SOLAR STORMS

A solar storm is a sudden explosion of particles, energy, magnetic fields, and material blasted into the solar system by the Sun.

These powerful eruptions can generate any or all of the following:
a bright flash of light called a ***solar flare***.
a ***radiation storm***, or flurry of solar particles propelled into space at high speeds.
an enormous cloud of solar material, called a ***coronal mass ejection***, that billows away from the Sun.

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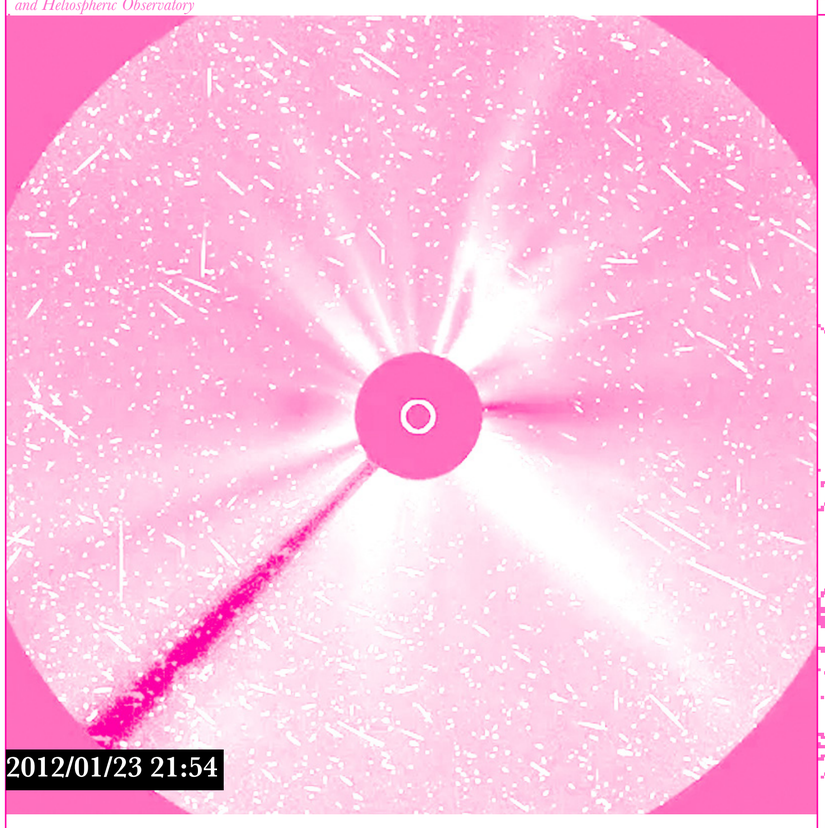
A solar storm in January 2012 released a flurry of energetic particles that looked like snow when they hit the detectors of the Solar and Heliospheric Observatory

Year	Solar Storm Events	Intensity	Impacts
1859/7/1	**Carrington Event**: First documented instance of a solar flare affecting Earth	Not specified in X-scale, but extreme	- Global telegraph systems severely disrupted; some equipment caught fire - Auroras visible as far south as the Caribbean
1972/8/4	**Major solar flare in 1972**	No specific X-class cited	- Long-distance phone lines knocked out in multiple states - Led AT&T to redesign transatlantic cable power systems
1989/3/13	**1989 Canada power outage event**	No specific X-class cited	- Triggered a power grid collapse in Quebec, leaving 6 million without electricity for ~9 hours - Melted some transformers in New Jersey
2000/7/14	**Bastille Day Event**: Occurred on France's national holiday	**X5**	- Caused short-circuits in some satellites - Led to radio blackouts - Most powerful flare since 1989
2003/10-11	**Halloween Storms of 2003**: A series of powerful flares & coronal mass ejections	Up to **X28–X45** (estimated)	- Aircraft rerouted - Satellite systems affected - Power outages in Sweden - SOHO spacecraft temporarily failed
2006/12/5	**Solar flare on Dec 5, 2006**	**X9**	- Disrupted satellite-to-ground communications & GPS signals for ~10 minutes - Damaged the solar X-ray imager on GOES 13
2022/2	**Starlink Satellite Failure**: Multiple newly deployed satellites destroyed by geomagnetic storm	Geomagnetic storm + atmospheric drag	- About 40 newly launched Starlink satellites lost, costing ~$50 million - Denser thermosphere made it impossible to maintain orbit



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SOLAR FLARES

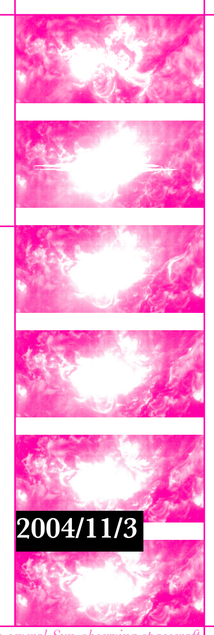
A solar flare is an intense burst of radiation, or light, on the Sun. These flashes span the electromagnetic spectrum — including X-rays, gamma rays, radio waves, and ultraviolet and visible light.
Solar flares are the most powerful explosions in the solar system — the biggest ones can have as much energy as a billion hydrogen bombs.

X-class flares can go even higher and have no upper limit. The most powerful flare ever measured was in 2003, which was recorded as an X28 before our sensors were overwhelmed.

The energy from a flare travels at the speed of light, which means it reaches Earth about 8 minutes after a flare happens. Essentially, by the time we see a flare, most of its effects are here.

Solar flares are classified according to their energy output.

A – the weakest flares, barely noticeable above the Sun's background radiation
B
C
M
X – the strongest flares
Much like the Richter scale for earthquakes, each higher class is a 10-fold increase in energy. So an X flare is 10 times stronger than an M flare and 100 times stronger than a C.



2004/11/3

On Nov. 4, 2003, this solar flare saturated the X-ray detectors on several Sun-observing spacecraft.

RADIATION STORMS

Solar eruptions can accelerate charged particles into space at incredibly high speeds, initiating a radiation storm.

The fastest particles travel so quickly they can zip across roughly 93 million miles from the Sun to Earth in about 30 minutes or less.

High-speed particles from solar eruptions can sometimes:
Get past most of Earth's magnetic defenses, following Earth's magnetic field lines toward the north and south poles, where they enter our atmosphere and possibly even hit the ground.

Knock electrons off of atoms and molecules in our atmosphere, altering high-frequency radio communication.

Pierce deep into satellite hardware, degrading solar panels and damaging circuits.

Pass through human tissue, posing radiation risks to astronauts in space or to crewmembers and passengers in high-flying polar aircraft.

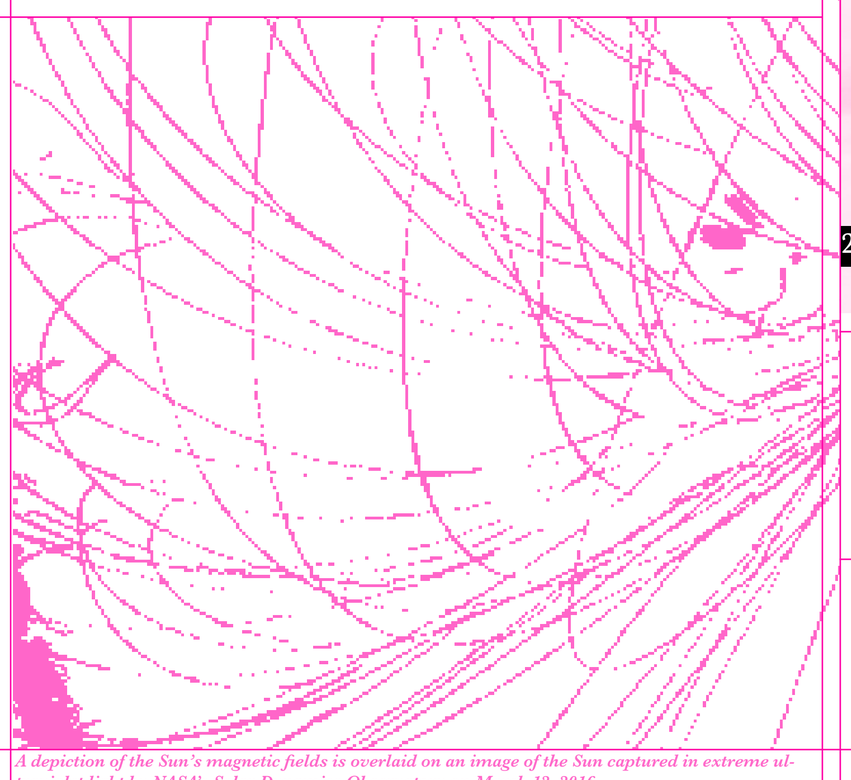
2013/10/25-28

Several coronal mass ejections erupted from the Sun between Oct. 25 and 28, 2013.

CORONAL MASS EJECTIONS

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.



A depiction of the Sun's magnetic fields is overlaid on an image of the Sun captured in extreme ultraviolet light by NASA's Solar Dynamics Observatory on March 12, 2016.