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BGS remote magnetic observatories in the South Atlantic - an operational history

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ABSTRACT The British Geological Survey (BGS) has operated magnetic observatories on Ascension Island (ASC) and the Falkland Islands (PST) since 1992 and 1994 respectively. These two remote South Atlantic locations were selected to increase the global distribution of continuous, quality vector magnetic data. However, such locations give rise to many operational problems with a resulting impact on data quality.

Unlike BGS observatories in the United Kingdom, the South Atlantic observatories are largely operated unmanned, which requires that the instruments, recording facilities and data communications are reliable and cost-effective. This poster describes the observatory sites, instrumentation and logistics of remote operation, contrasting the success of the two observatories over the preceding thirteen years, and concludes with a summary of the distribution and quality of the recorded data.

INTRODUCTION

Magnetic main field modelling and polar ionospheric current studies in the southern hemisphere have been limited by the sparse distribution of continuous, quality, absolute, vector magnetic field recordings. To improve the distribution in the South Atlantic, BGS established magnetic observatories on Ascension Island and the Falkland Islands in the early 1990's. Although the installations and subsequent operations were partly funded by a consortia of oil companies, it is not economically feasible to maintain these observatories as permanently manned stations (as those in the UK) and this, coupled with the remoteness and climatic conditions at the sites, has given rise to a variety of operational problems, which have had a detrimental effect on data quality. Here, we take a look at the some of the difficulties experienced aver the past thirteen years of operation and describe how these difficulties have been reflected on the availability and quality of the recordings.

PORT STANLEY OBSERVATORY (PST)

Geographic: 051° 42' 15'' S 302° 06' 24'' E
Geomagnetic: 041° 41' 36'' S 011° 29' 06'' E
Height above MSL: 135m
Date of Installation: February 1994

SITE SELECTION

The model for both of the South Atlantic observatories has been to use a largely automated, digital-recording system, but to make use of locally trained staff to oversee the general operation of the observatory and to perform regular absolute observations. Since neither observatory is permanently manned, the selection of a suitable site was heavily dependent on the available infrastructure. As well as cost considerations, sites have been selected based on the need for a reliable power source, available data communications and ease of access . In general, these criteria are mutually exclusive to the need to locate at a magnetically clean site, free from potential man-made magnetic interference and, therefore, site selection has been made as a compromise between the two. The ideal criteria for the sites were:

- The site should be as low magnetic gradient as possible with little man-made interference
- The observatory buildings should be located on a flat, well-drained, solid foundation
- The site should offer good visibility to distance reference objects for absolute observations
- There should be access to a reliable mains electricity supply, preferably with UPS, so that power outages are kept to short periods of time
- There should be access to local telephone or network communications for data transfer to the UK close to the site
- There should be an existing clean, dry environment nearby to house the data recording equipment
- The site should be easily accessed by local staff

Both of the observatories have been sited on land belonging to local telecommunications companies, in close proximity to remote communications relay stations where the infrastructure and technical assistance was readily available. The magnetic sensors are enclosed in a 2x2x2m hut built 40m from the relay station and an absolute position established some 30m further away again. Since the sites are leased from local companies, there is little control over site usage and there is often no prior warning to data disruption. This can make quality control difficult and it is essential that data are monitored and corrected on a daily basis. Site rental charges and provision of communications total around $1000 per month per site.

Ascension Island is volcanic and therefore magnetically anomalous - the locality of the observatory having gradients in excess of 10nT/m in parts. Although not naturally anomalous, the Port Stanley Observatory site is bordered by minefields and is littered with debris from the 1982 conflict, including used ordnance on the surface and buried in craters, leading to high gradients in some areas.

Other hazards at both sites include roaming animals (horses and donkeys) which means that structures must be made strong enough to withstand being pushed and cables have to be protected against grazing. Both sites are open to the public, so structures have to be tamper-proof, although this problem is tempered by the low populations of the islands.

ASCENSION ISLAND OBSERVATORY (ASC)

Geographic: 7° 56' 58'' S 345° 37' 27'' E
Geomagnetic: 2° 21' 12'' S 056° 37' 00'' E
Height above MSL: 177m
Date of Installation: August 1992

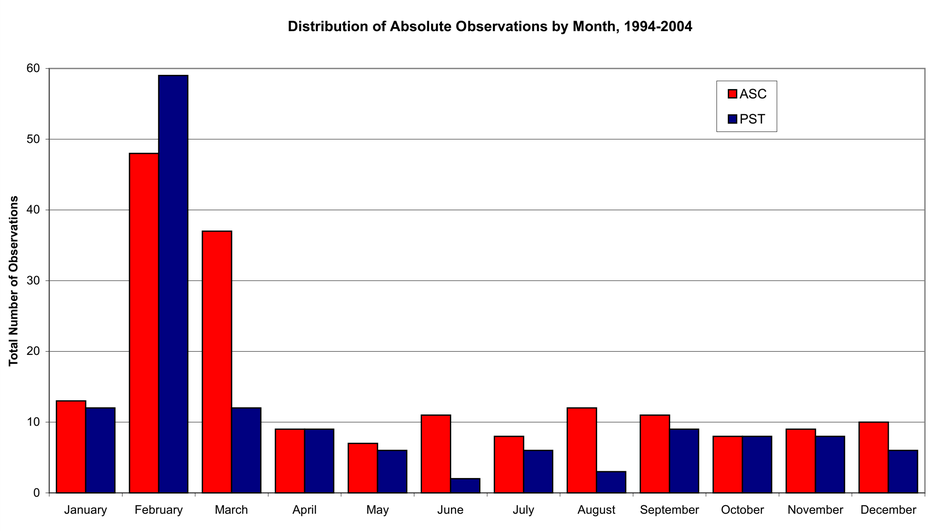
INSTRUMENTATION

Initially, both observatories were equipped with a proton vector magnetometer (PVM), specifically designed for remote operation. Due to power constraints, magnetometer sensors were not housed in a temperature controlled environment, and it was anticipated that the PVM would provide the stability of baseline required. The PVM comprised an Overhauser magnetometer mounted in a set of dual-axis 80cm diameter Helmholtz coils, oriented in dD/dI configuration. Data were sampled at one-minute intervals and were posted to BGS once per month on floppy disk and, in addition, Port Stanley transmitted data to the UK via a simplex Meteosat link. Being a simplex link, data were frequently lost (typically one hour per day), while floppy disks were occasionally found to be corrupt and the data lost. The recording system had no means of timing control and was able to drift by up to four minutes per annum.

The poor sampling rate and lack of timing control meant that the instrumentation did not meet the INTERMAGNET observatory specification and Port Stanley in particular had poor baseline control. This problem was largely environmental as humidity changes caused distortion of the Tufnol coils and a build-up of ice on the pillar in the winter months altered the coil alignment.

In June 2001, Ascension Observatory was upgraded to include a fluxgate magnetometer, higher sampling rate and network communications and Port Stanley was upgraded the following February. The new design also incorporates the scalar measurements from an Overhauser magnetometer, providing a valuable means of monitoring baseline variations (in the horizontal and vertical components) between the infrequent absolute observations. Since the fluxgate magnetometer temperature is not controlled, only insulated against external daily fluctuations, the comparison plots also provide a means of estimating a gross temperature dependence of the fluxgate magnetometer.

Duplex data communications have allowed the quality of data to be monitored daily, such that instrument faults are rectified more readily. The communications also allow certain faults to be addressed remotely, without the need for someone to visit the site. Since the data logger at the observatory maintains a data record for over four years, there are now no data losses due to communication faults.



ABSOLUTE OBSERVATIONS

At the time of installation, absolute measurement sites were established at both observatories and local observers given instruction in the use of a D/I theodolite. The original sites were simply a marker in the ground with three locators to erect a tripod, however, the plot showing the distribution of observations at the two observatories (left), shows the effect of the climate at the Port Stanley site. Here, the low temperature, strong winds and frequent precipitation have severely affected the frequency of observations, particularly in the winter months. The observing position is now protected by a fibre-glass enclosure, although the observatory still frequently suffers from poor visibility.

Typically, a set of two observations are performed monthly, which is sufficient to model the slow-varying baseline changes in Ascension where the climate is equatorial and temperature variations are low. In the temperate Falkland Island climate, however this was not the case for the original PVM system and is only just sufficient for the replacement fluxgate magnetometer system. Observations are made on a voluntary basis in the Falklands, while in Ascension they are charged at $120 per set, making it unfeasible to improve the frequency. Such infrequent observations also exacerbate the effect of any instrumental problems as it may be a number of months before the problem is identified. Often problems are not identified until the annual BGS service visits, scheduled around February and March. As part of a service visit, although lasting no more than a week, time is allocated to make a number of additional absolute observations, explaining the relatively high number of observations in the first quarter of the year.

The undulating terrain and absence of buildings at both sites means that there is a lack of true north reference marks at a sufficient distance not to be affected by slight positioning errors of the theodolite over the mark. Since the surrounding land does not belong to the observatory, it is not possible to establish a distant mark and existing marks are often moved by the landowners and have to be verified every year by means of astronomical observations.

OPERATIONS

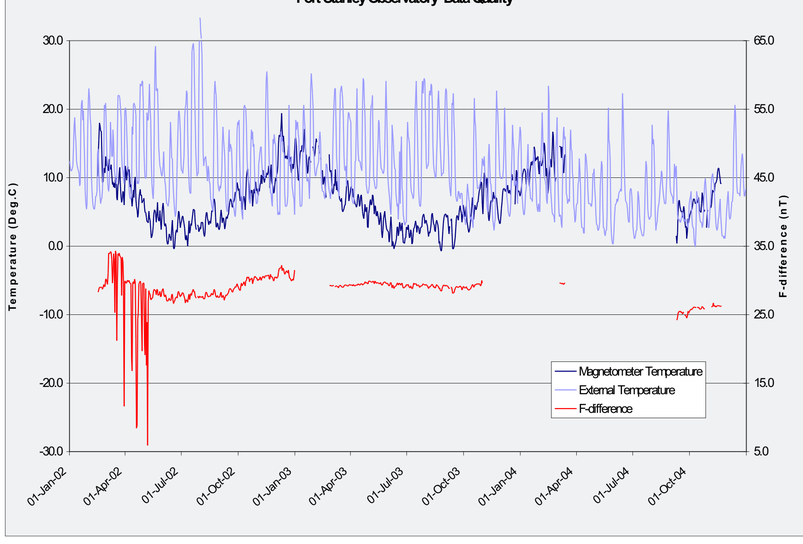
The success of the two observatories have been markedly different and the reasons have been two-fold: climate and man-made interference.

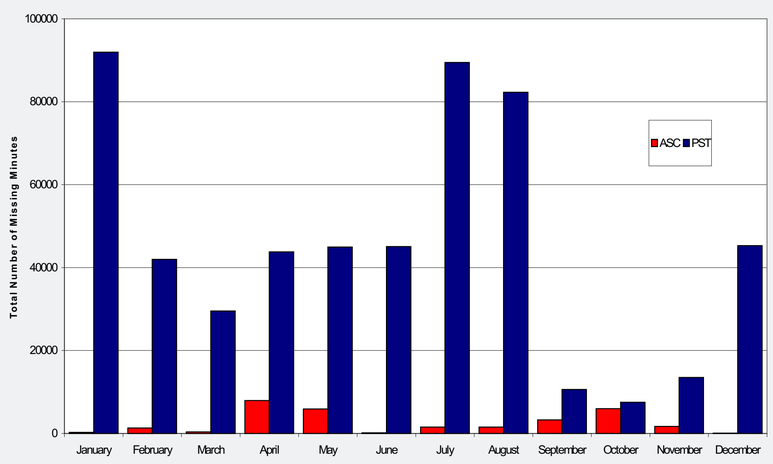
Shown below-left and below-right are the instrumental and external temperature fluctuations plotted along side the F-difference (comparisons between the fluxgate and Overhauser magnetometers). The plots summarise the quality and distribution of the magnetic data and also show how the relatively large temperature variations in the Falkland Islands have a related detrimental effect on the ability to maintain accurate baselines. This problem is exacerbated by a higher incidence of missing or rejected data points in the winter months and by the low frequency of absolute observations at the observatory, again due to poor weather. Both observatories had a period of instrument problems shortly after installation of the fluxgate magnetometers.

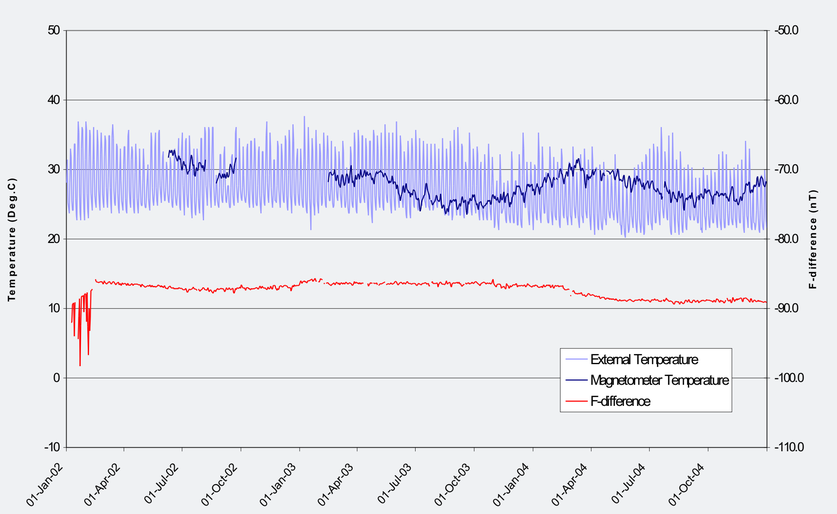
The Falkland Islands also has a greater incidence of lightning strikes than Ascension Island and lightning has resulted in long periods of data loss on a number of occasions. The most severe instrument damage occurred following strikes in March 2000, March 2004 and December 2004. In all cases, damage to electronic components has been caused by induced, transient currents in long data and power cables between the recording hut and the sensor hut, despite the inclusion of lightning protection barriers. In late 2005, copper data lines are to be replaced with fibre-optic and efforts will be made to improve the protection provided by the barriers with the aim of preventing a recurrence. It may be the case that the addition of large steel masts in close proximity to the instruments has increased the incidence of lightning strikes in recent years.

Neither observatory is located on land owned or controlled by BGS and frequently, poor data quality (at Port Stanley in particular) has resulted from land use by other organisations. The communication relay station along side PST observatory makes use of a number of radio transmitters and between 1994 and 1999, the F site difference (between the absolute observing site and the site of the Overhauser magnetometer) changed by 22nT, possibly indicating the introduction or removal of magnetic contamination to the site - one example being a new 30m steel mast in June 1999. These site difference changes are removed as the data are corrected to the absolute site, but of more concern is the effect of radiated interference. The PVM installation at PST suffered from many data spikes and the cause is now thought to be radio interference on the Overhauser magnetometer. This problem has also been evident on the fluxgate magnetometer, but is thought to manifest as a DC shift i.e. where the interference is picked up by the fluxgate magnetometer sensor, fails to be sufficiently attenuated by the input filter, is rectified by the phase detector and passes through to the integrator. Some measures to reduce this effect have had a degree of success, including shielding the fluxgate magnetometer sensor with aluminium foil and reducing the length of the Overhauser magnetometer sensor cable.

The logistics of operating a station at such a distance also have an effect on the continuity and quality of the data. The cost of a return air ticket to The Falkland Islands is over $3000 and visits by BGS staff are normally restricted to one per year. The itinerary of such visits includes absolute observations, equipment repairs and upgrades, local observer training and sometimes hut construction and cable laying. The cost of transporting equipment to both sites is also restrictive. Heavy items must be shipped by sea, which can take over one month and this frequently gives rise to long periods of lost data.







CONCLUSION

Although both observatories have demonstrated the stability of baselines required to meet INTERMAGNET standards, it is clear that the location and environment of Port Stanley Observatory have a greater effect on the quality and consistency of data in comparison with Ascension Island Observatory. It is becoming apparent that the methods put into practice in Ascension are not necessarily applicable in the harsher climate of the Falkland Islands and it may also be the case that the location of the observatory there will have to be revised in the near future. In the meantime, efforts are being made by BGS to put into place specific measures to improve the automatically recorded data quality, reduce the incidence of missing data and improve the frequency and distribution of absolute observations.

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