What is space weather?

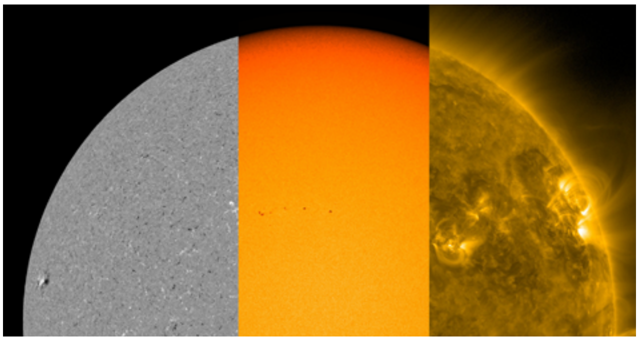
The Sun is the principal driver of what is known as space weather. Space weather is the effect of the space environment on technology and the near-Earth space environment.

Space weather and technology

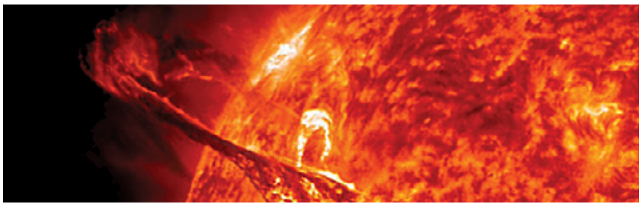
Space weather can pose a serious threat to increasingly complex communications and technological systems. It can impact technology in the near-Earth space environment and on Earth by:

- varying the Earth's magnetic field
- enhancing electrical fields and currents in the atmosphere and the ground
- increasing the amount of radiation entering the upper atmosphere
- varying the density and stability of the upper atmosphere.

As reliance on technology grows, so does the risk of disruption to our daily lives.



Images of the Sun on 2 March 2017. The left is a magnetogram showing magnetic fields in black and white. The middle is the Sun's surface in filtered light. The right image is the Sun's surface in extreme ultraviolet light, showing ions along magnetic field lines. (Image credit: NASA/SDO and the AIA, EVE, and HMI science teams).



Solar flare – Image couresty of NASA.

What causes space weather?

The Sun's turbulent activity is the main source of space weather. Solar events that cause space weather impacts include solar flares, coronal mass ejections (CME) and particle radiation events.

Particle radiation

Solar energetic particle events are bursts of high-energy protons accelerated from the Sun's outer atmosphere. The protons are accelerated to speeds comparable to the speed of light. They can affect satellites and cause health concerns for astronauts and airline passengers..

Solar flare

Solar flares are sudden bursts of X-ray energy from the Sun. The X-rays travel at the speed of light and impact Earth within eight minutes of occurring. These can cause what is known as radio blackouts. Radio communications, GPS and radar technology can all be affected.

Coronal mass ejection

DDuring a CME, billions of tonnes of magnetised solar plasma erupts into space at up to 3000 km/s. If the material is directed towards the Earth, geomagnetic and ionospheric storms can occur.

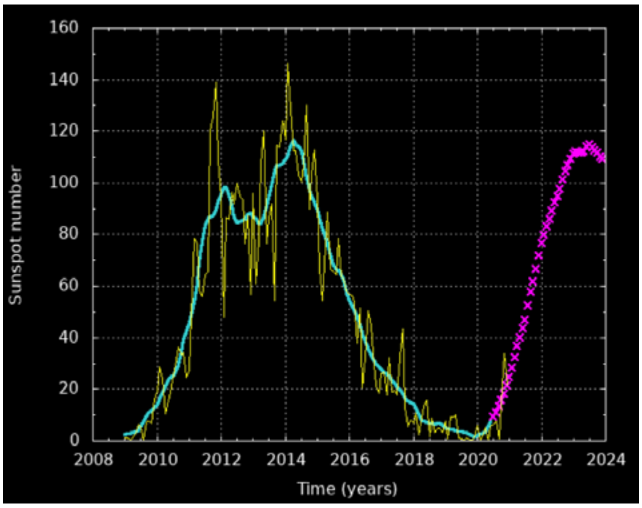
Both can significantly disrupt technology in the near-Earth space environment. The event's size and scale will determine the level of impact and type of disruption to technologies.

Impacts on the space sector

Severe-to-extreme space weather is a key threat to the space industry, particularly satellites and space-based assets. Impacts could include:

- surges of electric current capable of disrupting satellites in orbit
- an increase in ions impacting satellites, overwhelming sensors, damaging solar cells, and degrading wiring and other equipment
- increased risk of exposure for astronauts to harmful solar radiation
- changes to orbital dynamics, such as satellite drag, impacting the lifespan of low-Earth orbit satellites.

To communicate space weather conditions and their possible effects on Australian industry sectors, the Bureau developed the Australian Space Weather Alert System.



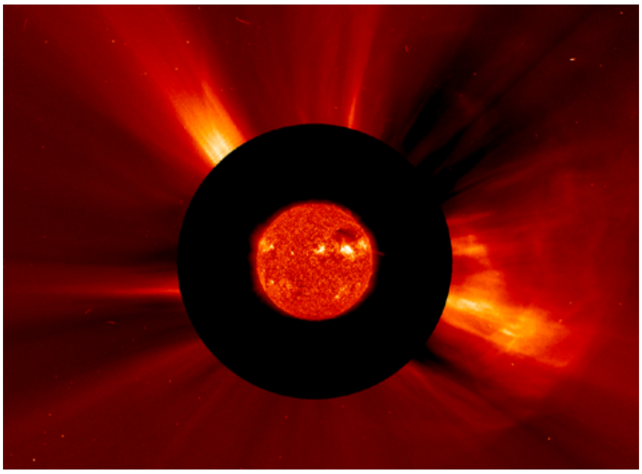
Sunspot measurements for solar cycle 24, which ended in 2019, (thick turquoise line) and prediction for solar cycle 25 (magenta crosses). The thin yellow line shows observed monthly sunspot numbers. Solar cycle 24 was the least active since solar cycle 14, which started in 1902.

Solar cycles

The Sun's magnetic field goes through a complete cycle approximately every 11 years. This is called the solar cycle. During a solar cycle the Sun's north and south magnetic poles reverse.

The beginning of a solar cycle is a solar minimum – when solar activity is generally low. Over time, activity increases to its maximum roughly halfway through the cycle. This is when sunspots increase in size and number, and solar flares and coronal mass ejections are most likely to affect the near-Earth space environment.

Some solar cycles are much more active than others. The current cycle – known as cycle 25 – is expected to be similar in strength to cycle 24 and will likely reach its peak between 2023 and 2026. The Bureau of Meteorology forecasts solar activity for the years ahead, allowing affected sectors to prepare for the impacts of an increase in solar activity.



Coronal mass ejections occur when large clouds of plasma and magnetic field erupt in the Sun's outer atmosphere. (Image credit: NASA/SDO and the AIA, EVE, and HMI science teams).

July 2012 coronal mass ejection

On 23 July 2012, a large coronal mass ejection occurred, projecting massive amounts of solar plasma into space. The eruption missed the Earth, but enveloped NASA's STEREO-A satellite, which measured the eruption as one of the fastest coronal mass ejections ever observed.

A 2013 study estimated that the USA would have suffered between $600 billion and $2.6 trillion in damages, mainly to electrical infrastructure, if this coronal mass ejection had been directed towards the Earth. The 2012 event highlights the risk geomagnetic storms pose to critical infrastructure on Earth and in the near-Earth space environment. Our ability to observe and monitor solar activity is crucial.

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