Australian Geomagnetism Report 2012

Volume 60

GEOSCIENCE AUSTRALIA
RECORD 2018/15

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ISBN 978-1-925297-85-0 (PDF)
eCat 120934

Bibliographic reference: Paskos, G. A., Crosthwaite, P. G., Jones, W. V., Lewis, A. M., Wang L. 2018. *Australian Geomagnetism Report 2012*. Record 2018/15. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2018.015

Version: 1801

Contents

1 Summary

During 2012, Geoscience Australia operated eleven geomagnetic observatories in Australia, the Subantarctic and the Australian Antarctic Territory. The observatories were located in the Cocos (Keeling) Islands; Kakadu and Alice Springs in the Northern Territory; Charters Towers in Queensland; Learmonth, Gingin and Gnangara in Western Australia; Canberra in the Australian Capital Territory; Macquarie Island in the Subantarctic; and Casey and Mawson in the Australian Antarctic Territory.

The Gingin observatory was commissioned to replace the Gnangara observatory due to the increasing magnetic disturbance at the Gnangara site primarily as the result of residential and industrial development. Gingin became operational in November 2011 and operated in parallel with Gnangara during 2012. Gnangara remained the primary magnetic observatory in southern Western Australia until 2012-12. From 2013-01-01 Gingin magnetic observatory assumed this role.

On 2012-10-01 a new observatory became operational on West Island of Cocos (Keeling) Islands.

At the Learmonth and Cocos (Keeling) Islands observatories, operations were conducted with the assistance of IPS Radio and Space Services, Bureau of Meteorology, Department of Sustainability, Environment, Water, Population and Communities. At Macquarie Island, Casey and Mawson, operational assistance was provided by the Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities.

The absolute magnetometers in routine service at Canberra magnetic observatory also served as the Australian reference magnetometers. The calibration of these instruments can be traced to international standards and reference instruments. Absolute magnetometers at all Australian observatories are referenced against those at Canberra through instrument comparisons.

Geomagnetic time-series data with a range of temporal resolutions were provided to stakeholders and data repositories in Australia, Japan, France, Germany, UK, USA and Finland in near real-time or at a regular interval. K indices were scaled weekly with computer assistance for the Canberra, Gnangara, Gingin and Mawson observatories. K indices for the Canberra and Gnangara were provided to agencies in Australia, Japan, France, Germany, Spain, Belgium, UK and USA. The rapid magnetic variation (RMV) events including Principal magnetic storms, storm sudden commencement and solar flare effect were scaled for Canberra and Gnangara. The RMV events for Canberra and Gnangara were provided monthly to an agency in Spain, and then distributed worldwide in a monthly RMV bulletin.

K indices from Canberra contributed to the southern hemisphere Ks index and to the global Kp, am and aa indices, and those from Gnangara contributed to the global am index.

During 2012, the geomagnetic repeat stations at Tibooburra, Parafield, Eucla, Carnegie, Derby, Mount Isa and Maryborough were reoccupied.

This report describes instrumentation and activities, and presents data collected at the magnetic observatories and repeat stations operated by Geoscience Australia during the 2012 calendar year.

2 Notation and conventions

Figure 2.1 indicates the notation used in this report for describing the magnetic flux density vector at the point where it is recorded at a ground magnetic observatory.

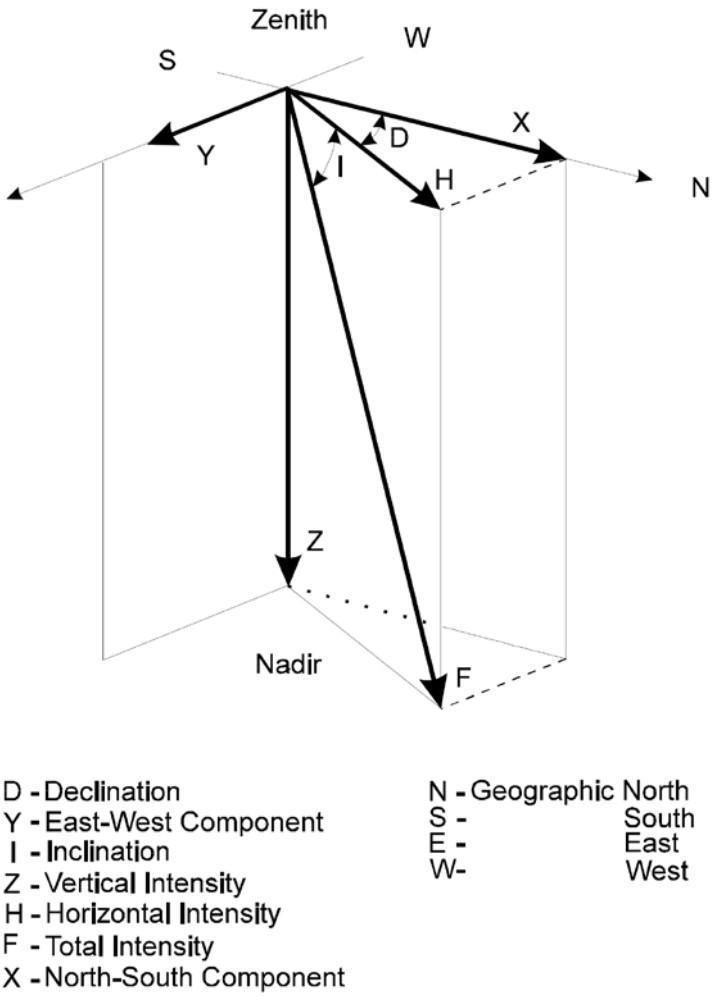

Figure 2.1 Relations among the magnetic elements. Figure reproduced with permission from the INTERMAGNET Technical Reference Manual Version 4.6 (ed. St-Louis 2012, p. 23, sec. 6.2, fig. 1).

The magnitude of the magnetic flux density vector and its dimensional components are usually quantized in units of nanoteslas (nT), where 1 T = 1 $kg \cdot s^{-2} \cdot A^{-1}$ in the SI base units. Historically, other units have been used. Equivalent units are given in Table 2.1.

Table 2.1 Equivalent magnetic flux density units.

10^4 Gauss
1 $Weber/meter^2$
10^9 gamma
1 Tesla

At Geoscience Australia (GA) magnetic observatories most vector variometers (see Section 5.1 Variometers) are positioned such that at the time of installation Z is in the direction of local gravity and H is approximately equally distributed among X and Y. In variometer instrumentation tables in Section 7 Permanent observatories this orientation is described as 'NW, NE, Z'.

In 2012, the majority of GA's magnetic observatories had only one set of continuously recording variometers. Such sets of variometers are identified by the 3-character IAGA code[1] of the observatory which they belong to. In the case where an observatory has more than one set of variometers, additional sets of variometers have arbitrary 3-character identifiers (e.g. Canberra observatory has had the CNB and CN1 sets of variometers).

Another convention used for identifying instrumentation is to refer to an instrument as a combination of a text string indicating the type of instrument or manufacturer or product name and the serial numbers of its components. For example, 'DIM DI0102/311864' refers to the declination-inclination fluxgate magnetometer (see Section 5.2 Absolute magnetometers) consisting of the single channel Danish Meteorological Institute (DMI) fluxgate magnetometer sensor with serial DI0102 and the Zeiss 020B theodolite with serial 311864.

Concerning GA's geomagnetic data products (see Section 4 Data distribution), Table 2.2 lists some terms used internally and within this report to described various data types as well as any equivalences to external data type definitions.

Unless otherwise stated, all references to data types throughout this report refer to the internal terms.

[1] Codes assigned by the International Association of Geomagnetism and Aeronomy (IAGA) for identification in several international observatory networks.

Table 2.2 Internal data type definitions and comparison to external equivalents. IAGA2002 Data Exchange Format data types have been omitted because ambiguity in their definitions[2].

Internal term	Internal term description	Closest INTERMAGNET data type equivalent	INTERMAGNET data type description
Raw (V)	Variometer data in digitizer counts. No spike or corrupt data removal, no baseline reference measurements (BRM) or temperature corrections. No time shifts. Vector data in instrument coordinates (ABC).	Reported (R)	The raw data obtained from the IMO (in nanoteslas), either by satellite, computer link, or other means, without any RM (reference measurements), or other modifications applied to it.
Preliminary/Reported/Real-time (P)	Data in nanoteslas and in the XYZ coordinates. Temperature corrections applied but without removal of spikes or periods of contamination, time shifts or other modifications. Preliminary baselines applied (usually those used for quasi-definitive data production).	n/a	n/a
n/a	n/a	Adjusted (A)	The reported data with RM, spike removal, timeshifts, and/or other modifications applied to it. It is emphasized that only one (1) adjusted version of the data would be allowed, to be completed within 7 days of receipt of the reported data to prevent the proliferation of multiple versions of the adjusted data.
Quasi-definitive/Adjusted (Q)	Same as INTERMAGNET equivalent.	Quasi-definitive (Q)	Quasi-definitive data are defined as data that have been corrected using provisional baselines. Produced soon after their acquisition, their accuracy is intended to be very close to that of an observatory's definitive data product. 98% of the differences between quasi-definitive and definitive data (X, Y, Z) monthly mean values should be less than 5 nT.
Definitive (D)	Same as INTERMAGNET equivalent.	Definitive (D)	Definitive data are defined as the final adopted data values. Definitive data will only be distributed by the institution responsible for the observatory.

[2] http://www.intermagnet.org/faqs-eng.php#data-types (accessed 2018-01-15).

The arithmetic mean (AM) and standard deviation (SD) are used to indicate the central tendency and statistical dispersion of a sample, respectively (i.e. AM ± SD).

ISO 8601:2004 notation is used to represent dates, times and durations.

IAGA codes[1] are used often to refer to observatories.

Terms such as ‘absolute shelter’ or ‘absolute house’ refer to the non-magnetic shelters where absolute observations are taken. Similarly, some GA magnetic observatories may have a ‘control house’ where instrumentation control electronics are housed.

3 Activities and services

3.1 Permanent geomagnetic observatories

During 2012, GA operated eleven permanent geomagnetic observatories within the Commonwealth of Australia. Table 3.1 lists these observatories and Figure 3.1 shows their relative locations.

Table 3.1 Locations of geomagnetic observatories operated by GA in 2012.

Observatory location	IAGA code	Colatitude	East longitude
West Island, Cocos (Keeling) Islands	CKI	102.1875°	096.8336°
Kakadu, Northern Territory	KDU	102.69°	132.47°
Charters Towers, Queensland	CTA	110.1°	146.3°
Learmonth, Western Australia	LRM	112.22°	114.1°
Alice Springs, Northern Territory	ASP	113.77°	133.88°
Gingin, Western Australia	GNG	121.356°	115.715°
Gnangara, Western Australia	GNA	121.8°	116.0°
Canberra, Australian Capital Territory	CNB	125.32°	149.36°
Macquarie Island Station, Tasmania	MCQ	144.5°	158.95°
Mawson Station, Australian Antarctic Territory	MAW	157.6°	062.88°
Casey Station, Australian Antarctic Territory	CSY	156.283°	110.533°

Source: http://www.intermagnet.org/imos/imotblobs-eng.php (accessed 2017-12-21)

GNG began operations in November 2011. It is located approximately 70 km north of Perth and from 2013-01-01 replaced GNA which, due to expanding housing development, was at risk of unacceptable levels of magnetic interference. The two observatories operated in parallel for approximately 13 months to obtain accurate station differences. GNG continues the acquisition of geomagnetic data in southern Western Australia which began in 1919 with the establishment of an observatory at Watheroo by the Carnegie Institution of Washington.

On 2012-10-01 CKI became operational. The observatory is a three-way collaboration between GA, IPS Radio and Space Services (IPS), and Eidgenössische Technische Hochschule Zürich (ETH Zürich).

Time-series data recorded by the observatory network are transmitted to GA and other stakeholders in near real-time. At GA, data is processed and analysed to derive a range of products distributed to Australian and international clients.

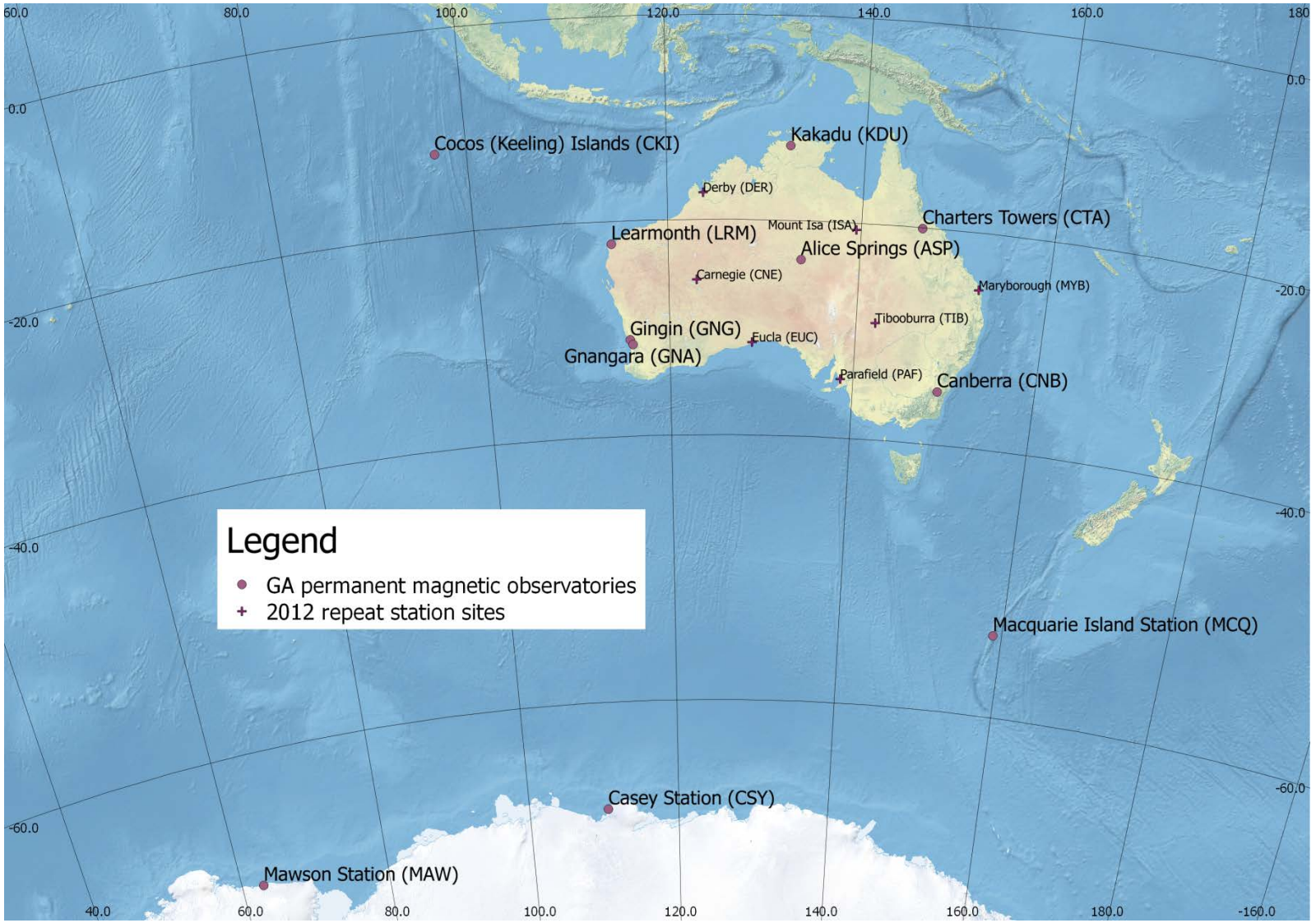

Figure 3.1 Relative locations of GA permanent magnetic observatories and repeat station sites occupied in 2012.

3.2 Antarctic operations

GA contributes to the Australian National Antarctic Research Expedition (ANARE) through its magnetic observatories at MCQ, CSY and MAW. Operations at these observatories are supervised and managed from GA headquarters in Canberra with logistic and operational support provided by the Australian Antarctic Division (AAD).

3.3 Repeat stations

GA maintains a network of magnetic repeat stations throughout continental Australia and its offshore islands, Papua New Guinea and New Caledonia. Stations are occupied every few years to measure geomagnetic secular variation. Repeat stations are located in areas between and outside the GA observatory network to improve spatial coverage. Data from the repeat station network contribute to the Australian Geomagnetic Reference Field (AGRF) models and secular variation model of the Australian region (see Section 3.4).

3.4 The Australian Geomagnetic Reference Field model

The AGRF model is a series of spherical cap harmonic models which describe the geomagnetic field and its secular variation in the Australian region. From 1990 to 2015 the AGRF has been updated at five yearly epochs. A main field model is produced for each five yearly epoch, along with a prospective secular variation model to extend the life of the model.

The AGRF model represents the Earth's main magnetic field originating from the core and the broad scale crustal field. The AGRF does not model short term variations of the magnetic field with time, such as those caused by solar activity or from electrical currents in the ionosphere. The AGRF is derived from vector magnetic data from ground level, aircraft and satellite surveys as well as the network of geomagnetic observatories and repeat stations run by GA and neighbouring countries.

3.5 Magnetometer calibration

Canberra magnetic observatory hosts the GA Magnetometer Calibration Facility. Built in 1999, in collaboration with the Department of Defence, it comprises a Finnish/Ukrainian-designed 3-axis coil system used to calibrate observatory tri-axial variometers and client instrumentation.

3.6 Compass calibration

GA provides a service for calibrating and testing direction finding and other instrumentation. This service is used by civilian and military agencies requiring the calibration of compasses and compass theodolites as well as the determination of magnetic signatures of other equipment.

4 Data distribution

4.1 Time-series data

Observatory specific details of data distribution are given the 'operations' subsections of Section 7 Permanent observatories.

Preliminary 1-minute time-series data were made available in near real-time on the public GA website[3]. One-minute time-series was also sent to the Edinburgh INTERMAGNET GIN (Geomagnetic Information Node) using HTTP and these data were then made available on the public INTERMAGNET website[4].

For 2012 and for all GA observatories excepting CKI, definitive 1-minute time-series data, annual means, baseline information and metadata was submitted to INTERMAGNET to standards described in the *INTERMAGNET Technical Reference Manual Version 4.6*.

Australian magnetic observatory data have been contributed to INTERMAGNET since the first CD of definitive data was produced (ed. St-Louis 2012, p. 13, sec. 4.2). Table 4.1 summaries the history of GA's INTERMAGNET contributions.

Data are also provided in response to direct requests from government, educational institutions, industry and individuals.

Table 4.1 History of GA's INTERMAGNET contributions.

IMO	First published on CD/DVD	Data first transmitted in near real-time
CTA	2000	2001-08
KDU	2000	2001-08
LRM	2005	2005-08-23
ASP	1999	1999-12
GNG	2012	2012-10-09
GNA	1994	Early 1995
CNB	1991	1994-10
MCQ	2001	2002-06
MAW	2005	2005-11-24
CSY	2011	2011-07-15

4.2 Magnetic activity indices

K indices (Bartels et al. 1939) for CNB, GNA, GNG and MAW are derived using a computer-assisted method developed at GA. The method uses the linear-phase, robust, non-linear smoothing (LRNS)

[3] http://www.ga.gov.au/oracle/geomag/gafoyer.jsp (accessed 2017-12-21).

[4] http://www.intermagnet.org/data-donnee/dataplot-eng.php (accessed 2017-12-21).

algorithm (Hattingh et al. 1989) to estimate the quiet or 'non-K' daily variation. This initial estimate can be adjusted on-screen using a spline fitting technique. The estimated non-K variation for the day is then automatically subtracted from the magnetic variations and the residual scaled for K indices.

Canberra (and its predecessors Toolangi and Melbourne) and Hartland (and its predecessors Abinger and Greenwich) in the UK are the two observatories used to determine the aa antipodal activity index (Mayaud 1971).

CNB is also one of thirteen mid-latitude observatories used in the derivation of the planetary three hourly Kp range index (Bartels 1949). Of these observatories, only Canberra and Eyrewell (NZ) are in the southern hemisphere. K indices from CNB and GNG/GNA also contribute to the derivation of the am index (Mayaud 1968).

K indices from both CNB and GNA/GNG were provided to:

- IPS, Sydney, from where they are further distributed to recipients of IPS bulletins and reports
- The International Service of Geomagnetic Indices (ISGI), France, for the compilation of the aa and am indices.

K indices from CNB were also provided to:

- GFZ Helmholtz Centre Potsdam, Germany, for the derivation of global geomagnetic activity indicators
- University of Newcastle, Australia
- Geomagnetism Team of the British Geological Survey (BGS)
- Collecte Localisation Satellites (CLS) and Centre national d'études spatiales (CNES), France
- Royal Observatory of Belgium (ROB), Brussels.

All routine K index information was transmitted by email.

4.3 Storms and rapid variations

Details of principal magnetic storms, sudden storm commencements (SSCs), solar flare effects (SFEs) and other rapid magnetic variations at CNB, GNG and GNA were provided monthly to the:

- World Data Center for Solar-Terrestrial Physics (WDC-STP), USA
- World Data Center (WDC) for Geomagnetism, Kyoto, Japan
- Observatori de l'Ebre, Spain

4.4 Australian Geomagnetism Reports

The Australian Geomagnetism Report was first published as the monthly *Observatory Report* in September 1952. The series was renamed the *Geophysical Observatory Report* in January 1953 (vol. 1, no. 1) and became the *Australian Geomagnetism Report* in January 1990 (vol. 38, no. 1). The monthly series became an annual report with volume 41 (for the year 1993). Details of other reports containing Australian geomagnetic data are given in volumes 43 and 44 of the *Australian Geomagnetism Report*.

The current annual report series includes data from the magnetic observatories and repeat stations operated by GA. Detailed information about the instrumentation and the observatories is included in volumes 41 and 42 of the Australian Geomagnetism Report.

From 1999 the Australian Geomagnetism Report has been produced in digital form only. They may be viewed or downloaded at GA's public website[5].

4.5 Public web services

The public GA website offer facilities for:

- Downloading and displaying preliminary and definitive 1-minute time-series data for all GA IMOs[6]
- Querying the latest iteration of the AGRF model[7]
- Obtaining K indices for CNB, GNA, GNG and MAW[8]
- Visualizing the first time derivative of the total intensity, F[9].

Additionally, GA magnetic time-series data and activity indices are available indirectly through INTERMAGNET, the Kyoto and Edinburgh WDCs for Geomagnetism and ISGI.

[5] http://www.ga.gov.au/scientific-topics/positioning-navigation/geomagnetism/australian-geomagnetism-report (accessed 2017-12-21).

[6] http://www.ga.gov.au/oracle/geomag/minute_ftp.jsp (accessed 2017-12-21); http://www.ga.gov.au/oracle/geomag/gafoyer.jsp (accessed 2017-12-21).

[7] http://www.ga.gov.au/oracle/geomag/agrfform.jsp (accessed 2017-12-21).

[8] http://www.ga.gov.au/oracle/geomag/geomagnetism_indices.jsp (accessed 2017-12-21).

[9] http://www.ga.gov.au/geomag/widearеamag/ (accessed 2017-12-21).

5 Instrumentation

5.1 Variometers

The standard variometer system used at GA magnetic observatories consists of a 3-component vector variometer and a total-field scalar variometer. Time-series data is recorded digitally and transmitted to GA in near real-time.

Vector variometer sensors at GA observatories are orientated such that the two horizontal components have similar magnitude. In the typical configuration the horizontal sensors are aligned at 45° to the magnetic meridian (i.e. magnetic NW and NE) and the third sensor is vertical, in the direction of local gravity. However, at MCQ each sensor makes an angle of approximately 55° with the magnetic vector so that all 3 components have similar magnitude.

One of the benefits of these alignments is the optimisation of the 'Delta-F Check' (ΔF) (eds Mandea & Korte 2011, pp. 132-133, sec. 6.2.3.2) quality control test which compares the difference between F determined using the vector variometer and F obtained from the scalar variometer. Additionally, should one of the vector channels become unserviceable, vector data may be recovered using the remaining two channels and the scalar variometer data.

In 2012, GA magnetic observatories employed Danish Meteorological Institute (DMI) FGE[10], EDA Instruments Inc. (EDA), LEMI LLC. (LEMI) and Narod Geophysics Ltd. (NGL) 3-component vector variometers. Some sites may have had more than one vector variometer.

FGE variometers provided single-ended analogue output that required digitization prior to recording on the data acquisition (DAQ) computer/system. NGL variometers provided an 8 sps (samples per second) digital signal via an integrated analog-to-digital converter (ADC). NGL variometers also benefitted from a UTC (Coordinated Universal Time) synchronized pulse per second (PPS) for timing control.

Most fluxgate variometers integrated temperature sensors into their magnetic sensor and electronics components. Where available, these two temperature data channels were also recorded to correct for temperature variations (see Section 6.1 Data reduction) and for state of health (SOH) monitoring.

5.2 Absolute magnetometers

Declination-inclination fluxgate magnetometers (DI-flux/DIM, see Jankowski & Sucksdorff 1996, sec. 5) and total-field scalar magnetometers are used in GA observatories as part of the 'absolute observations' routine used to calibrate an observatory's variometer(s).

The DIMs used at GA magnetic observatories consist of combinations of DMI Model G or Bartington MAG 01H fluxgate sensors mounted on either Zeiss Jena 020B or 010B non-magnetic theodolites.

Absolute observations at most observatories are performed nominally weekly using the 'offset/residual' method (Lauridsen 1985). In this method, the theodolite is set to the whole number of

[10] Production of FGE variometers has since moved to the Technical University of Denmark (DTU). Current model specifications available at http://www.space.dtu.dk/english/research/instruments_systems_methods/3-axis_fluxgate_magnetometer_model_fgm-fge.aspx (accessed 2017-12-21).

arc minutes nearest a null (0 nT) fluxgate output. The theodolite circle reading and a series of eight fluxgate time and value readings are then recorded in each position. At some observatories the 'zero/null' method (Kerridge 1988) continues to be used. In this method, the theodolite is set to achieve a null fluxgate output and a single theodolite reading is recorded in each position.

5.3 Reference magnetometers

Participation in the IAGA Workshops on Geomagnetic Observatory Instruments, Data Acquisition and Processing relate the Australian reference magnetometers to international standards. Absolute instruments used at Australian observatories are periodically compared with the devoted 'reference DIM' (DIM B0610H/160459), sometimes indirectly through the 'travelling DIM' (DIM DI135/100856).

5.4 Data acquisition system

DAQ computers used at GA's magnetic observatories consist of the in-house Geophysical Data Application Platform (GDAP) software built around the proprietary QNX Neutrino[11] real-time operating system (RTOS) running on x86 single-board computers (SBCs).

Timing is governed by a software clock which is maintained to within 1 millisecond of UTC using an external GPS receiver providing NMEA 0183[12] strings and PPS interrupt signals. The Network Time Protocol (NTP), which can maintain a software clock to within 10 milliseconds of UTC, depending on network congestion and server accuracy[13] is also used for a backup software clock at some observatories.

ADAM 4017 ADCs[14] are used to convert analogue outputs from the DMI FGE and EDA 3-component variometers to digital data for recording on DAQ computers. These ADCs sampled at 1 sps, with triggering provided by the DAQ computer.

The NGL variometers had integrated ADCs (see Section 5.1 Variometers). Digital output was moving average filtered on the DAQ computer prior to recording 1-second values.

Uninterruptible Power Supplies (UPS) or DC battery power supplies were installed at all observatories, supplying power to DAQ computers and variometers in the advent of primary power outage. Lightning surge filters are installed where required.

[11] https://www.qnx.com/content/qnx/en/products/neutrino-rtos/neutrino-rtos.html (accessed 2017-12-21).

[12] A specification for communication between marine electronics, including GNSS receivers.

[13] http://www.ntp.org/ntpfaq/NTP-s-algo.htm#Q-ACCURATE-CLOCK (accessed 2017-12-21).

[14] Configured to operate with different input voltage ranges depending on observatory. Specifications available from http://www.advantech.net.au/products/gf-5vtd/adam-4017/mod_170c40f4-e6ac-485e-9df9-1e6ef60f971f (accessed 2017-12-21).

6 Data processing

6.1 Data reduction

With constant scale and orientation values, Equation (1) defines the model applied to the arbitrarily orientated, near orthogonal raw vector variometer data, A, B, C to enable the reduction of the X, Y, Z magnetic elements and derived elements D, I, H and F (see Section 2 Notation and conventions).

$$\begin{bmatrix} X(t) \\ Y(t) \\ Z(t) \end{bmatrix} = \boldsymbol{S} \cdot \begin{bmatrix} A(t) \\ B(t) \\ C(t) \end{bmatrix} + \boldsymbol{b} + \boldsymbol{d}(t) + \boldsymbol{q}(t) \quad (1)$$

In (1):

- Matrix **S** combines constant scale and orientation values
- Vector **b** applies DC baseline values
- Vector **d** applies drifts and steps from DC baselines
- Vector **q** compensates for vector variometer sensor and electronics temperature effects.

6.2 Data retrieval

Recorded data are transmitted to GA via different routes and network access technologies (DSL, LTE, VSAT, etc.) depending on the observatory.

In a first pass, a GA host retrieves raw data from the DAQ computer frequently through rsync[15] over the Secure Shell (SSH) protocol. This raw data is then automatically processed with instrumentation constants and baselines to provide provisional data (see Section 2 Notation and conventions) to subscribers in almost real-time. For this, only a select number of protocols are supported.

Data is more thoroughly inspected and quality controlled by GA Geomagnetism Team 'observatory managers' prior to distributing quasi-definitive and definitive data to INTERMAGNET.

6.3 Recording intervals and mean values

In 2012, at GA magnetic observatories, vector and scalar variometer data was recorded at 1-second and 10-second intervals, respectively (see Section 5.4 Data acquisition system).

Vector variometer minute means were obtained by using the INTERMAGNET recommended digital filter (ed. St-Louis 2012, sec. 2.2.).

Up to 12 missing 1-second records were filled by linear interpolation. If more than twelve 1-second records were missing, the associated minute mean was not calculated.

[15] An efficient file synchronization utility program incorporating data differencing.

Scalar variometer minute means were derived from the 7 enclosing 10-second records, centred on the minute. At least three out of the seven 10-second records needed to be present for the minute mean to be calculated.

Hourly means were derived from the minute means for the hour (minutes 00 to 59). At least 12 minute means needed to be present for the hourly mean to be calculated.

Daily means were derived from the hourly means for the day (hours 00 to 23). All 24 hourly values needed to be present for the daily mean to be calculated.

Monthly means were derived from the daily means for the month. At least one daily mean was required for the monthly mean to be calculated.

6.3.1 Annual means

Three different annual mean values were derived:

- The 'All Days' annual mean from all available minute means in the year.
- The 'Quiet Days' annual mean from all minute means falling within each month's 5 quietest days, according to ISGI's monthly international quietest days (Q-days)[16]
- The 'Disturbed Days' annual mean from all minute values falling within each month's 5 most disturbed days, according to ISGI's monthly international most disturbed days (D-days)[16]

Annual mean values for the total intensity, F, are derived solely from vector variometer data and missing data is *not* infilled from scalar variometer data where available.

[16] http://isgi.unistra.fr/events_qdays.php (accessed 2017-12-21).

7 Permanent observatories

This section gives information about observatory conditions, instrumentation and calibration details, operations and data quality and statistics for GA magnetic observatories operated in 2012.

Much of this information has been edited from the appropriate plaintext 'readme' files featured on the 2012 INTERMAGNET definitive data DVD[17]. The precision of numerical values featured in this section may vary from values in the 2012 readme files.

All weather data featured in this section was provided by the BOM.

7.1 Cocos (Keeling) Islands

CKI is located on West Island within the Cocos (Keeling) Islands, 2750 km northwest of Perth, Western Australia and 900 km southwest of Christmas Island in the Indian Ocean. Cocos (Keeling) Islands is a coral atoll formed on top of a volcanic seamount. The site of the magnetic observatory is located approximately 150 m north of the Bureau of Meteorology (BOM) meteorological office. Cocos (Keeling) Islands BOM staff act as local observers for CKI. Continuous magnetic field recording began at CKI in August 2011, but usable, fully calibrated magnetic observatory data only commenced on 2012-10-01.

In addition to the geomagnetic observatory, GA also maintains a Global Navigation Satellite System (GNSS) base station and a Comprehensive Nuclear-Test-Ban Treaty (CTBT) Infrasound station on West Island.

CKI comprises:

- An absolute shelter
- An above ground aerated concrete vault (approximately 2×3 m^2) for housing a vector fluxgate variometer and control electronics
- An above ground aerated concrete vault (approximately 1×1 m^2) for housing a scalar magnetometer.
- A fibre-glass instrument cabinet beneath solar panels containing batteries, recording and communication equipment
- A radio mast and telemetry to communicate to the BOM meteorological office.

The primary azimuth mark for the observatory is the middle of three bolts on the base of the airport main windsock.

Prior to the establishment of CKI, secular variation data for the region was measured on a series of repeat stations on the atoll.

Important details regarding CKI are given in Table 7.1.

[17] Available from http://www.intermagnet.org/data-donnee/cdrom/cddata-eng.php (accessed 2017-12-21).

Table 7.1 Important CKI details for 2012.

IAGA code	CKI
Commenced operation	2012-10-01
Geographic latitude	012° 11′ 14.8″ S
Geographic longitude	096° 50′ 01.0″ E
Geomagnetic latitude	021.90° S (IGRF 2010)
Geomagnetic longitude	168.45° E (IGRF 2010)
K 9 index lower limit	280 nT
Principal pier	Pier AO
Pier elevation (top)	4.9 m AMSL
Principal reference mark	Windsock
Reference mark azimuth	256° 15′ 17″
Reference mark distance	370 m
Observatory manager(s)	Peter Crosthwaite
Observer(s)	Trevor Menadue, Will Tankard, Sean Fitzgerald

7.1.1 Local meteorological conditions

The meteorological temperature at Cocos (Keeling) Islands during 2012 varied from a minimum +20.9 °C (2012-09-23) to a maximum +31.2 °C (2012-03-06). Daily minimum temperatures varied from +20.9 °C to +29.3 °C (average +25.1 °C ± 1 °C). Daily maximum temperatures varied from +26.8 °C to +31.2 °C (average +29.3 °C ± 1 °C). Daily temperature ranges varied from 0 °C to +7.7 °C (average +4 °C ± 1 °C).

The daily maximum wind gust varied from 19 km/h to 72 km/h (average 40 km/h ± 10 km/h). The maximum daily maximum wind gust of 72 km/h occurred in February and April. The minimum daily maximum wind gust of 19 km/h occurred twice in January.

7.1.2 Variometers

Table 7.2 shows specifics of the variometers and DAQ system used at CKI during 2012.

Table 7.2 Variometer systems used at CKI in 2012.

CKI vector variometer	Model	DMI FGE
	Serial number	E0461/S0250 from March 2012 (see Section 7.1.6)
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
CKI scalar variometer	Model	GEM Systems GSM-90
	Serial number	0023526/03768
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
CKI DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS16 receiver
Other	Communications	Freewave radio link to BOM office, Internet through BOM to GA

Analogue output from FGE E0461/S0250 (including sensor and electronics temperature channels) was digitized using an ADAM 4017 ADC mounted inside the FGE electronics unit. These data and the digital PPM (Proton precession magnetometer) data were recorded on the data acquisition computer located in the green coloured fibre-glass instrument cabinet.

The magnetic sensors were located in the concrete above-ground vaults. Both vaults were insulated to minimise short period temperature fluctuations.

After installation during 2011-08, the vector variometer enclosure suffered from water leakage through the roof, accumulating several centimetres of water inside (this was first noticed during a maintenance visit during March 2012). During this period the fluxgate variometers were unstable with rapid drifts in the vertical component. It could also be possible that high humidity was the cause of the instability. In 2012-07 the roofs of both the scalar and vector enclosures were covered with fibreglass solving the leakage problem. Silica gel sachets were also installed inside the acrylic cover of the FGE E0461/S0250. The instrumentation has been reasonably stable since the housing modifications in 2012-07.

The FGE E0461/S0250 variometer scale values, alignment, and temperature sensitivity parameters (see Section 6.1 Data reduction) were determined at the GA Magnetometer Calibration Facility at Canberra observatory before installation at CKI. The sensor assembly was aligned with the two horizontal fluxgate sensors at 45 degrees to the magnetic meridian at the time of installation and the Z fluxgate sensor vertical. This alignment was achieved by using a bulls-eye spirit level to set the base of the sensor horizontal, setting the X and Y offsets equal and rotating the instrument until the two

horizontal channel ordinates were equal. This method has been found to be accurate using tests performed at the calibration facility.

No part of the variometer system was temperature regulated. Temperatures within the primary vault varied over a range of about +2 °C for the FGE sensor and +3 °C for the FGE electronics during 2012-10/12.

7.1.3 Variometer clock corrections

During 2012, most adjustments to the software clock were less than 1 ms, however from 2012-10-01 until the end of 2012 there were 2313 adjustments in excess of 1 ms. Adjustments of 10 ms and greater for CKI are shown in table Table 7.3 below.

Table 7.3 Software clock adjustments greater than 10 ms for CKI in 2012.

Time before correction	Correction (s)	Comment
2012-11-18T00:19:16Z	0.010	n/a

7.1.4 Absolute instruments

The principal absolute magnetometers used at CKI and their adopted corrections for 2012 are shown in Table 7.4. The corrections applied correct for the differences between the 2012 CKI DIM and the international average (as defined by observations at IAGA instrument workshops).

Table 7.4 Absolute instrumentation (with corrections) used at CKI in 2012.

CKI DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0102
	Theodolite	Zeiss 020B
	Theodolite serial	311864
	Theodolite resolution	+0.1′
	D correction	+0.0′
	I correction	+0.0′
CKI absolute PPM	Model	GEM Systems GSM-90
	Serial number	3091315/42186
	Type	Overhauser effect scalar magnetometer
	Resolution	+0.01 nT
	F Correction	+0.00 nT

DIM observations were performed using the offset/residual method. All DIM and absolute PPM measurements were made on the principal pier at the standard height.

7.1.5 Baselines

After 2012-10-01 acceptable observations were made on 11 separate days. Usually a pair of observations was made on each of those days. Baseline measurements used two offset/residual method DI-flux observations and two minutes of absolute scalar magnetometer data recorded at 10 second intervals.

Figure 7.1 shows the accepted observed and adopted baseline values in XYZ for CKI in 2012. Table 7.5 shows statistics regarding the difference between these observed and adopted baseline values (residuals).

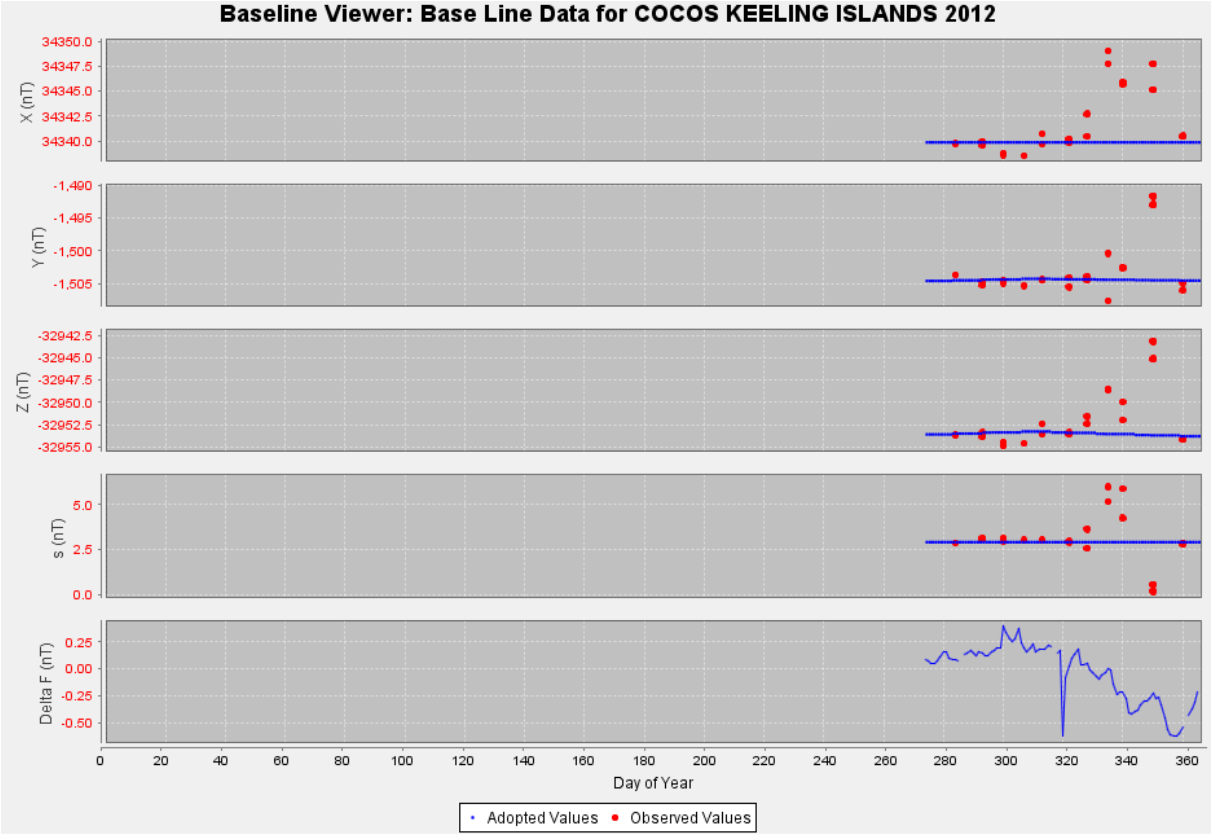

Figure 7.1 CKI 2012 baseline plots.

Table 7.5 Standard deviation of residuals from accepted absolute observations at CKI during 2012.

Component	SD
X	3.5 nT
Y	4.0 nT
Z	3.3 nT
D	25″
I	19″
F	1.4 nT

7.1.6 Operations

In 2012, Trevor Menadue and Will Tankard were the BOM employees stationed on Cocos (Keeling) Island responsible for operating and maintaining CKI and undertaking weekly absolute observations.

The observatory is situated on a mown grass area, surrounded by the invasive ‘cabbage bush’ plant, coconut palms, other trees, a golf course, airstrip apron and the atoll's lagoon. It is necessary to mow around the observatory, including the variometers, to halt cabbage bush encroachment. Consequently there are regular monthly data losses whilst landscaping is undertaken and this is unavoidable. Other magnetic field contamination, resulting in data losses may be caused by golfers, bird watchers and tourists.

During a maintenance visit in March 2012 the malfunctioning fluxgate variometer, FGE E0462/S0353, was replaced with FGE E0461/S0250. The GNSS receiver for the DAQ computer was also replaced during this visit and it was also discovered that the vector variometer vault was damp with pooling water—the result of faulty roofing.

Another visit in July 2012 was made to oversee the construction of a waterproof fibre-glass cover on the roof of both the vector and scalar variometer vaults. Dehumidifying gel sachets were installed inside the fluxgate sensor dome. A shade cloth roof was also installed on the absolute shelter to provide morning shade during absolute observations. A tablet PC was introduced into the absolute observation routine to record data.

A third visit in November was required to replace faulty dedicated SOH temperature sensors in the main vault and the green coloured fibre-glass instrument cabinet.

The distribution of 2012 CKI data after primary transmission to GA is shown in Table 7.6.

Table 7.6 Distribution of CKI 2012 data.

	Recipient	Data type	Sent
1-second values	IPS, Sydney	P	Real-time
1-minute values	ETH Zürich	P	Real-time

7.1.7 Missing one-minute definitive data

No definitive data were submitted to INTERMAGNET from CKI in 2012.

7.1.8 Significant events

Table 7.7 Significant event that took place at CKI in 2012.

Time or duration	Description of event
2012-01-01T04:40Z	Z channel goes off scale. GNSS software clock still not functioning.
2012-03-14	David Pownall and Trevor Dalziel working on replacing fluxgate equipment.
2012-03-14T01:16:59Z	Fluxgate variometer switched off.
2012-03-14T08:56Z	Fluxgate variometer switched on.
2012-03-28	First noticed that one of the SOH temperature channels (vault temperature) failed on 2011-358.
2012-04-01T01:21:30Z	Telemetry stops.
2012-04-05	Report from CKI that the BOM VPN has returned.
2012-04-10	Recovered all data after VPN failure.
2012-07-24	David Pownall and Trevor Dalziel travelling to CKI to oversee fibre-glassing roof, drying variometer and installing silica gel and humidity sensor strips into variometer. Delivered tablet PC.
2012-07-27T03:25Z	System reboot after variometer work completed.
2012-11-15T03:30Z	David Pownall at CKI, checking the temperature sensor in the geomagnetism vault. There was a spike at 03:08:04Z in variometer data when the lid on the vault was opened.
2012-11-16	Contact from David Pownall at CKI during his visit. Variometer hut is dry and functioning. Replaced both SOH temperature sensors.
2012-11	David Pownall and Paul Jameson visited CKI (primarily for infrasound requirements) and fixed both SOH temperature sensors, serviced the green box, checked the interior of the variometer vault. The conditions inside the vault were dry indicating that the previous fibre-glassing work has been successful.

7.1.9 Annual mean values

No annual means were calculated for CKI in 2012 as insufficient data was available.

7.2 Kakadu

Kakadu Geophysical Observatory is located in the Northern Territory, 210 km east of Darwin and 40 km west of Jabiru on the Arnhem Highway, near the South Alligator Ranger Station, Kakadu National Park. It comprises magnetic and seismological observatories and a gravity station. Kakadu magnetic observatory is situated on unconsolidated ferruginous and clayey sand. Continuous magnetic-field recording began there in March 1995.

KDU comprises:

- A 3×3 m^2 air-conditioned concrete-brick control house, with a concrete ceiling and aluminium cladding and roof, where recording instrumentation and control equipment are housed
- A 3×3 m^2 roofed absolute shelter, 50 m NW of the control house, that houses a 380×380 mm^2 fibre-mesh-concrete observation pier (Pier A), the top of which is 1200 mm from the concrete floor
- Two 300 mm diameter azimuth pillars, both approx. 100 m from Pier A with approx. true bearings of 27° and 238°, respectively
- Two 600 mm square underground vaults that house the variometer sensors, both located 50-60 m from the control house, one to its SSW and one to its WSW (cables between the sensor vaults and the control house are routed via underground conduits)
- A concrete slab, with tripod foot placements and a marker plate, used as an external reference site E (at a standard height of 1.6 m above the marker plate). The marker plate is 60 m, at a bearing of 331°, from the principal observation pier A.

Important details regarding KDU are given in Table 7.8.

Table 7.8 Important KDU observatory details for 2012.

IAGA code	KDU
Commenced operation	05 March 1995
Geographic latitude	012° 41′ 10.9″ S
Geographic longitude	132° 28′ 20.5″ E
Geomagnetic latitude	021.49° S (IGRF 2010)
Geomagnetic longitude	206.11° E (IGRF 2010)
K 9 index lower limit	300 nT
Principal pier	Pier A
Pier elevation (top)	14.6 m AMSL
Principal reference mark	Pillar AW
Reference mark azimuth	237° 52.8′
Reference mark distance	99.6 m
Observatory manager(s)	Liejun Wang
Observer(s)	Andy Ralph, John Cianchi, Liejun Wang, Andrew Lewis

7.2.1 Local meteorological conditions

The meteorological temperature at Jabiru airport (about 50km to the observatory) during 2012 varied from a minimum of +12.1 °C (2012-07-22) to a maximum +40.5 °C (2012-10-31). Daily minimum temperatures varied from +12.1 °C to +27.9 °C (average +22.3 °C ± 3.4 °C). Daily maximum temperatures varied from +23.7 °C to +40.5 °C (average +34.6 °C ± 2.9 °C). Daily temperature ranges varied from +2.5 °C to +22.0 °C (average +12.3 °C ± 3.2 °C).

The daily maximum wind gust varied from 17 km/h to 91 km/h (average 36.0 km/h ±8.7 km/h). The maximum daily maximum wind gust was 91 km/h on 2012-11-28. The minimum daily maximum wind gust was 17 km/h in 2012-03-23.

7.2.2 Variometers

Table 7.9 shows specifics of the variometers and acquisition system used at KDU during 2012.

Table 7.9 Variometer systems used at KDU in 2012.

KDU vector variometer	Model	DMI FGE
	Serial number	E0198/S0183
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
KDU scalar variomenter	Model	GEM Systems GSM-90
	Serial number	4071413/42185
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
KDU DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Trimble Acutime GPS receiver
Other	Communications	VSAT

Analogue outputs from the three fluxgate sensors, and the sensor and electronics temperatures, were converted to digital data using an ADAM 4017 ADC mounted inside the fluxgate electronics unit. This data and the digital PPM data were recorded on the DAQ computer located in the control house.

The variometers were located in the concrete underground vaults—the FGE E0198/S0183 in the northern vault (the one nearer the absolute shelter) and the GSM 4071413/42185 in the southern vault. Both vaults were completely buried in soil to minimise temperature fluctuations.

The GSM 4071413/42185 electronics were located in the covered vault with its sensor. Power and data cables ran between the GSM vault and the control house.

The FGE E0198/S0183 electronics console was placed in its own partially insulated plastic box, resting on the concrete floor in the control house, with some bricks acting as heat sinks to minimise temperature fluctuations. This arrangement proved to be effective in reducing the amplitude of temperature fluctuations with periods of the order of hours.

The FGE E0198/S0183 scale-values, alignment, and temperature sensitivity parameters (see Section 6.1 Data reduction) were measured at the GA Magnetometer Calibration Facility in Canberra prior to installation at KDU. The sensor assembly was aligned with the two horizontal fluxgate sensors at 45° to the declination at the time of installation and the Z fluxgate sensor vertical. This alignment was achieved by setting the X and Y offsets equal and rotating the instrument until the X and Y ordinates

were equal. This method has been found to be accurate using tests performed at the calibration facility.

The control house, housing the FGE E0198/S0183 electronics, had its temperature maintained by an air conditioning unit. During 2012 the temperature of the FGE electronics ranged from +24.4 °C (in the winter months) to +28.8 °C (in the summer months). The annual temperature variation of +4.4 °C converted to variations 0.2 nT, 0.7 nT and 0.0 nT in the X, Y and Z channels, respectively.

The FGE sensor temperature ranged from +25.7 °C to +33.4 °C during the year. Although buried underground, it varied during the year in accordance with the seasons at long periods with temporary effects from weather systems at shorter periods. The annual temperature variation of +7.7 °C converted to variations 0.2 nT, 0.5 nT and 0.5 nT in the X, Y and Z channels, respectively.

FGE E0198/S0183 variometer data from 2012-05-26 through 2012-05-30 were lost during a power system upgrade and are listed in Table 7.15. One second of data lost at 2012-07-21T04:32:57Z was due to timing corrections. Data from the GSM variometer has a few seconds data loss each day during most of 2012.

During 2012-06-05 to 2012-06-26, from 05:00Z to 12:00Z each day, 2-3 nT peak-to-peak high frequency signals were recorded, possibly resulting from a power generator at South Alligator Ranger Station.

FGE 1-second data required despiking. The despiking parameters required a spike to exceed 0.2 nT and 10 times the average ‘spike-factor’ of the following minute of data with the rejected data visually verified and confirmed. Any data deemed valid was reinstated. During 2012-06-05/26 data was rejected due to high frequency noise. During thunderstorms in the November to March monsoon season up to 1000 s of data may be rejected, daily. The highest amount of rejection occurred on 2012-02-27 where 3066 s of data was rejected however a large proportion was reinstated.

7.2.3 Variometer clock corrections

During 2012, adjustments to the software clock were less than 10 ms except on the following occasions indicated in Table 7.10.

Table 7.10 Software clock adjustments greater than 10 ms for KDU in 2012.

Time before correction	Correction (s)	Comment
2012-05-27T08:43:20Z	+0.445	n/a
2012-05-27T10:29:52Z	−0.002	System restart following power upgrade
2012-05-30T01:54:53Z	+0.617	System restart following power upgrade
2012-07-01T00:01:23Z	−1.000	Leap second correction
2012-07-21T04:31:33Z	+0.204	n/a
2012-07-21T04:32:57Z	+0.754	n/a

7.2.4 Absolute instruments

The principal absolute magnetometers used at Kakadu and their adopted corrections for 2012 are described in Table 7.11. DIM observations at Kakadu were performed using the offset method. All DIM and absolute PPM measurements were made on the principal pier at the standard height.

Table 7.11 Absolute instrumentation (with corrections) used at KDU in 2012.

KDU initial DIM	Sensor	Bartington MAG-01H
	Sensor serial	B0622H
	Theodolite	Zeiss 020B
	Theodolite serial	359142
	Theodolite resolution	+0.10′
	D correction	−0.05′
	I correction	−0.15′
	Usage period	To 20 July 2012
KDU replacement DIM	Sensor	DMI
	Sensor serial	DI0049
	Theodolite	Zeiss 020B
	Theodolite serial	311847
	Resolution:	+0.10′
	D correction:	−0.05′
	I correction:	−0.15′
	Usage period	From 21 July 2012
KDU absolute PPM	Model	GEM Systems GSM-90
	Serial number	4081421/42186
	Type	Overhauser effect scalar magnetometer
	Resolution	+0.01 nT
	F Correction	+0.00 nT

Absolute instrument corrections for DIM DI0049/311847 and DIM B0622H/35914 were checked through a number of instrument comparisons carried out at the Canberra and Kakadu geomagnetic observatories.

DIM DI0049/311847 was compared with the Australian standard DIM at Canberra observatory on the 6th, 21st and 26th of March 2012 and the 7th and 18th of July 2012. The correction to the international standard is −0.05′ in D and −0.15′ in I.

DIM DI0049/311847 and DIM B0622H/35914 were compared at KDU observatory on 2012-07-21/25. The difference is −0.06′ ± 0.12′ in D and −0.04′ ± 0.15′ in I, indicating the instrument difference between DIM DI0049/311847 and DIM B0622H/35914 is negligible.

DIM B0622H/359142 was compared with the Australian standard DIM at the Canberra observatory on the 7th and 14th of August 2012, the correction to the international standard was calculated to be −0.05′ in D and −0.15′ in I.

These corrections have been applied to all KDU 2012 final data through the correction of absolute observations.

7.2.5 Baselines

There were 47 pairs of weekly absolute measurements during 2012 and 4 sets of daily measurements during maintenance visits on 2012-07-20 and 2012-11-22. Among these observations, 7 pairs were not included in the final baseline processing because of magnetic contamination. These contaminated observations were made on:

- The 10th and 16th of January
- The 4th of Feburary
- The 17th and 31st of March
- The 20th and 27th of October, 2012.

In addition, weather conditions such as floods and heavy rains during monsoons, and extreme high temperature in summer also affected the performance of local observers, leading to a number of scattered observations. For these reasons, through 2012, quality baseline observations were less frequent in the first half year and were more scattered in the second half year. Overall the vector variometer baseline variations were reasonably well controlled though the absolute observations.

ΔF throughout 2012 displays three distinct ranges:

- −1 nT to +1 nT from 2012-01-01/05-26
- +4.8 nT to +6 nT from 2012-05-27/11-23
- +1.5 nT to +2 nT from 2012-11-25/12-31

In each section, ΔF was in the range of 2 nT, suggesting the DMI variometer baselines through 2012 were stable except for the major baseline shifts taking place on 2012-05-26/27 and 2012-11-23/24.

The baseline jump on 2012-05-27 was caused by a power system upgrade. There was approximately one day of data loss from 2012-05-26/27. Baseline steps for X, Y and Z were determined through ΔF and weekly absolute observations.

The second baseline step occurred without a clear reason during 2012-11-23T21:22Z/35. The X and Y field components were offset by +2.6 nT. Soon afterwards, the third baseline step occurred between 2012-11-24T06:50Z/07:17 where X and Y where offset by approximately +2 nT. Through visual inspection of 1-second time-series data, these steps were more correctly identified as sharp baseline drifts.

Figure 7.2 shows the accepted observed and adopted baseline values in XYZ for KDU in 2012. Table 7.12 shows statistics regarding the difference between these observed and adopted baseline values (residuals).

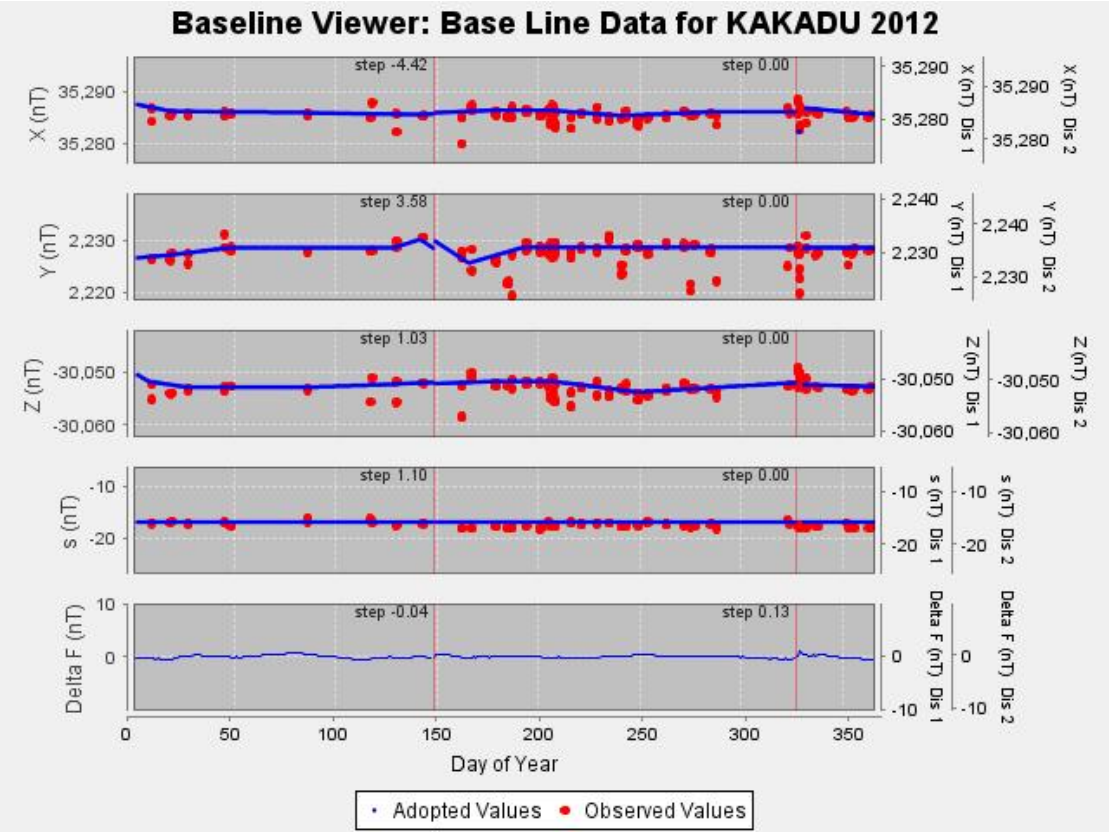

Figure 7.2 KDU 2012 baseline plots.

Table 7.12 Standard deviation of residuals from accepted absolute observations at KDU during 2012.

Component	SD
X	1.2 nT
Y	2.1 nT
Z	1.4 nT
D	12″
I	08″
F	0.4 nT

7.2.6 Real-time, quasi-definitive and definitive data comparison

Table 7.13 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for KDU.

Table 7.13 Data type differences statistics for KDU in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+02.2	+01.8	−05.4
	SD	+06.6	+01.6	+05.1
	Sample minimum	−03.9	−00.7	−14.1
	Sample maximum	+13.1	+04.2	−01.5
D−Q	AM	−01.3	+00.2	−02.0
	SD	+00.4	+01.5	+00.5
	Sample minimum	−01.9	−02.5	−02.9
	Sample maximum	−00.5	+02.2	−01.2

The KDU 2012 preliminary data has relatively larger variations due to spikes caused by lightning strikes and baseline steps due to maintenance work. Baselines were updated quarterly to produce quasi-definitive data.

The KDU 2012 quasi-definitive data are within the specification for INTERMAGNET quasi-definitive data.

7.2.7 Operations

When possible, stationed observer Andy Ralph performed absolute observations weekly. Andy was trained at KDU in September 2006 with refresher training during maintenance visits by Geomagnetism Team staff from Canberra. In general, absolute observations were of good quality. Occasionally some observations were unacceptable, the most likely reason being magnetic contamination.

From 2012-06/10 a second observer, John Cianchi, perform weekly absolute observations. This arrangement was to fill the weekly observation gaps when the primary observer had other commitments, particularly during the tourist seasons.

From 2012-01-01/11-22 absolute observation data were recorded on paper forms, and the completed forms were scanned and then emailed to GA. From 2012-11-22 onwards absolute observation data were recorded on a tablet PC and digital observation files were emailed to GA where they were reduced and used to calibrate variometer data.

On weekly visits, the observer checked the operation of the observatory and maintained the observatory in good condition, such as building pest control, mowing grass and changing batteries.

The power system was upgraded during the period 2012-05-26 to 2012-05-30. The equipment was protected from power blackouts, surges and lightning strikes by a mains filter, a UPS and a surge absorber.

A maintenance visit by Liejun Wang during 2012-07-21/25 facilitated annual maintenance work, instrument comparisons and observer training. During this visit, DIM DI0049/322847 was introduced

into the weekly routine and DIM B0622H/359142 was returned to Canberra for service and comparisons.

A maintenance visit by Andrew Lewis commencing 2012-11-22 introduced a tablet PC for absolute data recording and also provided refresher training for the observer.

Although some lightning protection measures were incorporated in its original construction, KDU has suffered lightning damage since its installation in 1995. Additional protection measures were taken in December 1998 and October 1999, including the installation of an ERICO lightning protection system. KDU now employs components of the ERICO System 3000[18] including a Dynasphere Air Terminal, mast and a copper-coated-steel earthing rod. The system is specified to protect an area of 80 m radius. Lengths of copper ribbon and aluminium power cables were buried in shallow trenches around the vicinity of KDU, grounding the Dynasphere Air Terminal. The upgraded lightning protection measures are working well, and no data loss occurred in 2012 due to lightning strikes.

Data was retrieved from the DAQ system at least every 10 minutes using rsync over SSH using the VSAT satellite link.

The distribution of 2012 KDU data after primary transmission to GA is shown in Table 7.14.

Table 7.14 Distribution of KDU 2012 data.

	Recipient	Data type	Sent
1-second values	IPS, Sydney	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Quarterly
	WDC for Geomagnetism, Kyoto	P	Real-time

[18] https://www.erico.com/catalog/literature/E429B-WWEN.pdf (accessed 2017-12-21).

7.2.8 Missing one-minute definitive data

In 2012, 1699 and 427 values were missing from the KDU definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.15.

Table 7.15 KDU Missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-05-26T22:46Z/2012-05-27T22:17	XYZ	1412	n/a
2012-05-27T23:31Z/23:41	XYZ	11	n/a
2012-05-28T07:36Z/07:39	XYZ	4	n/a
2012-05-30T01:37Z/01:56	XYZ	20	n/a
2012-10-12T00:33Z/00:39	XYZ	7	n/a
2012-11-22T01:07Z/01:12	XYZ	6	n/a
2012-11-23T21:22Z/23:00	XYZ	99	n/a
2012-11-24T06:50Z/09:00	XYZ	131	n/a
2012-12-10T16:54Z/17:02	XYZ	9	n/a
2012-05-27T01:39Z/08:29	F	411	n/a
2012-05-30T01:38Z/01:47	F	10	n/a
2012-11-22T01:04Z/01:06	F	3	n/a
2012-12-05T08:12Z/08:12	F	1	n/a
2012-12-05T08:26Z/08:26	F	1	n/a
2012-12-08T08:49Z/08:49	F	1	n/a

7.2.9 Significant events

Table 7.16 Significant event that took place at KDU in 2012.

Time or duration	Description of event
2012-01-16	PDA battery fully drained and could not be restored; consequently no PPM observations were conducted.
2012-01-25	Connector from DIM fluxgate into electronics malfunctioning with a new connector requested. More observation forms and envelopes were also requested.
2012-02-07	Connector for Bartington DIM arrives at KDU and fitted before observation on 2012-02-12.
2012-03-17	First observation after Andy Ralph returns from leave. Bartington DIM battery fails. Andy checked seismic vault for water ingress. Vault is dry.
2012-03-19	Send replacement battery to KDU.
2012-05-28	Data loss during power system maintenance by networks personnel.
2012-07-20	Liejun Wang visited KDU from 2012-07-21/25. DIM DI0049/311847 swapped with DIM B0622H/359142. Instrument correction needs adjustment in the baseline file. Correction of −0.05′ in D and −0.15′ in I for both DIMs.
2012-08-01	Posted a new stopwatch to KDU.
2012-11-22	Andrew Lewis visited KDU. Introduced tablet PC for absolute observation data recording.
2012-11-23T04:24Z	Noise in variometer Z channel.
2012-11-23T21:51Z	SSC. ΔF check changed approximately 2 nT just before SSC.
2012-11-24T06:51Z	ΔF shifted 2 nT and variometer noise.

7.2.10 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for KDU in 2012 are given in Table 7.17. Annual means for X, Y, Z and F since 1995 are plotted in Figure 7.3 and tabulated in Appendix E.1.

Table 7.17 KDU 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+003° 23.8′	−039° 54.9′	35448	35386	2100	−29655	46217
Quiet Days	+003° 23.8′	−039° 54.4′	35458	35395	2100	−29655	46224
Disturbed Days	+003° 23.8′	−039° 56.1′	35426	35364	2099	−29658	46202

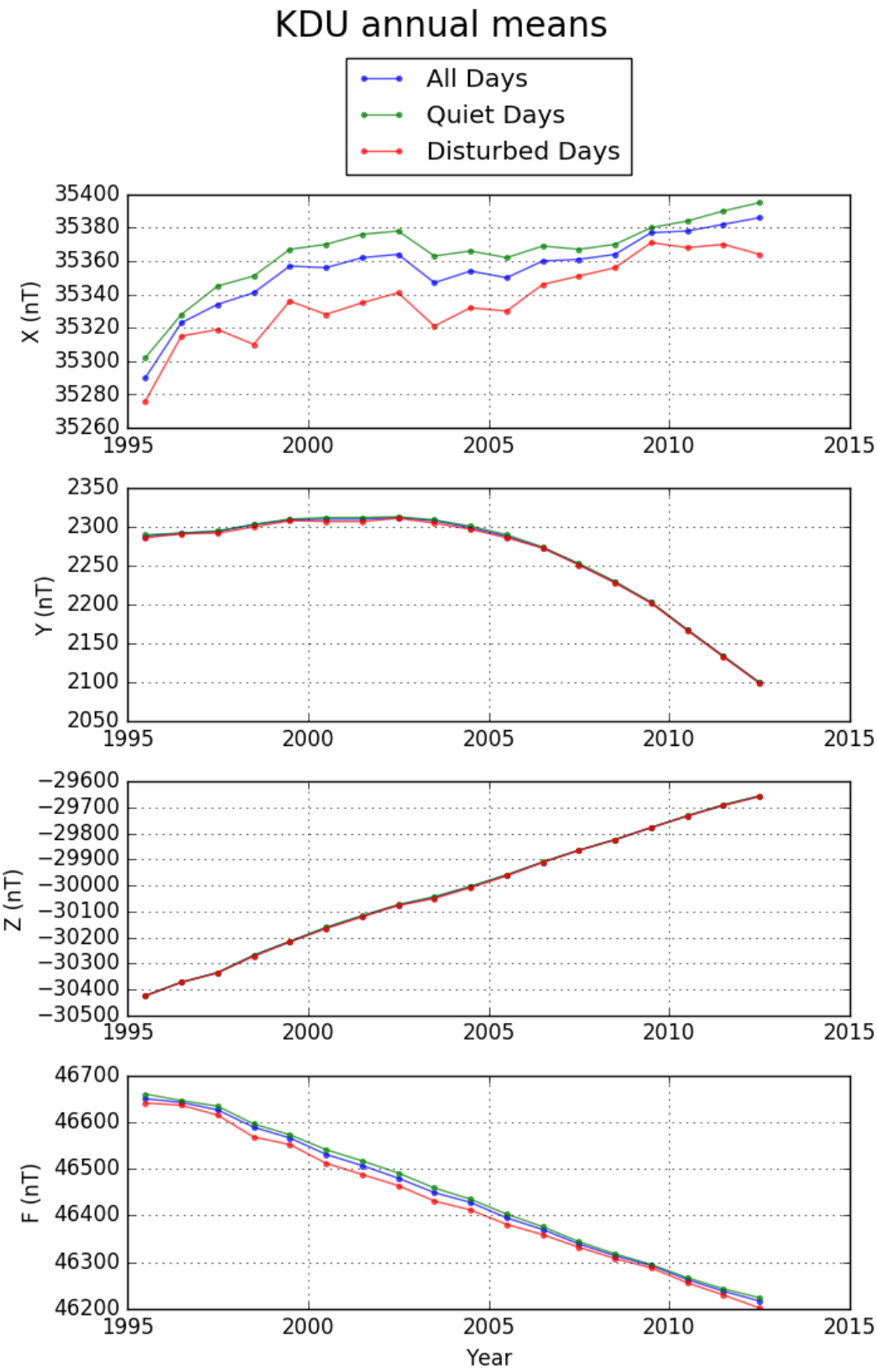

Figure 7.3 KDU annual means since 1995.

7.3 Charters Towers

Charters Towers is 120 km southwest of Townsville in North Queensland. CTA is located at Towers Hill, 1.7 km southwest of the town centre, in an area leased to GA by the Charters Towers Regional Council.

The observatory comprises:

- A disused gold mine adit ('the tunnel') approximately 100 m into the northern side of Towers Hill, which houses the variometers
- A VSAT communications dish outside the tunnel
- An absolute shelter on a hillside approximately 250 m to the southwest of the tunnel.

Important details regarding CTA are given in Table 7.18.

Table 7.18 Important CTA observatory details for 2012

IAGA code	CTA
Commenced operation	June 1983
Geographic latitude	020° 05′ 25″ S
Geographic longitude	146° 15′ 51″ E
Geomagnetic latitude	027.51° S (IGRF 2010)
Geomagnetic longitude	221.39° E (IGRF 2010)
K 9 index lower limit	300 nT
Principal pier	Pier C
Pier elevation (top)	370 m AMSL
Principal reference mark	Post office spire
Reference mark azimuth	34° 40′ 45″
Reference mark distance	1.75 km
Observatory manager(s)	Andrew Lewis
Observer(s)	Bradley Stevenson

7.3.1 Local meteorological conditions

The meteorological temperature at Charters Towers during 2012 varied from a minimum of +2 °C (2012-08-12) to a maximum +41 °C (2012-12-04). Daily minimum temperatures varied from +2 °C to +24 °C (average +17 °C ± 5 °C); daily maximum temperatures varied from +15 °C to +41 °C (average +30 °C ± 5 °C); daily temperature ranges varied from +1 °C to +24 °C (average +13 °C ± 4 °C).

7.3.2 Variometers

Table 7.19 shows specifics of the variometers and acquisition system used at CTA during 2012.

Table 7.19 Variometer systems used at CTA in 2012.

CTA vector variometer	Model	DMI FGE
	Serial number	E0227/S0210
	Type	3-channel, non-suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
CTA scalar variometer	Model	GEM Systems GSM-90
	Serial number	4081420/42178
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
CTA DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS16 receiver
Other	Communications	VSAT

The vector variometer at CTA was a DMI FGE non-suspended 3-component fluxgate magnetometer with the sensor mounted on a concrete pillar and orientated magnetic NW, magnetic NE, and vertical. Throughout most of 2012 an Overhauser effect total field magnetometer monitored variations of the total intensity, F. The total field sensor was mounted on a concrete pillar.

Although not temperature controlled, the temperature within the tunnel where the variometer sensors and electronics were located varied over a range of +2.6 °C throughout the year. The temperature of the fluxgate sensor ranged from about +26 °C in (July-August) to about +29 °C in March. There was no discernible diurnal temperature variation. The DAQ system (except the electronics for both the FGE and GSM variometers) was housed in an air-conditioned room in an adjacent arm of the tunnel.

From 2012-05-12/06-29 there no total field data was recorded as the GSM 4081420/42178 failed.

Sub-nanotesla interference between the GSM 4081420/42178 and the FGE E0227/S0210 during the GSM's polarisation cycles continues to be a problem at CTA.

There were several periods of disturbance to the variometer data during 2012 caused by maintenance and repair work to the tunnel structure. Periods of contaminated data were removed from the variometer data. These data were despiked automatically and visually inspected during definitive data processing.

7.3.3 Variometer clock corrections

Time stamps applied to the variometer data were obtained from the DAQ software clock, which was synchronized to UTC. During 2012, CTA's timing control system performed poorly, with hundreds of corrections of approximately 1 second in magnitude. This was the result of the Garmin GPS 16 receiver being faulty and it was replaced in February 2013. Appendix Table A.1 lists clock corrections exceeding 10 ms for CTA in 2012.

7.3.4 Absolute instruments

Both absolute PPM and DIM observations were performed on Pier C in the absolute shelter of CTA during 2012. The principal absolute magnetometers used and their adopted corrections for 2012 are described in Table 7.20. The D and I corrections applied in 2012 were determined through instrument comparisons performed during maintenance and calibration visits in 2013-02. Instrument corrections are to the international reference and these corrections have been applied to all CTA 2012 final data through the correction of absolute observations.

Table 7.20 Absolute instrumentation (with corrections) used at CTA in 2012.

CTA DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0036
	Theodolite	Zeiss 020B
	Theodolite serial	394050
	Theodolite resolution	+0.1′
	D correction	+0.0′
	I correction	−0.2′
CTA absolute PPM	Model	GEM Systems GSM-90
	Serial number	3091318/91472
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

The three instrument mounting pads secured to the top of the absolute pier were found to be loose on 2012-04-14. They were re-fitted in the same positions as previously on 2012-04-19.

7.3.5 Baselines

In 2012 there were 49 pairs of absolute observations for CTA. The FGE E0227/S0210 variometer performed reliably throughout 2012. The baseline drifts had ranges of approx. 5 nT in the X, Y and Z components throughout the year.

Figure 7.4 shows the accepted observed and adopted baseline values in XYZ. Table 7.21 shows statistics regarding the difference between observed and adopted baseline values (residuals).

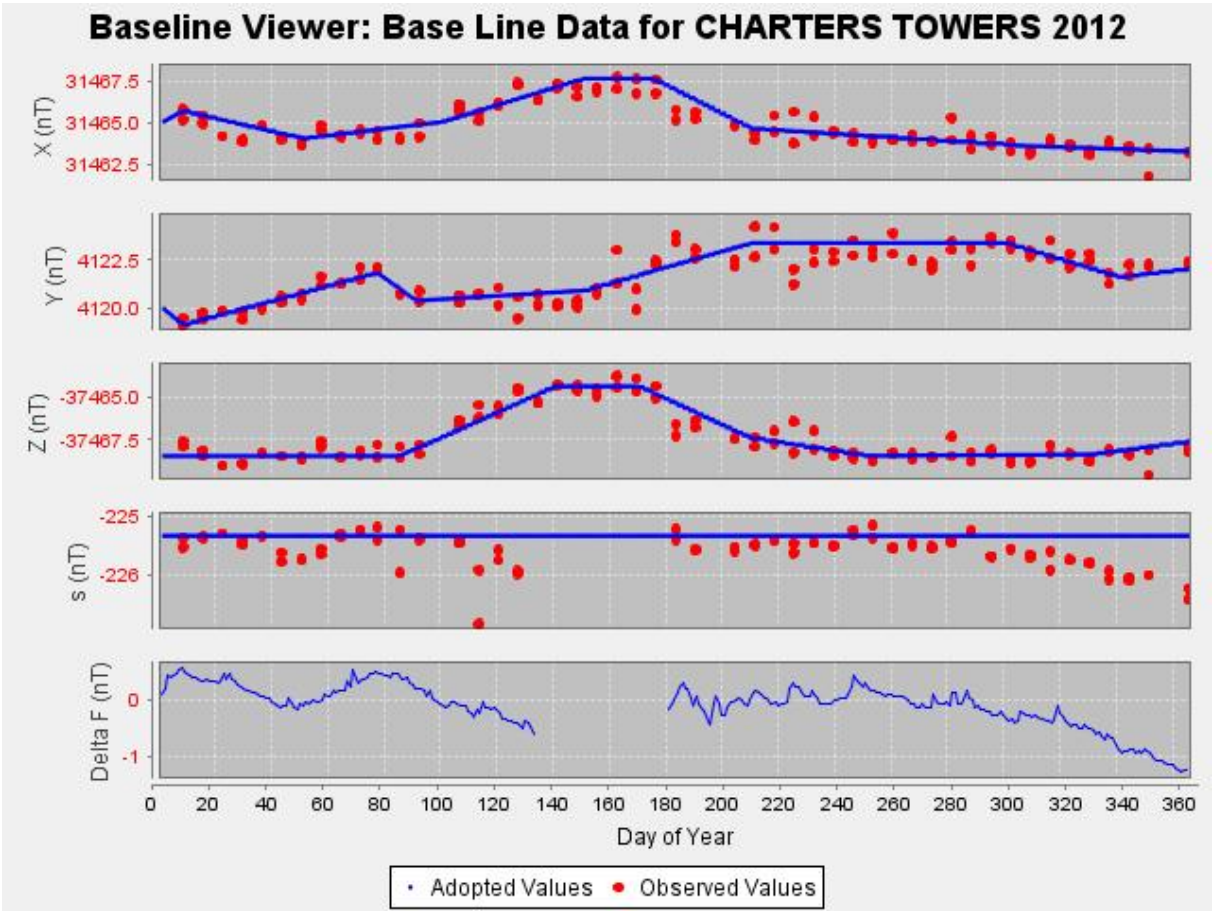

Figure 7.4 CTA 2012 baseline plots.

Table 7.21 Standard deviation of residuals from accepted absolute observations at CTA during 2012

Component	SD
X	0.5 nT
Y	0.6 nT
Z	0.5 nT
D	04″
I	03″
F	0.2 nT

7.3.6 Real-time, quasi-definitive and definitive data comparison

Table 7.22 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for CTA.

Table 7.22 Data type differences statistics for CTA in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+0.6	−0.4	+1.0
	SD	+1.6	+0.8	+1.9
	Sample minimum	−1.2	−1.9	−1.9
	Sample maximum	+2.9	+0.8	+4.3
D−Q	AM	−0.2	−0.1	+0.1
	SD	+0.5	+0.7	+0.4
	Sample minimum	−0.9	−1.2	−0.7
	Sample maximum	+0.7	+1.3	+0.9

The CTA 2012 quasi-definitive data are within the specification for INTERMAGNET quasi-definitive data.

7.3.7 Operations

In 2012, Bradley Stevenson performed weekly absolute observations and checks at CTA.

The system was powered by a 12 V DC source which also powers the Charters Towers seismic observatory. The 240 V (rms) ac FGE E0227/S0210 electronics was powered with a dedicated inverter running from the 12 V dc seismic power system. DAQ system timing control was provided by a Garmin GPS 16 receiver; which was faulty throughout 2012 and replaced in 2013 (see Section 7.3.3 Variometer clock corrections)

The distribution of 2012 CTA data after primary transmission to GA is shown in Table 7.23.

Table 7.23 Distribution of CTA 2012 data.

	Recipient	Data type	Sent
1-second values	IPS, Sydney	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Quarterly
	WDC for Geomagnetism, Kyoto	P	Real-time

7.3.8 Missing one-minute definitive data

In 2012, 348 and 69163 values were missing from the CTA definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.24.

Table 7.24 CTA Missing one-minute definitive data for in 2012.

Duration	Components	Samples	Comment
2012-02-16T01:45Z/01:46	XYZ	2	n/a
2012-06-23T01:09Z/01:09	XYZ	1	n/a
2012-06-24T01:20Z/04:00	XYZ	161	n/a
2012-06-24T23:40Z/2012-06-25T02:40	XYZ	181	n/a
2012-06-25T05:07Z/05:09	XYZ	3	n/a
2012-05-12T03:39Z/2012-06-29T04:21	F	69163	n/a

7.3.9 Significant events

Table 7.25 Significant event that took place at CTA in 2012.

Time or duration	Description of event
2012	Multiple GPS clock corrections greater than 10 ms throughout the year.
2012-01-27	GPS synchronized clock issues.
2012-02-15T00:46Z	Possible data contamination.
2012-02-15T01:09Z	Possible data contamination.
2012-02-24T05:00Z	Tunnel structural survey. Engineer inside tunnel.
2012-03-16T18:23Z	Time jump.
2012-03-18T05:15Z	Time jump.
2012-04-14	Brad noted that all three aluminium footpads on top of the observing pier had separated from the concrete. Observations were done.
2012-04-20	Footpads glued back onto the pier.
2012-05-14	GSM 3091318/91472 data stopped in last 48 hours. Only ‘C quality’ data being recorded.
2012-05-21T19:36Z	Baseline instability.
2012-05-25	Tunnel repair work starts. Expected to continue over the next few weeks.
2012-06-04	Backward time jumps.
2012-06-16	Observation during storm.
2012-06-22	Tunnel repairs in progress on this day and over the weekend.
2012-06-25	Tunnel repairs continue today.
2012-06-27	GSM 3091318/91472 sent back to CTA.
2012-06-29T04:30Z	GSM 3091318/91472 installed and running. Engineering repair work in the tunnel completed. A support near the GSM90 required repair with stainless steel bolts.
2012-06-30T23:59:59Z	Leap second.
2012-07-15	No weekly observations due to continuing wet weather.
2012-09-08	Multiple time jumps.
2012-09-09	Multiple time jumps.

7.3.10 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for CTA in 2012 are given in Table 7.26. Annual means for X, Y, Z and F since 1995 are plotted in Figure 7.5 and tabulated in Appendix E.2.

Table 7.26 CTA 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+007° 29.4′	−049° 41.8′	31771	31500	4141	−37459	49118
Quiet Days	+007° 29.4′	−049° 41.3′	31780	31509	4142	−37458	49123
Disturbed Days	+007° 29.4′	−049° 43.0′	31751	31480	4139	−37462	49107

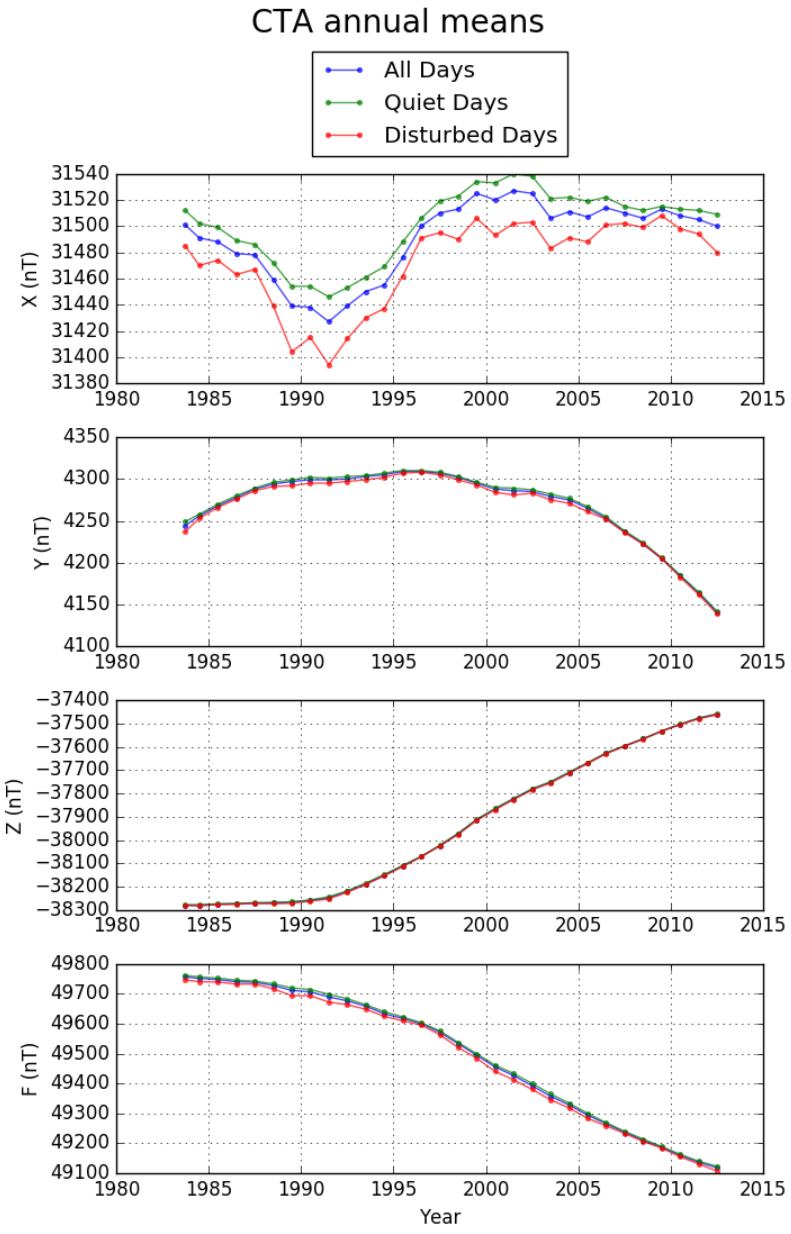

Figure 7.5 CTA annual means since 1983.

7.4 Learmonth

LRM is located on North West Cape about 1100 km north of Perth and 35 km from Exmouth in Western Australia. The magnetic observatory is co-located with the Learmonth Solar Observatory (LSO), which was jointly staffed by IPS and the Unites States Air Force. The observatory complex is situated on coastal sand dunes bordering the Exmouth Gulf.

LRM consists of:

- Three underground vaults located on IPS land, housing variometer sensors and control equipment;
- An absolute shelter, located on land belonging to the Royal Australian Air Force (RAAF) 200 m from the LSO, enclosing a concrete observation pier (Pier A), the top of which is 1200 mm above the concrete floor
- An external station on RAAF land.

Important details regarding LRM are given in Table 7.27.

Table 7.27 Important LRM observatory details for 2012

IAGA code	LRM
Commenced operation	November 1986
Geographic latitude	022° 13′ 19″ S
Geographic longitude	114° 06′ 03″ E
Geomagnetic latitude	031.89° S (IGRF 2010)
Geomagnetic longitude	187.07° E (IGRF 2010)
K 9 index lower limit	300 nT
Principal pier	Pier A
Pier elevation (top)	4 m AMSL
Principal reference mark	West windsock
Reference mark azimuth	283° 02′ 18″
Reference mark distance	Approx. 1 km
Observatory manager(s)	William Jones
Observer(s)	Emily Lindsay, Owen Giersch, Jenny Howse, Andrew Lewis, William Jones

7.4.1 Local meteorological conditions

The meteorological temperature at Learmonth during 2012 varied from a minimum +4 °C (2012-07-06) to a maximum +46.6 °C (2012-12-23). Daily minimum temperatures varied from +4 °C to +29.2 °C (average +17.8 ± 5.4 °C). Daily maximum temperatures varied from +21.6 °C to +46.6 °C (average +32.6 °C ± 5 °C). Daily temperature ranges varied from 0 °C to +22 °C (average +6 °C ± 3 °C). The daily maximum wind gust varied from 17 km/h to 78 km/h (average 39.7 km/h ± 11.2 km/h). The greatest daily maximum wind gust was 78 km/h in January. The least maximum wind gust was 17 km/h in July. No meteorological ‘sunshine hours’ data was available for Learmonth during 2012.

7.4.2 Variometers

Table 7.28 shows specifics of the variometers and acquisition system used at LRM during 2012.

Table 7.28 Variometer systems used at LRM in 2012.

LRM vector variometer	Model	DMI FGE
	Serial number	E0271/S0237
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
LRM scalar variometer	Model	GEM Systems GSM-90
	Serial number	8092903/83385
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
	Duration of use	2012-01-01/12-31
LRM original DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Trimble AcuTime GPS receiver
	Duration of use	Until 2012-02-22
LRM replacement DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Trimble AcuTime GPS receiver
	Duration of use	From 2012-03-01
Other	Communications	Either radio modem to Giralia seismic station then VSAT to GA or IPS link to Sydney then to GA

Recording equipment, some of the variometer electronic control equipment, and back-up power systems were housed in the Radio Solar Telescope Network (RSTN) building of the LSO. The magnetometers and control electronics were housed in three semi-underground concrete vaults, each 0.8×0.8×0.8 m^3, lying in a north-south line about 110 m from the RSTN building. The vaults are about 7 m apart and covered in local sand. The fluxgate sensor was in the northern most vault with the control electronics in the central vault. The GSM 8092903/83385 was in the southern most vault with its electronics in the central vault.

Underground conduits containing wiring connect the central vault to the two sensor vaults. An underground conduit between the RSTN building and the central vault contained 12 V dc power and

digital data cables. The variometer and recording system were powered by a 12 V dc battery charged from mains power. The recording computer and 12 V dc battery box were housed in the RSTN building.

The central vault was opened on 2012-08-09 to replace a digital signal converter. Approximately four days of instability in ΔF followed, likely caused by temperature stabilisation after opening the vault.

7.4.3 Variometer clock corrections

Time stamps applied to the variometer data were obtained from the DAQ system software clock. That clock was synchronised to UTC. During 2012, adjustments to the system clock were only greater than 10 ms on the occasions listed in Table 7.29.

Table 7.29 Software clock adjustments greater than 10 ms for LRM in 2012.

Time before correction	Correction (s)	Comment
2012/02/28T00:01:28Z	+0.333	n/a
2012/02/28T00:04:03Z	+0.251	n/a
2012/02/28T01:47:37Z	−0.236	n/a
2012/02/28T01:57:10Z	+0.168	n/a
2012/02/28T02:30:15Z	+0.322	n/a
2012/02/28T03:00:44Z	+0.058	n/a
2012/03/06T06:07:22Z	−8.077	Replacement computer installed
2012/03/20T01:32:50Z	+1.476	Replacement of protocol converters
2012/07/01T00:02:05Z	−1.000	Leap second

7.4.4 Absolute instruments

The principal absolute magnetometers used at LRM and their adopted corrections for 2012 are described in Table 7.30. The corrections applied correct for the differences between the 2012 LRM DIM and the international average (as defined by observations at IAGA instrument workshops). These corrections have been applied to all LRM 2012 final data through the correction of absolute observations.

Table 7.30 Absolute instrumentation (with corrections) used at LRM in 2012.

LRM DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0051
	Theodolite	Zeiss 020B
	Theodolite serial	313888
	Theodolite resolution	+0.10′
	D correction	−0.05′
	I correction	−0.10′
LRM absolute PPM	Model	GEM Systems GSM-90
	Serial number	2101216/83387
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

DIM DI0051/313888 was compared to the Canberra geomagnetic observatory reference instrument, DIM DI0086/353756, on 2009-07-21, 2009-07-28, 2009-08-17, 2009-08-25, 2009-09-01, and 2009-09-22 at the Canberra geomagnetic observatory before being deployed to LRM. Adopted Instrument corrections were −0.05′, and −0.10′ in D and I, respectively. During an observatory maintenance visit in August 2012 a comparison was made between the travelling reference (DIM 160459/B0610H) and the DIM DI0051/313888. The results of the comparison showed that no change was required to the previously applied instrument corrections for the LRM absolute instruments.

7.4.5 Baselines

Figure 7.6 shows the accepted observed and adopted baseline values in XYZ. Table 7.31 shows statistics regarding the difference between observed and adopted baseline values (residuals).

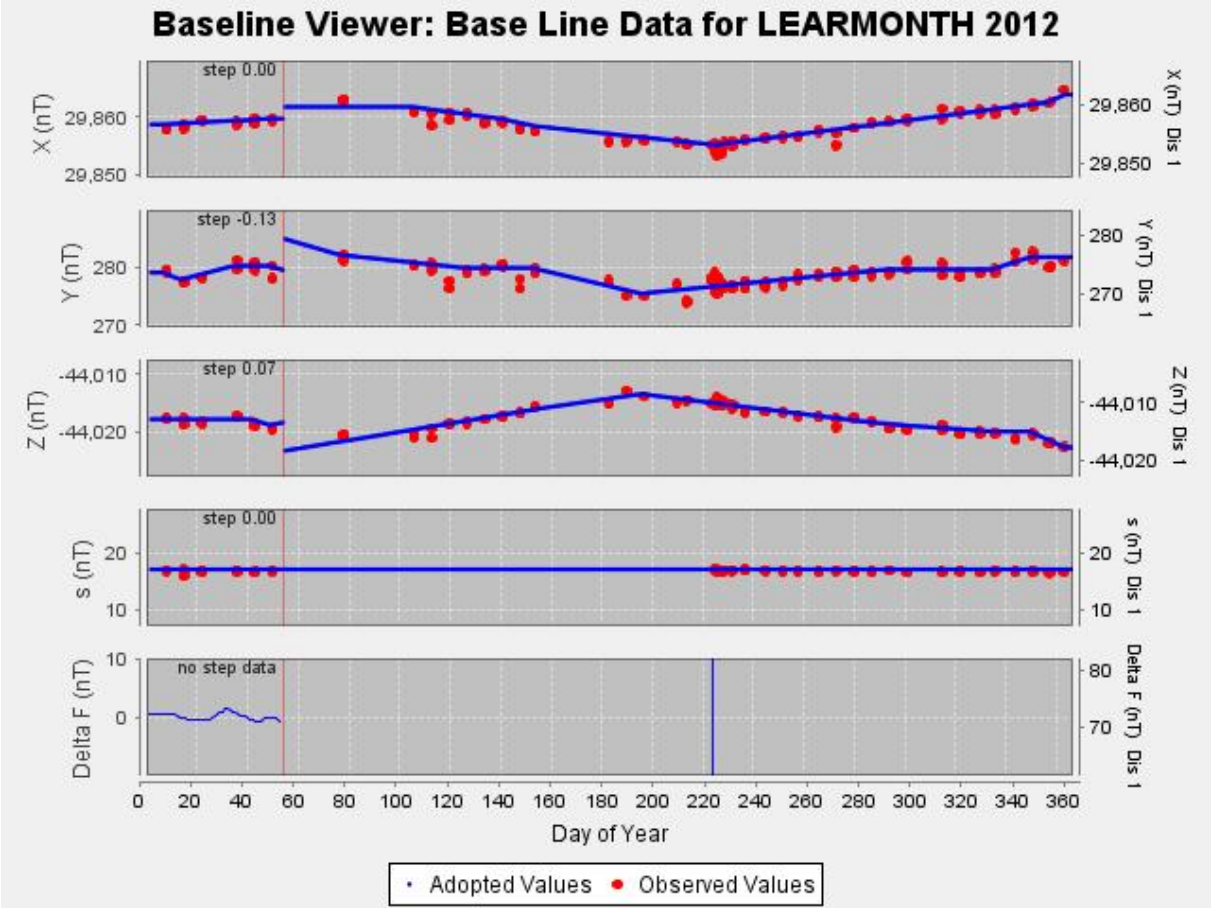

Figure 7.6 LRM 2012 baseline plots.

Table 7.31 Standard deviation of residuals from accepted absolute observations at LRM during 2012

Component	SD
X	0.7 nT
Y	1.1 nT
Z	0.6 nT
D	08″
I	03″
F	0.5 nT

7.4.6 Real-time, quasi-definitive and definitive data comparison

Table 7.32 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for LRM.

Table 7.32 Data type differences statistics for LRM in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	−02.3	−02.2	+06.0
	SD	+08.9	+13.4	+22.1
	Sample minimum	−28.7	−43.6	−06.1
	Sample maximum	+06.2	+05.2	+74.6
D−Q	AM	−00.1	−00.2	−00.2
	SD	+00.2	+00.4	+00.3
	Sample minimum	−00.6	−01.0	−00.8
	Sample maximum	+00.2	+00.3	+00.3

The comparison between the real-time data and the definitive data highlighted that large variations in the monthly averages occurred after the lightning strike in February. This was due to problems with the temperature channel data. These problems where corrected for the definitive data.

The LRM 2012 reported data monthly averages were outside the specification for INTERMAGNET quasi-definitive data.

The LRM 2012 quasi-definitive data are within the specification for INTERMAGNET quasi-definitive data.

7.4.7 Operations

Absolute observations were performed nominally weekly by Emily Lindsay, Owen Giersch and Jenny Howse from IPS; with additional observations performed by Andrew Lewis and William Jones from GA on the 2012-08-09/14 maintenance visit.

Data was also provided directly to IPS via a direct serial link from the DAQ computer in the RSTN building. IPS applied nominal scale values and rotation parameters.

On 2012-02-22 lightning struck the LSO which resulted in a failure of equipment housed in the RSTN building. The geomagnetic equipment located within the building was also affected. Both the computer and battery box were damaged.

A replacement acquisition computer, battery, monitor and keyboard were air freighted to LRM and installed on 2012-03-06 by the local observer. After installation and initialization, the FGE E0271/S0237 was functioning but the GSM 8092903/83385 was not. The serial data communications protocol converter for the scalar variometer data in the RSTN building was replaced on 2012-03-20 resulting in approximately 15 minutes of data loss. This, however, did not resolve the issues with the GSM 8092903/83385.

Since the 2012-02-22 lightning related issues, it is likely that several FGE E0271/S0237 sensor temperature values were incorrectly reported. This corrupted data affected data delivered to ‘real-time clients’ (see Section 6.2 Data retrieval) through incorrect temperature effect corrections being applied

(see Section 6.1 Data reduction). For the 2012 LRM definitive data, corrupted sensor temperature values were infilled by values estimated from correct neighbouring values.

The GSM 2101216/83387 failed during the absolute observation on 2012-03-26. The electronics and cable were subsequently sent to GA for testing and repair. It was found that a wire in one of the connectors of the cable had malfunctioned. The repaired electronics and cable were freighted back to LRM on 2012-04-04.

The responsibility of local observer transferred to Owen Giersch in 2012-04 after Emily Lindsay left IPS. The combination of this change and also the previously mentioned GSM 2101216/83387 issue resulted in no absolute observations for 2012-03-17/04-14 being performed.

During a maintenance visit in August two serial data protocol converters were replaced and this resulted in data being received from the GSM 8092903/83385 once again.

This maintenance visit also provided an opportunity to train Jenny Howse in taking absolute observations. The battery powering the absolute instrumentation failed on 2012-08-23. A new battery was freighted to LRM which was installed upon arrival. No interruption to absolute observations occurred during this period.

On 2012-12-28 the system recorded a large spike in temperature which was corrected in software.

The distribution of 2012 LRM data after primary transmission to GA is shown in Table 7.33.

Table 7.33 Distribution of CTA 2012 data.

	Recipient	Data type	Sent
1-second values	IPS	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Monthly[1]
	WDC for Geomagnetism, Kyoto	P	Real-time from August
	WDC for Geomagnetism, Kyoto	P	Daily from August

[1] *A six month block of monthly quasi-definitive data was prepared in July and sent to the Edinburgh INTERMAGNET GIN. After the July submission, the quasi-definitive data was prepared and sent within two weeks of the end of the month.*

7.4.8 Missing one-minute definitive data

In 2012, 18356 and 243140 values were missing from the LRM definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.34.

Table 7.34 LRM Missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-02-22T15:36Z/2012-03-06T09:00	XYZ	18325	n/a
2012-03-06T23:59Z/23:59	XYZ	1	n/a
2012-03-07T07:03Z/07:03	XYZ	1	n/a
2012-03-20T01:17Z/01:31	XYZ	15	n/a
2012-04-10T06:12Z/06:13	XYZ	2	n/a
2012-08-09T06:57Z/06:59	XYZ	3	n/a
2012-08-11T00:09Z/00:10	XYZ	2	n/a
2012-08-11T00:13Z/00:19	XYZ	7	n/a
2012-02-22T15:19Z/2012-08-09T10:42	F	243084	n/a
2012-08-10T23:38Z/2012-08-11T00:27	F	50	n/a
2012-10-08T03:11Z/03:16	F	6	n/a

7.4.9 Significant events

Table 7.35 Significant event that took place at LRM in 2012.

Time or duration	Description of event
2012-01-27	No scheduled absolute observations due to imminent arrival of cyclone Iggy. Tested telemetry link through IPS. Cyclone Iggy did not make landfall.
2012-02-22T15:35Z	System stops delivering data. Spiky data approx. 30 min before failure. LSO struck by lightning.
2012-02-25	Stephen Pryde confirms battery, DAQ computer and monitor are damaged.
2012-03-01	Sent replacement battery, DAQ computer, monitor and keyboard.
2012-03-06	Emily Lindsay installed replacement computer and battery box.
2012-03-06T05:49Z	First FGE E0271/S0237 data. Rapid drifts and numerous steps (particularly in the A channel). No PPM data. No response from GSM90.
2012-03-06	Numerous 1 ms time corrections.
2012-03-09/12	Spikes on temperature channels.
2012-03-13	Send replacement serial protocol converter for variometer PPM.
2012-03-13T00:50	Step in temperature channels.
2012-03-14T22:04:27Z/05:41	Baseline jump. Approx. 4nT jump all channels.

Time or duration	Description of event
2012-03-15T01:00:55Z/57	Large spike.
2012-03-20	Replacement protocol converter installed in RSTN building by Emily Lindsay. Unsuccessful.
2012-03-20T01:16Z/32	Data loss. Computer rebooted. Still no scalar variometer data.
2012-03-23	Absolute PPM (GSM 2101216/83387) malfunctions. All returned data is ‘00000.0’.
2012-03-23	Observer will be on a 2 week break so no absolute observations.
2012-03-26	Damaged DAQ computer and battery box arrives at GA.
2012-03-26	DAQ computer will not power on. Power supply damaged. Battery charger on battery box is damaged.
2012-03-28	GSM 2101216/83387 arrives in Canberra with cables and PDA. The sensor cable has broken connection.
2012-04-04	Sensor cable repaired by Jim Whatman and Liejun Wang tests instrument with CNB absolute PPM. Cable functioning and is shipped back to LRM.
2012-04-10T06:13Z	Reboot to get GdapIPS running.
2012-04-11	A few steps on variometer data due to bad temperature data.
2012-05-24	Emily Lindsay leaving, no replacement observer arranged as yet.
2012-05-25	Last observation by Emily Lindsay.
2012-06-21T02:30:29Z, 2012-06-21T02:37:29Z, 2012-06-21T02:51:29Z, 2012-06-21T03:04:29Z	Square shaped anomalous readings, 1 nT to 2 nT jump for around 2 minutes. Related to changes in data of electronics temperature.
2012-08-09/14	Maintenance visit by Andrew Lewis and William Jones. Standard observations, re-align sensor on DIM DI0051/313888, replace PPM ADCs in vault and RSTN, replace DMI ADC in RSTN, instrument comparisons, pier differences, round of angles, refresh training for Owen Giersch, training for Jenny Howse, upgrade ovine exclusion fence.
2012-08-11T07:08Z	Restart GdapIPS.
2012-08-23	Replacement batteries sent for absolute battery box.
2012-08-24	Replacement batteries arrive in LRM Stephen Pryde will install them.
2012-09-11T07:46Z	Data stops. Network outage at LRM. IPS to rectify.
2012-11-23	Change mark reading to 224° 05.7′ for absolute observation taken on this day.
2012-12-28T07:50Z	Baseline jump caused by large spike in temperature. Baseline file changed.

7.4.10 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for LRM in 2012 are given in Table 7.36. Annual means for X, Y, Z and F since 1987 are plotted in Figure 7.7 and tabulated in Appendix E.3.

Table 7.36 LRM 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+000° 24.9′	−055° 28.8′	29993	29992	217	−43608	52927
Quiet Days	+000° 24.9′	−055° 28.3′	30002	30001	217	−43607	52930
Disturbed Days	+000° 25.0′	−055° 30.1′	29972	29972	218	−43612	52918

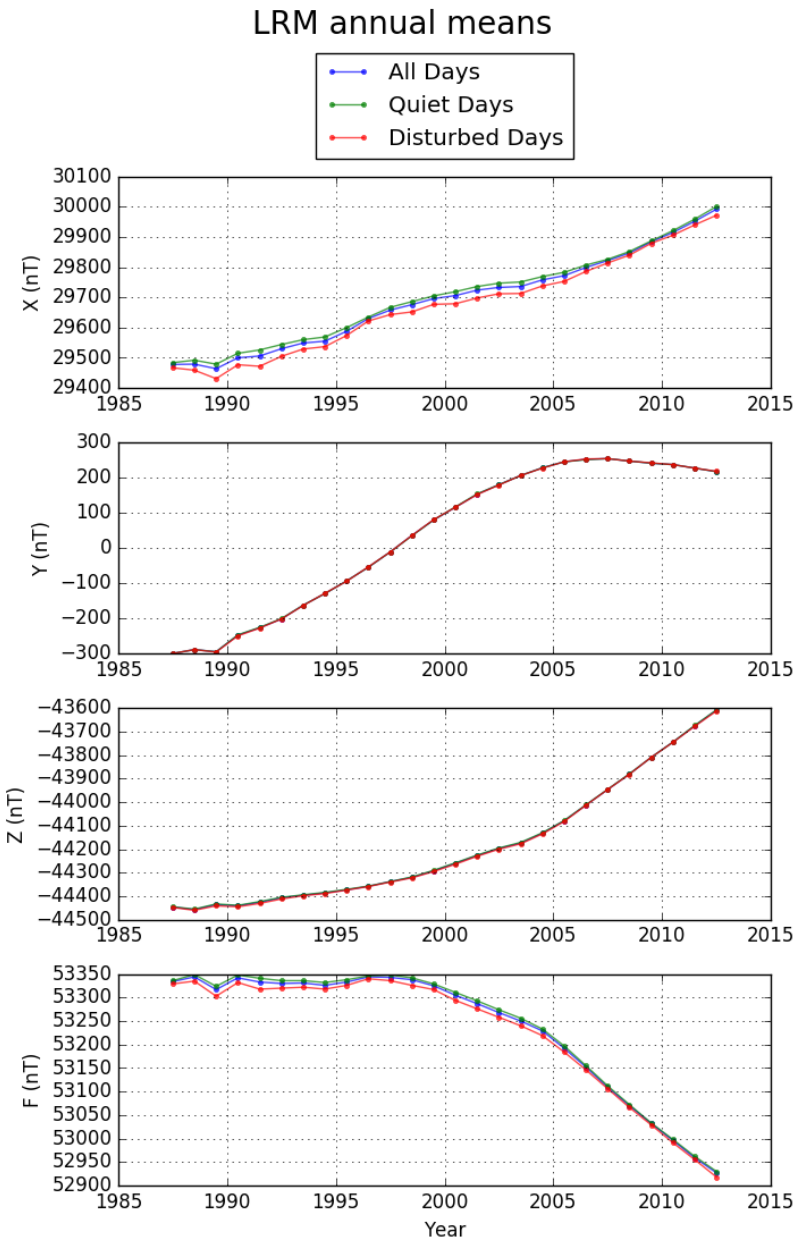

Figure 7.7 LRM annual means since 1987.

7.5 Alice Springs

ASP is located approximately 10 km south of Alice Springs in the Northern Territory, on land leased from the Centre for Appropriate Technology Limited (CAT). The observatory is situated on an alluvial plain over tertiary sediments, overlying late Proterozoic carbonates and quartzites.

The observatory comprises:

- A 3×3 m^2 insulated air-conditioned concrete-brick control house, housing recording instrumentation and control equipment (the control house)
- A 3×3 m^2 absolute shelter, 80 m southeast of the control house, which encloses a concrete observation pier (Pier G) with the top of the pier being 1277 mm above the concrete floor
- Two 300 mm diameter azimuth pillars about 85 m from the absolute shelter at approximate true bearings of 130° and 255°
- Two small (approx. 1 m^3) underground vaults located approximately 50 m north and 50 m east of the control house in which the variometer sensors and electronics are housed.

Important details regarding ASP are given in Table 7.37.

Table 7.37 Important ASP observatory details for 2012

IAGA code	ASP
Commenced operation	June 1992
Geographic latitude	023° 45′ 39.6″ S
Geographic longitude	133° 53′ 00.0″ E
Geomagnetic latitude	032.35° S (IGRF 2010)
Geomagnetic longitude	208.63° E (IGRF 2010)
K 9 index lower limit	350 nT
Principal pier	Pier G
Pier elevation (top)	557 m AMSL
Principal reference mark	Pillar B
Reference mark azimuth	255° 00′ 50″
Reference mark distance	85 m
Observatory manager(s)	William Jones
Observer(s)	Warren Serone, Shaun Evans, Liejun Wang, William Jones

7.5.1 Local meteorological conditions

The meteorological temperature at Alice Springs during 2012 varied from a minimum −5.2 °C (2012-07-07) to a maximum +43.2 °C (2012-12-24). Daily minimum temperatures varied from −5.2 °C to +29.1 °C (average +11.9 °C ± 9 °C); daily maximum temperatures varied from +14.6 °C to +43.2 °C (average +29.6°C ±8 °C).

The daily maximum wind gust varied from 17 km/h to 96 km/h (average 41.5 km/h ± 10 km/h). The greatest daily maximum wind gust was 96 km/h in January. The least daily maximum wind gust was 17 km/h in June. There was from 0 to 13.2 hours of sunshine (average 9.8 hours ± 3 hours) according to the meteorological definition.

7.5.2 Variometers

Table 7.38 shows specifics of the variometers and acquisition system used at ASP during 2012.

Table 7.38 Variometer systems used at ASP in 2012.

ASP vector variometer	Model	DMI FGE
	Serial number	E0306/S0261
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
ASP scalar variometer	Model	GEM Systems GSM-90
	Serial number	4081419/42177
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
ASP DAQ computer	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Trimble Acutime GPS receiver
Other	Communications	Cellular network

The FGE E0306/S0261 sensor and electronics were housed in the eastern underground vault and the GSM 4081419/42177 sensor and electronics in the northern vault. The fluxgate vault was insulated inside with foam. Both vaults were covered with soil to minimize diurnal temperature fluctuations. The DAQ system was housed in the control house.

Despite being housed in buried vaults, the variometers experienced seasonal temperature variations of approximately 20 °C. The FGE sensor temperature ranged from 12 °C to 32 °C during the year and the electronics from +18 °C to +35 °C. The FGE X, Y and Z channels exhibited temperature related variations of 1.0 nT, 0.2 nT and 1.7 nT, respectively.

7.5.3 Variometer clock corrections

Timestamps applied to the variometer data were obtained from the DAQ computer software clock. That clock was synchronised to UTC. During 2012, the single largest clock adjustment occurred at 2012-07-01T00:01:03Z when a 1 second adjustment for a leap second occurred. There were also numerous 1 ms to 10 ms adjustments throughout the year, in particular during March where another timing service was running, undesirably.

During 2012, adjustments to the system clock were only greater than 10 ms on the occasions listed in Table 7.39.

Table 7.39 Software clock adjustments greater than 10 ms for ASP in 2012.

Time before correction	Correction (s)	Comment
2012-03-10T18:06:00Z	+0.017	n/a
2012-03-11T03:00:17Z	+0.010	n/a
2012-03-11T08:54:51Z	+0.012	n/a
2012-03-11T09:09:42Z	+0.011	n/a
2012-03-11T21:47:54Z	+0.010	n/a
2012-03-12T01:35:55Z	+0.011	n/a
2012-03-12T06:46:26Z	+0.010	n/a
2012-03-13T05:16:29Z	+0.011	n/a
2012-03-13T10:18:54Z	+0.012	n/a
2012-03-13T12:00:13Z	+0.013	n/a
2012-03-14T20:05:06Z	+0.013	n/a
2012-03-14T20:17:13Z	+0.015	n/a
2012-03-14T21:34:51Z	+0.017	n/a
2012-03-15T05:42:21Z	+0.013	n/a
2012-03-15T08:50:07Z	+0.013	n/a
2012-03-15T15:06:25Z	+0.012	n/a
2012-03-15T19:15:55Z	+0.012	n/a
2012-03-15T21:23:55Z	+0.011	n/a
2012-03-16T00:23:23Z	+0.011	n/a
2012-03-16T13:12:48Z	+0.011	n/a
2012-03-17T06:39:27Z	+0.012	n/a
2012-03-17T11:16:43Z	+0.010	n/a
2012-03-17T14:13:45Z	+0.012	n/a
2012-03-17T19:36:00Z	+0.012	n/a
2012-03-17T23:08:18Z	+0.013	n/a
2012-03-18T00:21:27Z	+0.010	n/a
2012-03-18T07:43:28Z	+0.013	n/a
2012-03-18T19:04:06Z	+0.010	n/a
2012-03-18T20:01:25Z	+0.017	n/a
2012-03-19T05:51:05Z	+0.014	n/a
2012-03-19T08:48:38Z	+0.011	n/a
2012-03-19T13:22:24Z	+0.012	n/a

Time before correction	Correction (s)	Comment
2012-03-20T12:06:25Z	+0.016	n/a
2012-03-20T19:36:24Z	+0.012	n/a
2012-03-21T04:30:06Z	+0.010	n/a
2012-03-21T05:46:10Z	+0.010	n/a
2012-03-21T09:12:19Z	+0.010	n/a
2012-03-21T09:58:21Z	+0.011	n/a
2012-03-22T07:40:02Z	+0.010	n/a
2012-03-22T14:42:55Z	+0.012	n/a
2012-07-01T00:01:03Z	−1.000	Leap second

7.5.4 Absolute instruments

The principal absolute magnetometers used at ASP and their adopted corrections for 2012 are described in Table 7.40. The corrections applied correct for the differences between the 2012 ASP DIM and the international average (as defined by observations at IAGA instrument workshops). These corrections have been applied to all ASP 2012 final data through the correction of absolute observations.

Table 7.40 Absolute instrumentation (with corrections) used at ASP in 2012.

ASP DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0052
	Theodolite	Zeiss 020B
	Theodolite serial	313887
	Theodolite resolution	+0.1′
	D correction	+0.1′
	I correction	−0.1′
ASP absolute PPM	Model	GEM Systems GSM-90
	Serial number	4081422/01504
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

The ASP DIM (DIM DI0052/313887) was compared to the travelling reference DIM (DIM B0610H/160459) twice during 2012. The first comparison was made during a maintenance visit on the 2012-02-09 by Liejun Wang and the second comparison was made during a second maintenance visit on the 2012-11-08 by William Jones. Both of the comparison results confirmed the adopted correction for DIM DI0052/313887 to the international standard, given in Table 7.40.

7.5.5 Baselines

Figure 7.8 shows the accepted observed and adopted baseline values in XYZ. Table 7.41 shows statistics regarding the difference between observed and adopted baseline values (residuals).

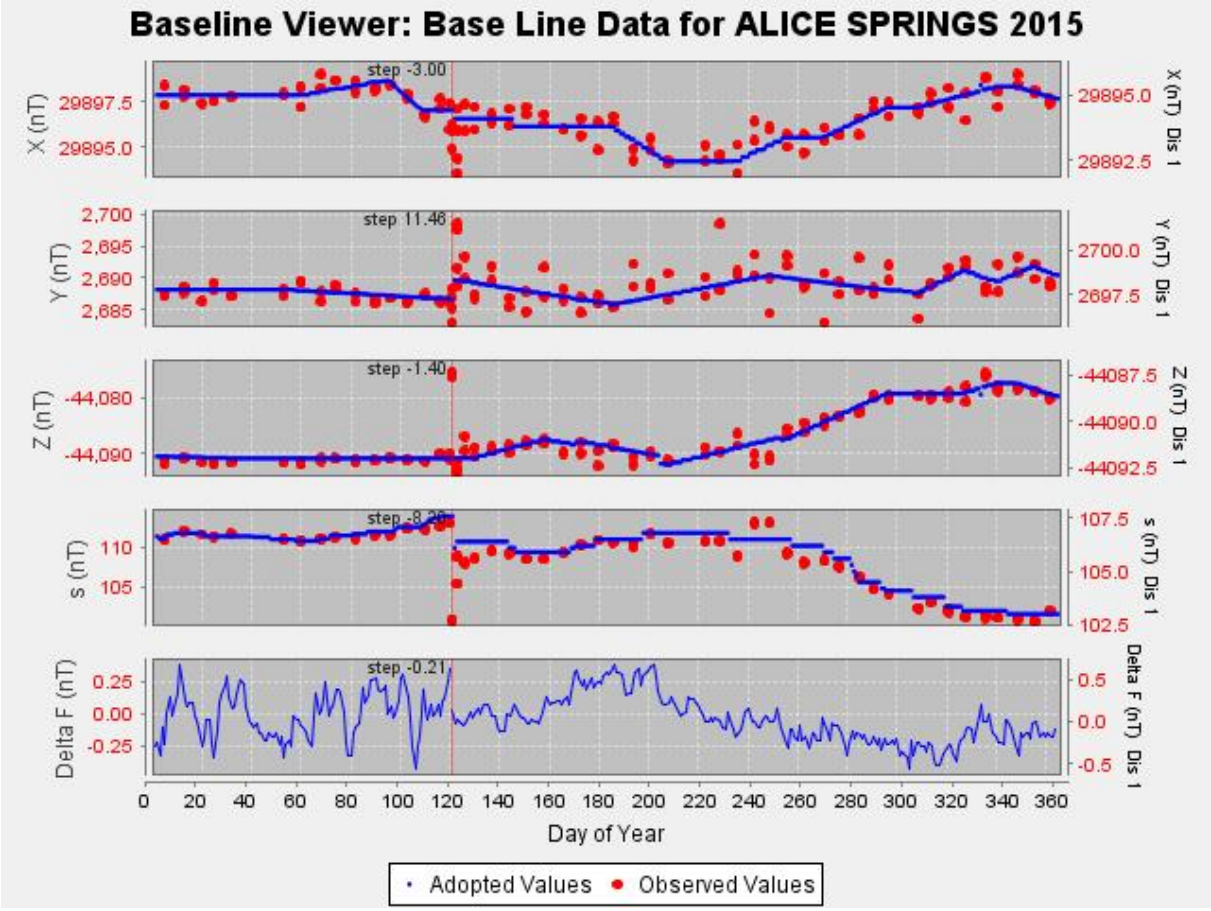

Figure 7.8 ASP 2012 baseline plots.

Table 7.41 Standard deviation of residuals from accepted absolute observations at ASP during 2012.

Component	SD
X	0.5 nT
Y	0.9 nT
Z	0.6 nT
D	06″
I	03″
F	0.5 nT

7.5.6 Real-time, quasi-definitive and definitive data comparison

Table 7.42 shows statistics regarding differences between 2012 definitive data and intermediate adjusted and quasi-definitive data for each magnetic field component for ASP.

Table 7.42 Data type differences statistics for ASP in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	−0.6	+2.5	−0.4
	SD	+0.7	+3.5	+0.8
	Sample minimum	−1.8	−0.9	−1.6
	Sample maximum	+0.2	+8.8	+1.0
D−Q	AM	+0.0	−0.1	−0.1
	SD	+0.2	+0.3	+0.3
	Sample minimum	+0.0	−0.1	−0.1
	Sample maximum	+0.7	+0.0	+0.0

The ASP 2012 quasi-definitive data are within the INTERMAGNET specification.

7.5.7 Operations

In 2012, absolute observations were performed weekly by Warren Serone and Shaun Evans—Alice Springs based officers of GA's Data Acquisition Facility (DAF). The DAF office is approximately 150 m from ASP.

On the 2012-01-25 the battery in the PDA used for recording absolute observations failed. Consequently no absolute observations were undertaken that week. A replacement battery was sent and installed on 2012-02-07 and absolute observations recommenced.

A maintenance visit occurred between 2012-02-09/10 by Liejun Wang. Inspection of the DIM DI0052/313887 identified loose screws on the cover of the sensor which were tightened. Comparison between the local DIM DI0052/313887 and the travelling reference DIM B060H/160 indicated no changes were required to the instrument corrections.

A suitable location for a new external reference station (i.e. a backup absolute observation reference station) was identified within the grounds of the observatory. The existing reference stations were located at the Alice Springs airport, some 5 km distance and were difficult to access.

The long-period magnetotelluric research project between GA and Dr Masahiro Ichiki (Tokyo Institute of Technology), Professor Kiyoshi Fujita (Osaka University) continued at locations in Hamilton Downs and Owen Springs. A visit by the Japanese researchers was timed to coincide with the maintenance visit.

The facilities manager for the CAT, from which the observatory site is leased, advised that mowing of fire breaks would occur within the grounds in late March. It was expected that mowing would occur in the vicinity of the ASP variometers around 2012-03-29. Contamination was noted during this period and was subsequently removed during processing of the definitive data.

During the absolute observations on the 2012-04-05 the absolute PPM failed. The instrument was freighted to Canberra where loose electronics boards were re-seated. The repaired instrument was sent back to Alice Springs on 2012-05-11.

For the period between 2012-090/153 no absolute observations were undertaken. In the future it is recommended that if the scalar instrument fails that D and I observations be continued without a scalar magnetometer.

Late in August the fluxgate sensor on the DIM DI0052/313887 was bumped and misaligned. The sensor was realigned on 2012-08-24 at the DAF by Warren Serone.

In November a maintenance visit by William Jones was timed to coincide with the completion of the long-period magnetotelluric research project at Hamilton Downs and Owen Springs. After completion of this project Liejun Wang and Jim Whatman travelled to ASP to assist William Jones with the construction of a new remote reference station (H). Absolute observations, round of angles, sunshots and a horizontal gradient survey were then conducted.

Research into ant behaviour by Macquarie University (MQ) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) continued within the observatory grounds during the summer months. The researchers establish temporary observation sites throughout the grounds each year. These may have at times been located within the vicinity of the magnetic observatory buildings. Each MQ/CSIRO site consisted of a few shallow trenches with plastic boards on the edges at surface level. The researchers had been made aware of the need to maintain the integrity of the magnetic quiet zone. Careful review of the magnetic field data shows that some contamination does occur due to the MQ/CSIRO project.

The distribution of 2012 ASP data after primary transmission to GA is shown in Table 7.43.

Table 7.43 Distribution of ASP 2012 data.

	Recipient	Data type	Sent
1-second values	IPS	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Monthly
	WDC for Geomagnetism, Kyoto	P	Real-time from August
	WDC for Geomagnetism, Kyoto	P	Daily from August

7.5.8 Missing one-minute definitive data

In 2012, 17 and 7 values were missing from the ASP definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.44.

Table 7.44 ASP Missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-03-29T01:28Z/01:39	XYZ	12	n/a
2012-03-29T01:46Z/01:46	XYZ	1	n/a
2012-07-01T00:01Z/00:01	XYZ	1	n/a
2012-07-01T00:03Z/00:03	XYZ	1	n/a
2012-09-23T17:30Z/17:31	XYZ	2	n/a
2012-04-09T18:24Z/18:24	F	1	n/a
2012-04-19T14:16Z/14:18	F	3	n/a
2012-07-14T19:34Z/19:34	F	1	n/a
2012-07-24T05:09Z/05:09	F	1	n/a
2012-12-01T07:09Z/07:09	F	1	n/a

7.5.9 Significant events

Table 7.45 Significant events that took place at ASP in 2012.

Time or duration	Description of event
2012-01-25	PDA battery failure. Replacement sent. No scheduled absolute observations taken.
2012-02-07	New PDA battery arrived.
2012-02-09	Liejun Wang visits and performs comparison of local DIM with travelling reference DIM.
2012-02-10	Liejun Wang checks DIM and discovers loose screws on housing. Tightens and completes full observation with DIM and travelling reference DIM. Also notices MQ/CSIRO sites between the control room and variometer and also further south of variometer. Talks to three students about the need keep distance from the variometer.
2012-03-23	Stopped GdapTimePips running. Seems to have solved the timing problem. No loss of data.
2012-03-29T01:30Z/38	CAT mowing near variometer buildings.
2012-04-05	Absolute PPM magnetometer not functioning. Warren Serone tested sensor cable for break.
2012-05-03	PPM delayed in transit to Canberra
2012-05-10	PPM received and repaired. Loose electronics boards re-seated. Tested and calibrated.
2012-153	First absolute observation completed since 2012-03-30.
2012-08-20	Problem with DIM fluxgate sensor collimation.
2012-08-24	Warren Serone re-aligned fluxgate sensor on DIM.
2012-11-06	Thunderstorm activity.
2012-11-08/11	Maintenance visit. William Jones does comparisons. Remote reference station H was constructed.
2012-331	No absolutes observations since 2012-314. Observers in Darwin. Warren Serone then on holidays.
2012-11-30	Thunderstorm activity.
2012-12-01T06:15Z/08:10	Spikes in data. Thunderstorms in area.

7.5.10 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for ASP in 2012 are given in Table 7.46. Annual means for X, Y, Z and F since 1992 are plotted in Figure 7.9 and tabulated in Appendix E.4.

Table 7.46 ASP 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+004° 51.9′	−055° 27.8′	30149	30040	2557	−43806	53179
Quiet Days	+004° 51.9′	−055° 27.3′	30157	30049	2558	−43805	53182
Disturbed Days	+004° 51.9′	−055° 28.9′	30130	30021	2555	−43810	53170

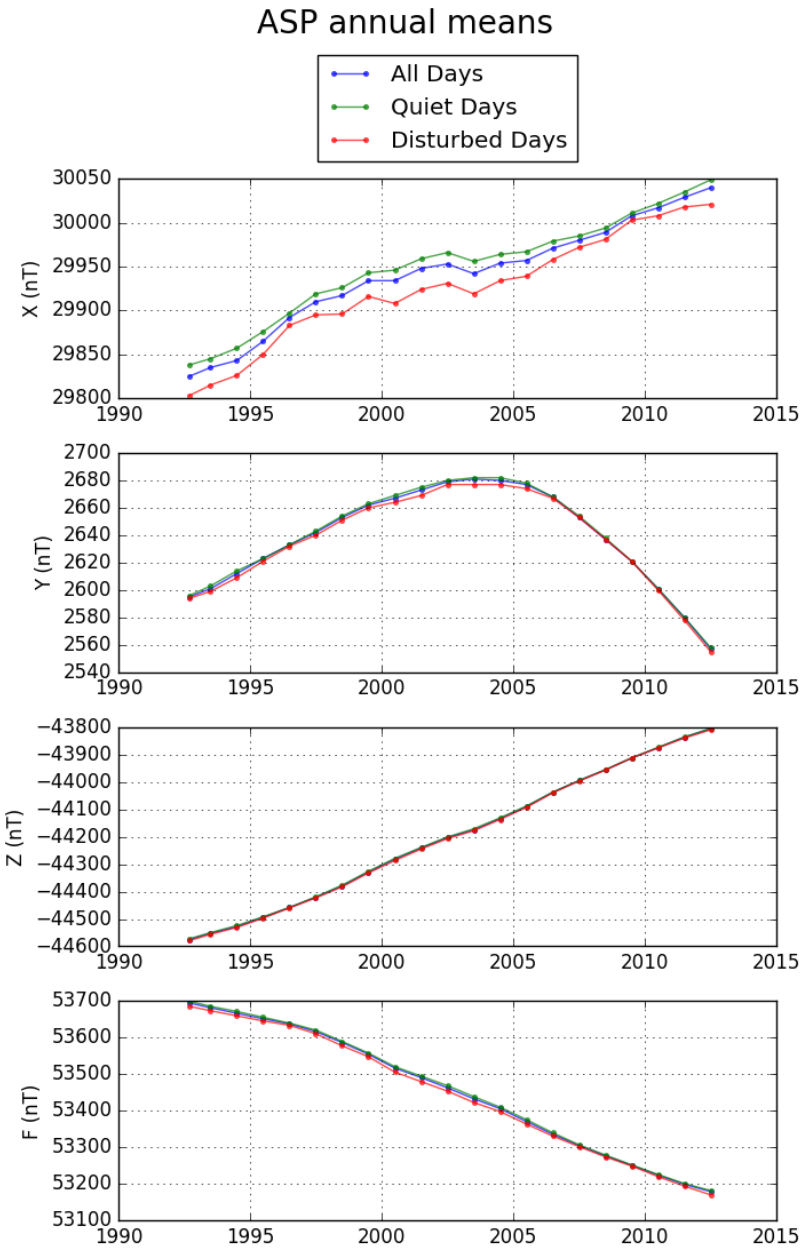

Figure 7.9 ASP annual means since 1992.

7.6 Gnangara

GNA is located within the Gnangara pine plantation approximately 27 km northeast of Perth in Western Australia. This places it within the limits of urban development. It succeeds the observatory at Watheroo (1919-1958) which was located 180 km north of Perth. Magnetic recording began at Gnangara in 1957.

The observatory is built on the north-eastern part of an approximately 260×140 m^2 site. It comprises:

- A 10×5 m^2 shared variometer/control vault, partially underground and partially buried beneath a mound of sand, that houses the recording equipment, fluxgate variometer sensor and electronics, total-field variometer electronics, GPS clock, backup power supply, telephone, and alarm system
- An absolute house approximately 70 m northeast of the vault
- A small sensor vault approximately 20 m southwest of the variometer/control vault that houses the total-field variometer sensor
- Four azimuth reference marks.

The site is on well drained sand with magnetic gradients of less than 1 nT/m, although in places some artificial features have introduced higher gradients.

Nearing the end of 2011, GNA was operating within a few kilometres of urban development and sand mining operations. Consequently GNA has been replaced by GNG as the primary geomagnetic observatory in Southwest Australia due to the potential of contamination. GNG commenced operations in 2011-11. Both GNA and GNG were run in parallel during 2012. Absolute calibrations ceased at GNA on 2013-01-31 and the observatory was decommissioned in 2013-04.

Important details regarding GNA are given in Table 7.47.

Table 7.47 Important GNA observatory details for 2012.

IAGA code	GNA
Commenced operation	June 1957
Geographic latitude	031° 46' 48″ S
Geographic longitude	115° 56' 48″ E
Geomagnetic latitude	041.33° S (IGRF 2010)
Geomagnetic longitude	189.40° E (IGRF 2010)
K 9 index lower limit	450 nT
Principal pier	Pier B
Pier elevation (top)	60 m AMSL
Principal reference mark	Pillar N
Reference mark azimuth	315° 21' 42″
Reference mark distance	70 m
Observatory manger(s)	Andrew Lewis
Observer(s)	Stephen Pryde, Chris Lord, Andrew Lewis, William Jones

7.6.1 Local meteorological conditions

The meteorological temperature at Perth Airport during 2012 varied from a minimum −0.7 °C (2012-07-25) to a maximum +42.2 °C (2012-12-31). Daily minimum temperatures varied from −0.7 °C to +27.5 °C (average +13 °C ± 5 °C); daily maximum temperatures varied from +42.2 °C to +14.7 °C (average +26 °C ± 6 °C); daily temperature ranges varied from +1.5 °C to +25.9 °C (average +13 °C ± 4 °C). There was from 0 to 13.4 hours (average 8.9 hours ± 3.3 hours) of sunshine according to the meteorological definition.

7.6.2 Variometers

Table 7.48 shows specifics of the variometers and DAQ system used at GNA during 2012.

Table 7.48 Variometer systems used at GNA in 2012.

GNA vector variometer	Model	EDA FM105B
	Serial number	2877/2887
	Type	3-channel, non-suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.01 nT/count
GNA scalar variometer	Model	Geometrics 856
	Serial number	50706
	Type	PPM
	Acquisition interval	10 s
	Resolution	0.1 nT
GNA DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS16HVS receiver
Other	Communications	ADSL

The fluxgate sensor was located at the eastern end of the variometer/control vault, while the electronic equipment and acquisition PC were at the western end. The total field variometer sensor was located in a small underground vault about 20 m to the southwest of the variometer/control vault. The total field electronics were housed in the western end of the variometer/control vault.

The DAQ PC was networked via an ADSL modem for remote control and data retrieval. The acquisition equipment was powered by a 12 V battery and trickle charger. All the equipment was protected with power and telephone line filters.

The fluxgate variometer sensor and electronics temperatures were monitored. As the variometers were housed below ground, the diurnal temperature changes were relatively small but there still was a significant annual temperature variation. In 2012 the fluxgate sensor and electronics temperatures

varied from about 15 °C in July-August to about 30 °C in February-March. Temperature fluctuations in the PPM sensor vault were not recorded but would have likely exceeded those in the vault housing the fluxgate variometer.

7.6.3 Variometer clock corrections

Table 7.49 Software clock adjustments greater than 10 ms for GNA in 2012.

Time before correction	Correction (s)	Comment
2012-03-29T04:32:47Z	−0.097	GPS clock restart after failure
2012-05-14T00:19:15Z	+0.251	System reboot to re-initialise timing services
2012-07-01T00:00:59Z	−1.000	Leap second

7.6.4 Absolute instruments

The principal absolute magnetometers used at GNA and their adopted corrections for 2012 are described in Table 7.50. The corrections applied correct for the differences between the 2012 GNA DIM and the international average (as defined by observations at IAGA instrument workshops). These corrections have been applied to all GNA 2012 final data through the correction of absolute observations.

Table 7.50 Absolute instrumentation (with corrections) used at GNA and GNG in 2012.

GNA/GNG DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0037
	Theodolite	Zeiss 020B
	Theodolite serial	390444
	Theodolite resolution	+0.10′
	D correction	−0.05′
	I correction	−0.15′
GNA/GNG absolute PPM	Model	GEM Systems GSM-90
	Serial number	3091317/91457
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

An instrument comparison was made between the GNA DIM (DIM DI0037/390444) and the travelling reference DIM (DIM B0610H/160459) at GNG in 2012-08. The instrument corrections for DIM DI0037/390444 were found to be consistent with previous comparisons.

7.6.5 Baselines

Figure 7.10 shows the accepted observed and adopted baseline values in XYZ. Table 7.51 shows statistics regarding the difference between observed and adopted baseline values (residuals).

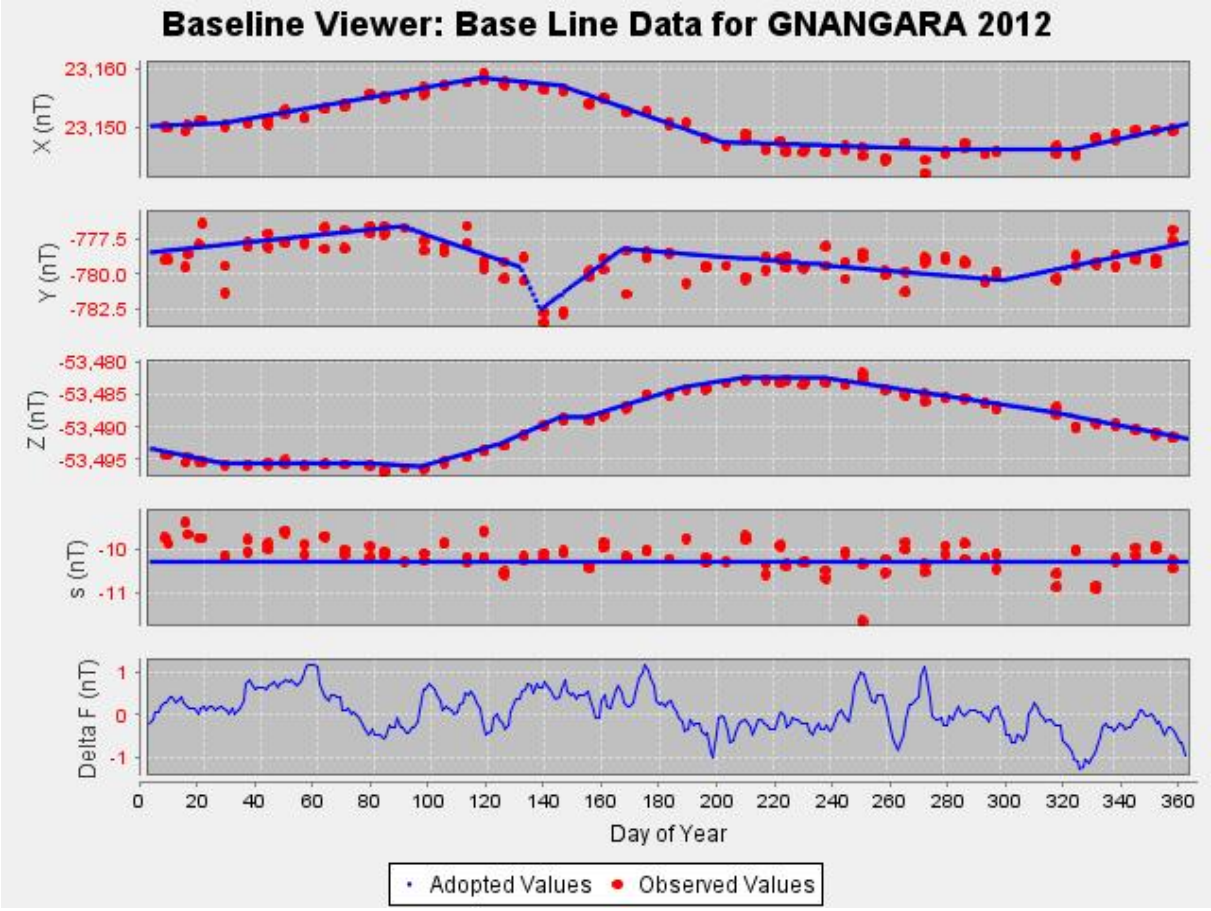

Figure 7.10 GNA 2012 baseline plots.

Table 7.51 Standard deviation of residuals from accepted absolute observations at GNA during 2012.

Component	SD
X	0.8 nT
Y	0.9 nT
Z	0.5 nT
D	08"
I	03"
F	0.5 nT

7.6.6 Real-time, quasi-definitive and definitive data comparison

Table 7.52 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for GNA.

Table 7.52 Data type differences statistics for GNA in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+3.0	+0.5	+0.1
	SD	+3.2	+1.1	+2.2
	Sample minimum	−2.7	−1.7	−2.2
	Sample maximum	+7.1	+2.1	+4.8
D−Q	AM	−0.5	+0.1	+0.2
	SD	+0.8	+0.2	+0.3
	Sample minimum	−1.9	−0.2	−0.2
	Sample maximum	+0.7	+0.6	+0.8

The GNA 2012 quasi-definitive data are within the specification for INTERMAGNET quasi-definitive data.

7.6.7 Operations

Throughout 2012, K indices for GNA were scaled and distributed weekly.

Absolute observations were performed weekly where possible. The distribution of GNA 2012 data is described in Table 7.53.

Table 7.53 Distribution of GNA 2012 data.

	Recipient	Data type	Sent
1-second values	IPS, Sydney	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	WDC for Geomagnetism, Kyoto	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	University of Oulu, Finland	P	Hourly
	INTERMAGNET, Edinburgh GIN	Q	Quarterly
K indices	IPS, Sydney	n/a	Weekly
	ISGI, France	n/a	Weekly
Storms and rapid variations	WDC-STP	n/a	Monthly
	WDC for Geomagnetism, Kyoto	n/a	Monthly
	Observatori de l'Ebre, Spain	n/a	Monthly

7.6.8 Missing one-minute definitive data

In 2012, 10 and 2 values were missing from the GNA definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.54.

Table 7.54 GNA Missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-05-14T00:17Z/00:18	XYZ	2	n/a
2012-06-09T02:05Z/02:12	XYZ	8	n/a
2012-05-14T00:18Z/00:18	F	1	n/a
2012-08-08T05:28Z/05:28	F	1	n/a

7.6.9 Significant events

Table 7.55 Significant event that took place at GNA in 2012.

Time or duration	Description of event
2012-03-08	Absolute hut padlock broken.
2012-03-28T01:47:18Z	Lost contact with GPS clock.
2012-03-29T04:26Z	Restart timing service.
2012-05-11T01:20Z	Lost contact with GPS clock.
2012-05-14	Timing appears to still be very good. Restarting GdapClock did not fix problem. Shutdown 00:17.
2012-06-09T02:05Z/10	Jump/contamination.
2012-06-30	23:59:60Z leap second.
2012-07-20	Padlock missing from vault door, probably removed between 13 and 20 July.
2012-08-08	Andrew Lewis and William Jones visit the observatory. Standard observations, 05:27 locate PPM external vault using magnetic DIM box.
2012-09-21	Sand mining has commenced within 500 m of the observatory. Bees swarming near absolute hut.
2012-09-27T23:06Z	GPS receiver fails to power up.
2012-09-28T04:41Z	Restart timing services.
2012-10-04	Bee infestation removed from absolute hut.
2012-10-05	Fibre-glass insect screening (checked as non-magnetic) installed over vents in absolute hut to prevent entry of bees.
2012-10-22	Host sun-geomag failure.
2012-10-24	Stephen Pryde unavailable for absolute observations for several weeks from this day.
2012-11-13	First observation by Chris Lord. At 11:15 security monitoring reported a ‘late-to-close alarm’ at Gnangara.
2012-11-16T04Z	Security monitoring centre report low battery signal from GNA alarm.
2012-11-20	Alarm set off when Chris Lord inspects control panel.
2012-11-27	Alarm technician visits to repair alarm control panel, Chris Lord is present.
2012-12-21T10:20Z	Alarm monitoring reports absolute hut alarm triggered.
2012-12-22	Stephen Pryde finds faulty PIR sensor. He cleans lens and resets the alarm.
2013-01-01T00:00Z	GNG officially replaced GNA as the southwest WA magnetic observatory.

7.6.10 K indices, principal storms and rapid variations

K indices for GNA have been derived using a computer-assisted method developed at GA and based on the IAGA-accepted LRNS algorithm (see Section 4.2 Magnetic activity indices).

K indices were scaled from adjusted time-series data using a K9 limit of 450 nT. K indices from GNA contribute to the global am index and its derivatives.

K indices measured in 2012 are listed in Appendix F.1. The frequency distribution of the K indices are shown in Figure 7.11 and Table 7.56. The annual mean daily K sum for GNA in 2012 was 12.8.

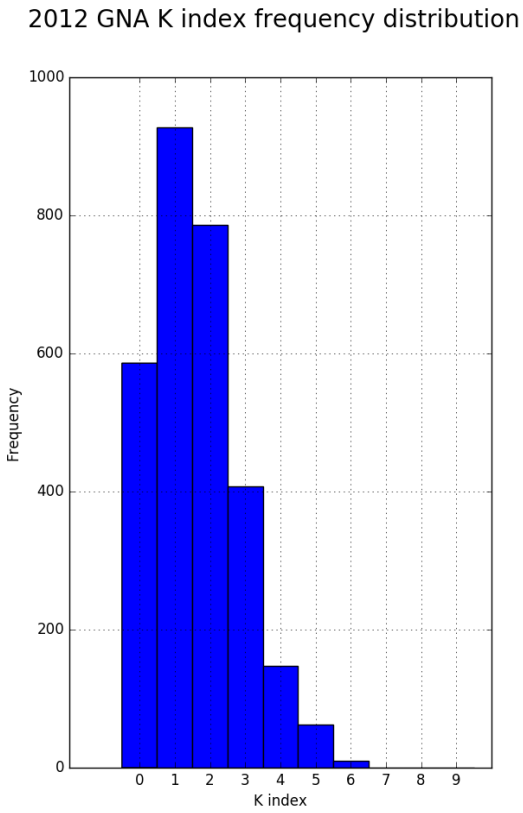

Figure 7.11 Frequency distribution of K indices for GNA in 2012.

Table 7.56 Frequency distribution of K indices for GNA in 2012.

K index	0	1	2	3	4	5	6	7	8	9
Frequency	586	928	786	408	147	63	10	0	0	0

Principle magnetic storms and SSCs observed at GNA in 2012 are listed in Appendix F.1. No SFEs were recorded at GNA in 2012.

7.6.11 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for GNA in 2012 are given in Table 7.57. Annual means for X, Y, Z and F since 1980 are plotted in Figure 7.12 and tabulated in Appendix E.5.

Table 7.57 GNA 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	−001° 51.1′	−066° 08.2′	23529	23517	−760	−53188	58160
Quiet Days	−001° 51.0′	−066° 07.7′	23537	23525	−760	−53185	58161
Disturbed Days	−001° 51.3′	−066° 09.3′	23511	23499	−761	−53193	58157

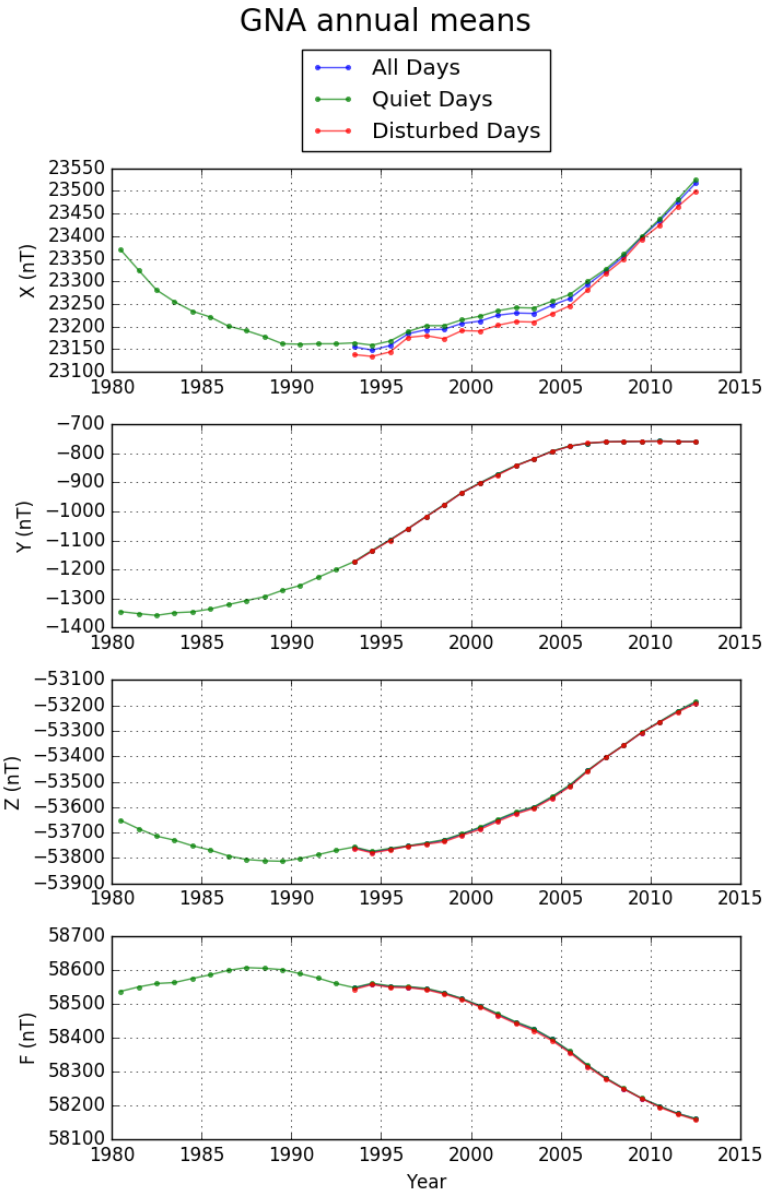

Figure 7.12 GNA annual mean values since 1980.

7.7 Gingin

GNG is located in southwest Western Australia approximately 100 km north of the city of Perth, 20 km east of the town of Gingin and 50 km north of GNA. GNG was established to replace GNA. After more than 50 years of operation, urban development and sand mining operations have encroached upon GNA causing problems with security and data continuity. The new Gingin observatory site was chosen after an extensive search of the areas surrounding Perth. Both GNG and GNA have run in parallel since 2011-11 and throughout 2012. The 2012 data set was the last from GNA and the observatory was decommissioned in 2013 (see Section 7.6 Gnangara).

The GNG site is located adjacent to the Australian International Gravitational Observatory (AIGO) and the Gingin Gravity Discovery Centre on well drained sand with magnetic gradients of less than 1 nT/m.

The Gingin observatory consists of:

- A variometer vault covered by a mound of sand, housing the recording equipment, fluxgate variometer sensor and electronics, total-field variometer sensor and electronics, and DAQ system
- An absolute house (housing an absolute pier) approx. 70 m northwest of the vault
- An external tripod reference station approx. 70 m north of the absolute house
- An azimuth reference mark approx. 90 m south of the absolute house.

Construction of the observatory took place during 2008. The variometer vault and absolute house are built from re-constituted limestone blocks. The variometer vault was covered with local sand to enhance thermal stability. The absolute pier was constructed from a fibreglass tube with a marble top.

Variometer instrumentation was installed in 2009-10. During installation magnetic contamination was discovered in both the absolute house and variometer vault. The contamination was later found to be largely due to magnetic bolts used during construction to fix wooden framework to the masonry. Other sources of contamination existed in security doors, door and window locks, weather strips and light fittings. Over the following two years the absolute house was slowly decontaminated. Magnetic contamination remains in the variometer vault.

Routine weekly absolute observations commenced in the magnetically clean absolute house in 2011-11 and fully calibrated observatory data was first produced on 2011-11-16.

Important details regarding GNG are given in Table 7.58.

Table 7.58 Important GNG observatory details for 2012.

IAGA code	GNG
Commenced operation	November 2011
Geographic latitude	031° 21′ 23″ S
Geographic longitude	115° 42′ 55″ E
Geomagnetic latitude	040.91° S (IGRF 2010)
Geomagnetic longitude	189.12° E (IGRF 2010)
K 9 index lower limit	430 nT
Principal pier	Pier A
Pier elevation (top)	50 m AMSL
Principal reference mark	Pillar S
Reference mark azimuth	186° 38' 32″
Reference mark distance	90 m
Observatory manager(s)	Andrew Lewis
Observer(s)	Stephen Pryde, Chris Lord, Andrew Lewis, William Jones

7.7.1 Local meteorological conditions

The meteorological temperature at the nearby Gingin airfield during 2012 varied from a minimum −2.7 °C (2012-07-25) to a maximum +41.5 °C (2012-12-31). Daily minimum temperatures varied from −2.7 °C to +26 °C (average +11.5 °C ± 6 °C); daily maximum temperatures varied from +14.8 °C to +41.5 °C (average +25.9 °C ± 7 °C); daily temperature ranges varied from +2 °C to +27 °C (average +14 °C ± 5 °C).

7.7.2 Variometers

Table 7.59 shows specifics of the variometers and acquisition system used at GNG during 2012.

Table 7.59 Variometer systems used at GNG in 2012.

GNG vector variometer	Model	DMI FGE
	Serial number	E0383/S0319
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.032 nT/count
GNG scalar variometer	Model	GEM Systems GSM-90
	Serial number	708729/21889
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.1 nT
GNG DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS-16 HVS GPS receiver
Other	Communications	Cellular network

The FGE E0383/S0319 sensor was installed on a plinth in the western arm of the variometer vault. The fluxgate sensors were orientated magnetic NW, magnetic NE and vertical. The GSM 708729/21889 was installed in the eastern arm of the variometer vault.

The variometer system is powered with a 12 V battery and mains charger with under/over voltage cut-off and mains power filters.

There is no active temperature control in the variometer vault, but it is well insulated with foam panels inside and local sand outside. This insulation suppressed diurnal temperature variations but an annual temperature change of 16 °C was measured inside the vault.

7.7.3 Variometer clock corrections

Time stamps applied to the variometer data were obtained from the DAQ system clock. That clock was synchronised to UTC. During 2012, the timing control system performed poorly, with many corrections of about 1 second in magnitude. The problem was caused by a faulty GPS receiver. The receiver was replaced in 2013-04. During 2012, adjustments to the system clock were only greater than 10 ms on the occasions listed in Appendix Table B.1.

7.7.4 Absolute instruments

Both absolute PPM and DIM observations were performed on Pier A in the absolute shelter. GNA absolute instruments and corrections were used at GNG in 2012. Table 7.50 lists these instruments and corrections.

Absolute instrumentation corrections have been applied to all GNG 2012 final data through the correction of absolute observations.

7.7.5 Baselines

Figure 7.13 shows the accepted observed and adopted baseline values in XYZ. Table 7.60 shows statistics regarding the difference between observed and adopted baseline values (residuals).

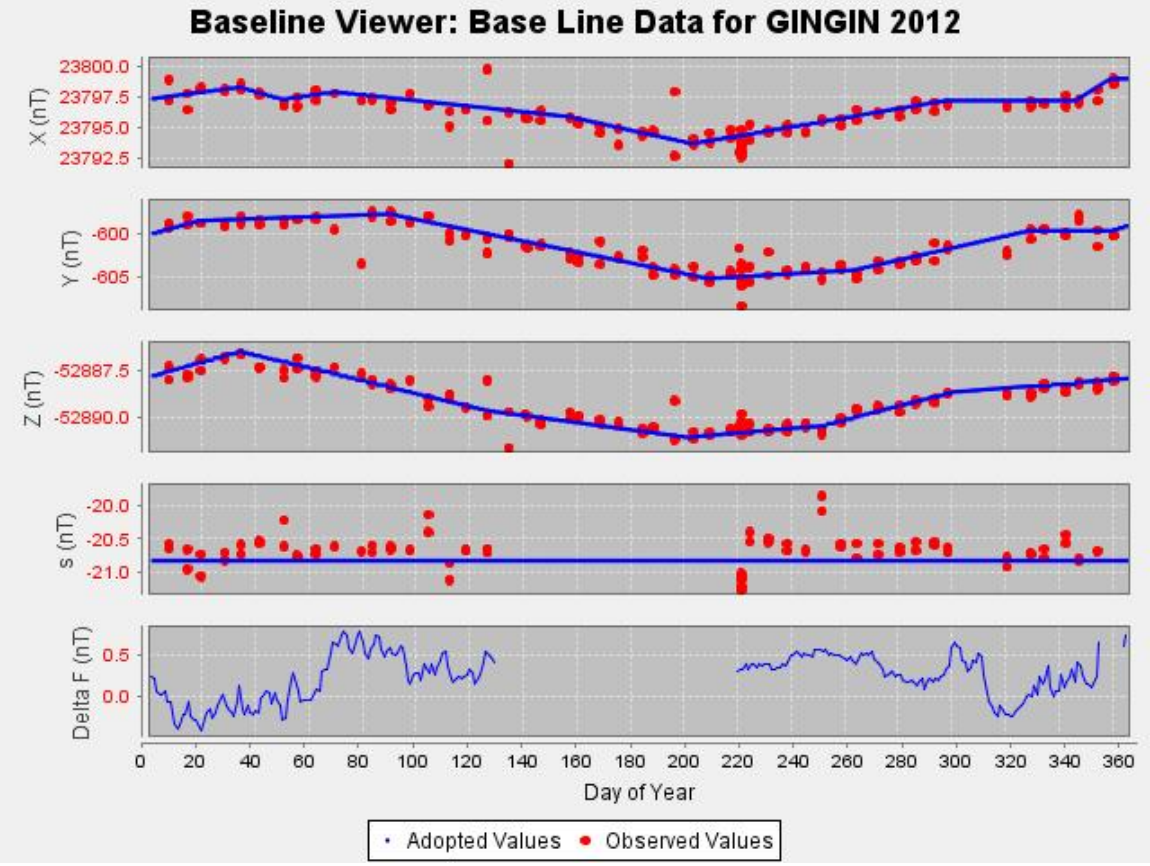

Figure 7.13 GNG 2012 baseline plots.

Table 7.60 Standard deviation of residuals from accepted absolute observations at GNG during 2012.

Component	SD
X	0.8 nT
Y	1.0 nT
Z	0.4 nT
D	09″
I	03″
F	0.3 nT

There was a period of baseline instability lasting several hours on 2012-03-05. Data over this period was removed. Numerous sub-nanotesla positive and negative baseline step pairs, lasting up to several hours remain and have not been excluded.

7.7.6 Real-time, quasi-definitive and definitive data comparison

Table 7.61 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for GNG.

Table 7.61 Data type differences statistics for GNG in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+0.3	+2.0	+0.3
	SD	+1.2	+1.9	+1.2
	Sample minimum	−2.0	−1.1	−1.6
	Sample maximum	+2.0	+4.8	+1.9
D−Q	AM	−0.0	−0.0	−0.1
	SD	+0.3	+0.3	+0.2
	Sample minimum	−0.7	−0.5	−0.5
	Sample maximum	+0.4	+0.5	+0.2

The GNG 2012 adjusted and quasi-definitive data are within the INTERMAGNET specification.

7.7.7 Operations

The local observer, Stephen Pryde performed weekly absolute observations and checks throughout the year, except for during the 2012-10-24/12-06 where Chris Lord fulfilled this role

The variometer system was powered by a 12 V, 18 A·h battery with trickle charger, under/over voltage cut-off protection and voltage regulators to deliver a constant 12 V dc to both the vector and scalar magnetometers.

Gingin was accepted as an IMO in October 2012. Delivery of one-second and one-minute data, in both real-time and daily, to the Edinburgh INTERMAGNET GIN commenced on 2012-10-09. One-minute data was provided to ISGI, France, via FTP both in real-time and at the end of each UTC day.

The distribution of 2012 GNG data (after initial transmission to GA) is shown in Table 7.62.

Table 7.62 Distribution of GNG 2012 data.

	Recipient	Data type	Sent
1-second values	INTERMAGNET, Edinburgh GIN	P	Real-time (from 2012-10-09)
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-08
	INTERMAGNET, Edinburgh GIN	P	Real-time (from 2012-10-09)
	INTERMAGNET, Edinburgh GIN	P	Daily (from 2012-10-09)
	INTERMAGNET, Edinburgh GIN	Q	Quarterly
	ISGI, France	P	Real-time
	ISGI, France	P	Daily
K indices	ISGI, France	n/a	Weekly

7.7.8 Missing one-minute definitive data

In 2012, 112 and 148843 values were missing from the GNG definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Appendix Table C.1.

The GSM 708729/21889 failed several times during 2012 causing significant periods of data loss. The instrument was sent to Canberra for testing from 2012-05/08 and was reinstalled at GNG on 2012-08-07. It failed again during mid-December.

7.7.9 Significant events

Table 7.63 Significant event that took place at GNG in 2012.

Time or duration	Description of event
2012-01-25	Remote update of firmware cellular network modem.
2012-03-05T13:36/14:41Z	ΔF anomaly. Appears to be a problem with the Z channel.
2012-03-05T18:17Z, 2012-03-05T19:33Z	Small jump in X channel.
2012-04-11T08:46/11:30Z	Earthquake interference on data
2012-05-09T00:43Z	PPM spikes commence.
2012-05-09T13:05Z	PPM spikes increase in frequency and amplitude.
2012-05-11T00:23:40Z	PPM fails. Requested Stephen Pryde to send electronics back to GA.
2012-05-16	Failed GSM 708729/21889 arrives at GA for testing.
2012-06-30T23:59:59Z	Leap second.
2012-07-31T01:51Z	Possible small baseline jump.
2012-08-07	Maintenance visit conducted by Andrew Lewis and William Jones. Standard observations. Re-install GSM 708729/21889 as variometer PPM. PPM survey of variometer PPM plinth, station differences, GPS data on landmarks S and B, unsuccessful attempt to install sign on access track
2012-09-08	Multiple time jumps.
2012-09-09	One time jump.
2012-10-01	GNG accepted as IMO at Ottawa INTERMAG meeting.
2012-10-09	Commence sending 1-second and 1-minute data to INTERMAGNET, Edinburgh GIN.
2012-10-22	Processing host sun-geomag failure (approx. 15 hours from 09 UT).
2012-10-24	Stephen Pryde unavailable for absolute observations for several weeks from this day. Chris Lord takes over as temporary local observer.
2012-12-06	Stephen Pryde recommences as observer.
2012-12-10T17:10Z	Earthquake interference on data.
2012-12-18	Variometer PPM starting to miss data and ‘b’ quality readings. Getting progressively worse.
2012-12-21	No PPM data until 2012-12-29.
2012-12-29	Intermittent variometer PPM data.

7.7.10 K indices, principle storms and rapid variations

K indices for GNG have been derived using a computer-assisted method developed at GA that implements the IAGA-accepted LRNS algorithm (see Section 6.2 Magnetic activity indices).

K indices were derived from preliminary time-series data. K indices have been scaled from GNG data since 2010-08-01 and forwarded to the ISGI since 2011-12-13 in preparation to replace GNA (with GNG) as a source of K indices for the global 'am' index and its derivatives.

K indices were scaled using a K9 limit of 450 nT during 2010-08-01/2013-01-14. Preliminary GNG K indices delivered weekly to the ISGI between 2011-12-13/2013-01-14 were scaled using K9 = 450 nT. On 2013-01-15 the K9 limit for GNG was updated from 450 nT to the official value of 430 nT (supplied by ISGI). All GNG K indices from 2010-08-01/2013-01-14 were rescaled using K9 = 430 nT.

The 2012 K indices were scaled using K9 = 430 nT and are listed in Appendix F.2. The frequency distribution of the K indices is shown in Figure 7.14 and Table 7.64.

The annual mean daily K sum for GNG in 2012 was 13.6.

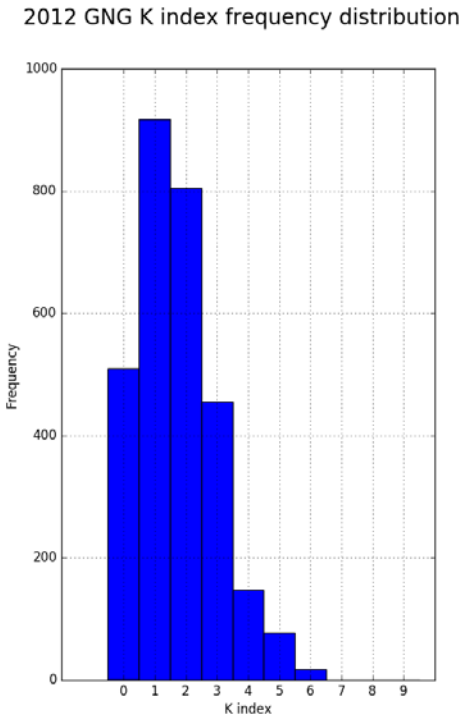

Figure 7.14 Frequency distribution of K indices for GNG in 2012

Table 7.64 Frequency distribution of K indices for GNG in 2012

K index	0	1	2	3	4	5	6	7	8	9
Frequency	509	917	805	455	147	78	17	0	0	0

Appendix F.2 list details of principle magnetic storms and SSCs observed at GNG in 2012, respectively.

No solar flare effects were observed at GNG in 2012.

7.7.11 Pier difference

Both GNA and GNG recorded fully calibrated one-second data from November 2011 to the end of December 2012. Parallel operations were maintained throughout 2012 to determine the vector pier difference between the two observatory sites. An accurate vector pier difference between primary observation piers at the two observatories (pier A at GNG and pier B at GNA) is important as it allows the secular variation record in southwest Western Australia, which began with the Watheroo observatory (1919-1958), to be continued into the future using the data from GNG.

Mean pier differences were calculated using various definitive data sets—definitive hourly data calculated from definitive one-minute data; definitive daily means calculated from definitive one-minute data; definitive all-day, 5 quiet-day and 5 disturbed-day monthly means calculated from definitive one-minutes data and definitive annual means calculated from definitive one-minute data. The mean pier difference was also calculated using definitive one-minute data from the INTERMAGNET binary monthly data files which were derived from definitive one-minute data. Results are presented in Table 7.65, Table 7.66 and Table 7.67.

Table 7.65 GNG − GNA definitive hourly means.

	X (nT)	Y (nT)	Z (nT)	H (nT)	F (nT)	D (°)	I (°)
Mean	298.4	77.7	416.6	295.9	−259.6	0.2098	0.4346
SD	1.6	1.5	4.6	1.6	4.8	0.0034	0.0012
Minimum	287.4	73.6	395.8	284.8	−293.5	0.2009	0.4304
Maximum	306.6	82.9	449.2	304.2	−237.4	0.2225	0.4400
Sample size	8784	8784	8784	8784	8784	8784	8784

Table 7.66 GNG − GNA definitive daily means.

	X (nT)	Y (nT)	Z (nT)	H (nT)	F (nT)	D (°)	I (°)
Mean	298.4	77.7	416.6	295.9	−259.6	0.2098	0.4346
SD	0.8	1.2	0.9	0.8	0.8	0.0029	0.0010
Minimum	296.1	75.1	414.2	293.7	−261.8	0.2037	0.4323
Maximum	300.8	81.2	419.3	298.3	−257.3	0.2186	0.4378
Sample Size	366	366	366	366	366	366	366

Table 7.67 GNG − GNA definitive all-day monthly means.

	X (nT)	Y (nT)	Z (nT)	H (nT)	F (nT)	D (°)	I (°)
Mean	298.4	77.7	416.6	295.9	−259.6	0.2099	0.4346
SD	0.7	1.0	0.7	0.7	0.5	0.0024	0.0009
Minimum	297.4	76.3	415.4	294.9	−260.4	0.2066	0.4335
Maximum	299.8	79.6	417.8	297.3	−258.8	0.2145	0.4364
Sample size	12	12	12	12	12	12	12

7.7.12 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for GNG in 2012 are given in Table 7.68. Annual means for X, Y, Z and F since 1980 are tabulated in Appendix E.6.

Table 7.68 GNG 2012 annual means.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	−001° 38.5′	−065° 42.1′	23825	23816	−683	−52771	57900
Quiet Days	−001° 38.4′	−065° 41.6′	23833	23823	−682	−52769	57901
Disturbed Days	−001° 38.6′	−065° 43.2′	23807	23797	−683	−52776	57897

7.8 Canberra

CNB is the principal observatory in the Australian geomagnetic observatory network. It is located in the Australian Capital Territory, approximately 30 km to the east of the city of Canberra.

The observatory is on an 8 hectare site and comprises:

- An office building, for historical reasons called the 'recorder house'
- A primary variometer house 85 m NW of the recorder house
- A secondary variometer house some 80 m west of the recorder house
- An absolute house 65 m NE of the recorder house
- A comparison house 12 m west of the absolute house
- A sheltered external observation site near the absolute house
- Four azimuth pillars
- Two tripod stations for azimuth control and external magnetic reference
- The GA Magnetometer Calibration Facility, 120 m SE of the recorder house
- A testing house 220 m north of the recorder house, which now houses Australian Tsunami Warning System (ATWS) equipment

Important details regarding CNB are given in Table 7.69.

Table 7.69 Important CNB observatory details for 2012.

IAGA code	CNB
Commenced operation	1978
Geographic latitude	035° 18′ 52.6″ S
Geographic longitude	149° 21′ 45.4″ E
Geomagnetic latitude	042.17° S (IGRF 2010)
Geomagnetic longitude	227.23° E (IGRF 2010)
K 9 index lower limit	450 nT
Principal pier	Pier AW
Pier elevation (top)	859 m AMSL
Principal reference mark	NW pillar
Reference mark azimuth	328° 37′ 03″
Reference mark distance	137.3 m
Observatory manager(s)	Peter Crosthwaite
Observer(s)	Peter Crosthwaite, Adrian Hitchman, Willian Jones, Andrew Lewis, Liejun Wang

7.8.1 Local meteorological conditions

The meteorological temperature at Canberra Airport during 2012 varied from a minimum −6.8 °C (2012-09-01) to a maximum +35.1 °C (2012-11-30). Daily minimum temperatures varied from −6.8 °C to +19.0 °C (average +5.5 °C ± 6.4 °C); daily maximum temperatures varied from +8.6 °C to +35.1 °C (average +20.1 °C ± 6.3 °C); daily temperature ranges varied from +1.6 °C to +24.6 °C (average +14.5 °C ± 5.0 °C). An average day around the peak of summer varied from +12 °C to +28 °C; an average day around peak of winter varied from −2 °C to +13 °C.

The daily maximum wind gust varied from 11 km/h to 93 km/h (average 40 km/h ± 13 km/h). The maximum daily maximum wind gust was 93 km/h on 2012-10-16. The minimum daily maximum wind gust was 11 km/h in 2012-07-05. There was from 0 to 12.3 h (average 6.8 h ± 3.1 h) of sunshine per day recorded according to the meteorological definition (although sunshine hours was only recorded February to November, and did not include the peak summer conditions). During June-July winter months, there was 0 to 8.5 h (average 5.4 h ± 2.5 h) of sunshine per day recorded.

7.8.2 Variometers

Table 7.70 shows specifics of the variometers and acquisition system used at CNB during 2012.

Table 7.70 Variometer systems used at CNB in 2012.

CNB vector variometer	Model	Narod
	Serial number	9004-2
	Type	3-channel, non-suspended, ring-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	Integrated (see Section 5.1 Variometers)
	Scale value	0.025 nT/count
CN1 vector variometer	Model	LEMI
	Serial number	004_A
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±5 V input voltage range)
	Scale value	0.05 nT/count
Shared scalar variometer	Model	GEM Systems GSM-90
	Serial number	803810/81225
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
CNB DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Trimble Acutime GPS receiver
CN1 DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS receiver
Other	Communications	Digital radio directly to GA

A Narod ring-core fluxgate variometer operated on a pier in the eastern room of the variometer house. The room was temperature-stabilised with an incandescent globe heater. The GSM 803810/81225 was housed in the western room of the same building. The CNB DAQ system, in the western room recorded both the data originating from the NGL 9004-2 and the GSM 803810/81225. Timing signals were provided by a Trimble Acutime GPS receiver.

The LEMI 004_A operated on a pier in the secondary variometer house. The room was temperature-stabilised with an incandescent globe heater. The CN1 DAQ system was located in the same room and timing signals were provided by a Garmin GPS receiver. The GSM 803810/81225 scalar data was also recorded on CN1 DAQ PC—retrieving it from CNB DAQ PC over the local area network.

During 2012, preliminary real-time 3-component variations were supplied to users and data repositories using the time-series recorded by the NGL 9004-2. The 2012 definitive 3-component data set for the observatory was also derived from the NGL 9004-2 time-series, with gaps in-filled with LEMI 004_A data, when such data were available. Weekly, semi-monthly, and monthly K indices and storm reports were scaled from the NGL 9004-2.

The variometer environments were controlled only by a heater, which was generally adequate on cold to mild days. However, on hot days the variometer temperatures were not well controlled. Further, the NGL 9004-2 temperature sensor (attached to the magnetic field sensor) has not functioned for some years, although it is in the same room as the temperature-monitored electronics.

The daily average NGL 9004-2 electronics temperature varied from +24.1 °C (2012-08-31) to +25.3 °C (2012-01-03) during the year. The daily-average LEMI 004_A magnetic field sensor temperature varied from +22.1 °C (2012-08-31) to +28.4 °C (2012-01-03) during the year; the magnetic field sensor temperature was well controlled from April to October, but not during hotter months. The daily average LEMI 004_A electronics temperature appeared to vary from +35.7 °C (2012-08-31) to +44.6 °C (2012-01-03) during the year.

The periods of greatest temperature stability (April to October) coincide with the best agreement between definitive NGL and LEMI data. During April to October, daily average NGL and LEMI data agree within 1 nT. During other periods, agreement is within 3.6 nT in X and Y (Z data agrees within 1 nT throughout the year). Inadequate temperature control was one of the major influences on data quality.

Data from the NGL 9004-2 during the period 2012-01-24T03:08/03:48Z was corrupted by repair work on the roof of the variometer building. Data from 2012-11-14T02:40:30/41:58 and 2012-11-14T02:45:30/46:54 was lost during UPS replacement work. Data from the LEMI 004_A was used during this period.

Data from the LEMI 004_A during the period 2012-10-02T00:46/50 was corrupted for unknown reasons. Narod data were used to fill the LEMI data set for comparison purposes.

Data from the GSM 803810/81225 during the periods 2012-11-14T02:41/42 and 2012-11-14T02:46/47 was also lost during UPS replacement work and was not recoverable.

NGL 9004-2 1-second data required despiking. The despiking filter required a spike to exceed 0.25 nT and 7 times the average ‘spike-factor’ of the following minute of data for a spike to be rejected. The average rejection rate was 57 s/day ± 18 s/day. The highest rejection rates were on thunderstorm days. On 2012-01-20 111 s of data were rejected, on 2012-02-17 230 s of data were rejected and on 2012-12-23 222 s of data were rejected.

LEMI 004_A data required little despiking except on days where there were thunderstorms. The same despiking filter was applied to LEMI data as for the NGL data. On 206 days, no data were rejected by the filter. On average, 4.4 s/day ± 17.3 s/day of data were rejected by the despiking filter. Again the highest rejection rates occurred on thunderstorm days. On 2012-01-20 81 s of data were rejected, on 2012-02-17 180 s of data were rejected and on 2012-12-23 229 s of data were rejected.

No despiking was applied to the GSM 803810/81225 data.

7.8.3 Variometer clock corrections

Software clock corrections for the CNB and CN1 DAQ systems in 2012 are listed in Table 7.71 and Table 7.72, respectively.

Table 7.71 CNB DAQ system software clock corrections in 2012 that were less than 10 ms.

Time before correction	Correction (s)	Comment
2012-03-03T21:39:59Z	−0.001	n/a
2012-04-13T12:07:29Z	−0.001	n/a
2012-04-27T03:17:02Z	+0.002	n/a
2012-06-01T07:03:40Z	−0.001	n/a
2012-06-10T06:27:49Z	−0.001	n/a
2012-06-16T04:06:05Z	+0.002	n/a
2012-07-01T00:03:25Z	−1.000	Late leap second adjustment
2012-11-14T02:44:09Z	+1.050	System restart following UPS maintenance
2012-11-14T02:58:22Z	+1.079	System restart following UPS maintenance

Table 7.72 CN1 DAQ system software clock corrections in 2012 that were less than 10 ms.

Time before correction	Correction (s)	Comment
2012-07-01T00:00:59Z	−1.000	Late leap second adjustment

7.8.4 Absolute instruments

The principal absolute magnetometers used at CNB and their adopted corrections for 2012 are described in Table 7.73. The absolute instruments used at Canberra also served as the Australian observatory reference instruments.

Table 7.73 Absolute instrumentation (with corrections) used at CNB in 2012.

CNB DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0086
	Theodolite	Zeiss 020B
	Theodolite serial	353756
	Theodolite resolution	+0.01′
	D correction	−0.05′
	I correction	−0.15′
CNB absolute PPM	Model	GEM Systems GSM-90
	Serial number	905926/21867
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

The instrument corrections given in Table 7.73 for DIM DI0086/353756 were obtained from comparisons against the travelling reference DIM B0610H/160459 at Canberra observatory on 2008-07-30. International comparison via a travelling reference PPM to other nations' PPMs and frequency standards resulted in the correction 0.0 nT adopted for PPM 905926/21867.

All CNB absolute instrumentation corrections have been applied to all CNB 2012 final data through the correction of absolute observations.

The absolute instrument parameters showed no unusual patterns during 2012. DIM DI0086/353756 fluxgate offset T_0 was −5.2 nT ± 1.1 nT; its sensor misalignment angles δ and ε were −2.0′ ± 0.2′ and 2.3′ ± 0.2′, respectively. The standard deviation of the difference between the absolute PPM 905926/21867 and the variometer GSM-90 during each set of 8 readings during 2012 was 0.06 nT ± 0.04 nT.

7.8.5 Baselines

Figure 7.15 shows the observed and adopted baseline values in XYZ. Table 7.74 shows statistics regarding the difference between accepted observed and adopted baseline values (residuals) for the 2012 CNB definitive one-minute data.

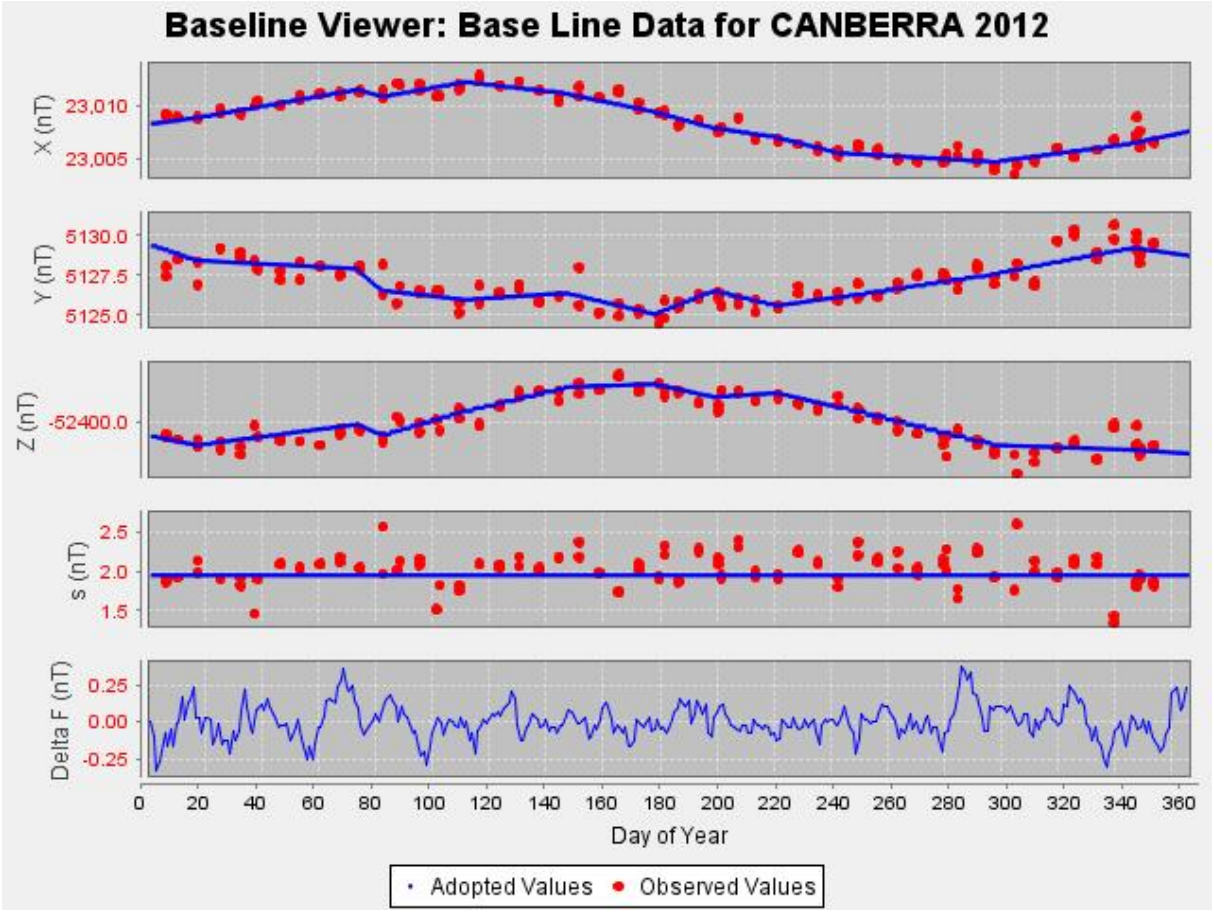

Figure 7.15 CNB 2012 baseline plots.

Table 7.74 Standard deviation of residuals from accepted absolute observations at CNB during 2012.

Component	SD
X	0.6 nT
Y	0.7 nT
Z	0.3 nT
D	06″
I	02″
F	0.3 nT

7.8.6 Variometer comparison

The 2012 definitive CNB vector data consisted primarily of NGL 9004-2 data (approx. 99.99%), with LEMI 004_A data used to fill gaps where available (approx. 0.01%). Table 7.75 shows statistics derived from the differences between these two datasets. In both datasets, baselines were applied using the same set of absolute observations. Note that in Table 7.75 'def' refers the submitted 2012 definitive data and 'CN1' refers to the LEMI 004_A data.

Table 7.75 CNB definitive data and CN1 variometer set data difference statistics.

Sample space	Statistic	$X_{def}-X_{CN1}$ (nT)	$Y_{def}-Y_{CN1}$ (nT)	$Z_{def}-Z_{CN1}$ (nT)
2012 minute values[1]	AM	−0.4	−0.1	−0.0
	SD	+0.8	+0.8	+0.3
	Sample minimum	−4.5	−2.6	−1.9
	Sample maximum	+3.5	+3.5	+1.5
2012 daily averages[1]	AM	−0.4	−0.1	−0.0
	SD	+0.7	+0.8	+0.2
	Sample minimum	−3.5	−1.6	−0.9
	Sample maximum	+1.2	+3.0	+0.6
2012 monthly averages[1]	AM	−0.4	−0.1	−0.0
	SD	+0.4	+0.4	+0.2
	Sample minimum	−1.4	−0.4	−0.4
	Sample maximum	+0.1	+0.9	+0.1

[1]*See Section 6.3 Recording intervals and mean values.*

7.8.7 Real-time, quasi-definitive and definitive data comparison

Table 7.76 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for CNB.

Table 7.76 Data type differences statistics for CNB in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	−0.3	−0.6	−0.2
	SD	+2.7	+2.1	+1.7
	Sample minimum	−3.7	−3.4	−2.4
	Sample maximum	+5.4	+3.0	+2.4
D−Q	AM	+0.2	−0.2	−0.3
	SD	+0.6	+0.3	+0.5
	Sample minimum	−0.8	−0.8	−1.0
	Sample maximum	+1.2	+0.5	+0.3

The CNB 2012 preliminary and quasi-definitive data are within the INTERMAGNET specification.

7.8.8 Operations

Weekly absolute observations were performed by GA Geomagnetism Team staff. Other duties included computer assisted hand scaling of K indices and monitoring database and data-delivery programs.

Quasi-definitive data were delivered to the Edinburgh GIN from about mid-2012. Errors in delivery due to a formatting flag at the GIN caused the data not to be accepted. Although all 2012 quasi-definitive data were all eventually delivered, timely delivery did not commence until 2013.

The distribution of 2012 CNB data (after initial transmission to GA) is shown in Table 7.77.

Table 7.77 Distribution of CNB 2012 data.

	Recipient	Data type	Sent
1-second values	IPS	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Monthly
	INTERMAGNET, Edinburgh GIN	D	July 2013
	WDC for Geomagnetism, Kyoto	P	Real-time
	ISGI, France	P	Real-time
	ISGI, France	P	Daily
	GFZ Helmholtz Centre Potsdam, Germany	P	3-hourly
	University of Oulu, Finland	P	Hourly
K indices	IPS, Sydney	n/a	Weekly
	University of Newcastle	n/a	Weekly
	BGS, Britain	n/a	Weekly
	CLS, France	n/a	Weekly
	CNES, France	n/a	Weekly
	ISGI, France	n/a	Weekly
	Royal Observatory of Belgium	n/a	Weekly
	GFZ Helmholtz Centre Potsdam, Germany	n/a	Semi-monthly
Storms and rapid variations	WDC-STP, Boulder, USA	n/a	Monthly
	WDC for Geomagnetism, Kyoto, Japan	n/a	Monthly
	Observatori de l'Ebre, Spain	n/a	Monthly

7.8.9 Missing one-minute definitive data

In 2012, 0 and 4 values were missing from the CNB definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.78.

Table 7.78 CNB 2012 Missing one-minute definitive data.

Duration	Components	Samples	Comment
2012-11-14T02:41Z/02:42	F	2	n/a
2012-11-14T02:46Z/02:47	F	2	n/a

7.8.10 Significant events

Table 7.79 Significant event that took place at CNB in 2012.

Time or duration	Description of event
2012-01-05	Absolute battery faulty. Replaced before absolute observations.
2012-01-09	No second absolute observation on this day.
2012-01-24	Discover roof tiles dislodged on SE section of primary/CNB/NGL variometer hut. Some tiles are broken (appears to be wind damage). Building maintenance staff visit to make a (temporary) repair to the tiles.
2012-01-24T22:30Z	Magnetometer calibration facility computer clock lost GPS signal.
2012-01-27T01:18Z	Restarted GdapClock on magcald. Not fixed.
2012-03-01T12:33Z	Data delivery ceases. Suspect telemetry issues due to rain.
2012-03-02T02:00Z	Power problems resolved with radio modem. Data accessible again.
2012-03-24/25, 2012-04-13/16	Kowen forest closed for 24 h bike race on 2012-03-24/25. It will be closed again from the 2012-04-13/16 for the Canberra rally (restricting access to observatory).
2012-06-03	CNB data retrieval and processing was changed to 2 minute intervals for NOAA space weather real time K indices.
2012-06-19	Last absolute observation of travelling DIM missing EU and ED measurements.
2012-07-05T9:00Z	Building maintenance staff visited CNB to check electrical boards in control room, Magnetometer Calibration Facility and ‘top room’. Noticed a small part of fence is sagging.
2012-07-12	Sent all 2012 January-June quasi-definitive month files in IAGA2002 format to INTERMAGNET Edinburgh GIN. Could not detect whether the data was loaded into the GIN; although it was loaded into the cache.
2012-10-02T00:46/50Z	Backup variometer (LEMI) data corrupted.
2012-10-09	GPS data collected at several important positions around the observatory. (Gn mark, Gs mark, NW mark, primary observation pier, centre of Calibration Facility 3-axis coil system).
2012-10-24	sun-geomag host fails.
2012-10-31T12:50/11-01T02Z	sun-geomag fails.
2012-11-02T00:30Z	sun-geomag fails. Rebooted and moved to different physical host.

Time or duration	Description of event
2012-11-05T06Z	sun-geomag fails. Unavailable for approx. 24 hours.
2012-11-06T23:30Z	sun-geomag fails. Rebooted.
2012-11-07T00:30Z	sun-geomag OS patch.
2012-11-14	Testing client equipment in Magnetometer Calibration Facility. Replaced CNB UPS. In the process, the ga-cnb-mag1 modem access computer failed and was removed.

7.8.11 K indices, principle storms and rapid variations

K indices for CNB have been derived using a computer-assisted method developed at GA and based on the IAGA-accepted LRNS algorithm (see Section 4.2 Magnetic activity indices).

CNB K indices contribute to the global Kp and aa indices, the southern hemisphere Ks index, and all their derivatives. K indices measured in 2012 are listed in Appendix F.3. The frequency distribution of the K indices are shown in Figure 7.16 and Table 7.80.

The annual mean daily K sum for CNB in 2012 was 11.8.

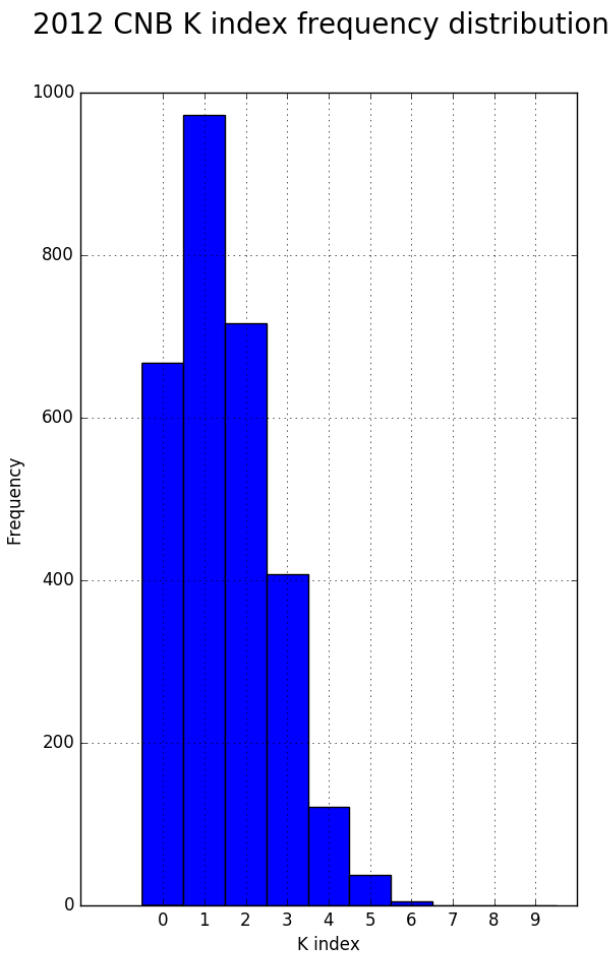

Figure 7.16 Frequency distribution of K indices for CNB in 2012.

Table 7.80 Frequency distribution of K indices for CNB in 2012.

K index	0	1	2	3	4	5	6	7	8	9
Frequency	667	973	716	408	121	38	5	0	0	0

Appendix F.3 list details of principle magnetic storms and SSCs observed at CNB in 2012, respectively.

No solar flare effects were observed at CNB in 2012.

7.8.12 Annual mean values

Different annual means (see Section 6.3.1 Annual means) for CNB for 2012 are given in Table 7.81. Annual means for X, Y, Z and F since 1995 are plotted in Figure 7.17 and tabulated in Appendix E.7.

Table 7.81 Annual mean values of CNB for 2012.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+012° 30.7′	−065° 52.1′	23742	23179	5143	−53000	58075
Quiet Days	+012° 30.6′	−065° 51.7′	23749	23185	5145	−52998	58076
Disturbed Days	+012° 30.7′	−065° 53.2′	23725	23162	5140	−53005	58072

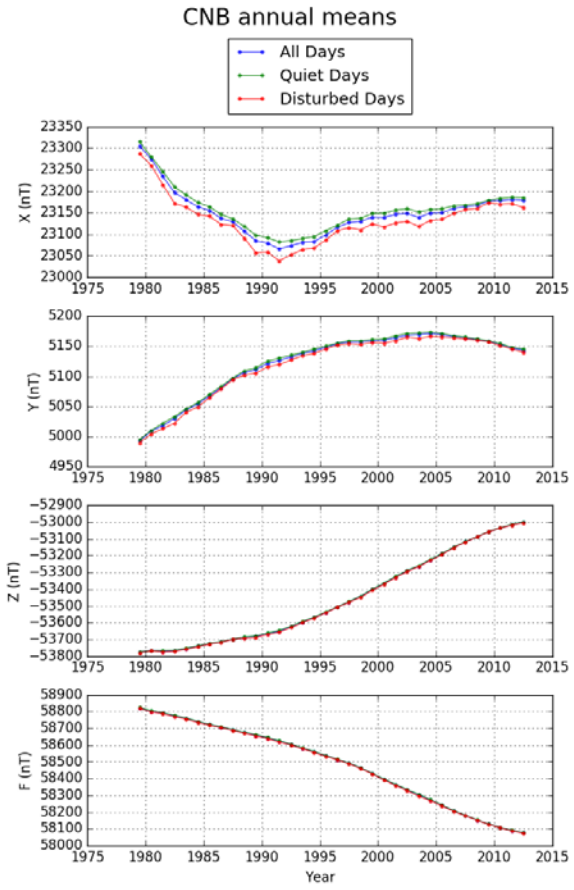

Figure 7.17 CNB annual mean values since 1979.

7.9 Macquarie Island Station

Macquarie Island is approximately 1500 km southeast of Tasmania and 1300 km north of the Antarctic coast. The magnetic observatory is part of the Australian Antarctic Division research station located on the isthmus at the northern end of the island.

MCQ observatory comprises:

- An office in the station's 'science building'
- A variometer house 100 m south of the office
- An absolute house approx. 30 m further south
- A PPM house between the variometer and absolute houses.

Power to the houses is routed underground. The area around the observatory is used by elephant seals and other native wildlife. The absolute and variometer houses are enclosed within non-magnetic protective fences.

Important details regarding MCQ are given in Table 7.82.

Table 7.82 Important MCQ observatory details for 2012.

IAGA code	MCQ
Commenced operation	1952
Geographic latitude	054° 30' S
Geographic longitude	158° 57' E
Geomagnetic latitude	059.61° S (IGRF 2010)
Geomagnetic longitude	244.13° E (IGRF 2010)
K 9 index lower limit	1500 nT
Principal pier	Pier AE
Pier elevation (top)	8 m AMSL
Principal reference mark	NMI
Reference mark azimuth	353° 44' 13"
Reference mark distance	200 m
Observatory manager(s)	Liejun Wang
Observer(s)	Trevor Hopps (to 2012-04-23), Mark Mangles (to 2012-10-22), Greg Bird (from 2012-10-30)

7.9.1 Local meteorological conditions

The meteorological temperature at Macquarie Island during 2012 varied from a minimum −4.4 °C (2012-05-05) to a maximum +10.9 °C (2012-02-06). Daily minimum temperatures varied from −4.4 °C to +8.2 °C (average +3.3 °C ± 2.5 °C); daily maximum temperatures varied from +0.8 °C to +10.9 °C (average +6.8 °C ± 1.9 °C); daily temperature ranges varied from 0 °C to +8.6 °C (average +3.6 °C ± 1.6 °C).

The daily maximum wind gust varied from 20 km/h to 130 km/h (average 71 km/h ± 19 km/h). The maximum daily maximum wind gust of 130 km/h occurred on 2012-09-29. The minimum daily maximum wind gust of 20 km/h occurred on 2012-06-14. Note that these wind gust data are corrected

from previously published data on the appropriate readme file featured in the 2012 INTERMAGNET definitive data DVD.

7.9.2 Variometers

Table 7.83 shows specifics of the variometers and DAQ system used at MCQ during 2012.

Table 7.83 Variometer systems used at MCQ in 2012.

MCQ vector variometer	Model	Narod
	Serial number	9305-1
	Type	3-channel, non-suspended, ring-core fluxgate magnetometer
	Orientation	Equally distributed
	Acquisition interval	1 s
	ADC	Integrated (see Section 5.1 Variometers)
	Scale value	0.025 nT/count
MQ2 vector variometer	Model	DMI FGE
	Serial number	E0307/S0262
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	A/D converter	ADAM 4017 (±10 V input voltage range)
	Scale value	0.32 nT/count
MCQ scalar variometer	Model	Elsec-820 M3
	Serial number	140
	Type	PPM
	Acquisition interval	10 s
	Resolution	0.1 nT
MQ2 scalar variometer	Model	GEM Systems GSM-90
	Serial number	4081418/42176
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
Share DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS 16 receiver
Other	Communications	ANARESAT

Two sets of variometer instrumentation operated at MCQ throughout 2012:

- 'MCQ' consists of the NGL 9305-1 and the Elsec 140
- 'MQ2' consists of the FGE E0307/S0262 and the GSM 4081418/42176.

Both variometer systems used the same DAQ computer.

The NGL 9305-1 electronics were situated in the 'ante room' of the variometer house and the sensor was mounted on a marble base on the SE pillar of the sensor room of the variometer house. It was oriented such that the three mutually orthogonal components recorded were of approximately equal magnitudes.

The Elsec 140 was located on the pillar in the PPM house with the electronics console on the floor of the PPM house. The PPM house had no temperature control.

There is no heating system in the ante room of the variometer house. Temperature variations recorded in the NGL electronics were +9.2 °C to +17.6 °C. The NGL sensor in the variometer house recorded temperatures ranging from +12.2 °C to +17.7 °C.

The FGE E0307/S0262 sensor was mounted on the NE pillar of the sensor room of the variometer house and aligned magnetic NW, NE and vertical. The FGE E0307/S0262 electronics were mounted in an insulated box situated on the floor in the SW corner of the sensor room.

The GSM 4081418/42176 sensor was mounted on a 22 cm high stand located on the floor of the sensor room, mid-way between the NE and SE pillar. The GSM electronics were located in an insulated box on the floor in the SW corner of the sensor room of the variometer house.

The temperature of the sensor room of the variometer house was controlled with a heating system. Temperatures recorded in FGE E0307/S0262 electronics throughout the year ranged from +20.3 °C to +28.3 °C. Temperatures recorded from the FGE sensor throughout the year ranged from +14.8 °C to +21.3 °C.

The DAQ system was situated in the ante-room of the variometer house. Backup power was provided by two separate systems:

- An UPS located in the office that served the MCQ variometer set
- A 12 V battery situated in the ante-room of the variometer house served the DAQ computer, the GPS receiver and the MQ2 variometer set.

FGE E0307/S0262 1-second data required despiking. The despiking parameters required a spike to exceed 0.2 nT and 10 times the average 'spike-factor' of the following minute of data. A Total of 95 seconds of 1-second data was rejected during 2012. From 1 s to 9 s of data were rejected on 7 days in January. Eleven seconds were rejected on 2012-06-22 due to earthquake noise, 10 seconds on 2012-07-09 and 23 seconds on 2012-08-03 due to high frequency noise.

NGL 9305-1 1-second data required de-spiking. The de-spiking parameters required a spike to exceed 1 nT and 10 times the average 'spike-factor' of the following minute of data. A total of 8390 seconds were rejected during 2012. Typically 20-30 seconds of data were rejected on each day. The highest rejection rate was on 2012-05-30, where 132 s of data was rejected.

The definitive 1-minute data for 2012 was derived from the MQ2 variometer set. Preliminary data provided to INTERMAGNET in real-time during 2012 was derived from the MCQ variometer set. Quasi-definitive 1-minute data provided to INTERMAGNET quarterly was derived from the MQ2 variometer set. The reason for adopting the DMI and GSM variometers for the quasi-definitive and

definitive data was that data rejection rate of the FGE E0307/S0262 was much less than the NGL 9305-1 and the GSM 4081418/42176 performed better than Elsec 140.

7.9.3 Variometer clock corrections

The time correction log file from 2012-01-01/11-06 was misplaced when the DAQ PC was modified. From 2012-11-07/12-31 all clock adjustments were less than 1 ms.

7.9.4 Absolute instruments

The principal absolute magnetometers used at MCQ and their adopted corrections for 2012 are described in Table 7.84.

Table 7.84 Absolute instrumentation (with corrections) used at MCQ in 2012.

MCQ primary DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0045
	Theodolite	Zeiss 020B
	Theodolite serial	393911
	Theodolite resolution	+0.10′
	D correction	+0.15′
	I correction	−0.10′
	Fluxgate magnetometer	DMI
MCQ secondary DIM	Fluxgate serial	DI0040
	Theodolite	Zeiss 020B
	Theodolite serial	394742
	Theodolite resolution	+0.10′
	D correction	+0.00′
	I correction	−0.10′
MCQ primary absolute PPM	Model	GEM Systems GSM-90
	Serial number	5091720/52453
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT
MCQ secondary absolute PPM	Model	Austral
	Serial number	525
	Type	PPM
	Resolution	+1.0 nT
	F Correction	−2.4 nT

The principal absolute instruments consisted of DIM DI0045/393911 and GSM 5091720/52453. The back-up absolute instruments consisted of DIM DI0040/394742 and Austral 525. There was no comparison done between principal and back-up instruments during 2012.

The absolute instruments at MCQ were last compared against the travelling reference instrument (DIM B0610H/160459) on 2009-03-20. The adopted corrections featured in Table 7.84 were these corrections and these have been applied to all MCQ 2012 final data through the correction of absolute observations.

Magnetic absolute measurements were nominally performed on a weekly basis in the absolute house. DIM observations were made on the principal pier AE.

Pier differences of −2.6 nT in X, +5.1 nT in Y, +4.2 in Z and −4.1 nT in F (for scalar magnetometers) were applied to adjust observations performed on pier AW to be equivalent to observations on the principal pier AE.

The principal absolute instrument parameters showed no unusual pattern during 2012. DIM DI0045/393911 fluxgate offset T_0 was 5.6 nT ± 0.9 nT; sensor misalignment angles δ and ε were −1.0′ ± 0.3′ and 0.1′ ± 0.1′, respectively. The standard deviation of the difference between absolute GSM 5091720/52453 and the variometer GSM 4081418/42176 during each set of 8 readings during 2012 was 0.7 nT.

7.9.5 Baselines

Figure 7.18 shows the observed and adopted baseline values in XYZ. Table 7.85 shows statistics regarding the difference between observed and adopted baseline values (residuals) for the MCQ 2012 definitive data.

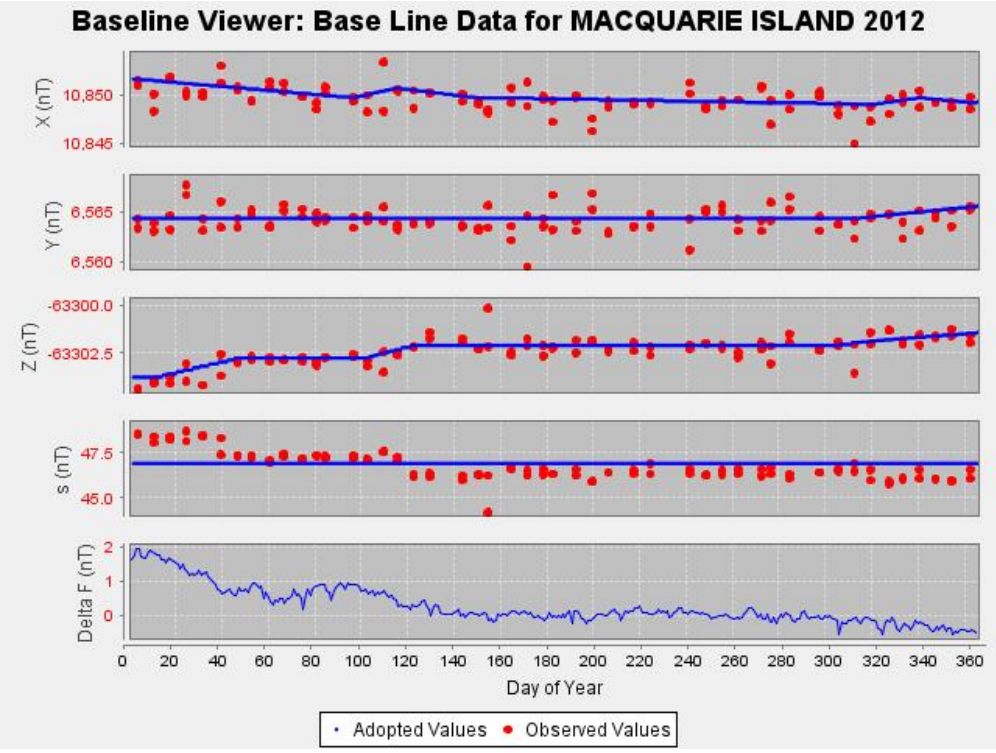

Figure 7.18 MCQ 2012 baseline plots.

Table 7.85 Standard deviation of residuals from accepted absolute observations at MCQ during 2012

Component	SD
X	0.9 nT
Y	0.9 nT
Z	0.7 nT
D	11″
I	04″
F	0.6 nT

7.9.6 Variometer comparison

Table 7.75 shows statistics regarding the differences between 2012 MCQ definitive vector data (subscripted 'def') and that derived solely from the NGL 9305-1 (subscripted 'MCQ'). In both datasets, baselines were applied using the same set of absolute observations.

Table 7.86 MCQ definitive data and MCQ variometer set data difference statistics.

Sample space	Statistic	$X_{def}-X_{MCQ}$ (nT)	$Y_{def}-Y_{MCQ}$ (nT)	$Z_{def}-Z_{MCQ}$ (nT)
2012 minute values[1]	AM	−0.3	+0.1	−0.0
	SD	+1.6	+1.3	+0.8
	Sample minimum	−38.4	−12.3	−12.3
	Sample maximum	+27.3	+17.5	+12.0
2012 daily averages[1]	AM	−0.2	+0.1	−0.0
	SD	+1.2	+1.0	+0.7
	Sample minimum	−5.5	−2.6	−1.9
	Sample maximum	+2.4	+3.2	+1.9
2012 monthly averages[1]	AM	−0.2	+0.1	−0.0
	SD	+0.8	+0.4	+0.5
	Sample minimum	−1.5	−0.8	−0.6
	Sample maximum	+0.8	+0.7	+0.8

[1] *See Section 6.3 Recording intervals and mean values.*

7.9.7 Real-time, quasi-definitive and definitive data comparison

Table 7.87 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for MCQ.

Table 7.87 Data type differences statistics for MCQ in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+3.0	+5.5	+3.0
	SD	+1.9	+4.2	+1.2
	Sample minimum	−0.2	+0.2	+1.5
	Sample maximum	+6.6	+9.6	+4.7
D−Q	AM	−0.1	+0.1	+0.1
	SD	+0.3	+0.3	+0.2
	Sample minimum	−0.5	−0.0	−0.2
	Sample maximum	+0.6	+0.9	+0.5

The MCQ 2012 preliminary and quasi-definitive data are within the INTERMAGNET specification.

7.9.8 Operations

The magnetic observers at MCQ were members of the ANARE and were employed by the AAD with funding support by GA. Their duties included maintaining the equipment, performing absolute observations to calibrate the variometers, transcribing the observations and emailing them to GA, maintaining the integrity of the observatory and reporting any changes to GA. During 2012, the role of magnetic observer was filled by ANARE communications technical officers.

DAQ computer timing signals were provided by a Garmin GPS receiver mounted on the roof of the variometer house.

The distribution of MCQ 2012 data (after initial transmission to GA) is described in Table 7.88

Table 7.88 Distribution of MCQ 2012 data.

	Recipient	Data type	Sent
1-second values	IPS	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Quarterly
	WDC for Geomagnetism, Kyoto	P	Real-time
	WDC for Geomagnetism, Kyoto	P	Daily

7.9.9 Missing one-minute definitive data

There was no missing one-minute definitive data for MCQ in 2012.

7.9.10 Significant events

Table 7.89 Significant events that took place at MCQ in 2012.

Time or duration	Description of event
2012-01-24T01:15Z	Slay GdapTimePips process which appears to have been running for some considerable time.
2012-04-30	Observer changeover. Mango Mangles replaced Trevor Hopps.
2012-05-30	Mango Mangles will be in the field for one week. Absolute observations will be done on Friday this week.
2012-08-14T00:50Z	Telemetry stops due to network reconfiguration at AAD.
2012-08-17T04:30	Data being received again. Elsec 140 data stops.
2012-08-19T22:38Z	Slay and restart GdapE820 (DAQ process).
2012-08-19T23:45Z	Change IP address of MCQ gateway (.1 to .254).
2012-08-27	No Elsec 140 data. slay GdapE820 process.
2012-08-27T02:10Z	Network connection drops out during session.
2012-08-27T02:19Z	Restart GdapE820 via Mawson.
2012-08-29	AAD IT (Tony Parker) fixes problems with AAD firewall to reinstate MCQ and CSY telemetry.
2012-08-29T22:38Z	Stop and restart GdapE820 process.
2012-09-07T11:45Z	Elsec 140 data data ceases.
2012-09-09	Approx. 23:50Z slay and restart GdapE820. 23:55Z slay GdapTimePips.
2012-10-11T22:05Z	Slay and restart GdapE820.
2012-10-25	Observer changeover this week. Greg Bird will be the observer from next week. Mango Mangles will return to Australia mainland.

7.9.11 Annual mean values

Different annual means (see Section 10.3.1 Annual means) for MCQ for 2012 are given in Table 7.90. Annual means for X, Y, Z and F since 1980 are plotted in Figure 7.19 and tabulated in Appendix E.8.

Table 7.90 Annual mean values of MCQ for 2012.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	+031° 32.1′	−078° 37.2′	12663	10792	6623	−62917	64178
Quiet Days	+031° 32.0′	−078° 36.8′	12671	10800	6627	−62920	64183
Disturbed Days	+031° 33.1′	−078° 38.4′	12639	10771	6614	−62913	64170

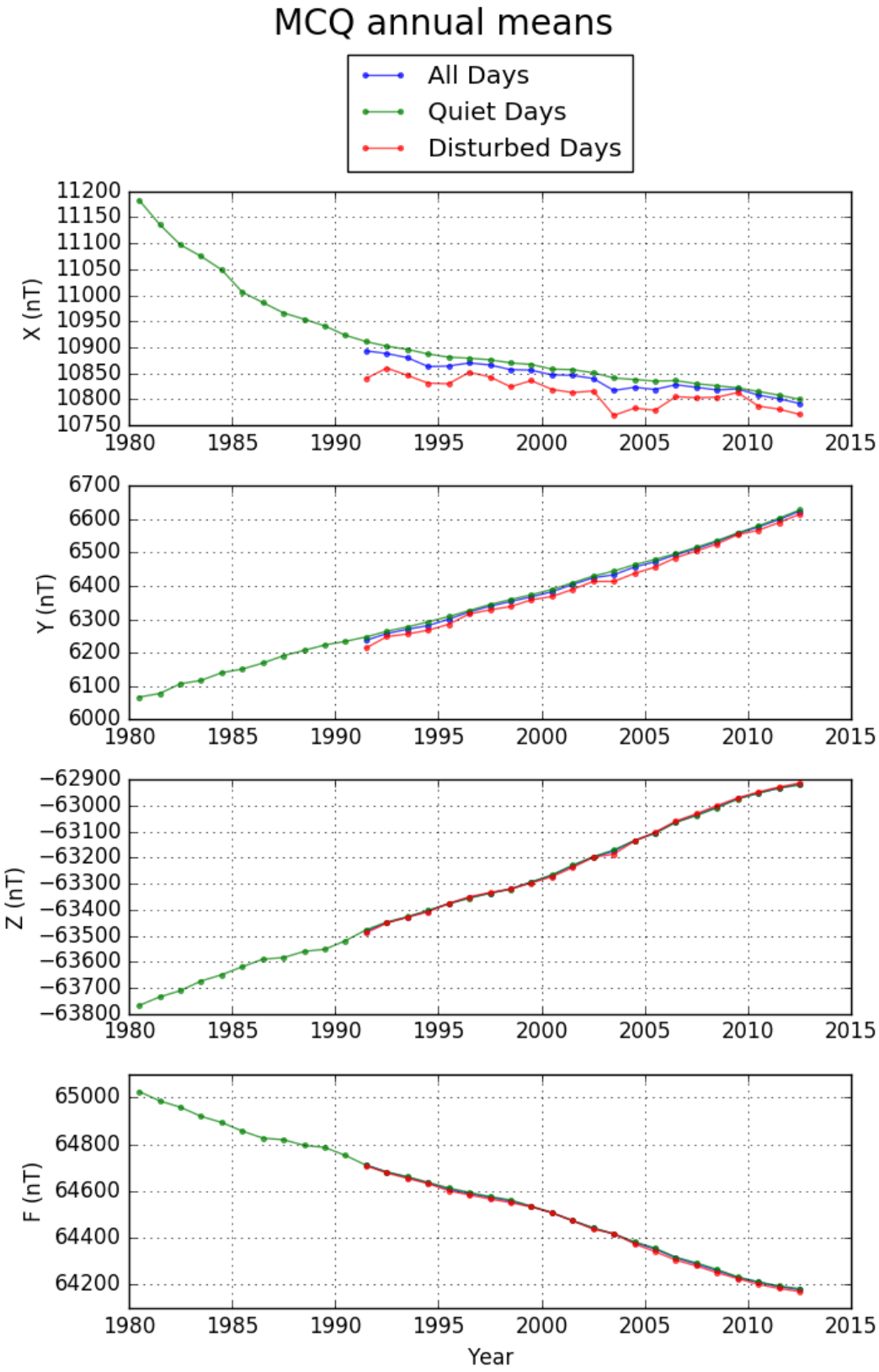

Figure 7.19 MCQ annual mean values since 1980.

7.10 Mawson Station

MAW is part of the Mawson Station in Mac. Robertson Land, Antarctica. The station is on the edge of Horseshoe Harbour and built on bare charnockite basement rock. There is no ice or soil cover. The magnetic observatory consists of:

- A variometer house
- An absolute house.

It is situated in a magnetic quiet zone at East Bay on the southeast extremity of the station.

In 1955 the Mawson Station observatory commenced recording magnetic variations with a 3-component analogue magnetograph. The observatory has continuously recorded the geomagnetic field at Mawson Station since that time. In December 1985 the magnetic observatory was converted to digital recording. It was accepted as an IMO at the start of 2006. It is operated by GA as part of the ANARE.

Important details regarding MAW are given in Table 7.91.

Table 7.91 Important MAW observatory details for 2012.

IAGA code	MAW
Commenced operation	1955
Geographic latitude	067° 36′ 14″ S
Geographic longitude	062° 52′ 45″ E
Geomagnetic latitude	073.05° S (IGRF 2010)
Geomagnetic longitude	112.21° E (IGRF 2010)
K 9 index lower limit	1500 nT
Principal pier	Pier A
Pier elevation (top)	12 m AMSL
Principal reference mark	BMR89/1
Reference mark azimuth	350° 36.9′
Reference mark distance	112 m
Observatory manager(s)	Peter Crosthwaite
Observer(s)	Ian Phillips (to 2012-02-29), Darren Henderson (from 2012-03-01)

7.10.1 Local meteorological conditions

The meteorological temperature at Mawson during 2012 varied from a minimum −34.5 °C (2012-05-26) to a maximum +5.5 °C (2012-12-26). Daily minimum temperatures varied from −34.5 °C to +0.3 °C (average −15 °C ± 9 °C); daily maximum temperatures varied from −27.4 °C to +5.5 °C (average −9 °C ± 8 °C); daily temperature ranges varied from 0 °C to +21 °C (average +6 °C ± 3 °C).

The daily maximum wind gust varied from 15 km/h to 207 km/h (average 86 km/h ± 31 km/h). The maximum daily maximum wind gust was 207 km/h in July. The minimum daily maximum wind gust was 15 km/h in December. Almost every day was windy due to either blizzard or katabatic conditions. There was from 0 to 17.6 h/day (average 5.3 h/day ± 5.7 h/day) of sunshine per day according to the meteorological definition.

7.10.2 Variometers

Table 7.92 shows specifics of the variometers and acquisition system used at MAW during 2012.

Table 7.92 Variometer systems used at MAW in 2012.

MAW vector variometer	Model	Narod
	Serial number	NGL-200907-1 with BMR 9004-3
	Type	3-channel, non-suspended, ring-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	Integrated (see Section 8.1 Variometers)
	Scale value	0.01 nT/count
	Duration of use	From 2011-02-26
MW2 vector variometer	Model	DMI FGE
	Serial number	E0291/S0244
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±10 V input voltage range)
	Scale value	0.32 nT/count
	Duration of use	From 2006-05-17
Shared scalar variometer	Model	GEM Systems GSM-90
	Serial number	8092902/83384
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
	Period of use	From 2011-03-11
MAW DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS 16 receiver
	Hostname	ga-maw-mag2
MW2 DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS 16 receiver
	Hostname	ga-maw-mag1

Other	Communications	ANARESAT

The FGE E0291/S0244 sensor was located in the recording (eastern) room of the variometer house and the NGL 200907-1 and GSM 8092902/83384 sensors were located within the sensor (western) room.

The NGL 200907-1 was installed during a maintenance visit to MAW during 2011-02-25/28. A pulse inverter was installed between the Garmin GPS receiver and the NGL 200907-1, as the receiver produces the opposite polarity timing signal required by the NGL.

During the 2011 maintenance visit, the FGE and NGL magnetometers were connected to independent DAQ computers with hostnames ‘ga-maw-mag1’ and ‘ga-maw-mag2’, respectively; each with its own battery and GPS receiver, but sharing a monitor and keyboard.

The GSM 8092902/83384 was connected to MAW DAQ computer but GSM data was recorded on both DAQ computers by forwarding over the LAN.

Temperature regulation during 2012, as in previous years, was not ideal. The heating system (a regulated heater in each sensor room) was inefficient and inadequate.

The NGL sensor was more temperature stable than the NGL electronics and both the FGE sensor and electronics. Narod sensor thermometer recorded an approximate temperature range of 7 °C over the year; the NGL electronics and FGE sensor and electronics recorded an approximate 18 °C range and were highly correlated. Temperature control of the variometers remains a priority in order to improve data quality.

The FGE E0291/S0244 and GSM 8092902/83384 variometer set (MW2) was the primary source for preliminary, quasi-definitive and definitive data, as well as K indices, in 2012 (with missing vector variometer data being filled with NGL data).

Spike filters were used to detect sharp spikes in the variometer data. The spike parameters required a spike to have a ‘spike level’ of at least 2 nT and 10 times the average of the following minute.

Most spike detections on the FGE data were either false detections or indicated periods of generally corrupted data (days 2012-01-19/20, 2012-10-18). No spike filtering was applied to the definitive FGE data.

Most spike detections on the NGL data were either false detections or indicated variometer range jumps[19]. It became apparent that the DAQ system was incorrectly filtering data around range jumps and inserting the spikes due to an issue with the NGL firmware.

The NGL data was spike filtered to remove these artificial spikes. Filtering rejected no data on 126 days; it rejected a total of 1862 seconds throughout the year; the maximum daily rejection was 84 on 2012-07-17 which was justified and caused by a large number of range jumps; 43 samples were rejected on 2012-01-19, however this was an indication of a period of data corruption caused during fire equipment testing.

Experience from 2011 data processing indicated that a spike filter was not useful for the scalar data as it eliminated apparently valid data during daily auroral zone activity. No spike filter was applied to 2012 GSM data.

[19] NGL variometers possess a mechanism for dynamically adjusting their range. This is represented in their output data as a range value and an offset value.

The MW2 DAQ OS driver stopped several times throughout the year, causing data losses on/during:

- 2012-04-17
- 2012-05-25/28
- 2012-07-05
- 2012-07-06
- 2012-07-21
- 2012-07-22
- 2012-10-02
- 2012-10-03.

These were days of high winds/blizzards and the problem appears to be caused by enhancement of static electricity during such events.

The NGL lost approx. 40-60 samples per day, sporadically, possibly due to data communication errors. Whether this was a problem with the NGL or the DAQ computer is unknown.

The GSM performed satisfactorily throughout 2012, although there were periods of missing samples on 2012-04-17, 2012-05-25, 2012-06-22, 2012-07-05, 2012-07-15, 2012-07-21, 2012-08-25, 2012-09-03, 2012-10-02. All of these occasions were days of high winds. Often there were concurrent issues—the FGE ADC converter driver failed, noisy FGE sensor thermometer data and oscillating FGE electronics thermometer data.

7.10.3 Variometer clock corrections

Software clock corrections for the MW2 DAQ computer in 2012 exceeding 10 ms are listed in Table 7.93.

Table 7.93 DAQ software clock corrections at MAW in 2012 that were greater than 10 ms.

Time before correction	Correction (s)	Comment
2011/02/07T03:17:24Z	−0.320	n/a
2011/02/08T01:08:00Z	−0.018	n/a
2011/02/08T01:31:30Z	−0.064	n/a
2011/02/08T01:34:42Z	−0.059	n/a
2010/12/02T09:01:06Z	+0.376	n/a
2010/12/02T09:02:36Z	+0.382	n/a
2011/02/03T08:50:11Z	+155.111	n/a
2011/02/03T09:13:58Z	+155.131	n/a
2011/02/03T09:16:18Z	+155.134	n/a
2011/02/03T09:20:06Z	+155.137	n/a
2011/02/03T09:45:01Z	+155.154	n/a
2011/02/03T09:53:09Z	+155.169	n/a

Time before correction	Correction (s)	Comment
2011/02/04T01:26:44Z	−0.858	n/a
2011/02/07T03:17:24Z	−0.320	n/a
2011/02/08T01:08:00Z	−0.018	n/a
2011/02/08T01:31:30Z	−0.064	n/a
2011/02/08T01:34:42Z	−0.059	n/a
2010/12/02T09:01:06Z	+0.376	n/a
2010/12/02T09:02:36Z	+0.382	n/a
2011/02/03T08:50:11Z	+155.111	n/a
2011/02/03T09:13:58Z	+155.131	n/a
2011/02/03T09:16:18Z	+155.134	n/a
2011/02/03T09:20:06Z	+155.137	n/a
2011/02/03T09:45:01Z	+155.154	n/a
2011/02/03T09:53:09Z	+155.169	n/a
2011/02/04T01:26:44Z	−0.858	n/a
2011/02/07T03:17:24Z	−0.320	n/a
2011/02/08T01:08:00Z	−0.018	n/a
2011/02/08T01:31:30Z	−0.064	n/a
2011/02/08T01:34:42Z	−0.059	n/a
2010/12/02T09:01:06Z	+0.376	n/a
2010/12/02T09:02:36Z	+0.382	n/a
2011/02/03T08:50:11Z	+155.111	n/a
2011/02/03T09:13:58Z	+155.131	n/a
2011/02/03T09:16:18Z	+155.134	n/a
2011/02/03T09:20:06Z	+155.137	n/a
2011/02/03T09:45:01Z	+155.154	n/a
2011/02/03T09:53:09Z	+155.169	n/a
2011/02/04T01:26:44Z	−0.858	n/a
2011/02/25T14:28:48Z	−0.149	n/a
2011/02/26T01:46:48Z	+0.558	n/a
2011/02/26T06:34:18Z	−0.144	n/a
2011/02/26T07:47:42Z	−0.065	n/a
2011/02/28T04:45:48Z	−0.250	n/a
2011/02/28T05:19:36Z	−0.223	n/a

Time before correction	Correction (s)	Comment
2011/02/28T06:27:12Z	−0.151	n/a
2011/02/28T07:07:30Z	−0.114	n/a
2012/01/20T09:54:18Z	−0.072	n/a
2012/07/01T00:00:55Z	−1.000	n/a

7.10.4 Absolute instruments

The principal absolute magnetometers used at MAW and their adopted corrections for 2012 are described in Table 7.94.

Absolute instrumentation corrections have been applied to all MAW 2012 final data through the correction of absolute observations.

Table 7.94 Absolute instrumentation (with corrections) used at MAW in 2012.

MAW DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0022
	Theodolite	Zeiss 020B
	Theodolite serial	353758
	Theodolite resolution	0.1’
	D correction	0.0’
	I correction	0.0’
MAW absolute PPM	Model	GEM Systems GSM-90
	Serial number	4081417/42187
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

Observations from 2012-05 were of lesser quality, and 11 observations (including pairs of observations from each of two weeks) were removed from baseline determination. Many attempts were made to try to improve the quality of absolute observations with the fluxgate sensor coupling tightened on 2012-06-06. In 2013-01 Darren noticed that the vertical circle of the theodolite was ‘sticky’ and it would move with a gentle tap to a more stable position. The instrument was taken out of regular use in 2013-01.

All absolute observations were performed on Pier A while the azimuth mark BMR89/1 was used as the declination reference.

Instrument corrections of zero have been adopted for all MAW absolute instruments for 2012 as no new evidence about corrections was gathered.

7.10.5 Baselines

Figure 7.20 shows the accepted observed and adopted baseline values in XYZ. Table 7.95 shows statistics regarding the difference between observed and adopted baseline values (residuals) for the MAW 2012 definitive one-minute data.

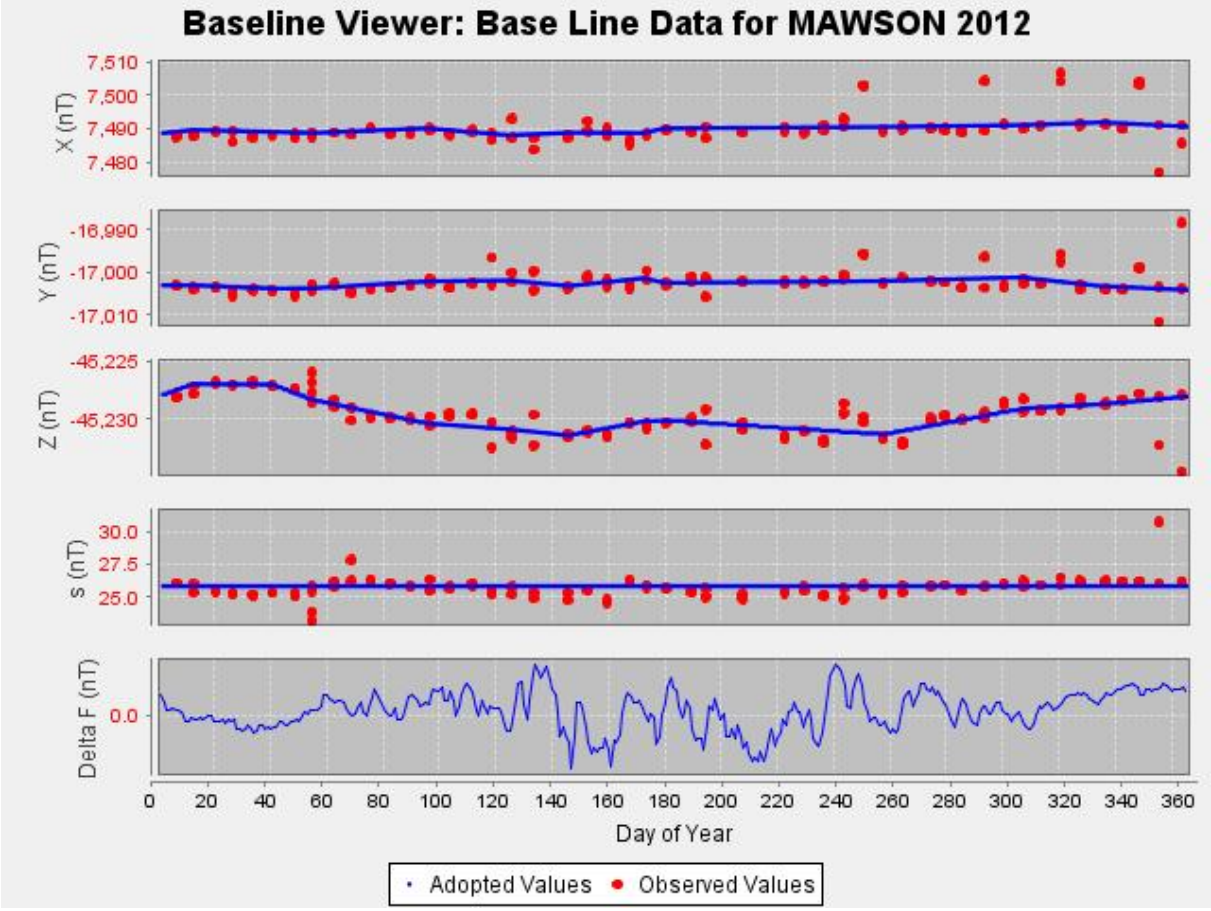

Figure 7.20 MAW 2012 baseline plots.

Table 7.95 Standard deviation of residuals from accepted absolute observations at MAW during 2012.

Component	SD
X	0.9 nT
Y	0.9 nT
Z	0.7 nT
D	11″
I	04″
F	0.6 nT

There were some differences between the absolute GSM 4081417/42187 and the variometer GSM 8092902/83384 throughout the year. During definitive data processing in 2012, it was noticed that there was a change in the difference between the variometer and absolute GSMs during absolute observations taken on 2012-01-11, between observations during 2012-02-16/22, between observations during 2012-06-06/14, and during observations on 2012-07-11; these were about 0.5 nT

in magnitude with alternating sign. Similar reports were made in previous years with no conclusions drawn. There appears to be a seasonal variation in the difference with a peak-peak magnitude 1 nT.

7.10.6 Variometer comparison

The 2012 definitive one-minute MAW data (98.42% primary FGE and 1.58% NGL) were compared to the NGL variometer data. Table 7.96 shows statistics derived from the differences between 2012 MAW definitive vector data (subscripted 'def') and that derived solely from the NGL 9305-1 (subscripted 'MAW'). In both datasets, baselines were applied using the same set of absolute observations.

Table 7.96 MAW definitive data and MAW variometer set data difference statistics.

Sample space	Statistic	$X_{def}-X_{MAW}$ (nT)	$Y_{def}-Y_{MAW}$ (nT)	$Z_{def}-Z_{MAW}$ (nT)
2012 minute values[1]	AM	−0.1	−0.5	−0.3
	SD	+1.0	+1.2	+0.5
	Sample minimum	−5.2	−5.5	−9.0
	Sample maximum	+11.8	+9.8	+5.2
2012 daily averages[1]	AM	−0.1	−0.5	−0.3
	SD	+0.8	+1.1	+0.5
	Sample minimum	−3.1	−3.9	−1.9
	Sample maximum	+1.8	+2.4	+0.8
2012 monthly averages[1]	AM	−0.1	−0.5	−0.3
	SD	+0.5	+0.8	+0.4
	Sample minimum	−1.1	−2.2	−1.1
	Sample maximum	+0.6	+0.3	+0.4

7.10.7 Real-time, quasi-definitive and definitive data comparison

Table 7.97 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for MAW.

Table 7.97 Data type differences statistics for MAW in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	−1.0	−1.8	−0.9
	SD	+1.9	+1.5	+0.8
	Sample minimum	−3.3	−3.4	−1.5
	Sample maximum	+2.6	+1.5	+1.4
D−Q	AM	−0.3	−0.2	+0.0
	SD	+0.5	+0.6	+0.3
	Sample minimum	−1.4	−1.0	−0.4
	Sample maximum	+0.5	+1.0	+0.4

7.10.8 Operations

The Mawson observers, Ian Phillips and Darren Henderson, were members of the ANARE and were employed by the AAD with funding support by GA. Mawson personnel change over each summer with varying periods of overlap. Darren Henderson took over responsibility for the observatory from Ian Phillips in late February (nominally the 1st of March) 2012.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. In 2012 the observers performed absolute observations weekly and forwarded them by email to GA. During the observations the variometer system was also checked. All data processing was performed at GA.

During 2012 data were recorded on two DAQ computers which were connected to the station's radio network hub.

Daily data plots were examined at GA for possible problems which were usually rectified quickly by the local observer. The final data for the year were reduced and analysed by GA staff.

The distribution of MCQ 2012 data (after initial transmission to GA) is described in Table 7.98.

Table 7.98 Distribution of MAW 2012 data.

	Recipient	Data type	Sent
1-second values	IPS	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Monthly (irregular during 2012)
	WDC for Geomagnetism, Kyoto	P	Real-time

7.10.9 Missing one-minute definitive data

In 2012, 18 and 527 values were missing from the MAW definitive one-minute vector data and scalar data, respectively. The full list of missing data is presented in Appendix Table D.1.

7.10.10 Significant events

Table 7.99 Significant events that took place at MAW in 2012.

Time or duration	Description of event
2012-01-13T23:03Z	Stopped and restarted GdapClock process.
2012-01-19T10:15/30Z	Electrical inspection work in variometer hut. Vehicle and equipment close to variometer system.
2012-01-20T07Z	Faulty battery charger unit swapped out, NGL moved to second battery. DAQ PC (maw2) and GSM powered from 12 V, 7 A·h batteries. GPS receiver was left unpowered. Replaced fan in battery charger.
2012-01-20T10Z	Equipment reinstated.

Time or duration	Description of event
2012-01-23T22:52Z	Restart GdapClock.
2012-02-06T02:30Z	GPS receiver failed.
2012-02-07T02:49Z	Restart GdapClock.
2012-02-16T05:00:01Z	GPS Clock failed.
2012-02-17T01:06Z	Restart GdapClock.
2012-04-17T00:46:00Z	MW2 stopped. Restart GdapAdam.
2012-05-22T03:07Z	Restart GdapClock.
2012-05-28	FGE data was not being acquired for the past few days. Shutdown/restarted GdapAdam resolved.
2012-06-06	Tightened DIM sensor before absolute observations. Very active magnetic field during following observation and some data entry errors.
2012-07-05T17:10Z	MAW stops working. Restart GdapNGL at 23:33Z. Did not start. Restart GdapNGL at 23:41Z. Still did not restart.
2012-07-05	Adam data stopped for unknown reasons.
2012-07-06T00:35Z	Restart GdapAdam.
2012-07-05/06	There seems to be a confusion caused by swapping of MAW/MW2 variometers in the Oracle database, and the dual computers/variometers. The NGL data did not stop. The FGE stopped and was restarted.
2012-07-06T07:30Z	Lost contact with GPS.
2012-07-09T00:47Z	Restart GdapClock; no fix, 0:54Z shutdown.
2012-07-22T23:36Z	Restarted GdapAdam to get FGE working after data stopped for no known reason over weekend.
2012-10-02	Lost contact with ga-maw-mag1 (147.66.40.154). Ping from MCQ to restart access. GdapAdam has stopped providing data. Reboot. 23:17Z GdapAdam stops providing data.
2012-10-03T00:37Z	Restart GdapAdam. 00:40Z GdapAdam stops proving data again. 00:43Z restart GdapAdam. 00:45:17Z fails again, 00:48Z reboot system. Blizzard currently in progress, static probably causing problems. 22:47Z restart GdapAdam.
2012-10-17	Problems with dropped and duplicated network data packets.
2012-11-02T03:00Z	Lost contact with GPS receiver on ga-maw-mag1.
2012-11-04T22:37Z	Restart GdapClock.
2012-11-09T06:07Z	Restart GdapClock (GdapClock failed at 2012-11-08T01:30Z).
2012-11-28T02:42	Lost contact with GPS clock (ga-maw-mag1).
2012-12-02T22:10Z	Restart GdapClock (ga-maw-mag1).
2013-01-07	Darren Henderson reported his discovery that the DIM DI0022/353758 vertical circle was sticky and may have been the cause of absolute observation errors.

7.10.11 K indices, principle storms and rapid variations

K indices for MAW have been derived using a computer-assisted method developed at GA and based on the IAGA-accepted LRNS algorithm (see Section 4.2 Magnetic activity indices).

MAW K indices contribute to the global Kp and aa indices, the southern hemisphere Ks index and derivatives. K indices measured in 2012 are listed in Appendix F.4. The frequency distribution of the K indices are shown in Figure 7.21 and Table 7.100.

The annual mean daily K sum for MAW in 2012 was 23.6.

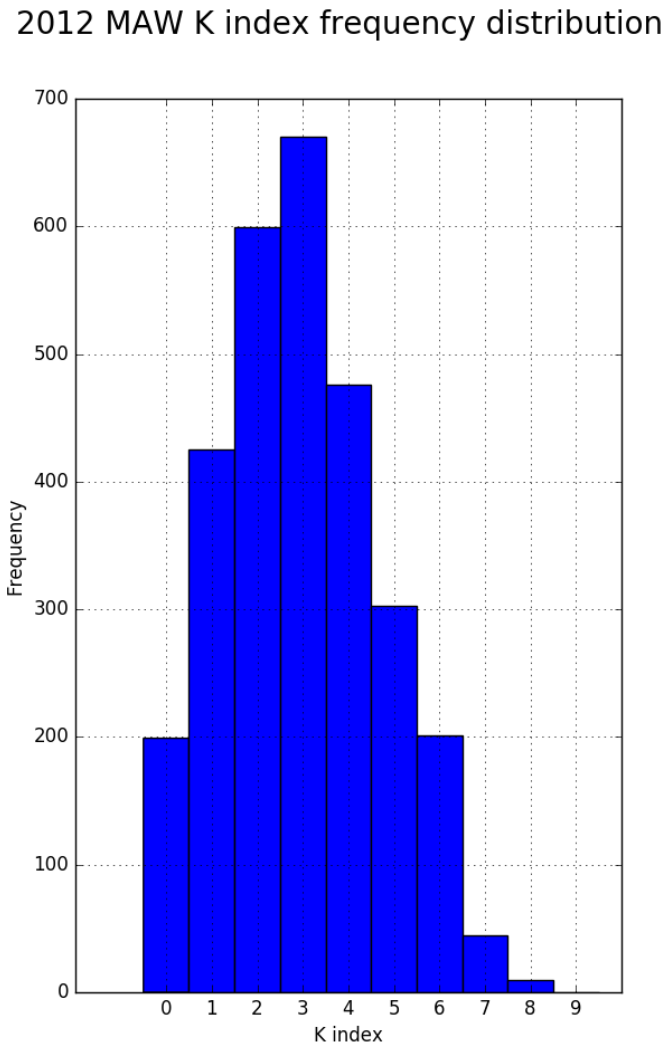

Figure 7.21 Frequency distribution of K indices for MAW in 2012.

Table 7.100 Frequency distribution of K indices for MAW in 2012.

K index	0	1	2	3	4	5	6	7	8	9
Frequency	199	425	599	670	476	303	201	45	10	0

No principle magnetic storms, SSCs or solar flare effects were observed at MAW in 2012.

7.10.12 Annual mean values

Different annual means (see Section 10.3.1 Annual means) for MAW for 2012 are given in Table 7.101. Annual means for X, Y, Z and F since 1995 are tabulated in Appendix E.9.

Table 7.101 Annual mean values of MAW for 2012.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	−67° 38.9′	−67° 50.6′	18534	7048	−17142	−45515	49144
Quiet Days	−67° 38.5′	−67° 49.5′	18548	7056	−17153	−45506	49141
Disturbed Days	−67° 40.8′	−67° 52.7′	18510	7030	−17123	−45534	49152

7.11 Casey Station

CSY is part of Casey Station; situated on the Antarctic coast in Wilkes Land, 3880 km south of Perth.. The absolute hut is about 120 m south of the 'tank house', the closest structure of the modern Casey Station. The 'old' Casey Station, in use until the late 1980s, lies about 1 km northeast of the present Casey Station.

The geology in the vicinity of Casey includes crystalline rocks with high concentrations of magnetic minerals. As a result there are high magnetic gradients in and around the observatory area.

Regular magnetic observations began at Casey in 1975. From 1988 a variation station operated there. From 1991 to 1998 it operated as a magnetic observatory, although not to a high standard. Observatory-standard absolute control commenced in 1999. A more detailed history of the Casey (and Wilkes) observatory is given in volumes 47–50 of the *Australian Geomagnetism Report*.

The magnetic observatory is part of the Casey scientific research station in Antarctica. The magnetic observatory consists of:

- A variometer hut
- An absolute hut.

The crystalline rocks of Casey have high concentrations of magnetic minerals that cause high magnetic gradients in the area. The observatory is located in one of the places of least magnetic gradient but still is situated in a higher than ideal gradient for a magnetic observatory.

Important details regarding CSY are given in Table 7.102.

Table 7.102 Important CSY observatory details for 2012.

IAGA code	CSY
Commenced operation	1999
Geographic latitude	066° 17' S
Geographic longitude	110° 32' E
Geomagnetic latitude	075.95° S (IGRF 2010)
Geomagnetic longitude	184.79° E (IGRF 2010)
K 9 index lower limit	N/A
Principal pier	Pier B
Pier elevation (top)	41 m AMSL
Principal reference mark	Trig station G11
Reference mark azimuth	308° 06' 00"
Reference mark distance	464 m
Observatory manager(s)	William Jones
Stationed observer(s)	Trevor Crewes, Andy Burgess, Jukka Pirhonen

7.11.1 Local meteorological conditions

The meteorological temperature at CSY during 2012 varied from a minimum of −32.4 °C (2012-09-11) to a maximum of +5.1 °C on four occasions (2012-03-22, 2012-10-24, 2012-10-26 and 2012-12-19). Daily minimum temperatures varied from −32.4 °C to +0 °C (average −12.9 °C). Daily maximum temperatures varied from −24.3 °C to +5.1 °C (average −6.5 °C).

The daily maximum wind gust varied from 15 km/h to 196 km/h with a daily average wind speed of 61.4 km/h. The maximum daily maximum wind gust was in September. The minimum daily maximum wind gust was in January, April, July, August and September. Windy conditions persisted throughout the year—with the higher wind gusts being attributed to blizzards.

7.11.2 Variometers

Table 7.103 shows specifics of the variometers and DAQ system used at CSY during 2012.

Table 7.103 Variometer systems used at CSY in 2012.

CSY vector variometer	Model	DMI FGE
	Serial number	E0199/S0160
	Type	3-channel, suspended, linear-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	ADC	ADAM 4017 (±10 V input voltage range)
	Scale value	0.32 nT/count
CSY scalar variometer	Model	GEM Systems GSM-90
	Serial number	4081423/42189
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
CSY DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS 16 receiver
Other	Communications	ANARESAT

The variometers at CSY were housed within the variometer hut. The FGE E0199/S0160 sensor was located in the southern corner of the hut. The GSM 4081423/42189 sensor was located in the northern corner. Both sensors were mounted on marble plinths. This configuration allows for the maximum separation between the two instruments. The variometer hut also contained the both variometers' electronics mounted within non-magnetic shelves. The instrument power supply, consisting of a 12 V battery and charger was also positioned within the shelves.

The DAQ computer was directly connected to the station's LAN via fibre optic cable and was located within the variometer hut. Power was supplied to the DAQ computer and variometers through a 12 V battery with a mains charger.

There were three periods during which data were contaminated or lost. The first occurred in February with 1442 minutes lost when the DAQ PC was shut down and would not restart, likely due to a corrupted secondary storage image. This was rectified by writing a new image and the DAQ PC was replaced 2012-066.

During 2012-10-08/11-10 the mains power supply to CSY was interrupted. The fault took several weeks to diagnose as dangerous weather conditions precluded AAD personnel from investigating the cause. Once weather conditions permitted, the fault was located and repaired. As CSY was without power for this extended period, the temperature within the hut had dropped to ambient and it took several days to return to around 10 °C after power was reinstated. Data collected during this period were removed from the final definitive dataset.

Another interruption to data collection occurred on 2012-12-17/18 when a fuse in the power supply system failed.

The definitive 1-minute ΔF values for the year varied within a range of about 6 nT.

7.11.3 Variometer clock corrections

Table 7.104 Software clock adjustments greater than 10 ms for CSY in 2012.

Time before correction	Correction (s)	Comment
2012-07-01T00:00:59Z	+1.0	Leap Second
2012/11/11T01:02:51Z	+1.448	System restart
2012/12/19T01:47:21Z	+0.648	Power restored after blown fuse

7.11.4 Absolute instruments

The absolute magnetometers used at CSY and their adopted corrections for 2012 are described in Table 7.105.

Absolute instrumentation corrections have been applied to all CSY 2012 final data through the correction of absolute observations.

Table 7.105 Absolute instrumentation (with corrections) used at CSY in 2012.

CSY DIM	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0047
	Theodolite	Zeiss 020B
	Theodolite serial	352229
	Theodolite resolution	+0.10′
	D correction	+0.15′
	I correction	−0.20′
CSY primary absolute PPM	Model	GEM Systems GSM-90
	Serial number	810881/31960
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT
CSY secondary absolute PPM	Model	Geometrics G816
	Serial number	766
	Type	PPM
	Resolution	1.0 nT
	F Correction	1.5 nT

7.11.5 Baselines

Figure 7.22 shows the accepted observed and adopted baseline values in XYZ. Table 7.106 shows statistics regarding the difference between observed and adopted baseline values (residuals).

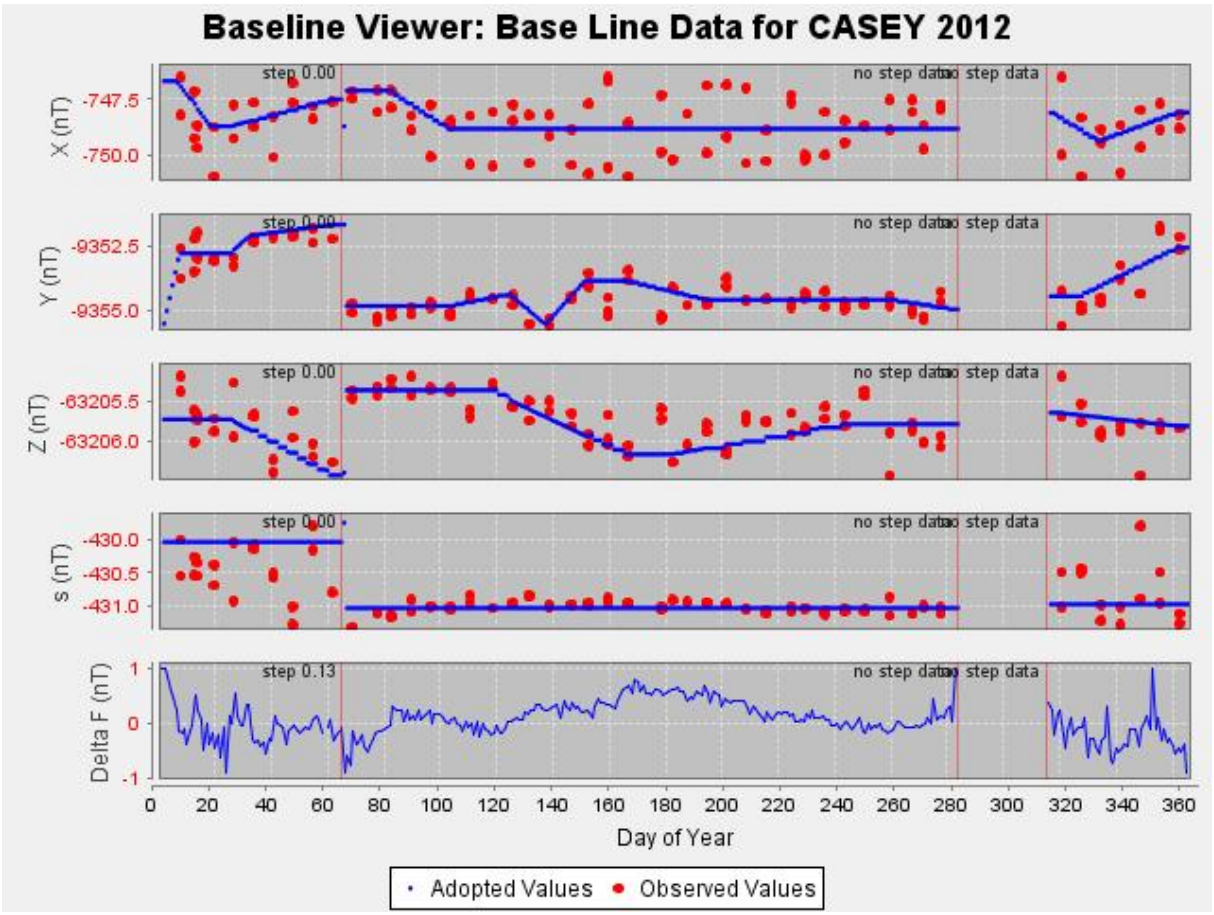

Figure 7.22 CSY 2012 baseline plots

Table 7.106 Standard deviation of residuals from accepted absolute observations at CSY during 2012.

Component	SD
X	0.9 nT
Y	0.7 nT
Z	0.5 nT
D	20″
I	03″
F	0.5 nT

7.11.6 Real-time, quasi-definitive and definitive data comparison

Table 7.107 shows statistics regarding differences between 2012 definitive data and preliminary and quasi-definitive data for each magnetic field component for CSY.

Table 7.107 Data type differences statistics for CSY in 2012.

Difference	Statistic	X (nT)	Y (nT)	Z (nT)
D−P	AM	+1.9	+0.7	+0.6
	SD	+1.9	+2.5	+1.1
	Sample minimum	−0.8	−2.2	−0.8
	Sample maximum	+4.8	+5.6	+3.1
D−Q	AM	+0.2	+0.1	−0.1
	SD	+0.2	+0.5	+0.2
	Sample minimum	−0.2	−1.3	−0.4
	Sample maximum	+0.5	+0.8	+0.1

7.11.7 Operations

The CSY observers, Trevor Crews, Andy Burgess and Jukka Pirhonen, were members of the ANARE and were employed by the AAD with funding support by GA. The observer was responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. The observer performed weekly absolute observations and forwarded them by email to GA. During the observations the variometer system was also checked. All data processing was performed at GA.

The distribution of CSY 2012 data (after initial transmission to GA) is described in Table 7.108.

Table 7.108 Distribution of CSY 2012 data.

	Recipient	Data type	Sent
1-second values	IPS, Sydney	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Real-time
1-minute values	INTERMAGNET, Edinburgh GIN	D	2013-07
	INTERMAGNET, Edinburgh GIN	P	Real-time
	INTERMAGNET, Edinburgh GIN	P	Daily
	INTERMAGNET, Edinburgh GIN	Q	Monthly
	WDC for Geomagnetism, Kyoto	P	Real-time
	WDC for Geomagnetism, Kyoto	P	Daily

7.11.8 Missing one-minute definitive data

In 2012, 49097 and 48764 values were missing from the CSY definitive one-minute vector data and scalar data, respectively. The complete list of missing values is shown in Table 7.109.

Table 7.109 CSY missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-01-17T02:19Z/02:21	XYZ	3	n/a
2012-01-21T05:01Z/05:01	XYZ	1	n/a
2012-02-06T17:52Z/17:52	XYZ	1	n/a
2012-02-06T18:16Z/18:16	XYZ	1	n/a
2012-02-27T23:59Z/2012-02-29T00:00	XYZ	1442	n/a
2012-03-05T23:59Z/2012-03-06T00:44	XYZ	46	n/a
2012-03-06T01:23Z/01:23	XYZ	1	n/a
2012-03-06T01:28Z/01:28	XYZ	1	n/a
2012-07-19T00:46Z/00:48	XYZ	3	n/a
2012-10-09T20:00Z/2012-11-11T08:00	XYZ	46801	n/a
2012-12-18T12:33Z/2012-12-19T01:49	XYZ	797	n/a
2012-02-28T05:03Z/23:59	F	1137	n/a
2012-03-06T00:00Z/01:27	F	88	n/a
2012-07-19T00:47Z/00:47	F	1	n/a
2012-10-09T20:01Z/2012-11-11T07:00	F	46740	n/a
2012-12-18T12:34Z/2012-12-19T01:51	F	798	n/a

7.11.9 Significant events

Table 7.110 Significant events that took place at CSY in 2012.

Time or duration	Description of event
2012-01-06	First observation by Andy Burgess
2012-01-17T11Z/13	Scheduled outage of telemetry. Maintenance of ANARESAT system.
2012-01-18	Error in measurements previously taken by Andy Burgess solved. Wrong Mark used for observations. A smaller marker approx. 1.07′ difference.
2012-02-27	New IP address allocated to geomag.
2012-02-28T05:07Z	Shutdown to fix clock. Couldn't 'su -' from ssh. Possibly caused by corrupted compact flashcard.
2012-02-28T05:08:30Z	System restarted.
2012-02-28	Files system is behaving strangely.
2012-03-01	First observation for day 2012-060 removed from data set.
2012-03-06	Swap old DAQ computer for new one. Data corruption between 00:31Z and approx. 01:30Z
2012-03-06T00:31:28Z	Enter hut. 00:33:54Z PPM disconnected from ga-csy-mag1 (old) computer. 00:37:23Z ga-csy-mag1 powered down accidently. 00:37:55Z ga-csy-mag1 rebooted. GPS clock disconnected from ga-csy-mag1 and connected to ga-csy-mag2. GPS clock correction to ga-csy-mag2 (new) computer.
2012-03-06T00:43:31Z	Fluxgate swapped from ga-csy-mag1 to ga-csy-mag2.
2012-03-06T00:52Z	Network swapped to ga-csy-mag2. The GPS, fluxgate and network all look okay. Andy departs the variometer hut. Andy re-enters the variometer hut. ga-csy-mag1 switched off and removed. 01:25Z GSM swapped to ga-csy-mag2.
2012-03-07	Attempt to repair CF card in ga-csy-mag1 failed. Install spare 2 GB 'Silicon Drive' CF marked 'CSY1' into system, still set up for ga-csy-mag1.
2012-03-28T11:07:01Z	Lost contact with GPS clock.
2012-03-29T05:35Z	Slay and restart GdapClock.
2012-05-11	1st absolute observation Hz readings changed from 265 260 and 85 260 to 265 480 and 85 480 to match 2nd obs and are then similar to previous weeks.
2012-06-19	Day 059 missing data, clean file before ingesting it for definitive.
2012-07-16T03:30Z	Lost contact with GPS clock.
2012-07-19T00:05Z	Slay GdapClock, 00:07Z restart GdapClock. No improvement. 00:47Z reboot.
2012-07-26	Stop watch for observations was not set to UTC. Observer noted after observation that watch as 18 s faster than UTC. Timing correction applied to absolute observations form by observer prior to emailing to GA.
2012-08-28	Data stops being received.
2012-08-29	Local observer can log in to computer. Problem finally located at AAD in Frankston in firewall changes. It was the same issue affecting MCQ. Now fixed.
2012-10-09T06Z	Data stops, probably cause is power failure poor weather is preventing rapid resolution of problems.
2012-10-11	Power still out to absolute, variometer 'Mabel hut' and remote transmitter hut.

Time or duration	Description of event
2012-10-17	Officer at Casey advises that power is still out to hut. Weather is hampering efforts to restore power.
2012-10-23	Still no power to hut. Two weeks without a resolution.
2012-11-10	Temporary generator installed near Mabel hut to provide power for variometer. System running again 06:42/12:59Z. Data may be unusable.
2012-11-11	System restarted ~01:03Z. Does not show signs of stabilising till 05:30Z to 06:00Z
2012-11-14	Jukka Pirhonen takes over as observer.
2012-11-17T03:33Z/37	Jukka Pirhonen enters variometer hut and leaves thermometer.
2012-11-19	Jukka Pirhonen retrieves the thermometer and confirms temperature is stable 10 °C.
2012-11-22	Andy Burgess does absolute observations.
2012-12-04	Data outage scheduled to start at 11:00Z. Finish time TBA.
2012-12-18	Power interruption at station. Computer stops at 07:38:20Z and has not restarted. Jukka will enter the hut to check UPS battery and charger, computer and Adam.

7.11.10 Annual mean values

Different annual means (see Section 10.3.1 Annual means) for CSY in 2012 are given in Table 7.111. Annual means for X, Y, Z and F since 2011 are tabulated in Appendix E.10.

Table 7.111 Annual mean values for CSY in 2012.

Annual mean	D	I	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
All Days	−095° 26.2′	−081° 43.2′	9215	−873	−9173	−63317	63984
Quiet Days	−095° 25.2′	−081° 43.2′	9213	−870	−9172	−63310	63977
Disturbed Days	−095° 29.8′	−081° 43.3′	9215	−883	−9173	−63333	64000

8 Repeat stations

Repeat station fieldwork was carried out during 2012-04/05. The stations occupied are listed in Table 8.1 along with the duration of variometer data acquisition. Figure 3.1 show the relative locations of these repeat stations.

Table 8.1 Repeat station occupation in 2012.

Station	Code	Duration of recording
Tibooburra, NSW	TIB	2012-04-12T22:46Z/15T23:58
Parafield, SA	PAF	2012-04-18T00:45Z/20T23:20
Eucla, WA	EUC	2012-04-23T05:10Z/25T23:05
Carnegie, WA	CNE	2012-04-30T06:18Z/05-02T23:15
Derby, WA	DER	2012-05-07T02:45Z/10T00:01
Mount Isa, QLD	ISA	2012-05-15T01:47Z/17T22:23
Maryborough, QLD	MYB	2012-05-21T00:30Z/23T22:11

8.1 Variometers

The variometers used during 2012 repeat station activities are described in Table 8.2

Table 8.2 Variometer systems used in the 2012 repeat station surveys.

Vector Variometer	Model	NGL
	Serial number	2506-1
	Type	3-channel, non-suspended, ring-core fluxgate magnetometer
	Orientation	NW, NE, Z
	Acquisition interval	1 s
	A/D converter	Integrated
	Scale value	0.01 nT/count
	Resolution	0.01 nT
Scalar Variometer	Model	GEM Systems GSM-90
	Serial number	810882/81315
	Type	Overhauser effect scalar magnetometer
	Acquisition interval	10 s
	Resolution	0.01 nT
DAQ system	Hardware	x86 SBC
	OS	QNX Neutrino
	Application/system	GDAP
	Timing	Garmin GPS 16 receiver

In the 2012 repeat station surveys the NGL 2506-1 was used to monitor variations in the three orthogonal components of the magnetic field.

The digital output from this magnetometer was recorded as 1-second values with a portable DAQ computer.

The GSM 810882/81315 was used to monitor the total magnetic intensity, F, at a rate of 10 sps.

The magnetometers and DAQ system were powered by either 12 V batteries, solar panels and/or mains power, depending on the location. Preliminary data processing and analysis was done on-site using a laptop computer.

8.2 Absolute instruments

The principal absolute magnetometers used at repeat stations and their adopted corrections for 2012 are described in Table 8.3.

Table 8.3 Absolute instrumentation (with corrections) used in 2012 repeat station activities.

DIM DI0050/308887	Fluxgate magnetometer	DMI
	Fluxgate serial	DI0050
	Theodolite	Zeiss 020B
	Theodolite serial	308887
	Theodolite resolution	+0.1′
	D correction	+0.0′
	I correction	−0.2′
GSM 810881/31960	Model	GEM Systems GSM-90
	Serial number	003985/11690
	Type	Overhauser effect scalar magnetometer
	Resolution	0.01 nT
	F Correction	0.00 nT

The GSM 003985/11690 was also used for total field surveys around each station.

8.3 Operations

The variometer recordings are calibrated to permanent observatory standards using a campaign of absolute magnetic observations. For a 3-day occupation, 24 sets of observations are usually made on the primary station at each site. Vector field differences between the primary and secondary stations are also measured. Azimuths to prominent features from both primary and secondary stations are checked and total intensity gradient surveys around each station are undertaken.

The normal or quiet level of the magnetic field at the primary station is determined by analysing the calibrated onsite variometer record with reference to the quiet level of the magnetic field derived from several months of suitable observatory hourly mean value data.

The average annual rate of change of the field over the time between station occupations is determined by first differences between the adopted normal field values at the repeat station and the adopted normal field values from the previous occupation of the station.

The adopted normal field values at the time of the 2012 occupations are shown in Table 8.4. The adopted average secular variation in the XYZ components over the period between the 2012 station occupations and the previous occupations is shown in Table 8.5. Adopted normal field values for the repeat station sites occupied in 2012 are shown in Appendix G.

Table 8.4 Adopted field values for the 2012 repeat station survey.

Station (site)	Occupation Date	Previous Occupation	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D	I
TIB (A)	2012-04-14	2008-05-01	26724	3939	−48962	55919	27013	08° 23.1′	−61° 06.8′
PAF (C)	2012-04-19	2008-05-06	22929	3356	−54469	59194	23173	08° 19.6′	−66° 57.2′
EUC (D)	2012-04-24	2008-05-11	23869	1871	−52975	58134	23942	04° 28.9′	−65° 40.8′
CNE (A)	2012-05-01	2008-05-18	28274	1107	−47096	54942	28296	02° 14.5′	−59° 00.1′
DER (E)	2012-05-08	2008-05-25	33461	1423	−36838	49787	33491	02° 26.1′	−47° 43.5′
ISA (C)	2012-05-16	2008-06-01	31790	3279	−39265	50627	31959	05° 53.3′	−50° 51.4′
MYB (D)	2012-05-22	2008-06-06	29209	5395	−42925	52200	29703	10° 27.9′	−55° 19.1′

Table 8.5 Adopted average secular variation since last repeat station occupation.

Station (site)	Colatitude (degrees)	Longitude (degrees)	Elevation (km)	X (nT/yr)	Y (nT/yr)	Z (nT/yr)
TIB (A)	119.451	142.058	0.174	+8	−12	26
PAF (C)	124.797	138.627	0.011	+17	−5	24
EUC (D)	121.678	128.879	0.086	+29	−10	34
CNE (A)	115.801	122.948	0.452	+31	−16	49
DER (E)	107.369	123.666	0.006	+2	−26	58
ISA (C)	110.664	139.489	0.339	+7	−22	34
MYB (D)	115.519	152.713	0.010	−1	−14	25

9 Staff

Staff contributing to the operation of GA's magnetic observatory network during 2012 are shown in Table 9.1 and Table 9.2.

Table 9.1 GA Geomagnetism Team Canberra based staff in 2012.

Staff member	APS Classification	Responsibilities
Dr Adrian Hitchman	EL2	Section leader
Mr Peter Crosthwaite	EL1	Digital acquisition, system and software development and maintenance; observatory manager for CNB, CKI and MAW
Mr Andrew Lewis	EL1	Operations manager; repeat station operations and AGRF model; observatory manager for CTA, GNA, GNG and CNB
Dr Liejun Wang	EL1	Information management; compass calibrations; observatory manager for KDU and MCQ
Mr William Jones	APS6	Observatory operations, scientific and technical support; observatory manager for ASP, LRM, CSY
Mr Jim Whatman	APS6	Technical support

Table 9.2 Observatory based staff in 2012.

IMO(s)	Organisation	Staff member
CSY	AAD	Mr Trevor Crews
		Mr Andy Burgess
		Mr Jukka Pirhonen
MAW	AAD	Mr Ian Phillips
		Mr Darren Henderson
ASP	GA	Mr Shaun Evans
MCQ	AAD	Mr Trevor Hopps
		Mr Mark Mangles
		Mr Greg Bird
LRM	IPS	Ms Emily Lindsay
		Mr Owen Giersch
		Ms Jenny Howse
GNA, GNG	Pryde Electronic Repairs	Mr Stephen Pryde
KDU	Kakadu Culture Camp	Mr Andy Ralph
		Mr John Cianchi
ASP	GA	Mr Warren Serone
		Mr Sean Evans
CTA	Bradley Stevenson Sales and Service	Mr Bradley Stevenson

IMO(s)	Organisation	Staff member
CKI	BOM	Mr Will Tankard
		Mr Trevor Menadue

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Appendix A CTA 2012 clock corrections

Appendix Table A.1 Software clock adjustments greater than 10 ms for CTA in 2012.

Time before correction	Correction (s)	Comment
2012/01/12T23:27:44Z	+0.988	n/a
2012/01/12T23:27:44Z	+0.988	n/a
2012/01/13T13:28:03Z	−1.000	n/a
2012/01/13T13:52:49Z	+1.000	n/a
2012/01/13T17:49:15Z	−1.000	n/a
2012/01/13T19:10:10Z	+1.000	n/a
2012/01/13T19:22:28Z	−1.000	n/a
2012/01/13T19:58:47Z	+1.000	n/a
2012/01/13T22:01:28Z	−1.000	n/a
2012/01/13T22:52:28Z	+1.000	n/a
2012/01/14T07:21:45Z	−1.000	n/a
2012/01/14T07:53:52Z	+1.000	n/a
2012/01/14T10:17:21Z	−1.000	n/a
2012/01/14T10:22:58Z	+1.000	n/a
2012/01/14T12:58:03Z	−1.000	n/a
2012/01/14T15:54:53Z	+1.000	n/a
2012/01/14T16:20:26Z	−1.000	n/a
2012/01/14T23:54:26Z	+1.000	n/a
2012/01/14T23:54:26Z	+1.000	n/a
2012/01/15T00:25:16Z	−1.000	n/a
2012/01/15T01:02:28Z	+1.000	n/a
2012/01/15T01:12:57Z	−1.000	n/a
2012/01/15T01:25:49Z	+1.000	n/a
2012/01/15T01:53:10Z	−1.000	n/a
2012/01/28T07:08:44Z	−0.020	n/a
2012/01/28T14:51:22Z	+1.001	n/a
2012/01/29T12:13:39Z	−1.000	n/a
2012/01/29T12:49:17Z	+1.000	n/a
2012/01/29T16:32:28Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2012/01/29T18:03:52Z	+1.000	n/a
2012/01/29T18:17:58Z	−1.000	n/a
2012/01/29T19:04:22Z	+1.000	n/a
2012/01/29T20:43:52Z	−1.000	n/a
2012/01/29T21:59:29Z	+1.000	n/a
2012/01/29T22:02:58Z	−1.000	n/a
2012/01/29T22:04:23Z	+1.000	n/a
2012/01/29T22:12:08Z	−1.000	n/a
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Time before correction	Correction (s)	Comment
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2012/02/16T01:45:15Z	+1.000	n/a
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2012/02/16T23:09:36Z	−0.057	n/a
2012/02/29T15:12:28Z	+0.998	n/a
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Time before correction	Correction (s)	Comment
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Time before correction	Correction (s)	Comment
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Time before correction	Correction (s)	Comment
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2012/06/03T22:02:48Z	+1.014	n/a

Time before correction	Correction (s)	Comment
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Time before correction	Correction (s)	Comment
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Time before correction	Correction (s)	Comment
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Time before correction	Correction (s)	Comment
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2012/08/08T22:42:26Z	−1.000	n/a
2012/08/09T00:04:34Z	+1.000	n/a
2012/08/09T00:07:21Z	−1.000	n/a
2012/08/09T01:43:51Z	+1.000	n/a
2012/08/09T02:11:24Z	−1.000	n/a
2012/08/23T11:37:02Z	+1.002	n/a
2012/08/24T02:33:10Z	−1.000	n/a
2012/08/24T05:03:09Z	+1.000	n/a
2012/08/24T06:14:52Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2012/08/24T08:21:04Z	+1.000	n/a
2012/08/24T11:44:20Z	−1.000	n/a
2012/08/24T12:22:15Z	+1.000	n/a
2012/08/24T13:11:34Z	−1.000	n/a
2012/08/24T13:42:47Z	+1.000	n/a
2012/08/24T14:02:11Z	−1.000	n/a
2012/08/24T14:54:41Z	+1.000	n/a
2012/08/24T15:32:26Z	−1.000	n/a
2012/08/24T15:37:21Z	+1.000	n/a
2012/08/24T15:45:44Z	−1.000	n/a
2012/08/24T16:41:04Z	+1.000	n/a
2012/08/24T18:33:52Z	−1.000	n/a
2012/08/24T19:02:28Z	+1.000	n/a
2012/08/24T21:32:27Z	−1.000	n/a
2012/08/25T00:34:31Z	+1.000	n/a
2012/08/25T00:42:33Z	−1.000	n/a
2012/09/07T17:02:29Z	+1.005	n/a
2012/09/08T01:42:17Z	−1.000	n/a
2012/09/08T02:16:16Z	+1.000	n/a
2012/09/08T05:55:59Z	−1.000	n/a
2012/09/08T06:45:57Z	+1.000	n/a
2012/09/08T20:55:16Z	−1.000	n/a
2012/09/08T21:35:15Z	+1.000	n/a
2012/09/08T22:22:27Z	−1.000	n/a
2012/09/08T23:15:57Z	+1.000	n/a
2012/09/09T01:06:27Z	−1.000	n/a
2012/09/09T07:21:07Z	+1.000	n/a
2012/09/09T08:15:03Z	−1.000	n/a
2012/09/09T08:24:53Z	+1.000	n/a
2012/09/09T08:35:16Z	−1.000	n/a
2012/09/09T08:40:53Z	+1.000	n/a
2012/09/09T09:27:22Z	−1.000	n/a
2012/09/09T09:30:53Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/09/09T10:42:56Z	−1.000	n/a
2012/09/09T11:18:03Z	+1.000	n/a
2012/09/09T11:51:34Z	−1.000	n/a
2012/09/09T13:51:46Z	+1.000	n/a
2012/09/09T14:01:45Z	−1.000	n/a
2012/09/09T15:38:46Z	+1.000	n/a
2012/09/09T17:07:16Z	−1.000	n/a
2012/09/09T17:32:17Z	+1.000	n/a
2012/09/09T17:45:35Z	−1.000	n/a
2012/09/09T18:03:51Z	+1.000	n/a
2012/09/09T18:40:52Z	−1.000	n/a
2012/09/09T18:58:55Z	+1.000	n/a
2012/09/09T19:52:51Z	−1.000	n/a
2012/09/23T23:33:40Z	+1.083	n/a
2012/09/23T23:33:40Z	+1.083	n/a
2012/09/24T20:04:20Z	−1.000	n/a
2012/09/24T20:22:27Z	+1.000	n/a
2012/09/25T00:07:20Z	−1.000	n/a
2012/09/25T01:38:03Z	+1.000	n/a
2012/09/25T01:52:26Z	−1.000	n/a
2012/09/25T02:48:06Z	+1.000	n/a
2012/09/25T04:02:23Z	−1.000	n/a
2012/09/25T06:11:05Z	+1.000	n/a
2012/09/25T09:31:45Z	−1.000	n/a
2012/09/25T10:12:16Z	+1.000	n/a
2012/09/25T12:02:27Z	−1.000	n/a
2012/09/25T12:25:56Z	+1.000	n/a
2012/09/25T13:38:32Z	−1.000	n/a
2012/09/25T14:31:03Z	+1.000	n/a
2012/09/25T16:32:27Z	−1.000	n/a
2012/09/25T16:47:21Z	+1.000	n/a
2012/09/25T19:46:59Z	−1.000	n/a
2012/09/25T22:08:45Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/09/25T22:15:03Z	−1.000	n/a
2012/10/09T23:31:41Z	+1.009	n/a
2012/10/09T23:31:41Z	+1.009	n/a
2012/10/10T04:35:15Z	−1.000	n/a
2012/10/10T04:41:45Z	+1.000	n/a
2012/10/10T23:01:03Z	−1.000	n/a
2012/10/11T01:25:05Z	+1.000	n/a
2012/10/11T03:00:04Z	−1.000	n/a
2012/10/11T05:03:18Z	+1.000	n/a
2012/10/11T08:36:46Z	−1.000	n/a
2012/10/11T08:57:09Z	+1.000	n/a
2012/10/11T15:24:33Z	−1.000	n/a
2012/10/11T15:41:33Z	+1.000	n/a
2012/10/11T18:15:15Z	−1.000	n/a
2012/10/25T23:22:00Z	+1.002	n/a
2012/10/26T03:17:21Z	−1.000	n/a
2012/10/26T03:55:46Z	+1.000	n/a
2012/10/26T17:58:10Z	−1.000	n/a
2012/10/26T18:14:35Z	+1.000	n/a
2012/10/26T19:14:21Z	−1.000	n/a
2012/10/26T20:08:03Z	+1.000	n/a
2012/10/26T21:51:52Z	−1.000	n/a
2012/10/27T04:27:21Z	+1.000	n/a
2012/10/27T04:52:28Z	−1.000	n/a
2012/10/27T05:11:33Z	+1.000	n/a
2012/10/27T05:41:45Z	−1.000	n/a
2012/10/27T05:51:34Z	+1.000	n/a
2012/10/27T05:55:03Z	−1.000	n/a
2012/10/27T06:13:17Z	+1.000	n/a
2012/10/27T07:13:49Z	−1.000	n/a
2012/10/27T08:03:51Z	+1.000	n/a
2012/10/27T08:48:45Z	−1.000	n/a
2012/10/27T09:06:23Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/10/27T10:18:46Z	−1.000	n/a
2012/10/27T10:20:53Z	+1.000	n/a
2012/10/27T11:21:45Z	−1.000	n/a
2012/10/27T11:38:46Z	+1.000	n/a
2012/10/27T11:50:40Z	−1.000	n/a
2012/10/27T12:22:27Z	+1.000	n/a
2012/10/27T14:12:22Z	−1.000	n/a
2012/10/27T14:58:33Z	+1.000	n/a
2012/10/27T15:27:19Z	−1.000	n/a
2012/10/27T16:18:13Z	+1.000	n/a
2012/10/27T16:42:44Z	−1.000	n/a
2012/11/10T07:14:03Z	+1.006	n/a
2012/11/10T21:07:51Z	−1.000	n/a
2012/11/10T21:35:24Z	+1.000	n/a
2012/11/10T21:44:35Z	−1.000	n/a
2012/11/10T22:24:21Z	+1.000	n/a
2012/11/11T01:36:54Z	−1.000	n/a
2012/11/11T01:51:46Z	+1.000	n/a
2012/11/11T02:01:03Z	−1.000	n/a
2012/11/11T02:33:53Z	+1.000	n/a
2012/11/11T16:16:38Z	−1.000	n/a
2012/11/11T17:12:58Z	+1.000	n/a
2012/11/11T17:57:50Z	−1.000	n/a
2012/11/11T19:02:57Z	+1.000	n/a
2012/11/11T19:18:34Z	−1.000	n/a
2012/11/11T19:28:24Z	+1.000	n/a
2012/11/11T20:21:33Z	−1.000	n/a
2012/11/12T03:26:28Z	+1.000	n/a
2012/11/12T03:46:10Z	−1.000	n/a
2012/11/12T04:28:47Z	+1.000	n/a
2012/11/12T04:31:41Z	−1.000	n/a
2012/11/12T05:37:41Z	+1.000	n/a
2012/11/12T06:03:12Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2012/11/12T07:05:16Z	+1.000	n/a
2012/11/12T07:35:56Z	−1.000	n/a
2012/11/12T08:22:23Z	+1.000	n/a
2012/11/12T09:12:36Z	−1.000	n/a
2012/11/12T09:19:54Z	+1.000	n/a
2012/11/12T10:14:32Z	−1.000	n/a
2012/11/12T11:11:45Z	+1.000	n/a
2012/11/12T12:57:51Z	−1.000	n/a
2012/11/12T13:31:03Z	+1.000	n/a
2012/11/12T14:13:05Z	−1.000	n/a
2012/11/26T14:53:20Z	+1.008	n/a
2012/11/27T00:32:32Z	−1.000	n/a
2012/11/27T00:44:41Z	+1.000	n/a
2012/11/27T01:22:29Z	−1.000	n/a
2012/11/27T01:28:48Z	+1.000	n/a
2012/11/27T16:57:26Z	−1.000	n/a
2012/11/27T17:27:53Z	+1.000	n/a
2012/11/27T17:31:46Z	−1.000	n/a
2012/11/27T17:47:28Z	+1.000	n/a
2012/11/27T19:41:38Z	−1.000	n/a
2012/11/27T22:57:20Z	+1.000	n/a
2012/11/27T23:20:50Z	−1.000	n/a
2012/11/28T01:41:03Z	+1.000	n/a
2012/11/28T01:52:34Z	−1.000	n/a
2012/11/28T02:05:53Z	+1.000	n/a
2012/11/28T05:07:21Z	−1.000	n/a
2012/11/28T05:52:27Z	+1.000	n/a
2012/11/28T06:47:20Z	−1.000	n/a
2012/11/28T07:20:53Z	+1.000	n/a
2012/11/28T07:26:28Z	−1.000	n/a
2012/11/28T07:31:24Z	+1.000	n/a
2012/11/28T07:48:11Z	−1.000	n/a
2012/11/28T08:19:27Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/11/28T09:08:45Z	−1.000	n/a
2012/11/28T10:18:04Z	+1.000	n/a
2012/11/28T10:56:38Z	−1.000	n/a
2012/11/28T11:12:07Z	+1.000	n/a
2012/11/28T11:42:27Z	−1.000	n/a
2012/11/28T12:47:21Z	+1.000	n/a
2012/11/28T13:21:47Z	−1.000	n/a
2012/11/28T13:31:45Z	+1.000	n/a
2012/11/28T14:53:51Z	−1.000	n/a
2012/12/12T19:23:46Z	+1.005	n/a
2012/12/13T18:41:02Z	−1.000	n/a
2012/12/13T20:59:15Z	+1.000	n/a
2012/12/13T21:27:21Z	−1.000	n/a
2012/12/13T21:36:28Z	+1.000	n/a
2012/12/13T22:44:30Z	−1.000	n/a
2012/12/14T00:36:40Z	+1.000	n/a
2012/12/14T02:47:20Z	−1.000	n/a
2012/12/14T03:27:02Z	+1.000	n/a
2012/12/14T03:52:17Z	−1.000	n/a
2012/12/14T04:41:05Z	+1.000	n/a
2012/12/14T04:43:52Z	−1.000	n/a
2012/12/14T05:14:21Z	+1.000	n/a
2012/12/14T05:17:22Z	−1.000	n/a
2012/12/14T07:26:27Z	+1.000	n/a
2012/12/14T07:32:46Z	−1.000	n/a
2012/12/14T09:24:53Z	+1.000	n/a
2012/12/14T09:52:46Z	−1.000	n/a
2012/12/14T12:23:52Z	+1.000	n/a
2012/12/14T13:38:26Z	−1.000	n/a
2012/12/27T23:37:11Z	+1.002	n/a
2012/12/28T17:41:03Z	−1.000	n/a
2012/12/28T18:30:42Z	+1.000	n/a
2012/12/28T18:36:17Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2012/12/28T18:51:49Z	+1.000	n/a
2012/12/28T21:41:04Z	−1.000	n/a
2012/12/28T23:45:47Z	+1.000	n/a
2012/12/28T23:45:47Z	+1.000	n/a
2012/12/29T03:02:26Z	−1.000	n/a
2012/12/29T03:12:57Z	+1.000	n/a
2012/12/29T03:32:27Z	−1.000	n/a
2012/12/29T03:46:41Z	+1.000	n/a
2012/12/29T07:23:09Z	−1.000	n/a
2012/12/29T07:58:03Z	+1.000	n/a
2012/12/29T12:53:08Z	−1.000	n/a

Appendix B GNG 2012 clock corrections

Appendix Table B.1 Software clock adjustments greater than 10 ms for GNG in 2012.

Time before correction	Correction (s)	Comment
2011/11/01T01:27:33Z	+0.726	n/a
2011/11/01T02:12:12Z	+0.114	n/a
2011/11/01T02:14:34Z	+0.452	n/a
2011/11/01T02:46:04Z	−0.999	n/a
2011/11/01T02:54:30Z	+1.001	n/a
2011/11/01T18:45:28Z	−0.999	n/a
2011/11/01T19:07:13Z	+1.000	n/a
2011/11/01T19:33:50Z	−1.000	n/a
2011/11/01T19:50:00Z	+1.002	n/a
2011/11/01T21:16:06Z	−0.998	n/a
2011/11/01T22:20:34Z	+1.003	n/a
2011/11/01T22:32:27Z	−1.000	n/a
2011/11/01T22:37:23Z	+1.000	n/a
2011/11/01T22:44:24Z	+1.827	n/a
2011/11/01T23:22:54Z	−0.999	n/a
2011/11/01T23:58:42Z	+1.003	n/a
2011/11/08T00:39:05Z	−2.511	n/a
2011/11/08T03:04:48Z	+1.000	n/a
2011/11/08T03:44:01Z	−1.000	n/a
2011/11/08T05:27:13Z	+1.000	n/a
2011/11/08T08:57:48Z	−1.000	n/a
2011/11/08T09:02:45Z	+1.000	n/a
2011/11/08T09:30:51Z	−1.000	n/a
2011/11/08T10:13:41Z	+1.000	n/a
2011/11/08T10:40:20Z	−1.000	n/a
2011/11/08T11:25:59Z	+1.000	n/a
2011/11/08T12:53:45Z	−1.000	n/a
2011/11/08T14:27:01Z	+1.000	n/a
2011/11/08T15:40:02Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2011/11/08T23:48:03Z	+1.000	n/a
2011/11/09T00:26:41Z	−1.000	n/a
2011/11/09T03:09:59Z	+1.000	n/a
2011/11/09T03:39:29Z	−1.001	n/a
2011/11/09T05:22:32Z	+1.000	n/a
2011/11/09T09:24:02Z	−1.001	n/a
2011/11/09T10:20:57Z	+1.000	n/a
2011/11/09T10:32:14Z	−1.000	n/a
2011/11/09T11:58:14Z	+0.999	n/a
2011/11/09T12:48:55Z	−1.000	n/a
2011/11/10T07:33:18Z	+1.000	n/a
2011/11/10T07:57:56Z	−1.000	n/a
2011/11/10T11:58:41Z	+0.999	n/a
2011/11/10T12:38:48Z	−1.000	n/a
2011/11/11T11:59:29Z	+1.000	n/a
2011/11/11T12:34:42Z	−1.000	n/a
2011/11/12T07:25:29Z	+1.000	n/a
2011/11/12T07:49:25Z	−1.000	n/a
2011/11/13T07:23:36Z	+1.000	n/a
2011/11/13T07:45:29Z	−1.000	n/a
2011/11/14T07:18:09Z	+1.000	n/a
2011/11/14T07:40:39Z	−1.000	n/a
2011/11/15T07:14:02Z	+1.000	n/a
2011/11/15T07:36:33Z	−1.000	n/a
2012/03/30T15:13:50Z	+1.000	n/a
2012/03/31T15:53:42Z	−1.000	n/a
2012/03/31T16:03:34Z	+1.000	n/a
2012/04/01T15:47:35Z	−1.000	n/a
2012/04/01T16:02:22Z	+1.000	n/a
2012/04/02T15:42:16Z	−1.000	n/a
2012/04/02T16:00:29Z	+1.000	n/a
2012/04/02T16:34:50Z	−1.000	n/a
2012/04/02T16:39:46Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/04/03T15:15:54Z	−1.000	n/a
2012/04/03T15:55:11Z	+1.000	n/a
2012/04/03T16:14:07Z	−1.000	n/a
2012/04/03T16:37:20Z	+1.000	n/a
2012/04/04T15:10:24Z	−1.000	n/a
2012/04/04T15:52:37Z	+1.000	n/a
2012/04/04T16:10:12Z	−1.000	n/a
2012/04/04T16:43:17Z	+1.000	n/a
2012/04/05T15:06:15Z	−1.000	n/a
2012/04/05T15:48:17Z	+1.000	n/a
2012/04/05T16:05:49Z	−1.000	n/a
2012/04/05T16:40:52Z	+1.000	n/a
2012/04/06T00:29:57Z	−1.000	n/a
2012/04/06T00:53:46Z	+1.000	n/a
2012/04/06T02:54:54Z	−1.001	n/a
2012/04/06T03:13:08Z	+1.000	n/a
2012/04/06T06:27:08Z	−1.001	n/a
2012/04/06T07:09:09Z	+1.000	n/a
2012/04/06T07:51:51Z	−1.000	n/a
2012/04/06T10:36:36Z	+1.000	n/a
2012/04/06T11:15:09Z	−1.001	n/a
2012/04/06T12:34:19Z	+1.000	n/a
2012/04/06T14:18:41Z	−1.000	n/a
2012/04/06T16:58:19Z	+1.000	n/a
2012/04/06T17:23:32Z	−1.000	n/a
2012/04/06T17:31:16Z	+1.000	n/a
2012/04/06T17:39:40Z	−1.000	n/a
2012/04/06T19:25:31Z	+0.999	n/a
2012/04/06T20:06:08Z	−1.000	n/a
2012/04/06T21:09:55Z	+1.000	n/a
2012/04/06T21:45:38Z	−1.000	n/a
2012/04/06T23:59:34Z	+0.999	n/a
2012/04/06T23:59:34Z	+0.999	n/a

Time before correction	Correction (s)	Comment
2012/04/07T00:25:30Z	−1.000	n/a
2012/04/07T00:59:50Z	+1.000	n/a
2012/04/07T02:27:36Z	−1.000	n/a
2012/04/07T03:37:44Z	+0.999	n/a
2012/04/07T05:24:56Z	−1.000	n/a
2012/04/07T13:37:25Z	+0.999	n/a
2012/04/07T14:12:39Z	−1.000	n/a
2012/04/07T19:26:04Z	+1.000	n/a
2012/04/07T20:01:13Z	−1.001	n/a
2012/04/07T21:10:13Z	+1.000	n/a
2012/04/07T21:40:27Z	−1.001	n/a
2012/04/08T01:51:02Z	+0.998	n/a
2012/04/08T02:24:50Z	−1.000	n/a
2012/04/08T03:45:48Z	+0.999	n/a
2012/04/08T05:13:46Z	−1.000	n/a
2012/04/08T13:37:33Z	+0.999	n/a
2012/04/08T13:59:22Z	−1.000	n/a
2012/04/08T21:23:18Z	+0.999	n/a
2012/04/08T21:24:41Z	−1.000	n/a
2012/04/09T01:53:35Z	+1.000	n/a
2012/04/09T02:16:01Z	−1.001	n/a
2012/04/09T03:47:45Z	+1.000	n/a
2012/04/09T05:01:59Z	−1.000	n/a
2012/04/09T13:52:39Z	+0.999	n/a
2012/04/09T13:55:27Z	−1.000	n/a
2012/04/10T03:44:28Z	+1.000	n/a
2012/04/10T04:58:06Z	−1.000	n/a
2012/04/11T03:41:17Z	+1.000	n/a
2012/04/11T03:42:40Z	−1.000	n/a
2012/04/11T03:56:46Z	+1.000	n/a
2012/04/11T04:52:20Z	−1.000	n/a
2012/04/12T03:53:00Z	+1.000	n/a
2012/04/12T04:42:14Z	−1.001	n/a

Time before correction	Correction (s)	Comment
2012/04/12T20:54:00Z	+1.000	n/a
2012/04/12T21:01:00Z	−1.000	n/a
2012/07/01T00:01:17Z	−1.000	n/a
2012/09/03T06:03:26Z	+0.997	n/a
2012/09/07T04:15:49Z	−1.002	n/a
2012/09/07T04:44:40Z	+0.999	n/a
2012/09/07T04:53:49Z	−1.001	n/a
2012/09/07T06:13:24Z	+0.999	n/a
2012/09/07T14:02:56Z	−1.001	n/a
2012/09/07T14:19:51Z	+0.999	n/a
2012/09/07T16:04:01Z	−1.000	n/a
2012/09/07T16:25:47Z	+0.999	n/a
2012/09/07T19:06:56Z	−1.001	n/a
2012/09/07T19:21:42Z	+0.999	n/a
2012/09/07T19:56:08Z	−1.001	n/a
2012/09/07T20:35:27Z	+1.000	n/a
2012/09/07T21:14:05Z	−1.001	n/a
2012/09/07T21:47:06Z	+0.999	n/a
2012/09/07T22:26:24Z	−1.001	n/a
2012/09/07T23:12:41Z	+0.999	n/a
2012/09/07T23:15:29Z	−1.000	n/a
2012/09/07T23:25:19Z	+0.999	n/a
2012/09/08T01:02:09Z	−1.002	n/a
2012/09/08T02:01:47Z	+0.999	n/a
2012/09/08T03:41:29Z	−1.000	n/a
2012/09/08T06:17:50Z	+0.999	n/a
2012/09/08T06:52:51Z	−1.000	n/a
2012/09/08T06:59:11Z	+1.000	n/a
2012/09/08T07:04:05Z	−1.000	n/a
2012/09/08T07:34:16Z	+1.000	n/a
2012/09/08T07:37:45Z	−1.000	n/a
2012/09/08T08:23:29Z	+1.000	n/a
2012/09/08T09:47:38Z	−1.000	n/a

Time before correction	Correction (s)	Comment
2012/09/08T10:31:53Z	+0.998	n/a
2012/09/08T11:34:15Z	−1.001	n/a
2012/09/08T12:05:51Z	+1.000	n/a
2012/09/08T12:07:56Z	−1.000	n/a
2012/09/08T12:55:38Z	+1.000	n/a
2012/09/08T13:39:08Z	−1.000	n/a
2012/09/08T14:23:15Z	+1.000	n/a
2012/09/08T15:53:39Z	−1.000	n/a
2012/09/08T16:46:11Z	+1.000	n/a
2012/09/08T18:52:56Z	−1.000	n/a
2012/09/08T20:40:49Z	+0.999	n/a
2012/09/08T20:57:39Z	−1.001	n/a
2012/09/09T02:29:37Z	+0.999	n/a
2012/09/09T03:30:32Z	−1.000	n/a
2012/09/09T08:24:38Z	+1.000	n/a
2012/09/09T09:39:36Z	−1.001	n/a
2012/09/09T10:30:44Z	+1.000	n/a
2012/09/09T11:12:43Z	−1.000	n/a
2012/09/09T12:59:09Z	+1.000	n/a
2012/09/09T13:06:52Z	−1.000	n/a
2012/09/09T14:58:23Z	+0.998	n/a
2012/09/09T15:49:29Z	−1.000	n/a
2012/09/09T17:10:47Z	+0.999	n/a
2012/09/09T18:48:48Z	−1.001	n/a
2012/09/10T02:54:46Z	+0.999	n/a
2012/09/10T03:24:51Z	−1.000	n/a
2012/09/10T08:30:08Z	+1.000	n/a
2012/09/10T08:57:28Z	−1.000	n/a
2012/09/10T10:32:03Z	+1.000	n/a
2012/09/10T11:04:17Z	−1.000	n/a
2012/09/10T15:01:02Z	+1.000	n/a
2012/09/10T15:43:05Z	−1.000	n/a
2012/09/10T17:07:06Z	+1.000	n/a

Time before correction	Correction (s)	Comment
2012/09/10T18:44:24Z	−1.000	n/a
2012/09/10T20:33:00Z	+1.000	n/a
2012/09/10T20:49:50Z	−1.000	n/a
2012/09/11T02:53:13Z	+1.000	n/a
2012/09/11T03:22:41Z	−1.000	n/a
2012/09/11T15:16:59Z	+1.000	n/a
2012/09/11T15:37:19Z	−1.001	n/a
2012/09/11T17:02:44Z	+1.000	n/a
2012/09/11T18:37:14Z	−1.000	n/a
2012/09/12T17:00:14Z	+1.000	n/a
2012/09/12T18:33:21Z	−1.000	n/a
2012/09/13T16:59:13Z	+1.000	n/a
2012/09/13T18:28:28Z	−1.000	n/a

Appendix C GNG 2012 Missing one-minute definitive data

Appendix Table C.1 GNG Missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-03-05T13:32Z/14:46	XYZ	75	n/a
2012-06-05T12:53Z/13:08	XYZ	16	n/a
2012-06-06T08:10Z/08:30	XYZ	21	n/a
2012-05-09T00:00Z/2012-08-07T01:28	F	129689	n/a
2012-08-07T01:31Z/01:36	F	6	n/a
2012-08-08T00:56Z/01:01	F	6	n/a
2012-12-18T04:54Z/04:55	F	2	n/a
2012-12-18T05:22Z/05:22	F	1	n/a
2012-12-18T05:44Z/05:49	F	6	n/a
2012-12-18T05:56Z/05:56	F	1	n/a
2012-12-18T06:06Z/06:08	F	3	n/a
2012-12-18T06:10Z/06:10	F	1	n/a
2012-12-18T06:12Z/06:14	F	3	n/a
2012-12-18T06:29Z/06:32	F	4	n/a
2012-12-18T06:37Z/06:37	F	1	n/a
2012-12-18T06:39Z/06:41	F	3	n/a
2012-12-18T06:43Z/06:43	F	1	n/a
2012-12-18T06:53Z/06:57	F	5	n/a
2012-12-18T06:59Z/07:00	F	2	n/a
2012-12-18T07:21Z/07:26	F	6	n/a
2012-12-18T07:29Z/07:29	F	1	n/a
2012-12-18T07:43Z/07:46	F	4	n/a
2012-12-18T07:48Z/07:50	F	3	n/a
2012-12-18T08:01Z/08:01	F	1	n/a
2012-12-18T08:04Z/08:06	F	3	n/a
2012-12-18T08:09Z/08:09	F	1	n/a

Duration	Components	Samples	Comment
2012-12-18T08:12Z/08:14	F	3	n/a
2012-12-18T08:16Z/08:16	F	1	n/a
2012-12-18T08:34Z/08:36	F	3	n/a
2012-12-18T08:38Z/08:38	F	1	n/a
2012-12-18T08:40Z/08:46	F	7	n/a
2012-12-18T08:49Z/08:49	F	1	n/a
2012-12-18T09:03Z/09:16	F	14	n/a
2012-12-18T09:18Z/09:19	F	2	n/a
2012-12-18T09:27Z/09:37	F	11	n/a
2012-12-18T09:43Z/09:43	F	1	n/a
2012-12-18T09:48Z/10:00	F	13	n/a
2012-12-18T10:09Z/10:09	F	1	n/a
2012-12-18T10:15Z/10:27	F	13	n/a
2012-12-18T10:29Z/10:29	F	1	n/a
2012-12-18T10:31Z/10:31	F	1	n/a
2012-12-18T10:33Z/10:33	F	1	n/a
2012-12-18T10:41Z/10:54	F	14	n/a
2012-12-18T10:56Z/11:01	F	6	n/a
2012-12-18T11:03Z/11:04	F	2	n/a
2012-12-18T11:07Z/11:07	F	1	n/a
2012-12-18T11:09Z/11:26	F	18	n/a
2012-12-18T11:31Z/11:31	F	1	n/a
2012-12-18T11:38Z/11:52	F	15	n/a
2012-12-18T11:55Z/11:55	F	1	n/a
2012-12-18T11:59Z/12:15	F	17	n/a
2012-12-18T12:18Z/12:19	F	2	n/a
2012-12-18T12:21Z/12:22	F	2	n/a
2012-12-18T12:24Z/12:45	F	22	n/a
2012-12-18T12:48Z/12:51	F	4	n/a
2012-12-18T12:53Z/12:53	F	1	n/a
2012-12-18T12:56Z/13:15	F	20	n/a
2012-12-18T13:18Z/13:32	F	15	n/a
2012-12-18T13:34Z/13:36	F	3	n/a

Duration	Components	Samples	Comment
2012-12-18T13:39Z/14:08	F	30	n/a
2012-12-18T14:10Z/14:23	F	14	n/a
2012-12-18T14:25Z/14:56	F	32	n/a
2012-12-18T14:59Z/15:50	F	52	n/a
2012-12-18T15:53Z/15:53	F	1	n/a
2012-12-18T15:55Z/16:06	F	12	n/a
2012-12-18T16:08Z/16:09	F	2	n/a
2012-12-18T16:11Z/16:11	F	1	n/a
2012-12-18T16:13Z/16:39	F	27	n/a
2012-12-18T16:41Z/17:00	F	20	n/a
2012-12-18T17:02Z/17:13	F	12	n/a
2012-12-18T17:16Z/17:36	F	21	n/a
2012-12-18T17:38Z/19:42	F	125	n/a
2012-12-18T19:45Z/20:02	F	18	n/a
2012-12-18T20:04Z/21:05	F	62	n/a
2012-12-18T21:07Z/21:20	F	14	n/a
2012-12-18T21:26Z/21:43	F	18	n/a
2012-12-18T21:47Z/21:50	F	4	n/a
2012-12-18T21:52Z/21:53	F	2	n/a
2012-12-18T21:55Z/21:56	F	2	n/a
2012-12-18T22:04Z/22:08	F	5	n/a
2012-12-18T22:10Z/22:10	F	1	n/a
2012-12-18T22:17Z/22:17	F	1	n/a
2012-12-18T22:23Z/22:23	F	1	n/a
2012-12-18T22:25Z/22:25	F	1	n/a
2012-12-18T22:27Z/22:45	F	19	n/a
2012-12-18T22:48Z/22:48	F	1	n/a
2012-12-18T22:51Z/23:13	F	23	n/a
2012-12-18T23:15Z/23:15	F	1	n/a
2012-12-18T23:19Z/23:19	F	1	n/a
2012-12-18T23:23Z/23:23	F	1	n/a
2012-12-18T23:27Z/23:27	F	1	n/a
2012-12-18T23:32Z/23:43	F	12	n/a

Duration	Components	Samples	Comment
2012-12-18T23:46Z/23:47	F	2	n/a
2012-12-18T23:56Z/23:56	F	1	n/a
2012-12-19T00:01Z/00:08	F	8	n/a
2012-12-19T00:16Z/00:16	F	1	n/a
2012-12-19T00:18Z/00:18	F	1	n/a
2012-12-19T00:25Z/00:35	F	11	n/a
2012-12-19T00:42Z/00:42	F	1	n/a
2012-12-19T00:45Z/00:48	F	4	n/a
2012-12-19T00:50Z/00:53	F	4	n/a
2012-12-19T00:59Z/00:59	F	1	n/a
2012-12-19T01:04Z/01:09	F	6	n/a
2012-12-19T01:11Z/01:11	F	1	n/a
2012-12-19T01:13Z/01:13	F	1	n/a
2012-12-19T01:22Z/01:23	F	2	n/a
2012-12-19T01:29Z/01:33	F	5	n/a
2012-12-19T01:35Z/01:37	F	3	n/a
2012-12-19T01:39Z/01:43	F	5	n/a
2012-12-19T01:48Z/01:48	F	1	n/a
2012-12-19T01:57Z/02:09	F	13	n/a
2012-12-19T02:21Z/02:26	F	6	n/a
2012-12-19T02:28Z/02:29	F	2	n/a
2012-12-19T02:31Z/02:33	F	3	n/a
2012-12-19T02:35Z/02:35	F	1	n/a
2012-12-19T02:39Z/02:39	F	1	n/a
2012-12-19T02:42Z/02:42	F	1	n/a
2012-12-19T02:47Z/02:59	F	13	n/a
2012-12-19T03:03Z/03:03	F	1	n/a
2012-12-19T03:12Z/03:24	F	13	n/a
2012-12-19T03:30Z/03:30	F	1	n/a
2012-12-19T03:40Z/03:52	F	13	n/a
2012-12-19T03:55Z/03:55	F	1	n/a
2012-12-19T03:57Z/03:59	F	3	n/a
2012-12-19T04:04Z/04:04	F	1	n/a

Duration	Components	Samples	Comment
2012-12-19T04:08Z/04:22	F	15	n/a
2012-12-19T04:24Z/04:24	F	1	n/a
2012-12-19T04:29Z/04:30	F	2	n/a
2012-12-19T04:36Z/04:48	F	13	n/a
2012-12-19T04:50Z/05:21	F	32	n/a
2012-12-19T05:23Z/23:29	F	1087	n/a
2012-12-19T23:31Z/2012-12-20T01:37	F	127	n/a
2012-12-20T01:39Z/21:09	F	1171	n/a
2012-12-20T21:11Z/2012-12-29T17:13	F	12723	n/a
2012-12-29T17:15Z/17:46	F	32	n/a
2012-12-29T17:48Z/17:50	F	3	n/a
2012-12-29T17:52Z/18:55	F	64	n/a
2012-12-29T18:57Z/19:17	F	21	n/a
2012-12-29T19:19Z/19:24	F	6	n/a
2012-12-29T19:26Z/19:27	F	2	n/a
2012-12-29T19:29Z/19:30	F	2	n/a
2012-12-29T19:32Z/19:41	F	10	n/a
2012-12-29T19:43Z/20:31	F	49	n/a
2012-12-29T20:33Z/20:38	F	6	n/a
2012-12-29T20:40Z/20:40	F	1	n/a
2012-12-29T20:42Z/20:43	F	2	n/a
2012-12-29T20:45Z/20:46	F	2	n/a
2012-12-29T20:48Z/21:01	F	14	n/a
2012-12-29T21:03Z/21:18	F	16	n/a
2012-12-29T21:20Z/21:20	F	1	n/a
2012-12-29T21:22Z/21:32	F	11	n/a
2012-12-29T21:35Z/21:35	F	1	n/a
2012-12-29T21:39Z/21:52	F	14	n/a
2012-12-29T21:54Z/21:55	F	2	n/a
2012-12-29T21:57Z/22:03	F	7	n/a
2012-12-29T22:05Z/22:08	F	4	n/a
2012-12-29T22:10Z/22:12	F	3	n/a
2012-12-29T22:14Z/22:14	F	1	n/a

Duration	Components	Samples	Comment
2012-12-29T22:16Z/22:16	F	1	n/a
2012-12-29T22:19Z/22:24	F	6	n/a
2012-12-29T22:26Z/22:27	F	2	n/a
2012-12-29T22:30Z/22:31	F	2	n/a
2012-12-29T22:35Z/22:36	F	2	n/a
2012-12-29T22:38Z/22:39	F	2	n/a
2012-12-29T22:43Z/22:48	F	6	n/a
2012-12-29T22:50Z/23:15	F	26	n/a
2012-12-29T23:17Z/23:21	F	5	n/a
2012-12-29T23:23Z/23:24	F	2	n/a
2012-12-29T23:27Z/23:34	F	8	n/a
2012-12-29T23:36Z/23:46	F	11	n/a
2012-12-29T23:48Z/23:48	F	1	n/a
2012-12-29T23:52Z/23:52	F	1	n/a
2012-12-29T23:54Z/23:54	F	1	n/a
2012-12-29T23:56Z/23:57	F	2	n/a
2012-12-29T23:59Z/2012-12-30T00:03	F	5	n/a
2012-12-30T00:05Z/00:05	F	1	n/a
2012-12-30T00:08Z/00:13	F	6	n/a
2012-12-30T00:17Z/00:17	F	1	n/a
2012-12-30T00:20Z/00:28	F	9	n/a
2012-12-30T00:30Z/00:33	F	4	n/a
2012-12-30T00:35Z/00:35	F	1	n/a
2012-12-30T00:37Z/14:03	F	807	n/a
2012-12-30T14:05Z/18:01	F	237	n/a
2012-12-30T18:03Z/18:15	F	13	n/a
2012-12-30T18:17Z/18:20	F	4	n/a
2012-12-30T18:22Z/18:39	F	18	n/a
2012-12-30T18:41Z/18:58	F	18	n/a
2012-12-30T19:00Z/19:02	F	3	n/a
2012-12-30T19:04Z/19:04	F	1	n/a
2012-12-30T19:06Z/19:09	F	4	n/a
2012-12-30T19:12Z/19:15	F	4	n/a

Duration	Components	Samples	Comment
2012-12-30T19:17Z/19:21	F	5	n/a
2012-12-30T19:23Z/19:24	F	2	n/a
2012-12-30T19:26Z/19:35	F	10	n/a
2012-12-30T19:37Z/19:39	F	3	n/a
2012-12-30T19:41Z/19:46	F	6	n/a
2012-12-30T19:48Z/20:01	F	14	n/a
2012-12-30T20:03Z/20:05	F	3	n/a
2012-12-30T20:07Z/20:12	F	6	n/a
2012-12-30T20:14Z/20:17	F	4	n/a
2012-12-30T20:19Z/20:20	F	2	n/a
2012-12-30T20:22Z/20:39	F	18	n/a
2012-12-30T20:41Z/20:42	F	2	n/a
2012-12-30T20:45Z/20:47	F	3	n/a
2012-12-30T20:49Z/20:51	F	3	n/a
2012-12-30T20:54Z/20:58	F	5	n/a
2012-12-30T21:02Z/21:04	F	3	n/a
2012-12-30T21:06Z/21:06	F	1	n/a
2012-12-30T21:08Z/21:08	F	1	n/a
2012-12-30T21:13Z/21:14	F	2	n/a
2012-12-30T21:17Z/21:17	F	1	n/a
2012-12-30T21:20Z/21:20	F	1	n/a
2012-12-30T21:24Z/21:29	F	6	n/a
2012-12-30T21:32Z/21:36	F	5	n/a
2012-12-30T21:39Z/21:51	F	13	n/a
2012-12-30T21:53Z/21:53	F	1	n/a
2012-12-30T21:56Z/21:56	F	1	n/a
2012-12-30T21:58Z/21:58	F	1	n/a
2012-12-30T22:00Z/22:01	F	2	n/a
2012-12-30T22:03Z/22:05	F	3	n/a
2012-12-30T22:07Z/22:09	F	3	n/a
2012-12-30T22:11Z/22:13	F	3	n/a
2012-12-30T22:15Z/22:16	F	2	n/a
2012-12-30T22:20Z/22:20	F	1	n/a

Duration	Components	Samples	Comment
2012-12-30T22:23Z/22:23	F	1	n/a
2012-12-30T22:46Z/22:46	F	1	n/a
2012-12-30T22:54Z/22:55	F	2	n/a
2012-12-30T23:00Z/23:01	F	2	n/a
2012-12-30T23:15Z/23:15	F	1	n/a
2012-12-30T23:21Z/23:26	F	6	n/a
2012-12-30T23:29Z/23:33	F	5	n/a
2012-12-30T23:35Z/23:40	F	6	n/a
2012-12-30T23:42Z/23:49	F	8	n/a
2012-12-30T23:53Z/23:53	F	1	n/a
2012-12-30T23:55Z/23:55	F	1	n/a
2012-12-30T23:59Z/2012-12-31T00:00	F	2	n/a
2012-12-31T00:03Z/00:06	F	4	n/a
2012-12-31T00:10Z/20:03	F	1194	n/a
2012-12-31T20:05Z/20:08	F	4	n/a
2012-12-31T20:10Z/20:12	F	3	n/a
2012-12-31T20:14Z/20:15	F	2	n/a
2012-12-31T20:20Z/20:22	F	3	n/a
2012-12-31T20:24Z/20:41	F	18	n/a
2012-12-31T20:43Z/20:46	F	4	n/a
2012-12-31T20:48Z/20:49	F	2	n/a
2012-12-31T20:51Z/20:55	F	5	n/a
2012-12-31T20:58Z/20:59	F	2	n/a
2012-12-31T21:01Z/21:02	F	2	n/a
2012-12-31T21:05Z/21:08	F	4	n/a
2012-12-31T21:10Z/21:21	F	12	n/a
2012-12-31T21:23Z/21:37	F	15	n/a
2012-12-31T21:39Z/21:39	F	1	n/a
2012-12-31T21:41Z/21:44	F	4	n/a
2012-12-31T21:46Z/21:47	F	2	n/a
2012-12-31T21:49Z/21:58	F	10	n/a
2012-12-31T22:00Z/22:00	F	1	n/a
2012-12-31T22:02Z/22:03	F	2	n/a

Duration	Components	Samples	Comment
2012-12-31T22:06Z/22:14	F	9	n/a
2012-12-31T22:17Z/22:19	F	3	n/a
2012-12-31T22:21Z/22:24	F	4	n/a
2012-12-31T22:26Z/22:26	F	1	n/a
2012-12-31T22:33Z/22:33	F	1	n/a
2012-12-31T22:36Z/22:37	F	2	n/a
2012-12-31T22:43Z/22:46	F	4	n/a
2012-12-31T22:50Z/22:50	F	1	n/a
2012-12-31T22:52Z/22:54	F	3	n/a
2012-12-31T22:58Z/22:59	F	2	n/a
2012-12-31T23:04Z/23:04	F	1	n/a
2012-12-31T23:06Z/23:06	F	1	n/a
2012-12-31T23:08Z/23:09	F	2	n/a
2012-12-31T23:12Z/23:14	F	3	n/a
2012-12-31T23:16Z/23:17	F	2	n/a
2012-12-31T23:20Z/23:59	F	40	n/a

Appendix D MAW 2012 Missing one-minute definitive data

Appendix Table D.1 MAW missing one-minute definitive data in 2012.

Duration	Components	Samples	Comment
2012-01-19T10:12/10:29Z	XYZ	18	n/a
2012-01-20T07:34/07:34Z	F	1	n/a
2012-01-20T09:53/09:53Z	F	1	n/a
2012-04-17T02:04/02:05Z	F	2	n/a
2012-04-17T02:07/02:07Z	F	1	n/a
2012-04-17T02:13/02:13Z	F	1	n/a
2012-04-17T02:30/02:31Z	F	2	n/a
2012-04-17T02:57/02:57Z	F	1	n/a
2012-04-17T03:00/03:00Z	F	1	n/a
2012-04-17T03:14/03:14Z	F	1	n/a
2012-04-17T03:34/03:34Z	F	1	n/a
2012-04-17T03:47/03:47Z	F	1	n/a
2012-04-17T03:56/03:56Z	F	1	n/a
2012-04-17T04:01/04:01Z	F	1	n/a
2012-04-17T04:04/04:04Z	F	1	n/a
2012-04-17T04:08/04:09Z	F	2	n/a
2012-04-17T04:17/04:17Z	F	1	n/a
2012-04-17T04:22/04:22Z	F	1	n/a
2012-04-17T04:24/04:24Z	F	1	n/a
2012-04-17T04:29/04:29Z	F	1	n/a
2012-04-17T04:41/04:43Z	F	3	n/a
2012-04-17T04:46/04:47Z	F	2	n/a
2012-04-17T04:52/04:53Z	F	2	n/a
2012-04-17T04:57/04:57Z	F	1	n/a
2012-04-17T05:03/05:03Z	F	1	n/a
2012-04-17T05:07/05:07Z	F	1	n/a

Duration	Components	Samples	Comment
2012-04-17T05:12/05:14Z	F	3	n/a
2012-04-17T05:19/05:19Z	F	1	n/a
2012-04-17T05:22/05:22Z	F	1	n/a
2012-04-17T05:29/05:29Z	F	1	n/a
2012-04-17T05:40/05:40Z	F	1	n/a
2012-04-17T06:01/06:01Z	F	1	n/a
2012-04-17T06:10/06:10Z	F	1	n/a
2012-04-17T06:12/06:12Z	F	1	n/a
2012-04-17T06:24/06:25Z	F	2	n/a
2012-04-17T06:31/06:31Z	F	1	n/a
2012-04-17T06:34/06:34Z	F	1	n/a
2012-04-17T06:43/06:43Z	F	1	n/a
2012-04-17T06:46/06:46Z	F	1	n/a
2012-04-17T06:49/06:49Z	F	1	n/a
2012-04-17T06:55/06:56Z	F	2	n/a
2012-04-17T07:13/07:14Z	F	2	n/a
2012-04-17T07:23/07:24Z	F	2	n/a
2012-04-17T07:35/07:35Z	F	1	n/a
2012-04-17T07:59/08:00Z	F	2	n/a
2012-04-17T08:47/08:47Z	F	1	n/a
2012-04-17T08:50/08:50Z	F	1	n/a
2012-04-17T09:03/09:04Z	F	2	n/a
2012-04-17T09:19/09:19Z	F	1	n/a
2012-04-17T09:28/09:28Z	F	1	n/a
2012-04-17T09:34/09:34Z	F	1	n/a
2012-04-17T13:02/13:02Z	F	1	n/a
2012-04-17T15:21/15:21Z	F	1	n/a
2012-07-05T14:19/14:19Z	F	1	n/a
2012-07-05T14:47/14:49Z	F	3	n/a
2012-07-05T14:51/14:51Z	F	1	n/a
2012-07-05T15:10/15:10Z	F	1	n/a
2012-07-05T15:14/15:14Z	F	1	n/a
2012-07-05T15:39/15:39Z	F	1	n/a

Duration	Components	Samples	Comment
2012-07-05T16:14/16:14Z	F	1	n/a
2012-07-05T16:19/16:19Z	F	1	n/a
2012-07-05T16:36/16:37Z	F	2	n/a
2012-07-05T16:43/16:43Z	F	1	n/a
2012-07-05T18:15/18:15Z	F	1	n/a
2012-07-05T18:23/18:25Z	F	3	n/a
2012-07-05T18:29/18:30Z	F	2	n/a
2012-07-05T20:22/20:23Z	F	2	n/a
2012-07-05T20:34/20:34Z	F	1	n/a
2012-07-05T20:44/20:44Z	F	1	n/a
2012-07-15T21:25/21:25Z	F	1	n/a
2012-07-15T21:38/21:38Z	F	1	n/a
2012-07-15T21:48/21:48Z	F	1	n/a
2012-07-15T23:36/23:36Z	F	1	n/a
2012-07-15T23:52/23:52Z	F	1	n/a
2012-07-16T00:19/00:19Z	F	1	n/a
2012-07-21T09:59/09:59Z	F	1	n/a
2012-07-21T10:08/10:08Z	F	1	n/a
2012-07-21T10:17/10:17Z	F	1	n/a
2012-07-21T10:31/10:31Z	F	1	n/a
2012-07-21T10:33/10:33Z	F	1	n/a
2012-07-21T10:36/10:37Z	F	2	n/a
2012-07-21T10:39/10:39Z	F	1	n/a
2012-07-21T10:43/10:43Z	F	1	n/a
2012-07-21T11:04/11:04Z	F	1	n/a
2012-07-21T11:12/11:12Z	F	1	n/a
2012-07-21T11:14/11:14Z	F	1	n/a
2012-07-21T11:16/11:16Z	F	1	n/a
2012-07-21T11:21/11:22Z	F	2	n/a
2012-07-21T11:24/11:24Z	F	1	n/a
2012-07-21T11:26/11:27Z	F	2	n/a
2012-07-21T11:30/11:31Z	F	2	n/a
2012-07-21T11:35/11:37Z	F	3	n/a

Duration	Components	Samples	Comment
2012-07-21T11:41/11:41Z	F	1	n/a
2012-07-21T11:46/11:46Z	F	1	n/a
2012-07-21T11:52/11:52Z	F	1	n/a
2012-07-21T11:56/11:57Z	F	2	n/a
2012-07-21T12:01/12:01Z	F	1	n/a
2012-07-21T12:09/12:09Z	F	1	n/a
2012-07-21T12:13/12:13Z	F	1	n/a
2012-07-21T12:21/12:22Z	F	2	n/a
2012-07-21T12:27/12:27Z	F	1	n/a
2012-07-21T12:34/12:34Z	F	1	n/a
2012-07-21T12:37/12:38Z	F	2	n/a
2012-07-21T12:43/12:43Z	F	1	n/a
2012-07-21T12:53/12:53Z	F	1	n/a
2012-07-21T12:58/12:59Z	F	2	n/a
2012-07-21T13:01/13:07Z	F	7	n/a
2012-07-21T13:09/13:19Z	F	11	n/a
2012-07-21T13:21/13:21Z	F	1	n/a
2012-07-21T13:36/13:37Z	F	2	n/a
2012-07-21T13:39/13:42Z	F	4	n/a
2012-07-21T13:44/13:44Z	F	1	n/a
2012-07-21T13:47/13:47Z	F	1	n/a
2012-07-21T13:52/13:52Z	F	1	n/a
2012-07-21T14:02/14:03Z	F	2	n/a
2012-07-21T14:08/14:13Z	F	6	n/a
2012-07-21T14:15/14:15Z	F	1	n/a
2012-07-21T14:17/14:17Z	F	1	n/a
2012-07-21T14:21/14:21Z	F	1	n/a
2012-07-21T14:25/14:28Z	F	4	n/a
2012-07-21T14:30/14:30Z	F	1	n/a
2012-07-21T14:42/14:42Z	F	1	n/a
2012-07-21T14:45/14:45Z	F	1	n/a
2012-07-21T14:47/14:47Z	F	1	n/a
2012-07-21T14:52/14:53Z	F	2	n/a

Duration	Components	Samples	Comment
2012-07-21T14:58/14:58Z	F	1	n/a
2012-07-21T15:02/15:03Z	F	2	n/a
2012-07-21T15:07/15:07Z	F	1	n/a
2012-07-21T15:09/15:09Z	F	1	n/a
2012-07-21T15:14/15:14Z	F	1	n/a
2012-07-21T15:16/15:16Z	F	1	n/a
2012-07-21T15:20/15:20Z	F	1	n/a
2012-07-21T15:36/15:36Z	F	1	n/a
2012-07-21T15:43/15:43Z	F	1	n/a
2012-07-21T15:46/15:47Z	F	2	n/a
2012-07-21T15:54/15:55Z	F	2	n/a
2012-07-21T15:57/15:57Z	F	1	n/a
2012-07-21T16:03/16:03Z	F	1	n/a
2012-07-21T16:11/16:11Z	F	1	n/a
2012-07-21T16:26/16:26Z	F	1	n/a
2012-07-21T16:48/16:48Z	F	1	n/a
2012-07-21T16:51/16:51Z	F	1	n/a
2012-07-21T16:53/16:53Z	F	1	n/a
2012-07-21T19:06/19:06Z	F	1	n/a
2012-10-02T13:06/13:06Z	F	1	n/a
2012-10-02T13:21/13:23Z	F	3	n/a
2012-10-02T14:27/14:27Z	F	1	n/a
2012-10-02T14:40/14:41Z	F	2	n/a
2012-10-02T14:43/14:43Z	F	1	n/a
2012-10-02T14:50/14:51Z	F	2	n/a
2012-10-02T14:53/14:56Z	F	4	n/a
2012-10-02T14:59/15:00Z	F	2	n/a
2012-10-02T15:14/15:14Z	F	1	n/a
2012-10-02T15:18/15:19Z	F	2	n/a
2012-10-02T15:22/15:23Z	F	2	n/a
2012-10-02T15:27/15:28Z	F	2	n/a
2012-10-02T15:30/15:31Z	F	2	n/a
2012-10-02T15:34/15:34Z	F	1	n/a

Duration	Components	Samples	Comment
2012-10-02T15:37/15:37Z	F	1	n/a
2012-10-02T15:41/15:41Z	F	1	n/a
2012-10-02T15:50/15:50Z	F	1	n/a
2012-10-02T15:54/15:58Z	F	5	n/a
2012-10-02T16:00/16:00Z	F	1	n/a
2012-10-02T16:03/16:04Z	F	2	n/a
2012-10-02T16:07/16:10Z	F	4	n/a
2012-10-02T16:12/16:13Z	F	2	n/a
2012-10-02T16:15/16:18Z	F	4	n/a
2012-10-02T16:22/16:23Z	F	2	n/a
2012-10-02T16:26/16:29Z	F	4	n/a
2012-10-02T16:31/16:35Z	F	5	n/a
2012-10-02T16:37/16:39Z	F	3	n/a
2012-10-02T16:44/16:47Z	F	4	n/a
2012-10-02T16:51/16:53Z	F	3	n/a
2012-10-02T16:56/17:00Z	F	5	n/a
2012-10-02T17:02/17:04Z	F	3	n/a
2012-10-02T17:07/17:07Z	F	1	n/a
2012-10-02T17:09/17:11Z	F	3	n/a
2012-10-02T17:13/17:18Z	F	6	n/a
2012-10-02T17:21/17:25Z	F	5	n/a
2012-10-02T17:28/17:30Z	F	3	n/a
2012-10-02T17:32/17:35Z	F	4	n/a
2012-10-02T17:37/17:37Z	F	1	n/a
2012-10-02T17:41/17:48Z	F	8	n/a
2012-10-02T17:52/17:52Z	F	1	n/a
2012-10-02T17:55/17:58Z	F	4	n/a
2012-10-02T18:02/18:06Z	F	5	n/a
2012-10-02T18:09/18:14Z	F	6	n/a
2012-10-02T18:16/18:18Z	F	3	n/a
2012-10-02T18:20/18:36Z	F	17	n/a
2012-10-02T18:39/18:43Z	F	5	n/a
2012-10-02T18:45/18:46Z	F	2	n/a

Duration	Components	Samples	Comment
2012-10-02T18:49/18:51Z	F	3	n/a
2012-10-02T18:53/18:53Z	F	1	n/a
2012-10-02T18:55/18:58Z	F	4	n/a
2012-10-02T19:01/19:07Z	F	7	n/a
2012-10-02T19:09/19:10Z	F	2	n/a
2012-10-02T19:12/19:15Z	F	4	n/a
2012-10-02T19:17/19:18Z	F	2	n/a
2012-10-02T19:21/19:21Z	F	1	n/a
2012-10-02T19:23/19:23Z	F	1	n/a
2012-10-02T19:25/19:32Z	F	8	n/a
2012-10-02T19:34/19:34Z	F	1	n/a
2012-10-02T19:37/19:37Z	F	1	n/a
2012-10-02T19:41/19:41Z	F	1	n/a
2012-10-02T19:45/19:46Z	F	2	n/a
2012-10-02T19:51/20:06Z	F	16	n/a
2012-10-02T20:08/20:17Z	F	10	n/a
2012-10-02T20:19/20:27Z	F	9	n/a
2012-10-02T20:29/20:37Z	F	9	n/a
2012-10-02T20:39/20:40Z	F	2	n/a
2012-10-02T20:43/20:53Z	F	11	n/a
2012-10-02T20:55/21:01Z	F	7	n/a
2012-10-02T21:05/21:06Z	F	2	n/a
2012-10-02T21:15/21:16Z	F	2	n/a
2012-10-02T21:25/21:26Z	F	2	n/a
2012-10-02T21:31/21:33Z	F	3	n/a
2012-10-02T21:35/21:35Z	F	1	n/a
2012-10-02T21:42/21:43Z	F	2	n/a
2012-10-02T21:46/21:48Z	F	3	n/a
2012-10-02T21:51/21:51Z	F	1	n/a
2012-10-02T21:53/21:53Z	F	1	n/a
2012-10-02T21:55/21:55Z	F	1	n/a
2012-10-02T22:04/22:04Z	F	1	n/a
2012-10-02T22:49/22:49Z	F	1	n/a

Duration	Components	Samples	Comment
2012-10-02T22:53/22:54Z	F	2	n/a
2012-10-02T22:56/22:56Z	F	1	n/a
2012-10-02T23:02/23:03Z	F	2	n/a
2012-10-02T23:05/23:06Z	F	2	n/a
2012-10-02T23:21/23:21Z	F	1	n/a
2012-10-02T23:35/23:35Z	F	1	n/a
2012-10-02T23:57/23:57Z	F	1	n/a
2012-10-03T00:41/00:41Z	F	1	n/a
2012-10-03T01:03/01:03Z	F	1	n/a
2012-10-03T01:06/01:07Z	F	2	n/a
2012-10-03T01:17/01:17Z	F	1	n/a
2012-10-03T01:19/01:19Z	F	1	n/a
2012-10-03T01:22/01:23Z	F	2	n/a
2012-10-03T01:28/01:28Z	F	1	n/a
2012-10-03T01:52/01:52Z	F	1	n/a
2012-10-03T01:57/01:58Z	F	2	n/a
2012-10-03T02:03/02:03Z	F	1	n/a
2012-10-03T03:37/03:38Z	F	2	n/a
2012-10-03T03:46/03:46Z	F	1	n/a
2012-10-03T04:00/04:00Z	F	1	n/a
2012-10-03T04:03/04:03Z	F	1	n/a
2012-10-03T04:13/04:13Z	F	1	n/a
2012-10-03T04:40/04:41Z	F	2	n/a
2012-10-03T04:44/04:44Z	F	1	n/a
2012-10-03T04:46/04:46Z	F	1	n/a
2012-10-03T04:54/04:54Z	F	1	n/a
2012-10-03T05:00/05:01Z	F	2	n/a
2012-10-03T05:24/05:24Z	F	1	n/a
2012-10-03T05:26/05:26Z	F	1	n/a
2012-10-03T05:30/05:30Z	F	1	n/a
2012-10-03T05:43/05:46Z	F	4	n/a
2012-10-03T05:53/05:53Z	F	1	n/a
2012-10-03T05:56/05:56Z	F	1	n/a

Appendix E Annual means

The section reproduces the annual mean plaintext files featured on the *INTERMAGNET 2012 Definitive Data* DVD for each GA IMO.

Section 6.3 details the derivation of annual means from source data.

Values of ‘A’, ‘Q’ and ‘D’ refer to the All Days, Quiet Days and Disturbed Days annual means, respectively. The ‘year’ column refers to the centre minute of the data which the annual means were calculated from (e.g. a value of 1983.729 in the year column means that the minutes that comprise the 1983 year were centred on the 1983.729 minute and this data was used to calculate the annual mean).

E.1 KDU

ANNUAL MEAN VALUES

KAKADU, KDU, AUSTRALIA

COLATITUDE: 102.69 LONGITUDE: 132.47 E ELEVATION: 15 metres

YEAR	D		I		H	X	Y	Z	F	*	ELE	Note
	Deg	Min	Deg	Min	nT	nT	nT	nT	nT			
1995.500	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	A	ABZ	1
1996.500	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	A	ABZ	
1997.500	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	A	ABZ	
1998.500	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	A	ABZ	
1999.500	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	A	ABZ	
2000.500	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	A	ABZ	
2001.500	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	A	ABZ	
2002.500	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	A	ABZ	
2003.500	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	A	ABZ	
2004.500	3	43.3	-40	15.7	35429	35354	2299	-30005	46428	A	ABZ	
2005.500	3	42.2	-40	13.4	35424	35350	2288	-29960	46395	A	ABZ	
2006.500	3	40.7	-40	10.1	35433	35360	2273	-29910	46370	A	ABZ	
2007.500	3	38.6	-40	7.6	35432	35361	2252	-29864	46339	A	ABZ	
2008.500	3	36.4	-40	5.2	35434	35364	2229	-29823	46314	A	ABZ	
2009.500	3	33.8	-40	2.0	35445	35377	2203	-29777	46293	A	ABZ	
2010.500	3	30.4	-39	59.5	35445	35378	2168	-29732	46263	A	ABZ	
2011.500	3	27.1	-39	57.0	35447	35382	2134	-29690	46238	A	ABZ	2
2012.500	3	23.8	-39	54.9	35448	35386	2100	-29655	46217	A	ABZ	
1995.500	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	Q	ABZ	
1996.500	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	Q	ABZ	
1997.500	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	Q	ABZ	
1998.500	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	Q	ABZ	
1999.500	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	Q	ABZ	
2000.500	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	Q	ABZ	
2001.500	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	Q	ABZ	
2002.500	3	44.5	-40	18.4	35454	35378	2313	-30074	46491	Q	ABZ	
2003.500	3	44.2	-40	17.4	35438	35363	2309	-30043	46459	Q	ABZ	
2004.500	3	43.3	-40	15.0	35441	35366	2301	-30003	46435	Q	ABZ	
2005.500	3	42.3	-40	12.7	35436	35362	2290	-29959	46403	Q	ABZ	

2006.500	3	40.7	-40	9.6	35442	35369	2274	-29909	46376	Q	ABZ	
2007.500	3	38.7	-40	7.3	35438	35367	2253	-29864	46344	Q	ABZ	
2008.500	3	36.4	-40	4.8	35440	35370	2230	-29823	46318	Q	ABZ	
2009.500	3	33.8	-40	1.8	35448	35380	2203	-29776	46295	Q	ABZ	
2010.500	3	30.4	-39	59.1	35450	35384	2168	-29731	46267	Q	ABZ	
2011.500	3	27.0	-39	56.5	35454	35390	2134	-29689	46243	Q	ABZ	2
2012.500	3	23.8	-39	54.4	35458	35395	2100	-29655	46224	Q	ABZ	
1995.500	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	D	ABZ	
1996.500	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	D	ABZ	
1997.500	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	D	ABZ	
1998.500	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	D	ABZ	
1999.500	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	D	ABZ	
2000.500	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	D	ABZ	
2001.500	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	D	ABZ	
2002.500	3	44.5	-40	20.4	35416	35341	2311	-30077	46464	D	ABZ	
2003.500	3	44.0	-40	19.8	35396	35321	2305	-30050	46431	D	ABZ	
2004.500	3	43.2	-40	16.9	35407	35332	2297	-30008	46412	D	ABZ	
2005.500	3	42.1	-40	14.5	35404	35330	2286	-29963	46381	D	ABZ	
2006.500	3	40.8	-40	10.9	35419	35346	2273	-29911	46359	D	ABZ	
2007.500	3	38.6	-40	8.0	35423	35351	2251	-29865	46332	D	ABZ	
2008.500	3	36.4	-40	5.6	35426	35356	2228	-29824	46308	D	ABZ	
2009.500	3	33.8	-40	2.3	35439	35371	2202	-29777	46288	D	ABZ	
2010.500	3	30.4	-40	0.0	35434	35368	2167	-29733	46256	D	ABZ	
2011.500	3	27.1	-39	57.7	35435	35370	2133	-29692	46230	D	ABZ	2
2012.500	3	23.8	-39	56.1	35426	35364	2099	-29658	46202	D	ABZ	

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. The elements recorded were
   A: magnetic NW
   B: magnetic NE and
   Z: Vertical
   from which the standard magnetic elements were derived.

2. There was a +2nT step in X, and a -2nT step in Z
   across the 2010-2011 year boundary. See baselines section in readme
   file for explanation.

E.2 CTA

ANNUAL MEAN VALUES

CHARTERS TOWERS, CTA, AUSTRALIA

COLATITUDE: 110.090 LONGITUDE: 146.264 E ELEVATION:370 metres

YEAR	D		I		H	X	Y	Z	F	*	ELE	Note
	Deg	Min	Deg	Min	nT	nT	nT	nT	nT			
1983.729	7	40.4	-50	17.7	31786	31501	4244	-38280	49756	A	XYZ	
1984.500	7	41.9	-50	18.2	31777	31491	4256	-38280	49751	A	XYZ	
1985.500	7	43.2	-50	18.0	31776	31488	4268	-38276	49747	A	XYZ	
1986.500	7	44.4	-50	18.4	31768	31479	4278	-38274	49740	A	XYZ	
1987.500	7	45.5	-50	18.2	31769	31478	4288	-38271	49738	A	XYZ	
1988.500	7	46.3	-50	19.2	31751	31459	4294	-38270	49727	A	XYZ	
1989.500	7	47.0	-50	20.1	31731	31439	4297	-38267	49711	A	XYZ	
1990.500	7	47.2	-50	19.8	31731	31438	4299	-38260	49706	A	XYZ	
1991.500	7	47.4	-50	19.8	31719	31427	4299	-38248	49689	A	XYZ	
1992.500	7	47.3	-50	18.0	31732	31439	4300	-38221	49676	A	XYZ	
1993.500	7	47.4	-50	15.9	31743	31450	4303	-38188	49658	A	XYZ	
1994.500	7	47.6	-50	14.1	31748	31455	4305	-38151	49633	A	XYZ	
1995.500	7	47.7	-50	11.1	31770	31476	4309	-38112	49617	A	XYZ	
1996.500	7	47.4	-50	08.1	31793	31500	4309	-38071	49600	A	XYZ	
1997.500	7	47.0	-50	05.5	31803	31510	4307	-38024	49571	A	XYZ	
1998.500	7	46.5	-50	03.0	31805	31513	4302	-37972	49533	A	XYZ	
1999.500	7	45.5	-49	59.8	31816	31525	4295	-37913	49494	A	XYZ	1
2000.500	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	A	XYZ	2
2001.500	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	A	ABZ	
2002.500	7	44.5	-49	54.0	31815	31525	4285	-37781	49392	A	ABZ	
2003.500	7	44.1	-49	53.7	31796	31506	4279	-37751	49357	A	ABZ	
2004.500	7	43.6	-49	51.6	31800	31511	4275	-37710	49328	A	ABZ	
2005.500	7	42.5	-49	50.1	31795	31507	4265	-37670	49294	A	ABZ	
2006.500	7	41.2	-49	47.9	31800	31514	4253	-37627	49265	A	ABZ	
2007.500	7	39.5	-49	46.8	31793	31510	4237	-37596	49237	A	ABZ	3
2008.500	7	38.0	-49	45.7	31788	31506	4223	-37565	49210	A	ABZ	
2009.500	7	36.1	-49	44.0	31792	31513	4205	-37532	49187	A	ABZ	
2010.500	7	33.9	-49	43.1	31784	31508	4185	-37503	49160	A	ABZ	
2011.500	7	31.7	-49	42.2	31779	31505	4164	-37477	49137	A	ABZ	
2012.500	7	29.4	-49	41.8	31771	31500	4141	-37459	49118	A	ABZ	
1983.729	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	Q	XYZ	
1984.500	7	41.9	-50	17.5	31788	31502	4258	-38278	49756	Q	XYZ	
1985.500	7	43.2	-50	17.4	31787	31499	4270	-38274	49752	Q	XYZ	
1986.500	7	44.4	-50	17.8	31778	31489	4280	-38272	49745	Q	XYZ	
1987.500	7	45.5	-50	17.7	31776	31486	4289	-38269	49742	Q	XYZ	
1988.500	7	46.4	-50	18.3	31764	31472	4296	-38268	49733	Q	XYZ	
1989.500	7	47.0	-50	19.1	31746	31454	4299	-38265	49719	Q	XYZ	
1990.500	7	47.3	-50	18.8	31746	31454	4302	-38257	49714	Q	XYZ	
1991.500	7	47.3	-50	18.6	31739	31446	4301	-38244	49698	Q	XYZ	
1992.500	7	47.4	-50	17.1	31746	31453	4303	-38218	49683	Q	XYZ	
1993.500	7	47.4	-50	15.3	31754	31461	4304	-38185	49663	Q	XYZ	
1994.500	7	47.6	-50	13.2	31762	31469	4307	-38148	49640	Q	XYZ	
1995.500	7	47.7	-50	10.4	31781	31488	4310	-38109	49622	Q	XYZ	
1996.500	7	47.4	-50	07.7	31799	31506	4310	-38070	49603	Q	XYZ	
1997.500	7	46.9	-50	04.9	31812	31519	4308	-38023	49576	Q	XYZ	
1998.500	7	46.4	-50	02.5	31815	31523	4303	-37971	49537	Q	XYZ	
1999.500	7	45.5	-49	59.3	31825	31534	4296	-37911	49499	Q	XYZ	1
2000.500	7	44.8	-49	57.2	31823	31533	4290	-37864	49461	Q	XYZ	2
2001.500	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	Q	ABZ	
2002.500	7	44.5	-49	53.2	31828	31538	4287	-37780	49400	Q	ABZ	

2003.500	7	44.2	-49	52.7	31811	31521	4282	-37749	49365	Q	ABZ	
2004.500	7	43.6	-49	50.9	31810	31522	4277	-37708	49334	Q	ABZ	
2005.500	7	42.6	-49	49.4	31806	31519	4267	-37668	49300	Q	ABZ	
2006.500	7	41.2	-49	47.4	31808	31522	4255	-37625	49269	Q	ABZ	
2007.500	7	39.6	-49	46.5	31799	31515	4238	-37595	49240	Q	ABZ	3
2008.500	7	38.1	-49	45.4	31794	31512	4224	-37565	49214	Q	ABZ	
2009.500	7	36.1	-49	43.8	31795	31515	4206	-37532	49189	Q	ABZ	
2010.500	7	33.9	-49	42.8	31790	31513	4185	-37502	49163	Q	ABZ	
2011.500	7	31.8	-49	41.8	31786	31512	4165	-37476	49140	Q	ABZ	
2012.500	7	29.4	-49	41.3	31780	31509	4142	-37458	49123	Q	ABZ	
1983.729	7	39.9	-50	18.7	31769	31485	4237	-38281	49746	D	XYZ	
1984.500	7	41.8	-50	19.4	31756	31470	4253	-38283	49740	D	XYZ	
1985.500	7	43.1	-50	18.9	31761	31474	4266	-38277	49739	D	XYZ	
1986.500	7	44.4	-50	19.3	31752	31463	4276	-38276	49732	D	XYZ	
1987.500	7	45.4	-50	18.9	31757	31467	4286	-38272	49732	D	XYZ	
1988.500	7	46.3	-50	20.4	31731	31439	4291	-38274	49716	D	XYZ	
1989.500	7	46.9	-50	22.2	31696	31404	4292	-38272	49693	D	XYZ	
1990.500	7	47.1	-50	21.1	31707	31415	4295	-38263	49693	D	XYZ	
1991.500	7	47.4	-50	21.8	31687	31394	4295	-38253	49672	D	XYZ	
1992.500	7	47.3	-50	19.5	31706	31414	4297	-38225	49663	D	XYZ	
1993.500	7	47.4	-50	17.2	31723	31430	4299	-38191	49648	D	XYZ	
1994.500	7	47.6	-50	15.1	31730	31437	4302	-38154	49624	D	XYZ	
1995.500	7	47.7	-50	12.0	31755	31462	4307	-38114	49609	D	XYZ	
1996.500	7	47.4	-50	08.6	31784	31491	4308	-38072	49595	D	XYZ	
1997.500	7	47.0	-50	06.4	31788	31495	4305	-38026	49563	D	XYZ	
1998.500	7	46.5	-50	04.4	31782	31490	4299	-37976	49520	D	XYZ	
1999.500	7	45.5	-50	01.0	31797	31506	4293	-37916	49484	D	XYZ	1
2000.500	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	D	XYZ	2
2001.500	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	D	ABZ	
2002.500	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	D	ABZ	
2003.500	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	D	ABZ	
2004.500	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	D	ABZ	
2005.500	7	42.4	-49	51.2	31775	31488	4261	-37671	49283	D	ABZ	
2006.500	7	41.2	-49	48.6	31787	31501	4252	-37629	49258	D	ABZ	
2007.500	7	39.5	-49	47.3	31785	31502	4236	-37597	49233	D	ABZ	3
2008.500	7	38.1	-49	46.2	31780	31499	4222	-37567	49206	D	ABZ	
2009.500	7	36.1	-49	44.3	31787	31508	4205	-37532	49184	D	ABZ	
2010.500	7	33.9	-49	43.7	31775	31498	4183	-37504	49155	D	ABZ	
2011.500	7	31.7	-49	42.9	31768	31494	4162	-37479	49131	D	ABZ	
2012.500	7	29.4	-49	43.0	31751	31480	4139	-37462	49107	D	ABZ	

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. The elements recorded from 1983 to 27 August 2000 were magnetic X,Y,Z.(EDA instrument).

2. The elements recorded from 27 August 2000 were magnetic NW, NE and vertical (DMI instrument), from which the standard magnetic elements were derived. The NW, NE & Vertical components recorded are denoted A, B and Z respectively.

3. Before 31 Dec 2006, the CTA absolute instruments were corrected to the Canberra Observatory reference. The corrections for D, I, and F were zero.

From 00:00 01 Jan 2007, the CTA absolute instruments were corrected to the international reference.

E.3 LRM

ANNUAL MEAN VALUES
LEARMONTH, LRM, AUSTRALIA

COLATITUDE: 112.22 LONGITUDE: 114.10 E ELEVATION: 4 metres

YEAR	D Deg Min	I Deg Min	H nT	X nT	Y nT	Z nT	F nT	*	ELE	Note
1987.500	-0 34.9	-56 26.7	29480	29478	-299	-44446	53334	A	DHZ	
1988.500	-0 33.5	-56 27.0	29481	29479	-288	-44457	53344	A	DHZ	
1989.500	-0 34.3	-56 27.1	29465	29464	-294	-44436	53317	A	DHZ	
1990.500	-0 28.8	-56 25.4	29501	29500	-247	-44441	53342	A	DHZ	
1991.500	-0 26.3	-56 24.5	29507	29506	-226	-44426	53333	A	DHZ	
1992.500	-0 23.4	-56 22.6	29531	29530	-201	-44407	53330	A	DHZ	
1993.500	-0 18.9	-56 21.2	29550	29549	-162	-44396	53331	A	DHZ	
1994.500	-0 15.0	-56 20.5	29555	29555	-129	-44386	53326	A	DHZ	
1995.500	-0 10.8	-56 18.2	29588	29588	-93	-44373	53333	A	DHZ	
1996.500	-0 06.2	-56 15.5	29630	29630	-54	-44358	53344	A	DHZ	
1997.500	-0 01.3	-56 13.3	29658	29658	-11	-44338	53343	A	DHZ	
1998.500	0 04.2	-56 11.6	29676	29676	36	-44320	53338	A	DHZ	
1999.500	0 09.2	-56 09.6	29696	29696	80	-44292	53325	A	DHZ	
2000.500	0 13.5	-56 07.9	29707	29706	116	-44260	53305	A	ABZ	1
2001.500	0 17.7	-56 05.7	29724	29724	153	-44227	53287	A	ABZ	
2002.500	0 20.8	-56 04.2	29734	29733	180	-44197	53268	A	ABZ	
2003.500	0 23.8	-56 03.1	29737	29736	206	-44174	53250	A	ABZ	
2004.500	0 26.3	-56 00.4	29759	29758	228	-44132	53229	A	ABZ	
2005.500	0 28.3	-55 57.8	29773	29772	245	-44079	53192	A	ABZ	
2006.500	0 29.1	-55 53.9	29800	29799	252	-44012	53152	A	ABZ	
2007.500	0 29.2	-55 50.3	29823	29822	254	-43946	53109	A	ABZ	
2008.500	0 28.5	-55 46.5	29848	29847	247	-43880	53070	A	ABZ	
2009.500	0 27.8	-55 42.0	29885	29884	241	-43809	53032	A	ABZ	
2010.500	0 27.2	-55 37.9	29916	29915	237	-43744	52996	A	ABZ	
2011.500	0 26.1	-55 33.4	29953	29952	227	-43675	52959	A	ABZ	
2012.500	0 24.9	-55 28.8	29993	29992	217	-43608	52927	A	ABZ	
1987.500	-0 34.8	-56 26.3	29486	29484	-299	-44445	53336	Q	DHZ	
1988.500	-0 33.5	-56 26.3	29494	29492	-288	-44455	53349	Q	DHZ	
1989.500	-0 34.3	-56 26.2	29481	29479	-294	-44433	53324	Q	DHZ	
1990.500	-0 28.7	-56 24.5	29516	29515	-246	-44439	53348	Q	DHZ	
1991.500	-0 26.2	-56 23.4	29527	29526	-225	-44423	53341	Q	DHZ	
1992.500	-0 23.3	-56 21.7	29545	29544	-200	-44405	53336	Q	DHZ	
1993.500	-0 18.8	-56 20.5	29561	29560	-162	-44394	53336	Q	DHZ	
1994.500	-0 15.0	-56 19.7	29569	29569	-129	-44384	53332	Q	DHZ	
1995.500	-0 10.8	-56 17.5	29600	29600	-93	-44371	53338	Q	DHZ	
1996.500	-0 06.3	-56 15.2	29636	29635	-54	-44357	53346	Q	DHZ	
1997.500	-0 01.3	-56 12.8	29667	29667	-11	-44338	53348	Q	DHZ	
1998.500	0 04.1	-56 11.1	29686	29686	35	-44318	53342	Q	DHZ	
1999.500	0 09.2	-56 09.0	29705	29705	80	-44290	53329	Q	DHZ	
2000.500	0 13.5	-56 07.1	29719	29719	117	-44258	53311	Q	ABZ	1
2001.500	0 17.8	-56 05.0	29736	29736	154	-44225	53293	Q	ABZ	
2002.500	0 20.8	-56 03.4	29747	29747	180	-44195	53274	Q	ABZ	
2003.500	0 23.8	-56 02.2	29752	29751	206	-44171	53256	Q	ABZ	
2004.500	0 26.3	-55 59.8	29770	29769	228	-44130	53233	Q	ABZ	
2005.500	0 28.3	-55 57.2	29784	29783	245	-44078	53197	Q	ABZ	
2006.500	0 29.0	-55 53.4	29808	29807	251	-44011	53155	Q	ABZ	
2007.500	0 29.2	-55 50.0	29827	29826	254	-43945	53112	Q	ABZ	
2008.500	0 28.4	-55 46.2	29853	29852	247	-43879	53072	Q	ABZ	
2009.500	0 27.7	-55 41.8	29888	29887	241	-43809	53033	Q	ABZ	

2010.500	0	27.2	-55	37.6	29921	29921	237	-43744	52998	Q	ABZ	
2011.500	0	26.0	-55	33.0	29960	29959	227	-43673	52962	Q	ABZ	
2012.500	0	24.9	-55	28.3	30002	30001	217	-43607	52930	Q	ABZ	
1987.500	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	D	DHZ	
1988.500	-0	33.6	-56	28.2	29461	29459	-288	-44460	53335	D	DHZ	
1989.500	-0	34.4	-56	29.0	29433	29431	-295	-44441	53303	D	DHZ	
1990.500	-0	29.0	-56	26.7	29478	29477	-249	-44445	53332	D	DHZ	
1991.500	-0	26.5	-56	26.5	29473	29472	-227	-44431	53318	D	DHZ	
1992.500	-0	23.5	-56	24.1	29506	29505	-201	-44412	53320	D	DHZ	
1993.500	-0	18.9	-56	22.3	29530	29529	-163	-44398	53322	D	DHZ	
1994.500	-0	14.9	-56	21.6	29537	29537	-128	-44389	53318	D	DHZ	
1995.500	-0	10.9	-56	19.1	29574	29574	-94	-44374	53326	D	DHZ	
1996.500	-0	06.2	-56	16.0	29622	29622	-53	-44359	53340	D	DHZ	
1997.500	-0	01.3	-56	14.2	29643	29643	-11	-44340	53336	D	DHZ	
1998.500	0	04.2	-56	13.0	29652	29652	36	-44322	53326	D	DHZ	
1999.500	0	09.3	-56	10.7	29677	29677	81	-44295	53317	D	DHZ	
2000.500	0	13.4	-56	09.5	29679	29679	116	-44264	53294	D	ABZ	1
2001.500	0	17.6	-56	07.2	29699	29698	152	-44230	53276	D	ABZ	
2002.500	0	20.8	-56	05.4	29712	29712	179	-44200	53258	D	ABZ	
2003.500	0	23.8	-56	04.5	29713	29713	206	-44177	53240	D	ABZ	
2004.500	0	26.3	-56	01.6	29739	29738	227	-44135	53219	D	ABZ	
2005.500	0	28.3	-55	58.9	29754	29753	245	-44082	53184	D	ABZ	
2006.500	0	29.2	-55	54.6	29787	29786	253	-44013	53146	D	ABZ	
2007.500	0	29.3	-55	50.7	29816	29814	254	-43946	53106	D	ABZ	
2008.500	0	28.5	-55	46.9	29841	29840	247	-43881	53066	D	ABZ	
2009.500	0	27.8	-55	42.2	29880	29879	242	-43809	53029	D	ABZ	
2010.500	0	27.2	-55	38.5	29907	29906	237	-43745	52991	D	ABZ	
2011.500	0	26.1	-55	34.1	29941	29940	227	-43677	52955	D	ABZ	
2012.500	0	25.0	-55	30.1	29972	29972	218	-43612	52918	D	ABZ	

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:
1 The elements measured are actually Magnetic NW, NE and Vertical

E.4 ASP

ANNUAL MEAN VALUES

ALICE SPRINGS, ASP, AUSTRALIA

COLATITUDE: 113.76 LONGITUDE: 133.88 E ELEVATION: 557 metres

YEAR	D Deg	D Min	I Deg	I Min	H nT	X nT	Y nT	Z nT	F nT	*	ELE	Note
1992.700	004	58.4	-56	06.8	29938	29825	2595	-44575	53695	A	XYZ	1
1993.500	004	59.0	-56	05.5	29948	29835	2601	-44552	53682	A	XYZ	
1994.500	005	00.1	-56	04.1	29957	29843	2612	-44528	53667	A	XYZ	
1995.500	005	01.1	-56	01.7	29980	29865	2623	-44494	53652	A	XYZ	
1996.500	005	02.0	-55	59.0	30007	29892	2633	-44458	53638	A	XYZ	
1997.500	005	02.9	-55	56.6	30026	29910	2642	-44421	53617	A	XYZ	
1998.500	005	04.1	-55	54.7	30034	29917	2653	-44379	53587	A	XYZ	
1999.500	005	04.9	-55	51.9	30052	29934	2662	-44329	53555	A	XYZ	
2000.500	005	05.5	-55	50.2	30052	29934	2667	-44282	53517	A	XYZ	
2001.500	005	06.0	-55	47.9	30067	29948	2673	-44241	53491	A	XYZ	
2002.500	005	06.7	-55	46.3	30072	29953	2679	-44203	53463	A	XYZ	
2003.500	005	07.0	-55	45.8	30062	29942	2681	-44175	53433	A	XYZ	
2004.500	005	06.8	-55	43.7	30073	29954	2680	-44134	53406	A	XYZ	
2005.500	005	06.4	-55	42.0	30076	29957	2677	-44090	53371	A	ABZ	2
2006.500	005	05.2	-55	39.4	30090	29971	2668	-44038	53336	A	ABZ	
2007.500	005	03.5	-55	37.5	30097	29980	2653	-43995	53305	A	ABZ	
2008.500	005	01.5	-55	35.6	30104	29989	2637	-43956	53277	A	ABZ	
2009.500	004	59.5	-55	33.1	30122	30008	2621	-43913	53251	A	ABZ	
2010.500	004	57.1	-55	31.3	30130	30017	2601	-43875	53224	A	ABZ	
2011.500	004	54.6	-55	29.4	30140	30029	2580	-43837	53199	A	ABZ	
2012.500	004	51.9	-55	27.8	30149	30040	2557	-43806	53179	A	ABZ	
1992.700	004	58.4	-56	06.0	29950	29838	2596	-44572	53700	Q	XYZ	1
1993.500	004	59.0	-56	04.8	29959	29845	2603	-44550	53686	Q	XYZ	
1994.500	005	00.2	-56	03.3	29971	29857	2614	-44524	53672	Q	XYZ	
1995.500	005	01.1	-56	01.0	29991	29876	2623	-44492	53656	Q	XYZ	
1996.500	005	02.0	-55	58.6	30013	29897	2633	-44458	53640	Q	XYZ	
1997.500	005	02.9	-55	56.0	30035	29919	2643	-44419	53621	Q	XYZ	
1998.500	005	04.1	-55	54.1	30043	29926	2654	-44377	53590	Q	XYZ	
1999.500	005	04.9	-55	51.3	30061	29943	2663	-44326	53558	Q	XYZ	
2000.500	005	05.6	-55	49.5	30065	29946	2669	-44279	53521	Q	XYZ	
2001.500	005	06.1	-55	47.3	30078	29959	2675	-44239	53495	Q	XYZ	
2002.500	005	06.7	-55	45.5	30086	29966	2680	-44201	53469	Q	XYZ	
2003.500	005	07.0	-55	45.0	30076	29956	2682	-44171	53439	Q	XYZ	
2004.500	005	06.9	-55	43.1	30084	29964	2682	-44131	53410	Q	XYZ	
2005.500	005	06.4	-55	41.4	30087	29967	2678	-44088	53376	Q	ABZ	
2006.500	005	05.2	-55	38.9	30097	29979	2668	-44037	53340	Q	ABZ	
2007.500	005	03.5	-55	37.2	30102	29985	2654	-43995	53307	Q	ABZ	
2008.500	005	01.5	-55	35.3	30110	29994	2638	-43955	53279	Q	ABZ	
2009.500	004	59.5	-55	32.9	30125	30011	2621	-43912	53252	Q	ABZ	
2010.500	004	57.1	-55	31.0	30135	30022	2601	-43874	53226	Q	ABZ	
2011.500	004	54.6	-55	29.0	30146	30035	2580	-43836	53201	Q	ABZ	
2012.500	004	51.9	-55	27.3	30157	30049	2558	-43805	53182	Q	ABZ	
1992.700	004	58.4	-56	08.1	29915	29803	2594	-44579	53686	D	XYZ	1
1993.500	004	58.9	-56	06.7	29928	29815	2599	-44556	53674	D	XYZ	
1994.500	005	00.0	-56	05.1	29940	29826	2609	-44531	53660	D	XYZ	
1995.500	005	01.1	-56	02.6	29965	29850	2621	-44497	53646	D	XYZ	
1996.500	005	02.0	-55	59.5	29998	29883	2632	-44460	53634	D	XYZ	
1997.500	005	02.8	-55	57.5	30011	29895	2640	-44423	53611	D	XYZ	

1998.500	005	04.0	-55	55.9	30013	29896	2651	-44383	53578	D	XYZ	
1999.500	005	04.9	-55	53.0	30034	29916	2660	-44332	53548	D	XYZ	
2000.500	005	05.5	-55	51.8	30026	29908	2664	-44287	53506	D	XYZ	
2001.500	005	05.9	-55	49.4	30043	29924	2669	-44245	53480	D	XYZ	
2002.500	005	06.6	-55	47.6	30051	29931	2677	-44207	53454	D	XYZ	
2003.500	005	06.8	-55	47.2	30038	29919	2677	-44178	53423	D	XYZ	
2004.500	005	06.6	-55	44.9	30054	29934	2677	-44137	53398	D	XYZ	
2005.500	005	06.3	-55	43.1	30058	29939	2674	-44093	53364	D	ABZ	2
2006.500	005	05.3	-55	40.2	30077	29958	2667	-44040	53331	D	ABZ	
2007.500	005	03.5	-55	37.9	30089	29972	2653	-43997	53302	D	ABZ	
2008.500	005	01.6	-55	36.1	30097	29981	2637	-43957	53274	D	ABZ	
2009.500	004	59.5	-55	33.4	30117	30003	2621	-43913	53249	D	ABZ	
2010.500	004	57.1	-55	31.9	30120	30008	2600	-43876	53220	D	ABZ	
2011.500	004	54.6	-55	30.1	30129	30018	2578	-43840	53194	D	ABZ	
2012.500	004	51.9	-55	28.9	30130	30021	2555	-43810	53170	D	ABZ	

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. The observatory commenced operation on 1 June 1992
   Hence no data from 01 Jan 1992 to 31 May 1992

2. A new variometer was installed on 14 Sep 2005 that was aligned
   in the magnetic-NW, magnetic-NE and vertical orientations.

E.5 GNA

ANNUAL MEAN VALUES

GNANGARA, GNA, AUSTRALIA

COLATITUDE: 121.78 LONGITUDE: 115.95 E ELEVATION: 60 metres

YEAR	D		I		H	X	Y	Z	F	*	ELE	Noteg
	Deg.	'	Deg.	'	nT	nT	nT	nT	nT			
1993.500	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	A	ABZ	3
1994.000		-1.6		1.1	8	7	-11	27	-22	J	ABZ	4
1994.500	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	A	ABZ	
1995.500	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	A	ABZ	
1996.500	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	A	ABZ	
1997.500	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	A	ABZ	
1998.500	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	A	ABZ	5
1999.500	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	A	ABZ	
2000.500	-2	13.6	-66	36.0	23230	23212	-903	-53682	58493	A	ABZ	
2001.500	-2	09.0	-66	34.7	23241	23225	-872	-53651	58468	A	ABZ	
2002.500	-2	04.7	-66	33.8	23245	23230	-843	-53622	58444	A	ABZ	
2003.500	-2	01.1	-66	33.4	23243	23229	-819	-53601	58424	A	ABZ	
2004.500	-1	57.3	-66	31.6	23260	23247	-794	-53562	58395	A	ABZ	6
2005.500	-1	54.6	-66	29.7	23274	23262	-776	-53516	58358	A	ABZ	
2006.500	-1	53.0	-66	26.7	23306	23293	-766	-53457	58317	A	ABZ	
2007.500	-1	52.1	-66	23.8	23335	23323	-761	-53405	58280	A	ABZ	
2008.500	-1	51.8	-66	20.9	23368	23355	-760	-53357	58249	A	ABZ	
2009.500	-1	51.5	-66	17.5	23410	23398	-759	-53307	58220	A	ABZ	
2010.500	-1	51.2	-66	14.5	23446	23434	-758	-53265	58197	A	ABZ	
2011.500	-1	51.2	-66	11.3	23487	23475	-760	-53224	58176	A	ABZ	
2012.500	-1	51.1	-66	08.2	23529	23517	-760	-53188	58160	A	ABZ	7
1980.500	-3	17.8	-66	25.7	23409	23370	-1345	-53652	58536	Q	DHZ	1
1981.500	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	Q	DHZ	
1982.500	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	Q	DHZ	
1983.500	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	Q	DHZ	
1984.500	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	Q	DHZ	
1985.500	-3	17.6	-66	36.5	23259	23221	-1336	-53769	58585	Q	DHZ	
1986.500	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	Q	DHZ	
1987.500	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	Q	DHZ	
1988.500	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	Q	DHZ	
1989.500	-3	08.6	-66	40.8	23197	23162	-1272	-53813	58600	Q	DHZ	
1990.500	-3	06.1	-66	40.7	23195	23161	-1255	-53802	58588	Q	DHZ	2
1991.500	-3	02.0	-66	40.4	23194	23162	-1227	-53787	58575	Q	DFI	
1992.500	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	Q	DFI	
1993.500	-2	53.9	-66	39.7	23194	23164	-1173	-53757	58547	Q	ABZ	3
1994.000		-1.6		1.1	8	7	-11	27	-22	J	ABZ	4
1994.500	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	Q	ABZ	
1995.500	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	Q	ABZ	
1996.500	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	Q	ABZ	
1997.500	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	Q	ABZ	
1998.500	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	Q	ABZ	5
1999.500	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	Q	ABZ	
2000.500	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	Q	ABZ	
2001.500	-2	08.8	-66	34.1	23252	23235	-871	-53648	58470	Q	ABZ	
2002.500	-2	04.5	-66	33.1	23257	23242	-842	-53619	58446	Q	ABZ	
2003.500	-2	01.1	-66	32.7	23255	23241	-819	-53599	58426	Q	ABZ	
2004.500	-1	57.2	-66	31.0	23269	23256	-793	-53559	58396	Q	ABZ	6
2005.500	-1	54.5	-66	29.1	23284	23271	-775	-53513	58360	Q	ABZ	
2006.500	-1	53.0	-66	26.2	23313	23300	-766	-53455	58318	Q	ABZ	

2007.500	-1	52.1	-66	23.6	23339	23327	-761	-53404	58281	Q	ABZ	
2008.500	-1	51.8	-66	20.7	23372	23360	-760	-53356	58250	Q	ABZ	
2009.500	-1	51.5	-66	17.4	23412	23399	-759	-53306	58221	Q	ABZ	
2010.500	-1	51.2	-66	14.3	23451	23438	-758	-53264	58198	Q	ABZ	
2011.500	-1	51.2	-66	10.9	23493	23481	-760	-53222	58176	Q	ABZ	
2012.500	-1	51.0	-66	07.7	23537	23525	-760	-53185	58161	Q	ABZ	7
1993.500	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	D	ABZ	3
1994.000		-1.6		1.1	8	7	-11	27	-22	J	ABZ	4
1994.500	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	D	ABZ	
1995.500	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	D	ABZ	
1996.500	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	D	ABZ	
1997.500	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	D	ABZ	
1998.500	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	D	ABZ	5
1999.500	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	D	ABZ	
2000.500	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	D	ABZ	
2001.500	-2	09.6	-66	36.0	23219	23203	-875	-53656	58465	D	ABZ	
2002.500	-2	04.9	-66	34.9	23227	23211	-844	-53627	58441	D	ABZ	
2003.500	-2	01.3	-66	34.5	23224	23210	-819	-53605	58420	D	ABZ	
2004.500	-1	57.6	-66	32.7	23242	23228	-795	-53566	58391	D	ABZ	6
2005.500	-1	54.7	-66	30.7	23259	23246	-776	-53520	58355	D	ABZ	
2006.500	-1	53.0	-66	27.4	23294	23281	-765	-53459	58314	D	ABZ	
2007.500	-1	52.1	-66	24.2	23329	23317	-761	-53405	58278	D	ABZ	
2008.500	-1	51.9	-66	21.3	23362	23349	-760	-53358	58248	D	ABZ	
2009.500	-1	51.5	-66	17.7	23406	23393	-759	-53307	58220	D	ABZ	
2010.500	-1	51.3	-66	15.1	23437	23424	-759	-53267	58194	D	ABZ	
2011.500	-1	51.4	-66	11.9	23477	23465	-760	-53227	58174	D	ABZ	
2012.500	-1	51.3	-66	09.3	23511	23499	-761	-53193	58157	D	ABZ	7

* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month
* A = All days in the year
* J = Jump: jump value = old site value - new site value

ELE = Elements recorded

Notes: 1. Values taken from the Geophysical Observatory Report 1980-1992, and the Australian Geomagnetism Report 1993-1994.

2. In mid-1990 recording of variations was switched from an analogue Eschenhagen magnetometer to a digital Littlemore variometer.

3. From mid-1993 variations were recorded on an EDA fluxgate variometer in magnetic NW, NE and vertical components that were converted to X, Y, Z.
The EDA variometer was de-commissioned on 03 August 1998.

4. In September 1993 the absolute observations were transferred from pier NE in the old absolute house to pier B in the new absolute house. The pier differences determined at that time were: old new jump
D(NE) - D(B) = -1.6'
I(NE) - I(B) = +1.07'
F(NE) - F(B) = -22nT
These adjustments were applied to baselines determined from September to December 1993.

5. From 03 August 1998 variations were recorded with a Danish Meteorological Institute FGE fluxgate variometer in magnetic NW, NE and vertical components that were converted to X, Y, Z.

6. From 07 April 2004 variations in the magnetic NE, NW and vertical components were recorded with an EDA FM105B 3-axis fluxgate variometer.

7. The Gnangara observatory was replaced by Gingin (GNG) observatory on 2013-01-01T00:00Z. The 2012 data set is the last to be produced from Gnangara geomagnetic observatory.

E.6 GNG

ANNUAL MEAN VALUES

Gingin, GNG, AUSTRALIA

COLATITUDE: 121.356 LONGITUDE: 115.715 E ELEVATION:050 metres

YEAR	D		I		H	X	Y	Z	F	*	ELE	Note
	Deg	Min	Deg	Min	nT	nT	nT	nT	nT			
2011.937	-1	38.8	-65	43.0	23816	23807	-684	-52789	57913	A	ABZ	1,2
2012.500	-1	38.5	-65	42.1	23825	23816	-683	-52771	57900	A	ABZ	2
2011.937	-1	38.7	-65	42.7	23822	23812	-683	-52786	57912	Q	ABZ	1,2
2012.500	-1	38.4	-65	41.6	23833	23823	-682	-52769	57901	Q	ABZ	2
2011.937	-1	38.8	-65	43.1	23815	23805	-684	-52791	57914	D	ABZ	1,2
2012.500	-1	38.6	-65	43.2	23807	23797	-683	-52776	57897	D	ABZ	2

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:
1. Calibrated time-series data commenced on 2011-11-16T00:00UT

2. The elements recorded were magnetic NW, NE and vertical (DMI instrument), from which the standard magnetic elements were derived. The NW, NE & Vertical components recorded are denoted A, B and Z respectively.

E.7 CNB

ANNUAL MEAN VALUES

CANBERRA, CNB, AUSTRALIA

COLATITUDE: 125.31 LONGITUDE: 149.36 E ELEVATION: 859 metres

YEAR	D Deg	D Min	I Deg	I Min	H nT	X nT	Y nT	Z nT	F nT	*	ELE	Note
1979.500	12	5.6	-66	5.9	23833	23305	4993	-53778	58822	A	DFI	
1980.500	12	8.6	-66	6.9	23808	23275	5009	-53767	58801	A	DFI	
1981.500	12	11.2	-66	9.1	23770	23234	5018	-53771	58791	A	DFI	
1982.500	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	A	DFI	
1983.500	12	16.6	-66	11.3	23723	23180	5044	-53756	58758	A	DFI	
1984.500	12	18.4	-66	11.7	23709	23164	5054	-53741	58739	A	DFI	
1985.500	12	20.7	-66	11.6	23703	23155	5067	-53726	58723	A	DFI	
1986.500	12	23.2	-66	12.1	23689	23137	5081	-53716	58707	A	DFI	
1987.500	12	25.5	-66	12.0	23684	23129	5096	-53699	58690	A	DFI	
1988.500	12	27.6	-66	12.8	23665	23107	5106	-53690	58674	A	DFI	
1989.500	12	29.0	-66	13.8	23644	23085	5111	-53683	58659	A	DFI	
1990.500	12	30.7	-66	13.6	23641	23079	5121	-53667	58643	A	DFI	
1991.500	12	31.8	-66	13.9	23628	23066	5126	-53652	58624	A	DFI	
1992.500	12	32.4	-66	12.8	23637	23073	5132	-53625	58603	A	DFI	
1993.500	12	33.0	-66	11.6	23646	23081	5138	-53597	58581	A	DFI	
1994.500	12	33.5	-66	10.8	23649	23083	5142	-53571	58559	A	DFI	
1995.500	12	33.8	-66	09.2	23665	23098	5148	-53540	58537	A	DFI	1
1996.500	12	34.2	-66	07.4	23684	23116	5154	-53507	58514	A	ABZ	2
1997.500	12	34.2	-66	06.1	23695	23127	5157	-53476	58491	A	ABZ	
1998.500	12	34.2	-66	05.2	23698	23130	5157	-53444	58463	A	ABZ	
1999.500	12	34.1	-66	03.7	23709	23140	5159	-53403	58429	A	ABZ	
2000.500	12	34.2	-66	02.9	23708	23139	5160	-53367	58396	A	ABZ	
2001.500	12	34.7	-66	01.5	23716	23146	5164	-53327	58362	A	ABZ	
2002.500	12	35.1	-66	00.5	23718	23148	5168	-53291	58331	A	ABZ	
2003.500	12	35.5	-66	00.3	23710	23139	5169	-53264	58303	A	ABZ	
2004.500	12	35.5	-65	58.8	23719	23149	5171	-53225	58271	A	ABZ	
2005.500	12	35.2	-65	57.9	23720	23150	5169	-53190	58240	A	ABZ	
2006.500	12	34.5	-65	56.5	23729	23160	5166	-53151	58207	A	ABZ	
2007.500	12	34.0	-65	55.5	23732	23164	5164	-53118	58179	A	ABZ	
2008.500	12	33.5	-65	54.7	23735	23167	5161	-53088	58152	A	ABZ	
2009.500	12	32.8	-65	53.4	23744	23177	5158	-53057	58128	A	ABZ	
2010.500	12	32.1	-65	52.9	23744	23178	5153	-53035	58107	A	ABZ	
2011.500	12	31.2	-65	52.3	23745	23181	5147	-53015	58089	A	ABZ	
2012.500	12	30.7	-65	52.1	23742	23179	5143	-53000	58075	A	ABZ	
1979.500	12	05.5	-66	05.3	23844	23315	4995	-53775	58824	Q	DFI	
1980.500	12	08.6	-66	06.8	23813	23280	5010	-53769	58806	Q	DFI	
1981.500	12	11.4	-66	08.3	23783	23246	5022	-53767	58792	Q	DFI	
1982.500	12	14.1	-66	10.1	23749	23210	5033	-53766	58778	Q	DFI	
1983.500	12	16.5	-66	10.7	23734	23191	5046	-53753	58760	Q	DFI	
1984.500	12	18.5	-66	11.1	23719	23174	5056	-53739	58741	Q	DFI	
1985.500	12	20.7	-66	11.1	23713	23164	5070	-53724	58724	Q	DFI	
1986.500	12	23.2	-66	11.6	23697	23146	5083	-53714	58709	Q	DFI	
1987.500	12	25.5	-66	11.6	23690	23136	5097	-53698	58691	Q	DFI	
1988.500	12	27.7	-66	12.2	23675	23118	5109	-53687	58676	Q	DFI	
1989.500	12	29.1	-66	13.0	23657	23098	5114	-53680	58662	Q	DFI	
1990.500	12	30.8	-66	12.8	23653	23092	5125	-53663	58645	Q	DFI	
1991.500	12	31.8	-66	12.9	23645	23082	5130	-53647	58627	Q	DFI	
1992.500	12	32.5	-66	12.1	23649	23085	5135	-53622	58605	Q	DFI	
1993.500	12	33.0	-66	11.1	23655	23090	5140	-53594	58583	Q	DFI	

1994.500	12	33.6	-66	10.2	23661	23095	5145	-53568	58561	Q	DFI
1995.500	12	33.9	-66	08.7	23675	23108	5150	-53537	58538	Q	DFI
1996.500	12	34.2	-66	07.2	23689	23121	5155	-53506	58515	Q	ABZ
1997.500	12	34.2	-66	05.6	23703	23135	5159	-53474	58492	Q	ABZ
1998.500	12	34.3	-66	04.8	23706	23137	5159	-53443	58464	Q	ABZ
1999.500	12	34.1	-66	03.2	23716	23148	5161	-53400	58430	Q	ABZ
2000.500	12	34.3	-66	02.2	23718	23149	5162	-53365	58398	Q	ABZ
2001.500	12	34.7	-66	00.9	23726	23156	5167	-53324	58364	Q	ABZ
2002.500	12	35.1	-65	59.8	23730	23159	5171	-53289	58334	Q	ABZ
2003.500	12	35.6	-65	59.5	23723	23152	5172	-53261	58306	Q	ABZ
2004.500	12	35.5	-65	58.3	23728	23157	5173	-53223	58273	Q	ABZ
2005.500	12	35.2	-65	57.4	23730	23159	5171	-53188	58242	Q	ABZ
2006.500	12	34.5	-65	56.1	23736	23166	5167	-53149	58208	Q	ABZ
2007.500	12	34.0	-65	55.3	23737	23168	5165	-53117	58180	Q	ABZ
2008.500	12	33.5	-65	54.4	23739	23171	5162	-53087	58153	Q	ABZ
2009.500	12	32.8	-65	53.3	23746	23179	5159	-53056	58128	Q	ABZ
2010.500	12	32.1	-65	52.6	23749	23183	5154	-53034	58108	Q	ABZ
2011.500	12	31.2	-65	52.0	23751	23186	5148	-53013	58090	Q	ABZ
2012.500	12	30.6	-65	51.7	23749	23185	5145	-52998	58076	Q	ABZ
1979.500	12	5.6	-66	6.9	23816	23287	4990	-53782	58819	D	DFI
1980.500	12	8.4	-66	7.8	23792	23260	5004	-53770	58798	D	DFI
1981.500	12	11.1	-66	10.3	23750	23215	5013	-53776	58787	D	DFI
1982.500	12	13.7	-66	12.4	23710	23172	5022	-53773	58769	D	DFI
1983.500	12	16.6	-66	12.3	23706	23163	5040	-53760	58754	D	DFI
1984.500	12	18.4	-66	12.7	23691	23146	5049	-53745	58735	D	DFI
1985.500	12	20.5	-66	12.4	23690	23142	5064	-53729	58719	D	DFI
1986.500	12	23.3	-66	12.9	23675	23123	5079	-53717	58703	D	DFI
1987.500	12	25.5	-66	12.6	23674	23120	5094	-53701	58688	D	DFI
1988.500	12	27.5	-66	13.8	23647	23091	5102	-53693	58670	D	DFI
1989.500	12	29.0	-66	15.5	23615	23057	5105	-53690	58654	D	DFI
1990.500	12	30.5	-66	14.8	23619	23059	5116	-53671	58639	D	DFI
1991.500	12	31.6	-66	15.5	23600	23038	5119	-53658	58618	D	DFI
1992.500	12	32.3	-66	14.1	23615	23052	5127	-53630	58600	D	DFI
1993.500	12	33.0	-66	12.7	23628	23064	5134	-53601	58578	D	DFI
1994.500	12	33.4	-66	11.8	23633	23068	5138	-53574	58555	D	DFI
1995.500	12	33.8	-66	10.0	23652	23086	5145	-53542	58533	D	DFI
1996.500	12	34.2	-66	07.9	23676	23108	5152	-53508	58512	D	ABZ
1997.500	12	34.1	-66	06.9	23683	23115	5154	-53479	58488	D	ABZ
1998.500	12	34.2	-66	06.4	23678	23110	5153	-53450	58459	D	ABZ
1999.500	12	34.1	-66	04.6	23692	23124	5156	-53407	58427	D	ABZ
2000.500	12	34.2	-66	04.2	23685	23117	5155	-53372	58392	D	ABZ
2001.500	12	34.6	-66	02.7	23695	23126	5159	-53331	58358	D	ABZ
2002.500	12	35.2	-66	01.6	23700	23130	5165	-53296	58328	D	ABZ
2003.500	12	35.4	-66	01.5	23688	23118	5163	-53266	58295	D	ABZ
2004.500	12	35.3	-65	59.8	23702	23132	5166	-53229	58267	D	ABZ
2005.500	12	35.2	-65	58.9	23704	23135	5165	-53194	58236	D	ABZ
2006.500	12	34.6	-65	57.2	23717	23148	5164	-53153	58204	D	ABZ
2007.500	12	34.1	-65	55.9	23725	23157	5162	-53119	58177	D	ABZ
2008.500	12	33.6	-65	55.1	23728	23160	5160	-53089	58151	D	ABZ
2009.500	12	32.8	-65	53.7	23740	23173	5157	-53058	58127	D	ABZ
2010.500	12	32.1	-65	53.4	23736	23170	5151	-53036	58105	D	ABZ
2011.500	12	31.1	-65	52.9	23735	23171	5145	-53017	58087	D	ABZ
2012.500	12	30.7	-65	53.2	23725	23162	5140	-53005	58072	D	ABZ

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. The elements recorded from November 1995 were magnetic NW, NE and Vertical, from which the standard magnetic elements were derived.

2. The NW, NE & Vertical components recorded since November 1995 are denoted A, B and Z respectively.

E.8 MCQ

ANNUAL MEAN VALUES

MACQUARIE ISLAND, MCQ, ANTARCTICA

COLATITUDE: 144.50 LONGITUDE: 158.95 E ELEVATION: 8 metres

YEAR	D Deg	D Min	I Deg	I Min	H nT	X nT	Y nT	Z nT	F nT	*	ELE	Note
1991.500	029	47.7	-78	48.9	12553	10893	6237	-63482	64711	A	XYZ	3
1992.500	029	53.1	-78	48.3	12557	10888	6257	-63450	64681	A	XYZ	
1993.500	029	57.2	-78	48.1	12558	10880	6270	-63428	64659	A	ABC	
1994.500	030	02.2	-78	48.3	12549	10863	6281	-63404	64634	A	ABC	
1995.500	030	06.6	-78	47.5	12559	10864	6300	-63376	64608	A	ABC	
1996.500	030	11.0	-78	46.4	12574	10870	6322	-63353	64589	A	ABC	
1997.500	030	15.4	-78	45.9	12580	10866	6339	-63336	64573	A	ABC	
1998.500	030	20.0	-78	45.8	12579	10857	6353	-63320	64557	A	ABC	
1999.500	030	23.6	-78	45.2	12586	10856	6367	-63294	64534	A	ABC	
2000.500	030	28.4	-78	45.0	12585	10847	6382	-63268	64507	A	ABC	
2001.500	030	33.5	-78	44.1	12595	10846	6404	-63231	64473	A	ABC	
2002.500	030	39.1	-78	43.5	12600	10840	6424	-63198	64442	A	ABC	
2003.500	030	44.5	-78	44.0	12585	10817	6433	-63174	64416	A	ABC	
2004.500	030	49.1	-78	42.7	12603	10823	6456	-63134	64380	A	ABC	
2005.500	030	53.3	-78	42.1	12607	10819	6472	-63104	64352	A	ABC	
2006.500	030	57.0	-78	40.8	12625	10828	6493	-63063	64315	A	ABC	
2007.500	031	01.9	-78	40.2	12631	10823	6511	-63035	64288	A	ABZ	4
2008.500	031	07.3	-78	39.5	12637	10818	6532	-63005	64260	A	ABZ	
2009.500	031	12.9	-78	38.4	12651	10820	6556	-62973	64231	A	ABZ	
2010.500	031	19.0	-78	38.2	12651	10808	6576	-62951	64210	A	ABZ	
2011.500	031	25.2	-78	37.7	12657	10801	6598	-62932	64192	A	ABZ	
2012.500	031	32.1	-78	37.2	12663	10792	6623	-62917	64178	A	ABZ	
1980.500	028	28.8	-78	43.0	12723	11183	6067	-63768	65025	Q	HDZ	1
1981.500	028	37.5	-78	44.5	12687	11136	6078	-63735	64985	Q	HDZ	
1982.500	028	49.5	-78	45.4	12666	11097	6107	-63711	64958	Q	HDZ	
1983.500	028	54.9	-78	45.7	12652	11075	6117	-63674	64919	Q	HDZ	
1984.500	029	03.7	-78	46.1	12640	11049	6140	-63650	64893	Q	HDZ	2
1985.500	029	12.0	-78	47.4	12608	11006	6151	-63619	64856	Q	XYZ	
1986.500	029	19.0	-78	47.5	12600	10986	6169	-63590	64826	Q	XYZ	
1987.500	029	26.8	-78	47.8	12593	10966	6191	-63584	64819	Q	XYZ	
1988.500	029	32.2	-78	47.8	12590	10954	6207	-63560	64795	Q	XYZ	
1989.500	029	37.8	-78	47.8	12587	10941	6223	-63552	64786	Q	XYZ	
1990.500	029	42.8	-78	48.0	12577	10923	6234	-63519	64752	Q	XYZ	
1991.500	029	47.5	-78	47.8	12573	10911	6247	-63477	64710	Q	XYZ	3
1992.500	029	53.0	-78	47.5	12573	10902	6264	-63447	64681	Q	XYZ	
1993.500	029	56.9	-78	47.2	12575	10896	6277	-63427	64661	Q	ABC	
1994.500	030	01.5	-78	47.0	12574	10887	6292	-63403	64637	Q	ABC	
1995.500	030	06.2	-78	46.5	12577	10881	6308	-63377	64613	Q	ABC	
1996.500	030	10.5	-78	45.9	12585	10879	6326	-63356	64594	Q	ABC	
1997.500	030	15.2	-78	45.4	12591	10876	6344	-63336	64576	Q	ABC	
1998.500	030	19.7	-78	45.1	12593	10870	6359	-63321	64562	Q	ABC	
1999.500	030	23.5	-78	44.6	12598	10867	6373	-63293	64535	Q	ABC	
2000.500	030	28.3	-78	44.3	12598	10858	6389	-63266	64508	Q	ABC	
2001.500	030	33.3	-78	43.4	12608	10857	6409	-63229	64474	Q	ABC	
2002.500	030	38.9	-78	42.8	12613	10851	6429	-63196	64442	Q	ABC	
2003.500	030	43.7	-78	42.6	12611	10841	6444	-63170	64417	Q	ABC	
2004.500	030	48.6	-78	41.8	12619	10838	6463	-63134	64383	Q	ABC	
2005.500	030	52.7	-78	41.3	12624	10835	6479	-63106	64356	Q	ABC	
2006.500	030	56.6	-78	40.3	12634	10836	6496	-63064	64317	Q	ABC	

2007.500	031	01.8	-78	39.8	12639	10830	6515	-63038	64293	Q	ABZ	4
2008.500	031	07.1	-78	39.1	12645	10826	6535	-63008	64265	Q	ABZ	
2009.500	031	12.8	-78	38.3	12654	10822	6558	-62974	64233	Q	ABZ	
2010.500	031	18.7	-78	37.8	12658	10815	6579	-62952	64212	Q	ABZ	
2011.500	031	25.1	-78	37.3	12664	10808	6602	-62932	64194	Q	ABZ	
2012.500	031	32.0	-78	36.8	12671	10800	6627	-62920	64183	Q	ABZ	
1991.500	029	49.4	-78	52.0	12495	10840	6214	-63489	64708	D	XYZ	3
1992.500	029	54.7	-78	49.8	12529	10860	6248	-63451	64677	D	XYZ	
1993.500	029	58.5	-78	50.0	12521	10846	6256	-63429	64654	D	ABC	
1994.500	030	03.3	-78	50.2	12514	10831	6267	-63408	64632	D	ABC	
1995.500	030	07.8	-78	49.4	12522	10830	6285	-63376	64601	D	ABC	
1996.500	030	11.9	-78	47.4	12556	10852	6316	-63350	64583	D	ABC	
1997.500	030	16.0	-78	47.3	12555	10843	6328	-63334	64566	D	ABC	
1998.500	030	21.0	-78	47.7	12543	10824	6338	-63320	64550	D	ABC	
1999.500	030	24.3	-78	46.4	12564	10836	6358	-63297	64532	D	ABC	
2000.500	030	29.0	-78	46.6	12554	10819	6368	-63273	64507	D	ABC	
2001.500	030	34.6	-78	46.0	12560	10813	6389	-63238	64473	D	ABC	
2002.500	030	40.0	-78	44.8	12574	10816	6413	-63198	64437	D	ABC	
2003.500	030	46.6	-78	46.8	12534	10769	6413	-63186	64418	D	ABC	
2004.500	030	50.3	-78	45.0	12559	10783	6437	-63136	64374	D	ABC	
2005.500	030	55.2	-78	44.3	12565	10779	6456	-63102	64341	D	ABC	
2006.500	030	58.1	-78	42.0	12601	10805	6484	-63059	64305	D	ABC	
2007.500	031	02.9	-78	41.2	12610	10803	6504	-63031	64280	D	ABZ	4
2008.500	031	07.9	-78	40.3	12622	10804	6525	-62999	64251	D	ABZ	
2009.500	031	13.2	-78	38.8	12643	10813	6553	-62970	64226	D	ABZ	
2010.500	031	19.8	-78	39.4	12628	10787	6566	-62947	64201	D	ABZ	
2011.500	031	26.0	-78	38.8	12635	10781	6589	-62928	64184	D	ABZ	
2012.500	31	33.1	-78	38.4	12639	10771	6614	-62913	64170	D	ABZ	

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. Quiet day annual means from 1980 to 1991 are calculated using preliminary data.
   A LaCour variometer operated at MCQ from 1951 to September 1984

2. A PhotoElectronic Magnetometer (PEM) operated at MCQ from October 1984 to December 1991

3. A Narod Ring Core Fluxgate magnetometer operated as the primary variometer at MCQ from December 1991.to Dec 2006

4. A Danish Meteorological Institute suspended linear-core fluxgate variometer operated as the primary variometer from January 2007

E.9 MAW

ANNUAL MEAN VALUES

MAWSON, MAW, ANTARCTICA

COLATITUDE: 157.60 LONGITUDE: 62.88 E ELEVATION: 12 m

YEAR	D		I		H	X	Y	Z	F	*	ELE	Note
	Deg.	min	Deg.	min	nT	nT	nT	nT	nT			
1955.500	-58	38.1	-69	33.3	18272	9510	-15602	-49012	52307		DHZ	1
1956.500	-58	53.2	-69	32.5	18282	9447	-15652	-49006	52305		DHZ	
1957.500	-59	08.7	-69	31.1	18292	9381	-15703	-48974	52279		DHZ	
1958.500	-59	25.6	-69	30.3	18293	9305	-15750	-48940	52247		DHZ	
1959.500	-59	42.6	-69	28.5	18293	9227	-15796	-48860	52172		DHZ	
1960.500	-59	59.6	-69	25.2	18323	9163	-15867	-48800	52127		DHZ	
1961.500	-60	14.6	-69	23.1	18322	9094	-15906	-48707	52039		DHZ	
1962.500	-60	30.1	-69	21.1	18333	9027	-15956	-48650	51990		DHZ	
1963.500	-60	45.2	-69	17.6	18356	8968	-16016	-48562	51915		DHZ	
1964.500	-60	59.2	-69	15.4	18353	8901	-16050	-48460	51819		DHZ	
1965.500	-61	12.6	-69	13.1	18356	8840	-16087	-48368	51734		DHZ	
1966.500	-61	24.0	-69	09.6	18362	8790	-16122	-48235	51612		DHZ	
1967.500	-61	34.4	-69	07.2	18374	8747	-16159	-48168	51553		DHZ	
1968.500	-61	43.8	-69	05.2	18365	8698	-16175	-48060	51449		DHZ	
1969.500	-61	53.0	-69	03.4	18353	8649	-16187	-47954	51346		DHZ	
1970.500	-62	00.5	-69	00.4	18358	8616	-16210	-47840	51241		DHZ	
1971.500	-62	05.3	-68	56.4	18375	8602	-16237	-47719	51135		DHZ	
1972.500	-62	11.4	-68	53.1	18381	8575	-16258	-47600	51026		DHZ	
1973.500	-62	17.6	-68	49.7	18391	8551	-16282	-47486	50923		DHZ	
1974.500	-62	24.8	-68	47.2	18390	8516	-16299	-47380	50824		DHZ	
1975.500	-62	31.4	-68	44.0	18397	8488	-16322	-47269	50723		DHZ	
1976.500	-62	37.3	-68	40.0	18418	8470	-16355	-47157	50626		DHZ	
1977.500	-62	43.9	-68	36.9	18425	8442	-16377	-47051	50530		DHZ	
1978.500	-62	51.9	-68	35.5	18421	8402	-16393	-46986	50468		DHZ	
1979.500	-62	57.9	-68	32.9	18425	8375	-16412	-46890	50380		DHZ	
1980.500	-63	05.8	-68	29.8	18432	8340	-16437	-46784	50284		DHZ	
1981.500	-63	14.6	-68	27.1	18443	8303	-16468	-46705	50215		DHZ	
1982.500	-63	21.2	-68	25.5	18433	8267	-16475	-46616	50128		DHZ	
1983.500	-63	26.6	-68	22.3	18439	8244	-16494	-46503	50025		DHZ	
1984.500	-63	33.1	-68	19.3	18446	8216	-16515	-46404	49936		DHZ	
1985.500	-63	40.2	-68	17.0	18457	8186	-16542	-46342	49882		DHZ	2
1986.500	-63	48.7	-68	15.1	18460	8147	-16565	-46276	49822		XYZ	
1987.500	-63	56.6	-68	12.5	18470	8113	-16593	-46198	49753		XYZ	
1988.500	-64	04.4	-68	10.7	18475	8078	-16616	-46142	49703		XYZ	
1989.500	-64	12.8	-68	09.7	18474	8037	-16634	-46099	49663		XYZ	
1990.500	-64	21.1	-68	06.4	18492	8004	-16670	-46015	49592		XYZ	
1991.500	-64	28.8	-68	04.2	18502	7971	-16697	-45957	49542		XYZ	3
1992.500	-64	36.9	-68	02.8	18499	7930	-16712	-45894	49482	A	XYZ	4
1993.500	-64	44.2	-68	00.7	18506	7898	-16736	-45830	49426	A	XYZ	
1994.500	-64	52.9	-67	59.4	18511	7858	-16760	-45794	49394	A	XYZ	
1995.500	-65	00.9	-67	56.7	18532	7828	-16798	-45741	49352	A	XYZ	
1996.500	-65	09.8	-67	54.5	18548	7791	-16833	-45698	49319	A	XYZ	
1997.500	-65	19.4	-67	53.0	18560	7749	-16865	-45670	49297	A	XYZ	
1998.500	-65	29.1	-67	52.4	18561	7702	-16887	-45648	49278	A	XYZ	
1999.500	-65	39.0	-67	51.5	18561	7653	-16910	-45618	49250	A	XYZ	
2000.500	-65	48.2	-67	50.6	18566	7610	-16935	-45594	49230	A	XYZ	
2001.500	-65	56.2	-67	49.8	18567	7571	-16953	-45565	49203	A	XYZ	
2002.500	-66	05.8	-67	49.3	18568	7524	-16975	-45546	49185	A	ABZ	
2003.500	-66	15.6	-67	50.7	18546	7466	-16976	-45546	49177	A	ABZ	

2004.500	-66	24.1	-67	49.6	18549	7426	-16998	-45514	49149	A	ABZ
2005.500	-66	33.0	-67	50.1	18535	7376	-17004	-45499	49129	A	ABZ
2006.500	-66	40.8	-67	49.3	18536	7338	-17022	-45472	49105	A	ABZ
2007.500	-66	49.2	-67	49.2	18533	7295	-17037	-45460	49093	A	ABZ 5
2008.500	-66	58.1	-67	49.4	18528	7249	-17051	-45454	49085	A	ABZ
2009.500	-67	6.6	-67	48.9	18533	7209	-17073	-45448	49082	A	ABZ
2010.500	-67	16.8	-67	49.5	18531	7157	-17093	-45466	49097	A	ABZ
2011.500	-67	27.5	-67	49.9	18534	7105	-17118	-45487	49118	A	ABZ
2012.500	-67	38.9	-67	50.6	18534	7048	-17142	-45515	49144	A	ABZ
1992.500	-64	36.5	-68	01.7	18513	7938	-16724	-45885	49479	Q	XYZ
1993.500	-64	43.6	-67	59.4	18522	7908	-16749	-45819	49422	Q	XYZ
1994.500	-64	51.8	-67	57.4	18537	7874	-16781	-45779	49389	Q	XYZ
1995.500	-65	00.4	-67	55.3	18550	7838	-16813	-45731	49350	Q	XYZ
1996.500	-65	09.2	-67	53.5	18561	7799	-16843	-45692	49318	Q	XYZ
1997.500	-65	18.9	-67	52.0	18572	7757	-16875	-45663	49295	Q	XYZ
1998.500	-65	28.6	-67	51.3	18575	7710	-16900	-45642	49277	Q	XYZ
1999.500	-65	38.5	-67	50.2	18579	7663	-16925	-45611	49250	Q	XYZ
2000.500	-65	48.0	-67	49.6	18579	7616	-16946	-45585	49225	Q	XYZ
2001.500	-65	56.3	-67	48.9	18577	7574	-16963	-45555	49198	Q	XYZ
2002.500	-66	05.2	-67	48.2	18581	7532	-16986	-45540	49185	Q	ABZ
2003.500	-66	14.7	-67	48.7	18570	7480	-16997	-45532	49174	Q	ABZ
2004.500	-66	23.5	-67	48.1	18568	7436	-17014	-45503	49146	Q	ABZ
2005.500	-66	32.1	-67	48.4	18557	7389	-17022	-45488	49127	Q	ABZ
2006.500	-66	39.9	-67	48.1	18552	7349	-17035	-45465	49105	Q	ABZ
2007.500	-66	48.7	-67	48.4	18544	7302	-17046	-45455	49092	Q	ABZ
2008.500	-66	57.6	-67	48.6	18539	7256	-17060	-45450	49085	Q	ABZ
2009.500	-67	6.3	-67	48.4	18540	7213	-17080	-45447	49083	Q	ABZ
2010.500	-67	16.2	-67	48.5	18544	7165	-17104	-45460	49097	Q	ABZ
2011.500	-67	27.3	-67	48.9	18546	7111	-17128	-45480	49115	Q	ABZ
2012.500	-67	38.5	-67	49.5	18548	7056	-17153	-45506	49141	Q	ABZ
1992.500	-64	39.6	-68	05.2	18466	7904	-16689	-45907	49482	D	XYZ
1993.500	-64	45.9	-68	03.0	18476	7877	-16713	-45847	49430	D	XYZ
1994.500	-64	55.3	-68	01.9	18476	7831	-16734	-45804	49390	D	XYZ
1995.500	-65	01.7	-67	58.8	18504	7812	-16774	-45752	49353	D	XYZ
1996.500	-65	11.1	-67	56.2	18525	7775	-16814	-45707	49318	D	XYZ
1997.500	-65	20.4	-67	55.0	18534	7733	-16844	-45682	49299	D	XYZ
1998.500	-65	30.9	-67	54.8	18530	7680	-16864	-45665	49282	D	XYZ
1999.500	-65	41.0	-67	53.9	18528	7630	-16884	-45626	49245	D	XYZ
2000.500	-65	49.7	-67	52.6	18543	7593	-16917	-45614	49239	D	XYZ
2001.500	-65	56.4	-67	51.6	18547	7561	-16935	-45583	49212	D	XYZ
2002.500	-66	07.6	-67	51.2	18540	7504	-16953	-45552	49180	D	ABZ
2003.500	-66	17.4	-67	53.2	18510	7443	-16947	-45556	49173	D	ABZ
2004.500	-66	26.0	-67	52.1	18517	7403	-16972	-45530	49152	D	ABZ
2005.500	-66	35.4	-67	53.4	18492	7347	-16970	-45516	49129	D	ABZ
2006.500	-66	42.6	-67	51.6	18504	7316	-16997	-45482	49102	D	ABZ
2007.500	-66	50.0	-67	50.7	18512	7282	-17019	-45463	49087	D	ABZ
2008.500	-66	59.2	-67	51.0	18506	7235	-17034	-45461	49084	D	ABZ
2009.500	-67	7.3	-67	49.9	18520	7200	-17063	-45454	49082	D	ABZ
2010.500	-67	17.8	-67	51.2	18508	7143	-17074	-45475	49097	D	ABZ
2011.500	-67	28.2	-67	51.3	18516	7094	-17103	-45495	49119	D	ABZ
2012.500	-67	40.8	-67	52.7	18510	7030	-17123	-45534	49152	D	ABZ

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes:

1. A LaCour operated at MAW from August 1955 to November 1985.
2. A PEM operated at MAW from December 1985 to October 1992 as principle instrument. The PEM continued in parallel with the Narod from November 1992 and into 1993.
3. The source of annual means 1955 to 1991 in this file did not specify the type A, Q, or D. Examination of the data plots indicate that these means are most likely All Day means.
4. A Narod RCF operated at MAW from November 1992.
5. A Danish DMI FGE magnetometer operated at MAW since 2006 and was the primary source of data from 2007.

E.10 CSY

ANNUAL MEAN VALUES
CASEY, CSY, ANTARCTICA

COLATITUDE: 156.28 LONGITUDE: 110.53 E ELEVATION: 40 m

YEAR	D		I		H	X	Y	Z	F	*	ELE	Note
	Deg.	min	Deg.	min	nT	nT	nT	nT	nT			
2011.500	-95	13.3	-81	41.2	9246	-841	-9208	-63284	63956	A	ABZ	1
2012.500	-95	26.2	-81	43.2	9215	-873	-9173	-63317	63984	A	ABZ	1
2011.500	-95	13.7	-81	41.4	9243	-842	-9205	-63280	63952	Q	ABZ	1
2012.500	-95	25.2	-81	43.2	9213	-870	-9172	-63310	63977	Q	ABZ	1
2011.500	-95	13.2	-81	41.3	9246	-841	-9208	-63291	63962	D	ABZ	1
2012.500	-95	29.8	-81	43.3	9215	-883	-9173	-63333	64000	D	ABZ	1

* A = All days
* Q = 5 International Quiet days each month
* D = 5 International Disturbed days each month

ELE = Elements recorded

Notes: 1. Annual means prior to 2011 will be provided later.

Appendix F K indices, principal storms and rapid variations

These appendices list K indices, principle magnetic storms, SSCs and SFEs observed at GNA, GNG, CNB and MAW in 2012. This data is presented in the plaintext format specified by Observatori de l'Ebre, Spain, for contributions to the International Service on Rapid Magnetic Variations[20]. A description of the interpretation of this format is beyond the scope of this report.

F.1 GNA

```
GEOSCIENCE AUSTRALIA (email: geomag@ga.gov.au)
Gnangara             (GNA) Geomagnetic data for Jan 2012
Location:    Geographic:-31.78d  115.947d
K9 range:  450nT
Variometer: LC
                  P R I N C I P A L    M A G N E T I C   S T O R M S
-------------------------------------------------------------------------------
Commencement      SSC-amplitudes    Max. 3hr-K-indices   Storm Ranges       UT End
Yr Mth Dy Hr Mn   D(') H(nT) Z(nT)  Day(3Hr Periods)  K  D(')  H(nT) Z(nT)  Mth Dy Hr
_______________________________________________________________________________

12 Jan 22 06 11   3.06,29.87,22.74  22(7)             6  24.1  188.4 168.4  Jan 23 06
12 Feb 18 16 43   0.66,7.03,4.32    19(1,2)           5  12.7  80.1  90.1   Feb 19 18
12 Mar 07 04 19   -2.46*,3.79,-8.23 7(3,4,5,6,7)      5  21.9  91.7  146.2  Mar 07 23
12 Mar 08 11 03   -4.5*,41.07,12.78 9(2,4,5)          6  22.0  190.4 170.9  Mar 09 17
12 Mar 12 09 14   4.5,48.75,28.02   12(5)             6  21.6  109.8 147.0  Mar 13 03
12 Mar 15 13 07   -1.98,36.36,1.79  15(6)             6  25.0  110.8 141.1  Mar 16 03
12 Apr 23 03 20   -3.12,18.0,22.18* 23(7,8)           5  15.4  145.2 90.4   Apr 24 09
12 Apr 25 06 00   ...               25(7,8)           5  13.7  84.6  72.7   Apr 26 06
12 Jun 16 09 56   1.26,15.22,3.67   17(4)             6  18.2  220.8 173.1  Jun 17 23
12 Jul 09 09 05   ...               9(5)              6  18.4  101.3 120.4  Jul 10 00
12 Jul 14 18 11   4.02,26.8,27.52   15(4)             6  22.7  182.9 165.0  Jul 16 18
12 Sep 30 11 32   0.66,18.6,8.01    1(1)              6  24.1  169.4 148.4  Oct 01 18
12 Oct 08 05 16   2.52,11.95,13.43  8(4),9(1,2,4,8)   5  21.2  135.7 152.8  Oct 10 03
12 Oct 13 03 06   ...               13(4,5,6)         5  15.0  105.2 118.2  Oct 15 03
-------------------------------------------------------------------------------
  S U D D E N   S T O R M   C O M M E N C E M E N T S
-----------------------------------------------------
UT Date           Type & Quality    Chief movement(nT)
Yr Mth Dy Hr Mn   ssc/ssc* A,B,C    H(x)   D(y)   Z
_____________________________________________________

12 Jan 15 16 22   ssc      c        9.9    2.38   3.55
12 Jan 22 06 11   ssc      b        29.87  21.17  22.74
12 Jan 24 15 04   ssc      a        60.35  17.44  27.45
12 Feb 18 16 43   ssc      b        7.03   4.44   4.32
12 Feb 22 02 16   ssc      c        3.67   -19.67 -8.5
12 Feb 26 21 39   ssc*     a        11.6   22.19* 15.81
12 Mar 07 04 19   ssc*     c        3.79   -16.65*-8.23
12 Mar 08 11 03   ssc*     a        41.07  -30.78*12.78
12 Mar 12 09 14   ssc      a        48.75  30.86  28.02
12 Mar 15 13 07   ssc      a        36.36  -13.6  1.79
12 Apr 23 03 20   ssc*     b        18.0   -21.22 22.18*
12 May 21 19 38   ssc      a        5.45   13.44  10.33
12 Jun 16 09 56   ssc      a        15.22  8.71   3.67
12 Jul 14 18 11   ssc      a        26.8   27.37  27.52
12 Jul 20 04 49   ssc*     a        15.97  23.98* 19.8
12 Aug 02 10 51   ssc      c        5.64   3.28   2.82
12 Sep 03 12 13   ssc      a        40.68  13.06  8.6
12 Sep 20 06 23   ssc      b        18.44  14.19  12.12
12 Sep 30 11 32   ssc      a        18.6   4.52   8.01
12 Sep 30 23 05   ssc*     a        7.04   -51.4* -30.95*
```

[20] http://www.obsebre.es/en/76-english/observation/magnetismrapidvariations/208-rapid-variations (accessed 2018-01-15).

```
12 Oct 08 05 16   ssc      a        11.95  17.21  13.43
12 Oct 31 15 38   ssc      a        28.63  13.33  17.25
12 Nov 12 23 12   ssc*     a        11.15  -37.81*-22.01*
12 Nov 23 21 52   ssc*     c        4.63   -12.47*-9.35*
12 Nov 26 05 07   ssc*     c        13.51* 8.48*  8.68*
-------------------------------------------------------
                  S O L A R  F L A R E  E F F E C T S
-------------------------------------------------------------------------
Yr Mth Dy    UT of movement      Amplitude in nT    Confirmation
             Start  Max   End    H(x)  D(y)   Z
_________________________________________________________________________
Nil
-------------------------------------------------------------------------
     K - I N D I C E S  O F  G E O M A G N E T I C  A C T I V I T Y
-------------------------------------------------------------------------------
UT-Date              K - i n d i c e s          K-sum
12 Jan 01     2   1   1   1     1   2   2   1     11
12 Jan 02     1   0   1   1     2   1   2   4     12
12 Jan 03     4   2   1   2     2   2   1   1     15
12 Jan 04     1   1   0   0     2   0   1   2     7
12 Jan 05     2   1   1   2     3   1   2   2     14
12 Jan 06     2   1   1   2     1   2   2   2     13
12 Jan 07     2   1   1   1     2   2   2   2     13
12 Jan 08     2   1   1   1     1   2   2   1     11
12 Jan 09     3   1   2   2     2   2   2   2     16
12 Jan 10     1   1   1   3     3   2   2   3     16
12 Jan 11     2   2   1   1     0   2   1   2     11
12 Jan 12     2   2   1   2     1   2   3   2     15
12 Jan 13     3   2   3   2     1   2   1   1     15
12 Jan 14     1   1   1   0     0   0   0   1     4
12 Jan 15     1   1   1   0     1   2   2   3     11
12 Jan 16     3   2   2   3     3   3   3   3     22
12 Jan 17     3   1   0   1     2   1   2   1     11
12 Jan 18     1   0   1   1     1   2   1   1     8
12 Jan 19     2   1   1   1     0   2   0   2     9
12 Jan 20     2   2   0   0     1   2   1   0     8
12 Jan 21     2   2   1   3     3   2   2   2     17
12 Jan 22     2   2   5   4     5   4   6   5     33
12 Jan 23     5   2   2   2     1   1   0   1     14
12 Jan 24     3   2   1   2     1   5   4   3     21
12 Jan 25     3   3   4   4     3   2   2   2     23
12 Jan 26     2   1   1   2     2   2   1   2     13
12 Jan 27     1   2   2   2     2   2   1   2     14
12 Jan 28     2   2   2   1     2   1   2   3     15
12 Jan 29     2   1   1   1     0   2   2   1     10
12 Jan 30     0   0   0   0     1   3   4   3     11
12 Jan 31     1   1   1   1     0   0   0   2     6
12 Feb 01     2   2   2   2     2   1   1   1     13
12 Feb 02     2   2   1   2     1   0   2   2     12
12 Feb 03     2   2   1   2     3   2   1   1     14
12 Feb 04     2   1   1   2     4   3   2   3     18
12 Feb 05     3   2   1   2     3   3   3   2     19
12 Feb 06     2   1   0   1     1   4   4   2     15
12 Feb 07     2   2   2   3     4   3   4   3     23
12 Feb 08     3   2   1   1     3   2   3   1     16
12 Feb 09     1   1   0   2     2   3   3   1     13
12 Feb 10     1   1   2   0     1   1   3   2     11
12 Feb 11     2   1   1   0     2   1   1   0     8
12 Feb 12     2   0   0   1     1   1   1   1     7
12 Feb 13     1   2   3   2     3   4   3   2     20
12 Feb 14     3   2   2   2     2   4   3   4     22
12 Feb 15     3   3   2   3     3   4   4   4     26
12 Feb 16     1   0   2   2     3   1   0   1     10
12 Feb 17     0   0   1   1     0   0   0   0     2
12 Feb 18     0   0   0   1     0   1   2   3     7
12 Feb 19     5   5   2   2     3   3   2   3     25
12 Feb 20     4   2   2   3     4   4   3   2     24
12 Feb 21     3   2   1   1     0   2   1   1     11
12 Feb 22     3   2   3   3     3   2   2   1     19
12 Feb 23     0   0   0   2     0   0   1   2     5
12 Feb 24     2   1   1   1     2   2   1   1     11
12 Feb 25     1   0   2   2     3   2   3   2     15
12 Feb 26     3   1   1   1     2   0   2   3     13
12 Feb 27     4   1   1   2     4   4   5   2     23
12 Feb 28     1   2   4   2     1   2   2   3     17
12 Feb 29     2   2   3   1     0   1   1   2     12
12 Mar 01     2   3   3   3     3   3   4   3     24
```

12 Mar 02	3	1	2	1	3	2	2	1	15
12 Mar 03	2	1	2	3	1	3	1	2	15
12 Mar 04	3	2	2	3	2	3	4	1	20
12 Mar 05	1	1	1	3	1	2	2	3	14
12 Mar 06	3	2	2	0	4	3	3	3	20
12 Mar 07	3	3	5	5	5	5	5	4	35
12 Mar 08	2	1	1	4	4	3	4	4	23
12 Mar 09	5	6	5	6	6	5	3	2	38
12 Mar 10	3	2	3	4	3	3	3	1	22
12 Mar 11	2	0	0	2	3	3	3	3	16
12 Mar 12	2	1	1	5	6	3	2	2	22
12 Mar 13	2	1	1	2	3	2	3	1	15
12 Mar 14	2	1	0	2	3	3	3	3	17
12 Mar 15	2	2	2	2	5	6	5	4	28
12 Mar 16	3	2	2	5	3	5	5	4	29
12 Mar 17	4	2	3	4	3	4	4	3	27
12 Mar 18	3	3	1	3	2	3	2	2	19
12 Mar 19	2	2	2	3	3	2	3	3	20
12 Mar 20	2	0	0	1	0	2	2	1	8
12 Mar 21	1	0	0	1	1	1	3	2	9
12 Mar 22	1	1	0	0	0	0	3	4	9
12 Mar 23	2	0	1	1	1	2	2	0	9
12 Mar 24	1	1	3	2	2	3	1	1	14
12 Mar 25	2	1	1	2	2	1	0	0	9
12 Mar 26	1	0	0	1	1	0	0	1	4
12 Mar 27	1	1	1	2	4	3	3	4	19
12 Mar 28	4	3	2	2	4	2	3	1	21
12 Mar 29	0	0	0	0	1	0	1	2	4
12 Mar 30	2	1	1	1	0	1	0	1	7
12 Mar 31	0	0	0	1	1	2	2	0	6
12 Apr 01	1	2	1	2	2	3	4	2	17
12 Apr 02	2	2	2	2	3	3	2	3	19
12 Apr 03	2	2	1	0	0	1	2	3	11
12 Apr 04	2	2	1	0	1	3	2	3	14
12 Apr 05	2	1	4	4	5	3	2	2	23
12 Apr 06	2	0	0	0	0	0	0	1	3
12 Apr 07	2	2	3	4	3	1	0	2	17
12 Apr 08	2	1	1	1	1	1	2	1	10
12 Apr 09	0	0	0	0	0	1	2	1	4
12 Apr 10	2	0	1	1	1	1	2	3	11
12 Apr 11	1	1	2	2	1	0	0	2	9
12 Apr 12	0	3	3	1	2	4	5	4	22
12 Apr 13	4	3	3	3	2	2	3	2	22
12 Apr 14	3	3	2	2	1	3	3	1	18
12 Apr 15	1	1	1	1	2	1	3	1	11
12 Apr 16	2	0	0	0	2	1	1	1	7
12 Apr 17	1	0	1	2	3	2	4	2	15
12 Apr 18	3	3	2	2	2	2	2	1	17
12 Apr 19	1	0	0	0	0	0	3	3	7
12 Apr 20	1	2	3	2	2	1	1	1	13
12 Apr 21	1	1	1	1	1	1	3	3	12
12 Apr 22	3	2	2	3	3	2	2	2	19
12 Apr 23	1	3	3	1	2	3	5	5	23
12 Apr 24	4	3	3	2	3	4	5	3	27
12 Apr 25	3	2	4	3	3	4	5	5	29
12 Apr 26	4	4	2	2	2	2	3	2	21
12 Apr 27	2	2	2	1	2	1	2	1	13
12 Apr 28	0	0	0	2	2	3	3	2	12
12 Apr 29	2	0	0	0	1	0	1	0	4
12 Apr 30	0	0	1	0	0	0	0	0	1
12 May 01	0	0	0	0	0	2	1	1	4
12 May 02	1	0	0	1	2	0	2	2	8
12 May 03	2	1	1	2	2	0	1	2	11
12 May 04	1	2	0	0	0	0	0	0	3
12 May 05	0	0	0	1	1	0	0	1	3
12 May 06	1	0	2	2	1	0	0	0	6
12 May 07	0	1	1	1	0	0	0	0	3
12 May 08	1	1	0	1	1	2	2	3	11
12 May 09	4	3	3	3	4	4	4	3	28
12 May 10	3	3	2	2	2	3	3	3	21
12 May 11	3	3	2	2	2	4	3	2	21
12 May 12	2	2	2	2	3	2	3	2	18
12 May 13	3	2	2	3	3	2	3	2	20
12 May 14	1	1	1	0	0	1	1	1	6
12 May 15	1	1	2	0	0	0	0	1	5
12 May 16	2	1	1	1	3	3	3	4	18
12 May 17	1	0	0	0	0	0	0	1	2

12 May 18	3	1	1	1	1	2	2	1	12
12 May 19	1	1	1	1	1	1	1	1	8
12 May 20	2	3	3	1	3	2	1	0	15
12 May 21	1	0	0	0	0	0	2	1	4
12 May 22	2	4	2	3	3	3	5	4	26
12 May 23	3	3	4	2	1	3	3	2	21
12 May 24	1	2	1	3	2	3	1	1	14
12 May 25	2	1	1	3	2	3	1	1	14
12 May 26	1	1	1	1	0	0	0	0	4
12 May 27	1	2	0	0	0	0	0	0	3
12 May 28	0	1	0	1	1	2	2	1	8
12 May 29	1	1	0	0	0	1	1	2	6
12 May 30	2	2	2	2	2	2	2	1	15
12 May 31	1	1	2	2	1	1	2	0	10
12 Jun 01	0	0	0	2	1	1	1	0	5
12 Jun 02	2	1	1	1	1	2	2	3	13
12 Jun 03	2	1	2	3	4	5	4	1	22
12 Jun 04	1	2	2	4	3	4	2	4	22
12 Jun 05	2	3	3	2	4	4	3	4	25
12 Jun 06	3	3	2	3	3	3	5	2	24
12 Jun 07	2	2	2	2	0	2	3	1	14
12 Jun 08	2	2	3	3	1	0	1	0	12
12 Jun 09	2	1	0	1	2	1	1	1	9
12 Jun 10	0	0	0	0	2	1	1	2	6
12 Jun 11	1	2	2	2	3	2	4	5	21
12 Jun 12	3	2	1	0	0	1	1	0	8
12 Jun 13	1	1	1	1	0	1	1	1	7
12 Jun 14	1	1	0	1	0	0	1	1	5
12 Jun 15	0	0	0	0	0	1	0	0	1
12 Jun 16	0	0	0	2	3	3	4	5	17
12 Jun 17	3	2	4	6	5	4	3	3	30
12 Jun 18	3	4	2	3	2	2	1	1	18
12 Jun 19	0	0	0	0	0	0	0	0	0
12 Jun 20	1	2	1	0	0	0	0	0	4
12 Jun 21	0	0	0	0	0	0	0	1	1
12 Jun 22	1	1	1	1	2	0	0	0	6
12 Jun 23	0	0	1	1	0	1	1	1	5
12 Jun 24	1	1	0	1	1	1	0	0	5
12 Jun 25	1	1	2	1	2	2	3	1	13
12 Jun 26	2	2	2	2	1	1	0	1	11
12 Jun 27	1	1	1	0	2	2	1	2	10
12 Jun 28	1	1	2	1	1	1	1	0	8
12 Jun 29	1	1	1	0	1	0	1	2	7
12 Jun 30	2	2	3	4	4	4	4	4	27
12 Jul 01	3	3	3	3	3	3	3	2	23
12 Jul 02	3	3	3	3	5	4	3	2	26
12 Jul 03	2	2	1	3	2	4	1	1	16
12 Jul 04	2	2	2	2	2	1	0	1	12
12 Jul 05	3	2	1	3	3	2	2	2	18
12 Jul 06	2	2	2	1	3	2	4	4	20
12 Jul 07	2	2	2	1	1	1	1	2	12
12 Jul 08	1	2	1	2	2	1	1	5	15
12 Jul 09	5	3	2	5	6	4	3	4	32
12 Jul 10	2	3	2	3	2	3	3	2	20
12 Jul 11	1	2	3	3	1	1	2	2	15
12 Jul 12	2	2	3	4	1	1	0	1	14
12 Jul 13	0	0	0	1	1	0	0	0	2
12 Jul 14	0	0	0	0	1	3	4	4	12
12 Jul 15	4	4	5	6	5	5	5	5	39
12 Jul 16	4	3	5	5	5	4	3	3	32
12 Jul 17	2	3	4	2	2	2	1	2	18
12 Jul 18	1	1	1	0	1	0	2	1	7
12 Jul 19	1	1	1	1	2	2	1	0	9
12 Jul 20	1	3	1	2	1	5	2	3	18
12 Jul 21	1	1	2	1	0	3	2	1	11
12 Jul 22	1	2	2	3	1	0	0	1	10
12 Jul 23	2	2	1	1	2	3	3	2	16
12 Jul 24	3	2	2	1	3	2	2	1	16
12 Jul 25	2	1	2	1	1	1	1	0	9
12 Jul 26	0	0	0	0	1	0	0	0	1
12 Jul 27	0	2	1	0	0	0	0	1	4
12 Jul 28	1	1	2	1	2	3	2	3	15
12 Jul 29	2	2	1	2	1	0	2	0	10
12 Jul 30	1	1	3	3	4	4	4	2	22
12 Jul 31	1	1	1	0	1	1	1	1	7
12 Aug 01	1	2	1	1	1	1	1	2	10
12 Aug 02	0	0	0	1	4	4	3	3	15

12 Aug 03	2	2	1	1	1	1	0	0	8
12 Aug 04	1	1	1	0	1	2	2	3	11
12 Aug 05	1	0	1	1	0	0	1	2	6
12 Aug 06	2	2	2	2	2	3	2	3	18
12 Aug 07	2	1	1	1	0	1	2	2	10
12 Aug 08	4	1	0	3	2	2	2	1	15
12 Aug 09	2	2	1	1	1	1	0	0	8
12 Aug 10	1	1	1	0	0	0	0	0	3
12 Aug 11	0	0	0	1	1	1	2	2	7
12 Aug 12	1	1	1	0	2	2	3	2	12
12 Aug 13	1	1	2	3	1	4	3	1	16
12 Aug 14	2	1	1	2	2	3	1	2	14
12 Aug 15	1	0	1	1	1	1	2	2	9
12 Aug 16	1	2	2	1	4	4	4	2	20
12 Aug 17	2	1	2	2	1	1	2	2	13
12 Aug 18	0	2	1	3	2	1	4	3	16
12 Aug 19	2	1	2	3	4	2	1	3	18
12 Aug 20	3	2	2	2	4	1	3	2	19
12 Aug 21	1	1	1	2	2	2	1	3	13
12 Aug 22	1	1	1	1	3	1	1	2	11
12 Aug 23	2	1	2	2	3	2	3	1	16
12 Aug 24	1	1	1	1	3	1	2	1	11
12 Aug 25	1	2	2	2	3	3	3	2	18
12 Aug 26	1	1	1	2	4	3	4	2	18
12 Aug 27	2	2	1	1	0	2	0	1	9
12 Aug 28	1	1	0	0	1	0	0	1	4
12 Aug 29	1	1	1	0	0	1	0	1	5
12 Aug 30	1	0	0	0	0	0	2	0	3
12 Aug 31	0	0	0	0	0	0	0	0	0
12 Sep 01	1	1	3	1	2	1	1	0	10
12 Sep 02	2	2	2	3	2	2	5	3	21
12 Sep 03	2	3	2	3	5	3	4	3	25
12 Sep 04	3	2	3	2	2	2	1	3	18
12 Sep 05	3	3	4	3	2	2	3	2	22
12 Sep 06	3	2	1	1	0	2	3	1	13
12 Sep 07	2	2	2	2	3	2	4	3	20
12 Sep 08	2	2	1	2	2	3	2	1	15
12 Sep 09	1	0	1	0	1	2	1	1	7
12 Sep 10	1	1	1	0	1	1	0	0	5
12 Sep 11	0	0	0	0	0	1	0	0	1
12 Sep 12	2	0	1	1	1	1	2	2	10
12 Sep 13	2	1	0	0	0	3	1	1	8
12 Sep 14	1	1	1	0	1	3	0	2	9
12 Sep 15	2	1	1	1	1	2	2	1	11
12 Sep 16	1	1	1	1	1	1	4	1	11
12 Sep 17	1	1	0	0	2	1	1	1	7
12 Sep 18	2	2	2	2	3	3	1	2	17
12 Sep 19	2	2	1	1	2	3	4	5	20
12 Sep 20	2	2	3	2	2	3	2	2	18
12 Sep 21	2	0	1	3	2	3	1	1	13
12 Sep 22	2	1	2	2	0	1	0	1	9
12 Sep 23	0	0	0	0	0	0	0	0	0
12 Sep 24	0	0	0	0	0	1	1	1	3
12 Sep 25	1	0	0	0	1	0	0	0	2
12 Sep 26	1	1	1	1	2	1	3	3	13
12 Sep 27	3	2	1	1	0	0	0	1	8
12 Sep 28	1	0	0	0	0	0	0	1	2
12 Sep 29	0	1	1	0	1	1	1	1	6
12 Sep 30	2	1	1	3	3	3	2	4	19
12 Oct 01	6	3	3	2	2	1	1	2	20
12 Oct 02	2	0	0	2	3	3	2	3	15
12 Oct 03	3	1	1	1	0	1	0	1	8
12 Oct 04	0	1	0	0	1	0	0	0	2
12 Oct 05	0	1	0	1	0	2	2	2	8
12 Oct 06	2	1	1	2	3	2	2	2	15
12 Oct 07	1	1	1	2	1	0	2	2	10
12 Oct 08	2	3	4	5	4	2	4	4	28
12 Oct 09	5	5	4	5	2	2	3	5	31
12 Oct 10	3	1	1	2	2	4	4	3	20
12 Oct 11	2	1	1	1	3	2	1	2	13
12 Oct 12	3	2	2	2	4	3	3	1	20
12 Oct 13	2	2	4	5	5	5	3	3	29
12 Oct 14	4	2	2	4	4	3	3	3	25
12 Oct 15	2	0	1	3	2	1	2	2	13
12 Oct 16	2	1	1	1	2	3	0	1	11
12 Oct 17	3	1	2	1	2	1	1	3	14
12 Oct 18	2	1	0	1	0	2	1	2	9

```
12 Oct 19     2   0   0   0     0   0   0   1     3
12 Oct 20     0   0   0   1     0   0   0   0     1
12 Oct 21     1   0   0   1     1   1   0   0     4
12 Oct 22     2   1   0   0     0   1   1   1     6
12 Oct 23     2   2   1   3     2   2   2   1     15
12 Oct 24     1   0   0   1     1   1   0   0     4
12 Oct 25     1   0   0   0     0   0   0   2     3
12 Oct 26     1   0   1   0     0   2   1   2     7
12 Oct 27     1   0   1   1     1   1   0   1     6
12 Oct 28     1   1   1   1     2   1   1   0     8
12 Oct 29     0   0   0   0     0   0   0   1     1
12 Oct 30     0   0   0   1     1   0   0   1     3
12 Oct 31     1   0   1   0     2   3   2   2     11
12 Nov 01     4   2   2   4     4   5   3   3     27
12 Nov 02     2   2   1   1     1   1   2   2     12
12 Nov 03     1   0   1   1     2   2   1   1     9
12 Nov 04     1   1   0   0     1   1   0   0     4
12 Nov 05     0   0   0   1     1   2   1   1     6
12 Nov 06     0   1   1   1     2   2   0   2     9
12 Nov 07     3   2   1   1     3   4   3   2     19
12 Nov 08     2   0   0   1     1   0   0   1     5
12 Nov 09     0   1   0   0     1   0   0   0     2
12 Nov 10     0   0   0   1     1   0   2   2     6
12 Nov 11     1   0   1   1     2   1   0   2     8
12 Nov 12     1   0   0   0     1   2   1   4     9
12 Nov 13     5   3   3   4     2   3   3   4     27
12 Nov 14     5   4   5   4     4   2   0   2     26
12 Nov 15     1   0   0   1     1   1   0   2     6
12 Nov 16     2   1   1   0     2   3   3   2     14
12 Nov 17     2   2   2   3     2   2   3   1     17
12 Nov 18     1   1   1   1     2   2   0   2     10
12 Nov 19     2   0   1   1     2   2   0   1     9
12 Nov 20     2   1   2   2     2   3   4   2     18
12 Nov 21     2   2   2   2     2   2   2   1     15
12 Nov 22     2   0   0   0     1   0   0   1     4
12 Nov 23     1   0   0   0     1   1   2   3     8
12 Nov 24     4   2   3   3     3   3   2   3     23
12 Nov 25     1   2   2   1     3   3   1   2     15
12 Nov 26     2   2   2   1     1   1   1   2     12
12 Nov 27     1   0   0   1     2   1   2   2     9
12 Nov 28     1   1   0   0     0   0   2   1     5
12 Nov 29     1   0   1   1     0   2   1   2     8
12 Nov 30     1   0   0   1     1   1   0   1     5
12 Dec 01     1   1   1   0     2   2   2   1     10
12 Dec 02     2   1   3   3     3   1   0   1     14
12 Dec 03     1   0   1   1     2   2   1   3     11
12 Dec 04     1   3   3   1     0   0   1   1     10
12 Dec 05     1   0   0   0     0   0   0   1     2
12 Dec 06     1   0   0   0     0   0   0   0     1
12 Dec 07     0   0   0   0     0   0   0   1     1
12 Dec 08     1   0   0   0     0   0   1   1     3
12 Dec 09     1   2   1   1     2   2   2   3     14
12 Dec 10     1   1   0   1     1   1   1   2     8
12 Dec 11     2   1   1   0     1   0   1   2     8
12 Dec 12     1   0   2   1     1   1   1   1     8
12 Dec 13     2   1   0   0     0   1   1   1     6
12 Dec 14     1   1   2   1     1   1   2   3     12
12 Dec 15     2   2   2   2     3   3   3   2     19
12 Dec 16     2   1   1   2     2   3   3   1     15
12 Dec 17     3   1   2   3     3   3   1   2     18
12 Dec 18     3   1   1   2     2   3   0   2     14
12 Dec 19     1   1   1   1     2   1   1   1     9
12 Dec 20     2   1   2   2     4   3   2   2     18
12 Dec 21     2   1   1   1     1   1   0   1     8
12 Dec 22     0   0   0   0     0   1   0   1     2
12 Dec 23     0   0   0   0     1   2   0   1     4
12 Dec 24     1   0   0   0     1   3   1   1     7
12 Dec 25     2   1   1   1     0   1   1   2     9
12 Dec 26     2   0   1   1     1   0   0   2     7
12 Dec 27     2   0   0   0     0   0   0   0     2
12 Dec 28     0   1   0   1     1   1   2   1     7
12 Dec 29     1   1   1   1     1   1   1   2     9
12 Dec 30     2   1   1   2     2   2   2   1     13
12 Dec 31     1   1   1   0     0   1   0   1     5
Mean of K-Sum is  12.8
Frequency Distribution of K-Indices
K-Index :   0    1    2    3    4    5    6    7    8    9    -
```

```
           586   928   786   408   147   63   10   0    0    0    0
-------------------------------------------------------------------------
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F.2 GNG

GEOSCIENCE AUSTRALIA (email: geomag@ga.gov.au)
Gingin (GNG) Geomagnetic data for Jan 2012
Location: Geographic:-31.356d 115.715d
K9 range: 430nT
Variometer: LC

P R I N C I P A L M A G N E T I C S T O R M S

Commencement Yr Mth Dy Hr Mn	SSC-amplitudes D(') H(nT) Z(nT)	Max. 3hr-K-indices Day(3Hr Periods)	K	Storm Ranges D(') H(nT) Z(nT)	UT End Mth Dy Hr
12 Sep 30 11 32	...	1(1)	6	24.2 165.4 96.3	Oct 01 18
12 Oct 08 05 16	...	9(1,4)	6	22.1 146.1 111.4	Oct 10 06
12 Oct 13 03 19	...	13(4,5,6)	5	15.3 119.2 89.6	Oct 16 03

S U D D E N S T O R M C O M M E N C E M E N T S

UT Date Yr Mth Dy Hr Mn	Type & Quality ssc/ssc* A,B,C	Chief movement(nT) H(x)	D(y)	Z
12 Jan 15 16 22	ssc c	10.59	1.38	0.87
12 Oct 31 15 40	ssc a	25.98	11.81	5.28

S O L A R F L A R E E F F E C T S

Yr Mth Dy	UT of movement Start	Max	End	Amplitude in nT H(x)	D(y)	Z	Confirmation
Nil							

K - I N D I C E S O F G E O M A G N E T I C A C T I V I T Y

UT-Date	K - i n d i c e s								K-sum
12 Jan 01	2	1	1	2	2	2	2	1	13
12 Jan 02	1	0	1	1	2	1	3	4	13
12 Jan 03	4	3	2	2	2	2	1	1	17
12 Jan 04	1	1	0	0	2	0	1	2	7
12 Jan 05	2	2	1	2	3	1	2	2	15
12 Jan 06	2	1	1	2	1	2	2	2	13
12 Jan 07	2	1	1	1	2	2	2	2	13
12 Jan 08	2	1	1	1	1	2	2	1	11
12 Jan 09	3	1	2	2	2	2	2	2	16
12 Jan 10	2	1	1	3	3	2	3	3	18
12 Jan 11	2	1	1	1	0	2	1	2	10
12 Jan 12	2	2	1	2	2	2	3	3	17
12 Jan 13	3	2	3	2	1	2	1	1	15
12 Jan 14	1	1	2	0	0	0	0	1	5
12 Jan 15	1	1	1	0	1	2	2	3	11
12 Jan 16	3	2	2	3	3	3	3	3	22
12 Jan 17	3	1	1	1	2	1	2	1	12
12 Jan 18	1	0	1	1	1	2	1	1	8
12 Jan 19	2	2	1	1	0	2	1	2	11
12 Jan 20	2	2	0	1	2	2	1	0	10
12 Jan 21	2	2	1	3	3	2	2	2	17
12 Jan 22	2	3	5	5	5	4	6	5	35
12 Jan 23	5	2	2	2	1	1	0	1	14
12 Jan 24	3	2	1	2	2	5	4	4	23
12 Jan 25	3	3	4	4	3	2	2	2	23
12 Jan 26	2	1	1	2	2	3	1	2	14
12 Jan 27	1	2	2	2	3	2	1	2	15
12 Jan 28	2	2	2	1	2	1	2	3	15
12 Jan 29	2	1	1	1	0	2	2	1	10
12 Jan 30	0	0	0	0	1	3	4	3	11
12 Jan 31	1	1	1	1	0	0	0	2	6
12 Feb 01	2	2	2	2	2	1	1	1	13
12 Feb 02	2	2	1	2	1	0	2	2	12
12 Feb 03	2	2	1	2	3	2	1	1	14
12 Feb 04	2	1	1	2	4	3	2	3	18
12 Feb 05	3	2	1	1	3	3	3	2	18
12 Feb 06	2	1	0	1	1	4	4	2	15
12 Feb 07	2	3	2	3	5	4	5	3	27
12 Feb 08	3	2	2	1	3	2	3	1	17
12 Feb 09	1	1	0	2	2	3	3	1	13
12 Feb 10	1	1	2	0	1	1	3	2	11

12 Feb 11	2	0	1	0	2	1	1	0	7
12 Feb 12	2	1	0	1	1	1	1	1	8
12 Feb 13	1	2	3	2	4	4	3	2	21
12 Feb 14	3	2	3	2	2	4	3	4	23
12 Feb 15	3	3	2	3	3	4	4	4	26
12 Feb 16	2	0	2	2	3	1	0	2	12
12 Feb 17	0	0	1	0	1	0	0	0	2
12 Feb 18	0	1	0	1	0	1	2	3	8
12 Feb 19	5	5	3	2	3	3	2	3	26
12 Feb 20	4	2	2	3	4	4	3	3	25
12 Feb 21	3	2	1	1	0	2	1	1	11
12 Feb 22	3	1	3	3	3	2	2	1	18
12 Feb 23	0	0	1	2	0	1	1	2	7
12 Feb 24	2	1	0	1	2	2	1	1	10
12 Feb 25	1	0	2	2	3	2	3	2	15
12 Feb 26	3	1	1	1	3	1	2	3	15
12 Feb 27	4	2	1	2	4	5	5	2	25
12 Feb 28	1	2	4	2	2	2	2	3	18
12 Feb 29	2	3	3	1	0	1	1	2	13
12 Mar 01	2	3	3	3	4	3	4	3	25
12 Mar 02	3	1	2	2	4	2	2	1	17
12 Mar 03	2	1	2	3	1	3	1	3	16
12 Mar 04	3	2	3	3	2	3	4	2	22
12 Mar 05	1	0	2	3	1	2	3	3	15
12 Mar 06	3	2	2	0	4	3	3	3	20
12 Mar 07	3	3	5	6	6	5	5	4	37
12 Mar 08	1	1	1	5	4	4	4	4	24
12 Mar 09	5	6	5	6	6	5	3	2	38
12 Mar 10	3	3	3	4	3	3	3	1	23
12 Mar 11	3	0	0	2	3	3	3	3	17
12 Mar 12	2	1	1	6	6	3	3	3	25
12 Mar 13	2	1	1	2	3	2	3	2	16
12 Mar 14	3	1	1	2	3	3	3	3	19
12 Mar 15	2	2	1	2	5	6	5	4	27
12 Mar 16	3	2	2	5	3	5	5	4	29
12 Mar 17	4	2	3	4	3	4	5	3	28
12 Mar 18	3	3	2	3	2	3	2	2	20
12 Mar 19	2	2	1	3	3	2	3	3	19
12 Mar 20	2	1	0	2	1	2	2	1	11
12 Mar 21	1	1	0	1	1	1	3	2	10
12 Mar 22	1	1	0	0	0	0	3	4	9
12 Mar 23	2	0	1	0	1	2	2	0	8
12 Mar 24	1	2	3	2	2	3	1	1	15
12 Mar 25	2	1	2	2	2	1	0	0	10
12 Mar 26	1	0	0	1	1	0	0	1	4
12 Mar 27	1	2	1	3	4	4	3	4	22
12 Mar 28	4	3	2	2	4	2	3	2	22
12 Mar 29	0	0	0	0	1	1	1	2	5
12 Mar 30	2	1	1	1	0	1	0	1	7
12 Mar 31	1	0	0	1	1	2	2	0	7
12 Apr 01	1	2	1	2	3	3	4	2	18
12 Apr 02	2	2	2	2	3	3	2	3	19
12 Apr 03	1	1	0	1	0	1	2	3	9
12 Apr 04	3	2	1	0	1	3	2	3	15
12 Apr 05	2	2	4	5	5	3	2	2	25
12 Apr 06	2	0	1	0	0	0	0	2	5
12 Apr 07	2	2	3	4	3	1	0	2	17
12 Apr 08	2	1	1	1	1	1	2	1	10
12 Apr 09	0	0	0	0	0	1	2	1	4
12 Apr 10	2	0	1	1	1	1	2	3	11
12 Apr 11	1	1	3	2	2	0	0	2	11
12 Apr 12	0	3	3	2	2	4	5	4	23
12 Apr 13	5	3	3	3	2	2	3	2	23
12 Apr 14	3	3	2	2	2	3	3	1	19
12 Apr 15	1	1	1	1	2	1	3	1	11
12 Apr 16	2	0	0	0	2	1	1	1	7
12 Apr 17	1	0	1	2	3	2	4	2	15
12 Apr 18	3	3	3	1	2	2	2	2	18
12 Apr 19	1	0	0	0	0	1	3	3	8
12 Apr 20	1	2	2	2	2	1	1	1	12
12 Apr 21	2	1	0	1	1	1	3	3	12
12 Apr 22	3	2	1	2	3	2	2	1	16
12 Apr 23	1	4	3	1	3	3	5	5	25
12 Apr 24	5	3	3	2	3	5	5	3	29
12 Apr 25	3	2	4	3	3	4	5	5	29
12 Apr 26	4	4	2	2	3	2	3	2	22
12 Apr 27	2	2	2	1	2	1	2	1	13

12 Apr 28	1	1	1	2	2	3	3	2	15
12 Apr 29	2	0	0	0	1	0	1	1	5
12 Apr 30	0	0	1	0	0	0	0	0	1
12 May 01	0	0	0	0	0	2	1	1	4
12 May 02	1	0	0	1	2	0	2	2	8
12 May 03	2	1	1	2	2	0	1	2	11
12 May 04	1	2	0	0	0	1	0	1	5
12 May 05	0	0	0	1	1	0	0	1	3
12 May 06	1	0	2	2	1	0	1	0	7
12 May 07	0	1	1	2	0	0	0	0	4
12 May 08	0	1	1	1	2	2	2	3	12
12 May 09	4	4	3	3	3	4	4	3	28
12 May 10	3	3	2	3	2	3	3	3	22
12 May 11	3	3	2	2	2	4	3	2	21
12 May 12	2	2	2	3	3	2	4	3	21
12 May 13	3	2	2	3	3	2	3	2	20
12 May 14	2	1	1	0	0	1	1	1	7
12 May 15	2	1	2	1	0	0	0	1	7
12 May 16	2	2	1	1	3	3	3	4	19
12 May 17	1	0	0	0	0	0	1	1	3
12 May 18	3	1	1	1	1	2	2	2	13
12 May 19	1	1	1	1	1	1	1	1	8
12 May 20	2	3	3	1	3	2	1	1	16
12 May 21	1	1	0	0	0	0	2	1	5
12 May 22	2	4	2	3	3	4	5	4	27
12 May 23	3	3	4	2	2	3	3	2	22
12 May 24	1	2	1	3	2	3	1	1	14
12 May 25	2	1	1	3	2	3	1	1	14
12 May 26	1	1	1	1	0	0	0	0	4
12 May 27	1	2	0	0	0	0	0	0	3
12 May 28	0	1	0	1	1	2	2	1	8
12 May 29	1	1	0	0	1	1	1	3	8
12 May 30	2	2	2	2	2	2	2	1	15
12 May 31	1	1	2	2	1	2	2	0	11
12 Jun 01	0	1	0	2	1	2	1	1	8
12 Jun 02	2	1	1	1	1	2	3	4	15
12 Jun 03	2	2	2	3	5	5	4	1	24
12 Jun 04	1	2	2	4	3	4	3	4	23
12 Jun 05	2	3	3	2	4	4	3	5	26
12 Jun 06	3	3	2	3	3	3	5	2	24
12 Jun 07	2	2	2	2	0	2	3	1	14
12 Jun 08	2	2	3	4	1	0	1	0	13
12 Jun 09	1	1	1	1	2	1	1	1	9
12 Jun 10	0	1	0	0	2	1	1	3	8
12 Jun 11	1	2	3	3	3	2	4	5	23
12 Jun 12	3	2	1	0	1	1	1	0	9
12 Jun 13	1	2	2	2	0	1	1	1	10
12 Jun 14	1	1	0	1	0	0	1	1	5
12 Jun 15	0	0	0	0	0	1	0	0	1
12 Jun 16	0	0	0	2	3	3	4	5	17
12 Jun 17	3	3	4	6	5	4	3	3	31
12 Jun 18	3	4	3	3	2	3	2	1	21
12 Jun 19	0	0	0	0	0	0	0	0	0
12 Jun 20	1	2	1	0	0	0	0	0	4
12 Jun 21	1	0	0	0	0	0	0	1	2
12 Jun 22	1	1	2	2	2	1	0	0	9
12 Jun 23	0	0	1	1	0	1	1	1	5
12 Jun 24	1	1	0	1	1	1	0	0	5
12 Jun 25	1	1	2	1	2	2	3	1	13
12 Jun 26	2	2	3	2	1	1	0	2	13
12 Jun 27	1	1	1	1	2	2	1	2	11
12 Jun 28	1	1	2	1	1	2	1	0	9
12 Jun 29	1	1	1	0	1	0	1	2	7
12 Jun 30	2	2	3	5	5	5	4	4	30
12 Jul 01	3	3	3	3	3	3	3	3	24
12 Jul 02	3	3	4	3	5	4	3	3	28
12 Jul 03	2	2	2	3	2	4	1	1	17
12 Jul 04	2	2	2	2	2	1	0	1	12
12 Jul 05	3	2	1	3	3	2	2	2	18
12 Jul 06	2	2	2	1	3	2	5	4	21
12 Jul 07	2	2	2	1	1	1	1	2	12
12 Jul 08	1	2	2	3	2	1	1	5	17
12 Jul 09	5	3	2	5	6	4	3	4	32
12 Jul 10	2	3	2	3	2	3	3	2	20
12 Jul 11	1	2	3	3	1	1	2	3	16
12 Jul 12	3	3	3	4	1	1	1	1	17
12 Jul 13	0	0	0	1	1	0	1	0	3

12 Jul 14	0	1	0	0	1	3	5	4	14
12 Jul 15	4	4	5	6	5	6	5	5	40
12 Jul 16	4	4	5	5	6	4	3	4	35
12 Jul 17	2	3	4	2	2	2	1	2	18
12 Jul 18	1	1	1	0	1	0	2	1	7
12 Jul 19	1	1	1	1	2	2	1	0	9
12 Jul 20	1	3	1	3	1	5	2	3	19
12 Jul 21	1	1	2	1	1	3	2	1	12
12 Jul 22	0	2	2	3	2	0	0	1	10
12 Jul 23	2	2	1	1	2	3	3	2	16
12 Jul 24	3	2	2	1	4	2	2	1	17
12 Jul 25	2	1	2	1	1	1	1	0	9
12 Jul 26	1	0	0	0	1	0	0	0	2
12 Jul 27	0	2	1	0	0	0	0	1	4
12 Jul 28	1	1	2	1	2	3	2	3	15
12 Jul 29	2	2	1	2	0	0	2	0	9
12 Jul 30	1	2	3	4	4	4	4	2	24
12 Jul 31	1	1	1	0	1	2	1	1	8
12 Aug 01	1	2	1	1	1	1	1	3	11
12 Aug 02	0	0	0	2	5	4	4	3	18
12 Aug 03	2	3	2	1	1	1	0	0	10
12 Aug 04	1	1	1	0	1	2	2	3	11
12 Aug 05	1	0	1	1	0	1	1	2	7
12 Aug 06	2	3	2	2	2	3	2	3	19
12 Aug 07	2	1	1	2	1	1	2	2	12
12 Aug 08	5	1	1	3	2	2	2	1	17
12 Aug 09	2	2	1	1	1	1	1	0	9
12 Aug 10	1	1	0	0	0	0	0	0	2
12 Aug 11	0	0	1	0	1	1	2	2	7
12 Aug 12	1	1	1	0	2	2	3	3	13
12 Aug 13	1	1	2	2	1	4	3	1	15
12 Aug 14	2	2	2	2	2	3	1	2	16
12 Aug 15	1	0	1	1	1	1	2	2	9
12 Aug 16	1	2	3	1	4	4	4	2	21
12 Aug 17	2	1	2	2	1	1	2	2	13
12 Aug 18	0	2	1	3	2	1	4	3	16
12 Aug 19	2	2	2	3	4	2	1	3	19
12 Aug 20	3	2	2	2	4	2	3	2	20
12 Aug 21	1	1	1	2	2	2	2	3	14
12 Aug 22	1	1	1	1	3	2	1	2	12
12 Aug 23	3	2	2	2	3	3	3	1	19
12 Aug 24	1	1	1	1	3	2	2	1	12
12 Aug 25	2	2	2	2	3	3	3	2	19
12 Aug 26	2	2	1	2	4	3	4	2	20
12 Aug 27	2	2	1	1	0	2	0	1	9
12 Aug 28	2	1	0	0	1	0	0	1	5
12 Aug 29	1	1	1	0	0	1	0	1	5
12 Aug 30	1	0	0	0	0	0	2	0	3
12 Aug 31	0	0	0	1	1	0	0	0	2
12 Sep 01	1	1	3	1	2	1	1	0	10
12 Sep 02	2	2	2	3	2	2	5	3	21
12 Sep 03	2	2	3	3	5	4	4	3	26
12 Sep 04	3	2	3	2	2	2	1	3	18
12 Sep 05	3	3	5	3	2	2	3	2	23
12 Sep 06	3	2	2	1	0	2	3	1	14
12 Sep 07	2	1	2	2	3	2	5	3	20
12 Sep 08	2	1	1	2	2	3	3	1	15
12 Sep 09	1	0	1	1	1	2	1	1	8
12 Sep 10	1	1	1	0	1	1	0	0	5
12 Sep 11	0	0	0	0	1	1	0	0	2
12 Sep 12	2	0	1	1	1	1	2	2	10
12 Sep 13	3	2	1	0	1	3	1	1	12
12 Sep 14	1	0	1	0	1	3	1	2	9
12 Sep 15	2	1	1	1	1	2	2	1	11
12 Sep 16	1	1	1	1	1	1	4	1	11
12 Sep 17	1	1	0	1	2	1	1	2	9
12 Sep 18	2	2	2	2	3	3	1	2	17
12 Sep 19	2	2	1	1	2	3	4	5	20
12 Sep 20	3	2	3	2	2	3	2	2	19
12 Sep 21	2	1	1	3	2	3	2	1	15
12 Sep 22	2	1	2	2	1	1	0	1	10
12 Sep 23	0	0	0	0	0	0	0	1	1
12 Sep 24	0	0	1	0	0	1	1	1	4
12 Sep 25	1	1	0	0	0	0	0	0	2
12 Sep 26	1	1	1	1	2	2	3	3	14
12 Sep 27	3	2	1	1	1	1	0	1	10
12 Sep 28	1	0	0	0	0	0	0	1	2

12 Sep 29	1	1	2	1	1	2	1	1	10
12 Sep 30	2	2	1	3	3	3	3	4	21
12 Oct 01	6	3	2	2	2	2	1	2	20
12 Oct 02	2	1	0	3	3	3	2	4	18
12 Oct 03	3	1	2	1	1	1	0	0	9
12 Oct 04	0	1	0	1	1	0	0	0	3
12 Oct 05	0	1	1	1	1	2	2	2	10
12 Oct 06	2	0	1	2	3	3	2	2	15
12 Oct 07	1	1	1	2	1	0	2	2	10
12 Oct 08	2	3	4	5	4	2	4	4	28
12 Oct 09	6	5	5	6	2	3	3	5	35
12 Oct 10	3	2	1	3	2	4	4	3	22
12 Oct 11	2	1	1	1	3	2	1	2	13
12 Oct 12	3	2	2	3	4	3	3	1	21
12 Oct 13	2	2	4	5	5	5	3	3	29
12 Oct 14	4	2	2	4	4	3	3	3	25
12 Oct 15	2	1	1	3	2	1	2	2	14
12 Oct 16	2	1	1	1	2	3	0	1	11
12 Oct 17	3	1	2	1	2	1	1	3	14
12 Oct 18	2	1	1	1	0	2	1	2	10
12 Oct 19	2	1	0	0	0	0	1	1	5
12 Oct 20	0	0	0	1	0	0	0	0	1
12 Oct 21	1	0	0	1	1	1	1	0	5
12 Oct 22	2	1	0	0	0	1	1	1	6
12 Oct 23	3	3	1	3	2	2	2	1	17
12 Oct 24	2	0	0	1	1	1	0	1	6
12 Oct 25	1	1	0	0	1	0	0	2	5
12 Oct 26	1	1	1	0	0	2	1	2	8
12 Oct 27	2	1	1	1	1	1	1	1	9
12 Oct 28	1	1	1	1	2	1	2	0	9
12 Oct 29	0	0	0	0	0	0	0	1	1
12 Oct 30	0	0	0	1	1	0	1	1	4
12 Oct 31	1	0	1	0	2	3	2	2	11
12 Nov 01	4	2	2	4	4	5	4	3	28
12 Nov 02	2	2	1	1	1	2	2	2	13
12 Nov 03	1	0	1	1	2	2	1	1	9
12 Nov 04	1	1	0	0	1	2	0	0	5
12 Nov 05	1	0	1	1	1	2	1	1	8
12 Nov 06	0	1	1	1	1	2	1	2	9
12 Nov 07	3	2	2	2	3	4	4	3	23
12 Nov 08	2	1	0	2	1	0	0	1	7
12 Nov 09	0	1	0	0	1	0	1	0	3
12 Nov 10	0	0	0	1	1	0	2	2	6
12 Nov 11	1	0	1	1	2	1	0	2	8
12 Nov 12	2	0	0	0	1	2	1	4	10
12 Nov 13	5	3	3	4	3	3	3	4	28
12 Nov 14	5	4	5	4	4	2	0	2	26
12 Nov 15	1	0	0	1	1	1	0	2	6
12 Nov 16	2	1	1	0	2	3	3	2	14
12 Nov 17	2	1	2	3	3	2	3	1	17
12 Nov 18	1	1	1	1	2	2	0	1	9
12 Nov 19	2	0	1	1	2	2	0	2	10
12 Nov 20	2	1	2	3	2	3	4	2	19
12 Nov 21	2	2	2	2	2	2	2	1	15
12 Nov 22	2	1	0	0	1	0	0	1	5
12 Nov 23	1	0	0	0	1	0	2	3	7
12 Nov 24	4	3	3	3	3	3	2	3	24
12 Nov 25	2	2	2	1	3	3	1	2	16
12 Nov 26	2	2	2	1	1	2	1	2	13
12 Nov 27	1	0	0	1	2	1	2	2	9
12 Nov 28	1	1	0	0	0	0	2	1	5
12 Nov 29	1	0	1	1	0	2	1	2	8
12 Nov 30	1	0	0	2	1	1	0	1	6
12 Dec 01	1	1	1	1	2	2	2	2	12
12 Dec 02	2	1	3	3	3	1	0	1	14
12 Dec 03	1	0	1	1	2	2	1	3	11
12 Dec 04	1	3	3	1	0	0	1	1	10
12 Dec 05	1	0	0	0	0	0	1	1	3
12 Dec 06	2	0	0	0	0	0	0	1	3
12 Dec 07	0	0	0	0	0	0	1	1	2
12 Dec 08	1	0	0	0	0	0	1	1	3
12 Dec 09	2	2	1	2	2	2	2	3	16
12 Dec 10	1	1	1	1	1	1	1	2	9
12 Dec 11	2	0	1	0	1	0	1	2	7
12 Dec 12	1	0	2	1	1	0	1	1	7
12 Dec 13	2	2	0	0	1	2	1	1	9
12 Dec 14	1	1	2	1	1	1	2	3	12

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12 Dec 15     2   2   2   2     3   3   3   2     19
12 Dec 16     2   1   1   2     2   3   3   1     15
12 Dec 17     3   1   2   3     3   3   1   2     18
12 Dec 18     3   1   1   2     2   3   0   2     14
12 Dec 19     1   2   1   1     2   1   1   1     10
12 Dec 20     2   1   2   2     4   3   2   3     19
12 Dec 21     2   1   1   1     1   1   1   1     9
12 Dec 22     0   0   0   0     0   1   0   1     2
12 Dec 23     0   0   0   0     1   2   0   1     4
12 Dec 24     1   0   0   0     1   3   1   1     7
12 Dec 25     2   0   1   0     0   2   1   1     7
12 Dec 26     2   0   1   1     1   0   0   2     7
12 Dec 27     2   0   0   0     0   0   0   0     2
12 Dec 28     1   1   0   1     2   1   2   2     10
12 Dec 29     1   1   1   2     1   1   1   2     10
12 Dec 30     2   1   2   2     2   2   3   1     15
12 Dec 31     1   1   1   1     0   1   0   1     6
Mean of K-Sum is  13.6
Frequency Distribution of K-Indices
K-Index :   0    1    2    3    4    5    6    7    8    9    -
            509   917   805   455   147   78   17   0    0    0    0
--------------------------------------------------------------------------------
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F.3 CNB

GEOSCIENCE AUSTRALIA (email: geomag@ga.gov.au)
Canberra (CNB) Geomagnetic data for Jan 2012
Location: Geographic:-35.314d 149.363d
K9 range: 450nT
Variometer: RC

P R I N C I P A L M A G N E T I C S T O R M S

Commencement Yr Mth Dy Hr Mn	SSC-amplitudes D(') H(nT) Z(nT)	Max. 3hr-K-indices Day(3Hr Periods)	K	Storm Ranges D(') H(nT) Z(nT)	UT End Mth Dy Hr
12 Mar 07 04 19	1.2,24.13*,1.83	7(3,4,5,6)	5	26.9 136.9 61.4	Mar 07 23
12 Mar 08 11 03	-4.14*,52.91,16.189	(3,4)	6	26.5 210.8 104.3	Mar 09 18
12 Mar 12 09 15	-3.54*,56.78,16.7	12(4)	6	16.7 129.5 43.9	Mar 12 21
12 Mar 15 13 07	-1.74,56.66,14.25	15(5,6),16(4)	5	18.2 141.4 47.1	Mar 16 12
12 Jun 03 09 07	...	3(5,6)	5	14.3 73.5 26.2	Jun 03 21
12 Jun 16 09 56	0.48,20.0,3.78	17(4)	6	21.8 221.6 74.1	Jun 17 23
12 Jul 14 18 11	3.66,22.88,2.25	15(4)	6	27.3 190.3 90.8	Jul 16 18
12 Oct 08 05 16	2.46,29.18,2.49	8(3,4),9(3,4)	5	25.9 172.5 61.0	Oct 09 15
12 Oct 13 03 04	...	13(4,5,6)	5	18.8 112.0 58.7	Oct 14 15
12 Nov 12 23 12	-5.58*,-18.85*,12.14	(2,3)	5	23.9 164.8 74.0	Nov 14 15

S U D D E N S T O R M C O M M E N C E M E N T S

UT Date Yr Mth Dy Hr Mn	Type & Quality ssc/ssc* A,B,C	Chief movement(nT) H(x)	D(y)	Z
12 Jan 15 16 22	ssc c	9.12	2.14	1.22
12 Jan 22 06 12	ssc b	51.81	7.81	7.31
12 Jan 24 15 04	ssc a	62.77	14.17	10.0
12 Feb 13 05 08	ssc b	14.38	1.32	1.44
12 Feb 18 16 43	ssc b	6.38	1.52	1.09
12 Feb 22 02 16	ssc b	16.75	-7.87	7.14
12 Feb 26 21 40	ssc c	4.9	19.31	4.72
12 Mar 07 04 19	ssc* b	24.13*	8.32	1.83
12 Mar 08 11 03	ssc* a	52.91	-28.48*	16.18
12 Mar 12 09 15	ssc* a	56.78	-24.56*	16.7
12 Mar 15 13 07	ssc b	56.66	-11.84	14.25
12 Apr 01 03 51	ssc b	11.83	2.98	0.39
12 Apr 23 03 20	ssc* b	28.41	10.97*	5.33
12 May 21 19 36	ssc b	6.28	2.03	1.3
12 Jun 16 09 56	ssc a	20.0	3.32	3.78
12 Jul 14 18 11	ssc a	22.88	25.52	2.25
12 Jul 20 04 48	ssc* a	32.08	-10.76*	8.96
12 Aug 02 10 52	ssc c	6.02	1.29	1.16
12 Sep 03 12 13	ssc a	56.47	6.53	11.49
12 Sep 20 06 23	ssc b	24.73	1.96	2.47
12 Sep 30 11 32	ssc a	22.74	1.45	3.99
12 Sep 30 23 05	ssc* a	9.27	-40.32*	12.94*
12 Oct 03 02 23	ssc c	20.66	5.68	3.82
12 Oct 08 05 16	ssc b	29.18	17.09	2.49
12 Nov 12 23 12	ssc* a	-18.85*	-38.5*	12.46
12 Nov 23 21 52	ssc* a	-20.71*	-44.65*	14.73
12 Nov 26 05 13	ssc c	21.21	3.37	2.55

S O L A R F L A R E E F F E C T S

Yr Mth Dy	UT of movement Start	Max	End	Amplitude in nT H(x)	D(y)	Z	Confirmation
Nil							

K - I N D I C E S O F G E O M A G N E T I C A C T I V I T Y

UT-Date	K - i n d i c e s								K-sum
12 Jan 01	1	1	1	1	2	1	0	1	8
12 Jan 02	1	0	1	1	2	1	3	2	11
12 Jan 03	3	2	1	2	1	2	1	1	13
12 Jan 04	0	1	0	0	1	0	1	1	4
12 Jan 05	1	2	1	2	3	1	1	0	11
12 Jan 06	1	2	2	2	1	1	2	2	13
12 Jan 07	2	2	2	1	3	2	1	2	15
12 Jan 08	1	2	2	1	1	1	2	1	11
12 Jan 09	2	2	2	2	2	2	1	2	15

12 Jan 10	1	1	1	3	3	2	1	2	14
12 Jan 11	1	2	1	1	0	2	1	2	10
12 Jan 12	1	2	2	2	2	2	3	3	17
12 Jan 13	2	2	3	2	1	1	1	1	13
12 Jan 14	0	1	2	1	0	0	0	1	5
12 Jan 15	1	2	2	0	0	2	1	3	11
12 Jan 16	2	2	2	3	4	2	3	2	20
12 Jan 17	2	1	1	0	2	1	1	1	9
12 Jan 18	1	0	1	1	1	1	0	1	6
12 Jan 19	0	1	1	1	0	2	0	1	6
12 Jan 20	1	1	0	1	1	1	1	1	7
12 Jan 21	2	3	2	3	2	2	2	2	18
12 Jan 22	1	3	5	4	5	4	5	3	30
12 Jan 23	4	3	3	1	1	1	0	1	14
12 Jan 24	2	3	2	2	2	5	4	3	23
12 Jan 25	2	3	4	4	3	2	1	2	21
12 Jan 26	2	1	1	3	2	3	2	2	16
12 Jan 27	1	2	2	2	3	2	1	1	14
12 Jan 28	1	2	2	1	2	1	1	2	12
12 Jan 29	1	2	1	1	0	2	1	1	9
12 Jan 30	0	0	1	1	1	3	3	3	12
12 Jan 31	1	2	2	1	0	0	0	1	7
12 Feb 01	1	3	3	2	2	0	0	1	12
12 Feb 02	1	2	1	2	1	0	2	2	11
12 Feb 03	2	2	2	2	3	1	0	1	13
12 Feb 04	2	2	2	2	3	3	2	2	18
12 Feb 05	1	2	1	2	3	3	2	1	15
12 Feb 06	1	1	1	0	2	3	3	1	12
12 Feb 07	1	1	2	4	4	3	3	3	21
12 Feb 08	2	3	2	2	3	1	2	1	16
12 Feb 09	1	1	0	2	3	2	3	1	13
12 Feb 10	1	2	1	1	1	1	2	3	12
12 Feb 11	1	1	1	0	2	1	1	1	8
12 Feb 12	1	1	1	2	1	1	1	1	9
12 Feb 13	1	2	3	2	4	4	3	2	21
12 Feb 14	2	2	3	2	2	3	2	3	19
12 Feb 15	2	3	3	3	3	3	3	3	23
12 Feb 16	1	0	1	3	3	1	0	1	10
12 Feb 17	0	0	1	1	0	0	0	0	2
12 Feb 18	0	0	0	1	1	1	1	2	6
12 Feb 19	3	4	2	3	3	3	1	2	21
12 Feb 20	2	3	2	3	3	3	3	2	21
12 Feb 21	2	1	2	2	1	1	0	0	9
12 Feb 22	3	1	4	3	3	1	1	1	17
12 Feb 23	0	0	1	2	1	0	0	1	5
12 Feb 24	1	2	1	2	2	2	1	0	11
12 Feb 25	0	1	1	3	3	2	2	2	14
12 Feb 26	2	1	1	2	3	0	2	3	14
12 Feb 27	2	1	1	2	4	4	4	2	20
12 Feb 28	0	2	4	2	2	2	0	2	14
12 Feb 29	1	3	3	1	0	1	1	2	12
12 Mar 01	1	4	4	4	3	3	3	2	24
12 Mar 02	2	1	3	2	4	2	1	1	16
12 Mar 03	1	1	3	3	1	3	1	1	14
12 Mar 04	3	1	3	3	3	2	2	1	18
12 Mar 05	1	1	1	3	2	2	2	3	15
12 Mar 06	2	1	3	1	3	3	2	2	17
12 Mar 07	3	3	5	5	5	5	3	3	32
12 Mar 08	1	2	1	5	4	3	3	3	22
12 Mar 09	4	5	6	6	5	5	2	2	35
12 Mar 10	3	3	3	4	2	2	2	1	20
12 Mar 11	2	1	1	3	3	2	1	2	15
12 Mar 12	2	2	1	6	5	3	2	2	23
12 Mar 13	1	2	1	3	2	2	2	1	14
12 Mar 14	2	1	1	3	2	3	2	2	16
12 Mar 15	1	2	2	2	5	5	4	3	24
12 Mar 16	2	2	3	5	3	4	3	3	25
12 Mar 17	3	3	3	3	3	4	3	3	25
12 Mar 18	3	2	1	3	1	2	2	2	16
12 Mar 19	1	3	2	3	2	2	2	3	18
12 Mar 20	1	1	1	1	0	1	1	1	7
12 Mar 21	1	0	0	2	1	1	2	1	8
12 Mar 22	1	1	0	1	0	0	2	3	8
12 Mar 23	2	0	1	1	1	1	1	0	7
12 Mar 24	1	2	4	3	2	2	1	1	16
12 Mar 25	1	2	2	2	3	0	0	0	10
12 Mar 26	0	0	0	2	1	0	0	1	4

12 Mar 27	1	2	3	3	3	3	2	3	20
12 Mar 28	3	3	2	2	4	1	2	1	18
12 Mar 29	0	0	1	0	1	0	1	2	5
12 Mar 30	1	2	1	1	1	0	0	0	6
12 Mar 31	0	0	0	1	1	2	1	0	5
12 Apr 01	0	2	1	2	2	2	3	1	13
12 Apr 02	2	2	2	2	3	2	1	2	16
12 Apr 03	0	1	0	1	0	1	1	1	5
12 Apr 04	2	2	0	0	1	3	2	2	12
12 Apr 05	1	2	4	5	4	3	1	1	21
12 Apr 06	1	1	1	0	0	0	0	1	4
12 Apr 07	1	1	2	4	3	0	0	0	11
12 Apr 08	1	1	0	2	1	1	0	0	6
12 Apr 09	0	0	0	0	0	0	1	1	2
12 Apr 10	1	1	1	1	1	1	1	1	8
12 Apr 11	1	1	3	2	1	0	0	1	9
12 Apr 12	1	3	3	2	1	3	5	3	21
12 Apr 13	3	3	4	4	2	2	2	2	22
12 Apr 14	2	3	2	2	2	2	2	1	16
12 Apr 15	1	1	1	2	2	1	2	1	11
12 Apr 16	1	0	0	0	2	1	1	0	5
12 Apr 17	0	0	2	3	3	2	4	1	15
12 Apr 18	2	3	3	1	2	2	1	1	15
12 Apr 19	1	1	0	0	1	1	2	2	8
12 Apr 20	0	3	3	3	2	1	1	1	14
12 Apr 21	1	1	1	1	0	1	3	2	10
12 Apr 22	2	2	2	3	2	2	1	1	15
12 Apr 23	0	4	3	1	2	3	4	3	20
12 Apr 24	3	3	4	2	3	3	4	3	25
12 Apr 25	3	2	4	4	3	3	4	3	26
12 Apr 26	4	4	2	2	3	1	2	2	20
12 Apr 27	2	2	2	2	2	1	1	1	13
12 Apr 28	0	1	0	2	2	3	2	1	11
12 Apr 29	1	1	0	1	1	0	0	0	4
12 Apr 30	0	0	1	1	0	0	0	0	2
12 May 01	0	0	0	0	0	1	0	0	1
12 May 02	1	0	0	1	2	0	0	1	5
12 May 03	2	1	1	2	2	0	1	2	11
12 May 04	1	2	0	0	0	0	0	0	3
12 May 05	0	0	0	1	1	0	0	0	2
12 May 06	1	0	1	2	1	0	0	0	5
12 May 07	0	1	0	2	0	0	0	0	3
12 May 08	1	2	1	2	1	1	1	3	12
12 May 09	3	3	4	4	3	3	3	2	25
12 May 10	2	3	2	3	2	2	2	3	19
12 May 11	2	2	2	2	2	2	2	1	15
12 May 12	3	1	2	3	3	2	2	2	18
12 May 13	1	2	2	3	2	2	2	1	15
12 May 14	1	1	0	0	0	1	1	0	4
12 May 15	2	2	2	1	0	0	0	1	8
12 May 16	1	1	1	1	3	3	2	2	14
12 May 17	1	0	0	0	1	0	0	1	3
12 May 18	2	2	1	2	1	2	1	1	12
12 May 19	1	1	1	1	1	1	0	0	6
12 May 20	3	3	2	2	3	1	1	0	15
12 May 21	0	0	0	0	0	0	2	1	3
12 May 22	2	4	2	3	3	3	4	3	24
12 May 23	3	4	3	3	2	2	2	1	20
12 May 24	1	1	2	3	2	2	1	1	13
12 May 25	1	1	1	3	2	3	1	0	12
12 May 26	1	1	1	1	0	0	0	0	4
12 May 27	0	1	0	0	0	0	0	0	1
12 May 28	0	0	0	1	1	2	2	0	6
12 May 29	0	1	0	0	1	1	1	1	5
12 May 30	2	1	1	3	3	1	2	0	13
12 May 31	1	1	2	2	1	2	2	0	11
12 Jun 01	0	1	0	2	1	1	0	1	6
12 Jun 02	1	1	1	1	1	2	2	3	12
12 Jun 03	1	2	1	3	5	5	4	0	21
12 Jun 04	1	2	2	4	4	4	3	3	23
12 Jun 05	2	4	3	3	4	3	3	4	26
12 Jun 06	3	3	1	3	3	2	3	1	19
12 Jun 07	2	2	1	2	0	2	1	1	11
12 Jun 08	1	1	3	4	1	0	1	0	11
12 Jun 09	1	1	1	2	2	1	1	0	9
12 Jun 10	0	0	0	0	1	1	0	2	4
12 Jun 11	1	2	2	2	2	2	3	4	18

```
12 Jun 12     3   2   1   1     1   1   1   0     10
12 Jun 13     1   2   2   2     0   0   0   0     7
12 Jun 14     0   0   0   1     0   0   0   0     1
12 Jun 15     0   0   0   0     0   1   0   0     1
12 Jun 16     0   0   0   3     3   3   2   4     15
12 Jun 17     3   3   4   6     5   4   3   2     30
12 Jun 18     2   4   3   3     2   3   2   0     19
12 Jun 19     0   0   0   0     0   0   0   0     0
12 Jun 20     1   2   0   1     0   0   0   0     4
12 Jun 21     0   0   0   0     0   0   0   0     0
12 Jun 22     0   0   1   2     2   0   0   0     5
12 Jun 23     0   0   1   2     0   1   1   0     5
12 Jun 24     1   0   1   0     1   1   0   0     4
12 Jun 25     1   1   3   2     3   2   2   0     14
12 Jun 26     1   2   2   2     1   1   0   0     9
12 Jun 27     0   1   1   0     2   2   1   1     8
12 Jun 28     0   1   3   2     1   2   0   0     9
12 Jun 29     1   1   0   0     0   0   0   1     3
12 Jun 30     2   3   3   5     4   4   3   3     27
12 Jul 01     3   3   3   3     3   2   3   2     22
12 Jul 02     3   3   3   2     4   3   3   1     22
12 Jul 03     2   2   1   4     2   3   1   1     16
12 Jul 04     2   3   2   2     3   0   0   1     13
12 Jul 05     1   2   1   3     3   2   1   2     15
12 Jul 06     1   2   1   2     2   2   4   4     18
12 Jul 07     2   2   2   2     1   0   1   1     11
12 Jul 08     1   2   2   3     2   1   1   3     15
12 Jul 09     3   2   3   3     5   3   2   3     24
12 Jul 10     2   2   2   3     2   2   2   1     16
12 Jul 11     1   2   3   3     2   1   1   1     14
12 Jul 12     2   2   3   4     1   1   0   0     13
12 Jul 13     0   0   0   1     0   0   0   0     1
12 Jul 14     0   1   1   0     1   2   4   4     13
12 Jul 15     4   4   5   6     4   4   4   5     36
12 Jul 16     3   3   5   4     5   4   2   2     28
12 Jul 17     2   3   4   2     2   2   1   1     17
12 Jul 18     0   1   0   0     1   0   1   1     4
12 Jul 19     0   1   1   1     2   2   1   0     8
12 Jul 20     0   4   0   3     1   3   2   1     14
12 Jul 21     1   1   2   1     0   3   2   1     11
12 Jul 22     0   2   2   3     2   0   1   1     11
12 Jul 23     2   2   1   2     2   3   2   1     15
12 Jul 24     2   2   1   1     3   2   2   0     13
12 Jul 25     2   1   2   2     1   0   1   0     9
12 Jul 26     0   0   0   0     1   0   0   0     1
12 Jul 27     0   2   1   1     1   0   0   1     6
12 Jul 28     1   1   2   2     2   3   2   1     14
12 Jul 29     2   1   2   3     1   0   1   0     10
12 Jul 30     0   2   3   4     4   3   3   1     20
12 Jul 31     1   2   1   0     2   1   0   0     7
12 Aug 01     0   1   0   1     1   0   1   1     5
12 Aug 02     0   0   0   2     4   4   2   2     14
12 Aug 03     1   3   2   1     1   1   1   0     10
12 Aug 04     1   1   1   0     1   2   1   2     9
12 Aug 05     0   1   1   2     0   1   1   1     7
12 Aug 06     1   2   1   3     2   2   1   1     13
12 Aug 07     1   1   0   2     1   1   1   2     9
12 Aug 08     2   1   1   2     2   2   0   0     10
12 Aug 09     1   1   1   1     0   0   0   0     4
12 Aug 10     0   1   0   0     0   0   0   0     1
12 Aug 11     0   0   0   0     1   1   1   1     4
12 Aug 12     0   2   1   1     2   1   2   2     11
12 Aug 13     1   1   2   3     1   3   2   1     14
12 Aug 14     1   2   1   2     1   2   1   2     12
12 Aug 15     0   0   1   1     1   1   1   1     6
12 Aug 16     1   1   2   2     4   4   3   2     19
12 Aug 17     2   2   2   3     1   1   1   0     12
12 Aug 18     0   2   2   3     2   1   3   2     15
12 Aug 19     1   2   3   4     4   2   1   3     20
12 Aug 20     2   3   3   2     4   2   3   1     20
12 Aug 21     1   1   1   3     2   3   1   2     14
12 Aug 22     1   1   1   1     3   1   0   1     9
12 Aug 23     1   2   2   3     3   2   2   1     16
12 Aug 24     1   1   2   2     3   1   1   1     12
12 Aug 25     1   2   3   3     3   3   2   1     18
12 Aug 26     0   1   1   2     4   2   3   1     14
12 Aug 27     1   3   1   1     0   1   0   1     8
```

12 Aug 28	0	0	0	1	1	0	0	0	2
12 Aug 29	1	1	0	0	0	1	0	0	3
12 Aug 30	0	0	0	0	0	0	1	0	1
12 Aug 31	0	0	0	1	1	0	0	0	2
12 Sep 01	1	1	3	2	2	1	1	1	12
12 Sep 02	1	3	2	3	2	2	3	3	19
12 Sep 03	1	2	3	3	5	3	3	4	24
12 Sep 04	2	2	3	3	2	1	1	2	16
12 Sep 05	3	3	5	3	2	3	2	2	23
12 Sep 06	3	3	1	1	0	2	2	1	13
12 Sep 07	2	2	2	2	3	2	3	2	18
12 Sep 08	1	1	1	2	1	3	2	1	12
12 Sep 09	0	1	1	1	0	2	0	0	5
12 Sep 10	0	1	1	0	1	1	0	0	4
12 Sep 11	0	0	0	0	0	1	0	0	1
12 Sep 12	1	1	2	3	2	1	1	2	13
12 Sep 13	1	2	2	0	0	2	1	1	9
12 Sep 14	1	1	1	1	1	2	1	2	10
12 Sep 15	1	2	2	2	0	2	1	1	11
12 Sep 16	1	2	1	2	1	1	3	2	13
12 Sep 17	0	2	0	1	2	0	0	0	5
12 Sep 18	1	2	1	3	3	3	0	2	15
12 Sep 19	1	1	0	1	2	3	4	4	16
12 Sep 20	2	2	3	3	3	2	1	1	17
12 Sep 21	1	1	1	3	2	3	1	1	13
12 Sep 22	1	1	2	3	0	0	0	1	8
12 Sep 23	0	0	0	0	0	0	0	0	0
12 Sep 24	0	0	1	0	0	1	1	1	4
12 Sep 25	0	1	1	0	1	0	0	0	3
12 Sep 26	1	1	1	1	2	2	3	3	14
12 Sep 27	2	2	1	1	0	0	0	1	7
12 Sep 28	0	0	0	0	0	0	0	0	0
12 Sep 29	0	1	2	1	0	2	1	1	8
12 Sep 30	1	1	1	3	3	4	3	4	20
12 Oct 01	4	4	3	3	2	1	1	2	20
12 Oct 02	2	1	0	3	2	2	2	2	14
12 Oct 03	3	2	2	1	1	1	1	1	12
12 Oct 04	1	1	0	1	0	0	0	0	3
12 Oct 05	0	1	1	1	0	2	2	1	8
12 Oct 06	1	1	1	2	3	2	2	2	14
12 Oct 07	1	1	0	2	1	0	1	1	7
12 Oct 08	0	3	5	5	4	1	4	3	25
12 Oct 09	4	4	5	5	3	2	3	4	30
12 Oct 10	2	2	2	4	3	3	3	1	20
12 Oct 11	1	0	1	1	2	1	0	2	8
12 Oct 12	2	3	3	3	4	3	2	1	21
12 Oct 13	2	3	4	5	5	5	4	2	30
12 Oct 14	3	3	3	3	4	1	2	3	22
12 Oct 15	2	1	2	3	2	1	1	0	12
12 Oct 16	1	1	1	2	2	2	1	1	11
12 Oct 17	2	1	3	2	2	1	1	2	14
12 Oct 18	1	2	0	1	0	2	1	1	8
12 Oct 19	1	1	0	0	0	0	0	1	3
12 Oct 20	0	0	0	0	0	0	0	1	1
12 Oct 21	0	1	1	1	1	0	0	0	4
12 Oct 22	0	1	0	0	0	0	0	0	1
12 Oct 23	3	3	2	3	2	2	2	1	18
12 Oct 24	1	0	0	1	0	1	1	0	4
12 Oct 25	0	0	0	1	1	0	0	2	4
12 Oct 26	1	1	1	1	0	2	1	2	9
12 Oct 27	0	1	0	1	1	1	1	2	7
12 Oct 28	1	1	1	1	2	0	1	0	7
12 Oct 29	0	0	1	0	0	0	0	0	1
12 Oct 30	0	0	0	1	1	0	0	0	2
12 Oct 31	0	0	1	0	2	3	2	2	10
12 Nov 01	3	3	3	4	4	4	3	2	26
12 Nov 02	1	3	2	1	1	2	2	2	14
12 Nov 03	0	1	1	1	2	2	1	1	9
12 Nov 04	0	1	0	0	1	2	0	0	4
12 Nov 05	0	0	1	1	1	1	1	1	6
12 Nov 06	0	2	0	1	1	2	1	1	8
12 Nov 07	2	3	2	2	3	3	3	2	20
12 Nov 08	1	1	0	1	2	0	0	1	6
12 Nov 09	0	1	0	0	0	0	0	0	1
12 Nov 10	0	0	0	1	1	0	1	1	4
12 Nov 11	1	0	1	1	2	1	0	1	7
12 Nov 12	0	0	0	0	0	2	1	4	7

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12 Nov 13     4   3   3   4     3   3   2   2     24
12 Nov 14     3   5   5   4     4   1   1   1     24
12 Nov 15     1   0   0   1     1   0   0   1     4
12 Nov 16     1   2   2   0     2   1   1   2     11
12 Nov 17     1   2   2   3     3   3   2   1     17
12 Nov 18     1   1   1   1     2   1   0   0     7
12 Nov 19     1   0   2   2     3   3   1   1     13
12 Nov 20     2   2   3   3     2   3   4   2     21
12 Nov 21     2   2   2   3     0   1   1   1     12
12 Nov 22     0   0   0   0     1   0   1   1     3
12 Nov 23     0   0   0   1     1   0   1   4     7
12 Nov 24     4   4   3   3     3   3   2   2     24
12 Nov 25     1   3   3   1     3   2   1   1     15
12 Nov 26     2   3   2   1     1   1   1   1     12
12 Nov 27     1   2   1   1     2   1   1   1     10
12 Nov 28     1   0   1   0     0   0   0   1     3
12 Nov 29     0   0   1   2     0   1   0   1     5
12 Nov 30     0   0   0   2     1   0   0   1     4
12 Dec 01     0   1   1   1     2   2   2   1     10
12 Dec 02     2   1   3   4     3   1   0   0     14
12 Dec 03     0   1   1   2     2   2   1   2     11
12 Dec 04     1   4   3   1     0   0   1   0     10
12 Dec 05     0   0   0   1     0   0   0   1     2
12 Dec 06     0   0   1   0     0   0   0   0     1
12 Dec 07     0   0   0   0     1   0   1   0     2
12 Dec 08     0   1   1   0     0   0   0   1     3
12 Dec 09     1   1   1   2     2   1   2   3     13
12 Dec 10     1   1   1   2     2   1   1   1     10
12 Dec 11     1   1   0   0     1   0   2   1     6
12 Dec 12     0   0   2   1     2   0   0   1     6
12 Dec 13     2   2   0   0     1   1   1   0     7
12 Dec 14     1   2   2   1     1   0   2   2     11
12 Dec 15     1   2   3   2     3   2   1   2     16
12 Dec 16     1   1   2   2     2   2   2   1     13
12 Dec 17     2   1   2   3     3   2   0   1     14
12 Dec 18     2   2   1   3     2   2   0   1     13
12 Dec 19     1   2   1   1     1   0   1   1     8
12 Dec 20     1   2   2   2     3   3   1   2     16
12 Dec 21     1   2   1   1     0   1   0   1     7
12 Dec 22     0   1   1   1     0   0   0   1     4
12 Dec 23     0   0   0   1     2   2   0   0     5
12 Dec 24     0   0   0   0     1   3   0   1     5
12 Dec 25     1   1   1   0     0   1   1   1     6
12 Dec 26     1   1   2   2     2   0   0   1     9
12 Dec 27     1   0   0   0     0   0   0   0     1
12 Dec 28     0   1   1   1     1   0   1   1     6
12 Dec 29     0   2   1   2     1   0   0   1     7
12 Dec 30     1   1   2   2     2   2   2   1     13
12 Dec 31     1   0   1   0     0   1   1   2     6
Mean of K-Sum is  11.8
Frequency Distribution of K-Indices
K-Index :   0    1    2    3    4    5    6    7    8    9    -
            667   973   716   408   121   38   5    0    0    0    0
--------------------------------------------------------------------------------
```

F.4 MAW

GEOSCIENCE AUSTRALIA (email: geomag@ga.gov.au)
Mawson (MAW) Geomagnetic data for Jan 2012
Location: Geographic:-67.6d 62.88d
K9 range: 1500nT
Variometer: RC

P R I N C I P A L M A G N E T I C S T O R M S

Commencement Yr Mth Dy Hr Mn	SSC-amplitudes D(') H(nT) Z(nT)	Max. 3hr-K-indices Day(3Hr Periods) K	Storm Ranges D(') H(nT) Z(nT)	UT End Mth Dy Hr
Nil				

S U D D E N S T O R M C O M M E N C E M E N T S

UT Date Yr Mth Dy Hr Mn	Type & Quality ssc/ssc* A,B,C	Chief movement(nT) H(x) D(y) Z
Nil		

S O L A R F L A R E E F F E C T S

Yr Mth Dy	UT of movement Start Max End	Amplitude in nT H(x) D(y) Z	Confirmation
Nil			

K - I N D I C E S O F G E O M A G N E T I C A C T I V I T Y

UT-Date	K - i n d i c e s								K-sum
12 Jan 01	4	4	3	2	2	3	3	3	24
12 Jan 02	2	2	1	1	2	2	2	4	16
12 Jan 03	4	6	4	4	3	3	3	3	30
12 Jan 04	4	1	1	0	1	1	1	3	12
12 Jan 05	4	2	2	2	4	2	3	3	22
12 Jan 06	3	4	3	3	3	3	5	5	29
12 Jan 07	5	3	3	2	2	2	3	5	25
12 Jan 08	4	5	4	2	2	2	4	4	27
12 Jan 09	5	5	5	3	3	3	2	4	30
12 Jan 10	4	3	2	4	4	3	4	3	27
12 Jan 11	5	6	4	2	1	2	5	4	29
12 Jan 12	3	3	2	2	3	2	2	4	21
12 Jan 13	4	4	4	2	2	2	2	4	24
12 Jan 14	3	3	2	2	2	0	1	3	16
12 Jan 15	2	5	1	1	1	2	4	5	21
12 Jan 16	4	5	3	3	5	4	5	4	33
12 Jan 17	6	4	2	2	2	2	5	3	26
12 Jan 18	5	3	2	3	3	3	3	4	26
12 Jan 19	3	2	2	3	1	2	1	3	17
12 Jan 20	4	3	3	2	2	3	4	3	24
12 Jan 21	3	4	3	1	3	2	4	4	24
12 Jan 22	2	2	6	5	5	5	5	6	36
12 Jan 23	4	6	6	1	2	1	3	4	27
12 Jan 24	5	6	5	3	3	6	6	5	39
12 Jan 25	5	4	5	6	4	4	3	4	35
12 Jan 26	3	3	4	4	3	3	4	4	28
12 Jan 27	4	4	4	3	4	3	2	2	26
12 Jan 28	4	5	3	1	3	3	6	6	31
12 Jan 29	4	4	3	2	1	3	6	5	28
12 Jan 30	1	2	2	1	1	4	6	4	21
12 Jan 31	4	3	2	1	1	1	0	1	13
12 Feb 01	4	5	3	4	3	1	1	1	22
12 Feb 02	2	3	4	3	3	0	2	5	22
12 Feb 03	4	4	4	2	3	3	2	1	23
12 Feb 04	5	5	3	4	4	3	4	6	34
12 Feb 05	4	4	3	3	4	3	6	6	33
12 Feb 06	3	3	3	2	2	6	5	2	26
12 Feb 07	4	3	4	3	3	3	5	7	32
12 Feb 08	5	4	4	2	3	3	6	5	32
12 Feb 09	4	2	1	2	3	3	5	3	23
12 Feb 10	3	2	3	1	3	2	4	4	22
12 Feb 11	3	3	2	2	2	2	2	4	20
12 Feb 12	4	2	1	1	2	2	1	4	17
12 Feb 13	2	2	3	4	3	4	4	3	25

12 Feb 14	5	4	4	3	4	4	4	5	33
12 Feb 15	4	8	4	4	3	5	6	5	39
12 Feb 16	4	2	3	3	3	1	1	0	17
12 Feb 17	1	2	2	1	1	0	0	1	8
12 Feb 18	1	1	1	1	0	1	1	6	12
12 Feb 19	5	4	4	2	2	2	2	6	27
12 Feb 20	5	5	4	4	3	6	4	6	37
12 Feb 21	5	4	4	3	2	2	2	5	27
12 Feb 22	5	5	4	3	2	2	1	1	23
12 Feb 23	2	2	2	1	1	0	0	5	13
12 Feb 24	3	5	2	2	2	2	1	0	17
12 Feb 25	2	3	3	3	3	3	4	4	25
12 Feb 26	4	3	3	1	4	2	4	4	25
12 Feb 27	4	4	3	3	4	8	6	2	34
12 Feb 28	3	3	6	3	2	3	3	5	28
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12 Mar 02	5	6	4	3	3	3	5	4	33
12 Mar 03	5	4	4	3	3	5	3	5	32
12 Mar 04	5	4	3	3	3	3	7	4	32
12 Mar 05	5	4	5	3	2	2	5	7	33
12 Mar 06	5	4	4	3	4	3	2	6	31
12 Mar 07	5	5	6	6	6	5	4	7	44
12 Mar 08	4	3	3	4	6	5	5	7	37
12 Mar 09	6	7	7	7	5	5	3	4	44
12 Mar 10	6	6	4	3	3	4	6	5	37
12 Mar 11	4	3	3	3	3	3	5	5	29
12 Mar 12	4	3	3	6	6	4	6	6	38
12 Mar 13	5	4	3	2	3	3	6	5	31
12 Mar 14	5	5	4	3	3	5	6	5	36
12 Mar 15	6	5	4	3	6	8	6	6	44
12 Mar 16	4	5	5	5	3	7	7	6	42
12 Mar 17	6	5	4	5	3	6	7	7	43
12 Mar 18	7	6	4	3	4	5	5	6	40
12 Mar 19	4	5	3	3	1	3	6	6	31
12 Mar 20	5	3	2	1	1	2	3	6	23
12 Mar 21	3	2	1	1	2	2	6	5	22
12 Mar 22	2	5	1	2	0	0	2	6	18
12 Mar 23	4	2	2	2	1	2	1	1	15
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12 Mar 26	3	1	2	0	1	1	1	2	11
12 Mar 27	3	4	3	3	4	4	4	6	31
12 Mar 28	6	6	5	3	2	2	6	5	35
12 Mar 29	1	1	0	0	1	1	2	6	12
12 Mar 30	4	3	3	1	0	1	0	2	14
12 Mar 31	2	2	3	0	1	2	3	2	15
12 Apr 01	3	3	2	2	3	4	5	5	27
12 Apr 02	5	4	4	1	3	3	4	5	29
12 Apr 03	5	4	3	2	2	2	3	6	27
12 Apr 04	4	4	2	1	1	2	2	5	21
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12 Apr 06	3	2	1	1	0	1	1	5	14
12 Apr 07	3	4	4	3	3	2	1	3	23
12 Apr 08	3	2	3	1	1	2	4	3	19
12 Apr 09	3	1	0	1	2	0	5	5	17
12 Apr 10	5	2	2	1	0	1	4	5	20
12 Apr 11	4	2	2	2	2	0	0	4	16
12 Apr 12	3	6	5	3	2	4	7	7	37
12 Apr 13	7	6	5	4	3	3	6	6	40
12 Apr 14	5	5	4	3	3	3	5	3	31
12 Apr 15	2	3	2	2	1	3	6	4	23
12 Apr 16	3	3	1	0	0	2	1	4	14
12 Apr 17	3	1	2	3	3	3	4	4	23
12 Apr 18	6	5	4	3	3	3	4	5	33
12 Apr 19	4	2	2	0	0	1	6	5	20
12 Apr 20	3	5	5	3	3	2	2	3	26
12 Apr 21	4	0	0	1	0	2	6	6	19
12 Apr 22	5	4	4	3	2	2	4	4	28
12 Apr 23	4	5	5	2	2	5	7	6	36
12 Apr 24	7	7	4	3	3	2	8	6	40
12 Apr 25	6	6	5	4	4	6	7	6	44
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12 Apr 27	5	5	3	2	3	2	3	4	27
12 Apr 28	3	3	2	2	3	3	5	6	27
12 Apr 29	5	5	2	1	1	1	5	3	23
12 Apr 30	1	3	1	0	0	0	1	4	10

12 May 01	2	2	1	1	0	0	4	6	16
12 May 02	5	3	1	1	1	1	2	6	20
12 May 03	4	3	3	3	2	2	1	6	24
12 May 04	4	2	0	0	0	0	1	1	8
12 May 05	1	0	0	1	1	0	2	1	6
12 May 06	1	1	2	2	2	1	1	2	12
12 May 07	1	1	0	1	0	0	0	0	3
12 May 08	0	3	3	1	3	1	2	6	19
12 May 09	5	6	5	5	4	5	6	6	42
12 May 10	4	5	5	4	2	3	7	6	36
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12 May 15	4	3	4	2	2	1	0	1	17
12 May 16	5	3	2	1	3	3	5	5	27
12 May 17	4	4	2	1	2	1	1	2	17
12 May 18	5	4	2	2	3	3	2	5	26
12 May 19	4	3	2	2	1	3	2	3	20
12 May 20	3	6	6	2	1	2	2	3	25
12 May 21	1	2	1	0	0	0	3	4	11
12 May 22	2	5	4	3	3	3	6	5	31
12 May 23	5	5	6	4	3	4	6	6	39
12 May 24	5	4	3	3	2	3	3	1	24
12 May 25	2	1	1	2	2	2	3	5	18
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12 May 29	3	2	1	0	0	1	0	6	13
12 May 30	4	3	3	1	2	3	2	3	21
12 May 31	4	2	3	3	2	3	2	1	20
12 Jun 01	3	3	1	3	1	2	1	1	15
12 Jun 02	1	1	1	1	1	3	3	6	17
12 Jun 03	4	3	3	4	4	6	5	2	31
12 Jun 04	1	5	4	5	3	4	6	7	35
12 Jun 05	3	5	5	4	5	4	6	8	40
12 Jun 06	6	6	6	4	4	4	6	5	41
12 Jun 07	4	5	5	3	3	4	6	3	33
12 Jun 08	5	3	4	5	2	1	1	2	23
12 Jun 09	3	3	1	2	2	1	2	4	18
12 Jun 10	1	1	1	0	1	1	2	5	12
12 Jun 11	4	4	4	3	3	3	8	6	35
12 Jun 12	6	4	3	3	2	1	3	3	25
12 Jun 13	2	3	2	1	1	0	3	4	16
12 Jun 14	2	2	1	2	2	1	2	1	13
12 Jun 15	0	0	0	0	0	0	1	3	4
12 Jun 16	3	0	1	3	2	3	3	5	20
12 Jun 17	4	5	6	7	5	4	4	6	41
12 Jun 18	6	6	4	4	2	3	4	5	34
12 Jun 19	2	1	1	1	1	0	2	3	11
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12 Jun 22	3	3	3	3	2	1	0	0	15
12 Jun 23	2	1	2	1	1	1	2	3	13
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12 Jun 26	4	4	4	4	3	2	2	3	26
12 Jun 27	2	1	2	1	3	3	1	1	14
12 Jun 28	1	3	3	4	2	1	1	2	17
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12 Jun 30	4	4	6	5	4	4	6	5	38
12 Jul 01	4	6	6	5	3	3	6	7	40
12 Jul 02	6	6	6	4	5	7	5	4	43
12 Jul 03	3	4	4	4	4	3	2	4	28
12 Jul 04	4	6	5	4	4	1	1	5	30
12 Jul 05	4	3	2	3	3	2	1	2	20
12 Jul 06	6	5	3	2	3	2	6	5	32
12 Jul 07	2	3	4	3	2	2	1	4	21
12 Jul 08	2	3	3	2	3	3	2	8	26
12 Jul 09	8	6	5	3	5	4	6	7	44
12 Jul 10	4	4	3	4	3	3	5	6	32
12 Jul 11	5	5	4	4	2	2	2	7	31
12 Jul 12	5	6	6	4	4	2	1	4	32
12 Jul 13	3	0	0	0	0	1	1	0	5
12 Jul 14	3	2	2	2	3	3	7	7	29
12 Jul 15	4	4	5	4	3	3	6	8	37
12 Jul 16	6	6	6	3	4	4	6	6	41

12 Jul 17	7	8	7	3	3	3	3	5	39
12 Jul 18	4	2	3	1	2	1	4	4	21
12 Jul 19	4	2	2	2	3	2	2	3	20
12 Jul 20	3	6	4	3	4	5	6	7	38
12 Jul 21	5	3	4	3	1	4	2	1	23
12 Jul 22	1	5	6	3	2	1	1	5	24
12 Jul 23	3	4	2	2	3	4	6	6	30
12 Jul 24	5	4	4	3	4	3	4	4	31
12 Jul 25	5	4	4	2	2	2	1	3	23
12 Jul 26	3	2	1	1	1	1	0	0	9
12 Jul 27	0	2	1	0	0	0	0	2	5
12 Jul 28	0	2	2	1	2	3	6	6	22
12 Jul 29	4	3	3	3	2	0	3	2	20
12 Jul 30	3	4	4	3	3	6	5	5	33
12 Jul 31	4	3	3	1	1	1	1	5	19
12 Aug 01	3	3	3	2	3	3	1	5	23
12 Aug 02	3	1	1	1	3	4	5	6	24
12 Aug 03	4	5	5	3	2	2	1	3	25
12 Aug 04	3	4	3	1	1	1	4	5	22
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12 Aug 06	5	6	3	3	3	6	3	6	35
12 Aug 07	5	2	2	2	3	1	6	6	27
12 Aug 08	5	3	3	2	2	2	3	4	24
12 Aug 09	4	4	3	1	1	1	1	0	15
12 Aug 10	0	2	1	0	0	0	0	2	5
12 Aug 11	1	0	2	0	2	3	3	6	17
12 Aug 12	4	4	3	1	2	2	6	4	26
12 Aug 13	3	4	3	3	3	5	6	2	29
12 Aug 14	4	4	3	3	3	3	1	5	26
12 Aug 15	4	2	2	3	3	3	1	5	23
12 Aug 16	5	4	3	2	4	4	4	6	32
12 Aug 17	6	4	3	2	1	2	6	6	30
12 Aug 18	3	4	5	2	2	2	5	4	27
12 Aug 19	1	2	2	3	4	2	1	4	19
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12 Aug 21	4	2	3	3	3	2	4	6	27
12 Aug 22	3	3	2	2	1	2	5	6	24
12 Aug 23	5	5	3	4	3	4	6	3	33
12 Aug 24	4	4	3	2	2	2	4	5	26
12 Aug 25	3	4	4	4	4	3	5	5	32
12 Aug 26	3	3	4	3	4	3	6	4	30
12 Aug 27	3	4	2	2	2	2	3	5	23
12 Aug 28	4	3	2	1	1	1	2	4	18
12 Aug 29	4	2	3	1	0	0	0	2	12
12 Aug 30	2	1	1	1	1	0	3	3	12
12 Aug 31	3	1	1	0	0	0	0	1	6
12 Sep 01	5	4	2	1	2	3	3	5	25
12 Sep 02	6	5	5	3	3	4	5	5	36
12 Sep 03	5	6	4	6	6	4	7	4	42
12 Sep 04	4	4	5	3	2	3	5	7	33
12 Sep 05	5	6	6	5	3	2	5	5	37
12 Sep 06	6	6	2	1	0	3	3	5	26
12 Sep 07	4	6	3	2	3	3	6	6	33
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12 Sep 11	1	1	2	0	0	0	1	1	6
12 Sep 12	3	2	1	2	2	1	3	4	18
12 Sep 13	5	4	3	1	0	2	2	2	19
12 Sep 14	2	3	2	0	1	2	1	5	16
12 Sep 15	5	4	3	2	2	2	4	5	27
12 Sep 16	5	5	2	1	1	2	5	3	24
12 Sep 17	4	3	1	2	1	1	3	3	18
12 Sep 18	4	6	4	2	3	4	3	2	28
12 Sep 19	3	4	3	1	3	5	4	6	29
12 Sep 20	5	3	4	2	3	2	5	6	30
12 Sep 21	3	3	2	1	2	3	5	3	22
12 Sep 22	4	3	3	2	1	0	2	5	20
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12 Sep 25	2	3	2	0	0	0	1	2	10
12 Sep 26	1	1	1	1	1	0	5	5	15
12 Sep 27	4	3	3	1	0	1	3	3	18
12 Sep 28	2	0	0	0	0	0	0	1	3
12 Sep 29	0	1	1	1	0	2	3	4	12
12 Sep 30	3	2	2	2	2	4	5	5	25
12 Oct 01	6	7	5	3	3	2	1	2	29

12 Oct 02	3	1	0	2	1	2	1	2	12
12 Oct 03	4	4	1	1	1	1	1	4	17
12 Oct 04	2	2	0	0	0	0	2	1	7
12 Oct 05	1	2	0	0	1	3	4	5	16
12 Oct 06	3	3	2	2	3	3	3	5	24
12 Oct 07	3	3	2	1	1	1	5	4	20
12 Oct 08	4	4	7	5	4	2	5	6	37
12 Oct 09	5	7	4	5	3	2	4	6	36
12 Oct 10	3	3	3	3	3	7	7	5	34
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12 Oct 15	5	3	3	2	2	2	4	5	26
12 Oct 16	2	3	4	2	2	2	4	4	23
12 Oct 17	4	4	4	2	2	2	1	6	25
12 Oct 18	4	2	2	2	1	2	4	4	21
12 Oct 19	5	2	0	0	2	1	2	2	14
12 Oct 20	1	1	1	1	0	0	2	3	9
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12 Oct 23	3	3	2	3	2	2	5	4	24
12 Oct 24	2	2	2	0	1	2	3	2	14
12 Oct 25	4	4	2	1	2	1	3	4	21
12 Oct 26	2	2	2	1	2	2	4	4	19
12 Oct 27	4	5	2	1	2	1	2	2	19
12 Oct 28	2	2	2	2	1	1	3	2	15
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12 Oct 31	2	0	2	1	2	2	2	4	15
12 Nov 01	4	3	4	4	3	5	5	3	31
12 Nov 02	4	4	1	1	1	2	5	4	22
12 Nov 03	2	1	0	1	2	3	3	3	15
12 Nov 04	2	4	2	1	2	2	1	0	14
12 Nov 05	1	1	1	1	1	4	3	3	15
12 Nov 06	3	2	1	2	2	4	3	3	20
12 Nov 07	4	5	3	2	4	6	7	6	37
12 Nov 08	3	2	2	2	2	0	0	5	16
12 Nov 09	2	2	1	0	1	1	2	2	11
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12 Nov 11	3	3	1	1	2	2	0	1	13
12 Nov 12	3	2	2	0	1	3	4	5	20
12 Nov 13	5	5	4	3	3	4	5	4	33
12 Nov 14	6	6	5	5	4	3	2	2	33
12 Nov 15	3	3	1	2	3	2	4	6	24
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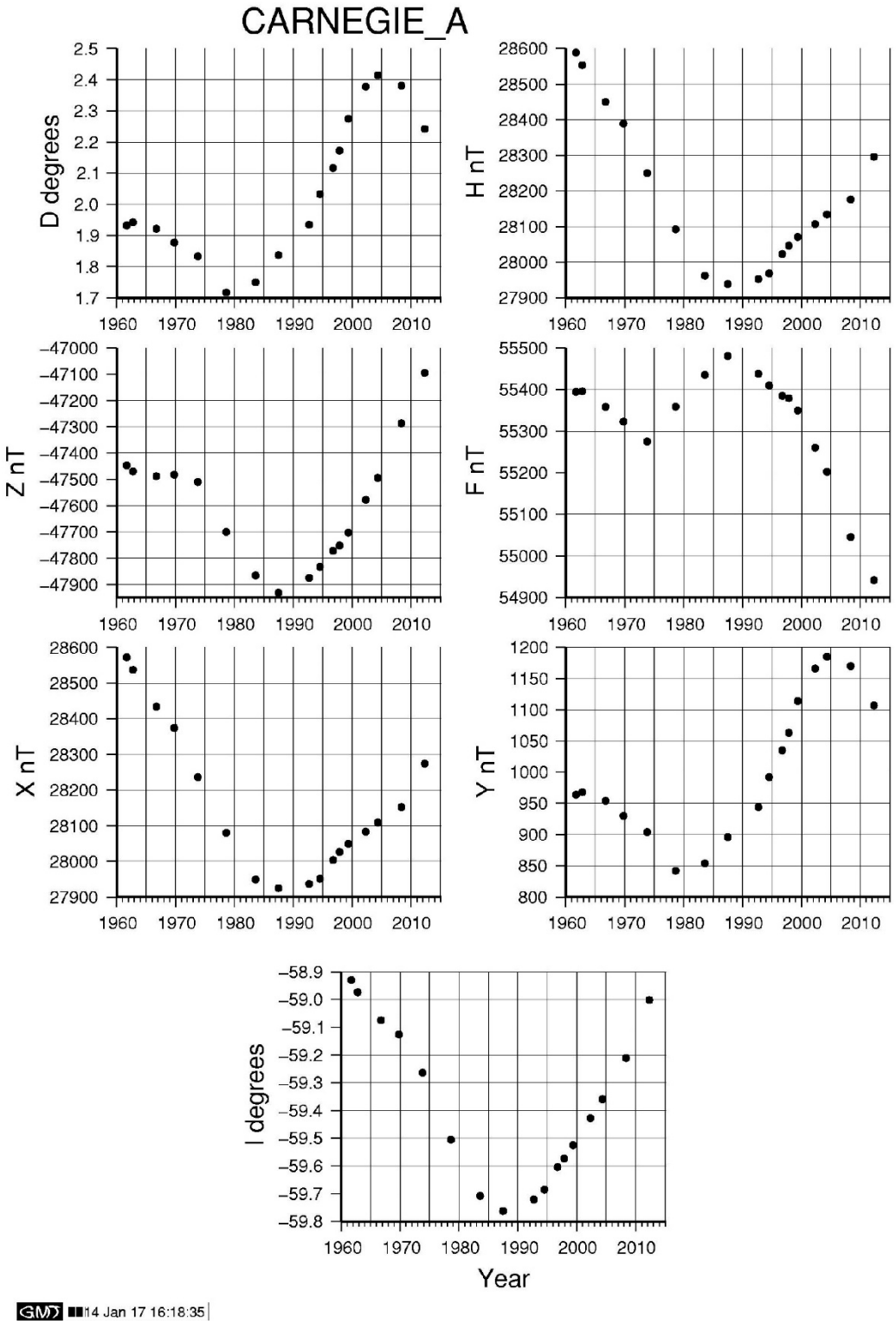
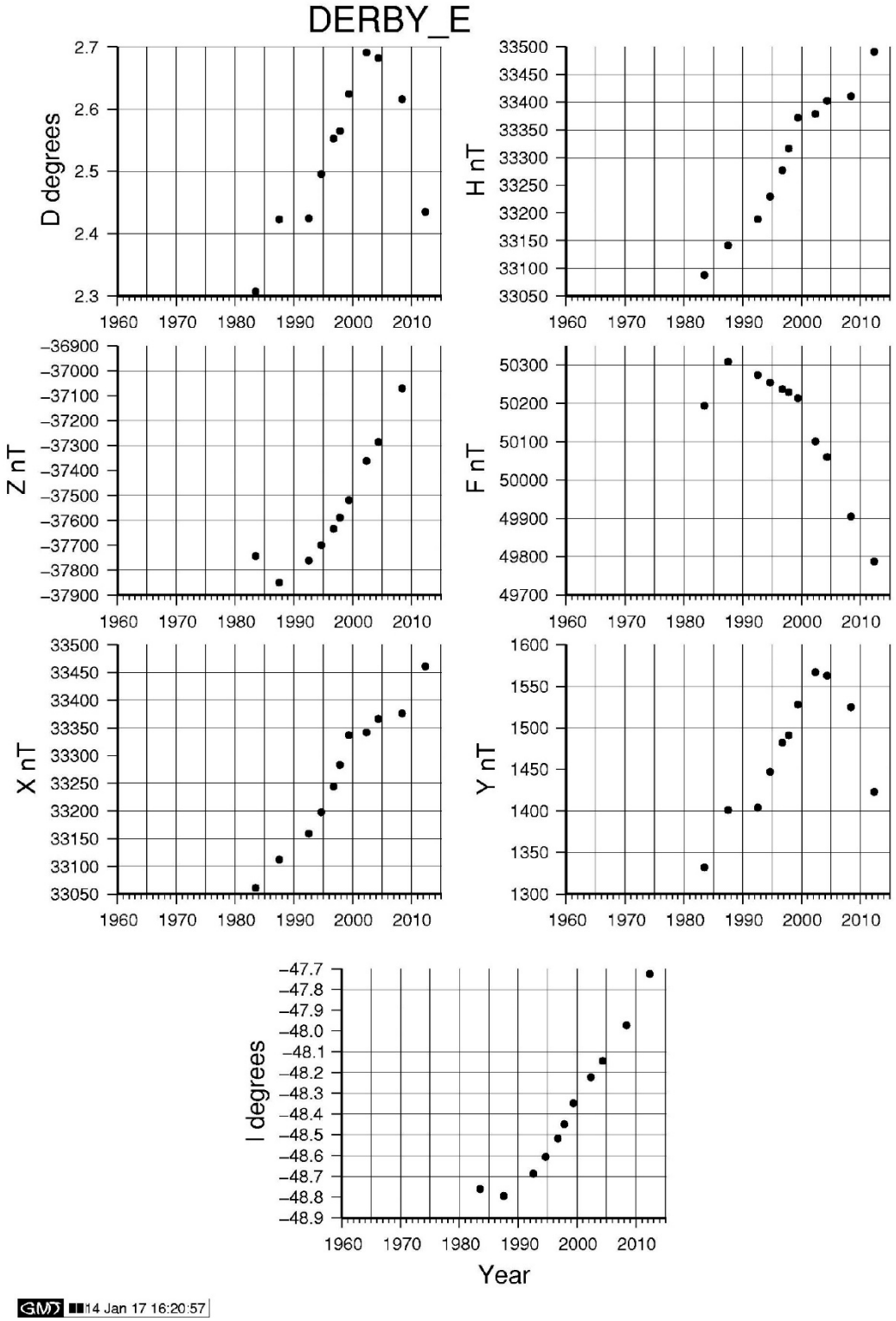
12 Nov 17	3	5	3	3	3	3	5	5	30
12 Nov 18	3	4	2	2	3	2	2	3	21
12 Nov 19	3	3	3	3	3	3	2	4	24
12 Nov 20	4	5	3	2	4	4	6	5	33
12 Nov 21	5	4	3	3	2	3	5	3	28
12 Nov 22	3	3	1	1	2	1	2	4	17
12 Nov 23	2	2	2	1	2	3	3	6	21
12 Nov 24	6	6	5	4	4	3	3	3	34
12 Nov 25	2	3	2	2	3	4	3	4	23
12 Nov 26	3	3	3	3	1	2	3	2	20
12 Nov 27	2	2	2	3	2	2	4	4	21
12 Nov 28	3	3	1	1	0	0	4	4	16
12 Nov 29	3	3	2	2	2	2	3	2	19
12 Nov 30	3	3	1	2	1	2	0	3	15
12 Dec 01	3	2	1	1	1	2	6	5	21
12 Dec 02	4	3	3	3	3	2	2	3	23
12 Dec 03	2	4	3	2	2	2	2	3	20
12 Dec 04	3	5	3	3	2	0	4	3	23
12 Dec 05	2	1	1	1	0	1	3	4	13
12 Dec 06	3	1	1	1	2	0	1	2	11
12 Dec 07	2	0	0	1	2	0	1	2	8
12 Dec 08	1	0	0	1	1	1	2	2	8
12 Dec 09	2	2	1	2	3	2	4	5	21
12 Dec 10	5	3	1	1	2	1	2	2	17
12 Dec 11	2	3	1	0	2	1	2	3	14
12 Dec 12	2	1	1	2	3	2	2	4	17
12 Dec 13	4	3	1	1	2	1	2	3	17
12 Dec 14	2	3	2	1	1	1	3	3	16
12 Dec 15	5	3	3	4	4	3	4	3	29
12 Dec 16	3	3	2	3	3	4	4	4	26
12 Dec 17	4	4	4	4	5	3	2	3	29

```
12 Dec 18     4   3   3   3     3   3   0   4     23
12 Dec 19     4   4   4   2     3   3   2   3     25
12 Dec 20     2   4   3   3     4   3   3   4     26
12 Dec 21     4   3   2   2     2   2   2   3     20
12 Dec 22     2   2   1   1     1   2   2   3     14
12 Dec 23     1   1   0   0     2   2   2   2     10
12 Dec 24     2   1   1   2     2   4   2   2     16
12 Dec 25     3   3   2   1     2   2   3   4     20
12 Dec 26     3   4   4   2     2   1   0   3     19
12 Dec 27     3   3   1   0     1   0   2   3     13
12 Dec 28     2   2   1   1     2   1   3   3     15
12 Dec 29     3   3   3   2     2   2   1   4     20
12 Dec 30     3   3   2   2     3   3   3   3     22
12 Dec 31     2   2   2   0     1   1   2   2     12
Mean of K-Sum is  23.6
Frequency Distribution of K-Indices
K-Index :   0    1    2    3    4    5    6    7    8    9    -
            199   425   599   670   476   303   201   45   10   0    0
--------------------------------------------------------------------------------
```

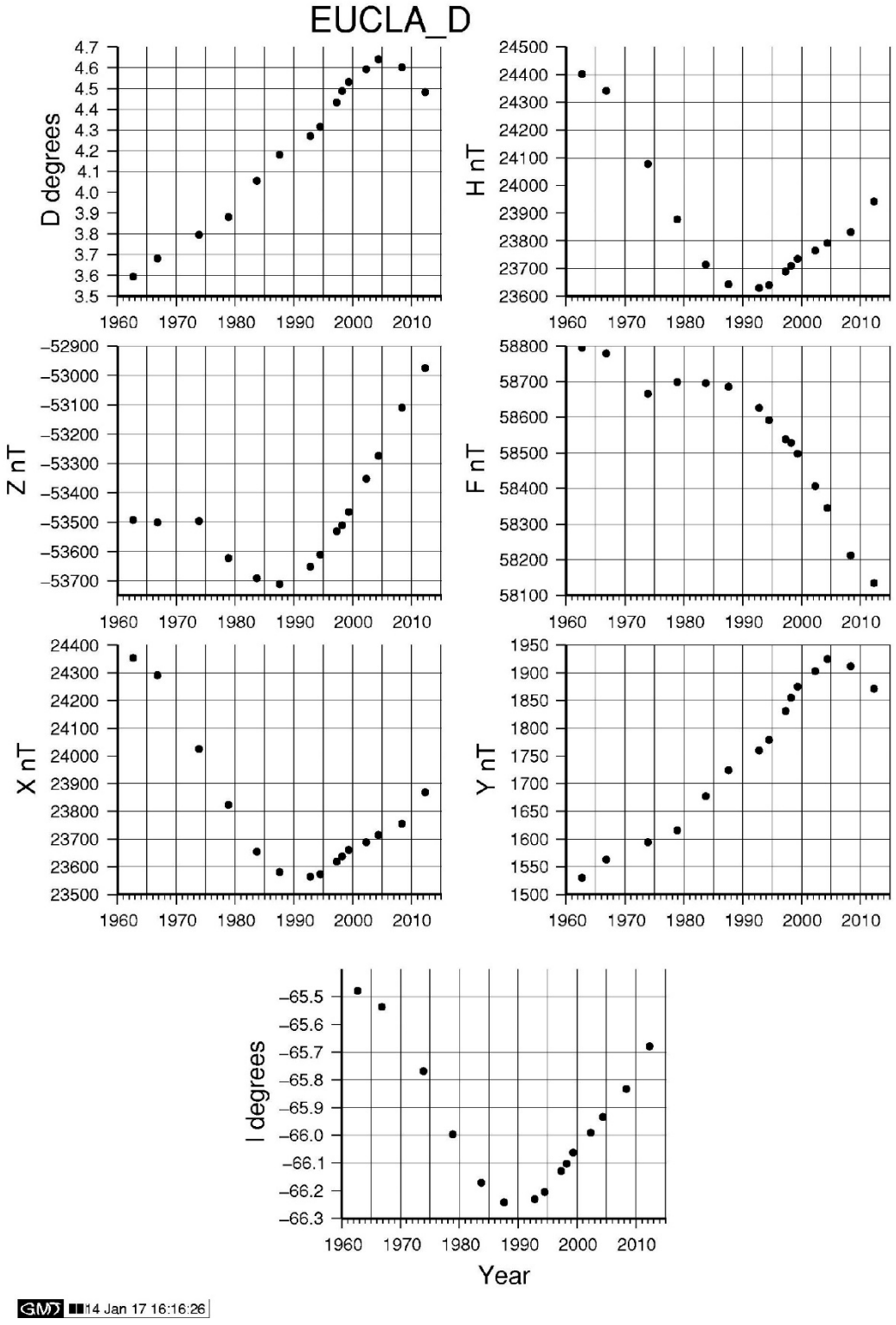
Appendix G Repeat station adopted normal field values



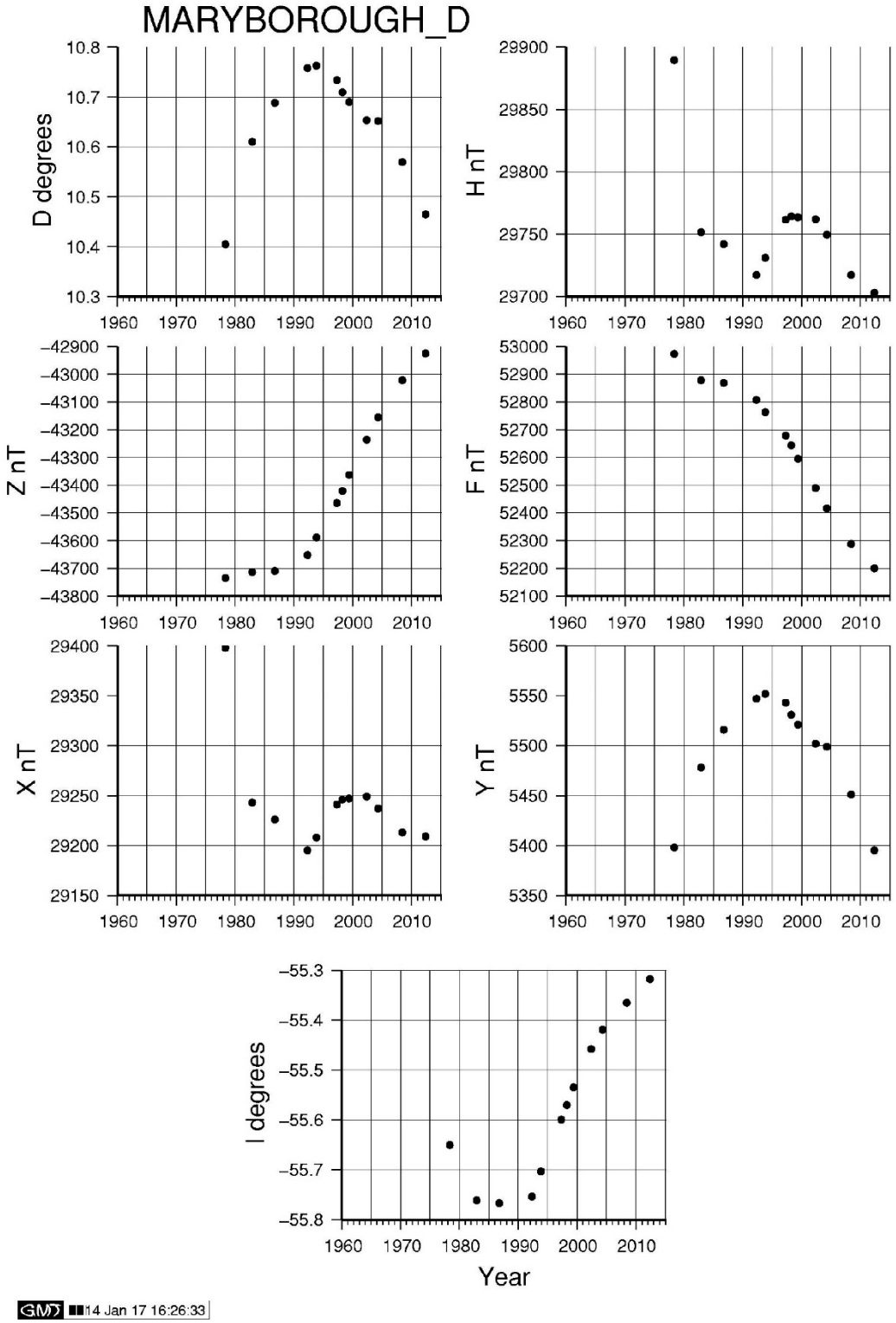
Appendix Figure G.1 CNE (A) adopted normal field values since 1961.



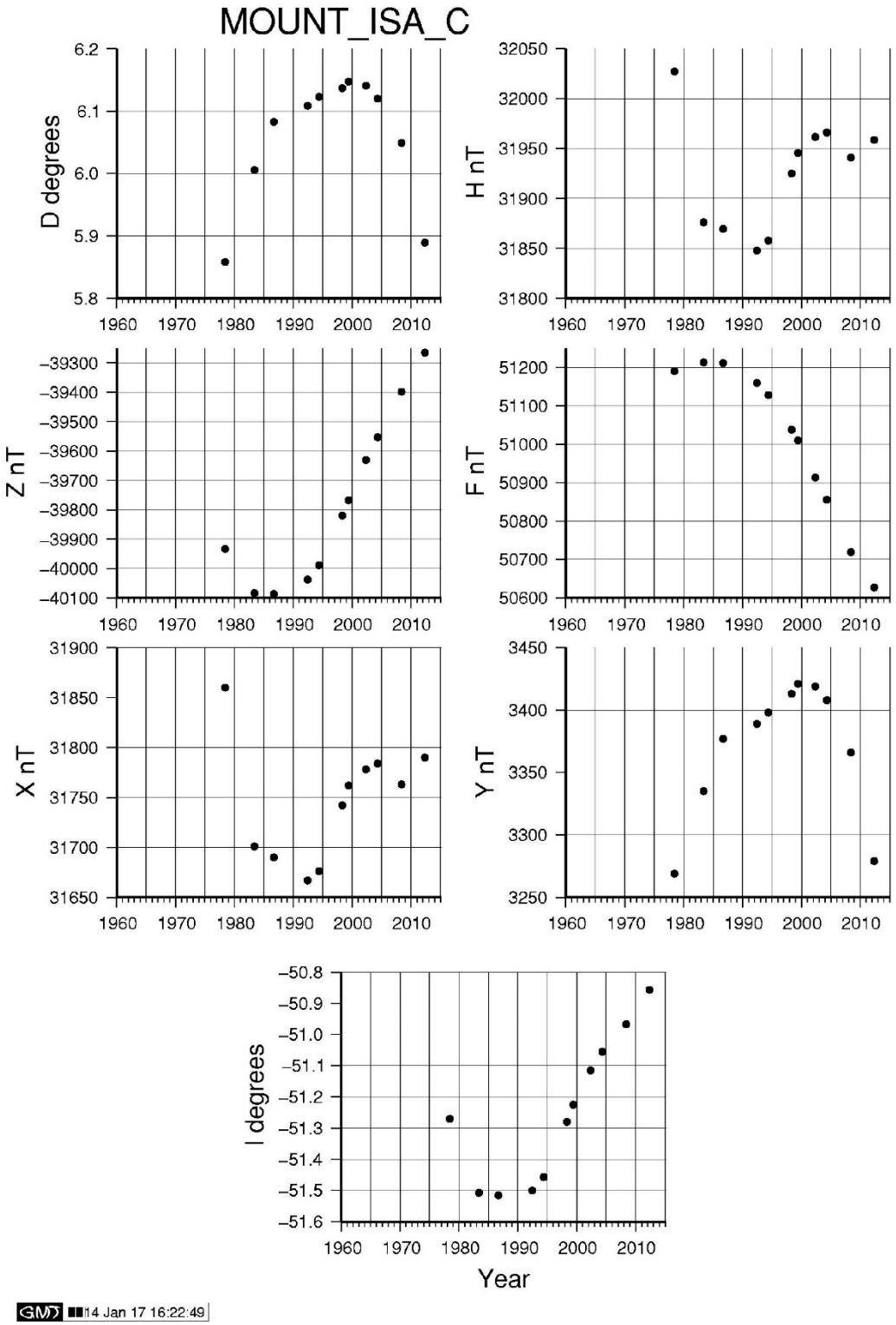
Appendix Figure G.2 DER (E) adopted normal field values since 1983.



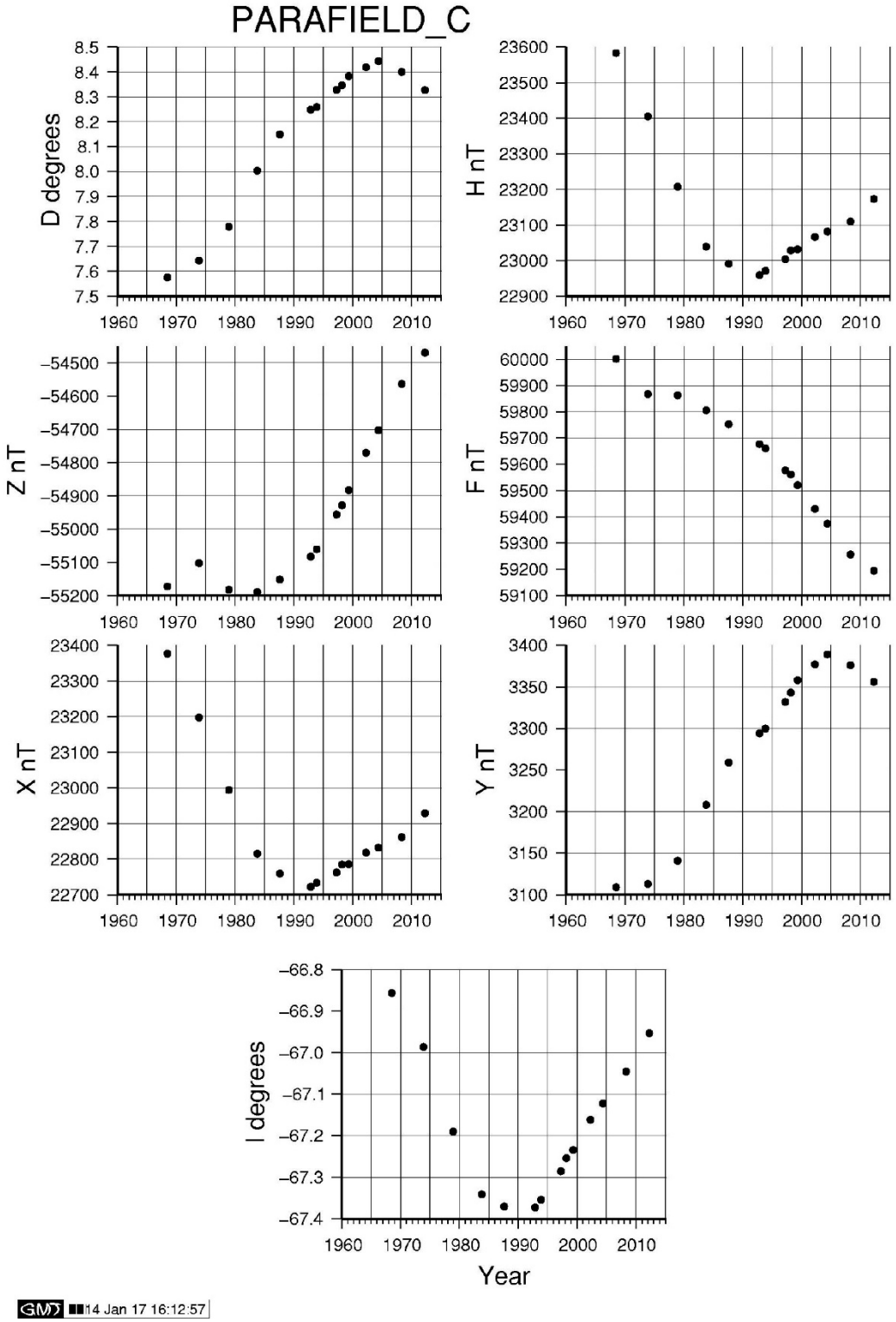
Appendix Figure G.3 EUC (D) adopted normal field values since 1962.



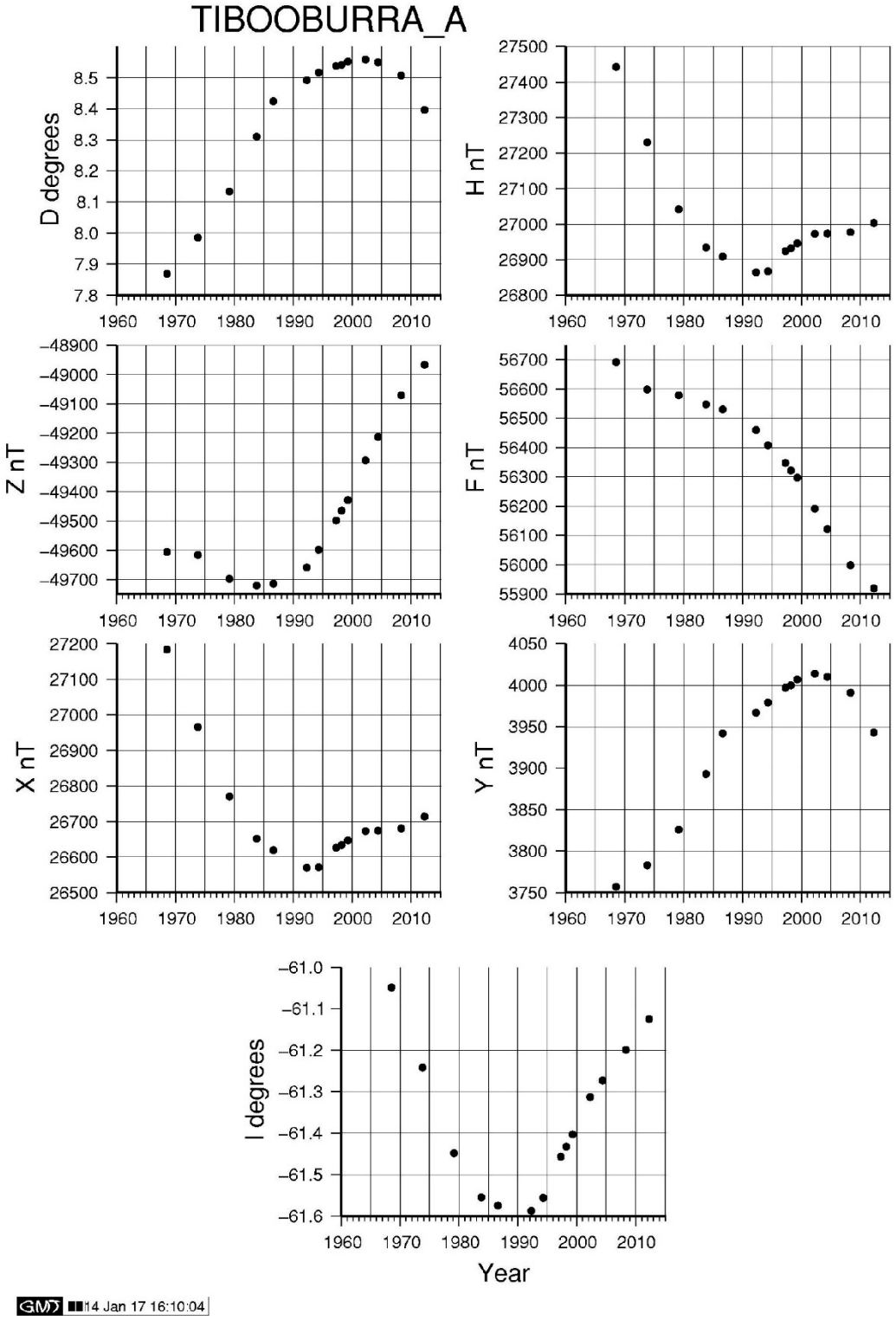
Appendix Figure G.4 MYB (D) normal field values since 1978.



Appendix Figure G.5 ISA (C) normal field values since 1978.



Appendix Figure G.6 PAF (C) normal field values since 1968.



Appendix Figure G.7 TIB (A) normal field values since 1968.

Appendix H List of shortened forms

AAD	Australian Antarctic Division
ADC	Analog-to-digital converter
ADSL	Asymmetric digital subscriber line
AGRF	Australian Geomagnetic Reference Field
AIGO	Australian International Gravitational Observatory
AM	Arithmetic mean
AMSL	Above mean sea level
ANARE	Australian National Antarctic Research Expedition
APS	Australian Public Service
ATWS	Australian Tsunami Warning System
BGS	British Geological Survey
BMR	Bureau of Mineral Resources, Geology and Geophysics
BOM	Bureau of Meteorology
BRM	Baseline reference measurements
CAT	Centre for Appropriate Technology Limited
CF	CompactFlash
CLS	Collecte Localisation Satellites
CNES	Centre national d'études spatiales
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTBT	Comprehensive Nuclear-Test-Ban Treaty
DAF	Data Acquisition Facility
DAQ	Data acquisition
DI-flux/DIM	Declination-Inclination Fluxgate Magnetometer
DMI	Danish Meteorological Institute
DSL	Digital subscriber line
EDA	EDA Instruments Inc.
ETH Zürich	Eidgenössische Technische Hochschule Zürich
FTP	File Transfer Protocol
GA	Geoscience Australia
GDAP	Geophysical Data Application Platform
GFZ	GeoForschungsZentrum

GIN	Geomagnetic Information Node
GNSS	Global navigation satellite system
GPS	Global Positioning System
HTTP	Hypertext Transfer Protocol
IAGA	International Association of Geomagnetism and Aeronomy
IATME	International Association of Terrestrial Magnetism and Electricity
IGRF	International Geomagnetic Reference Field
IMO	INTERMAGNET Magnetic Observatory
INTERMAGNET	International Real-time Magnetic Observatory Network
IP	Internet Protocol
IPS	IPS Radio and Space Services
ISGI	International Service of Geomagnetic Indices
ISO	International Organization for Standardization
LAN	Local area network
LEMI	LEMI LLC.
LRNS	Linear-phase, robust, non-linear smoothing
LSO	Learmonth Solar Observatory
LTE	Long-Term Evolution
NGDC	National Geophysical Data Center
NGL	Narod Geophysics Ltd.
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NTP	Network Time Protocol
OS	Operating system
PC	Personal computer
PDA	Personal digital assistant
PIR	Passive infrared
PPM	Proton precession magnetometer
PPS	Pulse per second
RAAF	Royal Australian Air Force
RM	Reference measurements
ROB	Royal Observatory of Belgium
RSTN	Radio Solar Telescope Network
RTOS	Real-time operating system

SBC	Single-board computer
SD	Standard deviation
SFE	Solar flare effect
SFTP	Secure File Transfer Protocol
SI	International System of Units
SOH	State of health
sps	Samples per second
SSC	Sudden storm commencement
SSH	Secure Shell
UPS	Uninterruptible power supply
UTC	Coordinated Universal Time
VPN	Virtual private network
VSAT	Very small aperture terminal
WDC-STP	World Data Center for Solar-Terrestrial Physics