Solar Activities

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The effects on satellites

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Flight Dynamics Division

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Introduction

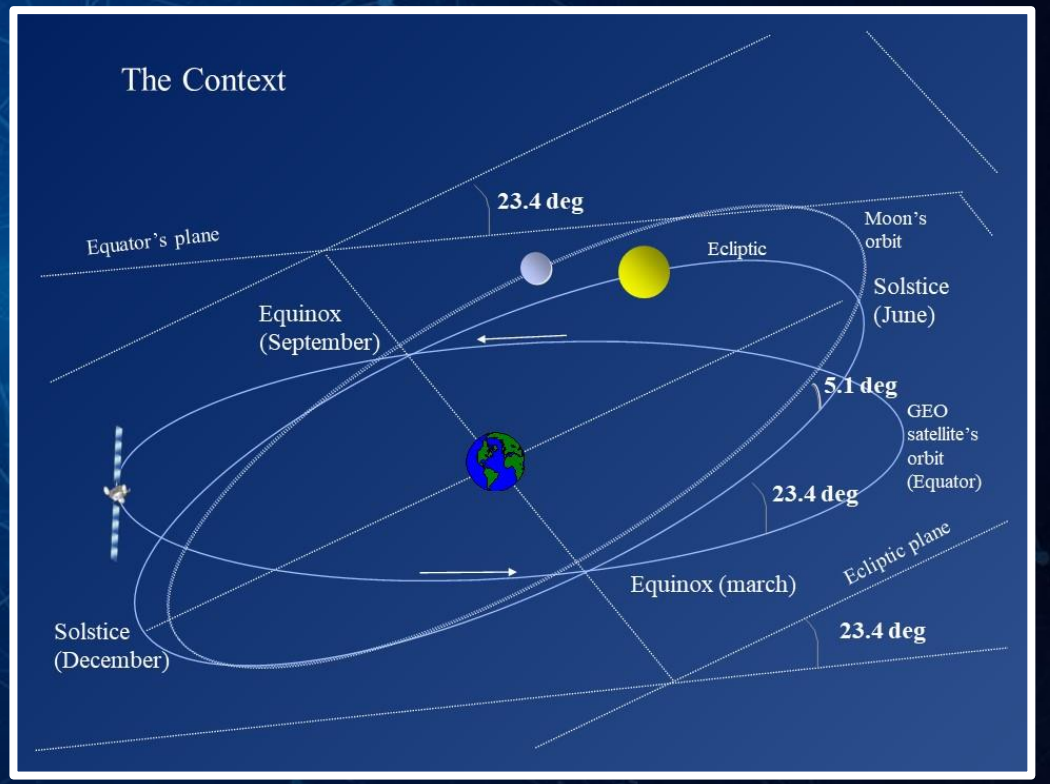
The Sun, as a star, generates high amount of energy and magnetic activity. In addition to gravitational effects, the thermal and magnetic energies generated by the Sun can affect telecommunications systems, including satellites.

We call “solar wind” the flux of particles that is constantly emitted by the Sun. The intensity of solar winds varies periodically. The solar magnetic activity also varies and, when it is very intense, can cause “solar flares”, generating a greater flux of high energetic particles.

The Sun travels an apparent path around the Earth with an inclination of 23.4 degrees with respect to equator’s plane, crossing it twice a year, while the geostationary satellites orbit the Earth in the equator’s plane, but at a distance of approximately 36,000 km above the Earth's surface.
In this context, the Sun affects the satellite communication systems in two different ways:

- when it is aligned with the Earth and the satellite, generating what we call **solar interference**;
- When a solar flare occurs.

Let’s understand better each one of this events.



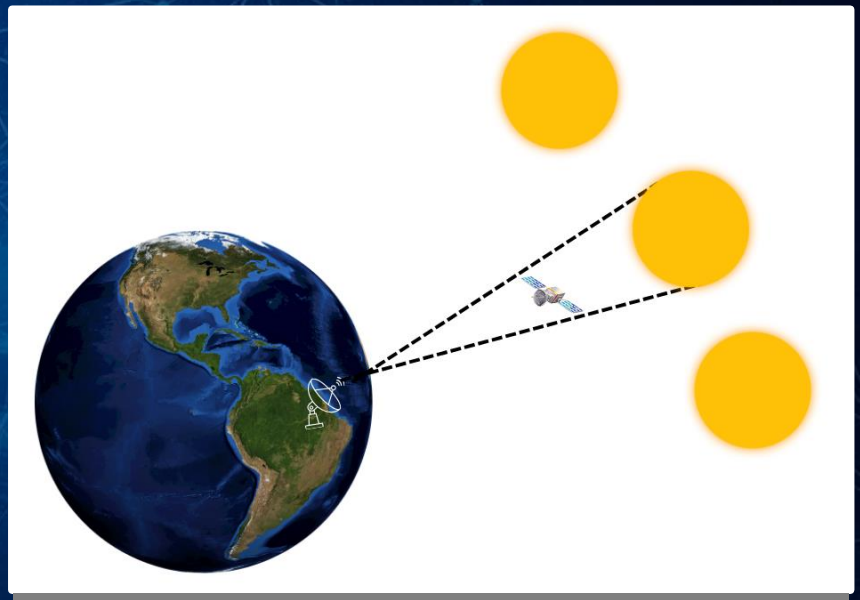
Solar Interference

During its apparent movement, the Sun, the ground station and the satellite occasionally are in the same line of sight. During this alignment, the energy emitted by the Sun interferes with the communication signal between the satellite and the station. We call this phenomenon **solar interference on ground station**.

This interference occurs because of the Earth-satellite-Sun alignment, since the earth station cannot distinguish the signal emitted by the satellite from the energy emitted by the Sun.

However, those are predictable and short-term events. They occur in two periods during the year (close to the March and September equinoxes) and vary depending on the position of each station.
In our WEBSITE it is possible to check the forecast and duration of each event per semester.

These events do not vary with solar magnetic activity, as they depend only on the apparent position of the Sun.



When the station , the satellite and the Sun are aligned the satellite signal is momentarily interrupted on the ground stations.

Solar Magnetic Activity

The Sun has a constant magnetic activity, but the intensity varies along a cycle of, approximately, eleven years.

On the Sun's surface, dark spots can be seen . These are areas where magnetic activity is more intense. When solar activity increases, the number of spots also increases. When solar activity is intense, explosions can occur emitting a high flux of energized particles. This event, also called a solar storm, can cause some effects such as "aurora borealis", disturbance in satellites, electrical networks problems, communication systems outage, etc.

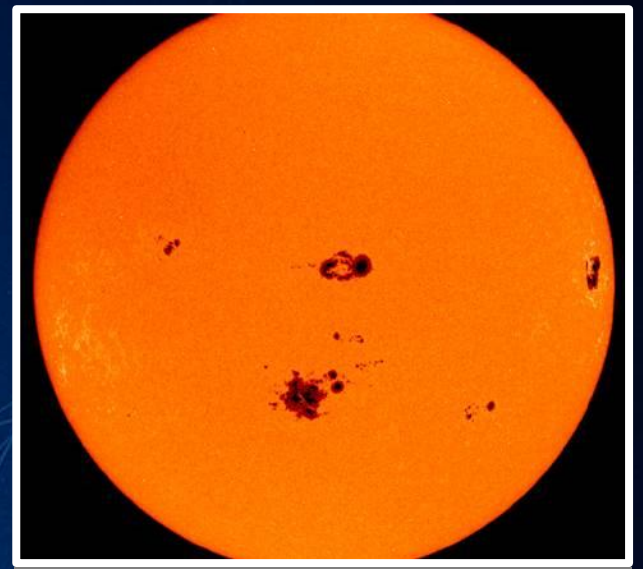
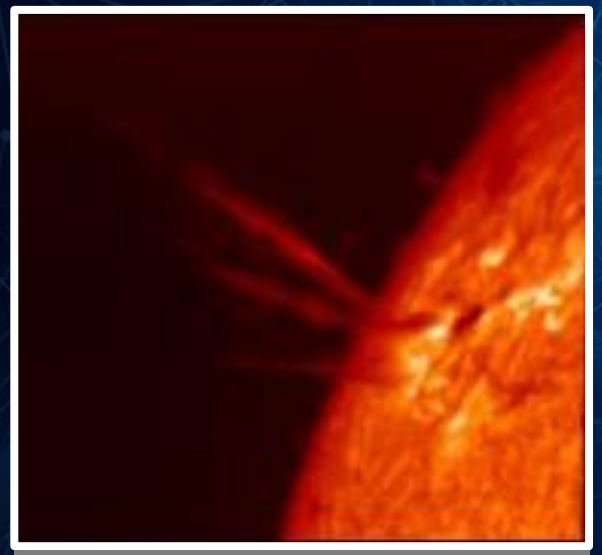


Image of dark spots on Sun's surface.
Source: NASA

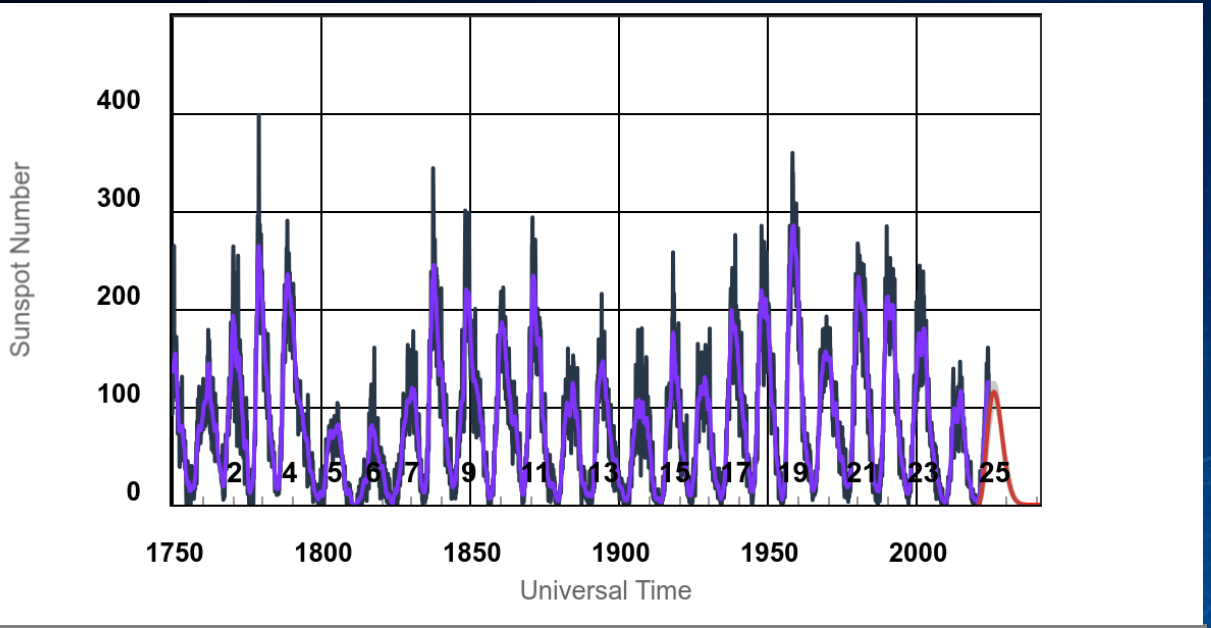


Solar flare captured by NASA.

Currently, there are some organizations monitoring the sun activity, and they predict upcoming events and their durations. Since 1749, 24 complete cycles have been identified. Now, the sun is on the 25th cycle, and its maximum activity is predicted to occur in the second half of 2024.

During the magnetic activity peak, the effects of solar flares will be more intense.

Solar Magnetic Activity



Monitoring and forecasting solar activity. The cycle 25, which started in 2019, will achieve the maximum around 2024. The red line indicates the forecast for the next cycle. It is possible to observe that it will not be the most intense ever.
Source: NOAA

Some organizations provide a *Space Weather* service. They observe the Sun constantly and register the number and size of dark spots.

Along each solar cycle of 11 years, individual events occur with different intensities, and these are called **solar storms and solar flares.**

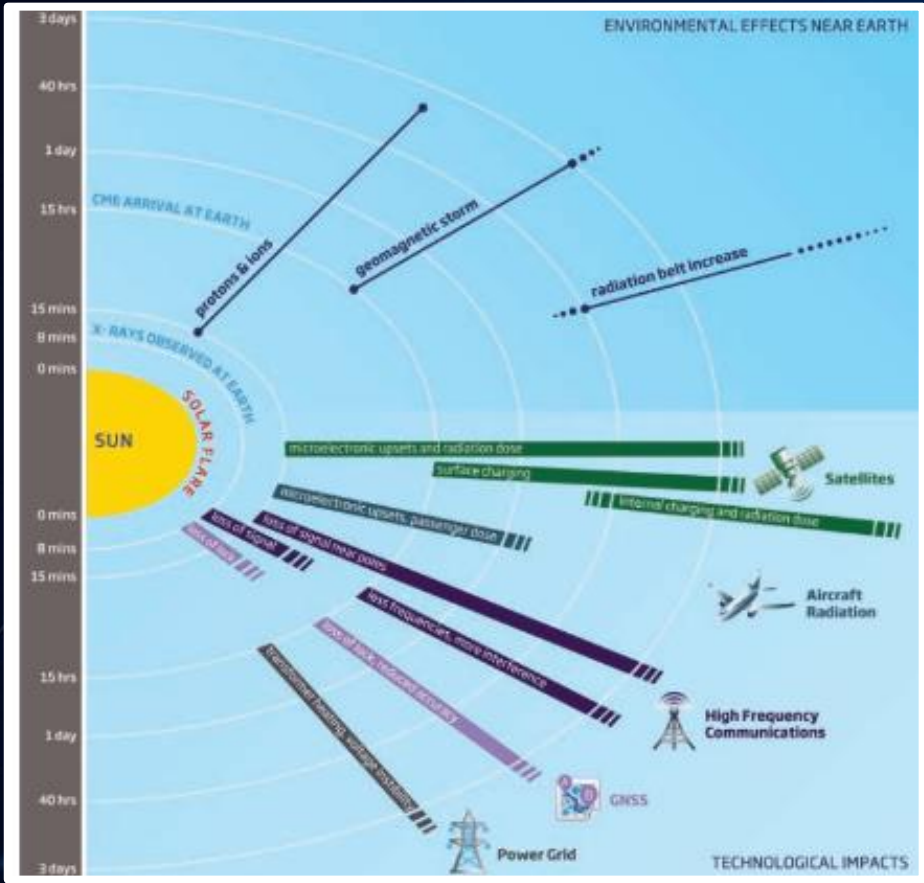
Using models based on historical data, it is possible to predict the intensity of upcoming events.

It is important to point out that **severe events** happen rarely, **around once per solar cycle**; the ones **with minimum impact** occur about 50 times per cycle, i.e., **less than 5 times per year**.

Solar storms and flares can affect mainly GPS systems, electrical transmission networks, radio communication networks and satellites.

Source: NOAA/NASA

Solar Flare impacts on satellites



Estimation of the effects of a solar flare made by the Royal Academy of Engineering in 2012

The satellites can be affected by solar flares in different ways. Energetic particles emitted by the Sun can reach satellites in space and damage electronic components, causing micro components upset or solar panel performance degradation.

The satellite signal may be degraded due to the intensification of ionospheric scintillation*. The communication system can be affected by cross-polarization variation.

Satellites in Low Earth Orbit (LEO) can be dragged by the flow of particles interacting in the Earth's atmosphere and with the planet's magnetic field.

(*) Ionospheric scintillation is a phenomenon that occurs in the Earth's ionosphere, due to magnetic variations in this region. It changes the amplitude of the radio signal flying by.

What we do

- Currently, there are organizations monitoring the Sun and providing Space Weather forecast. It is possible to subscribe to receive reports with risk classification of different matters. The main one is offered by NOAA and it is open to the public. The Embratel's orbital dynamics team receives the relevant information for the fleet.

- For the interference caused by the apparent position of the Sun - solar interference on ground stations - we calculate the time and duration of each event for all stations. The prediction is available for our customers on our website.

- In order to protect our satellites from the effects of solar flares, our satellites are designed with shielding to resist to an event of twice the intensity of the largest solar flare ever recorded.

- Additionally, we use a signal transmission computation model that takes into account margins to compensate the effects of solar flares and sunspots on cross polarization (Faraday Effect), considering the maximum activity ever recorded. With the adoption of such margins, we don't have any record of interruptions in our satellite communications due to solar magnetic activity.

References:
NOAA SPACE WEATHER PREDICTION CENTER
Extreme space weather: impacts on engineered systems and infrastructure
NOAA Weather Service