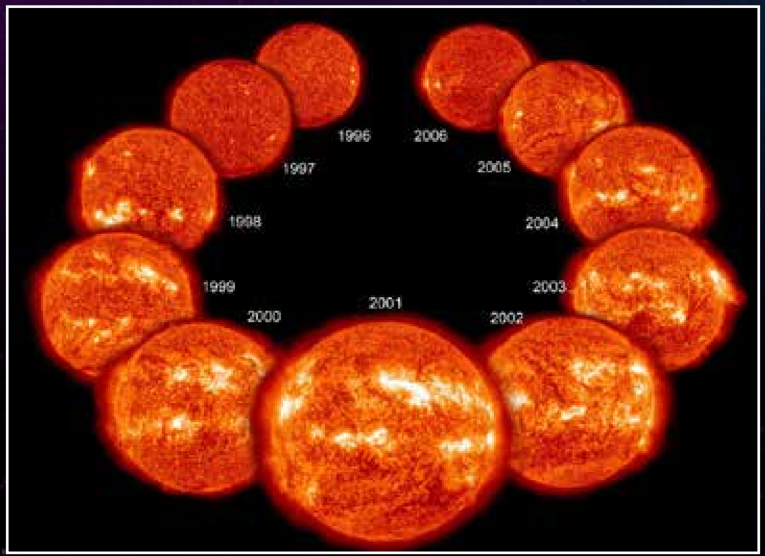
SANSA SPACE SCIENCE

The Impact of Space Weather

The Sun & its Solar Cycle

Our local star, the Sun, is a huge ball of boiling gas with a very strong magnetic field that rotates with a differential rotation on its axis with different velocities at the poles. This differential rotation twists the magnetic field and causes a variety of solar features. In order to see the different structures, the Sun is observed in a variety of wavelengths, ranging from hard X-rays to radio.



The Sun has an 11-year cycle of solar activity known as the solar cycle.

The magnitude of the magnetic flux that rises to the surface of the Sun, follows 11-year cycles of activity known as the solar cycle or sunspot cycle. During this cycle the Sun reaches periods of maximum and minimum solar activity. Solar minimum refers to a period when the number of sunspots is small, resulting in less solar activity. Solar maximum is the period when the number of sunspots is high, resulting in more frequent solar activity.

> *Solar winds travel at speeds of up to 800 km/s*

Coronal Holes

These are large holes in the Sun's corona that are caused by the Sun's magnetic field. They are less dense and cooler than surrounding areas.

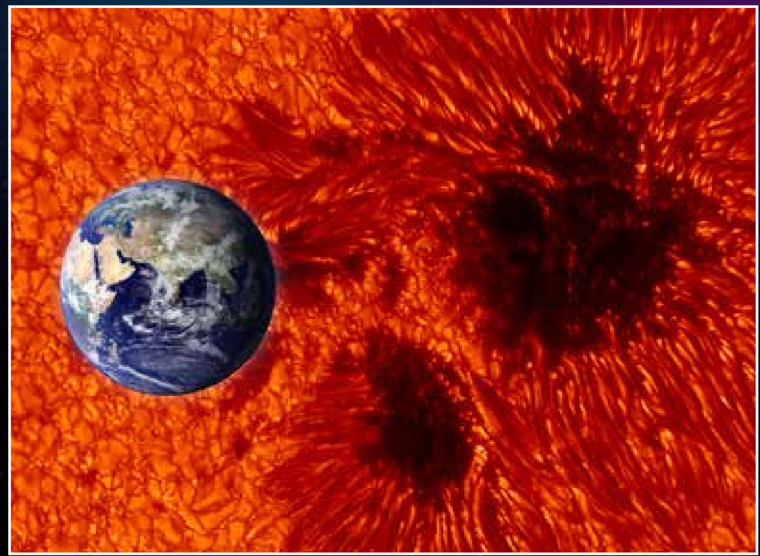
High-speed solar wind streams flow from coronal holes into space at speeds of up to 800 km per second. If conditions are right and these streams reach the Earth, geomagnetic storms may occur.

Solar Wind

The solar wind is a stream of charged particles constantly flowing from the upper atmosphere of the Sun. It consists mostly of electrons and protons and varies in temperature and speed over time.

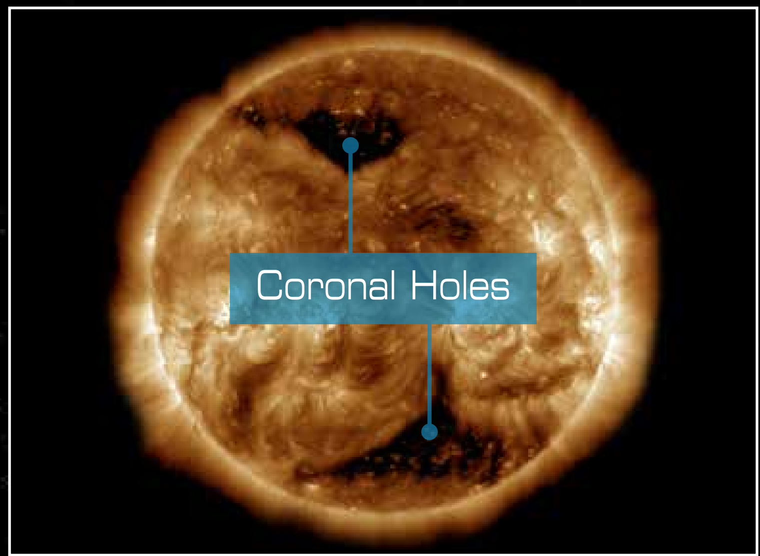
Main Solar Features

Sunspots and Solar Active Regions - Sunspots are dark features that appear on the surface of the Sun. They vary in size, shape and lifetime. Sunspots appear in areas where the magnetic field is very strong. They appear to be darker than the gas surrounding them, because they are several thousand degrees cooler.



A small sized sunspot is about the size of the Earth.

However, when sunspots are observed by means of ultraviolet or X-ray filters, there appears to be high emission activity in the corona. That emission is produced by the plasma that travels on the powerful magnetic fields emerging from the sunspots. We refer to the whole view as solar active regions. Active regions may produce coronal mass ejections which may result in solar superstorms.



High-speed solar wind streams from coronal holes may cause geomagnetic storms on Earth.

What is Space Weather?

Due to societies increasing dependence on modern technology space weather has become a hot topic around the world. Space weather refers to a collection of physical processes, beginning at the Sun and ultimately affecting technology on Earth and in space. The Sun emits energy by means of electromagnetic radiation, coronal mass ejections (CMEs) which release high-energy charged particles, and plasma streams.

The charged particles from the Sun travel outwards in the solar wind, carrying parts of the Sun's magnetic field. The electromagnetic radiation travels at the speed of light and takes about 8 minutes to move from the Sun to Earth, whereas the charged particles travel slower, taking a few hours to several days to complete the same journey. The radiation and particles interact with the Earth's magnetic field and outer atmosphere in complex ways which may cause disturbances to technological systems in space and on Earth.

> *Space weather poses a risk to society, the economy and national security.*

What are the effects of space weather?

An extreme space weather event or solar superstorm is a potentially high-impact, low-probability natural hazard. Due to a growing awareness of the potential consequences of extreme space weather, governments in numerous countries now consider this as an element of national risk assessment.

Superstorms may have detrimental effects to the power grid, satellites, avionics, and aircraft over polar regions, High Frequency (HF) radio communication, mobile telephones and GPS systems, to name a few. Solar superstorms have consequently been identified as a risk to the world economy and society.

Magnetic disturbances induce electric currents in long conductors such as power lines and pipelines. This may cause power outages or excessive pipeline corrosion. Magnetic disturbances also directly affect operations that use the magnetic field, such as magnetic surveys, directional drilling and the use of compasses. Radio waves, which are used for satellite communication and GPS navigation, may be affected leading to disruption of communication and/or navigation systems. Satellites may also suffer damage to electronics due to radiation.

Find out more about space weather at SANSA
Email: spaceweather@sansa.org.za | Tel: +27 (0)28 312 1196 ext 2764 | Website: http://spaceweather.sansa.org.za
SANSA Space Science, Hospital Road, Hermanus 7200, South Africa

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

In Service of Humanity

sansa
SOUTH AFRICAN NATIONAL SPACE AGENCY

Main Solar Events

Solar Flares

A solar flare is an eruption of matter on the surface of the Sun which is accompanied by an emission of electromagnetic energy in the form of gamma rays and X-rays. The biggest flares can be hundreds of times the size of the Earth.

A flare's intensity may be measured in X-ray flux and is grouped in 5 classes A, B, C, M and X. Each class of flare is ten times more powerful than the previous, with A-class flares being the weakest, and X-class flares being the most energetic.

The electromagnetic energy of a solar flare takes approximately 8 minutes to arrive on Earth and its effects may last for a few hours. Effects include interference in radio and satellite communication, HF radio blackouts and GPS errors.

Solar Energetic Particles

Solar Energetic Particles (SEPs) are high-energy charged particles originating from energised solar flare sites or by shock waves associated with CMEs. SEPs consist of protons, electrons and heavy ions and their energy ranges from a few tens of keV to GeV. They are of particular interest and importance as they can endanger life and technological systems in outer space.

SEPs travel between 15 minutes and a few hours on their journey to Earth and their effects may last for a few days. Effects include satellite anomalies, radiation risk to high latitude flights and astronauts, HF radio blackouts and glitches to avionics.

Coronal Mass Ejections

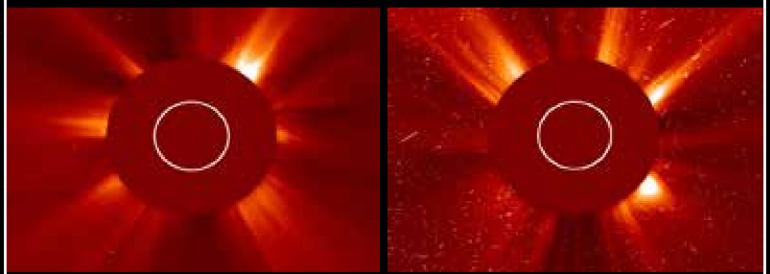
A Coronal Mass Ejection is a large cloud of charged particles that is ejected from the surface of the Sun when stored energy is suddenly released. A CME may disturb the Earth's magnetic field.

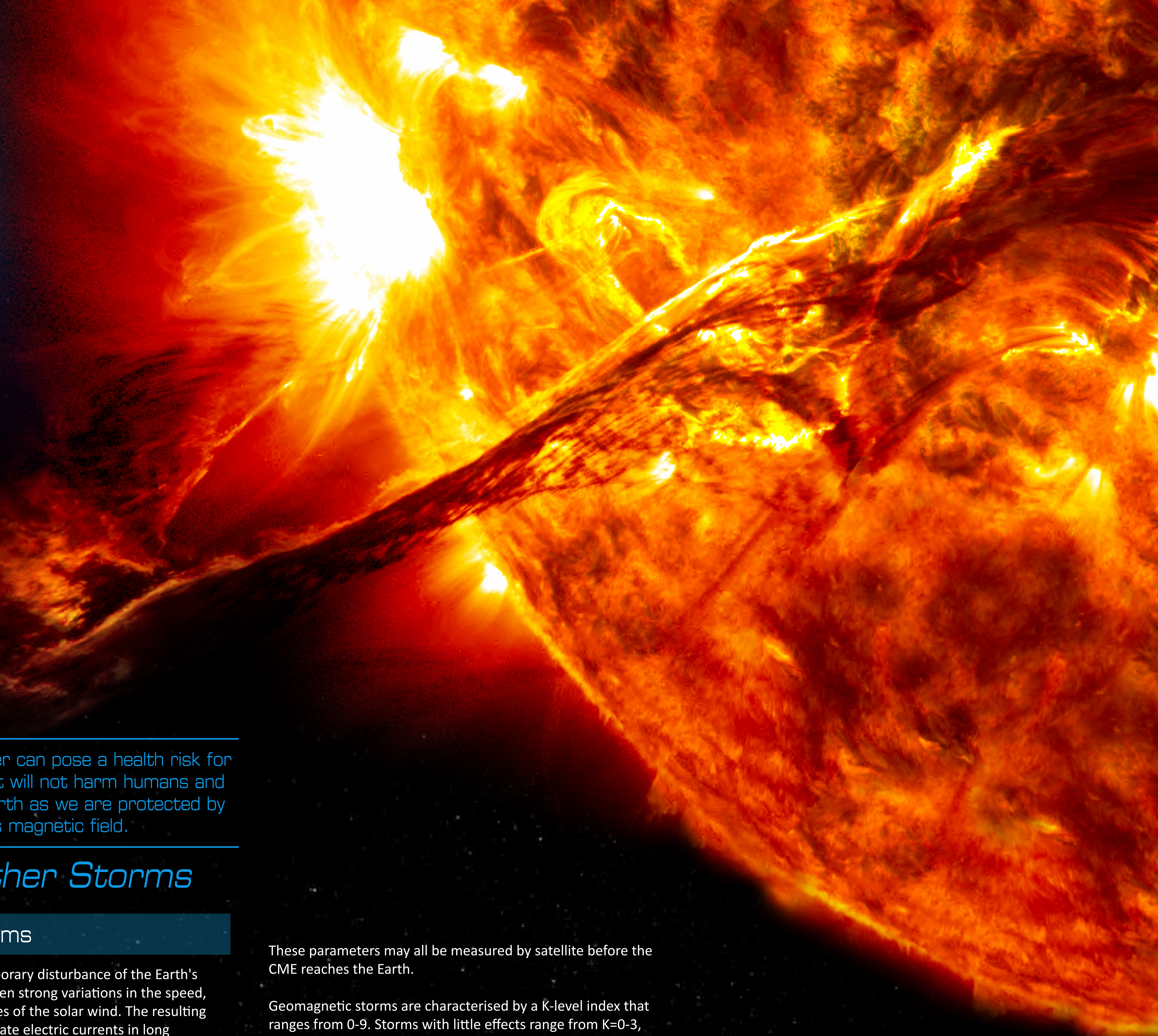
CMEs take approximately 1-4 days to arrive on Earth and their effects may last for a few days. Effects include geomagnetic storms, HF radio blackouts, disturbances to power grids and long distance pipelines, GPS errors and satellite anomalies.

Did you know?

FACT

Did you know? Solar energetic particles can pose a health risk for astronauts and can interfere with satellite electronics. These images show the difference between quiet and noisy SEP conditions.





Although space weather can pose a health risk for astronauts in space, it will not harm humans and other life forms on Earth as we are protected by the Earth's magnetic field.

Space Weather Storms

Geomagnetic Storms

A geomagnetic storm is a temporary disturbance of the Earth's magnetic field, caused by sudden strong variations in the speed, density and magnetic properties of the solar wind. The resulting magnetic field variations generate electric currents in long conductors such as power lines and pipelines. The effects of geomagnetic storms range from mild (interference with aeromagnetic surveys) to extreme (electric power grids may experience blackouts).

The strength of the geomagnetic storm depends on the size of the coronal mass ejection and the magnetic field associated with it. When that field points southward, its interaction with the Earth's magnetic field is stronger, increasing its influence on the Earth's magnetic field. How soon that storm impacts the Earth, is determined by the speed of the CME.

These parameters may all be measured by satellite before the CME reaches the Earth.

Geomagnetic storms are characterised by a K-level index that ranges from 0-9. Storms with little effects range from K=0-3, mid-level storms measure between K=4-7, and strong storms measure between K =7-9.

Ionospheric Storms

Solar activity such as solar flares and coronal mass ejections may lead to turbulence in the ionosphere known as ionospheric storms. These tend to generate large disturbances in ionospheric density distribution, total electron content, and the ionospheric current system. Ionospheric storms may impact satellite communication and the flow of electrical energy.

CMEs travel at supersonic speeds of up to 2000 km per second. That speed would get you from Johannesburg to Cape Town in less than one second.