
# SPACE WEATHER

*Rapid changes in the Earth's space environment can disrupt the technologies that society depends upon*

**What is space weather?**

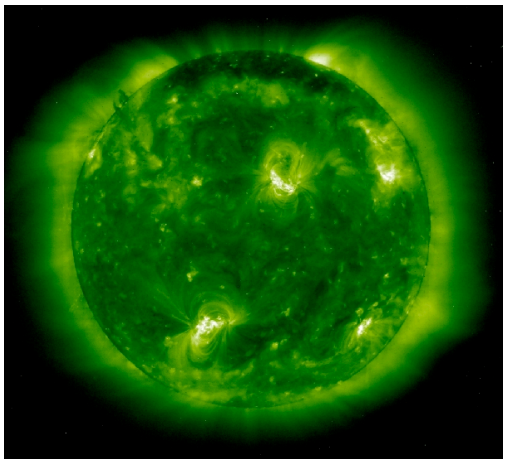
Space weather is the name we give to variations in the natural space environment that have possible impacts on biological and technological systems. These variations are caused by phenomena across the solar system, especially on the Sun, and can happen very quickly. For example, active regions on the Sun (see image) can emerge in a few hours with little or no warning and generate radiation, solar flares and coronal mass ejections at a few minutes notice. These phenomena are dangerous to astronauts and spacecraft and can disrupt operation of high-technology systems on Earth.

**How can space weather affect me?**

The surface of the Earth is shielded from most of the effects of space weather by our planet's strong magnetic field and dense atmosphere. Even the worst space weather disturbances have virtually no direct impact on life on the surface of the Earth. However, many of the modern technologies that we take for granted including power grids, satellite technology and air travel are vulnerable to inclement space weather.

**How big can the impact be?**

In 1859 severe space weather caused a geomagnetic storm that paralysed telegraph systems for hours. More recent storms caused black-outs in power grids in Quebec (1989) and Sweden (2003) and disrupted satellite operations and communications. Severe space weather occurs approximately once or twice during every 11-year sunspot cycle and, as our dependence on modern technology grows, our susceptibility to space weather also grows. A modern storm comparable to the 1859 event would have severe consequences for modern technology.



▲ ***Solar activity from bright regions shown here can disturb the near-Earth space environment in which satellites operate [image: ESA/NASA SOHO mission]***

**How well can we forecast space weather?**

At present it is difficult to predict unusual space weather more than one hour ahead. We do not yet understand how the many different elements of space weather (on the Sun, in the solar wind and around the Earth) come together to produce abnormal conditions. We also lack an observational network that can maintain adequate awareness of space weather conditions and that can enable future research. We can calculate rough probabilities that a sunspot region will produce a major solar flare within a given future time-frame, but we cannot yet forecast how large it will be, whether it will be accompanied by a coronal mass ejection, or whether the ejection will have substantial effects at Earth.

**Who is, or should be, considering the risk on our behalf?**

Space weather is both a national and global hazard. It poses a risk to our technology infrastructures and to strategic interests. Governments (UK and European), space agencies and industry regulators are therefore the most appropriate bodies to consider the risk from space weather.

**What is UK involvement in space weather activities?**

UK scientists and engineers are deeply involved across the full range of space weather activities. These activities include regular monitoring of space weather effects on the geomagnetic field and the ionosphere as well as advanced observations and scientific studies of the Sun, solar wind and magnetosphere. These studies include a strong interest in modelling space weather phenomena. There is also a growing interest in the provision of space weather services with involvement from universities, government labs and industry.

**Why has space weather become important?**

There is direct evidence of solar activity going back 400 years to the time of Galileo, and indirect evidence of space weather (such as spectacular aurorae) going back much further. But it is only within the last few decades – the space age – that space weather has come to be a threat to our way of life. This is because so much of our technology, in space and on the ground, is vulnerable to electro-magnetic and radiation disturbances.

**What can we do to mitigate the risk?**

We must provide engineers with good quality data and computer models on the range of space weather conditions, so they can try to design systems to cope with these conditions. Observations and data on current conditions and forecasts are also vital so operators are aware of adverse space weather and can take appropriate action to protect systems.

**What research is needed?**

We need substantial improvements in the accuracy of space weather models so that we can track space weather from the Sun to the Earth with the same accuracy found in ordinary weather observations and forecasts. We also need to learn what are the credible worst-case conditions, so that we can protect people and civilisation from the impact of these. To enable this research we need simultaneous high-quality observations of space weather phenomena at the Sun, in the solar wind and throughout geospace.

## FACTFILE

- The 1859 "Carrington Event" – named after British Astronomer Richard Carrington – is the biggest space weather event on record
- During the Carrington Event the global electric telegraph system – the "Victorian Internet" - was severely disrupted
- NASA has estimated that the total economic impact on the US economy of a similar event today could be $2 trillion in the first year alone
- Geomagnetic storms and space weather impacts usually peak 2-4 days after solar activity, e.g. solar flares and coronal mass ejections
- The UK space industry is estimated to contribute £7 billion to the UK economy annually, but many space assets are vulnerable to space weather

*Banner image: Pete Lawrence*