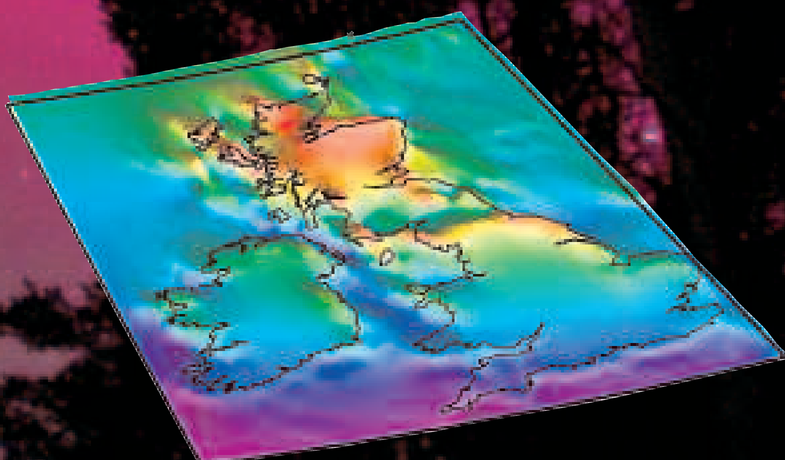
The Northern Lights can spell trouble for our hi-tech society. Alan Thomson explains how geomagnetism research helps tackle the threat.

Light sky at night?

Power companies' fright!



Rapid geomagnetic variations caused the strong surface electric field shown here, at around 9pm on 29 October 2003. The 'red zone' electric field was up to 50 times more intense than the normal quiet level seen far to the south. This electric field drove strong unwanted currents through the national power grid.

The aurora borealis, or Northern Lights, is a beautiful natural phenomenon best seen on clear winter nights. It has delighted and puzzled us for thousands of years. Ancient folk tales tell of its origins and portents. But the aurora also has a very modern consequence that many people don't know about. The same natural processes that cause the aurora put our technological society, connected by satellite communications and driven by electrical power, at risk.

Auroras are a side effect of geomagnetic storms and are powered by massive eruptions of gas from the Sun. We get the aurora light show because of passing clouds in the solar wind (caused when gases from the Sun's corona burst out into interplanetary space, dragging with them the Sun's magnetic field). These clouds energise electrical currents in space around the Earth. The aurora is then formed in great ovals, centred on the magnetic north and south poles. Protons and electrons rain down into the upper atmosphere above the auroral ovals. Each particle shower gives up energy as red, green and other coloured light through collisions with atmospheric gases. Knowing precisely when and how strongly the Sun's corona will erupt is a hot topic in the science of 'space weather'. What we do know is that the number of daily eruptions follows the 11-year sunspot cycle.

So what exactly is the problem? Well, geomagnetic storms can quickly alter the compass direction. For example, the compass changed temporarily by five degrees in as little as six minutes in the UK, during a storm on 30 October 2003. And strong electrical currents, made to flow in near-Earth space, readily divert into the upper atmosphere, causing localised heating. This heating changes atmospheric density and can drag satellites in low orbits off position. Telephone and TV reception from satellites can become poor as the strengthened ionosphere absorbs more of the energy from ground to satellite radio links. Satellites themselves can be damaged by fast, energetic particles. Even on the Earth, high-frequency radio communications can become erratic or fade completely.

Rapid geomagnetic variations under the auroral arcs also cause electricity to flow in the soil, water and rocks of the Earth. These currents find their way into earthed metal networks such as power grids, pipelines, railways and undersea cables. Power transformers can become inefficient, and power transmission over the grid can become unstable. Transformers can suffer permanent or cumulative damage. In March 1989, the power grid of Quebec, Canada, failed catastrophically during a particularly severe geomagnetic storm. Millions of people were without power for many hours, costing business and the public billions of dollars. There was widespread surprise at this 'new' phenomenon and power companies around the world invested time and money to find solutions to the unwanted Earth currents. They developed strategies for protecting at-risk equipment, but the problem has never been satisfactorily solved. Indeed, places as far apart as Sweden and South Africa still suffered significant power problems in October 2003, because of the largest geomagnetic storm of the current solar cycle. Given that one to three 'super storms', like that in March 1989, will occur each sunspot cycle, the risk remains.

In Britain, the British Geological Survey (BGS) has been assessing geomagnetic risk with the National Grid (in England and Wales) and Scottish Power (in central Scotland) since 1998. In 1999 we started supplying geomagnetic data and a daily, three-day space weather forecast to Scottish Power to help manage power safely and securely. We also analysed individual events to determine which types of geomagnetic storms cause the greatest impacts within the power grid.

In 2003 the European Space Agency wanted to explore the potential of space weather services for European industry and society. As part of this, the Agency asked BGS to develop new services in the power industry. We used our expertise in space weather, geomagnetic and geoelectric variations, induction of Earth currents and UK geology and geophysics.

We have now completed a state–of-the-art package of data, models and studies of events, all communicated through simple-to-use webpages. We've added two completely new functions to the service we were providing to Scottish Power.

The first function searches for shocks in the solar wind, akin to detecting the bow wave ahead of a fast-moving ship. Fast clouds in the solar wind cause geomagnetic storms. Detecting shocks ahead of these clouds provides about 20-60 minutes warning of impending geomagnetic storms.

The second function models the unwanted electrical currents that flow everywhere in the high voltage power grid during a geomagnetic storm. UK power grid companies typically only monitor at a few fixed sites in the grid, yet there are many hundreds of expensive transformers grounded in the earth. Our model highlights where the unwanted currents may be flowing, and potentially causing immediate or long-term damage. This should prove more economic and more practical than installing data monitors throughout the grid. Our package, together with recent industry and our scientific experience, will help in the European Space Agency's planned assessment of the market for space weather services this year.

So next time you get the chance to see the 'pretty side' of the aurora, remember that someone somewhere may be contemplating its darker side, trying to make our society less vulnerable to our variable Sun, and making decisions that ultimately help keep the lights on back indoors.

UK compass north changed by five degrees in as little as six minutes.

Want to know more?

You can read more about space weather at: www.geomag.bgs.ac.uk/spweather.html. A public access website, demonstrating some of the services BGS offers industry, is at www.geomag.bgs.ac.uk/gicpublic. The European Space Agency's space weather service 'SWENET' is at www.esa-spaceweather.net/swenet/. If you want to be added to BGS's 'auroral alerts' email service, operated during the normal working week, contact Alan.

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