Global geohazards

Magnetic storms

When the Sun threatens to turn out the lights

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At 02:45 EST on 14 March 1989 the entire electricity power grid in Quebec was blacked out, leaving six million people without electricity for a number of hours. This major disruption resulted from a natural geophysical phenomenon called a magnetic storm. It was known that magnetic storms may have detrimental effects on electricity transmission systems, but until this event no catastrophic failures had occurred, so the problem was more of engineering interest than of operational concern. Despite accurate prediction of the storm, which turned out to be one of the most severe on record, the operating company had no adequate procedures for dealing with the situation.

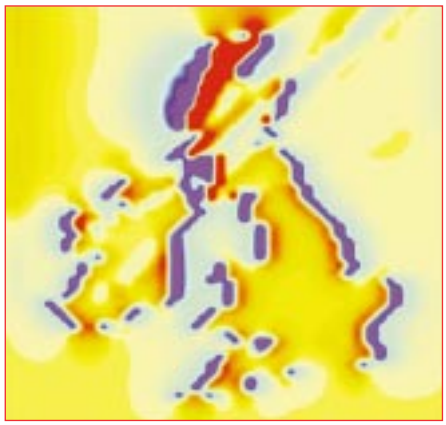
Magnetic storms are periods when the geomagnetic field exhibits large fluctuations on timescales of minutes to hours. A magnetic storm starts with an eruption on the Sun sending out a plasma cloud which takes between one and three days to reach Earth. When it arrives near Earth, electric currents are generated in the upper atmosphere resulting in variations in the surface magnetic field. These events are commonly associated with auroral displays. The occurrence of magnetic storms roughly follows the 11-year sunspot cycle, with fewest storms during sunspot minima, and most storms in the three years following sunspot maxima.

The hazard to power transmission stems from geomagnetically induced currents (GICs) which are induced in the Earth and in the grid by the varying geomagnetic field. When flowing through transformers at each end of the transmission line, intense GICs can cause half-cycle saturation, leading to overheating and harmonic generation. Additionally, transformer protection cut-outs may be triggered in many lines simultaneously, leading to the rest of the grid becoming overloaded.

Usually, high-latitude regions under the auroral zone experience the most intense magnetic storms. However, during severe magnetic storms the auroral belt moves equatorwards over the British Isles, so the GIC risk to the power grid is of concern to the UK electricity industry.

The UK grid is operated by the National Grid Company (NGC), Scottish Power and Scottish Hydro-Electric. These companies are preparing themselves for the next period of maximum magnetic activity due in 2000–2003. The BGS has carried out two GIC related studies for the NGC. One study used 15 years of recordings of magnetic variations from the three BGS observatories in the UK to provide statistics of storms resulting in noticeable GIC effects in the grid. This will help assess long term cumulative damage to transformers from GICs. The second study developed a 3-D model of earth conductivity around the British Isles to a depth of 1000 km, which is used by the NGC to compute the surface electric field which drives GICs in the grid.

An additional service developed by the BGS in recent years for customers in the space and oil industries is monitoring magnetic activity in near real-time, combined with prediction of magnetic activity up to three days ahead by neural networks using observations of geomagnetic and solar activity. This can be useful to grid operators for putting contingency plans into action during times of increased GIC risk.



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The surface electric field induced by geomagnetic variations over the British Isles, computed using a 3-D geological model.

Paul Tod © BGS, NERC

Magnetic storms may have detrimental effects on electricity transmission systems.