British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

# An Online Digital Archive of Magnetograms from 1846 to 1987

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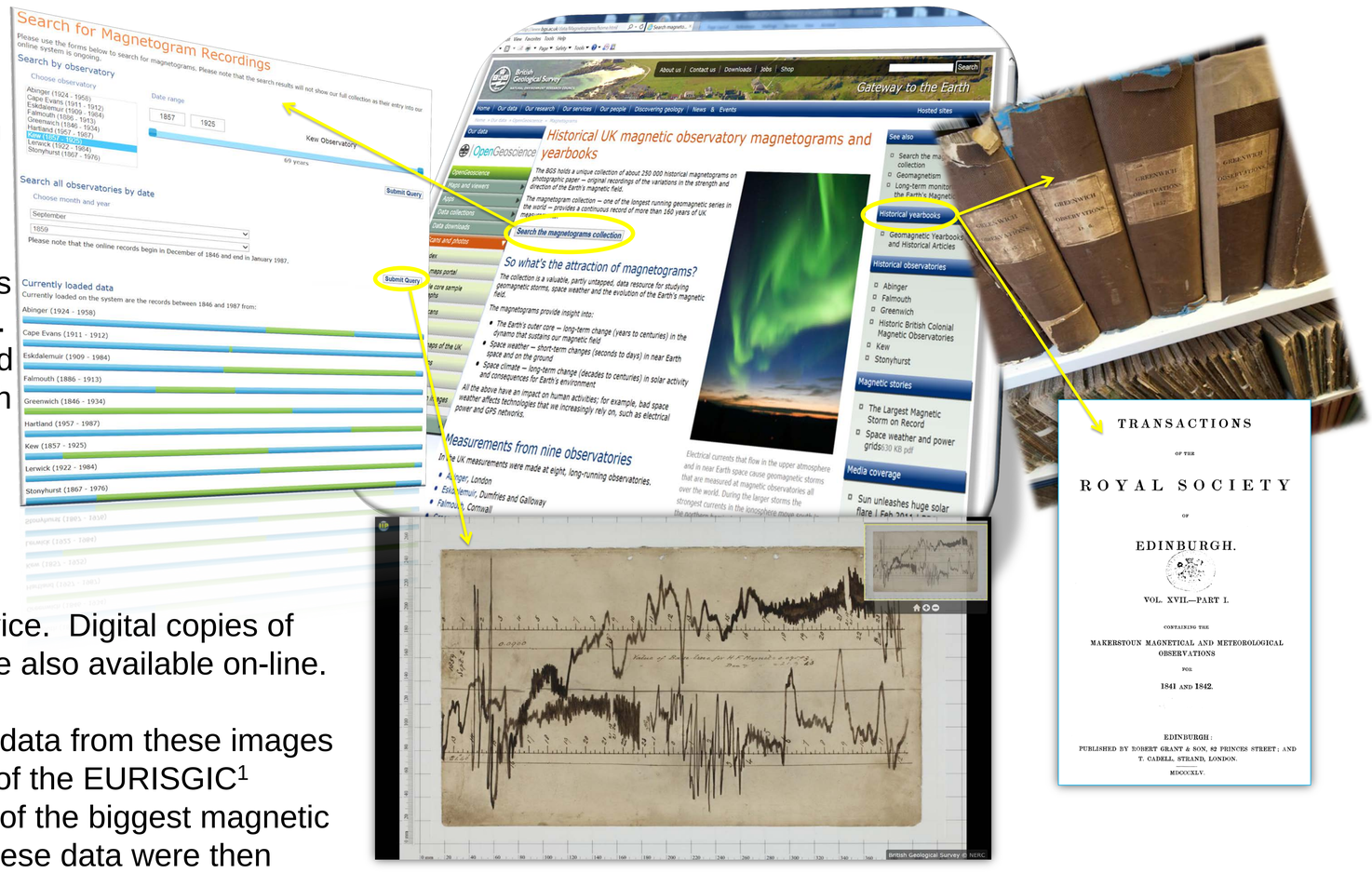
T. Humphries, E. Clarke [ecla@bgs.ac.uk], J. Williamson, S.J. Reay, E. Dawson, B.M. McIntyre, R.P. McIntosh, G.V. Nash and A. Thomson

## Introduction

A campaign lasting more than five years, to capture high quality digital images of the historical archive of analogue magnetograms and yearbooks was finally completed in 2013. Every magnetogram (front and back) dating from the mid 19th Century through to the digital era of geomagnetic recording (1983 in the UK) is now available to search, view and download from the BGS OpenGeoscience on-line service. Digital copies of the observatory yearbooks are also available on-line.




A method of extracting digital data from these images has been developed. As part of the EURISGIC[1] project we investigated a few of the biggest magnetic storms in recorded history. These data were then made available for research. Efforts are on-going to improve and streamline the data-retrieval process so that it can be applied to provide digital data over longer periods and with higher temporal cadence than has so far been available for science.

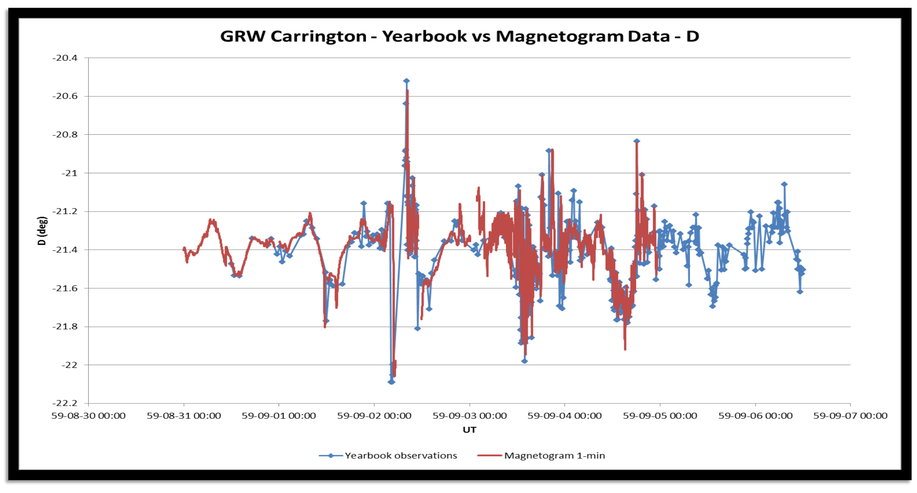
## BGS OpenGeoscience

The geomagnetism digital archive now contains around 300,000 magnetograms from nine observatories. A fixed-position, high-resolution digital camera (Canon D5 Mark 2 - 21 MP - 60 mm macro lens) was used to obtain the detailed digital copies. A web service was developed to enable access to the images as zoomable jpeg2000 format, and further work is planned to enable download of the images in a format selected by the user.

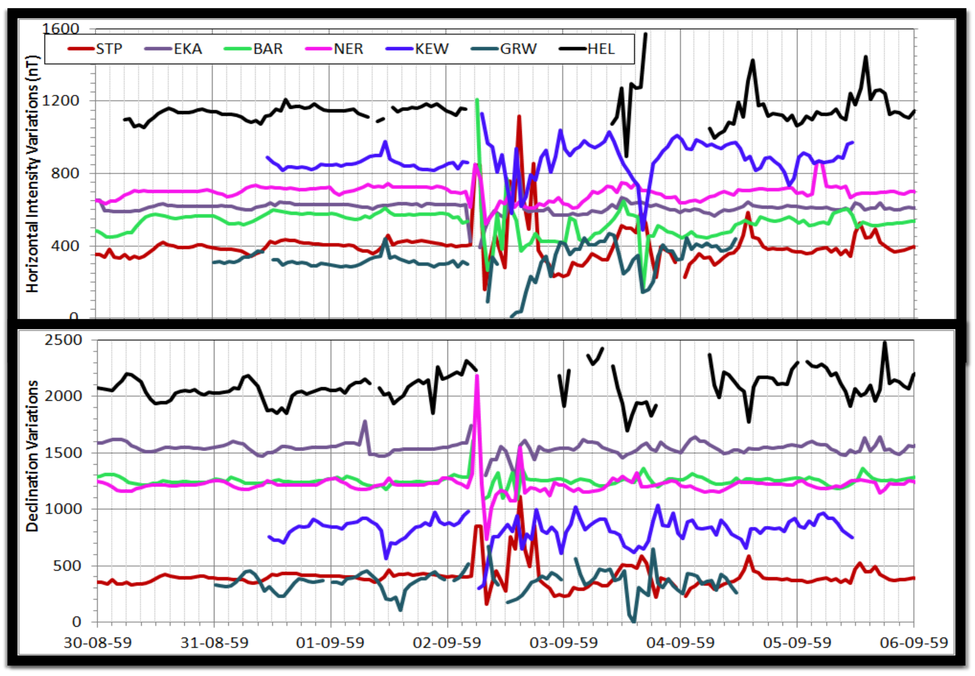
The entire BGS collection of yearbooks was digitised using a Bookeye 3 Scanner at 300 dpi resolution. These books detail vital metadata, such as instruments in use and scale factors for the magnetograms, as well as other data, such as hourly values.

## Digitised Data Comparisons

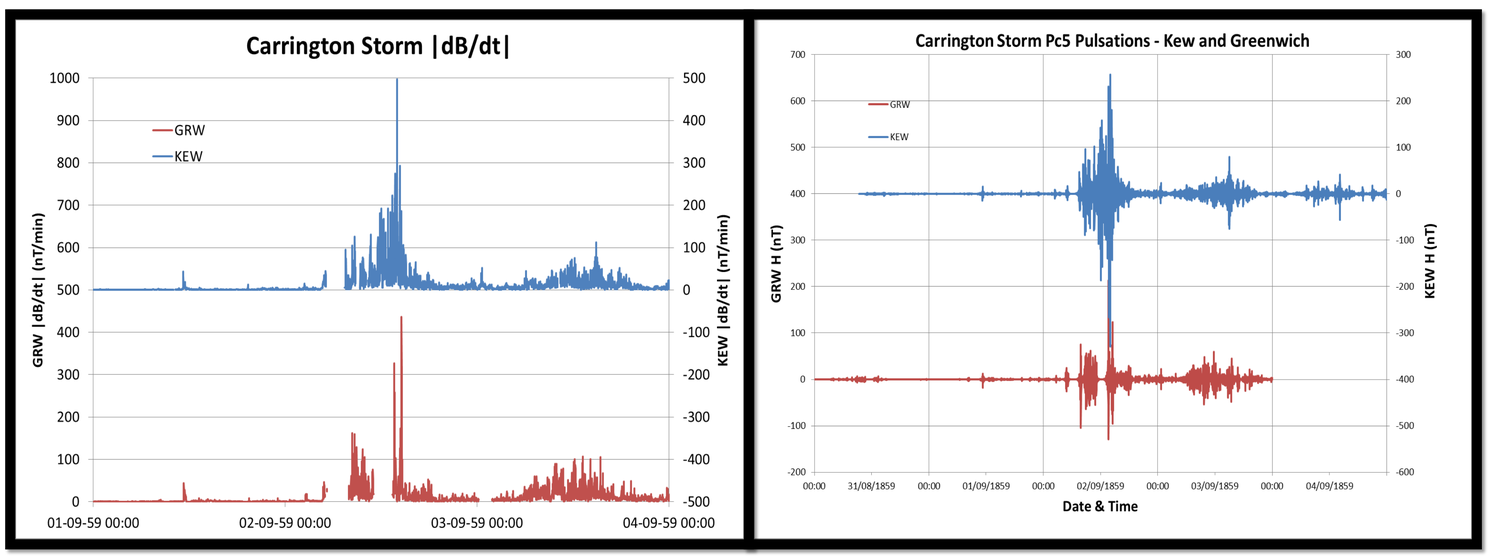
As well as continuously recording the Earth's magnetic field on photographic records, periodic spot measurements were also often made and recorded in the yearbooks. The Greenwich values over a well known magnetic storm have been digitised and comparisons with the data acquired from magnetograms are shown (below). The digitisation work is on-going and problems related to the absolute levels as well as the scale values are still to be resolved.




Published digitised hourly spot readings from Russia and Finland[2], are also compared to similar values extracted from the provisional GRW and KEW data (below) for the same storm as above.




## Solar-Terrestrial Studies




The task of digitising the traces for the most intense geomagnetic storms in history was part of the EURISGIC[1] project, to assess the risk of European power grids from the potentially damaging effects of geomagnetically induced current (GIC) flowing within the grid networks. Translating traces into digital data has provided estimates for the rate of change of the geomagnetic field (*dB/dt*), a driver of GIC. The example (above left) show the results obtained for the Carrington Storm at Greenwich and Kew. *dB/dt* is estimated to be nearly 500 nT/min from the available data. Greater levels are inferred from eyewitness testimony when the trace left the page. Both exceed the highest levels measured in the digital age at similar geomagnetic latitudes (327 nT/min S. England, 3 Mar 1989). The 100/200 year worst case scenario return levels for |*dH/dt*| in London is estimated to be ~600/~800 nT/min respectively[3].

An analysis of the digitised one-minute data has also been made to look at the pulsations during this same storm. Pc5s (2.5 to 10 min filter) have been derived (above right), which gives an indication of the dynamics of the energy exchange between the solar wind and the Earth's magnetosphere.

## Summary, Conclusions and the Future

- All UK analogue magnetograms and yearbooks from 1846 to 1983 are scanned and available online at www.bgs.ac.uk/data/magnetograms and http://www.geomag.bgs.ac.uk/data_service/data/yearbooks/yearbooks.html
- Methods for extracting digital data developed – initial results are promising
- Further development required to improve accuracy and to streamline the process
- Derivation of data products from the newly acquired digitised data e.g. *dB/dt* , magnetic pulsations, *K*-Indices can now be carried out
- Extension of data sets further back in time than has been achieved to date
- Many future opportunities for new research with old data

**References**
1. www.eurisgic.eu
2. Nevanlinna, H (2005), A Study on the great geomagnetic storm of 1859: Comparisons with other storms in the 19th century, Advances in Space Research 38, 180-187.
3. Thomson, A., Dawson, E., Reay, S. (2011), Quantifying extreme behaviour in geomagnetic activity, Space Weather, Vol. 9,