British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Space Weather and Extreme Geomagnetic Activity

Alan W P Thomson (awpt@bgs.ac.uk), Ewan B Dawson, Sarah J Reay

web: www.geomag.bgs.ac.uk twitter: @BGSspaceWeather

Introduction

Bad space weather can cause geomagnetic storms on Earth. Geomagnetically Induced Currents (GIC) caused by geomagnetic storms can damage the UK's power network, risking the security of the electricity supply[1].

In 1989, the Quebec grid shut down because of space weather, causing economic losses in the millions of dollars[2]. In the UK two of National Grid's major transformers were damaged by GIC in the storm and were replaced[3].

A 2008 US National Academy of Science report estimated a trillion dollar risk to the United States from a solar super-storm[4].

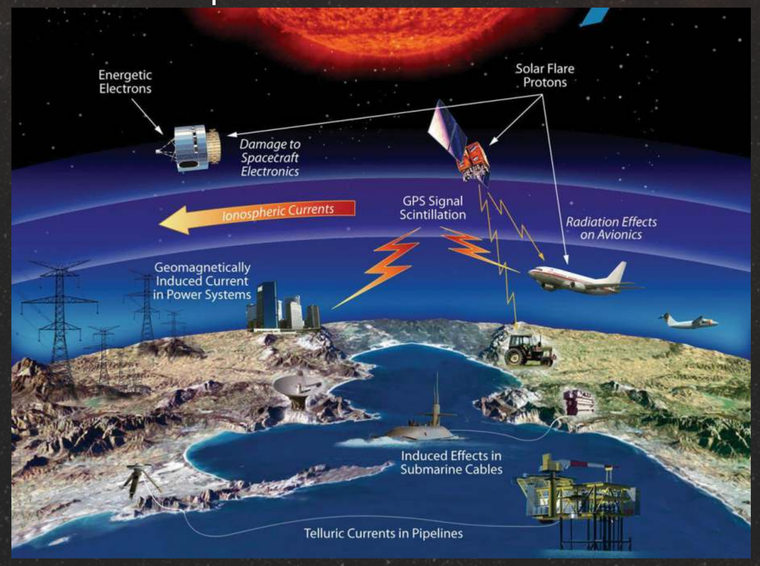

Figure 1. Space weather impacts a range of modern technologies that we rely on. Credit NASA

Analysis

The method of extreme value statistics is applied to 30 years of 12 hour de-clustered and 99.97% thresholded 1-minute geomagnetic data for 28 magnetic observatories in Europe[5].

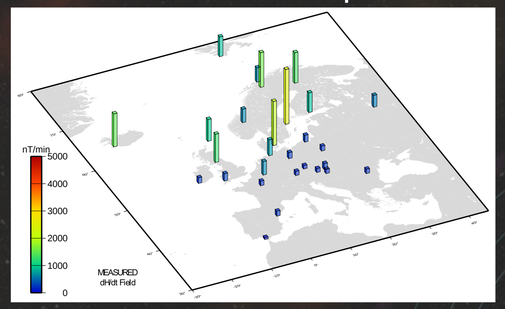

Figure 2. Measured maxima in dH/dt (i.e. the time rate of change in H) at 28 European magnetic observatories, spanning up to 30 years of digital operation. H is the strength in nano-Tesla (nT) of the horizontal magnetic field. H is around 50,000 nT in the UK. dH/dt most closely mirrors GIC flowing in power grids.

One in 100 and one in 200 year estimates for the rate of change of the horizontal magnetic field (significant for GIC) and of the compass direction (significant for navigation accuracy) are derived.

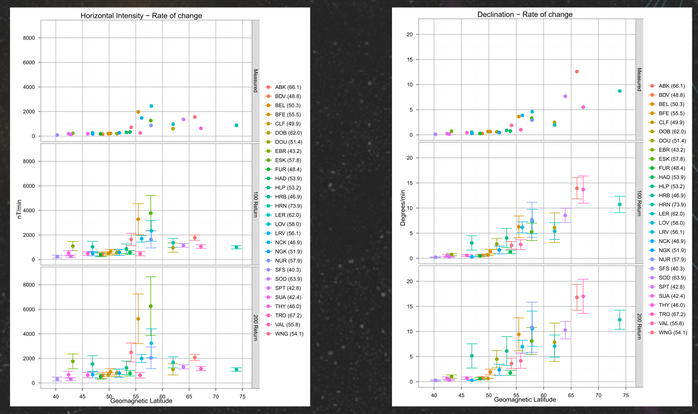

Figure 3. Observed (top) and predicted 1:100 year (middle) and 1:200 year (bottom) maxima in dH/dt (left) and in dD/dt (right). H = horizontal magnetic strength in nT; D = compass variation in degrees about true north.

Impact

BGS is working with National Grid and the UK government to assess the impact on the UK transmission system of a >1:100 year event, based on the results of our paper.

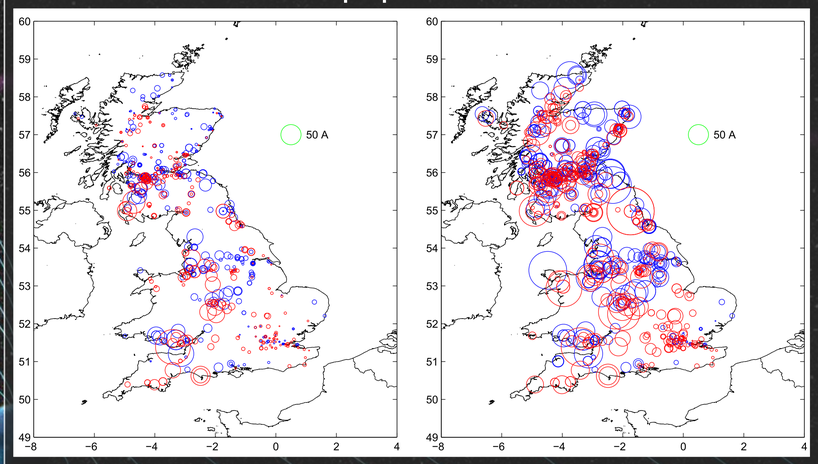

Figure 4. GIC in transformer earth lines from a hypothetical extreme event defined as dH/dt = 5000 nT per minute. Left: GIC due to magnetic variations in a north-south direction; Right: GIC due to magnetic variations in an east-west direction. Reality will be a combination of both.

BGS space weather analysis contributes to the UK government's National Risk Assessment and Register, the Natural Hazards Partnership, the UK space weather strategy, and European and international collaborations.

References

[1]Hapgood, M. And Thomson, A. W. P. (2011). Space Weather: It's Impact on Earth and Implications for Business. Lloyds 360 Risk Insight Report. http://www.lloyds.com/News-and-Insight/Risk-Insight

[2]http://www.zurich.com/internet/main/SiteCollectionDocuments/insight/solar-storms-impact-on-power-supply.pdf

[3]Erinmez, I. A., Kappenman, J. G. and Radasky, W. A., Management of the geomagnetically induced current risks on the national grid company's electric power transmission system. J. Atmos. Sol. Terr. Phys., 64(5-6), 743-756, 2002

[4]National Research Council. Severe Space Weather Events--Understanding Societal and Economic Impacts: A Workshop Report. Washington, DC: The National Academies Press, 2008.

[5]Thomson, A. W. P., E. B. Dawson, and S. J. Reay (2011), Quantifying extreme behaviour in geomagnetic activity, *Space Weather*, 9, S10001, doi:10.1029/2011SW000696

Acknowledgements

National Grid, Department of Energy and Climate Change, Government Office for Science, Civil Contingencies Secretariat, European geomagnetic observatories. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no 260330.