

# The Met Office and Space Weather

In 2012 the Met Office was tasked by Government with ownership of the space weather risk on the National Risk Register (NRR) of Civil Emergencies and has recently received £4.6 million funding from the Department for Business, Innovation & Skills (BIS) for an operational Space Weather prediction service.

## Why the Met Office?

The Met Office is at the forefront of science, researching and demonstrating new forecasting techniques. This Government investment in the Met Office space weather prediction capability will help Government and business to prepare for and mitigate the impacts of a high impact space weather event and support the growth and resilience of the UK space industry.

Through our work with other partners in the UK, the Met Office will help to ensure that efforts are coordinated as part of an international programme with the US National Oceanic and Atmospheric Administration (NOAA) National Weather Service Space Weather Prediction Centre (SWPC).

The Met Office is a member of International Space Environment Services (ISES) - international body for space weather - and a designated Regional Warning Centre.

## Met Office working in partnership

We're working to develop space weather capability and share valuable knowledge and create the UK's space weather forecasting centre with a range of partners in the US. We have a formal collaboration agreement with NOAA to build knowledge and capability to forecast space weather in the UK and to strengthen collaborative efforts to protect critical infrastructure from the impacts of space weather.

As part of the agreement we have implemented the state of the art 'Enlil' computer model that is used by NOAA to predict the arrival time of Coronal Mass Ejections. Our space weather forecasters liaise on a daily basis with NOAA forecasters to exchange views on the expected space weather conditions for the next few days. We also work with and receive solar imagery from NASA.

In the UK, we're working closely with a range of UK partners including Science and Technology Facilities Council (STFC), British Geological Survey (BGS), University of Bath, RAL Space, British Antarctic Survey and several other universities and research organisations to transfer data, knowledge and models into the Met Office to support our operational forecasting.



# Space weather

## What is space weather?

### Changing conditions in space that impact earth

Space weather describes the environmental conditions in space that can have an effect on Earth.

The most recognisable and visible effect might be the aurorae (Northern Lights) at high latitudes. However, as well as this spectacular natural phenomenon, space weather also provides a real danger to national infrastructure, technology, communications systems and personal health.

The threat of space weather to national infrastructure, UK industry and the wider public is such that in 2011 it was added to the Government National Risk Register of Civil Emergencies. In response, the new Met Office Space Weather Operations Centre (MOSWOC) was created to provide the critical information needed to help protect the country from the serious threats posed by space weather events.

## What causes space weather?

### Behaviour of the Sun, Earth's magnetic field and atmosphere

Space Weather is a consequence of the behaviour of the Sun, the nature of Earth's magnetic field and atmosphere, and our location in the solar system.

The active elements of space weather are particles, electromagnetic energy and magnetic fields, rather than the more commonly known weather contributors of water, temperature and air.

Magnetic fields, radiation, particles and matter which have been ejected from the Sun can interact with the Earth's magnetic field and upper atmosphere to produce a variety of effects.

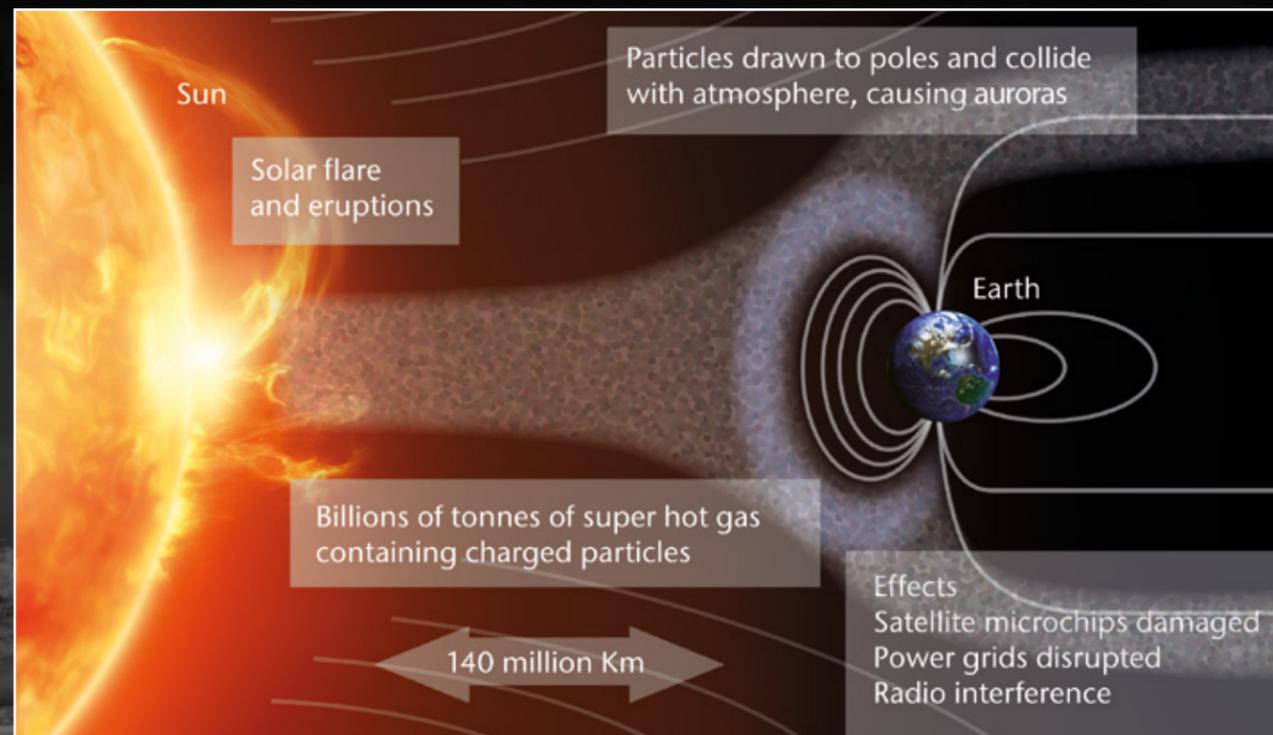
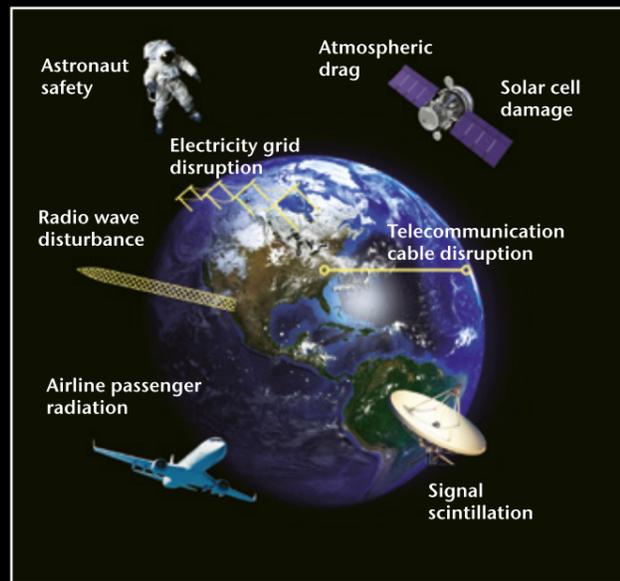
# What is the impact of space weather?

Disruption to Global Navigation Satellite System (GNSS) often known as GPS, satellite systems, radio communications and power grids. Damage to spacecraft and aircraft. Health risk to astronauts and high altitude airline passengers and crew

The Sun is in constant flux and the impact of this solar activity is more apparent as people become more reliant on technology.

Solar flares can cause high-frequency radio and GNSS to perform erratically. Extreme CMEs can put power grids at risk. Therefore, space weather forecasts are of crucial importance to the Armed Forces, electricity industry, satellite operators and the aviation industry.

Severe space weather events, such as geomagnetic storms, can cause significant disruption to everyday technologies such as satellites, GNSS and HF radio, as well as impacting critical infrastructure such as air transportation, the national grid and oil and gas pipelines. Other forms of space weather, such as solar radiation storms, can also provide dangerous levels of radiation to astronauts and, in severe cases, high altitude airline passengers.



# Types of space weather events

Coronal mass ejections, solar radio bursts, solar flares, charged particles

Space weather conditions vary, with streams of particles from the Sun constantly hitting Earth via the solar wind. Earth experiences an increased impact during periods of high solar activity, when a large number (compared to quiet periods) of solar eruptions can occur in the form of flares and coronal mass ejections (CMEs). Extreme events that cause the largest impacts can occur at any time during the 11 year solar cycle.

Solar flares are sudden releases of energy across the entire electromagnetic spectrum. They are hard to detect and the earliest the energy can be detected in Earth's atmosphere is 8.5 minutes after a solar flare (travelling at the speed of light). CMEs are often associated with flares, eruptions of large amounts of matter from the solar atmosphere. These can take approximately 18-96 hours to reach Earth. They carry a local magnetic field from the Sun and their arrival time is the focus of space weather forecasting.

Storm Type	Travel time	Physical Impact	Technological Impact
Geo-magnetic	18-96h	<ul style="list-style-type: none"> <li>Geomagnetic induced currents</li> <li>increased ionisation in ionosphere</li> <li>heating in the thermosphere</li> </ul>	<ul style="list-style-type: none"> <li>Power grid outages, etc</li> <li>GNSS, HF comms</li> <li>Satellite and other hardware damage (eg surface charging)</li> <li>Satellite orbits (drag, collision risk)</li> <li>HF comms</li> </ul>
Charged particles	10mins - 1 day	<ul style="list-style-type: none"> <li>increased radiation levels</li> <li>damage to sensitive electronics increased</li> <li>ionisation in ionosphere</li> </ul>	<ul style="list-style-type: none"> <li>Radiation health hazard (astronauts, aircrew)</li> <li>Satellite heating and instrument noise, avionics, digital chips</li> <li>as above - HF comms out for up to few days in polar regions</li> </ul>
Solar flares	8mins	<ul style="list-style-type: none"> <li>HF radio signal interference</li> <li>heating in the thermosphere</li> </ul>	<ul style="list-style-type: none"> <li>HF comms (~mins-hrs, sunlit side)</li> <li>As above</li> </ul>

# What is being done to minimize the threat?

In response to the threat, the Government has listed solar storms as the fourth most serious threat on the National Risk Register as they are recognised as having potential significant impact on the UK's critical national infrastructure.

Subsequently, the Met Office Space Weather Operations Centre (MOSWOC) was created to provide a UK operational space weather prediction centre to help protect the country from the serious threats posed by space weather events.