Australian Government
Bureau of Meteorology

Overview of space weather and potential impacts and mitigation for the Australian community

A severe space weather event can disrupt electrical currents in power lines, increase radiation in the atmosphere, disrupt communication and navigation, damage satellites and risk human health. Impacts for the Australian community can be serious. Response and mitigation planning is necessary.

Key points

- Severe space weather can significantly disrupt the technology that underpins our energy, transport, communication, and financial systems. There are major flow-on effects for the Australian community.
- Further research and planning are required to build awareness and resilience to severe space weather for the community.

What causes space weather?

The main driver of space weather is the Sun. Solar activity and the resulting space weather vary day-to-day, seasonally, and over multi-year cycles. Irregular solar activity, including explosive eruptions called solar flares and coronal mass ejections (CMEs), can have a significant impact on the near-Earth space environment.

Major solar flares can be associated with an increase in:

- x-ray and radio emissions that reach Earth within 8 minutes
- energetic protons, reaching the Earth in 20 minutes to 6 hours
- solar wind particles and magnetic field strength, typically reaching Earth within half a day to 3 days.

During a CME, billions of tonnes of magnetised solar plasma erupt into space at up to 3000 km/s with increased solar wind particles and magnetic field strength, typically reaching Earth within half a day to 3 days. If the material is directed towards the Earth, geomagnetic, ionospheric and radiation storms can occur.

Severe space weather can significantly impact the technologies we rely on in different ways and over different time scales.

How does space weather affect the community?

Power networks

Severe space weather can cause the failure of key power network infrastructure and destabilise the electricity transmission network. This can have a major effect on the communication, health, financial and transport systems the Australian community relies on.

A severe geomagnetic storm can induce electrical surges in long-distance power lines, causing damage to high-voltage transformers. Power lines at high latitudes are particularly susceptible. The conductivity of the ground nearby can also influence the level of impact.

The impact on power networks can range from short-term outages and restrictions to extended loss of electricity supply due to widespread infrastructure damage.

EXAMPLE: SEVERE SPACE WEATHER CAUSES SHUT DOWN OF POWER GRID IN QUEBEC

In Canada in 1989, a severe space weather event caused a complete shut down of Quebec's power grid. The outage affected 6 million people and lasted over 9 hours, before power was eventually restored.

Satellites

Satellite technology underpins many of the communication and navigation services used by the Australian community. Satellites are vulnerable to severe space weather because of their location in the near-earth space environment, where they can be exposed to damaging radiation. Impacts on the community include poor performance or loss of global positioning system (GPS) navigation and satellite-based communication services.

The main source of damaging radiation is the Sun. However the Earth's own radiation belts and distant cosmological sources such as black holes can also disrupt satellites. Radiation can interact with satellite electronic systems, causing temporary disruption or permanent damage.

Severe space weather does not just threaten satellites themselves, but also the functions they perform. Radio waves passing between satellites and ground receivers may be interrupted, causing disruption to satellite-based communication and navigation services. This would affect the performance of car navigation computers, smart phones, and watches.

Estimates show that during a major storm, there could be a complete loss of global navigation satellite system service for one day, and an extended loss of service for 3 days.

EXAMPLE: SEVERE SPACE WEATHER CAUSES LOSS OF DATA AND TELEVISION SERVICES IN CANADA

In 1994 severe space weather caused the failure of two Canadian communications satellites within 9 hours of each other. The failure resulted in disrupted data transmissions across Canada and disconnected data and television services to over 1,600 remote communities for several hours.

Aviation

Radiation exposure, disruption to aircraft electronics, and potential loss of communication and navigation systems pose a risk to the safety of air transport for the Australian community.

- During a severe space weather event, levels of harmful radiation exposure at high altitudes increase. This can have short and long-term impacts on human health. The risk of radiation exposure is heightened in polar regions.
- Navigation systems used by aircraft, such as GPS, can become inaccurate or unavailable.
- Radiation can interrupt or damage an aircraft's electronic systems.
- Availability of communication systems such as high frequency (HF), very-high frequency (VHF) and ultra-high frequency (UHF) radio can be disrupted or lost.

EXAMPLE: SOLAR FLARE ACTIVITY IMPACTS AIR-TRAFFIC RADAR FOR 90 MINUTES

On 4 November 2015, air traffic control centres in Stockholm and Malmö, Sweden, noticed that radar stations of the Swedish air navigation service provider were not relaying the correct data to air traffic control. This was later attributed to solar flare activity. The interference resulted in a 90-minute impact to radar capability across Swedish airspace.

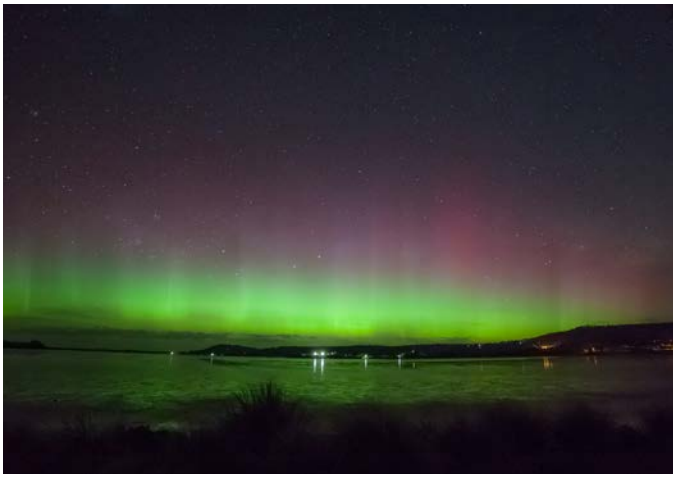
Radio communication

HF radio is an important tool used by some members of the community for long-distance communication. It is also used in the aviation, shipping, defence and emergency services sectors.

HF radio uses a layer of the Earth's upper atmosphere called the ionosphere to propagate radio signals over long distances. Space weather can cause variations in the Earth's ionosphere, resulting in decreased performance of HF radio communications.

Resource pipelines

Long steel pipelines that carry essential resources such as natural gas use protection systems to help extend their lifetimes. Geomagnetically induced currents caused by severe space weather can interfere with these protection systems, causing increased corrosion and a reduction in asset lifespan. Space weather can also interfere with routine inspection of pipelines.



Auroras

Auroras are a visual manifestation of space weather. They routinely occur in the night sky over high-latitude locations such as Antarctica, and even in southern parts of Australia, such as Tasmania. For some members of the community, viewing and photographing auroras is a recreational pursuit.

Bright auroras extending to unusually low latitudes may indicate that severe space weather is occurring.

Response to a severe space weather event

Like any severe weather, it is critical to plan and prepare for severe space weather.

The Bureau provides forecasting and real-time observations of space weather. This gives the opportunity to take protective action and prepare for disruptions. In extreme events we provide a severe space weather warning service.

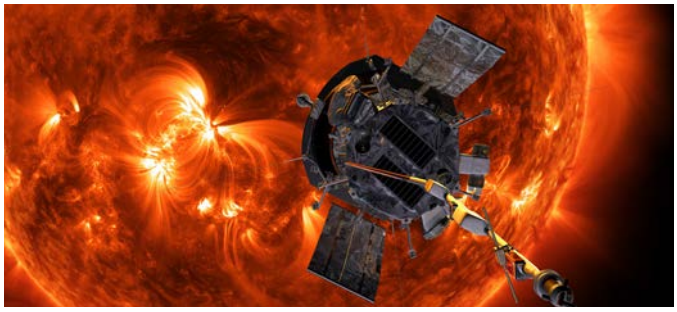
We work closely with the community to limit their space weather risks, including delivery of:

- space weather forecasts, warnings and alerts
- tailored space weather services for business
- real-time and historical observations
- HF radio advice and planning tools
- consultancy and technical support
- space weather training.

Longer-term mitigation measures

Understanding space weather risk also means designing and managing processes, systems, and infrastructure differently. With targeted research and development Australia's resilience can be increased. To ensure the community becomes more resilient in the future, the Bureau:

- continue to conduct risk assessments to obtain a comprehensive understanding of the direct impacts of space weather on the various industries within this sector and subsequent indirect impacts due to dependencies across other sectors.
- continue to practice under the Australian Government Crisis Management Framework to respond to space weather events that coordinates Australia's response to severe space weather across relevant departments, agencies and industry informed by appropriate risk assessment findings.
- collaborate with industry, government, and academia to develop and improve models and forecast capabilities, validated with expanded industry observations, that enhance industry's ability to adequately mitigate severe space weather with minimum disruption to society.



CONTACT

www.bom.gov.au

sws_office@bom.gov.au