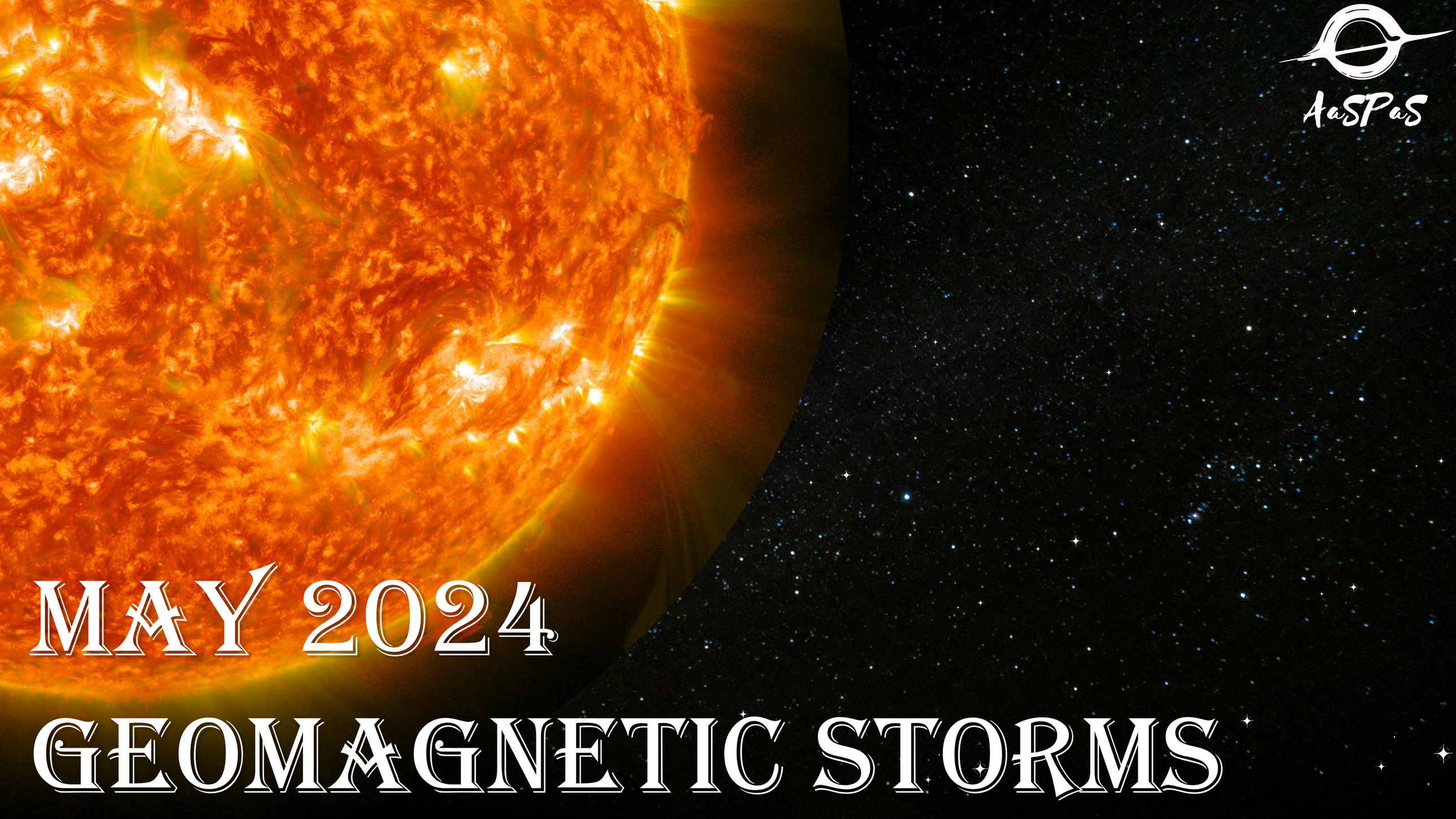
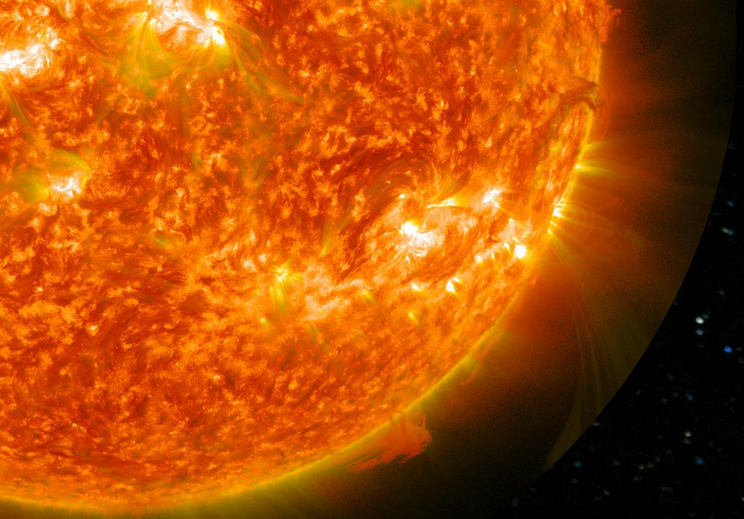
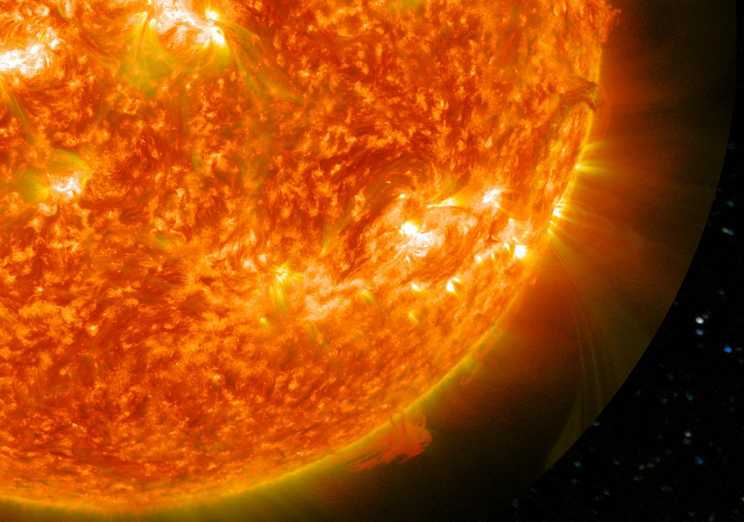

AuSPaS
MAY 2024
GEOMAGNETIC STORMS



What the May 2024 Geomagnetic Storms Looked Like



Background:

The Sun's activity—solar flares, coronal mass ejections, and accelerated particles—creates space weather, which can cause beautiful auroras but also disrupt satellites and communications. During peak solar activity, understanding space weather and its effects is crucial. Data from different sun observatories enhance our knowledge of space weather and its impacts.

OBJECTIVE

- Challenge: To use data from satellites or ground instruments to create a visual representation of the May 2024 solar storms.
- Purpose: Help the general public understand the impacts of these events.
- Project Focus: Educate people about space weather and its effects on Earth, the Moon, Mars, and the solar system.
- Perspective: Explaining the phenomenon and from the perspective of humans on earth.
- Important Information: Explain what causes space weather and how we gather information about it.

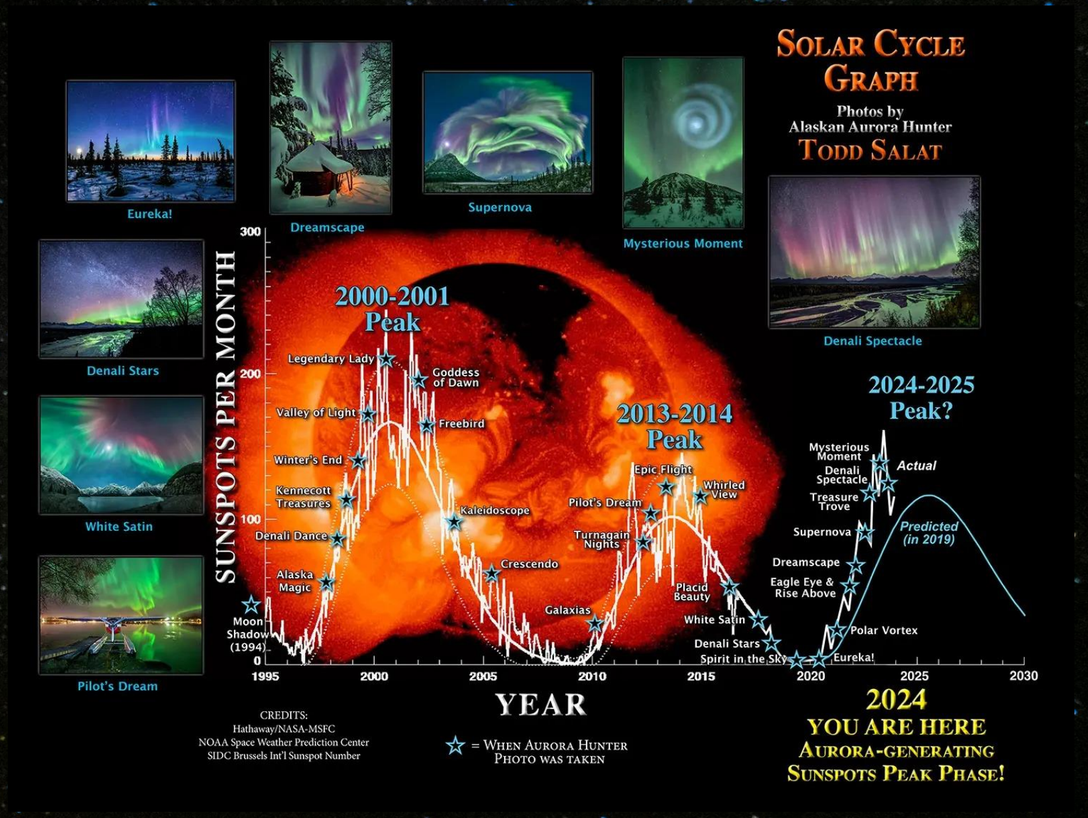
Geomagnetic storm

In order to understand Geomagnetic Storms, we have to first understand Solar Storms.

Solar Cycle

Solar storms and their related phenomena all wax and wane with the Sun's 11-year cycle of activity. Such events are more common during solar maximum (or peak of the solar cycle) but are less frequent during solar minimum (or low point of the cycle).

Sunspots, or dark "blemishes" on the Sun, also increase during solar maximum and mark magnetically active regions on the Sun, which give rise to solar eruptions. When a large group of sunspots or a particularly active region on the Sun comes into view, it's a good time to be on the lookout for solar storms that could be headed our way.



Solar Storm

What are solar storm

A **solar storm** occurs when the Sun violently hurls a cocktail of particles, energy, and magnetic fields into the surrounding solar system. This sudden, explosive release of solar material can have far-reaching effects throughout our cosmic neighborhood.

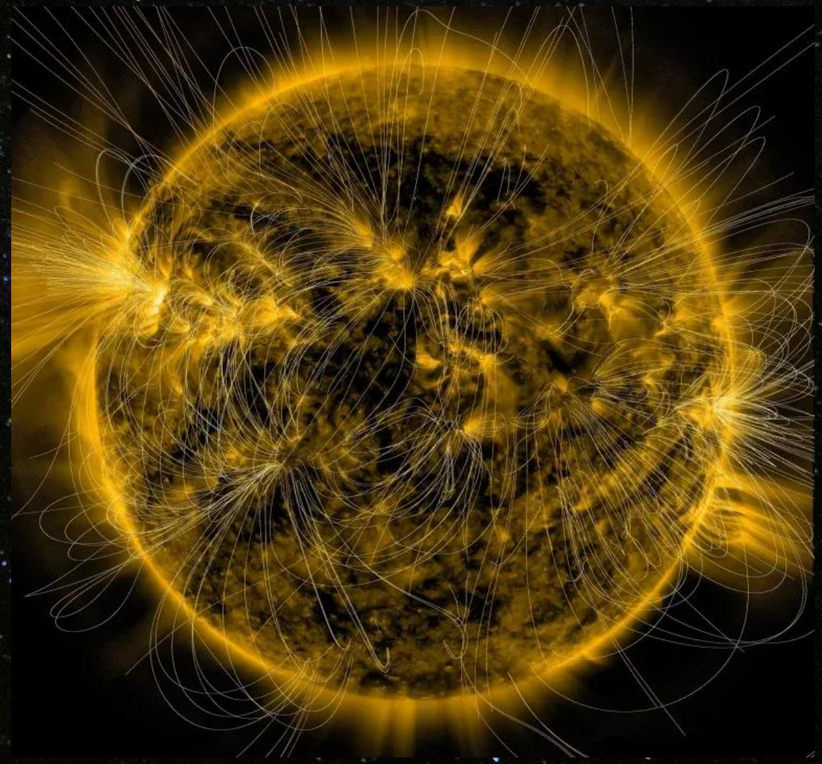
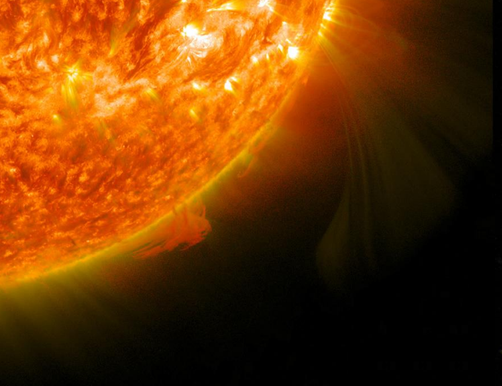


Image: A cloud of material erupts from the Sun.
Credit: NASA/ESA/SOHO



Solar Storm

What causes a solar storm?

The Sun's magnetic field is a complex, ever-changing structure. Imagine it as an unruly mop of hair, constantly tangling and twisting. This magnetic tangle is primarily caused by the Sun's differential rotation - its equator spins faster than its poles. As these magnetic fields become increasingly contorted and stretched, they eventually reach a breaking point. At this critical moment, they snap and reconnect in a process known as magnetic reconnection. This sudden release of pent-up energy is the typical trigger for solar storms, unleashing vast amounts of energy into space.

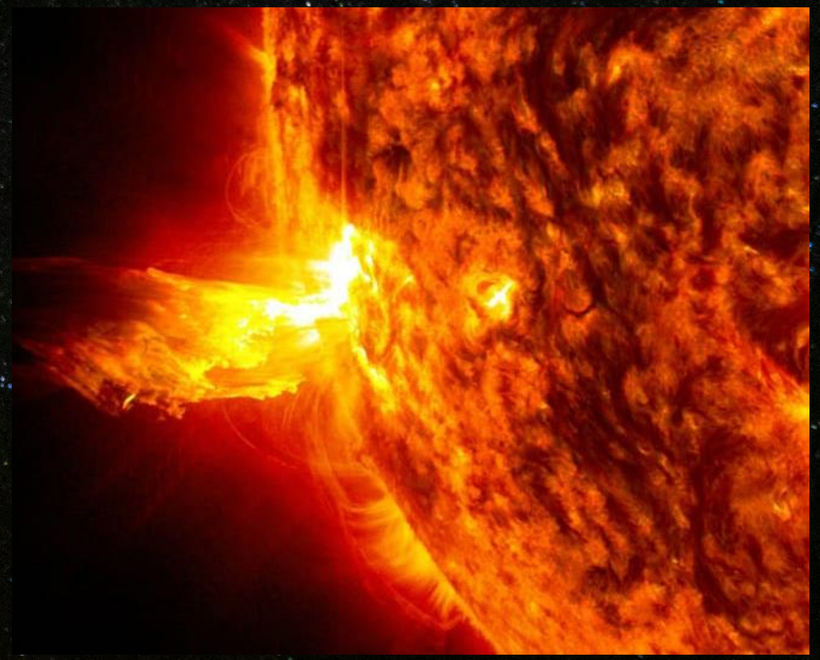
How can the solar storm affect us

These powerful eruptions can produce:

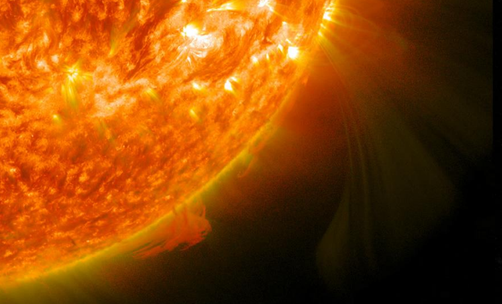
- A bright flash of light known as a **solar flare**.
- A **radiation storm**, where solar particles are rapidly hurled into space.
- A massive cloud of solar material called a **coronal mass ejection**, which expands outward from the Sun

Solar Flares what are those?

A **solar flare** is a powerful burst of radiation from the Sun that covers the entire electromagnetic spectrum, including X-rays, gamma rays, radio waves, ultraviolet, and visible light. These are the most energetic explosions in the solar system, with the largest solar flares releasing as much energy as a billion hydrogen bombs.



Material rises from the edge of the Sun, as seen in extreme ultraviolet light by NASA's Solar Dynamics Observatory .NASA/SDO



These Solar Flares are also categorized further based on their intensity:

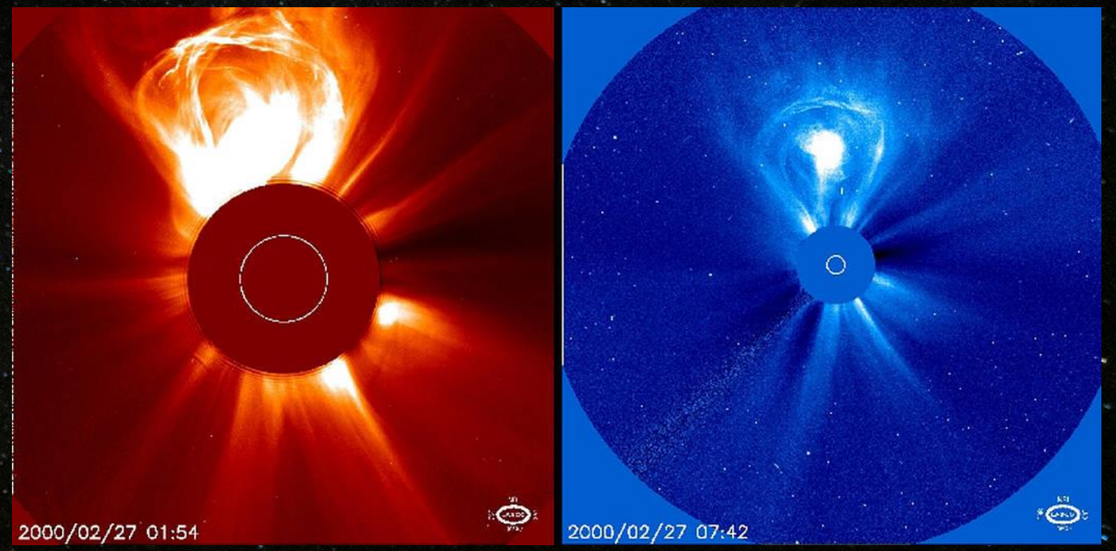
The energy from a flare travels at the speed of light, reaching Earth approximately 8 minutes after the flare occurs. Essentially, by the time we observe a flare, most of its effects have already arrived.

- **A** - the weakest flares, barely distinguishable from the Sun's background radiation
- **B**
- **C**
- **M**
- **X** - the strongest flares

Similar to the Richter scale for earthquakes, each successive class represents a tenfold increase in energy. For instance, an X flare is ten times more powerful than an M flare and one hundred times stronger than a C flare.

Coronal Mass Ejection (CME)

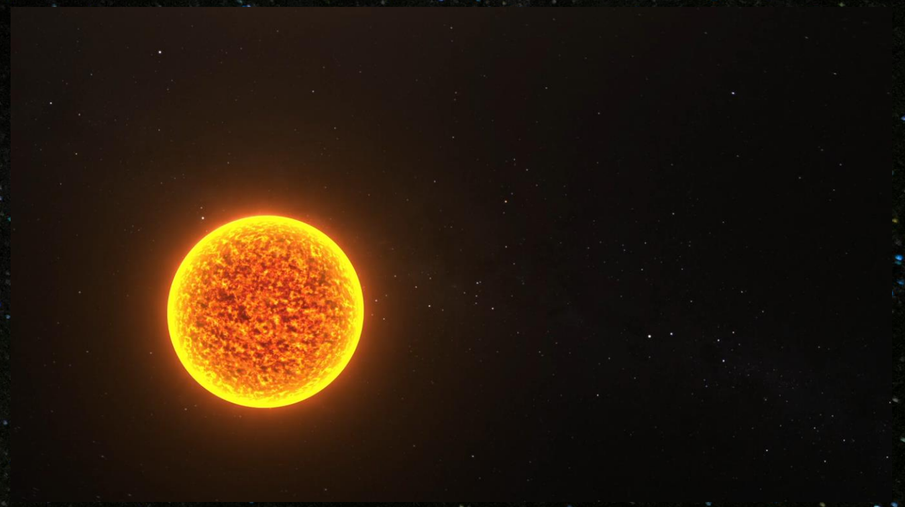
A **coronal mass ejection** (CME) is an enormous cloud of electrically charged gas, called plasma, that erupts from the Sun. A single coronal mass ejection can blast billions of tons of material into the solar system all at once.
CMEs occur in the outer atmosphere of the Sun, called the corona, and often look like giant bubbles bursting from the Sun.



Coronal mass ejection on Feb. 27, 2000 taken by SOHO LASCO C2 and C3. A CME blasts into space a billion tons of particles traveling millions of miles an hour. Credit: SOHO ESA & NASA

Radiation Storm

Solar eruptions can propel charged particles, such as electrons and protons, into space at extremely high speeds, triggering a **radiation storm**. The fastest of these particles can travel the nearly 93 million miles from the Sun to Earth in as little as 30 minutes.



2024 Geomagnetic Storm

In May 2024, Earth experienced a series of powerful solar storms, featuring extreme solar flares and geomagnetic storms from May 10-13. This period marked the most significant geomagnetic storm since March 1989.

Solar Flares and Coronal Mass Ejections (CMEs):

- On May 8, 2024, an active solar region unleashed an X1.0-class flare and multiple M-class flares, along with several CMEs aimed at Earth.
- On May 9, the same region produced flares of X2.25-class andX1.12-class, each accompanied by a full-halo CME.
- On May 10, it generated an X3.98-class flare.
- On May 11 at 01:23UTC, another X-class flare, ranging from 5.4 to5.7 in magnitude, occurred with an asymmetrical full-halo CME.
- The most intense flare happened on May 14, with an X8.7-class flare causing significant disruptions.

Its Impacts in 2024

The storm negatively affected the communication system and broadcasting in Canada, power companies BC Hydro and Hydro-Québec stated that they had prepared for the storm, and monitor edit as its ejecta struck Earth on 10–11 May. Unlike in 1989 where a previous solar storm caused a nine-hour long power outage in Québec, no outages were reported as a result of the storm's effects. In New Zealand, Transpower declared a grid emergency, and took some transmission lines out of service as a precaution against the storm. In the United States, telecommunications companies stated that they were prepared to respond to disruptions in their networks, but it was predicted that significant impacts to cell service were unlikely because the networks rely on different frequencies than the HF bands affected by the solar storm. University of Victoria researchers discovered that the geomagnetic storm triggered compasses in sub-sea observatories deployed as deep as 2.7 km under the ocean’s surface.

SIGHTINGS AURORA

Three comes from 8 may 2024 reached Earth on 10 may 2024, causing extreme geomagnetic storms with bright aurorae. In the states, aurorae were observed as far south as Florida keys and in Puerto Rico in Mexico. Portugal, Spain and Sardinia in Europe and Canary islands and Algeria in Africa also saw the lights. In Asia, aurorae could be seen from north India, turkey, Cyprus Iran etc. In Australia, the lights could be seen as far north as Townsville and Mackay in Queensland, while in the rest of the Southern Hemisphere aurorae were seen in New Zealand, Chile, Argentina, South Africa, and as far north as New Caledonia, Uruguay, southern Brazil and Namibia.

Different sun observatories

In May 2024, NASA played a crucial role in monitoring and studying the impacts of a significant geomagnetic storm. Here are some key points about NASA’s involvement:

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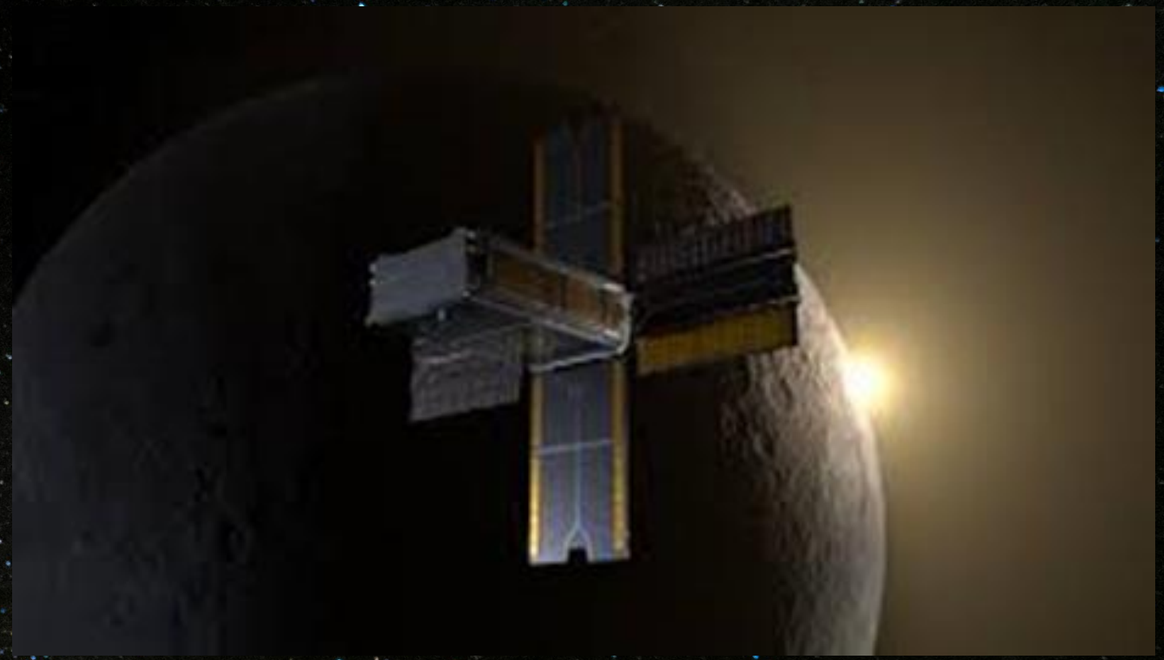
Monitoring and Data Collection

- **BioSentinel Mission**: NASA’s BioSentinel spacecraft, orbiting the Sun, collected data during the storm to study the impacts of solar radiation in deep space.
- **Solar Dynamics Observatory (SDO)**: Captured images of solar flares and other solar activities during the storm, providing valuable data on the Sun’s behaviour



Research and Analysis

- Aurorasaurus Project: NASA’s citizen science project, Aurorasaurus, gathered eyewitness accounts and photos of the auroras caused by the storm. This data helps verify models of aurora visibility and study the storm’s effects on Earth’s atmosphere.
- AI Predictions: NASA, in collaboration with other agencies, used artificial intelligence to predict the impacts of solar storms. This helps prepare for and mitigate the effects on technology and infrastructure.

Different sun observatories

ISRO (Indian Space Research Organisation has played a significant role in studying and monitoring space weather, including geomagnetic storms and has also been actively involved in this field.

Satellite Missions: ISRO has launched several satellites dedicated to space weather research, such as:

- Chandrayaan-1: This lunar orbiter carried instruments to study the Moon's interaction with the solar wind and the Earth's magnetosphere.
- Chandrayaan-2: This mission included a lander and rover to study the Moon's surface and its interaction with the solar wind.
- ADITYA-L1: This upcoming solar observatory will study the Sun's corona, which is the source of solar flares and CMEs.