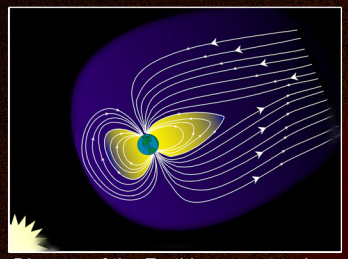
How can CMEs affect me?

Plasma is also released continuously from the Sun in all directions, making up the **solar wind**. The energy of the solar wind shapes and impacts Earth's magnetic field, its **magnetosphere**, which originates in its core. The magnetosphere extends out about 65,000 km (40,000 miles) on the Sun side, and more than ten times that distance on the opposite side, well beyond the Moon's orbit. The exact distances vary considerably with solar activity.

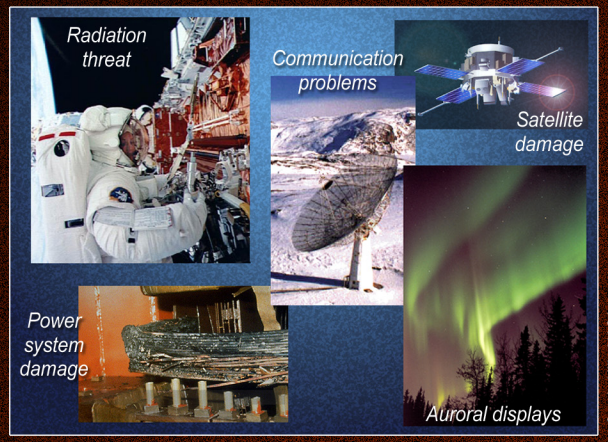
When a CME slams into the magnetosphere, most of its plasma is deflected. Yet its energy distorts the magnetosphere and creates substantial electric currents in space and in our atmosphere. An *average* CME pours in twice the power-generating capacity of the entire U.S.!



Steele Hill, NASA

Diagram of the Earth's magnetosphere

The behavior of the Sun, including CMEs, causes **space weather** that affects Earth. The electric currents a CME generates produce magnetic storms and magnificent auroras, alter the magnetic field in space and on the ground, and heat and expand the atmosphere. Space weather can set off electrical surges in power lines and oil pipelines and has caused power blackouts. It can lead to a loss of communications and GPS signals, increase the drag on satellites, and be a serious danger to astronauts.



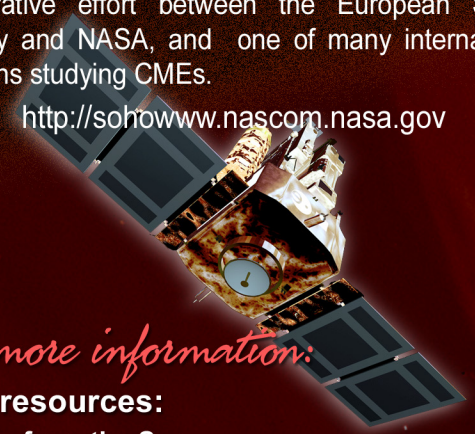
Steele Hill, NASA

Some effects of solar storms

About the Solar and Heliospheric Observatory (SOHO)

SOHO has been the primary spacecraft imaging CMEs since its launch on December 2, 1995. It has given us significant information about the internal structure of the Sun, its extensive outer atmosphere, and CMEs. From its orbit at a point one million miles (1.5 million km) sunward of the Earth, it has also presented us with amazing solar images. SOHO is a cooperative effort between the European Space Agency and NASA, and one of many international missions studying CMEs.

http://sohowww.nascom.nasa.gov



for more information:

Web resources:

Storms from the Sun
http://www-istp.gsfc.nasa.gov/istp/outreach/cmeposter/

SOHO Explore
http://sohowww.nascom.nasa.gov/explore/

Transition Region and Coronal Explorer (TRACE)
http://vestige.lmsal.com/TRACE/

Yohkoh Public Outreach Project
http://solar.physics.montana.edu/YPOP/

Exploration of the Earth's Magnetosphere
http://www.phy6.org/Education/Intro.html

Space Weather
http://www.spaceweather.com

Sun-Earth Connection Education Forum
http://sunearth.gsfc.nasa.gov/

Print resources:

Storms from the Sun *- The Emerging Science of Space Weather*. Michael Carlowicz and Ramon Lopez. Washington, DC: The Joseph Henry Press, 2002.

Exploring the Sun: *- Solar Science Since Galileo.* Hufbauer, K. Baltimore: Johns Hopkins University Press, 1991.

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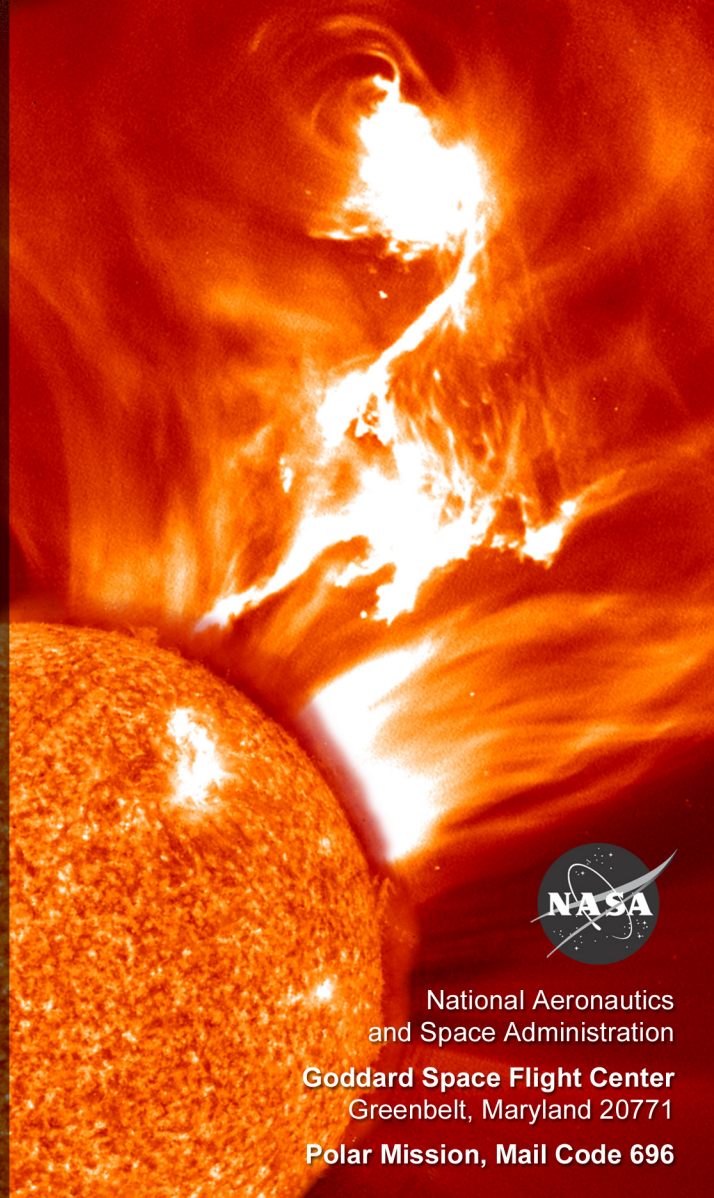
What Causes Storms from the Sun?

about coronal mass ejections



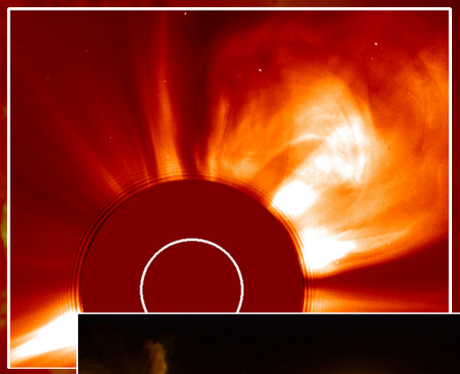
National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

Polar Mission, Mail Code 696

What is a Coronal Mass Ejection (CME)?

A CME is the explosion of an enormous ball of electrified gas from the Sun's outer atmosphere, the corona, and is one of the most violent events in the solar system. It can send more than 10 billion tons (9 trillion kg) of matter flying out into the solar system at tremendously high speeds and can cause effects here on Earth.



SOHO/LASCO, NASA/ESA

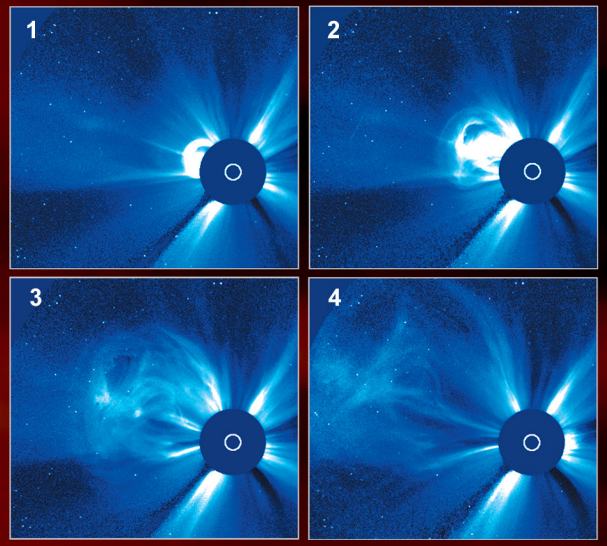
TRACE, NASA

A CME blast (above) and a magnetic loop

How does the Sun produce a CME?

In the Sun and its corona, matter is heated to extreme temperatures, up to millions of degrees. At these temperatures, electrons are pulled free from the nuclei of the atoms, and the matter becomes electrified. This mix of positive nuclei and electrons is called **plasma**. Electric currents from the movement of solar plasma create strong magnetic fields that loop far out into space.

CMEs originate with these magnetic loops. With time they overlap, stretch, and twist. Plasma is boiled off the Sun to become trapped in the loops. Eventually the stress from the stretching and twisting of the magnetic loops becomes too great, and they snap in an explosive release. Plasma, with massive amounts of energy and tangled with the magnetic field, is blasted into space as a CME. A solar flare, another type of eruption, often occurs deeper in the Sun's atmosphere as part of the same event.



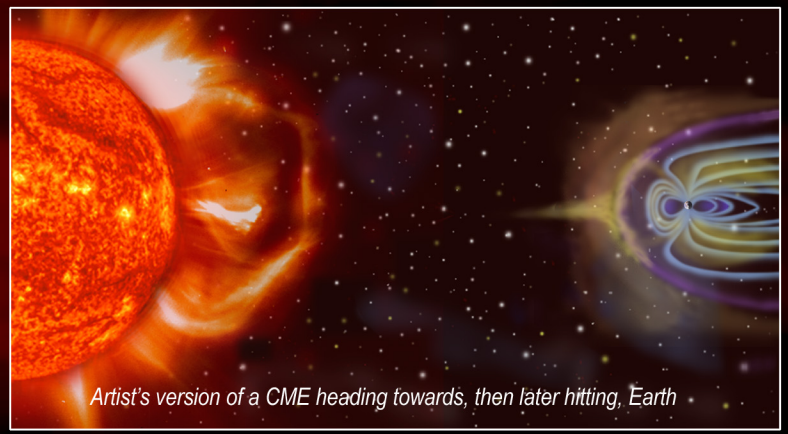
SOHO/LASCO, NASA/ESA

Progress of a CME over a few hours

How does a CME behave?

A CME explosion may be tens of thousands of miles (or km) wide when it leaves the Sun, but as it blazes out into space at speeds up to five million mph (eight million kph), the giant cloud expands. It may become larger than the Sun itself. It also thins out, from millions of particles per cubic inch (or cc) near the Sun to only a handful near Earth, a density lower than any vacuum we can create in a laboratory. Yet when it reaches Earth two to three days after its birth, it has lost very little speed.

CMEs can erupt in any direction from the Sun. One directed at us on Earth is called a "halo CME" because it looks like a halo around the Sun to instruments near us in space.

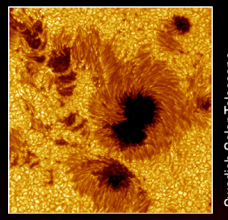


Artist's version of a CME heading towards, then later hitting, Earth

Steele Hill, NASA

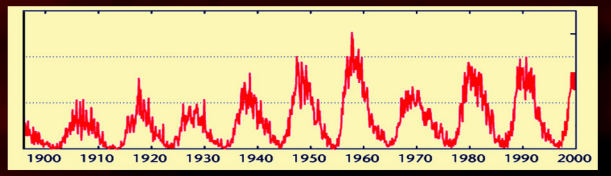
When do CMEs happen?

CMEs occur a few times a week to several times a day, depending on how active the Sun is. Most CMEs happen during the rising phase of the **solar cycle**. Sometimes called the sunspot cycle, the solar cycle is the rise and fall over time in the number of sunspots seen. A maximum occurs about every 11 years.

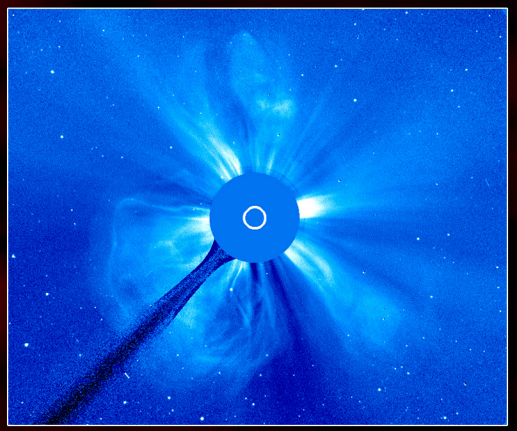


Swedish Solar Telescope

Sunspot close-up



Sunspot number graph shows the 11-year solar cycle



SOHO/LASCO, NASA/ESA

A halo CME blasts out from the Sun

How can we see a CME?

The Sun's surface is much brighter than a CME. So to see a CME, the solar disk must be covered, either by the moon during an eclipse, or with a disk in a special telescope (a coronagraph) to create a false eclipse. Not all of the Sun's energy penetrates the Earth's atmosphere, so scientists rely on both ground and space telescopes to investigate CMEs over a range of energies. From space, we also measure the velocities and density of the plasma in a CME and the strength and direction of its magnetic field.