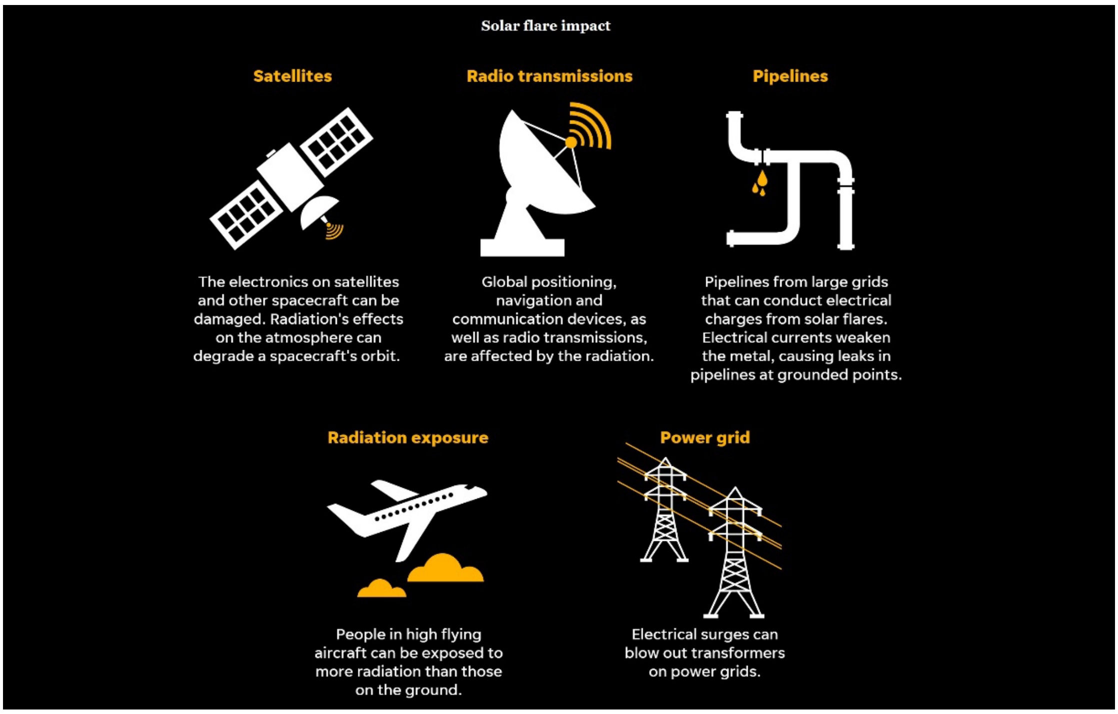
Data supplied by J.-M. Sleewaegen, Septentrio, Belgium



Both ionospheric delay and scintillation are caused by disturbances in the ionosphere, which are mainly driven by solar activities.

Ionospheric delay is related to the total electron content (TEC) and can be mitigated using multi-frequency observations.

Ionospheric scintillation is due to small-scale irregularities and cannot be corrected by multi-frequency techniques, making it harder to manage. It is driven by plasma instabilities and electrodynamic processes.



With regards the performance of your GNSS receiver, what can be expected?

Expected difficulties are a decrease of stability of position Fix, decreased precision and longer time to achieve a fixed solution.

Cycle slips may also be encountered, which will degrade the quality of the solution. The use of more satellite constellations will make the solution more robust and improve the performance of the GNSS receivers during such events.

What can be done to mitigate any effects of these events?

The effects change daily and at occur at various times of the day.

The use of GNSS planning tools is recommended to help lessen the effects.

Keep GNSS receivers updated to the Latest available firmware.

How long do these events last for?

A solar flare event can last from a few minutes to a few hours. The active region of the sun can produce flares which can last up to several weeks.

The impact of these events will vary between locations.

Recommended Action:

While technology is always improving and Topcon continues to work on solutions to improve system performance and to minimise the negative effect of any GNSS error source, complete mitigation of these events is not possible

We can summarise our recommendations as follows:

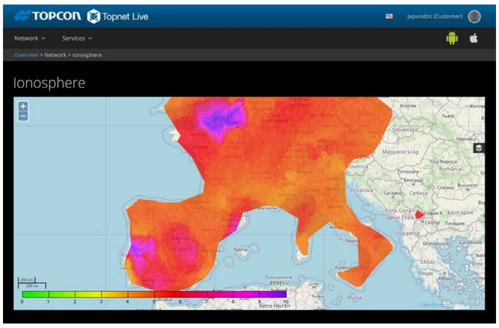
- Keep GNSS rover up to date
- Reduce baseline distance between the BASE and the Rover.
- Use multi-constellation signals
- In the case of currently high solar activity, plan the field activities for a time with less solar impact.

To confirm current software and firmware versions, use My Topcon NOW! or contact your local Topcon Support.

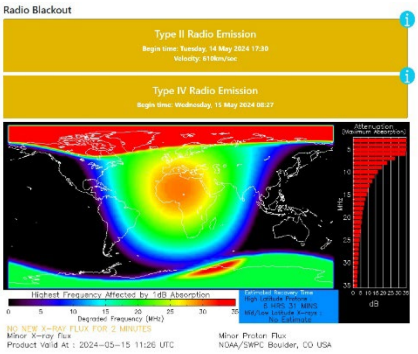
Useful resources

Space Weather Monitoring: Stay informed about space weather conditions and solar activity forecasts through dedicated space weather monitoring services and resources.

Users of the TopnetLive can find information can I95 graphical overview here:-
https://rtk.topnetlive.com/User/Ionosphere



Space weather – Solar Flare plot.
https://www.spaceweatherlive.com/en/solar-activity/solar-flares.html#radio



The use of skybridge maybe used to assist improve performance during these events. Further information on this service can be found here:-
https://www.topconpositioning.com/gb/support/article/topnet-live-starpointskybridge-general-information