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A.P. Hitchman, P.G. Crosthwaite, W.V. Jones, A.M. Lewis and L. Wang

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APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

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by

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Summary

During 2010, Geoscience Australia operated nine geomagnetic observatories in Australia, the sub-Antarctic, and Australian Antarctic Territory. The observatories were at Kakadu and Alice Springs in the Northern Territory, Charters Towers in Queensland, Learmonth and Gnangara in Western Australia, Canberra in the Australian Capital Territory, Macquarie Island, Tasmania, in the sub-Antarctic, and Casey and Mawson in the Australian Antarctic Territory.

At Learmonth observatory, 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 collaborators and data repositories in Australia, Japan, France, Germany, UK, USA and Oulu, Finland (from August 2010). K indices were scaled with computer assistance for Canberra, Gnangara and Mawson observatories. Principal magnetic storms and rapid variations were scaled for Canberra and Gnangara. Magnetic-activity data were provided to agencies in Australia, Japan, France, Germany, Spain, Belgium, UK and USA.

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

This report describes instrumentation and activities, and presents annual mean magnetic values, plots of hourly mean magnetic values and K indices, at the magnetic observatories operated by Geoscience Australia during the 2010 calendar year. No repeat stations were occupied during 2010.

Acronyms and abbreviations

AAD	Australian Antarctic Division
ACT	Australian Capital Territory
A/D	analogue to digital
ADAS	analogue data acquisition system
ADSL	asymmetric digital subscriber line
AGR	Australian Geomagnetism Report
AGRF	Australian Geomagnetic Reference Field
AGSO	Australian Geological Survey Organisation
AIGO	Australian International Gravitational Observatory
AMSL	above mean sea level
ANARE	Australian National Antarctic Research Expedition
ANARESAT	ANARE satellite
ASP	Alice Springs magnetic observatory
AusAID	Australian Agency for International Development
BGS	British Geological Survey
BMR	Bureau of Mineral Resources, Geology and Geophysics
BMG	Badan Meteorologi dan Geofisika, Indonesia
BoM	Bureau of Meteorology
CAT	Centre for Appropriate Technology
CLS	Collecte Localisation Satellites, France
CNB	Canberra magnetic observatory
CNES	Centre National d'Etudes Spatiales, France
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSY	Casey magnetic observatory
CTA	Charters Towers magnetic observatory
D	magnetic declination
DIM	Declination and Inclination Magnetometer (D, I-fluxgate magnetometer)
DMI	Danish Meteorological Institute
EDA	EDA Instruments Inc., Canada
F	total magnetic intensity
ftp	file transfer protocol
GA	Geoscience Australia
GDAP	Geophysical Data Acquisition Platform
GIN	Geomagnetic Information Node
GNA	Gnangara magnetic observatory
GPS	Global Positioning System
H	horizontal magnetic intensity
http	hypertext transfer protocol
I	magnetic inclination
INTER-MAGNET	International Real-time Magnetic observatory Network
IAGA	International Association of Geomagnetism and Aeronomy
IGRF	International Geomagnetic Reference Field
IPGP	Institut de Physique du Globe de Paris, France
IPS	IPS Radio and Space Services
ISGI	International Service of Geomagnetic Indices, France
K	logarithmic index of geomagnetic activity
KDU	Kakadu magnetic observatory
LRM	Learmonth magnetic observatory
LSO	Learmonth Solar Observatory
MAW	Mawson magnetic observatory
MCQ	Macquarie Island magnetic observatory
NGDC	National Geophysical Data Center, USA
NOAA	National Oceanic and Atmospheric Administration, USA
nT	nanoTesla
ntpd	Network Time Protocol daemon
OS	operating system
PPM	proton procession magnetometer
RAAF	Royal Australian Air Force
RCF	ring-core fluxgate
SC	sudden commencement
sfe	solar flare effect
ssc	storm sudden commencement
UPS	uninterruptible power supply
UT[C]	Universal Time [Coordinated]
VSAT	Very Small Aperture Terminal
WDC	World Data Center
X	north magnetic intensity
Y	east magnetic intensity
Z	vertical magnetic intensity

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Activities and services

Geomagnetic observatories

Geoscience Australia operates nine permanent geomagnetic observatories in Australia and the Australian Antarctic Territory (Figure 1), located at:

- Kakadu (KDU), Northern Territory;
- Charters Towers (CTA), Queensland;
- Learmonth (LRM), Western Australia;
- Alice Springs (ASP), Northern Territory;
- Gnangara (GNA), Western Australia;
- Canberra (CNB), Australian Capital Territory;
- Macquarie Island (MCQ), Tasmania (sub-Antarctic);
- Mawson (MAW), Australian Antarctic Territory, and;
- Casey (CSY), Australian Antarctic Territory.

Figure 1. The Geoscience Australia geomagnetic observatory network.

A new geomagnetic observatory at Gingin, about 70 km north of Perth, was constructed during 2008. Some post-construction rectification work has been necessary to remove magnetic material from the Absolute Hut. This work was completed in June 2011. Once operational, the observatory will replace the Gnangara observatory which is now too close to the outer suburbs of Perth. The proximity of residential development near to Gnangara has resulted in incidents of vandalism at the site. The two observatories will operate in parallel for about 12 months to obtain an accurate station difference before Gnangara is closed down. The new Gingin observatory will permit the continued acquisition of geomagnetic data in southern Western Australia which began in 1919 with the establishment of the first observatory at Watheroo by the Carnegie Institution of Washington.

Antarctic operations

Geoscience Australia contributes to the Australian National Antarctic Research Expedition through its magnetic observatories at Macquarie Island, Casey and Mawson. Operations at these observatories are supervised and managed from Geoscience Australia headquarters in Canberra with logistic and operational support provided by the Australian Antarctic Division.

Repeat stations

Geoscience Australia maintains a network of magnetic repeat stations throughout continental Australia and its offshore islands, Papua New Guinea, the Solomon Islands and New Caledonia. Stations are occupied every two to four years to provide secular variation data.

Magnetometer calibration

Canberra magnetic observatory hosts the Geoscience Australia 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 variometers and client instrumentation on a cost recovery basis.

Compass calibration

Geoscience Australia provides a service for calibrating and testing direction finding and other instrumentation at cost recovery rates. 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.

Data distribution

Geomagnetic time series recorded by the observatory network are transmitted to Geoscience Australia in near real-time. They are then processed automatically and analysed to derive a range of products distributed to Australian and international clients.

Time series

Preliminary 1-second time series are provided in near real-time by ftp to IPS Radio and Space Services, Sydney, where they are used for space weather forecasting and analysis. From 11 March 2008, 1-second data have also provided to the Edinburgh INTERMAGNET geomagnetic information node (GIN) using http.

Preliminary 1-minute time series are available in near real-time on the Geoscience Australia website. One-minute time series are also sent to the Edinburgh INTERMAGNET GIN using http. Prior to 11 March 2008 these data were sent by email. These data are made available on the INTERMAGNET website. Alice Springs 1-minute time series are sent to the World Data Center for Geomagnetism in Kyoto, Japan.

Definitive 1-minute mean values in X, Y, Z and F, and hourly mean values in all geomagnetic elements for all Geoscience Australia observatories except Casey, are submitted annually to the Paris INTERMAGNET GIN. Under agreement with the National Oceanic and Atmospheric Administration (NOAA), USA, these data are then obtained directly from INTERMAGNET by the National Geophysical Data Center (NGDC), Boulder, and ingested into the World Data Center for Solar-Terrestrial Physics repository.

Australian magnetic observatory data have been contributed to the INTERMAGNET project since the first CD of definitive data was produced (St-Louis, 2008). Table 1 summarises Australian data that have been distributed on INTERMAGNET CDs. The commencement of regular transmission of preliminary near real-time 1-minute data to the Edinburgh INTERMAGNET GIN and the frequency of data transmission are also shown in the table.

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

Observatory	Data first on CD	Data first transmitted	Data transmission frequency
KDU	2000	Aug 2001	real-time
CTA	2000	Aug 2001	real-time
LRM	2005	23 Aug 2005	real-time
ASP	1999	Dec 1999	real-time
GNA	1994	early 1995	real-time
CNB	1991	Oct 1994	real-time
MCQ	2001	Jun 2002	real-time
MAW	2005	24 Nov 2005	real-time

Table 1. Data distribution from Australian geomagnetic observatories to INTERMAGNET.

Magnetic activity indices

K indices for Canberra, Gnangara, and Mawson, are derived using a computer-assisted method developed at Geoscience Australia. The method uses the linear-phase, robust, non-linear smoothing (LRNS) 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 global 'antipodal' aa index.

Canberra is also one of thirteen mid-latitude observatories used in the derivation of the planetary three-hourly Kp range index. Of these observatories, only Canberra and Eyrewell (NZ) are in the southern hemisphere. Gnangara and Canberra are two of the twenty-one observatories in the sub-auroral zones used in the derivation of the 'mondial' am index.

K indices from both Canberra and Gnangara are provided to:

- IPS Radio and Space Services, Sydney, from where they are further distributed to recipients of IPS bulletins and reports, and;
- the International Service of Geomagnetic Indices (ISGI), France, for the compilation of the 'antipodal' aa index and the world-wide 'mondial' am index.

K indices from Canberra observatory are also provided to:

- GeoForschungsZentrum, Potsdam, Germany, for the derivation of global geomagnetic activity indicators such as the 'planetary' Kp index;
- University of Newcastle, Australia;
- Geomagnetism Group of the British Geological Survey;
- CLS, CNES (French Space Agency), Toulouse, France, and;
- Royal Observatory of Belgium, Brussels.

All routine K index information is transmitted by email.

Storms and rapid variations

Details of storms and rapid variations at Canberra and Gnangara are provided monthly to:

- World Data Center for Solar-Terrestrial Physics, Boulder, USA;
- World Data Center for Geomagnetism, Kyoto, Japan, and;
- Observatori de l'Ebre, Spain.

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 was replaced by an annual report in 1993 (Vol. 41). Details of other reports containing Australian geomagnetic data are given in Hopgood (1999 and 2000).

The current annual report series includes data from the magnetic observatories and repeat stations operated by Geoscience Australia. Detailed information about the instrumentation and the observatories is included in McEwin and Hopgood (1994) and Hopgood and McEwin (1997).

From 1999, the Australian Geomagnetism Report has been produced in digital form only. It may be viewed or downloaded at Geoscience Australia's website (http://www.ga.gov.au/earth-monitoring/geomagnetism.html).

World wide web

Australian geomagnetic information, including regularly updated data and indices from Australian observatories, the current AGRF model, and information about Earth's magnetic field, is available on the Geoscience Australia website.

Instrumentation

The basic system used at Australian geomagnetic observatories to monitor magnetic fluctuations comprises a 3-component vector variometer and a total-field scalar variometer. Time-series data are recorded digitally and transmitted to Geoscience Australia in near real-time.

Recording intervals and mean values

The primary recording intervals are 1 second for vector data and 10 seconds for scalar data. Longer-interval time series are derived from these data using the methods described below and summarised in Figure 2 and Table 2.

For vector data, a 1-minute time series is derived from the 1-second data by computing a weighted average of the 1-second value on the minute and the 45 s of data before and 45 s after the minute. The weightings are defined in the INTERMAGNET filter (St-Louis, 2008) and the resulting mean values are centred on the minute. (See Figure 2a.) For example, the minute value labelled 01^m is derived from the 1-second values from 00^m15^s to 01^m45^s inclusive. Where 1-second data are missing from the average window, gaps of up to 12 data points are filled by linear interpolation. Gaps greater than 12 points are not filled and the associated minute value is not computed.

For scalar data, 1-minute means are derived from the 10-second time series by using a box filter to average the 10-second value on the minute and the three 10-second values before and after the minute. The resulting mean minute values are also centred on the minute. (See Figure 2b.) At least three 10-second readings must be present in the average window for the 1-minute mean value to be computed.

Hourly mean values are computed from minutes 00^m to 59^m, using the IAGA-recommended method. (See Figure 2c.) For example, the hourly mean value labelled 01^h is the mean of the 1-minute values from 01:00 to 01:59 inclusive. At least twelve 1-minute values must be present in the average window for the hourly mean to be computed.

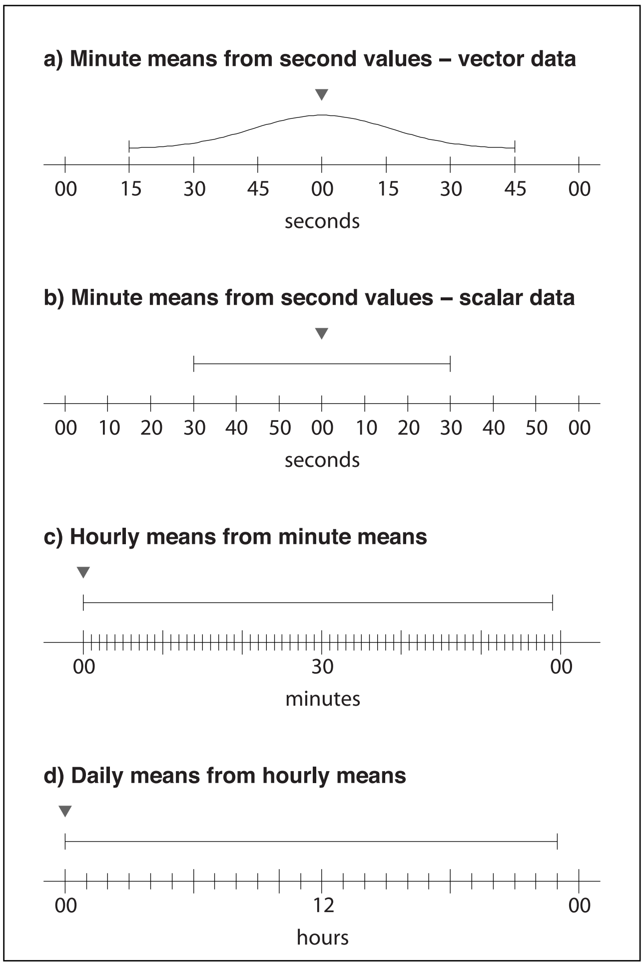


Figure 2. Derivation of a) minute means from second values for vector data, b) minute means from second values for scalar data, c) hourly means from minute values, and, d) daily means from hourly values.

Daily means are the average of twenty-four hourly mean values, from hours 00^h to 23^h. (See Figure 2d.) All twenty-four hourly values must be present in the average window for the daily mean to be computed.

Monthly means are computed from daily means. At least one daily value must exist in the month for the monthly mean to be calculated.

Quiet Day, Disturbed Day and All Day annual means are computed by averaging all available minute values for the 5 International Quiet Days and 5 International Disturbed Days each month, and for All Days in the year. No minimum number of data points is specified for the annual mean calculations.

Time series		Average	Data points	
Derived	**From**	**filter**	**Max**	**Min**
1-minute - vector	1-second	INTERMAGNET	91	7
1-minute - scalar	10-second	Box	7	3
hourly	1-minute	Box	60	12
daily	hourly	Box	24	24
monthly	daily	Box	28-31	1
annual - quiet	minutes	Box	86400	1
annual - disturbed	minutes	Box	86400	1
annual - all-day	minutes	Box	525600-527040	1

Table 2. Summary of the derivation of mean value time series.

The methods used to derive mean values have been inaccurately reported in the Australian Geomagnetism Reports for 2006 to 2009 (Hitchman *et al*. 2008, 2009, 2010a, 2010b). The methods above accurately describe the derivation of mean values since 2006.

Variometers

Vector variometer sensors at Australian observatories are orientated so the 2 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. However, at Macquarie Island 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 that quality control using the FCheck test, which calculates the difference between F determined using the vector variometer (final data model with drifts applied) and F obtained from the scalar variometer, is optimised. Another is that, should one of the vector channels become unserviceable, vector data may be recovered using the remaining two channels and the scalar variometer data (Crosthwaite, 1992, 1994).

Data reduction

Using regular absolute observations, parameters are obtained that enable the calculation of the X, Y and Z (and so H, D, I and F) components of the magnetic field using an equation of the form:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} S_{XA} & S_{XB} & S_{XC} \\ S_{YA} & S_{YB} & S_{YC} \\ S_{ZA} & S_{ZB} & S_{ZC} \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix} + \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix}$$

$$+ \begin{pmatrix} Q_X \\ Q_Y \\ Q_Z \end{pmatrix} (T - T_S) + \begin{pmatrix} q_X \\ q_Y \\ q_Z \end{pmatrix} (t - t_S) + \begin{pmatrix} D_X \\ D_Y \\ D_Z \end{pmatrix} (\tau - \tau_0)$$

where:

- A, B and C are the near-orthogonal, arbitrarily orientated variometer ordinates;
- matrix [S] combines scale values and orientation parameters;
- vector [B] contains baseline values;
- vectors [Q] and [q] contain temperature coefficients for sensors and electronics;
- T and t are the temperatures of the sensors and electronics;
- T_S and t_S are their standard temperatures;
- vector [D] contains drift-rates with a time origin at τ_0, where τ is the time.

The parameters in [S], [Q] and [q] are determined using the calibration coils at the Geoscience Australia Magnetometer Calibration Facility while those in [B] and [D] that best fit the absolute observations are determined by visual observation.

Absolute magnetometers

The principal absolute magnetometers used to calibrate variometers at Australian magnetic observatories are DI-fluxgate magnetometers (or Declination and Inclination Magnetometers – DIMs) to measure the magnetic field direction, and proton-precession or Overhauser-effect magnetometers to measure its total intensity.

DIMs at Australian observatories use Bartington MAG-01H and DMI Model G fluxgate sensors and electronics, mounted on Zeiss-Jena 020B and 010B non-magnetic theodolites.

DIM observations at most observatories are performed using the *offset* method. In this method, the theodolite is set to the whole number of minutes nearest a null fluxgate output, resulting in a small non-zero output. The theodolite reading and a series of eight fluxgate–time readings are then recorded in each position. At some observatories the *null* method continues to be used. In this method, the theodolite is set to achieve a null fluxgate output and a single theodolite–time reading is recorded in each position.

Reference magnetometers

Geoscience Australia maintains reference magnetometers for declination, inclination and total intensity at Canberra magnetic observatory where they are in routine use to calibrate the variometers. A DIM is used as both the declination and inclination reference and an Overhauser-effect magnetometer is used as the total-field reference.

Regular inter-comparisons performed at 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 reference magnetometers, sometimes through subsidiary travelling reference instruments.

Results identified as *final* in this report indicate that absolute magnetometers used to determine baselines have been corrected to international standards.

Data acquisition

Data-acquisition computers at Australian observatories use software built around the QNX operating system. Timing is governed by the operating system clock which is maintained to within 1 ms of UTC using an external GPS clock. The Network Time Protocol daemon (ntpd), which can maintain the system clock to within 10 ms of UTC, is also available as a backup. All observatories used an external GPS clock to maintain timing accuracy throughout 2010.

ADAM A/D converters are used to convert analogue outputs from the DMI FGE and EDA 3-component variometers to digital data for recording on data-acquisition computers. The Narod ring-core fluxgate magnetometers have built-in A/D converters that provide digital data direct to the acquisition computers.

Observatory data are retrieved to Geoscience Australia in near real-time via the NextG mobile phone network, satellite, ADSL, radio, network links and telephone-line modems within Australia and via the ANARESAT satellite link from Antarctica.

Uninterruptible Power Supplies (UPS) or DC-battery power supplies are installed at all observatories. Lightning surge filters are installed where required.

1. 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.

The magnetic observatory comprises:

- a 3x3 m air-conditioned concrete-brick Control House, with concrete ceiling and aluminium cladding and roof, where recording instrumentation and control equipment are housed;
- a 3x3 m roofed Absolute Shelter, 50 m NW of the Control House, that houses a 380 mm square fibre-mesh-concrete observation pier (Pier A), the top of which is 1200mm from its concrete floor;
- two 300 mm diameter azimuth pillars, both about 100 m from Pier A and with approximate true bearings of 27° and 238°;
- 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), and;
- 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.

Key data for the observatory are given in Table 1.1.

IAGA code:	KDU
Commenced operation:	05 March 1995
Geographic latitude:	12° 41' 10.9" S
Geographic longitude:	132° 28' 20.5" E
Geomagnetic latitude:	-21.54°
Geomagnetic longitude:	206.04°
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
Observer:	A. Ralph

Table 1.1 Key observatory data.

Variometers

The variometers used during 2010 are described in Table 1.2.

3-component variometer:	DMI FGE
Serial number:	E0198/S0183
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.03 nT
A/D converter:	ADAM 4017 module (±5V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	4071413/42185
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	VSAT satellite link

Table 1.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

Analogue outputs from the three fluxgate sensors, and the sensor and electronics temperatures, were converted to digital data using an ADAM 4017 analogue-to-digital converter mounted inside the fluxgate electronics unit. These data and the digital PPM data were recorded on the data acquisition computer located in the Control House.

The magnetic sensors were located in the concrete underground vaults: the fluxgate sensor in the northern vault (the one nearer the Absolute Shelter); and the PPM sensor in the southern vault. Both vaults were completely buried in soil to minimise temperature fluctuations.

The GSM-90 variometer electronics was located in the covered vault with its sensor. DC power and data cables ran between the GSM-90 vault and the Control House.

The fluxgate electronics console was placed in its own partially insulated plastic box, resting on the concrete floor in the Control Hut, with some bricks for heat-sinks to minimise temperature fluctuations. This proved to be effective in reducing the amplitude of temperature fluctuations with periods of the order of hours.

The equipment was protected from power blackouts, surges and lightning strikes by a mains filter, an uninterruptible power supply and a surge absorber. Before 2008 the data connections between the acquisition computer and both the ADAM A/D and the PPM variometer were via fibre-optic modems and fibre-optic cable to isolate any damage from lightning entering the system through any one piece of equipment. During 2007 the fibre-cables were rearranged and from 2008 there was no fibre in the PPM data link.

DI fluxgate:	Bartington MAG-01H
Serial number:	B0622H
Theodolite:	Zeiss 020B
Serial number:	359142
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081421/42186
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 1.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Although some lightning protection measures were incorporated in its original construction, Kakadu Observatory has suffered frequent lightning damage since its installation in 1995. Additional protection measures were taken in December 1998 and October 1999, including the installation of an ERICO system.

Since then, although power and communications have frequently been interrupted, the observatory has survived serious damage from electrical storms. Still, on 18 November 2010, between 06:30 and 09:30 UT, it appears that a lightning strike damaged nearby electrical infrastructure supporting the observatory and caused 5 days of GSM90 PPM data loss.

The ERICO System 3000 (Advanced Integrated Lightning Protection), comprising a Dynasphere Air Termination unit, mast, and copper-coated-steel earthing rod, was designed to protect an area of 80 m radius. Lengths of copper ribbon and aluminium power cables buried in shallow trenches towards the Absolute Shelter, in the opposite direction, and from the Control House to and around both variometer sensor vaults, and a conducting loop around the Control House, were connected to the ERICO system.

The DMI FGE variometer scale-value, alignment, and temperature sensitivity parameters were measured at the magnetometer calibration facility at Canberra observatory before installation at Kakadu. 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, which houses the DMI electronics, had its temperature maintained by an air conditioning unit. The current unit was installed in November 2008 and replaced the previous unit which had become unserviceable. The temperature of the DMI electronics ranged from 27°C (in the winter months) to 30°C (in the summer months) during the year, at an average of 28°C±0.7°C. During the period 17-23 November the air-conditioning unit stopped temporarily and electronics temperatures reached 33°C. Annual temperature variations converted to variations 0.2 nT, 0.4 nT and 0.5 nT in the X, Y and Z channels.

The DMI sensor temperature ranged from 28°C to 34°C during the year, with an average of 30.5°C±1.4°C. Although buried underground, it varied during the year in accordance with the seasons at long periods and probably with barometric pressure systems at short periods. Temperature variations converted to variations 0.3 nT, 1.0 nT and 0.0 nT in the X, Y and Z channels.

Variometer data timing was controlled by the QNX data-acquisition computer clock which was maintained using both the 1 PPS and data stream output of a GPS clock. A small error occasionally occurred just after computer resets which was corrected within a few minutes. Time corrections were logged automatically. All corrections are explainable as system restarts.

Absolute instruments

The principal absolute magnetometers used at Kakadu and their adopted corrections for 2010 are described in Table 1.3.

The best way to use the Kakadu DIM is to take all readings on the x10 scale and to switch to the x1 scale while rotating the theodolite. Additionally, the theodolite should be rotated so that the objective lens passes exclusively through positive field values (or alternatively exclusively through negative field values). These measures reduce the effects of hysteresis in the fluxgate sensor. The observer was trained to use this method throughout the year at Kakadu.

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

Table 1.3 describes the corrections applied to the absolute magnetometers to align them with the Australian reference instruments held in Canberra. The corrections applied in 2010 were changed from those applied in 2009.

At the 2010 mean magnetic field values at Kakadu the D, I and F corrections translate to corrections of:

$\Delta X = +0.0$ nT $\Delta Y = +0.0$ nT $\Delta Z = +0.0$ nT

These instrument corrections have been applied to the data described in this report and to other published definitive data.

Baselines

There were 26 pairs of absolute measurements during 2010. The DMI variometer baseline variations were reasonably well controlled, though the baseline observations were more scattered and less frequent than would be preferred. There was a baseline jump in both the DMI and PPM variometers on 16 July 2010 due to work on the fences around vaults. The baseline jump values determined from the absolute baseline measurements were:

X	-12.0 nT
Y	0.0 nT
Z	7.2 nT
F	5.0 nT

With the adjusted baseline jump for 16 July, daily averages of FCheck remained between -0.2 and 0.8 nT throughout the year, indicating the DMI variometer baseline was stable. Taking into account the daily averages of FCheck no drifts have been applied to the DMI variometer baseline.

The means and standard deviations of the weekly absolute observations from the final adopted variometer model and data were:

	mean	**stdev**		**mean**	**stdev**
X	-0.7 nT	2.7 nT	D	+0.4"	28"
Y	0.0 nT	4.9 nT	I	-3.1"	12"
Z	-0.3 nT	4.0 nT	F	-0.4 nT	4.2 nT

The baselines aligned with the 2009 baselines at 2010-01-01T00:00.

The baseline observations were more scattered and less frequent than is expected for an INTERMAGNET observatory.

During 2010, the difference between total-field absolute observations and the scalar variometer varied over a 5 nT range (after several unacceptable observations were rejected). This indicates a problem with the environment where observations were made (e.g. magnetic contamination).

Observed and adopted baseline values in X, Y and Z are shown in Figure 1.1.

Operations

When possible, absolute observations were performed weekly by the local observer, Andy Ralph. On these visits the operation of the observatory was also checked. Completed absolute observation forms were posted to Geoscience Australia where they were processed and used to calibrate the variometer data.

The local observer was trained at Kakadu Observatory in September 2006. Due to other commitments, he was unable to make as many observations as is customary at geomagnetic observatories, particularly during the tourist season (between monsoons). Also, some absolute observations were unacceptable, the most likely reason being magnetic contamination. Refresher training was given to the observer in October 2009. The lack of frequent quality observations is problematic but FCheck indicates the DMI FGE magnetometer baselines becomes stable again as they were in previous years (excluding 2009).

Jim Whatman from GA visited the observatory on 16 July 2010 to alter the power supply system and fix the wooden fences around the DMI and PPM variometer vaults. The fences were joined by bolts and nuts and it caused baseline shifts of the DMI and PPM.

Lightning damaged the power supply to the observatory at 06:30 18 November 2010, and caused 5 days of GSM-90 PPM data loss.

Unusually periodic signal on the ABC channels of the DMI variometer commenced at 03:04 on 21 November and continued into the following day. It is suspected that the problem was caused by the power supply. After a fuse holder was replaced, the periodic signal disappeared. For this reason, data between 03:42:00 21 November - 05:59:00 22 November have been deleted.

Data were retrieved from the data-acquisition system at least every 10 minutes using *rsync over ssh* in near real-time using the network connection.

The distribution of Kakadu 2010 data is described in Table 1.4. Data losses are identified in Table A.1.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011

Table 1.4. Distribution of Kakadu 2010 data.

Significant events

2010-02-15 21:54 Mag 6 Earthquake in Banda Sea

2010-02-26 15-20min scheduled telemetry interruption today due to service provider maintenance.

2010-04-13 04-07 Electronics temperature anomaly

2010-07-16 04:00 Jim W at KDU - alterations to power supply system. 06:50 Fences fixed, and now running off inverter / NO UPS any longer. PPM and DMI baseline jumps due to work on fences around the vaults.

2010-08-04 Today's absolute observations showed the T0 is 10057 nT. The toggle switch flipped to + side and offset value was 10 micro-Tesla. Asked Andy to set the offset to zero and the toggle switch in the neutral position.

2010-08-27 No obs as on Friday, it rained just about all day, had 40mm at KDU (AP)

2010-09-29 17:13 Quake noise Mag 7.2 Irian Jaya

2010-10-19 FP and EF changed about 5 nT from observation for 30 Sep. likely being magnetic contamination

2010-11-18 06:47 (approx) variometer ppm stops working - no response when checked using qtalk seismic (battery voltage) and geomag (electronics temperature) evidence suggests mains power off. probable lightning spikes on data 06:30 to 09:30

2010-11-19 Andy Ralph contacted by phone - he is in Darwin and will not be back in Jabiru until late on Sunday. Andy reported that he experienced trouble with the telephone in the hut on Monday 15 Nov.

2010-11-21 03:40 unusually periodic signal on ABC channels commences and continues into following day approx 04:30 Andy visits hut and confirms power is off - resets breakers. no improvements

2010-11-21 22:45 Jim Wilson from Blue Ridge Engineering contacted; he says he will have a look at power problems this morning.

2010-11-22 05:15 Electrician reports that a new fuse holder is required - it will be fitted later today. 06:00 (approx) mains power probably restored

2010-11-24 00:06 Andy cycles power on all geomag equipment coming out of the variometer battery box this gets the GSM90 PPM running again. Andy will be in Sydney next week, so may not be able to do observations. Bartington battery is flat and PDA had lost memory so no obs performed today. PDA restored and bartington put on charge - battery reporting 4.4 V. Report faulty telephone line to Telstra

2010-11-27 Absolute GSM90 will not work during observations - probably cable problems

2010-11-28 Speak to Andy - he will post back PDA/PDA cable/GSM90 power-data cable and GSM90 sensor cable.

2010-12-01 GSM90 power/data+sensor cable and PDA+serial cable + null modem arrives from KDU for repair

2010-12-02 Repaired GSM90 cable + PDA returned to KDU via Express Post

2010-12-06 GSM90 cable and PDA received at KDU

2010-12-08 Bartington flat again, so no observations today, will post it to Canberra tomorrow for checking

Annual mean values

The annual mean values for Kakadu are set out in Table 1.5 and displayed with the secular variation in Figure 1.2.

Hourly mean values

Plots of the hourly mean values for Kakadu 2010 data are shown in Figure 1.3.

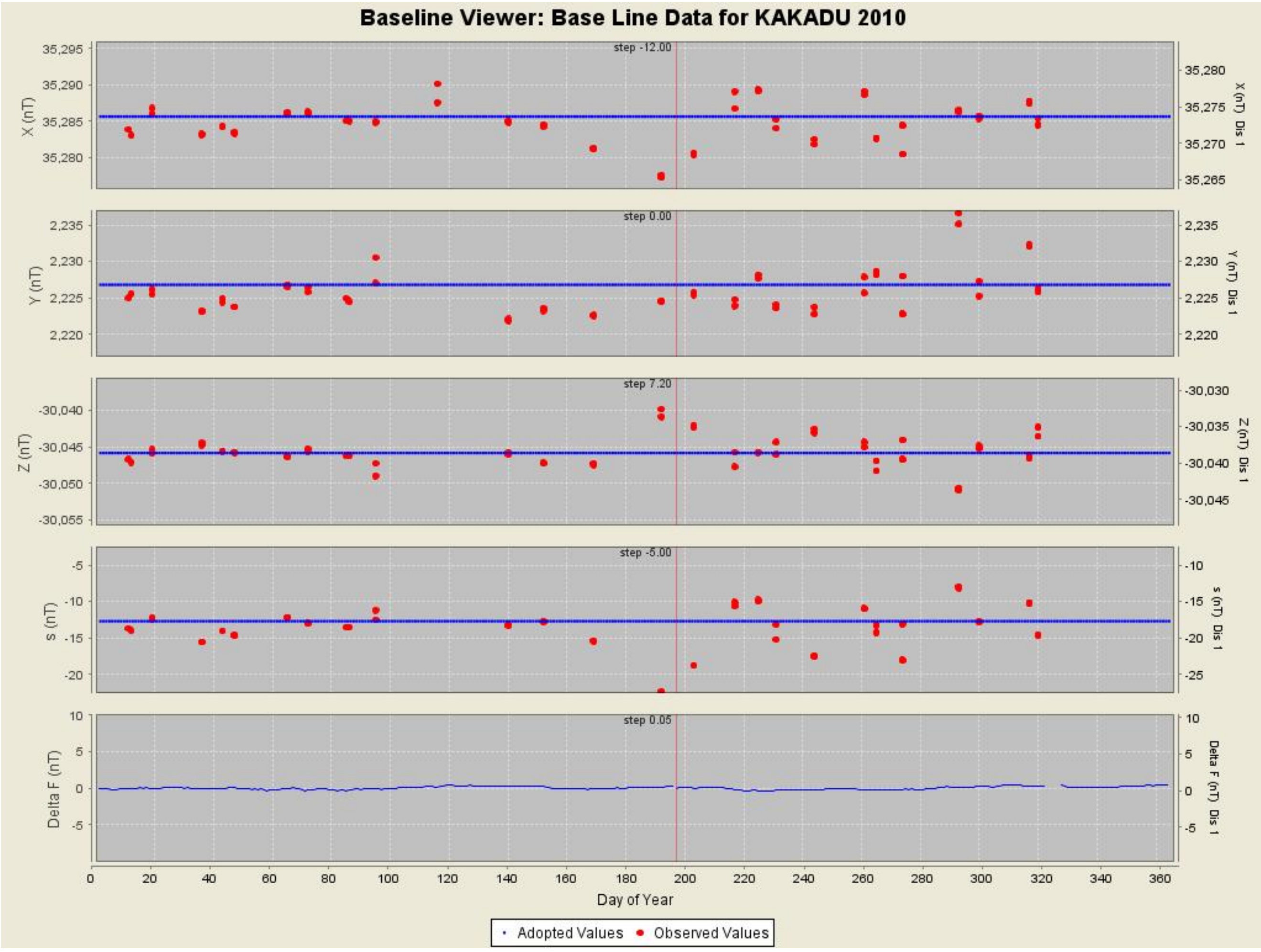
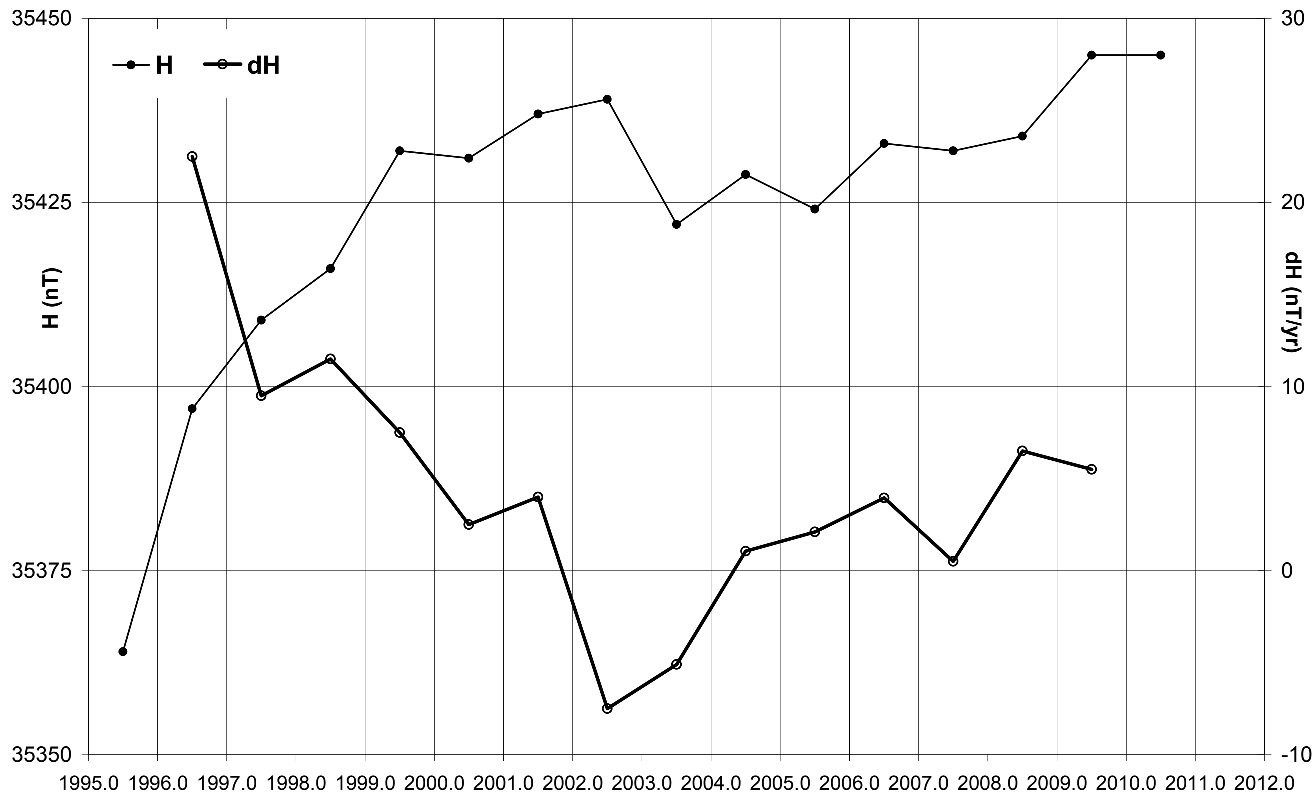


Figure 1.1. Kakadu 2010 baseline plots.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)	
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABZ
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABZ
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABZ
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABZ
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABZ
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABZ
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABZ
2002.5	A	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	ABZ
2003.5	A	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	ABZ
2004.5	A	3	43.3	-40	15.7	35429	35354	2299	-30005	46428	ABZ
2005.5	A	3	42.2	-40	13.4	35424	35350	2288	-29960	46395	ABZ
2006.5	A	3	40.7	-40	10.1	35433	35360	2273	-29910	46370	ABZ
2007.5	A	3	38.6	-40	07.6	35432	35361	2252	-29864	46339	ABZ
2008.5	A	3	36.4	-40	05.2	35434	35364	2229	-29823	46314	ABZ
2009.5	A	3	33.8	-40	02.0	35445	35377	2203	-29777	46293	ABZ
2010.5	A	3	30.4	-39	59.5	35445	35378	2168	-29732	46263	ABZ
1995.583	Q	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	ABZ
1996.728	Q	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	ABZ
1997.455	Q	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	ABZ
1998.5	Q	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	ABZ
1999.5	Q	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	ABZ
2000.5	Q	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	ABZ
2001.5	Q	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	ABZ
2002.5	Q	3	44.5	-40	18.4	35454	35378	2313	-30074	46491	ABZ
2003.5	Q	3	44.2	-40	17.4	35439	35363	2309	-30043	46459	ABZ
2004.5	Q	3	43.3	-40	15.0	35441	35366	2301	-30003	46435	ABZ
2005.5	Q	3	42.3	-40	12.7	35436	35362	2290	-29959	46403	ABZ

2006.5	Q	3	40.7	-40	09.6	35442	35369	2274	-29909	46376	ABZ
2007.5	Q	3	38.7	-40	07.3	35438	35367	2253	-29864	46344	ABZ
2008.5	Q	3	36.4	-40	04.8	35440	35370	2230	-29823	46318	ABZ
2009.5	Q	3	33.8	-40	01.8	35448	35380	2203	-29776	46295	ABZ
2010.5	Q	3	30.4	-39	59.1	35450	35384	2168	-29731	46267	ABZ
1995.583	D	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	ABZ
1996.728	D	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	ABZ
1997.455	D	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	ABZ
1998.5	D	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	ABZ
1999.5	D	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	ABZ
2000.5	D	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	ABZ
2001.5	D	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	ABZ
2002.5	D	3	44.5	-40	20.4	35416	35341	2311	-30077	46464	ABZ
2003.5	D	3	44.0	-40	19.8	35396	35321	2305	-30050	46431	ABZ
2004.5	D	3	43.2	-40	16.9	35407	35332	2297	-30008	46412	ABZ
2005.5	D	3	42.2	-40	14.5	35404	35330	2286	-29963	46381	ABZ
2006.5	D	3	40.8	-40	10.9	35419	35346	2273	-29911	46359	ABZ
2007.5	D	3	38.6	-40	08.0	35423	35351	2251	-29865	46332	ABZ
2008.5	D	3	36.4	-40	05.6	35426	35356	2228	-29824	46308	ABZ
2009.5	D	3	33.8	-40	02.3	35439	35371	2202	-29777	46288	ABZ
2010.5	D	3	30.4	-40	00.0	35434	35368	2167	-29733	46256	ABZ

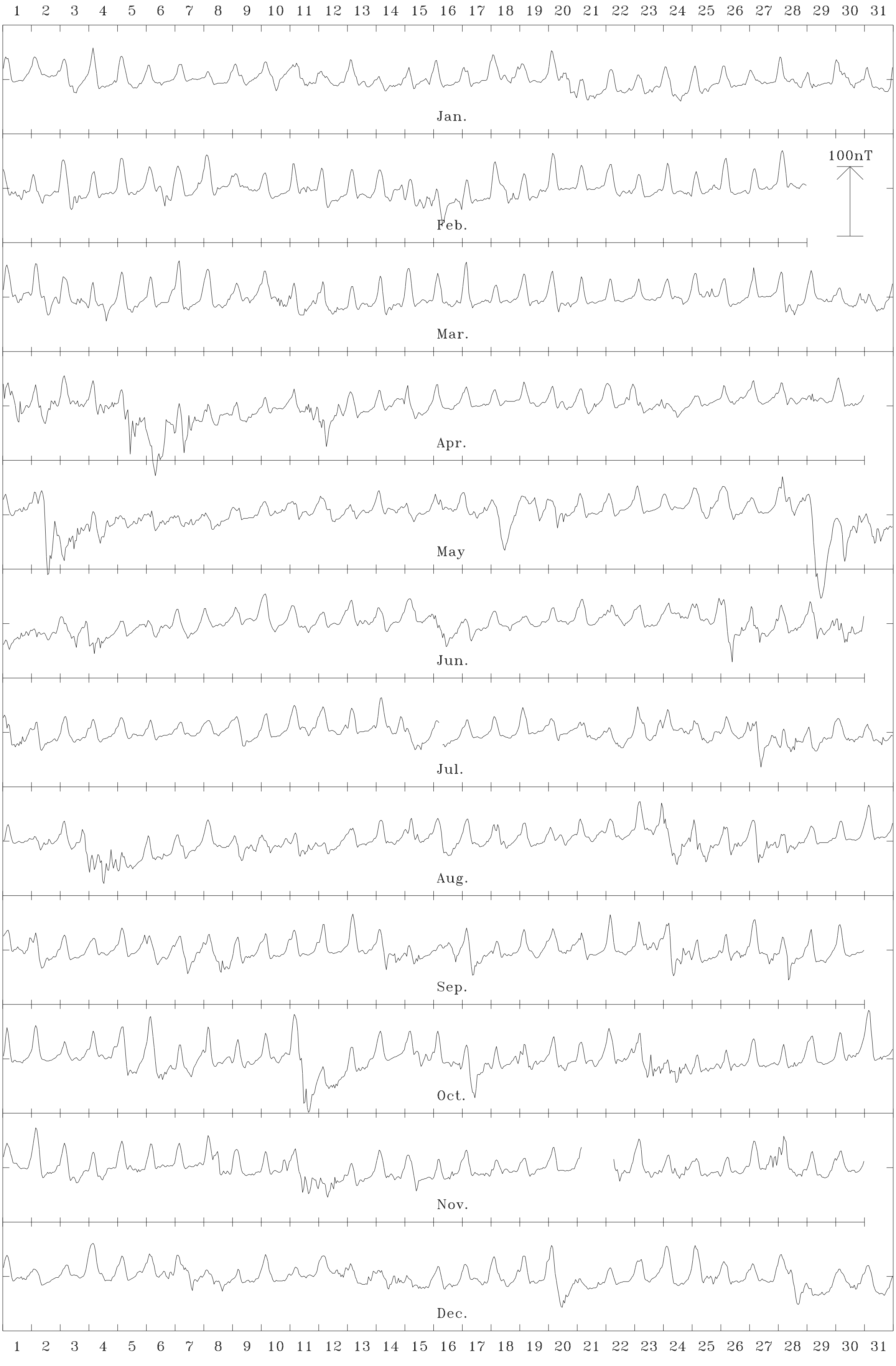
Table 1.5. Kakadu annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 1.2.


H
dH
H (nT)
dH (nT/yr)
35450
35425
35400
35375
35350
30
20
10
0
-10
1995.0 1996.0 1997.0 1998.0 1999.0 2000.0 2001.0 2002.0 2003.0 2004.0 2005.0 2006.0 2007.0 2008.0 2009.0 2010.0 2011.0 2012.0

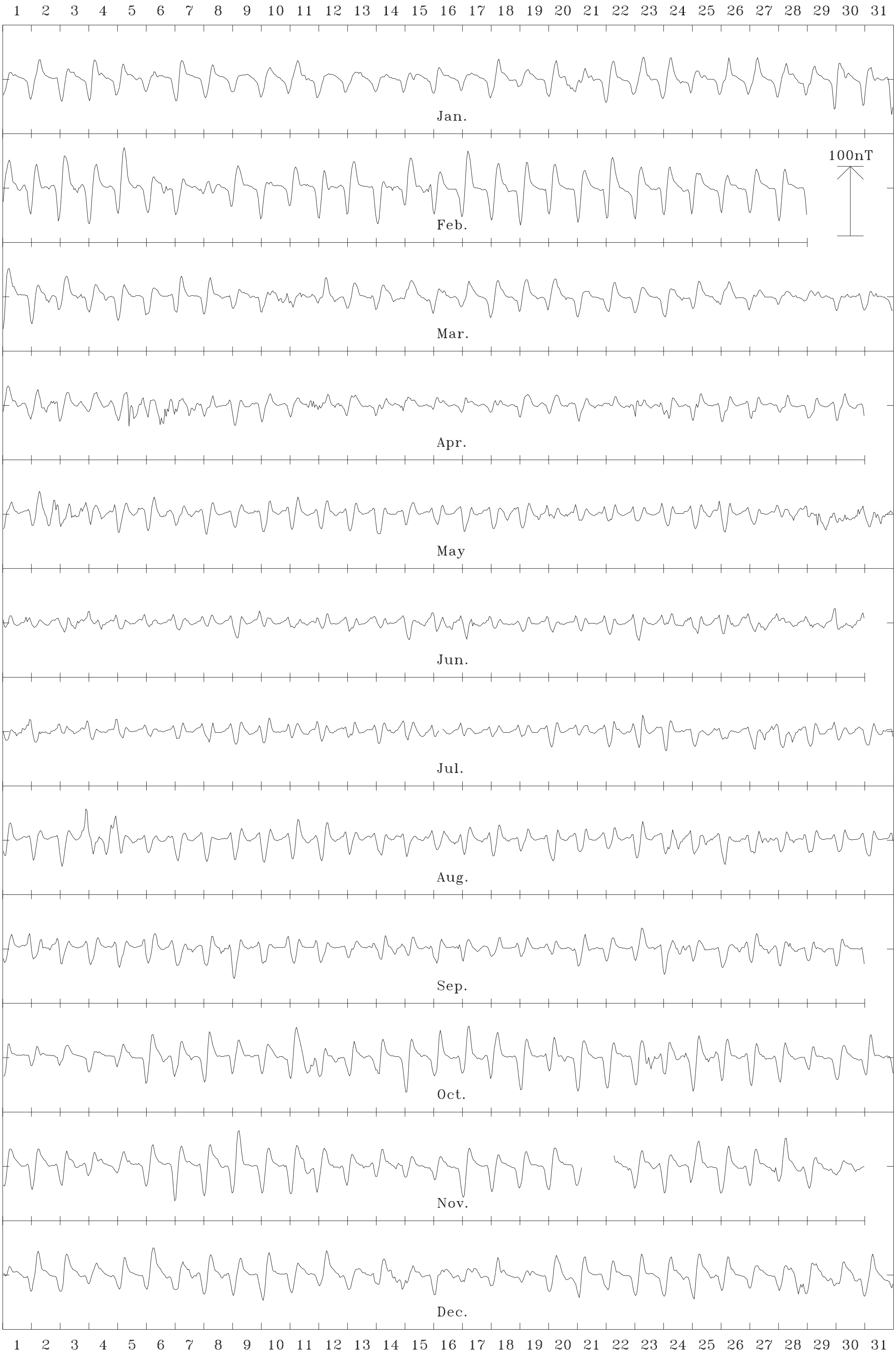

D
dD
D (deg)
dD ('/yr)
3.76
3.74
3.72
3.70
3.68
3.66
3.64
3.60
3.58
3.56
3.54
3.52
3.50
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.8
-2.2
-2.6
-3.0
-3.4
-3.8
1995.0 1996.0 1997.0 1998.0 1999.0 2000.0 2001.0 2002.0 2003.0 2004.0 2005.0 2006.0 2007.0 2008.0 2009.0 2010.0 2011.0 2012.0

Figure 1.2. Kakadu annual mean values and secular variation (all days) for H, D, Z and F.

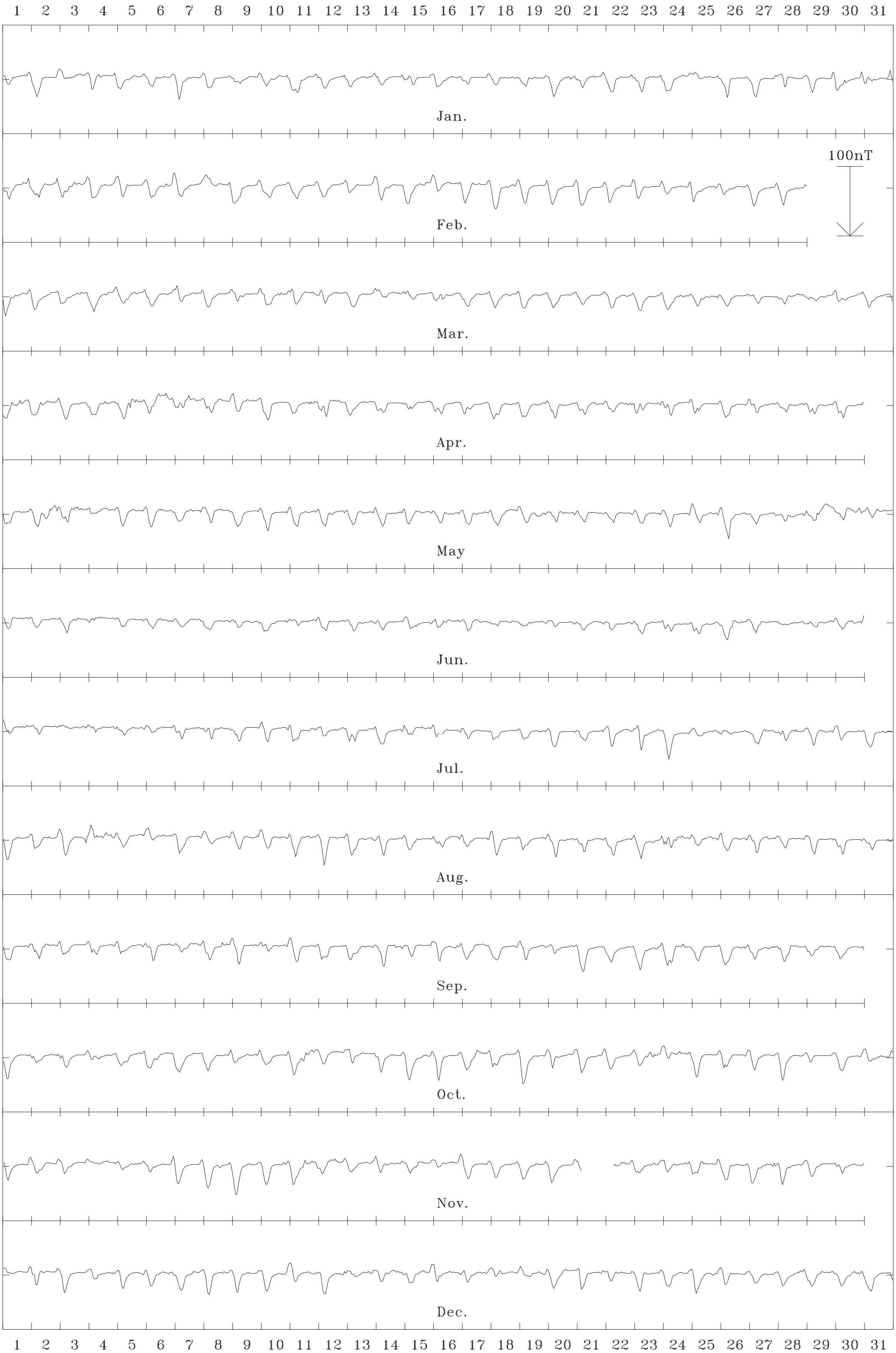
Kakadu, NT 2010 North component (X). Scale: 7.5 nT/mm. Mean: 35378 nT



Kakadu, NT 2010 East component (Y). Scale: 7.5 nT/mm. Mean: 2168 nT



Kakadu, NT 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −29732 nT



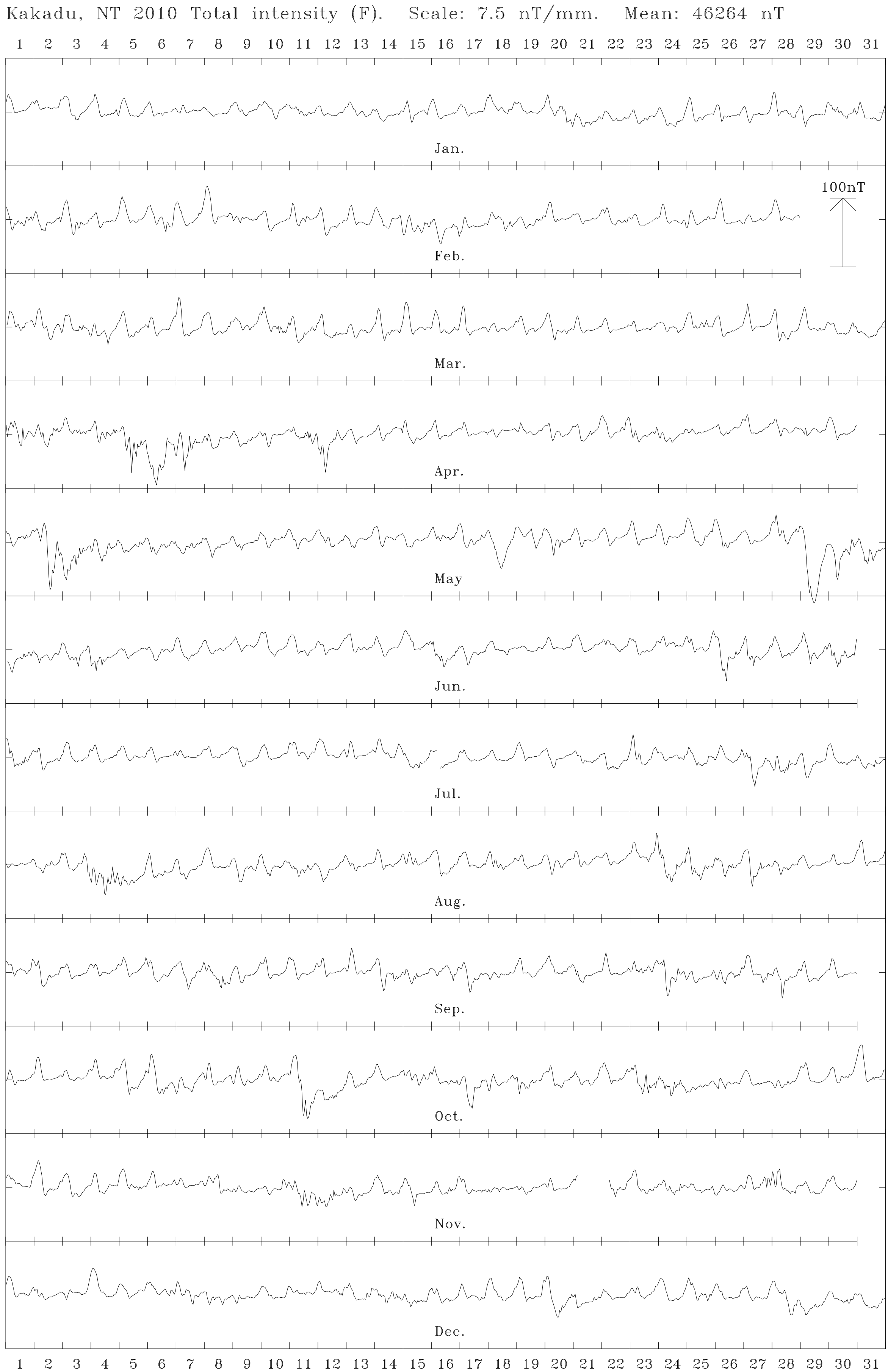


Figure 1.3. Kakadu 2010 hourly mean values in X, Y, Z and F.

2. Charters Towers

Charters Towers is 120 km southwest of Townsville in north Queensland. The Charters Towers magnetic observatory is located at Towers Hill, 1.7 km southwest of the town centre, in an area leased to Geoscience Australia by the Charters Towers Regional Council.

The observatory comprises:

- a disused gold mine tunnel approximately 100 m into the northern side of Towers Hill, which houses the variometers;
- a VSAT communications dish outside the tunnel, and;
- an Absolute Shelter on a hillside approximately 250 m to the west of the tunnel.

Continuous magnetic-field recording commenced at the observatory in June 1983 (Hopgood and McEwin, 1997).

Key data for the observatory are given in Table 2.1.

Variometers

The variometers used during 2010 are described in Table 2.2. Until November 2010 the DMI FGE fluxgate sensor was installed on a marble plate on a pier constructed of concrete blocks in the mine tunnel. The sensor was moved to a new concrete pier built deeper into the tunnel on 2010-11-10. Analogue outputs from the three magnetic channels and the temperature of the fluxgate sensor and electronics were digitized at 1-second intervals, using an ADAM 4017 A/D converter mounted inside the electronics console, and recorded on an acquisition computer.

Before November 2010 the total-field variometer sensor was suspended from the ceiling of the tunnel. It cycled at 10-second intervals and its digital output was input directly to the acquisition computer. On 10 November the total-field sensor was moved to a newly constructed concrete pier deeper inside the tunnel.

Although not actively controlled, the temperature within the tunnel housing the variometers varied within 2°C over the year – from about 27° in winter to 29° in summer. There was no discernible diurnal temperature variation in the tunnel. The control electronics associated with the variometers (except the DMI fluxgate magnetometer and GSM-90 total field magnetometer electronics) were housed in an air-conditioned room in an adjacent arm of the tunnel. Acquisition system timing was derived from a Garmin GPS 16 clock.

There were several periods of disturbance to the variometer data during 2010. Fencing on the surface above the tunnel in April caused contamination and baseline changes; upgrades to the electrical system in the tunnel during May and June, and upgrades to the seismic system in October caused interference during installation and ongoing periodic noise to the magnetometer data. The newly installed seismic battery charger introduced noise about every 18 minutes onto the magnetic variometer fluxgate data from October 2010. In addition, several periods of tunnel engineering rectification work were also carried out in 2010.

In November two new instrument piers made from aerated concrete blocks were constructed deeper into the tunnel. The magnetic variometer sensors were moved onto these new piers on 2010-11-10 to increase the distance between the sensors and the seismic power system and reduce the magnitude of the 18-minute periodic noise caused by the seismic power system battery charger. Moving the sensors successfully reduced the periodic interference but, after the move, interference developed on the 1-second DMI fluxgate data during the 10-second polarisation cycles of the Overhauser total-field magnetometer. This interference remains in the data. Some more details are available in *Significant events* below.

One-second fluxgate and 10-second PPM data were spike filtered using an automatic de-spiking algorithm applied during definitive data processing. The definitive 1-minute data were calculated from these de-spiked data.

IAGA code:	CTA
Commenced operation:	June 1983
Geographic latitude:	20° 05' 25" S
Geographic longitude:	146° 15' 51" E
Geomagnetic latitude:	-27.56°
Geomagnetic longitude:	221.32°
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
Observer:	J.M. Millican (to 2010-09-22) B.M. Stevenson (from 2010-11-12)

Table 2.1. Key observatory data.

3-component variometer:	DMI FGE (Version G)
Serial number:	E0227/S0210
Type:	non-suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.1 nT
A/D converter:	ADAM 4017 module (±5V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081420/42178
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	VSAT satellite link

Table 2.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

DI fluxgate:	DMI
Serial number:	DI0036
Theodolite:	Zeiss 020B
Serial number:	394050
Resolution:	0.1’
D correction:	0.0’
I correction:	-0.2’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091318/91472
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 2.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Absolute instruments

The variometers at CTA were calibrated nominally weekly with a pair of absolute observations. Both absolute PPM and DIM observations were performed on Pier C in the Absolute Shelter. The principal absolute magnetometers used and their adopted corrections for 2010 are described in Table 2.3. The D and I corrections applied in 2010 were determined through instrument comparisons performed during maintenance and calibration visits, most recently on 2010-11-14 Instrument corrections are to the international reference.

At the 2010 mean magnetic-field values at Charters Towers the D, I and F corrections in Table 2.3 translate to corrections of:

ΔX = -2.2 nT ΔY =-0.3 nT ΔZ = -1.9 nT ΔH = -2.2 nT

These instrument corrections have been applied to the data described in this report.

Baselines

Derivation of final baseline parameters for the fluxgate variometer was done by fitting linear sections to the weekly observed absolute observations baseline residuals.

The DMI E0227/S0210 variometer performed adequately well in 2010. There were several short periods (of about 1-hour duration) characterized by a sudden jump and slower recovery. Throughout 2010 the overall baseline drifts had a range of about 7 nT in the X, Y and Z components. The standard deviations in the difference between the weekly absolute observations and the final adopted vector variometer model and data were:

	σ		σ
X	0.8 nT	D	11"
Y	1.6 nT	I	04"
Z	0.8 nT	F	0.5 nT

Throughout the year the difference between F measured with the CTA vector variometer and the CTA scalar variometer varied over a range of about 1 nT.

Observed and adopted baseline values in X, Y and Z are shown in Figure 2.1.

Operations

The officers in charge at CTA observatory, Mr Jack Millican (to September 2010) and Mr Brad Stevenson (from November 2010) performed weekly absolute observations and checks. There were two periods during the year when weekly absolute observations were not performed – the first, in April when the power supply box for the absolute instruments was repaired in Canberra, and the second, from September to November when sickness prevented the observer carrying out observations.

Analogue outputs from the DMI FGE 3-channel fluxgate, as well as the fluxgate sensor and electronics temperature channels, were digitized with an ADAM 4017 A/D converter mounted inside the electronics console. Throughout 2010, data were recorded at 1-second intervals in the components A (NW), B (NE), and C (Z), as well as the DMI variometer sensor and electronics temperatures. These digital data were recorded on an acquisition computer. The digital readings from the PPM variometer were recorded at 10-second intervals. Data files were telemetered to Geoscience Australia in Canberra via satellite. The data transfer delay time was 2 to 15 minutes.

Until October the variometer and recording system was powered by 240V AC, backed-up by a Nikko UPS with sufficient capacity to power the system for a few hours. After the October upgrade the system was powered by the seismic 12V battery-backed system. The 240V AC DMI fluxgate electronics was powered with a dedicated inverter running from the 12V seismic system. Acquisition system timing control was provided by a GPS clock. Significant timing corrections applied to the system are listed in *Significant events* below.

The distribution of Charters Towers 2010 data is described in Table 2.4. Data losses are identified in Table A.2.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011

Table 2.4. Distribution of Charters Towers 2010 data.

Significant events

2010-01-04	01:05 Reboot system to restart GPS clock 06:36 - CLK I 0 Correction C 0 s 535474937 ns
2010-02-11	AML assumes management of CTA observatory
2010-02-23	05:40 05:41 variometer contamination
2010-02-26	15-20 min scheduled telemetry interruption today due to service provider maintenance
2010-03-09	02:30 Update baseline parameters. Jack confirms he is willing to continue doing observations into next FY
2010-03-14	23:02 sudden jump in X and Y channels - reason unknown
2010-03-15	01:42-44 several sudden jumps in X and Y channels - reason unknown
2010-04-07	22:10-24:00 contamination - fencing work on surface 30m above tunnel commences and will continue until about 2010-04-15
2010-04-08	21:50 Step in PPM data, step in Z data
2010-04-11	22:00-22:15 interference/anomalies - no problems with FCheck
2010-04-12	22:50-23:25 More interference
2010-04-14	01:17-01:40 more interference
2010-04-14	21:05-22:00 baseline jump + interference
2010-04-17	15:30 sun-geomag data server fails due to power problem
2010-04-19	01:45 sun-geomag back on-line
2010-04-27	Electrical work on upgrade to wiring in tunnel. (trenching outside the tunnel today)
2010-04-28	Absolute battery box switch fails. Jack will send it back for repair today.
2010-04-29	Interference on data - electrician?
2010-04-30	Battery box arrived in Canberra today
2010-05-10	Electrical, fencing and mine engineering tunnel repairs start today
2010-05-12	Repaired battery box returned to CTA
2010-05-27	Spikes - more work by electrician
2010-05-31	Spikes - more work by electrician
2010-06-01	Spikes
2010-06-09	contamination 05 and 23UT
2010-06-10	contamination 00-01
2010-06-28	03:15 Update baseline drifts days 083 to 111 in Y and Z

2010-07-07	00:29 and 00:31 spikes/contamination in data, possibly caused by vehicle on temporary road used for fence construction above the tunnel
2010-07-21	23:50 PPP (analogue modem) connection checked OK
2010-08-31	01:51 PPP (analogue modem) checked and failed
2010-09-13	01:49 PPP (analogue modem checked OK
2010-09-28	04:26-04:47 spikes on data, probably lightning
2010-10-11	Dave, Trevor. Matt in Charters Towers upgrading seismic system this week
2010-10-13	22:00 GPS antenna relocated into tunnel system running OK
2010-10-14	03:56 step then spikes every 18 minutes on all channels (XYZF) 05:12 - 05:22 No fluxgate data 06:02 - 06:32 no fluxgate data spikes on X channel diminish during the day
2010-10-14	04:28:36 - CLK I 0 C 0 s 1415470 ns
2010-10-15	18-minute spikes still persist, but now insignificant on X channel. Suspect magnetic fields caused by battery charging currents. Dave will twist cable and note times etc.
2010-10-20	D Pownall and T Dalziell depart from CTA observatory. Still have 18-minute spikes and offset due to battery charger. May need to re-locate variometer sensor further from the instrument room.
2010-10-21	00:53:23 - CLK I 0 C 0 s 1538526 ns
2010-10-22	Prospective observer to replace JMM is Brad Stevenson
2010-11-03	23:40 Lost contact with GPS clock
2010-11-04	00:55 Stop and restart GdapClock
2010-11-05	Control room door scheduled for replacement
2010-11-08	AML and Dave Pownall arrive for maintenance visit build two new instrument piers and re-locate variometer sensor; train new geomag observer, Brad Stevenson; instrument comparisons and test
2010-11-09	22:30 lost contact with GPS clock. restarted GdapClock
2010-11-12	00:29:50 - CLK I 0 Started 00:33:22 - CLK I 0 C 0 s -15685146 ns
2010-11-12	20:18:47 - CLK I 0 C 0 s 1142695 ns 23:11:04 - CLK I 0 C 0 s -1707439 ns
2010-11-16	AML departs CTA
2010-11-17	Tunnel repairs scheduled this week
2010-11-19	05:02 update baselines and FV to account for variometer relocation
2010-11-25	Problems with GSM90 connections
2010-11-29	Replacement GSM90 Power/data cable sent via Express post to PO Box 70
2010-12-23	09:20:12 - CLK I 0 C 0 s -1292748 ns
2010-12-25	21:26:37 - CLK I 0 C 0 s -1050051 ns

Annual mean values

The annual mean values for Charters Towers are set out in Table 2.5 and displayed with the secular variation in Figure 2.2.

Hourly mean values

Plots of the hourly mean values for Charters Towers 2010 data are shown in Figure 2.3.

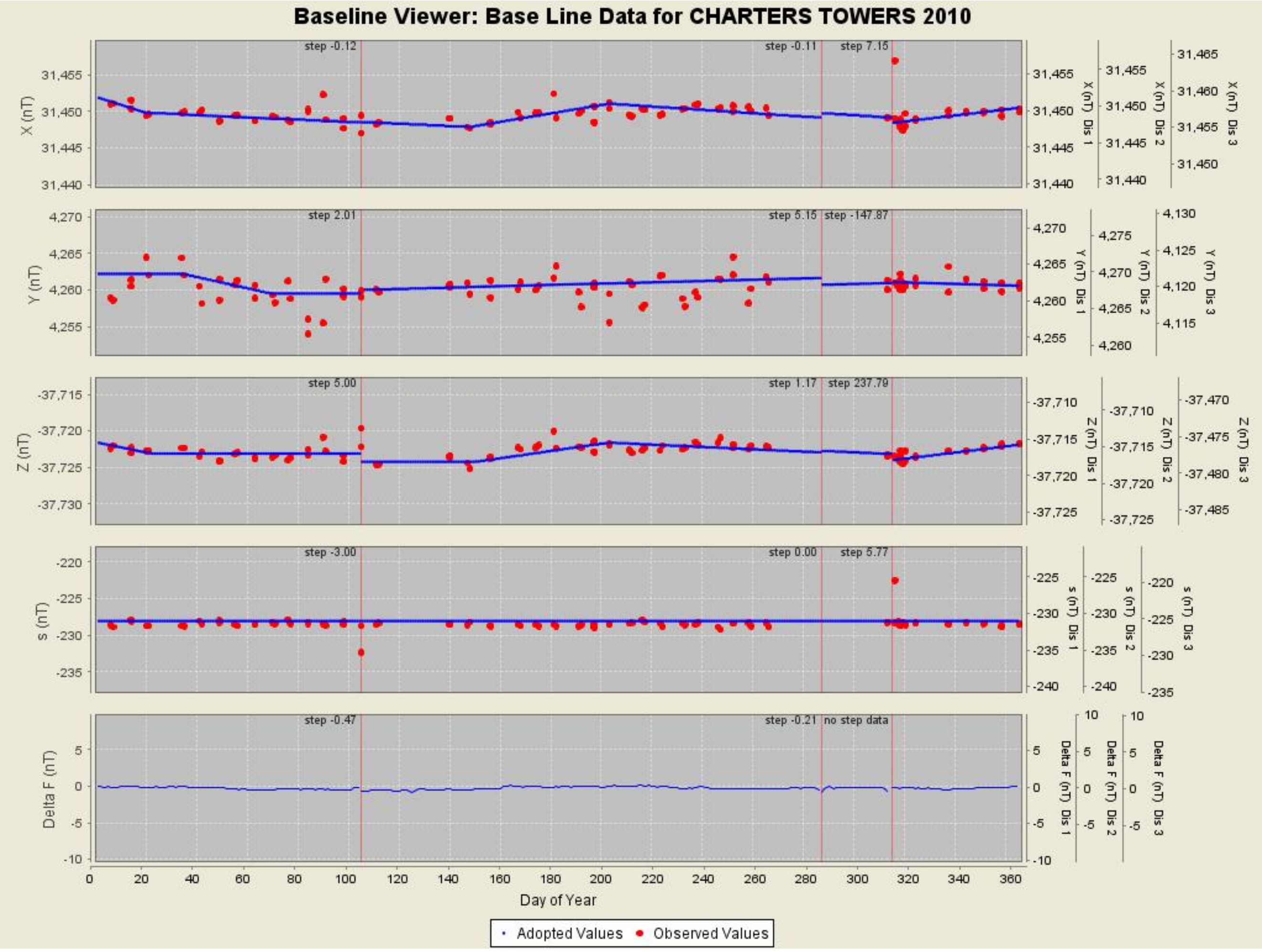
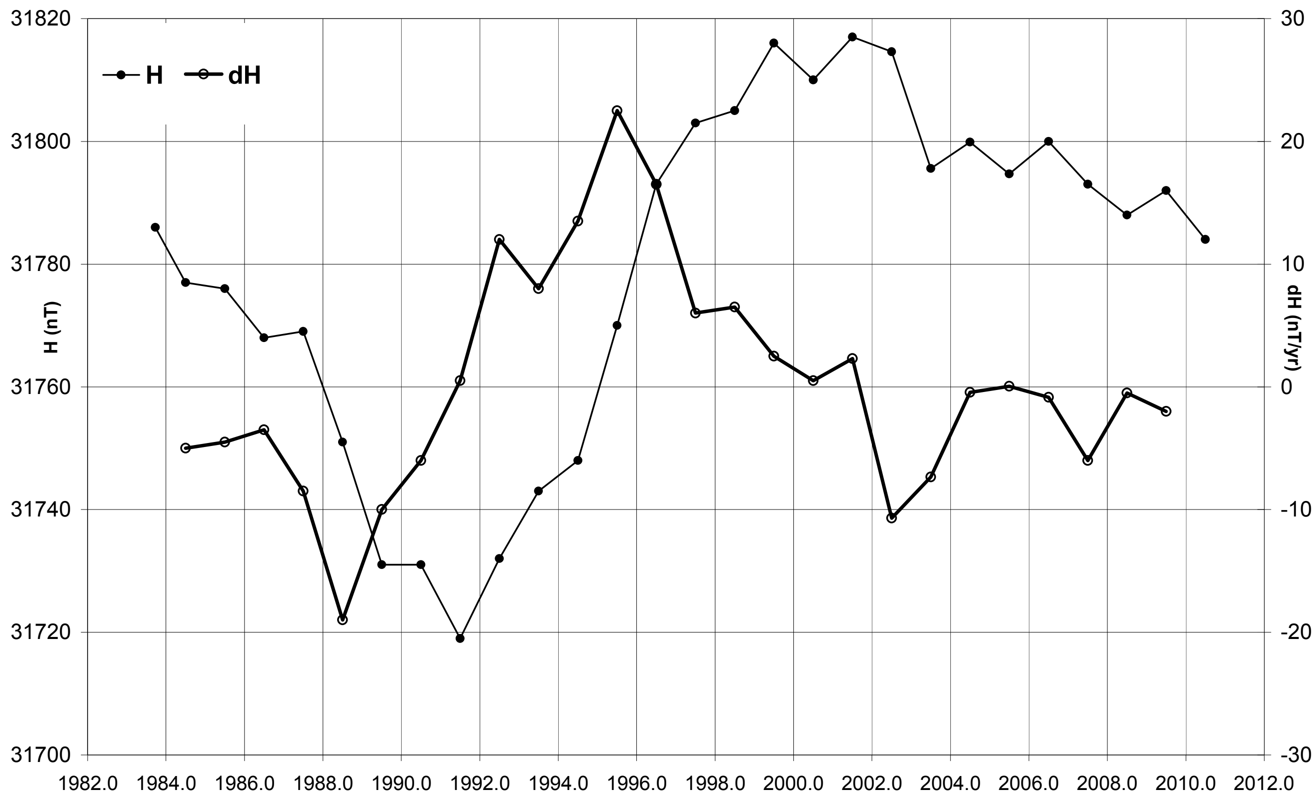


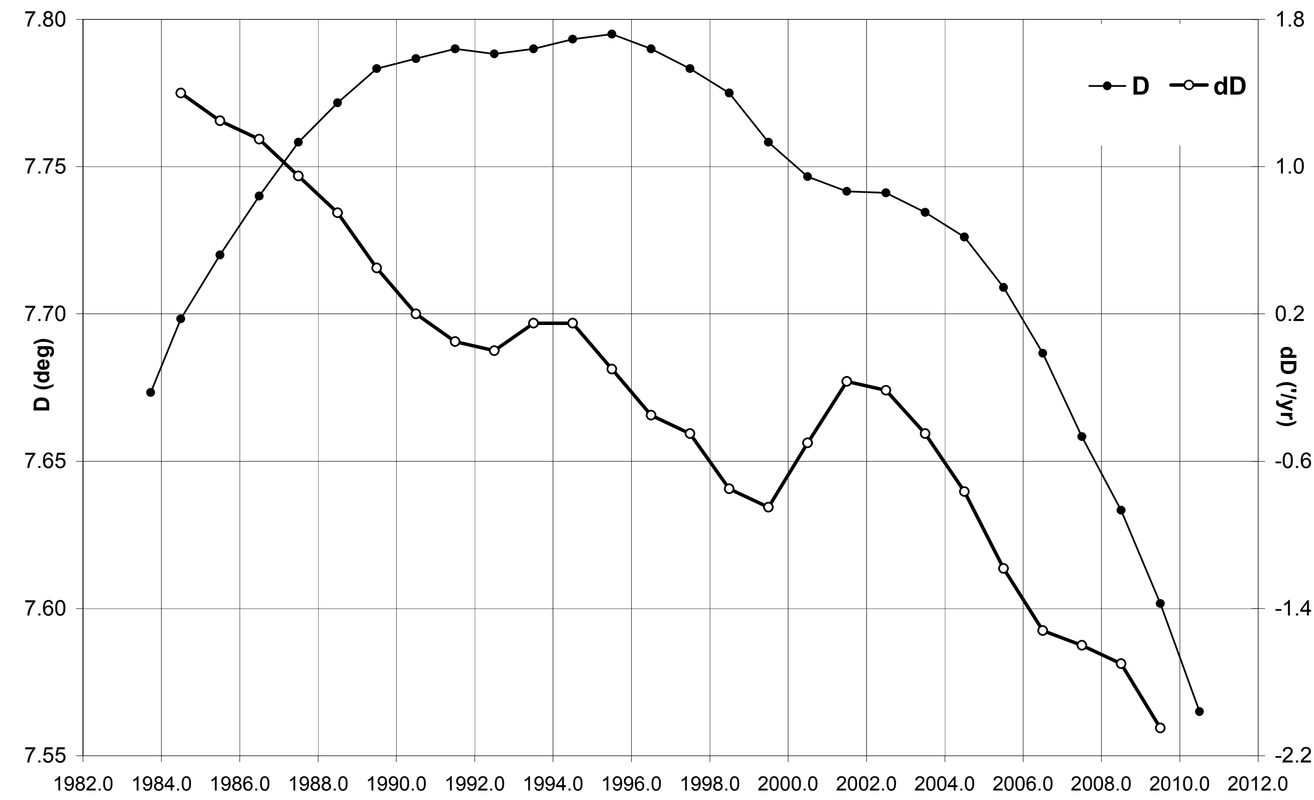
Figure 2.1. Charters Towers 2010 baseline plots.

Year	Days	D (°)	D (')	I (°)	I (')	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
1983.729	A	7	40.4	-50	17.7	31786	31501	4244	-38280	49756	XYZ
1984.5	A	7	41.9	-50	18.2	31777	31491	4256	-38280	49751	XYZ
1985.5	A	7	43.2	-50	18.0	31776	31488	4268	-38276	49747	XYZ
1986.5	A	7	44.4	-50	18.4	31768	31479	4278	-38274	49740	XYZ
1987.5	A	7	45.5	-50	18.2	31769	31478	4288	-38271	49738	XYZ
1988.5	A	7	46.3	-50	19.2	31751	31459	4294	-38270	49727	XYZ
1989.5	A	7	47.0	-50	20.1	31731	31439	4297	-38267	49711	XYZ
1990.5	A	7	47.2	-50	19.8	31731	31438	4299	-38260	49706	XYZ
1991.5	A	7	47.4	-50	19.8	31719	31427	4299	-38248	49689	XYZ
1992.5	A	7	47.3	-50	18.0	31732	31439	4300	-38221	49676	XYZ
1993.5	A	7	47.4	-50	15.9	31743	31450	4303	-38188	49658	XYZ
1994.5	A	7	47.6	-50	14.1	31748	31455	4305	-38151	49633	XYZ
1995.5	A	7	47.7	-50	11.1	31770	31476	4309	-38112	49617	XYZ
1996.5	A	7	47.4	-50	8.1	31793	31500	4309	-38071	49600	XYZ
1997.5	A	7	47.0	-50	5.5	31803	31510	4307	-38024	49571	XYZ
1998.5	A	7	46.5	-50	3.0	31805	31513	4302	-37972	49532	XYZ
1999.5	A	7	45.5	-49	59.8	31816	31525	4295	-37913	49494	XYZ
2000.5	A	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	ABZ
2001.5	A	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	ABZ
2002.5	A	7	44.5	-49	54.0	31815	31525	4285	-37781	49392	ABZ
2003.5	A	7	44.1	-49	53.7	31796	31506	4279	-37751	49357	ABZ
2004.5	A	7	43.6	-49	51.6	31800	31511	4275	-37710	49328	ABZ
2005.5	A	7	42.5	-49	50.1	31795	31507	4265	-37670	49294	ABZ
2006.5	A	7	41.2	-49	47.9	31800	31514	4253	-37627	49265	ABZ
2007.5	A	7	39.5	-49	46.8	31793	31510	4237	-37596	49237	ABZ
2008.5	A	7	38.0	-49	45.7	31788	31506	4223	-37565	49210	ABZ
2009.5	A	7	36.1	-49	44.0	31792	31513	4205	-37532	49187	ABZ
2010.5	A	7	33.9	-49	43.1	31784	31508	4185	-37503	49160	ABZ

1983.729	Q	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	XYZ
1985.5	Q	7	43.2	-50	17.4	31787	31499	4270	-38274	49752	XYZ
1986.5	Q	7	44.4	-50	17.8	31778	31489	4280	-38272	49745	XYZ
1987.5	Q	7	45.5	-50	17.7	31776	31486	4289	-38269	49742	XYZ
1988.5	Q	7	46.4	-50	18.3	31764	31472	4296	-38268	49733	XYZ
1989.5	Q	7	47.0	-50	19.1	31746	31454	4299	-38265	49719	XYZ
1990.5	Q	7	47.3	-50	18.8	31746	31454	4302	-38257	49714	XYZ
1991.5	Q	7	47.3	-50	18.6	31739	31446	4301	-38244	49698	XYZ
1992.5	Q	7	47.4	-50	17.1	31746	31453	4303	-38218	49683	XYZ
1993.5	Q	7	47.4	-50	15.3	31754	31461	4304	-38185	49663	XYZ
1994.5	Q	7	47.6	-50	13.2	31762	31469	4307	-38148	49640	XYZ
1995.5	Q	7	47.7	-50	10.4	31781	31488	4310	-38109	49622	XYZ
1996.5	Q	7	47.4	-50	7.7	31799	31506	4310	-38070	49603	XYZ
1997.5	Q	7	46.9	-50	4.9	31812	31519	4308	-38023	49576	XYZ
1998.5	Q	7	46.4	-50	2.5	31815	31522	4303	-37971	49537	XYZ
1999.5	Q	7	45.5	-49	59.3	31825	31534	4296	-37911	49499	XYZ
2000.5	Q	7	44.8	-49	57.2	31823	31533	4290	-37864	49461	ABZ
2001.5	Q	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	ABZ
2002.5	Q	7	44.5	-49	53.2	31828	31538	4287	-37780	49400	ABZ
2003.5	Q	7	44.2	-49	52.7	31811	31521	4282	-37749	49365	ABZ
2004.5	Q	7	43.6	-49	50.9	31810	31522	4277	-37708	49334	ABZ
2005.5	Q	7	42.6	-49	49.4	31806	31519	4267	-37668	49300	ABZ
2006.5	Q	7	41.2	-49	47.4	31808	31522	4255	-37625	49269	ABZ
2007.5	Q	7	39.6	-49	46.5	31799	31515	4238	-37595	49240	ABZ
2008.5	Q	7	38.1	-49	45.4	31794	31512	4224	-37565	49214	ABZ
2009.5	Q	7	36.1	-49	43.8	31795	31515	4206	-37532	49189	ABZ
2010.5	Q	7	33.9	-49	42.8	31790	31513	4185	-37502	49163	ABZ
1983.729	D	7	39.9	-50	18.7	31769	31485	4237	-38281	49746	XYZ
1984.5	D	7	41.8	-50	19.4	31756	31470	4253	-38283	49740	XYZ
1985.5	D	7	43.1	-50	18.9	31761	31474	4266	-38277	49739	XYZ
1986.5	D	7	44.4	-50	19.3	31752	31463	4276	-38276	49732	XYZ
1987.5	D	7	45.4	-50	18.9	31757	31467	4286	-38272	49732	XYZ
1988.5	D	7	46.3	-50	20.4	31731	31439	4291	-38274	49716	XYZ
1989.5	D	7	46.9	-50	22.2	31696	31404	4292	-38272	49693	XYZ
1990.5	D	7	47.1	-50	21.1	31707	31415	4295	-38263	49693	XYZ
1991.5	D	7	47.4	-50	21.8	31687	31394	4295	-38253	49672	XYZ
1992.5	D	7	47.3	-50	19.5	31706	31414	4297	-38225	49663	XYZ
1993.5	D	7	47.4	-50	17.2	31723	31430	4299	-38191	49648	XYZ
1994.5	D	7	47.6	-50	15.1	31730	31437	4302	-38154	49624	XYZ
1995.5	D	7	47.7	-50	12.0	31755	31462	4307	-38114	49609	XYZ
1996.5	D	7	47.4	-50	8.6	31784	31491	4308	-38072	49595	XYZ
1997.5	D	7	47.0	-50	6.4	31788	31495	4305	-38026	49563	XYZ
1998.5	D	7	46.5	-50	4.4	31782	31490	4299	-37976	49520	XYZ
1999.5	D	7	45.5	-50	1.0	31797	31506	4293	-37916	49484	XYZ
2000.5	D	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	ABZ
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABZ
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABZ
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABZ
2004.5	D	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	ABZ
2005.5	D	7	42.4	-49	51.3	31774	31487	4261	-37673	49283	ABZ
2006.5	D	7	41.2	-49	48.6	31787	31501	4252	-37629	49258	ABZ
2007.5	D	7	39.5	-49	47.3	31785	31502	4236	-37597	49233	ABZ
2008.5	D	7	38.1	-49	46.2	31780	31499	4222	-37567	49206	ABZ
2009.5	D	7	36.1	-49	44.3	31787	31508	4205	-37532	49184	ABZ
2010.5	D	7	33.9	-49	43.7	31775	31498	4183	-37504	49155	ABZ

Table 2.5. Charters Towers annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 2.2. Note that before 31 December 2006 the Charters Towers absolute instruments were corrected to the Canberra reference instruments using corrections of zero for D, I and F. From 00:00 on 1 January 2007, the absolute instruments were corrected to international reference instruments using corrections of D: 0.0’, I: -0.2’, F: 0.0 nT, H: -2.19 nT, X: -2.17 nT, Y: -0.29 nT and Z: -1.85 nT, as described in Hitchman *et al.* (2009).


H
dH
H (nT)
dH (nT/yr)
31820
31800
31780
31760
31740
31720
31700
30
20
10
0
-10
-20
-30
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0


D
dD
D (deg)
dD ('/yr)
7.80
7.75
7.70
7.65
7.60
7.55
1.8
1.0
0.2
-0.6
-1.4
-2.2
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0

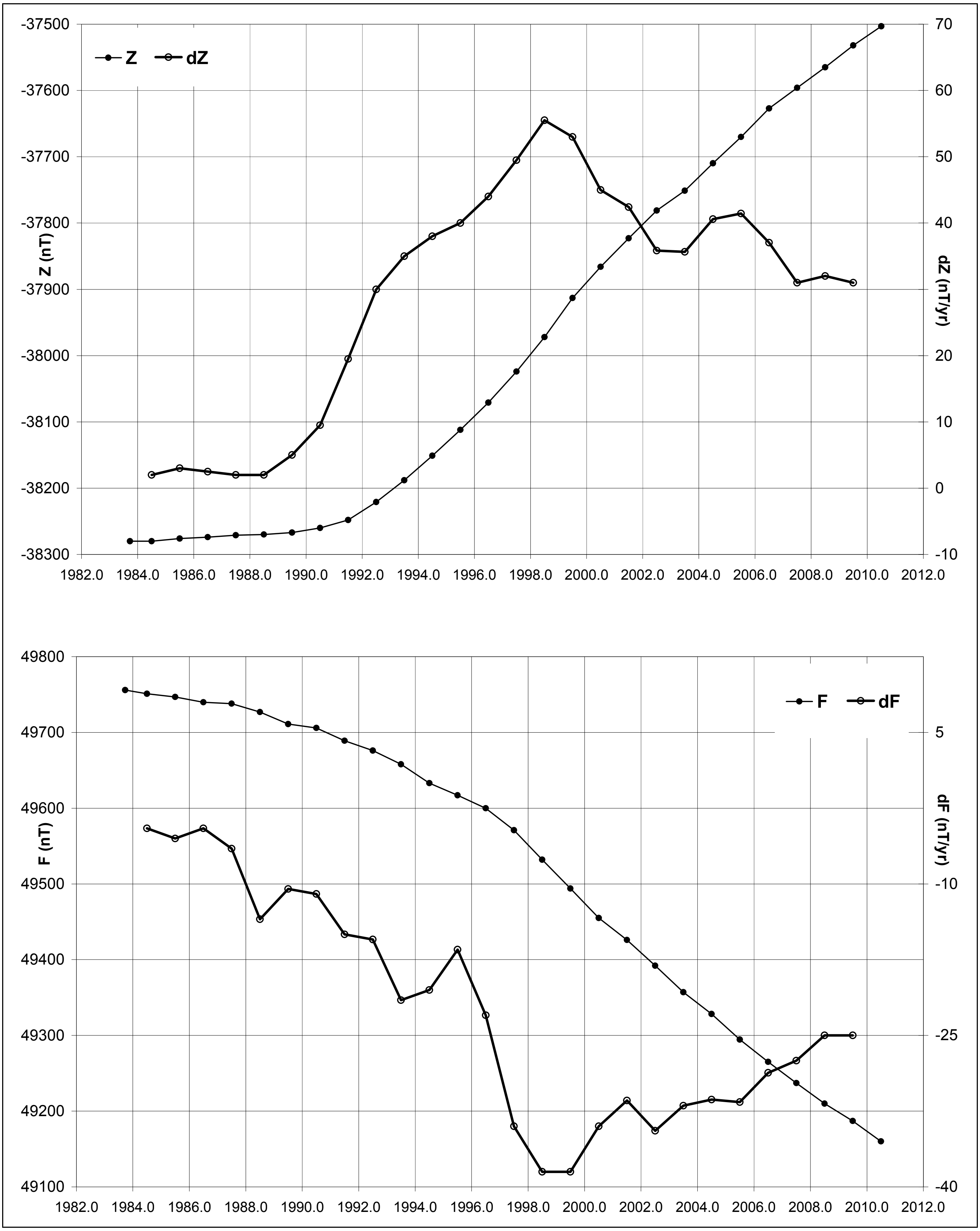
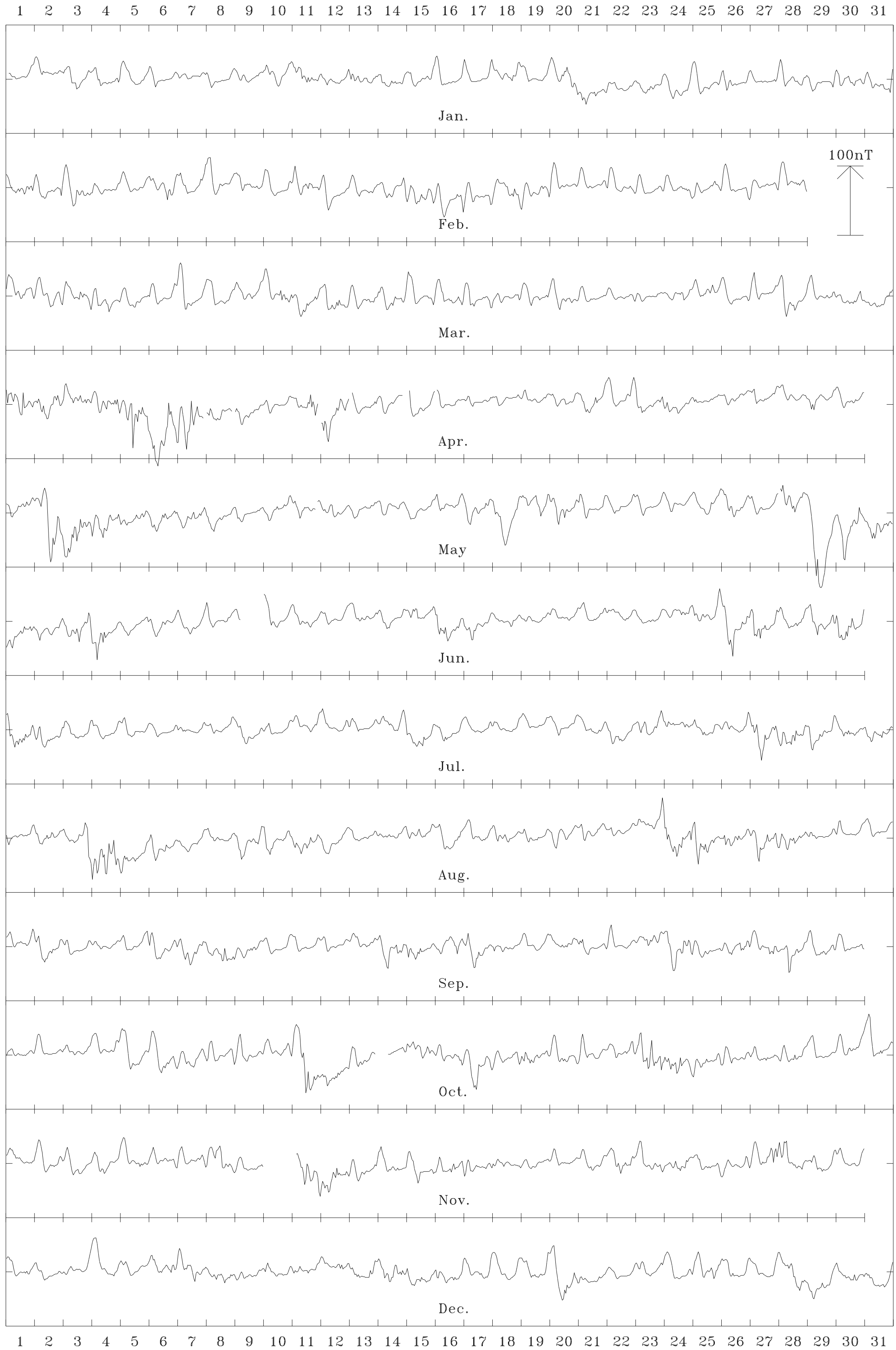
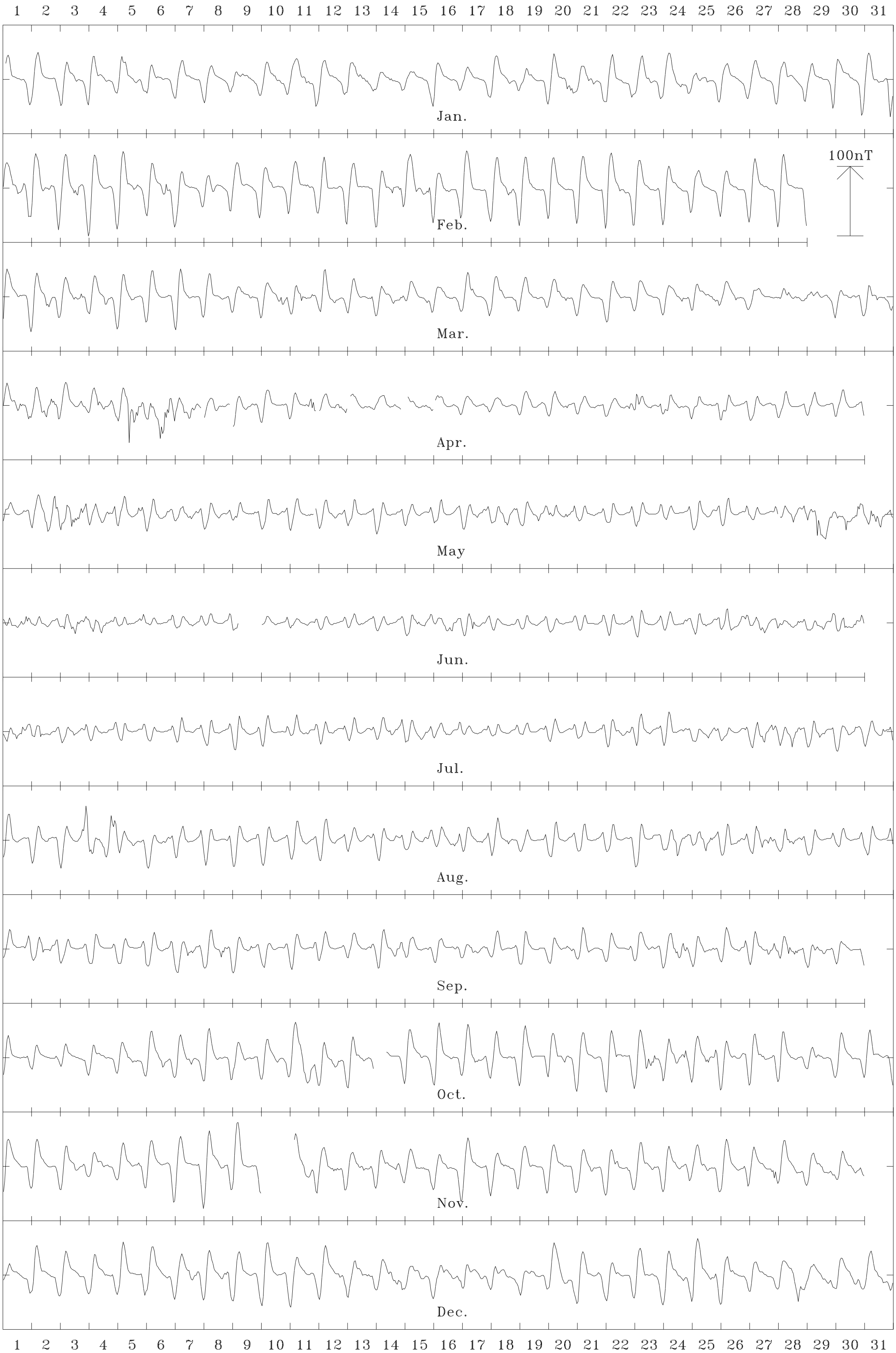


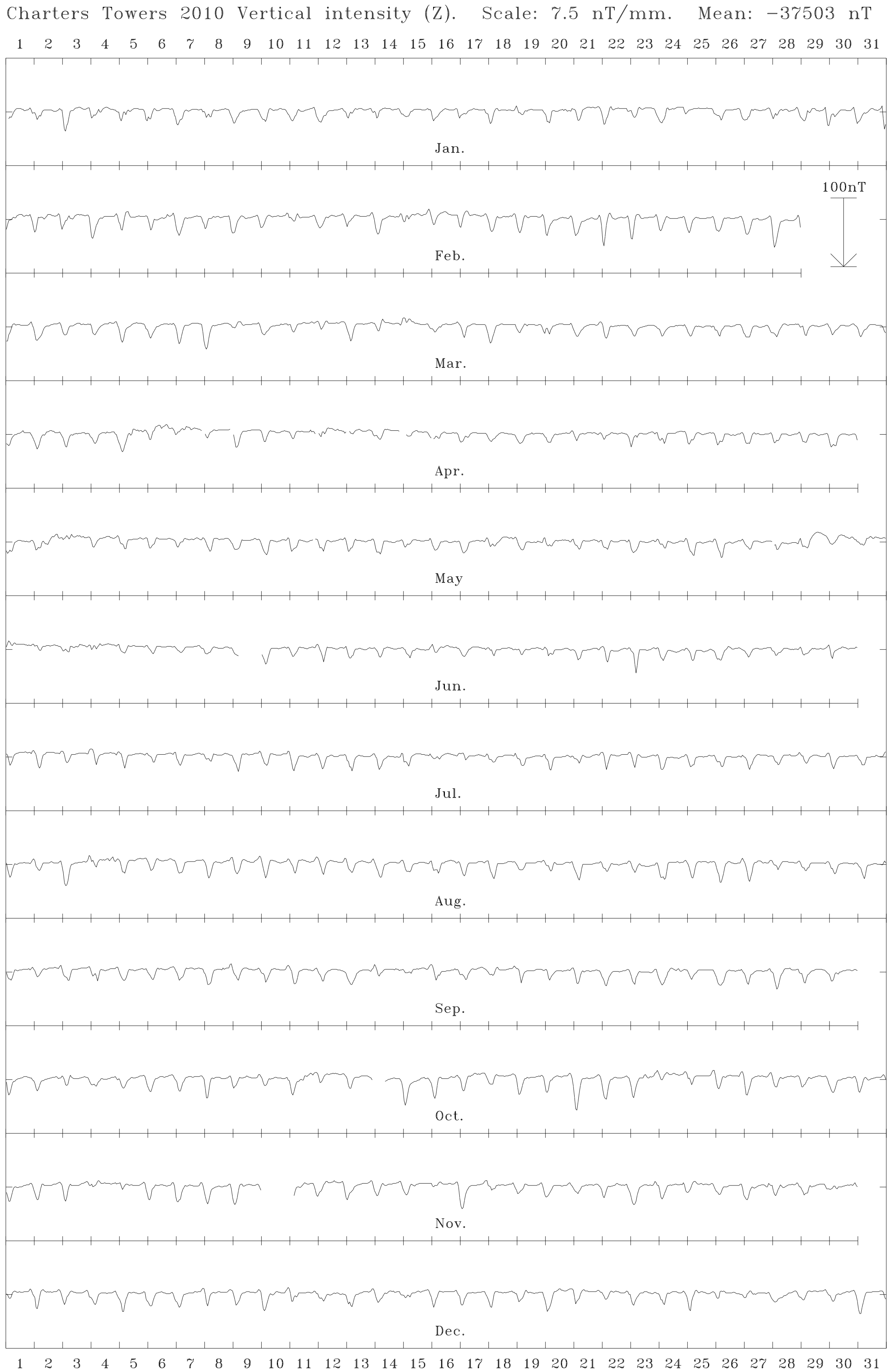
Figure 2.2. Charters Towers annual mean values and secular variation (all days) for H, D, Z and F.

Charters Towers 2010 North component (X). Scale: 7.5 nT/mm. Mean: 31508 nT



Charters Towers 2010 East component (Y). Scale: 7.5 nT/mm. Mean: 4185 nT




Charters Towers 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −37503 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

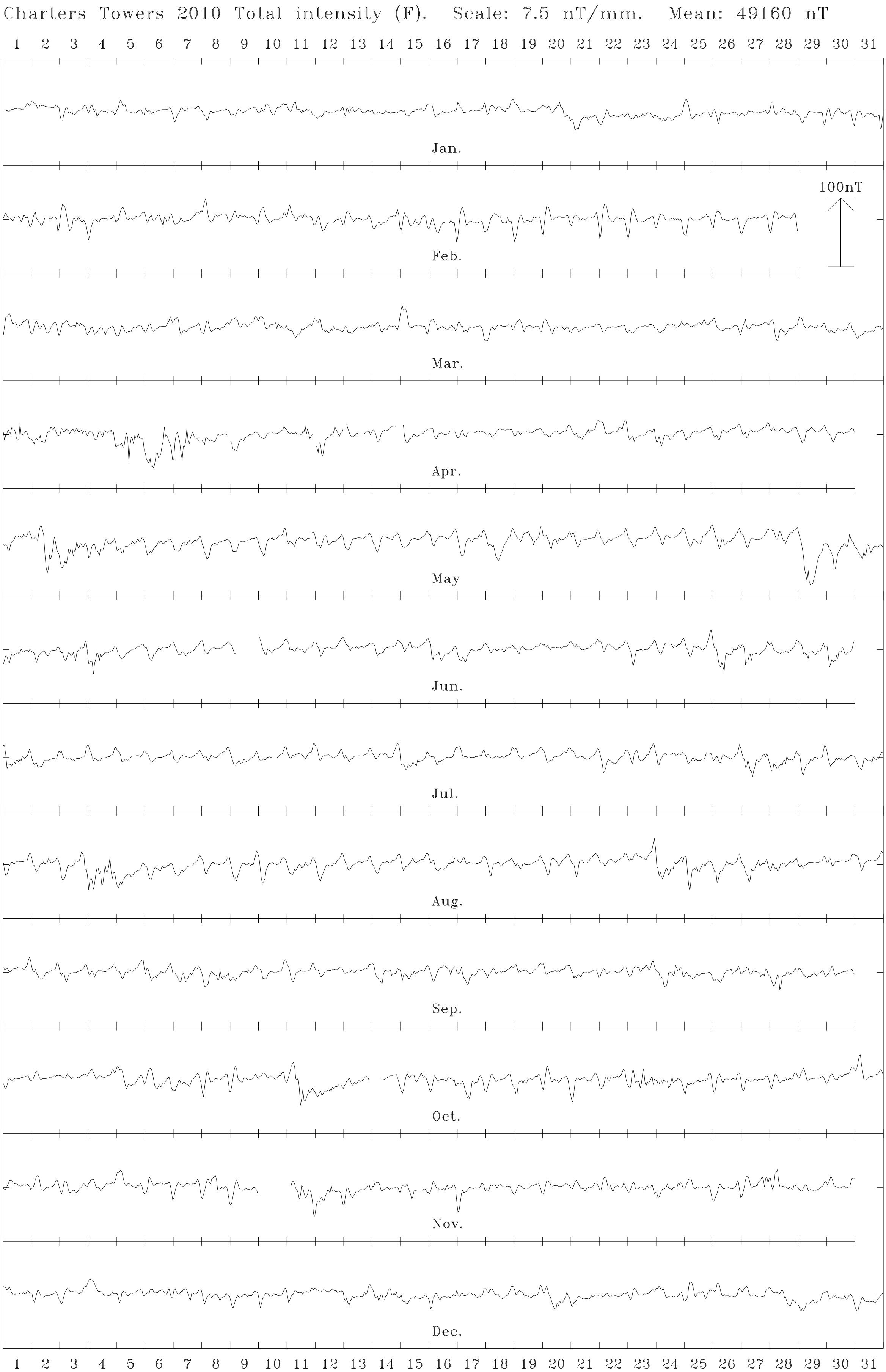


Figure 2.3. Charters Towers 2010 hourly mean values in X, Y, Z and F.

3. Learmonth

The Learmonth magnetic observatory 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, which is jointly staffed by IPS Radio and Space Services and the Unites States of America Air Force. The observatory complex is situated on coastal sand dunes bordering the Exmouth Gulf.

The magnetic observatory 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 solar observatory, enclosing a concrete observation pier (Pier A), the top of which is 1200 mm above the concrete floor, and;
- an external station on RAAF land.

IAGA code:	LRM
Commenced operation:	November 1986
Geographic latitude:	22° 13' 19" S
Geographic longitude:	114° 06' 03" E
Geomagnetic latitude:	-31.91°
Geomagnetic longitude:	186.94°
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:	1 km approx.
Observers:	C. Lord O. Giersch E. Lindsay J. Kennewell

Table 3.1. Key observatory data.

Variometers

The variometers used during 2010 are described in Table 3.2.

The recording equipment, some of the variometer electronic control equipment, and back-up power were housed in the Radio Solar Telescope Network (RSTN) building of the Solar Observatory. The magnetometers and control electronics were housed in three semi-underground concrete vaults, each 800×800×800 mm, 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 northernmost vault with the control electronics in the central vault. A GSM-90 total-field sensor was in the southernmost vault with its electronics in the central vault.

Underground conduits containing sensor cables connected 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 box charged from 240 V AC mains power. The recording computer and 12 V DC battery box were housed in the RSTN building. System timing was provided by a GPS clock with time corrections applied automatically and logged. Timing corrections greater than 1 ms are listed in *Significant events* below.

The scalar variometer was unreliable for most of the first half of the year and was replaced in June 2010. During the times when the scalar variometer was working between January and June the instrument produced 10-second data samples which alternated between two levels, separated by less than 1 nT. It has been assumed the two states of the data average to the correct level.

The vector variometer performed well throughout the year. The DMI sensor temperature ranged from 23°C to 36°C and the electronics from 22°C to 35°C during the year. Although the sensor and electronics were both buried in instrument vaults, the temperature varied during the year in accordance with the seasons. The temperature extremes recorded at Learmonth Airport during 2010 were 6.1°C on 2010-07-25 and 48.9°C on 2010-01-02. The standard temperature of the variometer system was set to 25°C. Temperature fluctuations in the PPM sensor vault were not recorded, but it is expected they would be similar to those experienced by the fluxgate sensor. Temperature corrections have been made in the final data. The maximum daily rainfall was 91 mm on 2010-06-16 with a total of 260 mm for the year.

3-component variometer:	DMI FGE
Serial number:	E0271/S0237
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.03 nT
A/D converter:	ADAM 4017 module (±5V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081416/42172
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use	2010-01-01 – 2010-06-04
Total-field variometer:	GEM Systems GSM-90
Serial number:	3091315/42172
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use	2010-06-04 – 2010-12-31
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	Communications were swapped several times throughout the year. The two telemetry paths available are via radio modem to Giralia seismic station and then VSAT to Canberra or via IPS dedicated data line to Sydney and then via Internet to Canberra.

Table 3.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

Absolute instruments

The principal absolute magnetometers used at Learmonth and their adopted corrections for 2010 are described in Table 3.3.

The absolute DIM fluxgate instrument, DI0051/313888, was compared to the Canberra geomagnetic observatory reference instrument DI0086/353756 on 21, 28 July, 17, 25 August and 1, 22 September 2009 at the Canberra geomagnetic observatory before being deployed to Learmonth. Instrument differences were measured as -0.05', -0.10' in D and I respectively.

The absolute total-field magnetometer, GSM-90 3091315/73103, operated from 2010-01-01 until 2010-06-04 when the electronics console was installed as the total-field variometer. GSM-90 2101216/83387 became the total-field absolute instrument on 2010-06-04.

The adopted differences between the LRM instruments and the international average (as defined by observations at IAGA instrument workshops) are given in Table 3.3.

At the 2010 mean magnetic-field values at Learmonth (X=29915 nT, Y=237 nT, Z=-43744 nT) the D, I and F corrections translate to corrections of:

DIM DI0051/313888, GSM-90 3091315/73103

(2010-01-01 – 2010-06-04)

ΔX = -1.2 nT ΔY = -0.4 nT ΔZ = -1.0 nT

DIM DI0051/313888, GSM-90 2101216/83387

(2010-06-04 – 2010-12-31)

ΔX = -1.3 nT ΔY = -0.4 nT ΔZ = -0.9 nT

These corrections have been applied to all LRM 2010 final data.

Baselines

The standard deviations of the differences between the weekly absolute observations and the final adopted variometer model and data were:

	σ		σ
X	0.6 nT	D	8"
Y	1.1 nT	I	3"
Z	0.6 nT	F	0.5 nT

Throughout the year adopted baselines drifted within a range of 5 nT and there was a range of about 2 nT in the total-field difference between the scalar variometer and the vector variometer.

Observed and adopted baseline values in X, Y and Z are shown in Figure 3.1.

Operations

Absolute observations were performed weekly by Mr Chris Lord, Mr Owen Giersch, Ms Emily Lindsay or Dr John Kennewell from IPS Radio and Space Services.

Variometer data were downloaded about every 3-10 minutes through a TCP/IP network connection. One-minute data were then automatically processed to reported status, made available on the Geoscience Australia website, and sent to the Edinburgh INTERMAGNET GIN via e-mail/HTTP. Raw data were also provided to IPS Radio and Space Services via a direct serial link from the acquisition computer in the RSTN building. IPS applied nominal scale values and rotation parameters.

On 4 June, the malfunctioning variometer PPM was replaced during a maintenance visit. Absolute instrument comparisons, tests and checks of reference azimuth marks and piers were also carried out at that time. (Lewis and Wang, 2010).

The distribution of Learmonth 2010 data is described in Table 3.4. Data losses are identified in Table A.3.

DI fluxgate:	DMI
Serial number:	DI0051
Theodolite:	Zeiss 020B
Serial number:	313888
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.10’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091315/73103
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.2 nT
Period of use:	to 2010-06-04
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	2101216/83387
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period of use:	from 2010-06-04

Table 3.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011

Table 3.4. Distribution of Learmonth 2010 data.

Significant events

2010-01-18	21:37 Radio link/VSAT telemetry path fails. IPS data line path still operating O.K.
2010-01-19	00:55 Swap data retrieval to IPS link (XgetObsLRM) Radio link comes up again 02:23 swap data retrieval back to radio link (XgetObsLRMG) 12:24-12:32 Z channel data problems.
2010-01-21	Still experiencing intermittent interruptions to data telemetry.
2010-01-29	As F had started itself up with noise, interrogated the GSM90 to get signal strength etc and switch to "b" mode to try and reduce the high noise levels. No luck. Switched T52 to T53 and restarted GdapGSM90.
2010-02-01	Owen Giersch arrives at LSO owen@ips.gov.au
2010-02-03	John Kennewell departs LSO
2010-02-12	06:09 variometer GSM90 PPM stopped again.
2010-02-15	21:56 Mag 6 earthquake in Banda Sea
2010-03-12	GSM-90 PPM variometer comes good spontaneously
2010-03-21	23:50-24:00 suspicious events do not look real -with no PPM running
2010-04-30	Owen away from LRM until 2010-05-10. Chris Lord will do observations during this time

2010-05-29	Telemetry problems over weekend, probably due to GA firewall changes on Sat 2010-05-28
2010-06-03	AML/LJW maintenance visit until 2010-06-06
2010-06-04	Change absolute PPM from GSM-90 3091315/73103 to GSM-90 2101216/83387 replace variometer PPM electronics GSM-90 4081416/42172 with GSM-90 3091315/42172
2010-06-05	Replace radio modems at LRM and Giralia 03:34:57 - CLK I 0 Correction -338148023 ns
2010-06-08	Could not ssh to LRMG (LRM via IPS still OK, and can ping from LRM to galah OK). Tried "route add 192.55.112.0 192.168.33.233" and then it seemed OK, but when I went to add that to rc.network, I saw that "route add galah 192.168.33.233" was already there, although that route didn't seem to be in the "route show" list.
2010-06-10	DI0051 DIM electronics loose display glass repaired and sent back to LRM
2010-06	Problems with GSM90_2101216 communicating with PDA during absolute observations, two weeks of absolute observations missed. Problem solved by adjusting PPM settings on 29 June
2010-06-30	AML takes over management of observatory from GT
2010-07-06	Update baseline file tidy 02:30 change BLV and drifts AML Update WHO.OBS to account for change in absolute PPM
2010-07-19	Upgrade LRM-Giralia radio link.
2010-07-23	00:00 Change telemetry from IPS to Giralia Radio link/VSAT
2010-08-05	00:00 Owen and Terry at LSO install power protection on radio link causing 30 min interruption to data telemetry
2010-08-31	00:05 Update baselines Y and Z drifts from day 200. 00:57 delete 2006, 2007 and 2008 data files from /mag
2010-09-13	01:05 try ssh to lrm via IPS from sun-proj2, no good try from epoch all o.k. try slrmg from sun-proj2 all O.K.
2010-09-29	17:17 Quake noise Mag 7.2 Irian Jaya
2010-10-15	last observation from Chris Lord future obs will be done by Owen Giersch
2010-10-22	First Obs by Owen Giersch
2010-12-03	PDA lost memory restored from SD card backup altered tuning from 54 to 53 First observations by Emily Lindsay (EL)

Annual mean values

The annual mean values for Learmonth are set out in Table 3.5 and displayed with the secular variation in Figure 3.2.

Hourly mean values

Plots of the hourly mean values for Learmonth 2010 data are shown in Figure 3.3.

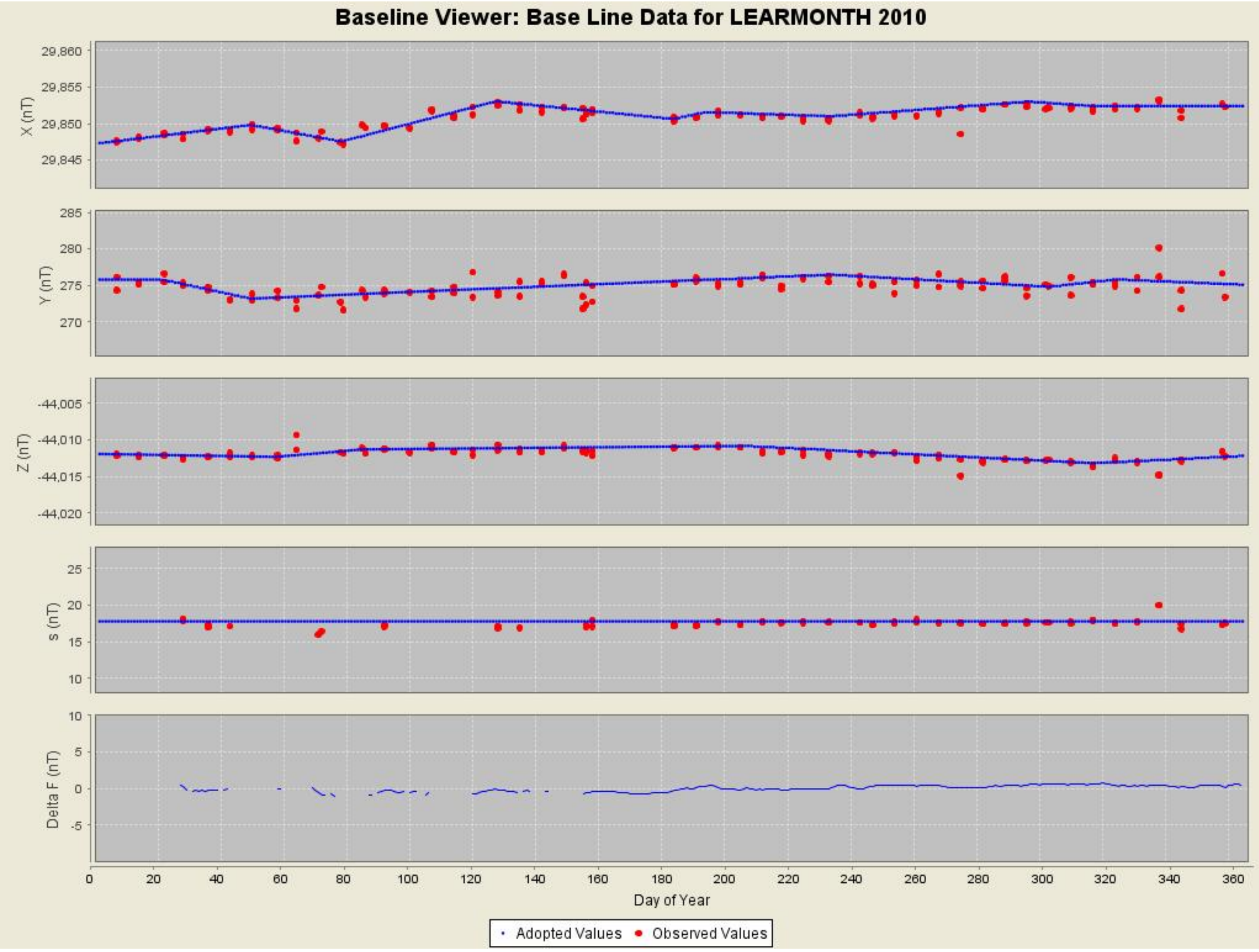
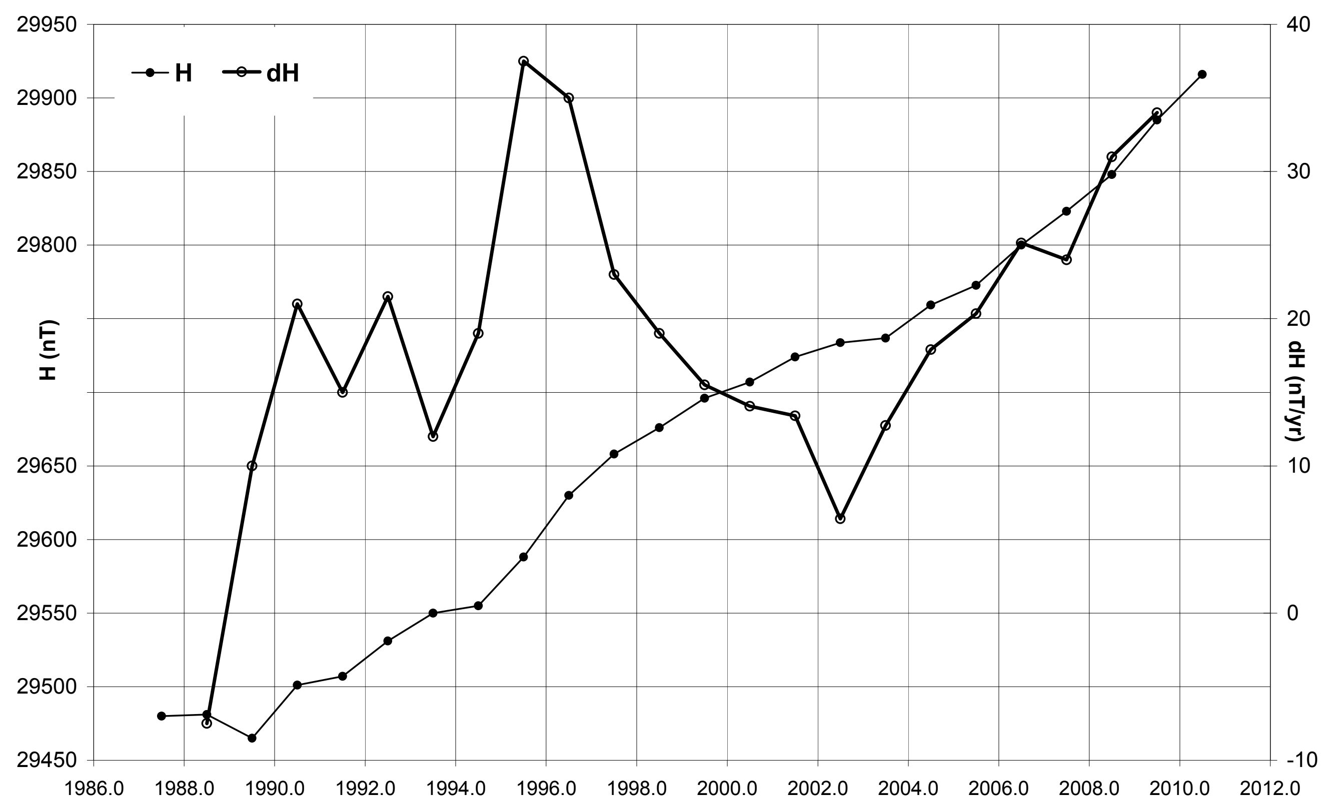


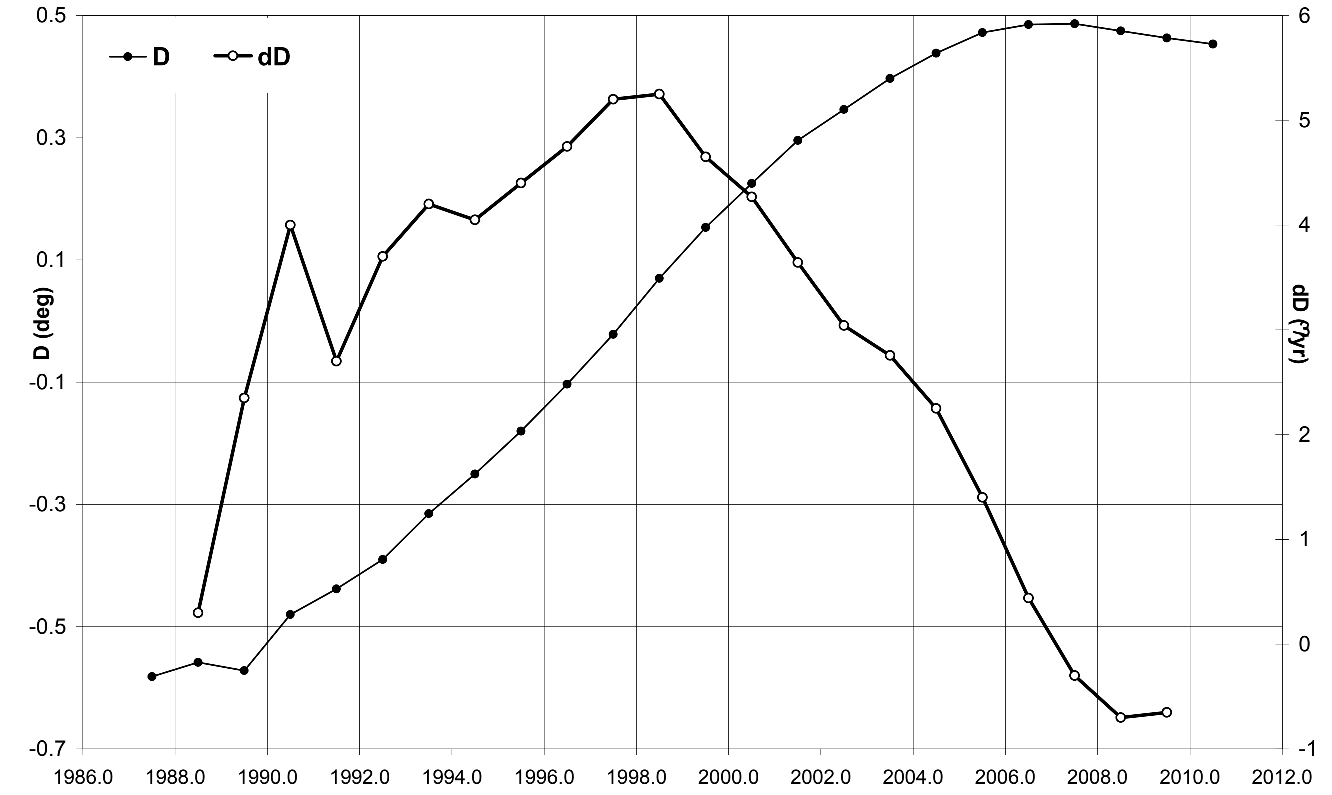
Figure 3.1. Learmonth 2010 baseline plots.

Year	Days	D (°	')	I (°	')	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441	53342	DHZ
1991.5	A	-0	26.3	-56	24.5	29507	29506	-226	-44426	53333	DHZ
1992.5	A	-0	23.4	-56	22.6	29531	29530	-201	-44407	53330	DHZ
1993.5	A	-0	18.9	-56	21.2	29550	29549	-162	-44396	53331	DHZ
1994.5	A	-0	15.0	-56	20.5	29555	29555	-129	-44386	53326	DHZ
1995.5	A	-0	10.8	-56	18.2	29588	29588	-93	-44373	53333	DHZ
1996.5	A	-0	06.2	-56	15.5	29630	29630	-54	-44358	53344	DHZ
1997.5	A	-0	01.3	-56	13.3	29658	29658	-11	-44338	53343	DHZ
1998.5	A	0	04.2	-56	11.6	29676	29676	36	-44320	53338	DHZ
1999.5	A	0	09.2	-56	09.6	29696	29696	80	-44292	53325	ABZ
2000.5	A	0	13.5	-56	07.9	29707	29706	116	-44260	53305	ABZ
2001.5	A	0	17.7	-56	05.7	29724	29724	153	-44227	53287	ABZ
2002.5	A	0	20.8	-56	04.2	29734	29733	180	-44197	53268	ABZ
2003.5	A	0	23.8	-56	03.1	29737	29736	206	-44174	53250	ABZ
2004.5	A	0	26.3	-56	00.4	29759	29758	228	-44132	53229	ABZ
2005.5	A	0	28.3	-55	57.8	29773	29772	245	-44079	53192	ABZ
2006.5	A	0	29.1	-55	53.9	29800	29799	253	-44011	53151	ABZ
2007.5	A	0	29.2	-55	50.3	29823	29822	254	-43946	53109	ABZ
2008.5	A	0	28.5	-55	46.5	29848	29847	247	-43880	53070	ABZ
2009.5	A	0	27.8	-55	42.0	29885	29884	241	-43809	53032	ABZ
2010.5	A	0	27.2	-55	37.9	29916	29915	237	-43744	52996	ABZ
1987.5	Q	-0	34.8	-56	26.3	29486	29484	-299	-44445	53336	DHZ
1988.5	Q	-0	33.5	-56	26.3	29494	29492	-288	-44455	53349	DHZ
1989.5	Q	-0	34.3	-56	26.2	29481	29479	-294	-44433	53324	DHZ

1990.5	Q	-0	28.7	-56	24.5	29516	29515	-246	-44439	53348	DHZ
1991.5	Q	-0	26.2	-56	23.4	29527	29526	-225	-44423	53341	DHZ
1992.5	Q	-0	23.3	-56	21.7	29545	29544	-200	-44405	53336	DHZ
1993.5	Q	-0	18.8	-56	20.5	29561	29560	-162	-44394	53336	DHZ
1994.5	Q	-0	15.0	-56	19.7	29569	29569	-129	-44384	53332	DHZ
1995.5	Q	-0	10.8	-56	17.5	29600	29600	-93	-44371	53338	DHZ
1996.5	Q	-0	06.3	-56	15.2	29636	29635	-54	-44357	53346	DHZ
1997.5	Q	-0	01.3	-56	12.8	29667	29667	-11	-44338	53348	DHZ
1998.5	Q	0	04.1	-56	11.1	29686	29686	35	-44318	53342	DHZ
1999.5	Q	0	09.2	-56	09.0	29705	29705	80	-44290	53329	ABZ
2000.5	Q	0	13.5	-56	07.1	29719	29719	117	-44258	53311	ABZ
2001.5	Q	0	17.8	-56	05.0	29736	29736	154	-44225	53293	ABZ
2002.5	Q	0	20.8	-56	03.3	29748	29747	180	-44195	53274	ABZ
2003.5	Q	0	23.8	-56	02.2	29752	29751	206	-44171	53256	ABZ
2004.5	Q	0	26.3	-55	59.8	29770	29769	228	-44130	53233	ABZ
2005.5	Q	0	28.3	-55	57.2	29784	29783	245	-44078	53197	ABZ
2006.5	Q	0	29.1	-55	53.4	29808	29807	252	-44010	53154	ABZ
2007.5	Q	0	29.2	-55	50.0	29827	29826	254	-43945	53112	ABZ
2008.5	Q	0	28.4	-55	46.2	29853	29852	247	-43879	53072	ABZ
2009.5	Q	0	27.7	-55	41.8	29888	29887	241	-43809	53033	ABZ
2010.5	Q	0	27.2	-55	37.6	29921	29921	237	-43744	52998	ABZ
1987.5	D	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	DHZ
1988.5	D	-0	33.6	-56	28.2	29461	29459	-288	-44460	53335	DHZ
1989.5	D	-0	34.4	-56	29.0	29433	29431	-295	-44441	53303	DHZ
1990.5	D	-0	29.0	-56	26.7	29478	29477	-249	-44445	53332	DHZ
1991.5	D	-0	26.5	-56	26.5	29473	29472	-227	-44431	53318	DHZ
1992.5	D	-0	23.5	-56	24.1	29506	29505	-201	-44412	53320	DHZ
1993.5	D	-0	18.9	-56	22.3	29530	29529	-163	-44398	53322	DHZ
1994.5	D	-0	14.9	-56	21.6	29537	29537	-128	-44389	53318	DHZ
1995.5	D	-0	10.9	-56	19.1	29574	29574	-94	-44374	53326	DHZ
1996.5	D	-0	06.2	-56	16.0	29622	29622	-53	-44359	53340	DHZ
1997.5	D	-0	01.3	-56	14.2	29643	29643	-11	-44340	53336	DHZ
1998.5	D	0	04.2	-56	13.0	29652	29652	36	-44322	53326	DHZ
1999.5	D	0	09.3	-56	10.7	29677	29677	81	-44295	53317	ABZ
2000.5	D	0	13.4	-56	09.5	29679	29679	116	-44264	53294	ABZ
2001.5	D	0	17.6	-56	07.2	29699	29699	152	-44230	53276	ABZ
2002.5	D	0	20.8	-56	05.4	29712	29712	179	-44200	53259	ABZ
2003.5	D	0	23.8	-56	04.5	29713	29713	206	-44177	53240	ABZ
2004.5	D	0	26.3	-56	01.6	29739	29738	227	-44135	53219	ABZ
2005.5	D	0	28.3	-55	58.9	29754	29753	245	-44082	53184	ABZ
2006.5	D	0	29.3	-55	54.6	29787	29786	253	-44012	53145	ABZ
2007.5	D	0	29.3	-55	50.7	29816	29814	254	-43946	53106	ABZ
2008.5	D	0	28.5	-55	46.9	29841	29840	247	-43881	53066	ABZ
2009.5	D	0	27.8	-55	42.2	29880	29879	242	-43809	53029	ABZ
2010.5	D	0	27.2	-55	38.5	29907	29906	237	-43745	52991	ABZ

Table 3.5. Learmonth annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 3.2.


H
dH
H (nT)
dH (nT/yr)
29950
29900
29850
29800
29650
29600
29550
29500
29450
40
30
20
10
0
-10
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0


D
dD
D (deg)
dD ('/yr)
0.5
0.3
0.1
-0.1
-0.3
-0.5
-0.7
6
5
4
2
1
0
-1
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0

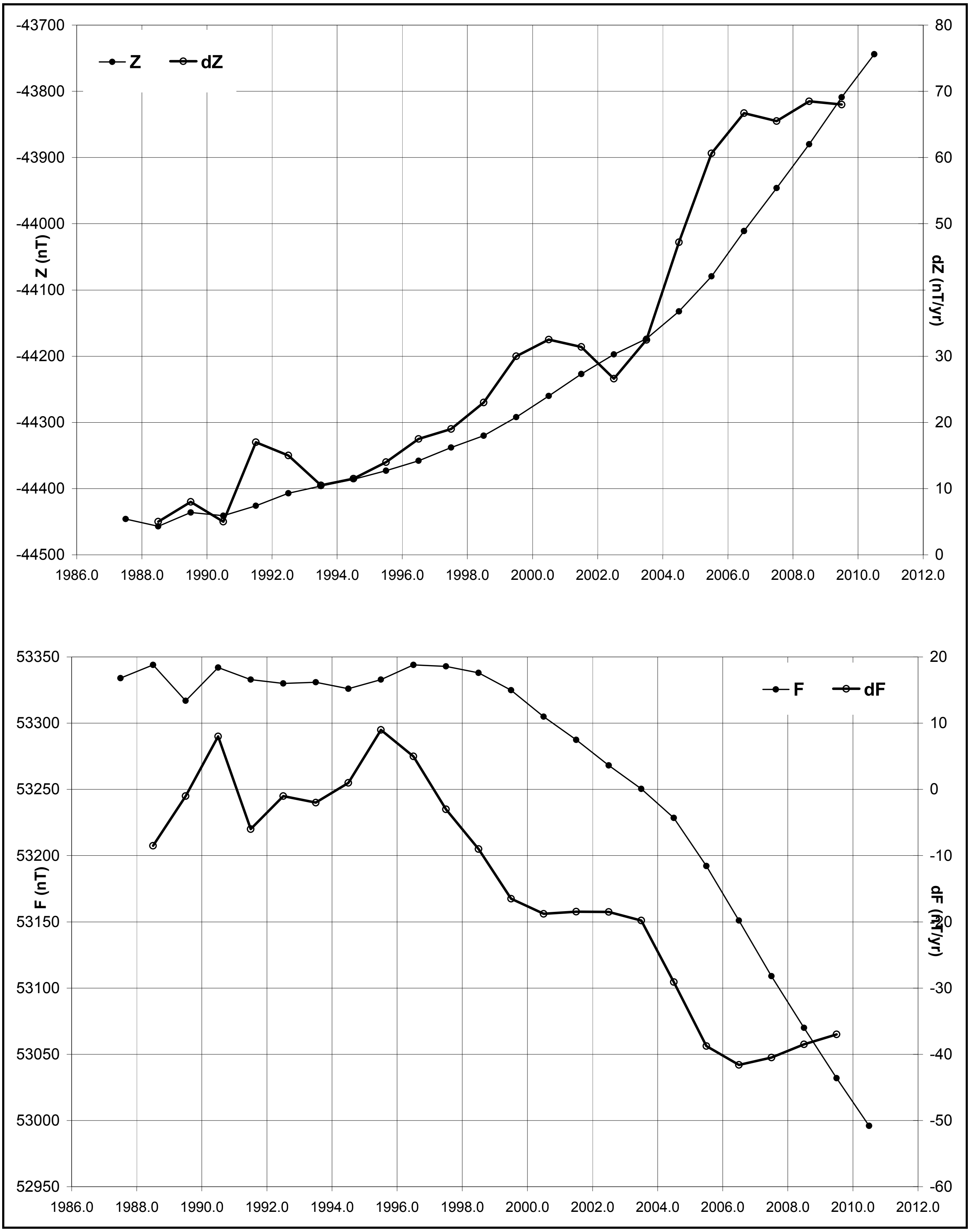
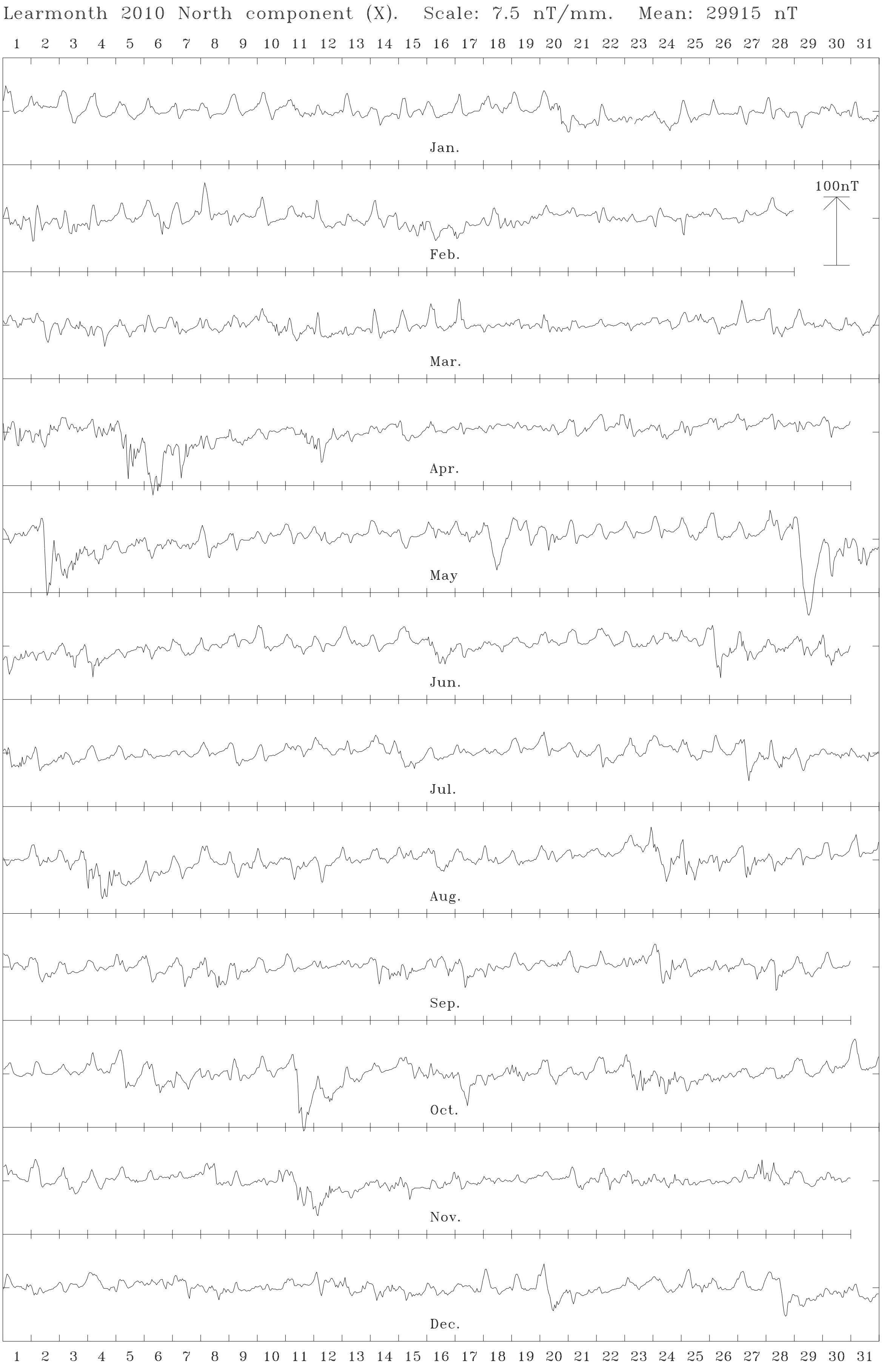
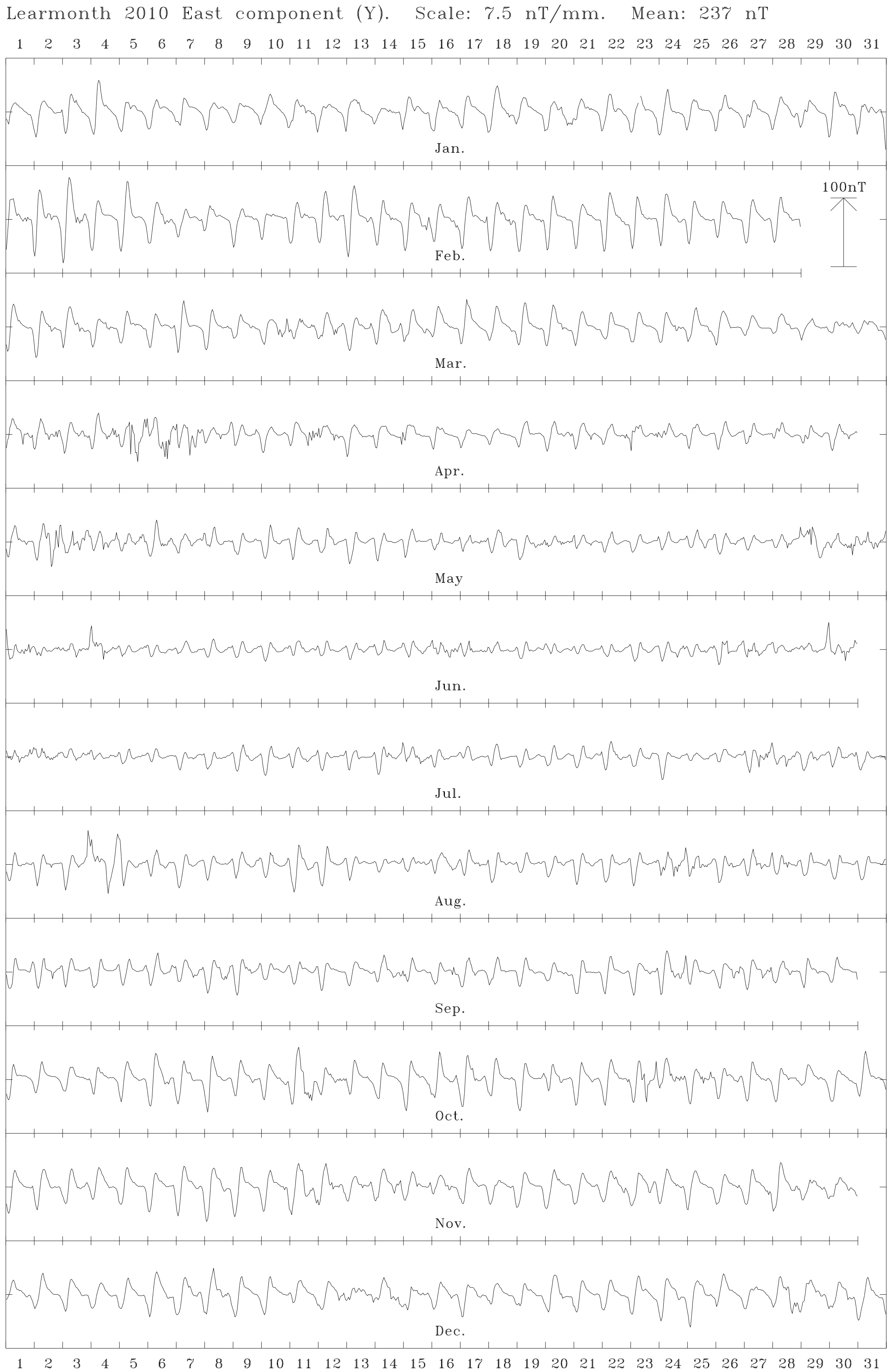
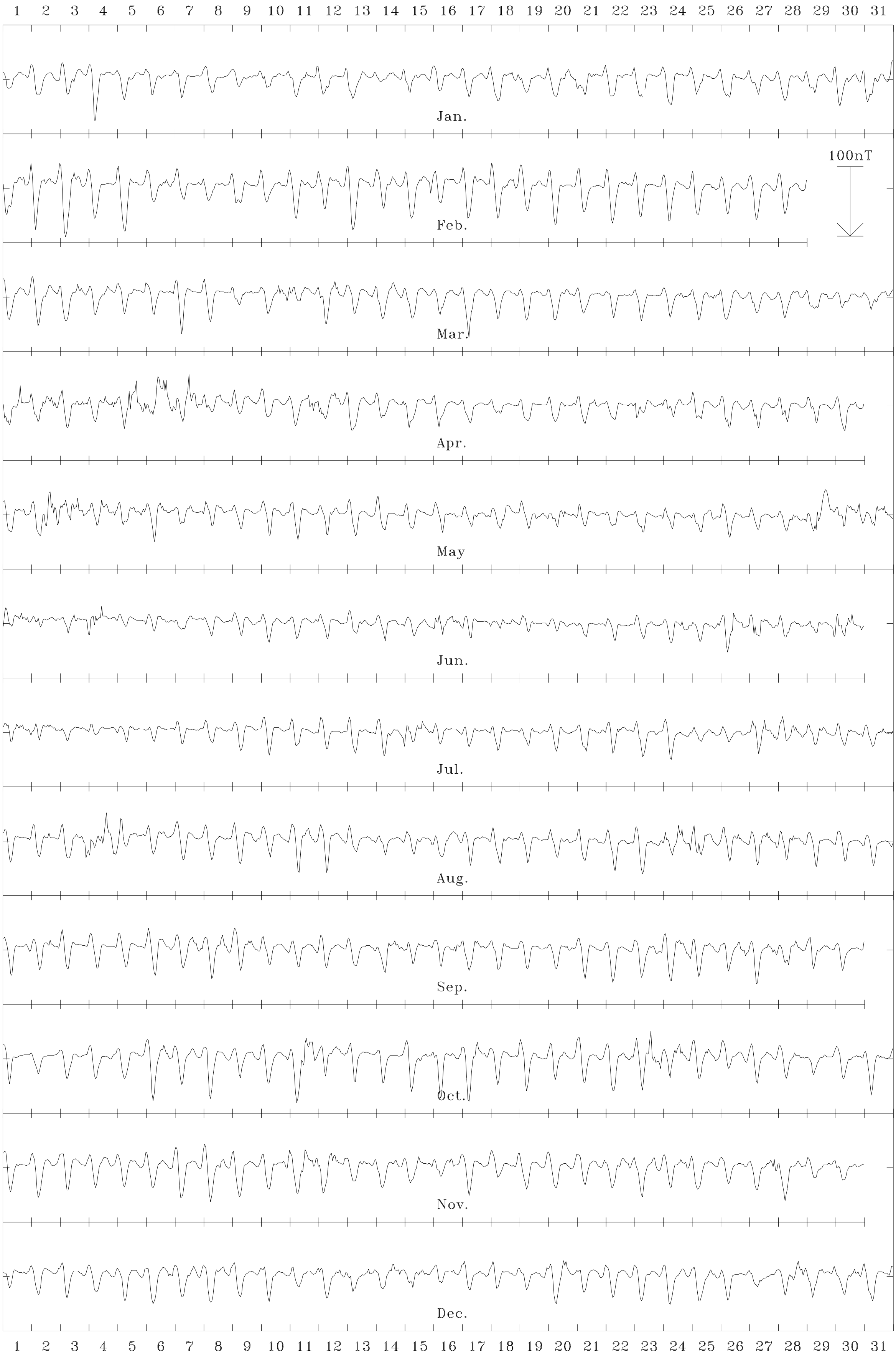


Figure 3.2. Learmonth annual mean values and secular variation (all days) for H, D, Z and F.


Learmonth 2010 North component (X). Scale: 7.5 nT/mm. Mean: 29915 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Learmonth 2010 East component (Y). Scale: 7.5 nT/mm. Mean: 237 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
100nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.

Learmonth 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −43745 nT



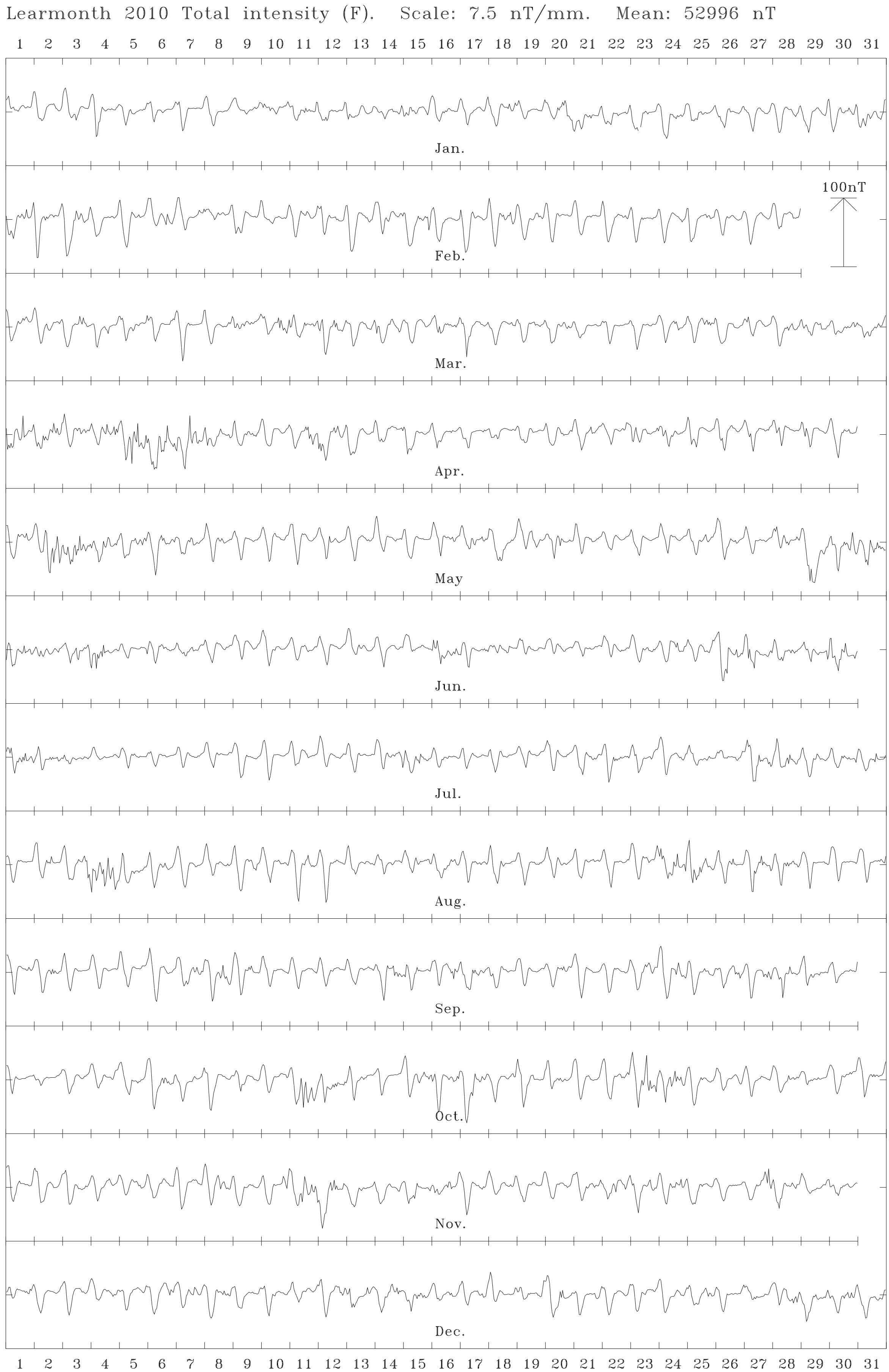


Figure 3.3. Learmonth 2010 hourly mean values in X, Y, Z and F.

4. Alice Springs

The Alice Springs magnetic observatory is located approximately 10 km south of Alice Springs in the Northern Territory, on the Centre for Appropriate Technology (CAT), a national indigenous science and technology organisation. The observatory is situated on an alluvial plain over tertiary sediments, overlying late Proterozoic carbonates and quartzites.

The observatory comprises:

- a 3×3m insulated air-conditioned concrete-brick Control House where recording instrumentation and control equipment are housed;
- a VSAT communications dish to the east of the Control House;
- a 3×3m Absolute Shelter, 80 m southeast of the Control House, which encloses a concrete observation pier (Pier G); the top of the pier is 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°, and;
- two small (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.

The unused VSAT communications dish to the east of the Control House was dismounted on 8 July 2010 and sent back to Canberra.

IAGA code:	ASP
Commenced operation:	June 1992
Geographic latitude:	23° 45' 39.6" S
Geographic longitude:	133° 53' 00.0" E
Geomagnetic latitude:	-32.41°
Geomagnetic longitude:	208.57°
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
Observers:	W. Serone S. Evans

Table 4.1. Key observatory data.

Variometers

The variometers used during 2010 are described in Table 4.2.

The DMI fluxgate sensor and electronics were housed in the eastern underground vault and the PPM 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 recording equipment was housed in the Control House.

Despite being in buried vaults, the variometers experienced seasonal temperature variations of approximately 20°C. The DMI sensor temperature ranged from 14° to 35° during the year and the electronics from 19° to 39°. Consequently, the DMI X, Y and Z channels exhibited temperature-related variations of 1.2 nT, 0.2 nT and 2.0 nT, respectively.

3-component variometer:	DMI FGE
Serial number:	E0306/S0261
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.03 nT
A/D converter:	ADAM 4017 module (±5V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081419/42177
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	NextG modem

Table 4.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

Absolute instruments

The principal absolute magnetometers used at Alice Springs and their adopted corrections for 2010 are described in Table 4.3. A Hewlett Packard H4300 hand-held computer was used to communicate via the serial data port of the PPM.

On 27 January 2010, DIM DI0052/313887 was calibrated at Canberra observatory against the Australian standard DIM DI0086/353756. The calibration results confirmed that the adopted correction value for DIM DI0052/313887 to the international standard given in Table 4.3 remains current. At the 2010 mean magnetic field values at Alice Springs (X=30017 nT, Y=2601 nT, Z=-43875 nT) the D, I and F corrections in Table 4.3 translate to corrections of:

$\Delta X = -1.4$ nT $\Delta Y = 0.8$ nT $\Delta Z = -0.9$ nT

These corrections have been applied to all Alice Springs 2010 final data.

DI fluxgate:	DMI
Serial number:	DI0052
Theodolite:	Zeiss 020B
Serial number:	313887
Resolution:	0.1'
D correction:	+0.1'
I correction:	-0.1'
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081422/01504
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 4.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Baselines

The fluxgate variometer baselines were controlled by 40 sets of weekly absolute observations through the year. The absolute data quality was good, indicated by low χ^2 values. Baseline variations determined by the weekly absolute observations were in the range of 4 nT for X, Y and Z, except for 3 separate observations in June, July and August when variations were 6-7 nT. The uncorrected baseline variation curve was similar to curves of the instrument head and electronics temperature. Temperatures in the variometer vaults varied seasonally by a maximum of 20°C, which converts to a maximum 2.0 nT in the variometer data.

There were a few jumps in the fluxgate and PPM variometer baselines mainly due to instrument instability:

Fluxgate

2010-02-21	14:55:21	X 2.43 nT, Y -2.1 nT
2010-02-21	14:55:29	X 1.00 nT, Y -0.62 nT
2010-03-06	07:28 - 07:44	X 0.8 nT, Z -0.5 nT
2010-03-06	07:28 - 07:41	Y -0.8 nT
2010-03-06	07:41 - 07:45	Y 0.6 nT
2010-03-09	09:53:59 - 10:04:28	Y:-0.7 nT, Z -0.5 nT
2010-03-10	05:53:32 - 05:57:16	Y -0.8 nT, Z -0.5 nT

PPM

2010-03-20	06:26:55 - 06:29:15	F 2.0 nT
2010-04-17	03:47 - 05:41	F 1.35 nT
2010-12-09	09:34:45	F 1.0 nT

The PPM variometer baseline variation changed within 4 nT. The baseline variation curve also resembled the temperature variation in the vault.

The final FCheck values for the year were in the range ±1.5 nT. The standard deviations in the 2010 weekly absolute observations from the final adopted variometer model and data were:

	σ		σ
X	0.9 nT	D	10"
Y	1.5 nT	I	4"
Z	0.7 nT	F	0.5 nT

Operations

In 2010, absolute observations were performed weekly by Warren Serone and Shaun Evans, Alice Springs-based officers of Geoscience Australia's Data Acquisition Facility (DAF). The DAF office is approximately 150 m from the observatory site. Magnetic time-series data were transferred to Geoscience Australia in Canberra every 5 minutes via the NextG mobile network.

The QNX acquisition computer used a GPS clock (both pulse-per-second and absolute-time-code) to set the system time. The clock was checked from Geoscience Australia regularly to ensure it was working correctly. If not, it was reset remotely or, if necessary, the computer was re-booted.

A new air-conditioner was installed on 5 January in the Control House to maintain a temperature-stable environment for instruments inside the house. A high-gain NextG antenna was installed on 29 January to improve the NextG mobile network performance.

The DIM absolute instrument was calibrated and compared at the Canberra observatory on 27 January. The magnetic sensor mounted on the theodolite was re-aligned, resulting in a horizontal misalignment of 3 minutes and vertical misalignment of 1 minute. The comparison results confirmed that the adopted correction for DIM DI0052/313887 remains unchanged.

Two major data losses occurred on 17 April and 26 August due to a power outage in the area. The system run on the UPS and then stopped when the batteries in the UPS were flat.

The distribution of Alice Springs 2010 data is described in Table 4.4. Data losses are identified in Table A.4.

Macquarie University and CSIRO continued the ant research project inside the observatory grounds in 2010. Two ant observation sites were established between the variometer vault and Absolute Shelter in 2009. The closest site was about 20 m from the variometer. A few shallow trenches were laid using plastic boards on the surface. There was no sign of contamination to magnetic field data in relation to the ant observations.

A collaborative long-period magnetotelluric (MT) experiment at Hamilton Downs continued in 2010. During 5 to 10 July, Masahiro Ichiki (Tokyo Institute of Technology), Kiyoshi Fujita (Osaka University), Liejun Wang and Jim Whatman made a maintenance visit to the Hamilton Downs MT site. They also attempted to install an MT instrument at Owen Springs but this plan was washed out by continuing heavy rain over the period.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011
WDC for Geomagnetism	preliminary	real time
WDC for Geomagnetism	preliminary	daily

Table 4.4. Distribution of Alice Springs 2010 data.

Significant events

2010-01-05 New air-conditioner installed in Control Hut

2010-01-10 13:48:29 all data ceases at this time - Shaun checks system and notes no signal lights on wireless modem. Cannot connect via landline until Shaun reboots system at about 22:50 10/01/10 22:50:29 - CLK I 0 Correction 1263163829 509178274 C 1 s 227574343 R 0 s -392

2010-01-12 Shaun attempts to reset NextG modem but cannot connect with his laptop. Modem removed and sent back to GA. Analogue land-line modem also appears to have failed. At 23:39 reboot gets analogue modem working - data retrieval every 30minutes.

2010-01-14 NextG modem arrives at GA - it is unserviceable, a replacement is prepared. Modem LAN-side IP is 192.168.0.1 and it will allocate 192.168.0.10 to Gdap computer.

2010-01-15 Replacement NextG modem air freighted to ASP. At 02:30 analogue modem connection fails.

2010-01-19 Replacement NextG modem arrives at ASP and installed. Change IP addresses in /etc/hosts to gate 192.168.0.1 and 192.168.0.10. Modem shows signal lights for a few minutes then no signal is evident. Three system-reboots starting at about 03:18 - cannot get modem to work, cannot get a ping response from modem. Get analogue modem running and catch up on data back-log.

2010-01-20 Change netmask from 255.255.255.248 to 255.255.255.0 on Gdap computer to put 192.168.0.1 and 192.168.0.10 on the same network. Still cannot ping modem. Swap modem to en1 – no improvement. Shaun checks power supply and finds it is delivering only 7V. Re-install onto en0 with replacement 12V power supply, can now ping modem and get a brief connection Wireless signal strength seems to be a problem. Several reboots today during modem re-configuration. Still retrieving data every 30 minutes via the analogue modem.

2010-01-27 DIM DI0052/313887 was calibrated at CNB. The sensor horizontal alignment was adjusted.
Set one: d=+2.95'(0.04) e=+0.99'(0.01)
Set two: d=+3.00'(0.04) e=+0.98'(0.01)
ASP DI0052/313887:
Ed=+0.13'(0.04), Ei=+0.22'(0.02) (insnull.con used)
Ed=+0.25'(0.04), Ei=+0.22'(0.02)
CNB DI0086/353756:
Ed=+0.11'(0.04), Ei=+0.18'(0.02)
Ed=+0.06'(0.04), Ei=+0.17'(0.02)
DIM was posted to ASP today

2010-01-29 Shaun installed high gain NextG antenna and connection was immediately re-established. Altered /etc/ppp/answer to put modem commands inside the loop - rmHAM PPP, addHAM PPP /etc/ppp/answer and the telephone modem also worked again.

2010-02-15 21:58 Mag 6 earthquake in Banda Sea

2010-02-04 03:56 to 06:20, shifted Z -0.57nT in the 1-minute database.

2010-02-21 X jumped 2.43 nT from 14:55:20 to 14:55:21. Y jumped -2.1 nT. Z is ok, X jumped 1.00nT from 14:55:28 to 14:55:29 Y jumped -0.62nT. Z is ok

2010-02-24 Rapid temperature drop due to 100mm rainfall

2010-03-06 07:28 - 07:44 X shifted 0.8, Z shifted -0.5. 07:28 - 07:41 Y shifted -0.8. 07:41 - 07:45 Y shifted 0.6

2010-03-09 1 second data: irregular baseline jumps between 09:53:48 to 09:53:58 and 10:04:29 to 10:04:33. data in these periods were delete in the database (final data). 09:53:59 to 10:04:28 shifted -0.7 nT in Y, -0.5nT in Z.

2010-03-10 1 second data: irregular baseline jumps between 05:53:29 to 05:53:31 and 05:57:17 to 05:57:31. data in these periods were delete in the database (final data). Shifted -0.5 in Z and -0.8 in Y between 05:53:32 to 05:57:16

2010-03-20 Deleted PPM data between 06:29:25 to 06:29:55 in database, and shifted 2.0nT between 06:26:55 to 06:29:15

2010-04-17 1h55m data loss between 03:47 to 05:41. System failed and then re-started. F check changed 1.35 nT. shifted PPM baseline up 1.35 nT. (not sure if it is variometer's baseline jump)

2010-04-29 Power off to absolute hut for most of the day due to electrical work at another unspecified shed.

2010-05-12 IP address of modem changed to 172.18.8.10

2010-07-05 LJW and JWW in Alice Springs for MT survey

2010-07-06 Heavy rain

2010-07-08 02:00 - 03:00 NT local time. Removed satellite dish on the back of Control House. Only the support pole remains.

2010-08-04 14:30 data telemetry fails

2010-08-05 01:40 Warren reboots NextG modem and data begin to flow. Analogue modem is not answering

2010-08-06 Shaun tests phone line and confirms it is dead. Telstra confirms there is a problem with the line.

2010-08-20 Warren connected the modem back to the phone line. It tested ok.

2010-08-26 Power outage at ASP for about 5 hours. data loss from 00:31 to 04:00

2010-08-27 Sensor alignment D = 47 minutes.

2010-09-13 00:55 Check analogue modem O.K.

2010-09-29 17:15 Quake noise Mag 7.2 Irian Jaya

2010-11-09 Mains power failure since 07:00 CST, 21:30 UTC. System runs on UPS. Apparently UPS ran out just before power was restored ~9 minutes data loss between 00:00 to 00:10

2010-11-22 Warren rang at 01:20 UT. Ant observations will be carried out by Uni of QLD at the site between variometer vault and control room. No obs for last week.

2010-12-09 09:35 1nT FCheck jump and change in noise characteristics removed spikes at 09:34:15, 09:40:15, and 09:44:45 PPM jump about 1 nT at 09:34:45.

Annual mean values

The annual mean values for Alice Springs are set out in Table 4.5 and displayed with the secular variation in Figure 4.2.

Hourly mean values

Plots of the hourly mean values for Alice Springs 2010 data are shown in Figure 4.3.

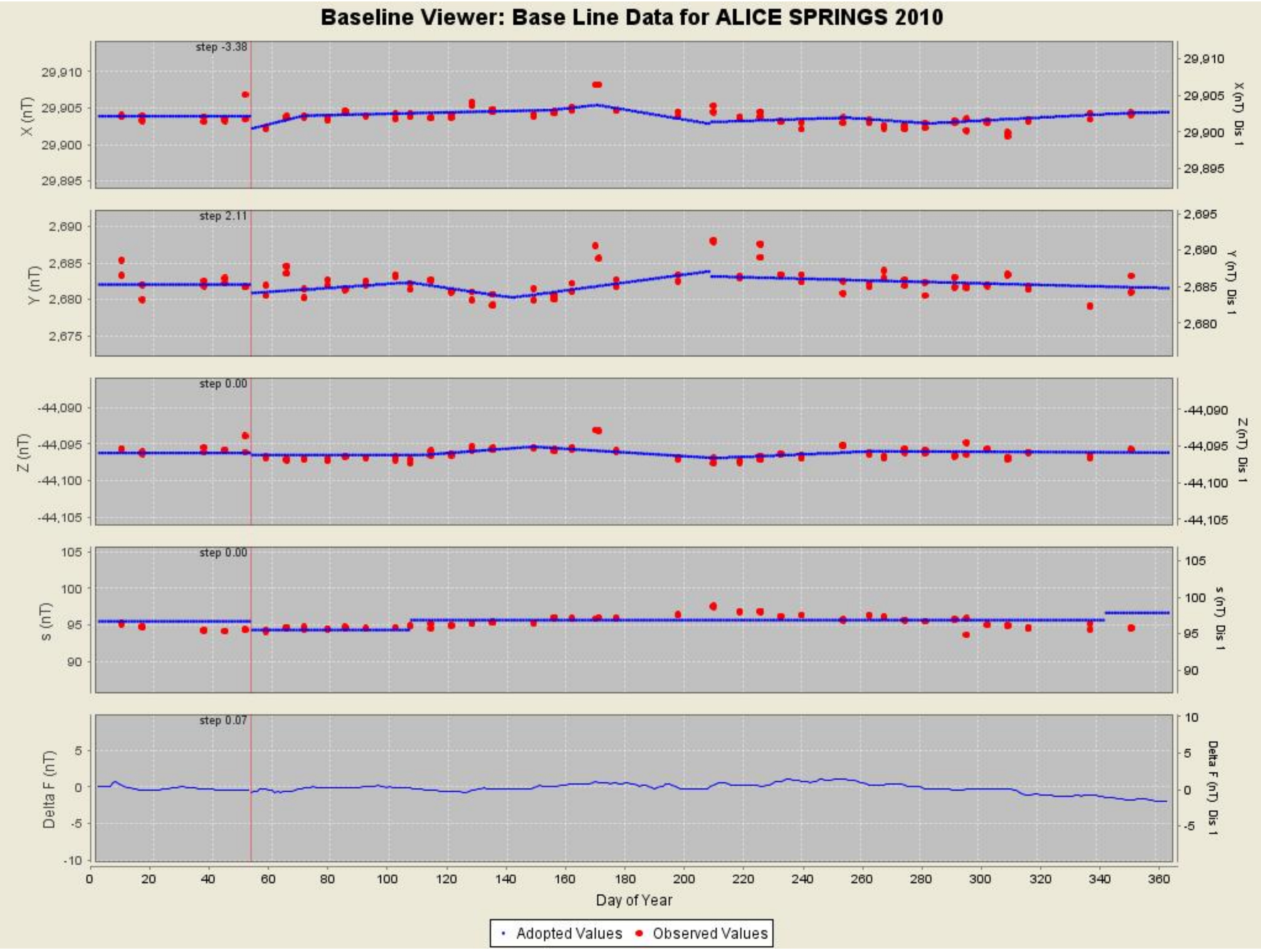
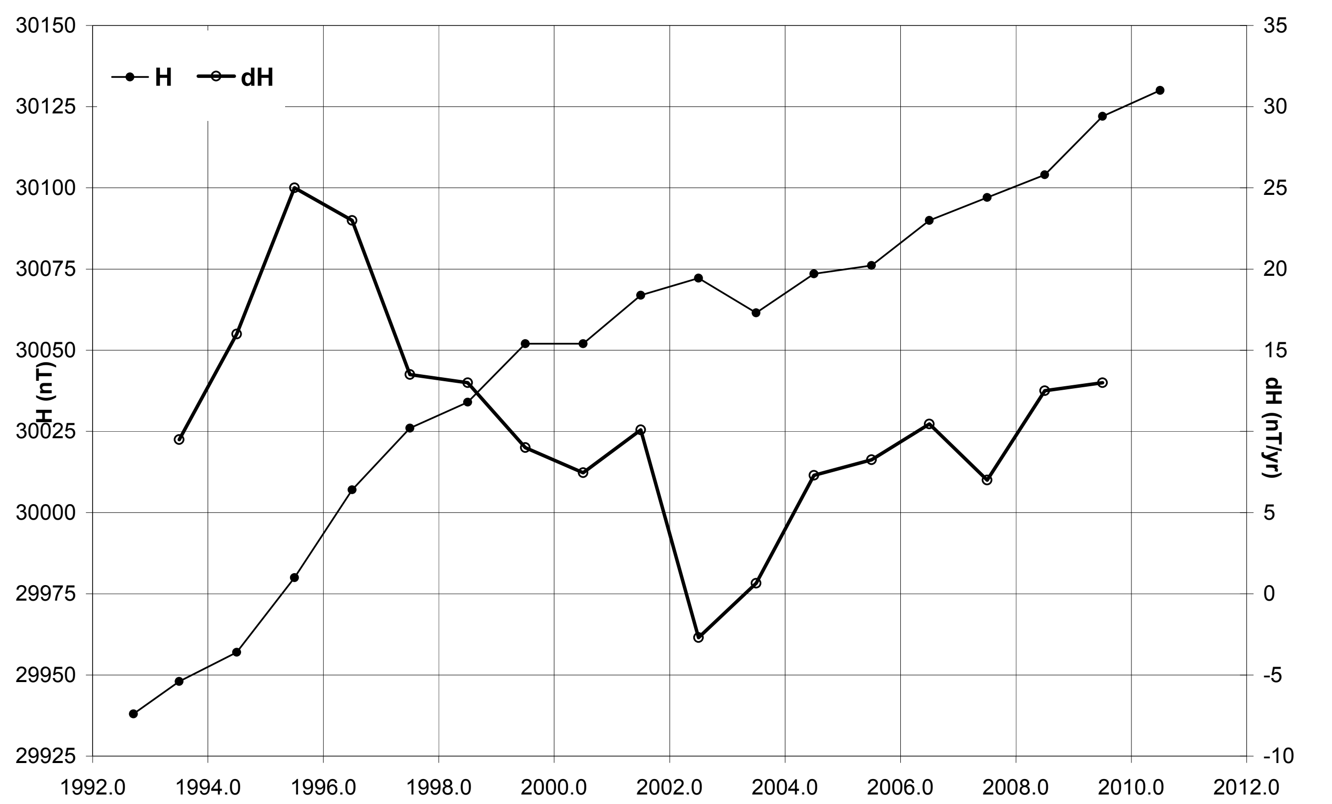


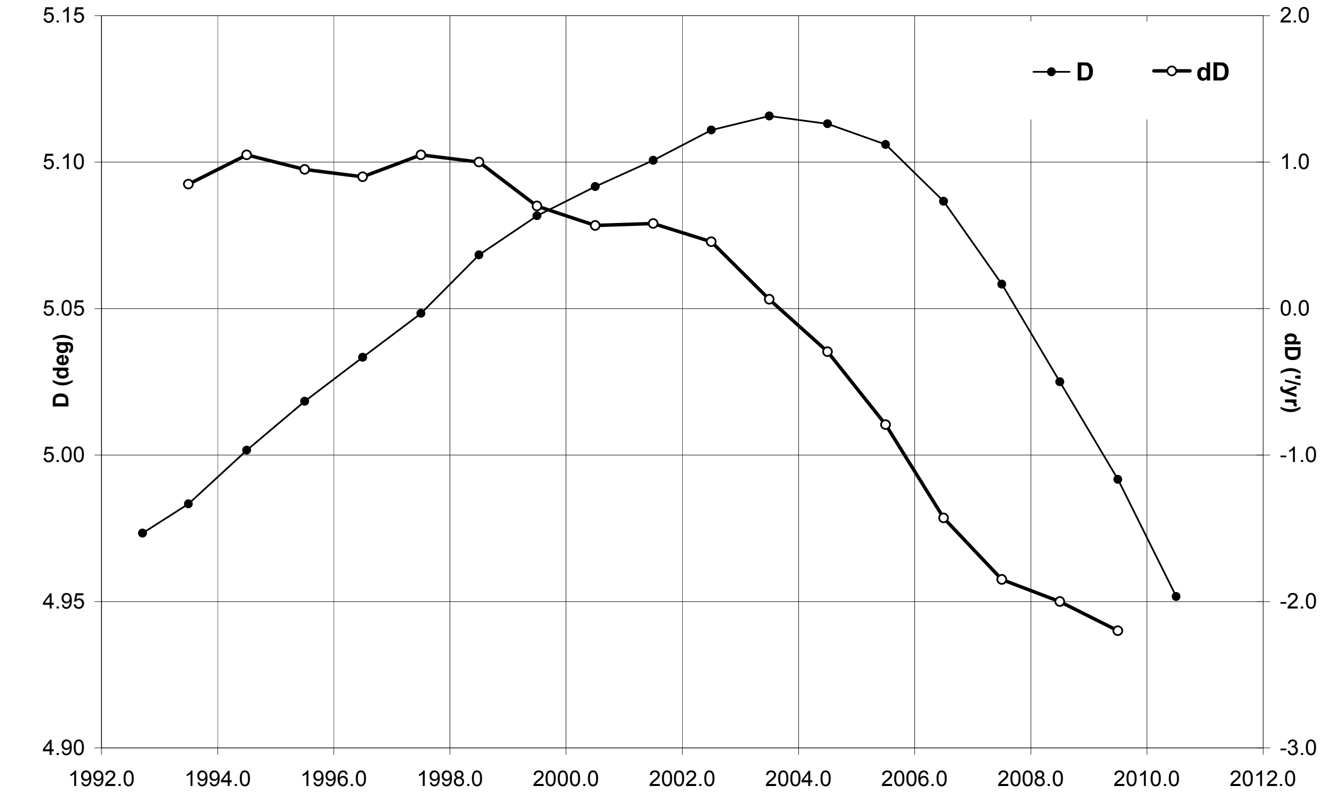
Figure 4.1. Alice Springs 2010 baseline plots.

Year	Days	D (°	')	I (°	')	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
1992.708	A	4	58.4	-56	06.8	29938	29825	2595	-44575	53695	XYZ
1993.5	A	4	59.0	-56	05.5	29948	29835	2601	-44552	53682	XYZ
1994.5	A	5	00.1	-56	04.1	29957	29843	2612	-44528	53667	XYZ
1995.5	A	5	01.1	-56	01.7	29980	29865	2623	-44494	53652	XYZ
1996.5	A	5	02.0	-55	59.0	30007	29892	2633	-44458	53638	XYZ
1997.5	A	5	02.9	-55	56.6	30026	29910	2642	-44421	53617	XYZ
1998.5	A	5	04.1	-55	54.7	30034	29917	2653	-44379	53587	XYZ
1999.5	A	5	04.9	-55	51.9	30052	29934	2662	-44329	53555	XYZ
2000.5	A	5	05.5	-55	50.2	30052	29934	2667	-44282	53517	XYZ
2001.5	A	5	06.0	-55	48.0	30067	29948	2673	-44241	53491	XYZ
2002.5	A	5	06.7	-55	46.3	30072	29953	2679	-44204	53463	XYZ
2003.5	A	5	07.0	-55	45.8	30062	29942	2681	-44175	53433	XYZ
2004.5	A	5	06.6	-55	44.9	30073	29954	2680	-44134	53406	XYZ
2005.5	A	5	06.4	-55	42.0	30076	29957	2677	-44090	53371	ABZ
2006.5	A	5	05.2	-55	39.4	30090	29971	2668	-44038	53336	ABZ
2007.5	A	5	03.5	-55	37.5	30097	29980	2653	-43995	53305	ABZ
2008.5	A	5	01.5	-55	35.6	30104	29989	2637	-43956	53277	ABZ
2009.5	A	4	59.5	-55	33.1	30122	30008	2621	-43913	53251	ABZ
2010.5	A	4	57.1	-55	31.3	30130	30017	2601	-43875	53224	ABZ
1992.708	Q	4	58.4	-56	06.0	29950	29838	2596	-44572	53700	XYZ
1993.5	Q	4	59.0	-56	04.8	29959	29845	2603	-44550	53686	XYZ
1994.5	Q	5	00.2	-56	03.3	29971	29857	2614	-44524	53672	XYZ
1995.5	Q	5	01.1	-56	01.0	29991	29876	2623	-44492	53656	XYZ
1996.5	Q	5	02.0	-55	58.6	30013	29897	2633	-44458	53640	XYZ
1997.5	Q	5	02.9	-55	56.0	30035	29919	2643	-44419	53621	XYZ
1998.5	Q	5	04.1	-55	54.1	30043	29926	2654	-44377	53590	XYZ
1999.5	Q	5	04.9	-55	51.3	30061	29943	2663	-44326	53558	XYZ

2000.5	Q	5	05.6	-55	49.5	30065	29946	2669	-44279	53521	XYZ
2001.5	Q	5	06.1	-55	47.3	30078	29959	2675	-44239	53495	XYZ
2002.5	Q	5	06.7	-55	45.5	30086	29966	2680	-44201	53469	XYZ
2003.5	Q	5	07.0	-55	45.0	30076	29956	2682	-44171	53439	XYZ
2004.5	Q	5	06.9	-55	43.1	30084	29964	2682	-44131	53410	XYZ
2005.5	Q	5	06.4	-55	41.4	30087	29967	2678	-44088	53376	ABZ
2006.5	Q	5	05.2	-55	38.9	30097	29979	2668	-44037	53340	ABZ
2007.5	Q	5	03.5	-55	37.2	30102	29985	2654	-43995	53307	ABZ
2008.5	Q	5	01.5	-55	35.3	30110	29994	2638	-43955	53279	ABZ
2009.5	Q	4	59.5	-55	32.9	30125	30011	2621	-43912	53252	ABZ
2010.5	Q	4	57.1	-55	31.0	30135	30022	2601	-43874	53226	ABZ
1992.708	D	4	58.4	-56	08.1	29915	29803	2594	-44579	53686	XYZ
1993.5	D	4	58.9	-56	06.7	29928	29815	2599	-44556	53674	XYZ
1994.5	D	5	00.0	-56	05.1	29940	29826	2609	-44531	53660	XYZ
1995.5	D	5	01.1	-56	02.6	29965	29850	2621	-44497	53646	XYZ
1996.5	D	5	02.0	-55	59.5	29998	29883	2632	-44460	53634	XYZ
1997.5	D	5	02.8	-55	57.5	30011	29895	2640	-44423	53611	XYZ
1998.5	D	5	04.0	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	04.9	-55	53.0	30034	29916	2660	-44332	53548	XYZ
2000.5	D	5	05.5	-55	51.8	30026	29908	2664	-44287	53506	XYZ
2001.5	D	5	05.8	-55	49.4	30043	29924	2669	-44245	53480	XYZ
2002.5	D	5	06.6	-55	47.6	30051	29931	2677	-44207	53454	XYZ
2003.5	D	5	06.8	-55	47.2	30038	29919	2677	-44178	53423	XYZ
2004.5	D	5	06.6	-55	44.9	30054	29934	2677	-44137	53398	XYZ
2005.5	D	5	06.3	-55	43.1	30058	29939	2674	-44093	53364	ABZ
2006.5	D	5	05.3	-55	40.2	30077	29958	2667	-44040	53331	ABZ
2007.5	D	5	03.5	-55	37.9	30089	29972	2653	-43997	53302	ABZ
2008.5	D	5	01.6	-55	36.1	30097	29981	2637	-43957	53274	ABZ
2009.5	D	4	59.5	-55	33.4	30117	30003	2621	-43913	53249	ABZ
2010.5	D	4	57.1	-55	31.9	30120	30008	2600	-43876	53220	ABZ

Table 4.5. Alice Springs annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 4.2.


H
dH
H (nT)
dH (nT/yr)
30150
30125
30100
30075
30050
30025
30000
29975
29950
29925
35
30
25
20
15
10
5
0
-5
-10
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0


D
dD
D (deg)
dD ('/yr)
5.15
5.10
5.05
5.00
4.95
4.90
2.0
1.0
0.0
-1.0
-2.0
-3.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
2008.0
2010.0
2012.0

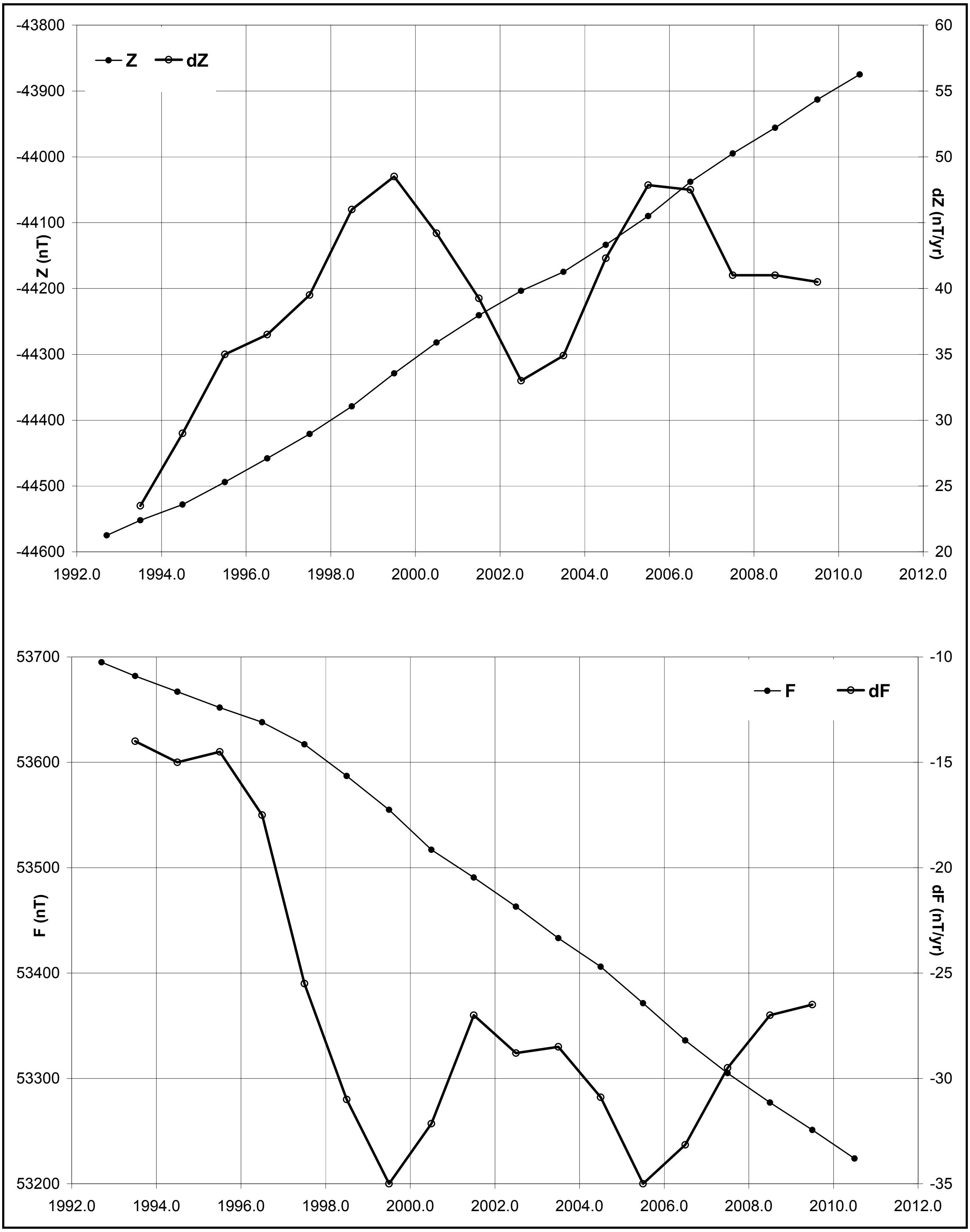
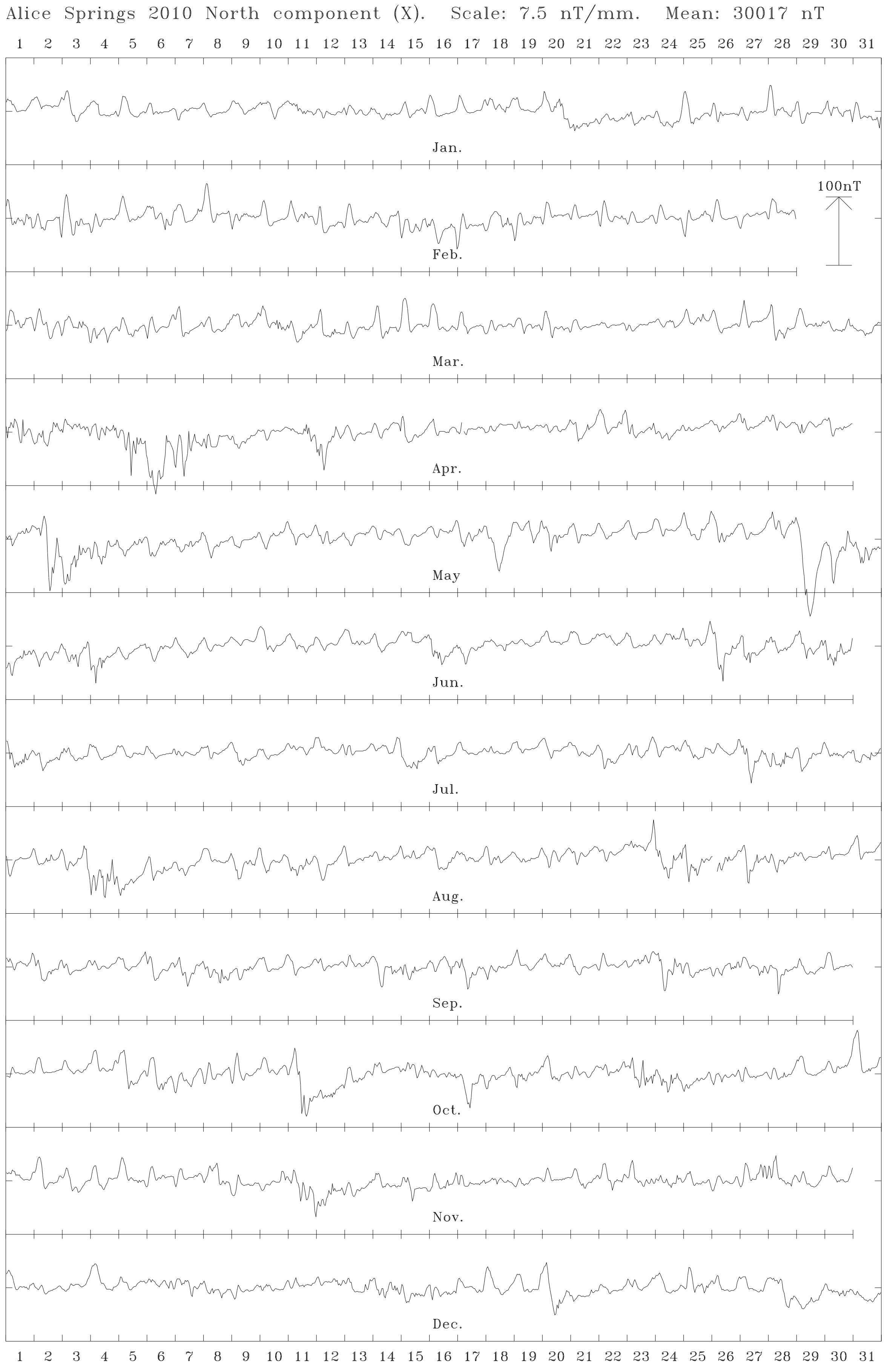
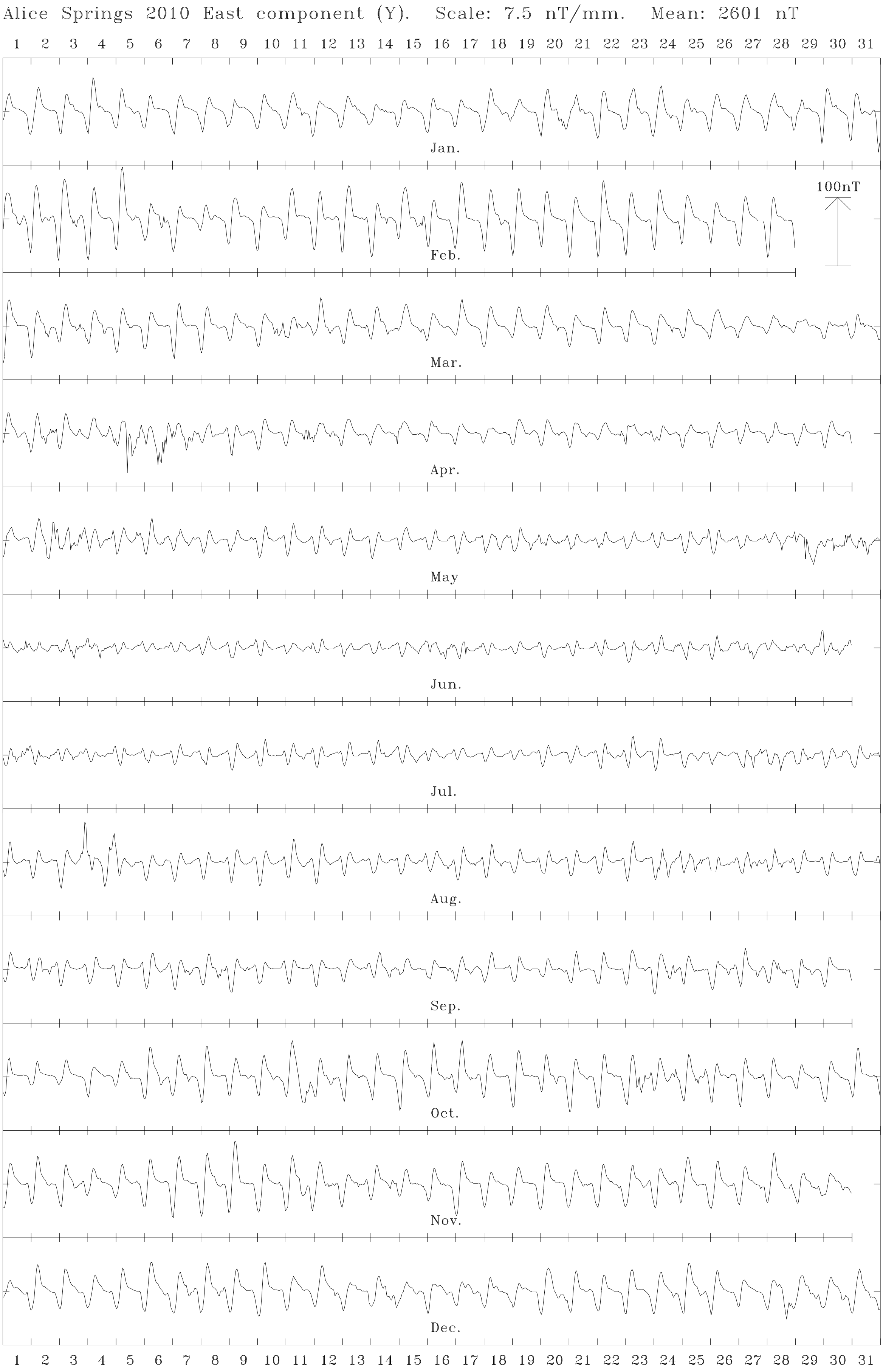
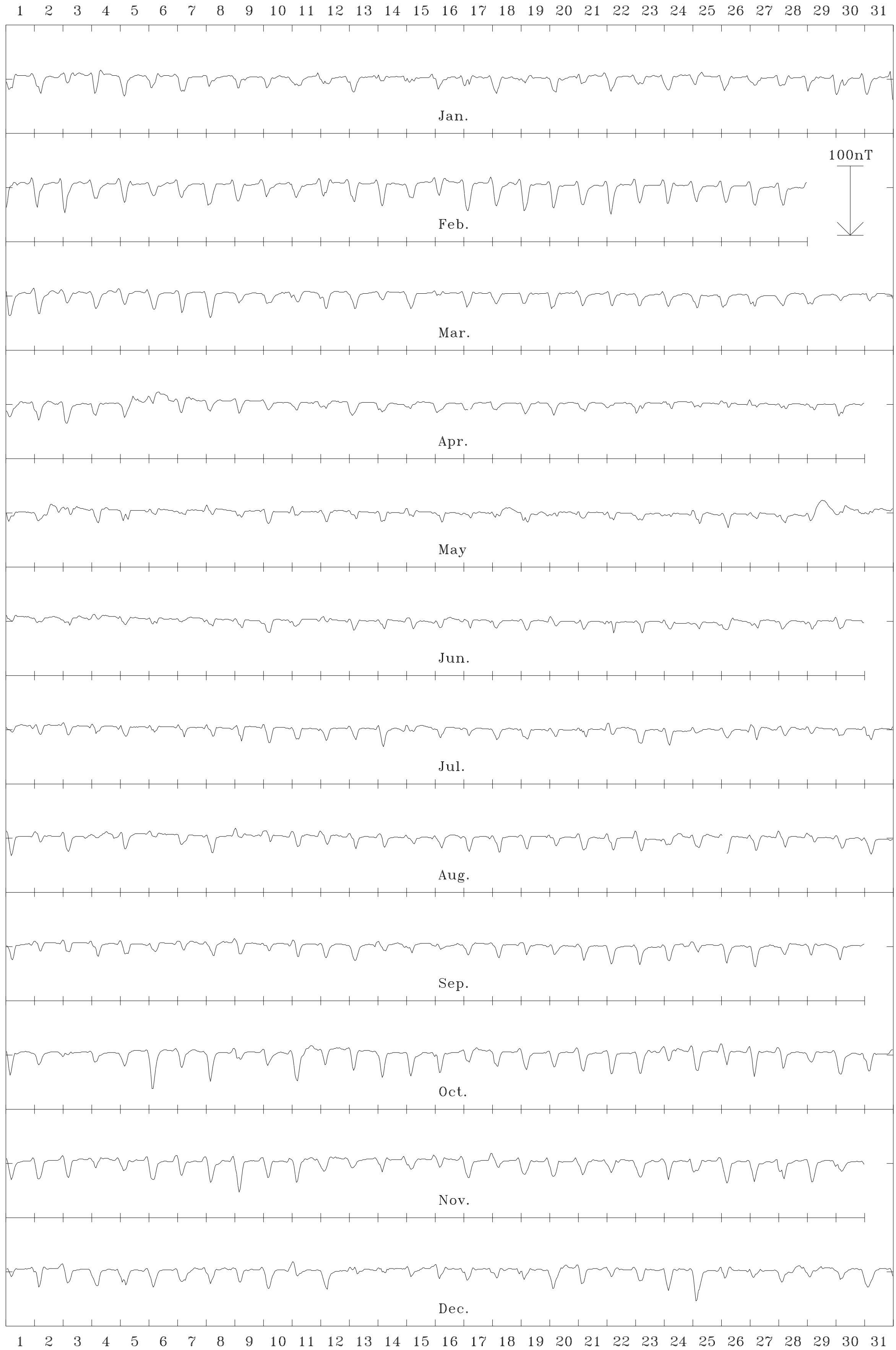


Figure 4.2. Alice Springs annual mean values and secular variation (all days) for H, D, Z and F.


Alice Springs 2010 North component (X). Scale: 7.5 nT/mm. Mean: 30017 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Alice Springs 2010 East component (Y). Scale: 7.5 nT/mm. Mean: 2601 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Alice Springs 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −43875 nT



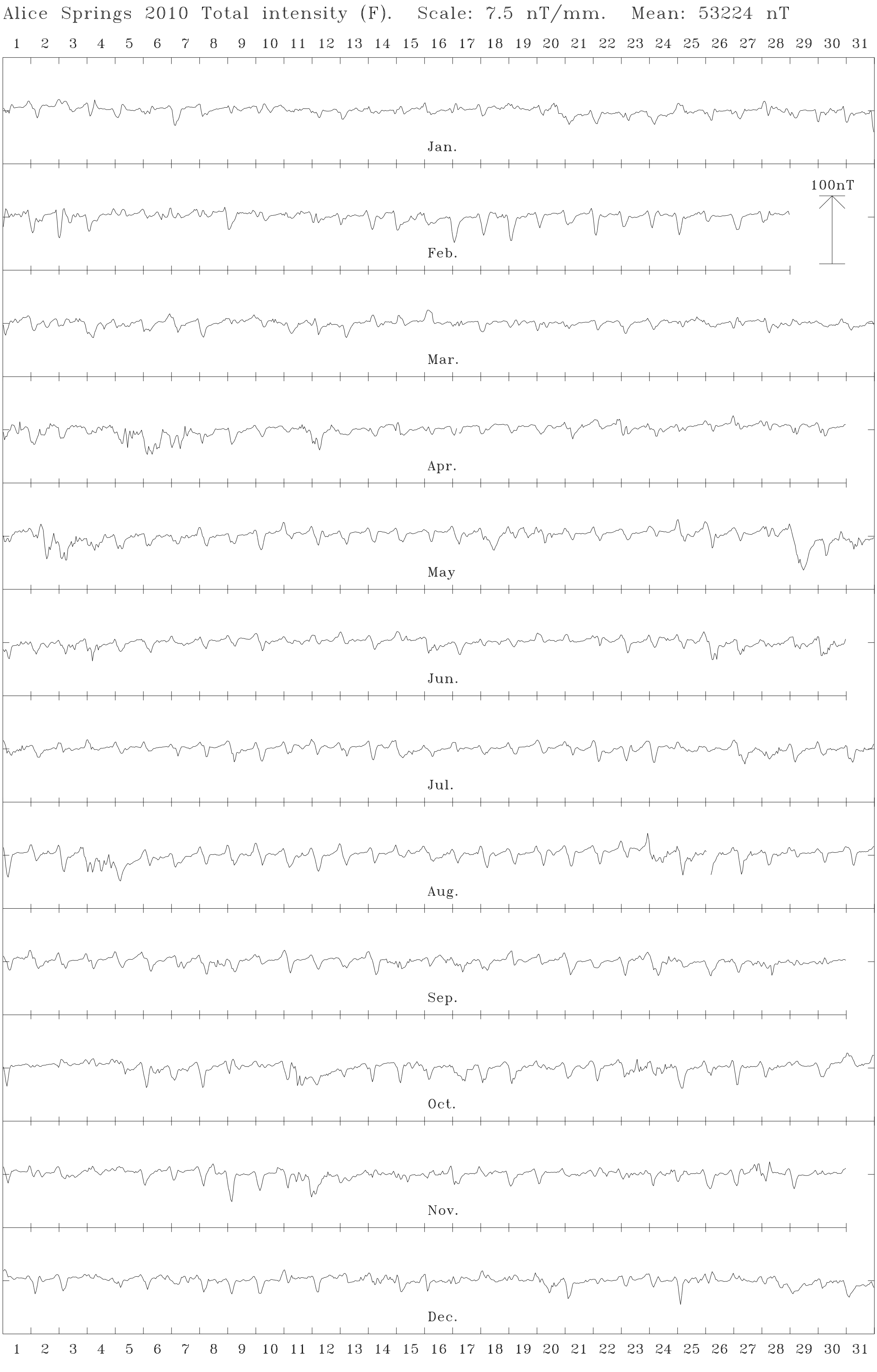


Figure 4.3. Alice Springs 2010 hourly mean values in X, Y, Z and F.

5. Gnangara

The Gnangara magnetic observatory is located within the Gnangara pine plantation approximately 27 km northeast of Perth in Western Australia. This places it only a few kilometres from the limits of urban development. It succeeds the observatory at Watheroo (1919–1959) which was located 180 km north of Perth. Magnetic recording began at Gnangara in 1957.

The observatory is built on the northeastern part of an approximately 260×140 m (3.6 hectare) site. It comprises:

- a 10×5 m Variometer/Recorder 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 northwest of the Variometer Vault that houses the total-field variometer sensor, and;
- 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.

As the Gnangara site is now within a few kilometres of urban development, plans are in place to relocate the observatory to a site near Gingin, about 50 km north of Gnangara. The new site is adjacent to the University of Western Australia's Australian International Gravitational Observatory (AIGO).

Variometers

The variometers used during 2010 are described in Table 5.2.

The fluxgate sensor was located at the eastern end of the vault, while the electronic equipment and acquisition PC were at the western end. The fluxgate variometer sensor and electronics temperatures were monitored.

The acquisition PC was accessible via an ADSL modem for remote control and data retrieval. The telephone and equipment were protected from lightning and powered through a UPS and power/telephone line filters. The acquisition PC clock was synchronised using a GPS clock.

As the variometers were below the ground the diurnal temperature changes were small but there was a significant annual temperature variation. Both the fluxgate sensor and electronics temperatures varied from about 15°C in August to about 30°C in February. The temperature extremes recorded at Perth Airport during 2010 were -1°C on 2010-07-03 and 43.2°C on 2010-01-18. The standard temperature of the variometer system was set to 20°C. Temperature fluctuations in the PPM sensor vault were not recorded but would have exceeded those in the vault housing the fluxgate variometer.

Absolute instruments

The principal absolute magnetometers used at Gnangara and their adopted corrections for 2010 are described in Table 5.3.

DIM DI0037/390444 required repairs in October 2010 after the vertical tangent screw was damaged in transit between the Canberra and Gnangara observatories. The DIM fluxgate sensor was also re-collimated. An instrument comparison was made between the Gnangara DIM (DI0037/390444) and the Canberra DIM (DI0086/353756) at Canberra Observatory on 2010-10-19 after the repairs and re-collimation. The instrument corrections and scale value for DI0037 were found to be consistent with previous results.

IAGA code:	GNA		
Commenced operation:	June 1957		
Geographic latitude:	31°	46'	48" S
Geographic longitude:	115°	56'	48" E
Geomagnetic latitude:	-41.38°		
Geomagnetic longitude:	189.32°		
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		
Observer:	S. Pryde		

Table 5.1. Key observatory data.

3-component variometer:	EDA FM105B
Serial number:	2877/2887
Type:	linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.2 nT
A/D converter:	ADAM 4017 module (±5V)
Total-field variometer:	Geometrics 856
Serial number:	50706
Type:	Proton precession
Acquisition interval:	10 s
Resolution:	0.1 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	ADSL

Table 5.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

DI fluxgate:	DMI
Serial number:	DI0037
Theodolite:	Zeiss 020B
Serial number:	390444
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.15’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091317/91457
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 5.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

At the 2010 mean magnetic field values at Gnangara (X= 23434 nT, Y= -758 nT, Z= -53265 nT) the D, I and F corrections translate to corrections of:

ΔX = -2.3 nT ΔY = -0.3 nT ΔZ = -1.0 nT

These corrections have been applied to all Gnangara 2010 final data.

Baselines

As in previous years, there was a significant seasonal variation in the X and Z baselines. However, because it appeared to lag the seasonal temperature variation there did not seem to be a direct correlation with temperature. Consequently no temperature coefficients were applied to the vector variometer data. Throughout the year baselines varied by about 15 nT in X and Z and less than 5 nT in Y.

The standard deviations in the difference between the 2010 absolute observations from the final adopted variometer model and data were:

	σ		σ
X	0.7 nT	D	8"
Y	0.9 nT	I	3"
Z	0.4 nT	F	0.1 nT

The daily average of the difference between F derived from the vector variometer and F measured by the scalar variometer varied between ±1.0 nT over the year

Observed and adopted baseline values in X, Y and Z are shown in Figure 5.1.

Operations

Stephen Pryde was the local observer at Gnangara throughout 2010 with technical assistance from O. McConnel, a Perth-based Geoscience Australia staff member.

Variometer data were recorded on an acquisition PC running the QNX operating system and Geophysical Data Acquisition Platform (GDAP) software. The vector variometer data sampled once per second, the scalar data was sampled once every 10 seconds. System timing was controlled by a GPS clock. Timing corrections greater than 1 ms are listed in *Significant events* below.

Data communications were over a TCP/IP network using an ADSL link. Data were transmitted to Geoscience Australia every 3-10 minutes where they were processed, stored in a database and distributed to data repositories.

Throughout 2010, K indices for Gnangara were derived using a computer-assisted method based on the IAGA-accepted LRNS algorithm. K indices were scaled and distributed weekly.

For most of the year absolute observations were performed weekly. The stainless steel security door on the Absolute Hut was left open in the same position during observations. There was a 67-day gap in observations between 2010-02-21 and 2010-04-30, when the local observer was unavailable, and another 28-day gap between 2010-09-24 and 2010-10-22, when the absolute instruments were returned to Canberra for repair and calibration.

The distribution of Gnangara 2010 data is described in Table 5.4. Data losses are identified in Table A.5.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011
University of Oulu, Finland	preliminary	hourly
K indices		
IPS Radio and Space Services		weekly
ISGI, France		weekly
Principal magnetic storms and rapid variations		
WDC for Solar-Terrestrial Physics		monthly
WDC for Geomagnetism		monthly
Observatori de l'Ebre, Spain		monthly

Table 5.4. Distribution of Gnangara 2010 data.

Significant events

2010-02-11	AML assumes management of observatory
2010-02-21	Stephen Pryde training stand-in observer Mark Lewis as Stephen will soon be away for an extended period Vault temperature disturbed 02:40-04:00, probably due to vault entry/lights on
2010-02-22	04:52 update preliminary XYZ variometer drift rate parameters
2010-04-16	15:30 sun-geomag Unix server fails due to power problem
2010-04-19	01:45 sun-geomag back on-line
2010-05-26	06:03 Update preliminary baseline drifts from day 052
2010-05-19	Western Power advised that power will be off on 27 June (Craig Bugden)
2010-06-02	AML/LJW visit GNA
2010-06-25	Temperature disturbed 06:30 - 07:00
2010-06-26	Mains power failure, data stops at about 12:00
2010-06-28	SP visits and resets UPS and 856 Data restarts 02:13. There have been some hours of data loss Ask Owen to remove UPS and replace battery box battery. Variometer PPM stops at approx 18:15 - probably full memory after restart.
2010-06-29	00:31 Update X and Y drifts from day 127. Vault temperature stabilised by 07:00
2010-06-28	02:15:23 GPS Clock Correction 0 s 480067544 ns
2010-06-30	Request Stephen Pryde to AUTO ERASE ENTER on variometer PPM 02:37 PPM restarted by Owen McConnel. Temperature disturbance 02:50 - 04:00 Owen will attempt to replace battery box battery and remove UPS next week.
2010-07-10	Lost contact with GPS clock 23:35
2010-07-12	Re-connected with GPS clock 00:15
2010-07-16	Burnt-out motor bike found in observatory car-park
2010-07-21	23:50 PPP (analogue modem) connection checked OK

2010-07-23	01:00 power off at observatory - may be off until 04:00 SP doing observations during the power outage - cannot read theodolite scale without lights
2010-07-06	Tree felling near observatory (on dirt access road after locked boom-gate)
2010-07-28	19:13:17 GPS Clock Correction C 0 s -1262584 ns
2010-08-04	21:55 Z range change from 0 to -1
2010-08-09	00:30 - 02:00 vault temperature disturbance
2010-08-18	Re-install cable-tie on DIM theodolite to provide strain-relief on cable into senor
2010-08-19	AML and SP clean up rubbish from GNA car park Prune trees on line of site between pier B and azimuth marks.
2010-08-20	Horizontal mis-alignment on DIM sensor changed by -10 minutes after using DIM at Gingin
2010-08-30	Missing data from database F 13,15th 23:59:26-23:59:59 Missing data from database XYZ and F 22 16:16:30-16:22:29 and 29 16:22:30-16:28:29.data 22, 29 August inserted into database.
2010-08-31	00:50 check analogue modem, connection OK
2010-09-03	Freight 6-port variometer battery-box to Owen for installation at GNA
2010-09-13	00:53 Check analogue modem OK
2010-09-21	03:00 - 04:16 data contaminated. Owen visited the observatory and made the following changes Connected ADSL modem to a 12V battery; Disconnected the faulty LINX 800 UPS; Tried to replace batteries in the variometer battery box and found the EDA plug will not fit into the new battery box. He is going to make a 15V DC-DC converter for the EDA and then come back next time.
2010-09-28	Theodolite arrives in Canberra for sensor re-alignment
2010-10-01	Vertical tangent screw on theodolite damaged in transit from CNB to GNA, theodolite sent back to Canberra
2010-10-22	First obs with repaired theo 390444 after vertical tangent screw repaired by Zelman
2010-11-01	02;12 update preliminary baseline values
2010-11-09	22:30:01 lost contact with GPS
2010-11-11	23:54:39 restarted GdapClock 11/11/10 23:54:39 - CLK I 0 Started 11/11/10 23:58:41 - CLK I 0 Correction 1289519921 271861990 C 0 s 7642744 R 0 s -953 11/11/10 23:59:23 - CLK I 0 Power Down 4298398 1 0 17224 11/11/10 23:59:23 - CLK I 0 Correction 1289519963 279231186 C 0 s 17224 R 0 s -1047
2010-12-03	Bees building nest on outside wall of Absolute Hut
2010-12-24	23:30 bees scheduled for removal from around Absolute Hut

Annual mean values

The annual mean values for Gnangara are set out in Table 5.5 and displayed with the secular variation in Figure 5.2.

Hourly mean values

Plots of the hourly mean values for Gnangara 2010 data are shown in Figure 5.3.

K indices

K indices for Gnangara have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. K indices were scaled from preliminary time-series data. During the period of data loss between 2010-06-27T12:00 and 2010-06-28T02:14 indices were scaled using data from the Gingin (GNG) variometer. GNG is located 52 km to the NNW of Gnangara.

K indices from Gnangara contribute to the global am index and its derivatives. K indices measured in 2010 are listed in Table 5.6. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 5.7. Principal magnetic storms observed at Gnangara are listed in Table 5.8, storm sudden commencements in Table 5.9 and solar flare effects Table 5.10.

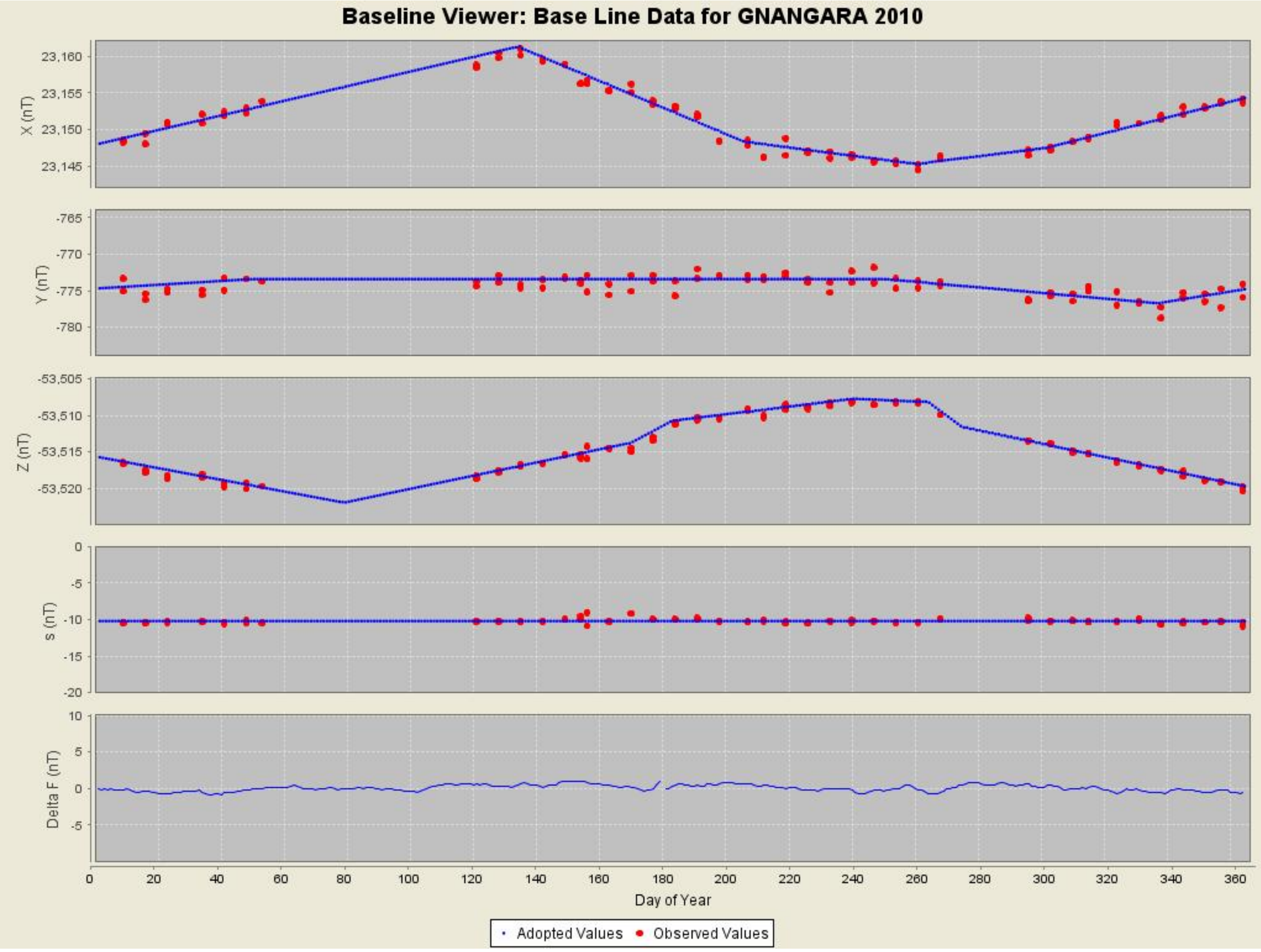
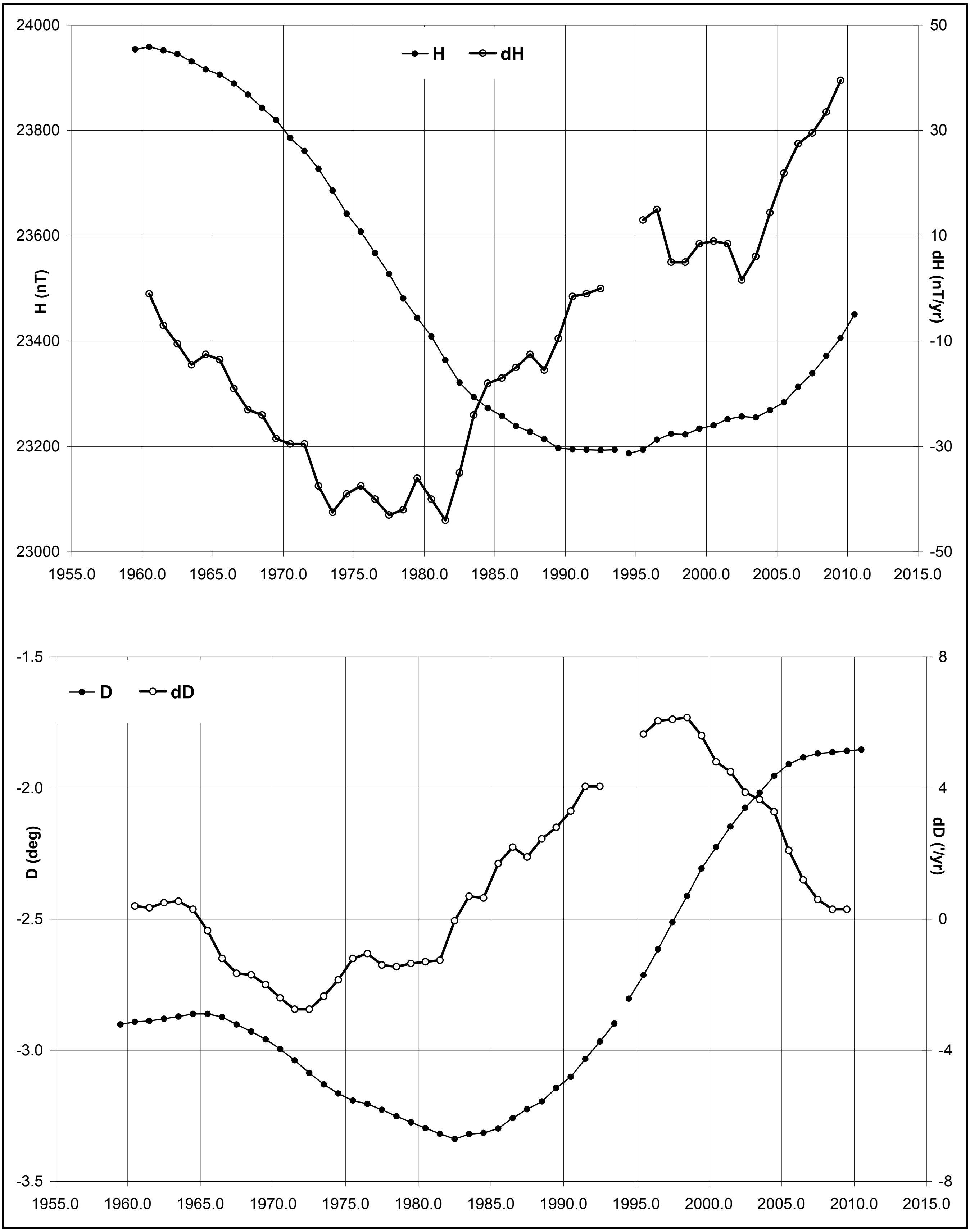


Figure 5.1. Gnangara 2010 baseline plots.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)	
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	ABZ
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	ABZ
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	ABZ
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	ABZ
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	ABZ
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	ABZ
2000.5	A	-2	13.6	-66	36.0	23230	23212	-903	-53682	58493	ABZ
2001.5	A	-2	09.0	-66	34.7	23241	23225	-872	-53651	58468	ABZ
2002.5	A	-2	04.7	-66	33.8	23245	23230	-843	-53622	58444	ABZ
2003.5	A	-2	01.1	-66	33.4	23243	23229	-819	-53601	58424	ABZ
2004.5	A	-1	57.3	-66	31.6	23260	23247	-794	-53562	58395	ABZ
2005.5	A	-1	54.6	-66	29.7	23274	23262	-776	-53516	58358	ABZ
2006.5	A	-1	53.0	-66	26.7	23306	23293	-766	-53457	58317	ABZ
2007.5	A	-1	52.1	-66	23.8	23335	23323	-761	-53405	58280	ABZ
2008.5	A	-1	51.8	-66	20.9	23368	23355	-760	-53357	58249	ABZ
2009.5	A	-1	51.5	-66	17.5	23410	23398	-759	-53307	58220	ABZ
2010.5	A	-1	51.2	-66	14.5	23446	23434	-758	-53265	58197	ABZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1345	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.6	-66	36.5	23259	23221	-1336	-53769	58585	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ

1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	08.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	06.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	02.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23164	-1173	-53757	58547	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	ABZ
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	ABZ
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	ABZ
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	ABZ
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	ABZ
1999.5	Q	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	ABZ
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	ABZ
2001.5	Q	-2	08.8	-66	34.1	23252	23235	-871	-53648	58470	ABZ
2002.5	Q	-2	04.5	-66	33.1	23257	23242	-842	-53619	58446	ABZ
2003.5	Q	-2	01.1	-66	32.7	23255	23241	-819	-53599	58426	ABZ
2004.5	Q	-1	57.2	-66	31.0	23269	23256	-793	-53559	58396	ABZ
2005.5	Q	-1	54.5	-66	29.1	23284	23271	-775	-53513	58360	ABZ
2006.5	Q	-1	53.0	-66	26.2	23313	23300	-766	-53455	58318	ABZ
2007.5	Q	-1	52.1	-66	23.6	23339	23327	-761	-53404	58281	ABZ
2008.5	Q	-1	51.8	-66	20.7	23372	23360	-760	-53356	58250	ABZ
2009.5	Q	-1	51.5	-66	17.8	23406	23393	-759	-53312	58224	ABZ
2010.5	Q	-1	51.2	-66	14.3	23451	23438	-758	-53264	58198	ABZ
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	ABZ
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	ABZ
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	ABZ
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	ABZ
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	ABZ
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	ABZ
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	ABZ
2001.5	D	-2	09.6	-66	36.0	23219	23203	-875	-53656	58465	ABZ
2002.5	D	-2	04.9	-66	34.9	23227	23211	-844	-53627	58441	ABZ
2003.5	D	-2	01.3	-66	34.5	23224	23210	-819	-53605	58420	ABZ
2004.5	D	-1	57.6	-66	32.7	23242	23228	-795	-53566	58391	ABZ
2005.5	D	-1	54.7	-66	30.7	23259	23246	-776	-53520	58355	ABZ
2006.5	D	-1	53.0	-66	27.4	23294	23281	-765	-53459	58314	ABZ
2007.5	D	-1	52.1	-66	24.2	23329	23317	-761	-53405	58278	ABZ
2008.5	D	-1	51.9	-66	21.3	23362	23349	-760	-53358	58248	ABZ
2009.5	D	-1	51.6	-66	18.3	23398	23386	-759	-53314	58222	ABZ
2010.5	D	-1	51.3	-66	15.1	23437	23424	-759	-53267	58194	ABZ

Table 5.5. Gnangara annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 5.2. In the table, J identifies a jump due to a change of observation site (jump value = old site value - new site value).



H
dH
H (nT)
dH (nT/yr)
24000
23800
23600
23400
23200
23000
50
30
10
-10
-30
-50
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
2015.0
D
dD
D (deg)
dD ('/yr)
-1.5
-2.0
-2.5
-3.0
-3.5
8
4
0
-4
-8

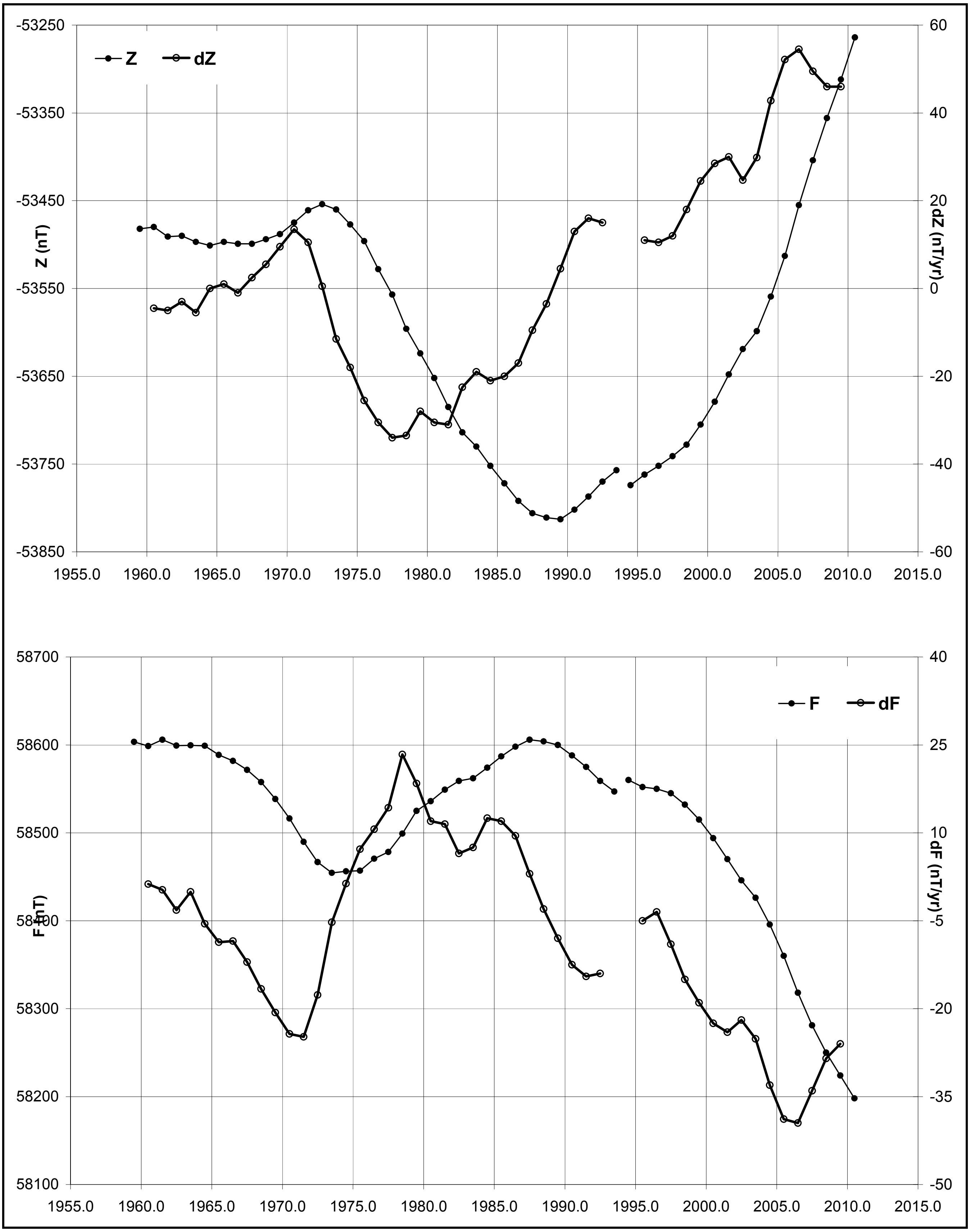


Figure 5.2. Gnangara annual mean values and secular variation (quiet days) for H, D, Z and F.

Day	January			February			March			April			May			June		
01	0000	0113	5	1022	3324	17	2211	2212	13	3111	4233	18	1001	2210	7	4222	2342	21
02	1111	1012	8	3112	2324	18	1102	3212	12	1133	3333	20	1224	5655	30	1111	1322	12
03	1112	2201	10	3223	3332	21	2112	3323	17	2110	3432	16	3324	4443	27	1114	4222	17
04	1011	1001	5	2000	0112	6	2211	3212	14	2121	3343	19	2224	3223	20	4324	2121	19
05	1110	1101	6	2100	2301	9	1012	2221	11	2247	5544	33	2201	2332	15	1110	0122	8
06	1000	0000	1	0002	3421	12	1000	0112	5	3335	5654	34	0223	3332	18	1102	1122	10
07	1000	0021	4	3210	0022	10	2220	0111	9	4245	4432	28	2212	3321	16	2101	1111	8
08	1000	0001	2	2121	0003	9	1100	1121	7	3223	3123	19	1112	2212	12	2000	0110	4
09	1000	0102	4	1011	1100	5	1001	2211	8	2002	2221	11	1000	1020	4	0010	0110	3
10	2011	1211	9	1101	1121	8	2111	3433	18	1000	0010	2	0012	1121	8	2212	1100	9
11	2223	3222	18	2211	3202	13	2123	2131	15	1010	4552	18	2211	1121	11	0101	2211	8
12	1110	0121	7	2120	1211	10	2221	3321	16	4322	3321	20	1111	3101	9	0000	0000	0
13	2122	2322	16	0100	0221	6	1001	0231	8	1010	1102	6	0000	0010	1	0122	1111	9
14	2001	2111	8	0000	3012	6	1111	3113	12	1001	0125	10	0100	0110	3	0012	0011	5
15	1110	1133	11	3212	3353	22	1000	0230	6	3210	1110	9	1001	1000	3	1122	1222	13
16	2101	1001	6	3111	0122	11	1120	1112	9	2010	0110	5	1110	0220	7	2333	4432	24
17	1000	0001	2	2111	0013	9	2221	0112	11	1110	0021	6	1102	2331	13	2232	0121	13
18	1211	1212	11	0002	3322	12	2100	1011	6	1000	0001	2	0113	2121	11	1111	1210	8
19	2000	0101	4	2000	1122	8	1000	0122	6	1112	2121	11	1112	3322	15	0000	0110	2
20	2101	3443	18	1000	0102	4	2121	3221	14	0011	2221	9	3122	2211	14	0000	0100	1
21	3221	1001	10	1000	0011	3	1000	0000	1	1111	3111	10	2110	1110	7	1020	0010	4
22	0010	1011	4	1102	1211	9	0000	0000	0	2111	0232	12	0111	0000	3	2111	1100	7
23	1002	2111	8	1100	0010	3	1000	0010	2	3221	1012	12	0000	0000	0	0001	0020	3
24	1112	2212	12	1100	1111	6	0000	2310	6	2101	2121	10	0000	0000	0	0000	2321	8
25	1100	1001	4	1010	0112	6	2001	2222	11	0100	0000	1	0111	2213	11	1212	2122	13
26	1000	0011	3	1000	1000	2	2110	2003	9	0000	0000	0	0221	1211	10	1334	2322	20
27	1001	0101	4	0000	0110	2	2110	0001	5	2111	0111	8	1000	0000	1	2332	3222	19
28	1001	1121	7	0120	2111	8	1212	2212	13	1000	1000	2	2222	4114	18	2222	2322	17
29	2101	1001	6				1000	1212	7	2301	0121	10	2244	4433	26	2222	2224	18
30	3211	1213	14				2100	2133	12	1000	2211	7	2242	2354	24	4333	4223	24
31	3111	2221	13				2112	0212	11				2233	4322	21			

Day	July			August			September			October			November			December		
01	1223	2332	18	1111	1111	8	0000	0123	6	1100	0102	5	1121	2102	10	1000	0121	5
02	2122	2222	15	1121	2211	11	2112	2310	12	1000	0001	2	1001	1101	5	1000	0012	4
03	1203	2222	14	2212	2346	22	1000	1000	2	1000	0100	2	1110	2121	9	1001	0001	3
04	1102	1211	9	5435	5555	37	0000	0011	2	0010	2112	7	1001	1102	6	0011	1011	5
05	0011	2110	6	4302	3221	17	0000	0002	2	2222	1211	13	1000	1211	6	0000	0012	3
06	0100	0010	2	1221	3221	14	2221	2122	14	1001	3111	8	0001	1101	4	0111	1211	8
07	1000	1110	4	1111	0100	5	1112	2323	15	1012	2102	9	1000	0021	4	1122	2212	13
08	0000	1010	2	1111	1011	7	2212	4432	20	2101	1102	8	1122	3211	13	2221	2331	16
09	0111	1101	6	1211	2232	14	1001	2302	9	2111	1210	9	1100	1010	4	2000	1000	3
10	0000	0000	0	1221	1113	12	1000	0000	1	1000	2212	8	0010	0233	9	1101	0110	5
11	0000	2211	6	2222	2221	15	0000	0001	1	1234	5442	25	3223	3333	22	0010	1001	3
12	1000	0021	4	0001	1011	4	0000	0010	1	2213	3333	20	3223	4323	22	1000	2323	11
13	1100	0000	2	1000	0200	3	1000	1110	4	2121	1202	11	1101	3232	13	3111	2323	16
14	0102	2123	11	1010	1201	6	1021	2332	14	1100	0002	4	2112	1334	17	2222	5333	22
15	5312	3211	18	1101	1121	8	3112	0001	8	1112	2221	12	3212	2113	15	3222	3221	17
16	0012	1011	6	1122	1320	12	1110	1342	13	2011	2332	14	3111	3212	14	2122	1222	14
17	0000	0000	0	1111	1321	11	2222	2222	16	3232	3122	18	1111	1122	10	2101	1231	11
18	0000	0100	1	1110	2000	5	2011	1111	8	2011	1032	10	1122	2122	13	2110	2111	9
19	0000	0000	0	0000	1000	1	0110	1101	5	3221	1112	13	1100	1000	3	1000	0102	4
20	1111	1122	10	1000	1101	4	1000	1221	7	2101	3121	11	0122	0111	8	2223	3113	17
21	1110	0110	5	0000	0101	2	2(2)21	0002	(9)	2100	2311	10	2012	1122	11	2000	1201	6
22	1112	1111	9	1000	0000	1	2100	0000	3	1012	2123	12	2123	2232	17	0000	0100	1
23	0221	1221	11	0000	0013	4	2131	2222	15	2224	5534	27	3232	2332	20	0010	0002	3
24	1110	0221	8	4343	4323	26	2222	2423	19	3323	3342	23	1121	2222	13	3000	1201	7
25	2101	2231	12	2324	3422	22	2112	1211	11	1222	4142	18	1111	2111	9	1011	3222	12
26	1110	0112	7	3233	2211	17	0000	4332	12	2111	1232	13	1000	1121	6	2110	0012	7
27	2333	4333	24	2223	4423	22	0001	2333	12	2002	2021	9	0000	1243	10	2000	0101	4
28	3233	3331	21	3223	3221	18	2143	3222	19	1011	2111	8	3332	1231	18	1122	4532	20
29	2222	2111	13	1000	0000	1	2111	2100	8	1100	3201	8	1111	2122	11	2110	2221	11
30	2112	2322	15	0000	0000	0	1001	0101	4	0002	1201	6	1011	1211	8	1011	1321	10
31	2101	2310	10	0010	0021	4				1212	3111	12				1111	1121	9

Table 5.6. Gnangara 2010 K indices and daily K sums.

K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	846	982	711	276	75	26	3	1	0	0	0
Mean sum	10.1										

Table 5.7. Frequency distribution of Gnangara 2010 K indices and the annual mean daily K sum.

UT Start			**SSC amplitudes**			**Maximum 3hr K indices**		**Storm Ranges**			**UT End**	
Date	**Time**	**Type**	**D(')**	**H(nT)**	**Z(nT)**	**Day (3hr periods)**	**K**	**D(')**	**H(nT)**	**Z(nT)**	**Date**	**Time**
2010-04-05	08:26		1.44	23.33	5.13	5(4)	7	29.3	103.2	170.1	2010-04-06	02:00
2010-04-06	08:00	...				6(6)	6	14.2	65.2	66.1	2010-04-07	23:00
2010-04-11	13:04		1.08	15.63	7.6	11(6,7)	5	11.6	66.8	52.3	2010-04-12	08:00
2010-05-02	10:12	...				2(6)	6	17.6	107.3	133.7	2010-05-05	06:00
2010-08-03	17:40		3.12*	20.86	17.27	3(8)	6	29.1	117.3	152.8	2010-08-05	05:00
2010-10-23	08:00	...				23(5,6)	5	19.4	66.3	103.9	2010-10-24	08:00

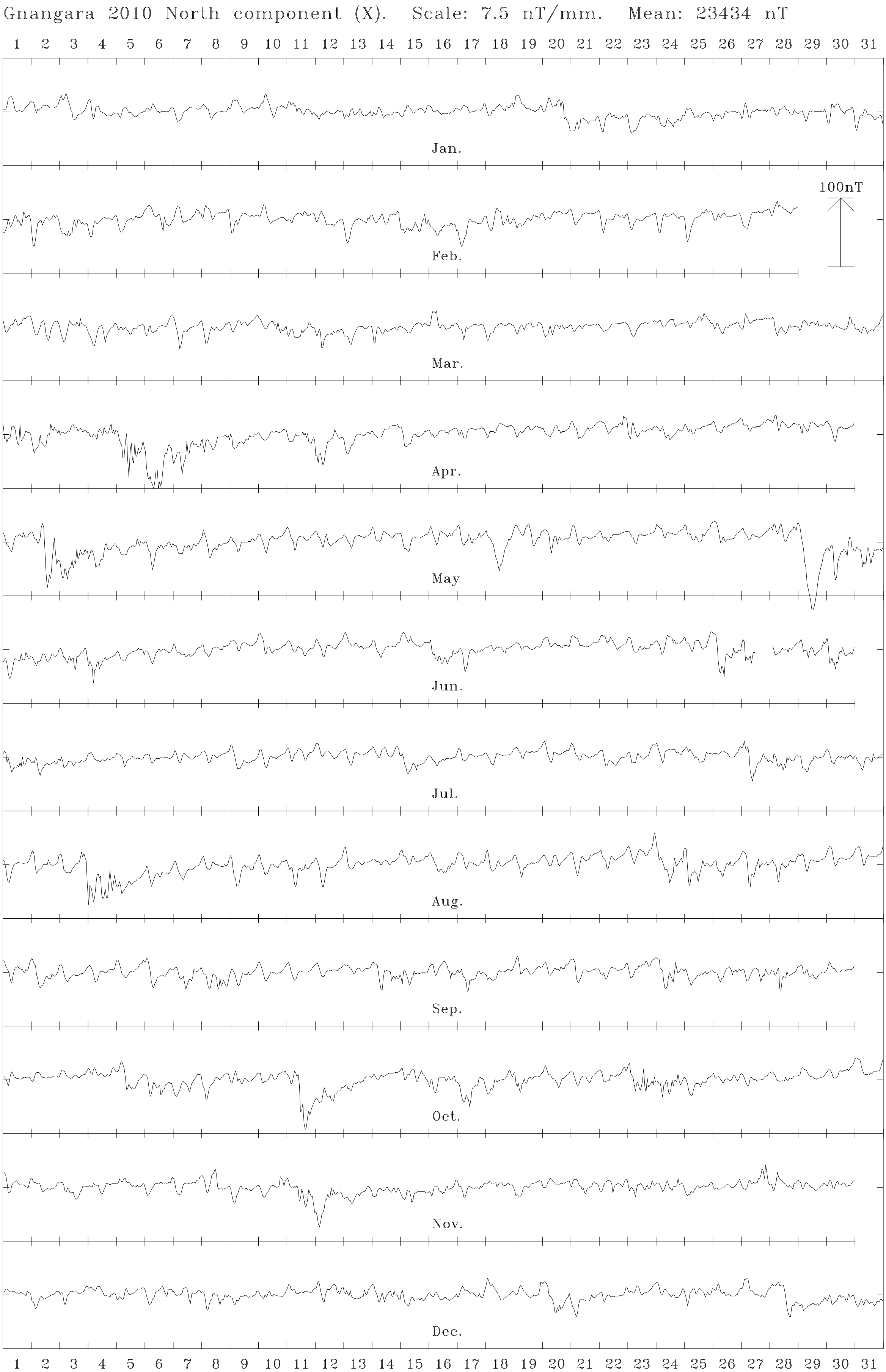
Table 5.8. Principal magnetic storms observed at Gnangara in 2010.

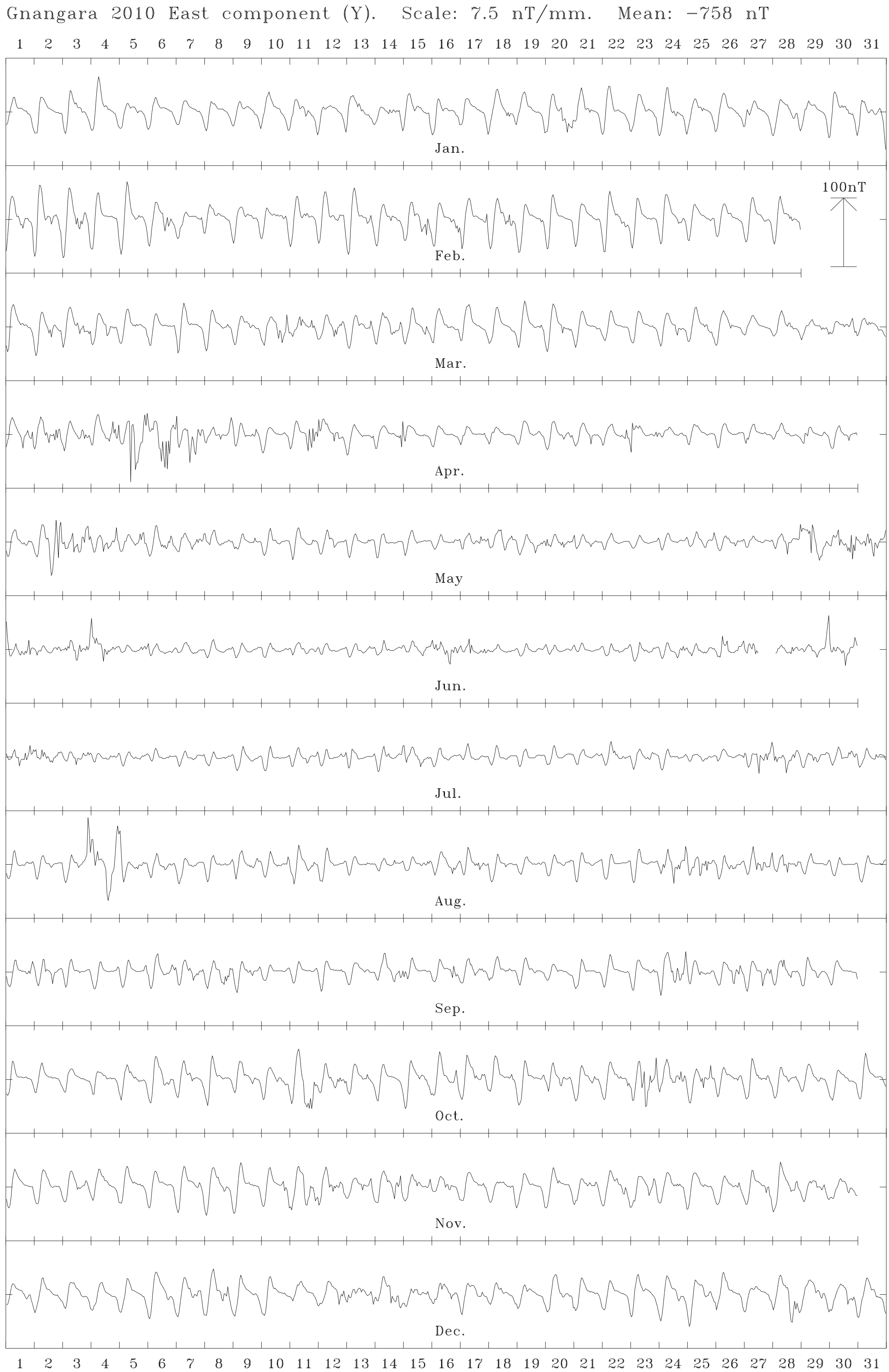
UT		**Type**	**Quality**	**Chief movement (nT)**		
Date	**Time**	**ssc/ssc***	**A,B,C**	**H(X)**	**D(Y)**	**Z**
2010-01-01	23:26	ssc*	B	2.83	24.98*	13.89*
2010-01-10	15:37	ssc	C	11.21	3.92	6.52
2010-03-24	12:45	ssc	C	3.92	3.69	3.57
2010-04-05	08:26	ssc	B	23.33	9.64	5.13
2010-04-11	13:04	ssc	A	15.63	7.16	7.6
2010-05-28	03:00	ssc*	A	3.56	15.34*	12.64
2010-08-03	17:40	ssc*	A	20.86	21.35*	17.27
2010-08-04	10:19	ssc*	A	69.32	37.25*	20.14
2010-10-30	10:13	ssc	A	9.37	3.69	5.11
2010-11-08	07:52	ssc	A	11.39	9.74	8.28
2010-11-10	17:44	ssc	A	11.87	10.32	10.21
2010-12-19	21:33	ssc	C	8.13	5.48	5.89

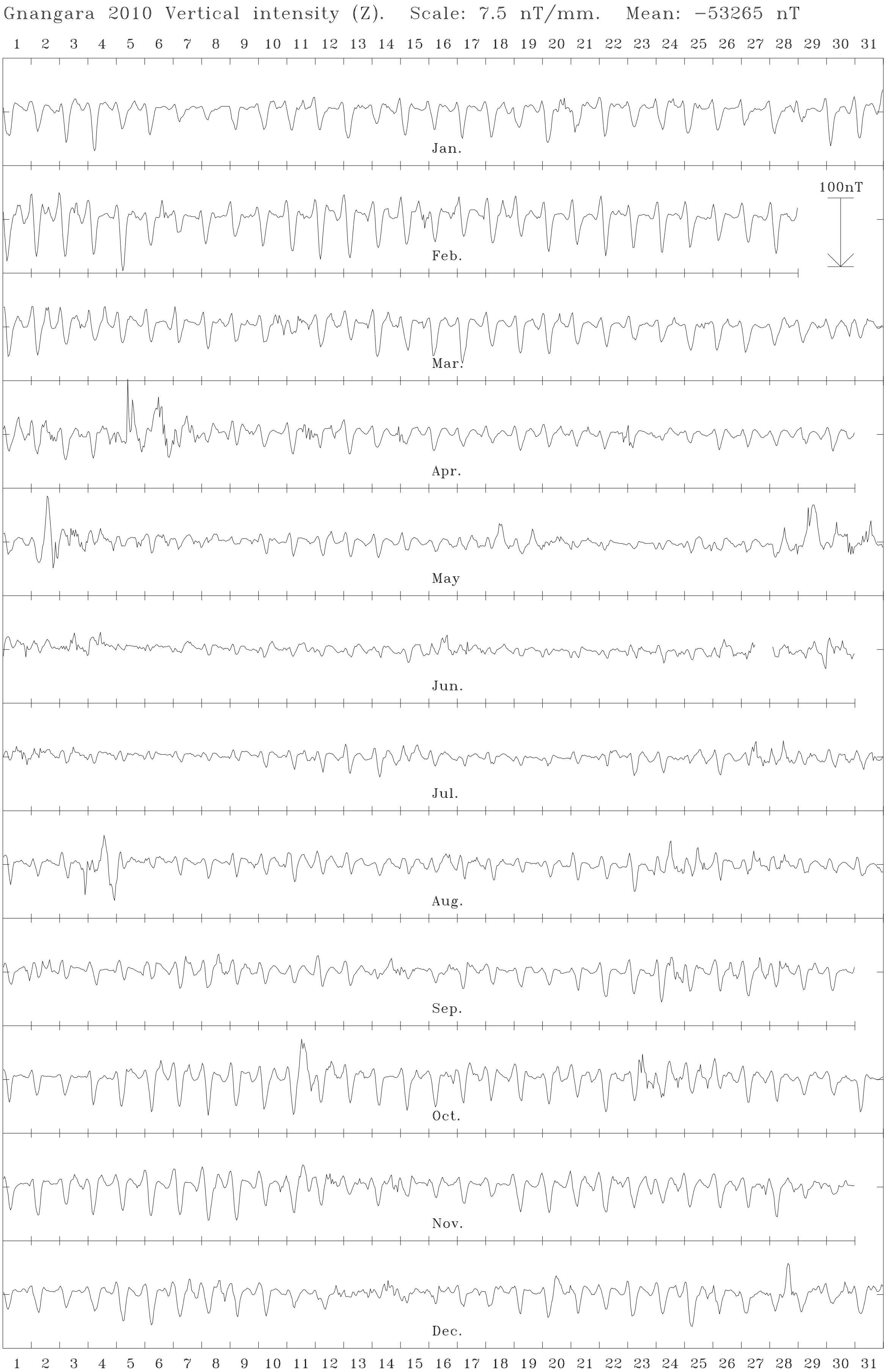
Table 5.9. Storm sudden commencements observed at Gnangara in 2010.

UT	**Movement**			**Amplitude (nT)**			**Confirmation**
Date	**Start**	**Max**	**End**	**H(X)**	**D(Y)**	**Z**	
2010-02-07	02:29	02:37	02:54	4.79	2.88	12.85	solar
2010-06-12	00:55	01:01	01:10	2.39	0.6	2.84	solar
2010-06-24	05:26	05:34	05:38	0.64	0.48	1.73	solar

Table 5.10. Solar flare effects observed at Gnangara in 2010.


Gnangara 2010 North component (X). Scale: 7.5 nT/mm. Mean: 23434 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Gnangara 2010 East component (Y). Scale: 7.5 nT/mm. Mean: −758 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Gnangara 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53265 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

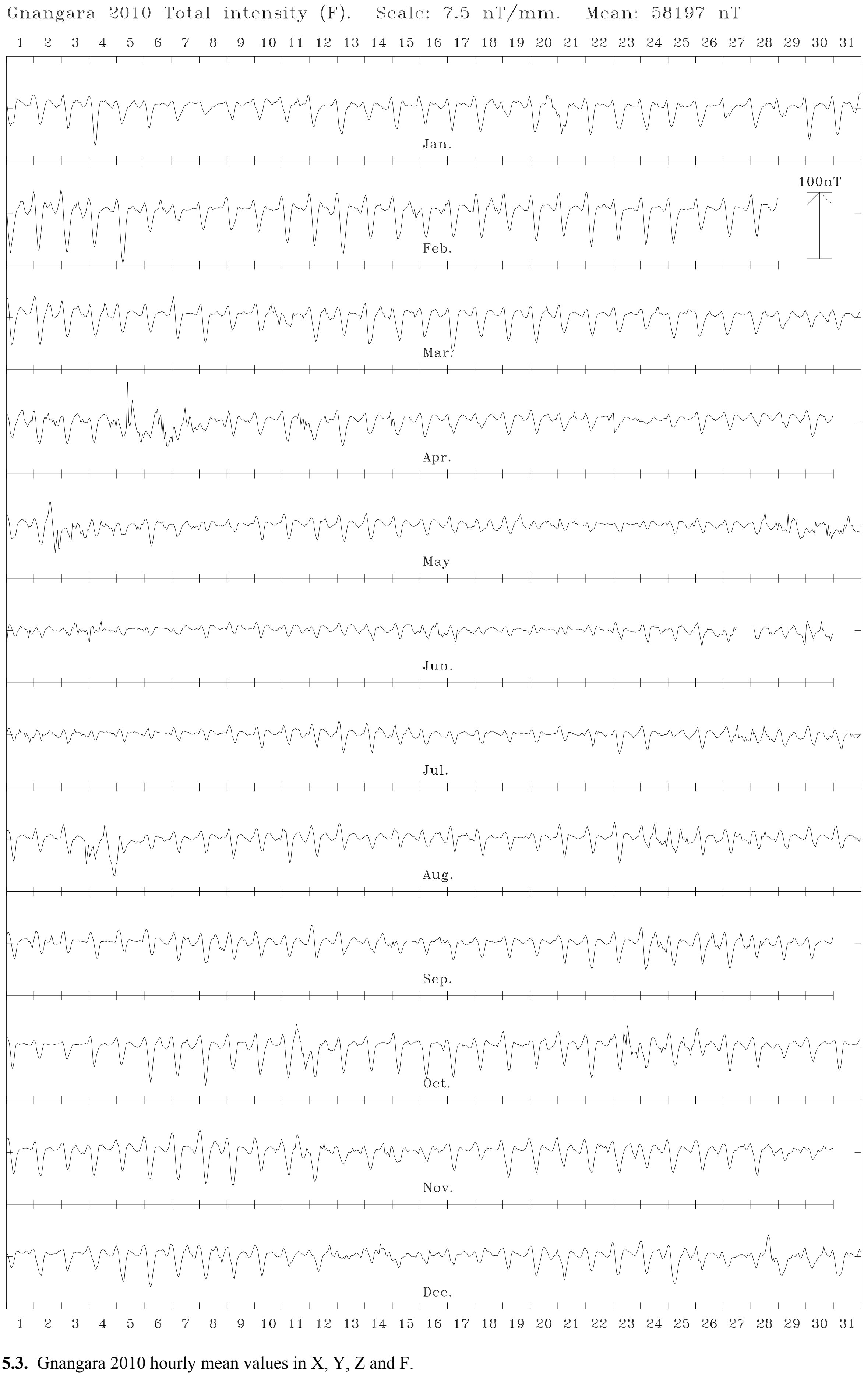


Figure 5.3. Gnangara 2010 hourly mean values in X, Y, Z and F.

6. Canberra

The Canberra magnetic observatory 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 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;
- the Geoscience Australia Magnetometer Calibration Facility 120 m SE of the Recorder House;
- a Test House 220 m north of the Recorder House (which now houses Australian Tsunami Warning System (ATWS) equipment);
- an ATWS vault, and;
- a seismic vault.

Variometers

The variometers used during 2010 are described in Table 6.2.

Two 3-component variometer systems operated at the Canberra observatory in 2010.

A Narod ring-core fluxgate operated on a pier in the eastern room of the Variometer House. The room was temperature-stabilised with a globe heater. An Overhauser-effect GSM-90 scalar variometer was housed in the western room of the same building. An acquisition computer in the western room recorded both vector and scalar data; timing was controlled by a Trimble Acutime GPS clock.

A LEMI fluxgate variometer operated on a pier in the Secondary Variometer House. The room was temperature-stabilised with a globe heater. An acquisition computer was located in the same room; timing was controlled by a Garmin GPS clock. The GSM 90 scalar data (accessed across the local area network) from the Narod variometer system were also recorded with LEMI data.

During 2010, preliminary real-time 3-component variations were supplied to users and data repositories using the time series recorded by the Narod magnetometer. The 2010 definitive 3-component data set for the observatory was also derived from the Narod time series, with gaps in-filled with LEMI data when such data were available. Weekly, semi-monthly, and monthly K indices and storm reports were scaled from the Narod data.

The weather conditions (as measured at the nearby Canberra Airport weather station) in Canberra were mild. An average day at the peak of summer varied from 17°C to 32°C; an average day at the peak of winter varied from 0°C to 13°C. The average daily range was 12.9°C ±4.4°C (varying from 1.5°C to 23.6°C). The coldest minimum was -5°C and the hottest maximum was +39°C.

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 Narod sensor temperature has not functioned for some years, although it is in the same room as the temperature-monitored electronics, which appeared to vary from 24°C to 26.5°C during the year. The most erratic temperatures were in January. The LEMI variometer temperatures were less well controlled, the electronics varying by 8°C, with particularly large variations during November and December.

IAGA code:	CNB		
Commenced operation:	1978		
Geographic latitude:	35°	18'	52.6" S
Geographic longitude:	149°	21'	45.4" E
Geomagnetic latitude:	-42.22°		
Geomagnetic longitude:	227.18°		
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		
Observer in charge:	P. Crosthwaite		

Table 6.1. Key observatory data.

3-component variometer:	Narod (CNB)
Serial number:	9004-2
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.025 nT
3-component variometer:	LEMI (CN1)
Serial number:	004_A
Type:	linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Total-field variometer:	GEM Systems GSM-90
Serial number:	803810/81225
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	radio link

Table 6.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

DI fluxgate:	DMI
Serial number:	DI0086
Theodolite:	Zeiss 020B
Serial number:	353756
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.15’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	905926/21867
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 6.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

The periods of greatest temperature variations coincide with the periods of greatest baseline scatter and vector-scalar variometer scatter.

Inadequate temperature control is one of the major influences on data quality.

Data from the Narod magnetometer during 2010-11-21T09:00 to 2010-11-21T21:00 were either lost or corrupted by large temperature related effects after a power outage to the observatory. Data from the LEMI variometer were used during this period. The two data sets were matched at 09:00, but separate shifts in X, Y, and Z had to be applied to the periods 09:54:05 - 15:56:07 and 15:56:12 - 21:00:00 to remove steps associated with power failing or resuming.

Narod 1-second data required de-spiking. The de-spiking parameters required a spike to exceed 0.25nT and 7 times the average “spike-factor” of the following minute of data. Typically 40 to 80 seconds of data per day were rejected (average rejection rate was 60 seconds/day). However, up to 256 seconds/day were rejected on days when there were thunderstorms.

LEMI data required little de-spiking except on days when there were thunderstorms – the same de-spiking was applied to LEMI data as for Narod data. On 211 days, no data were rejected. On average only 6 seconds/day were rejected, mostly on the same (thunderstorm) days when there were high rejection rates on the Narod data.

De-spiking provided no visible benefit to GSM-90 data and no de-spiking was applied to it.

Variometer data timing

Time stamps applied to the primary (Narod) variometer data were obtained from the acquisition computer system clock. That clock was synchronised to a GPS clock. During 2010, adjustments to the system clock were less than 1 ms except on the following occasions:

2010-05-21	13:38:37 -0.001s
2010-07-29	20:31:30 +0.001s
2010-09-07	15:57:59 +0.001s
2010-10-02	00:47:49 +0.001s
2010-11-21	16:05:27 +1.248s Computer restart after prolonged power failure

Time stamps applied to the backup (LEMI) variometer data were applied in the same manner from an independent acquisition computer system clock. That clock was synchronised to a GPS clock. During 2010, adjustments to that system clock were less than 1 ms except on the following occasions:

2010-01-19	00:21:23 +3.993s Computer restart after prolonged power failure.
2010-11-12	00:21:52 +0.056s Clock program failed and there was no synchronisation for more than 48 hours.

Absolute instruments

The principal absolute magnetometers used at Canberra and their adopted corrections for 2010 are described in Table 6.3. The absolute instruments used at Canberra also served as the Australian observatory reference instruments.

The instrument corrections given in Table 6.3 for DIM DI0086/353756 were obtained from comparisons against the travelling reference, B0610H/160459, at Canberra observatory on 30 July 2008. International comparison via a travelling reference PPM to other nations' PPMs and frequency standards results in the correction adopted for GSM-90 905926/21867.

At the 2010 mean magnetic field values at Canberra (X=23178 nT, Y=5153 nT, Z=-53035 nT) these D, I and F corrections translate to corrections of:

ΔX = -2.2 nT ΔY = -0.8 nT ΔZ = -1.0 nT

These corrections have been applied to Canberra 2010 final data.

The absolute instrument parameters (e.g. fluxgate sensor alignment) showed no unusual pattern during 2010.

Baselines

An automated procedure that fits a piecewise linear spline curve to the baseline residuals was used to derive final baseline parameters for the variometers. The adopted baselines had a range of 8 nT, 6 nT and 3 nT in X, Y and Z during 2010.

With drift corrections applied, the standard deviations in the difference of absolute observations from the final variometer model were:

	σ		σ
X	0.6 nT	D	8"
Y	0.9 nT	I	2"
Z	0.4 nT	F	0.3 nT

These data are based on 51 pairs and one single weekly observations. A pair of weekly observations on 2010-10-01 was rejected.

With drift corrections applied, there was a 0.9 nT range/0.2nT standard deviation in daily-average of FCheck throughout the year.

Observed and adopted baseline values in X, Y and Z for 2010 are shown in Figure 6.1.

For comparison, the corresponding standard deviations for the LEMI variometer were:

	σ		σ
X	0.6 nT	D	7"
Y	0.8 nT	I	2"
Z	0.3 nT	F	0.3 nT

Variometer comparison

The Narod and LEMI variometer records provided 363 days of data for comparison. Both Narod and LEMI data sets were aligned using the same methodology using the one set of absolute observations, and used to create INTERMAGNET Archive Format binary files which were compared.

The annual statistics of the 521853 available minute-differences of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.2	+0.4	+0.0
Std.dev	+0.8	+0.8	+0.4
Min	-4.2	-1.9	-2.8
Max	+2.9	+4.7	+1.7

The annual statistics of the 363 daily averages of the difference of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.2	+0.4	+0.0
Std.dev	+0.8	+0.8	+0.4
Min	-3.5	-1.6	-1.3
Max	+1.3	+4.1	+1.3

The annual statistics of the 12 monthly averages of the average daily difference of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.2	+0.4	+0.0
Std.dev	+0.6	+0.5	+0.2
Min	-1.3	-0.2	-0.4
Max	+0.9	+1.7	+0.4

The average daily difference between the variometers was most significant in X and Y in November and December. The adopted baselines for the secondary variometer were not chosen carefully enough for those months – this has no impact on the definitive data for CNB, although it does distort the comparison of variometers. If those **two months are excluded** the differences become:

The statistics of the 434015 available minute-differences of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.0	+0.2	+0.0
Std.dev	+0.7	+0.6	+0.3
Min	-2.6	-1.9	-2.8
Max	+2.9	+4.7	+1.7

(The 4.7nT maximum in Y was an isolated event on day 2010-04-27T02:46 on the secondary LEMI data and can be ignored.)

The statistics of the 302 daily averages of the difference of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.0	+0.2	+0.0
Std.dev	+0.6	+0.6	+0.3
Min	-2.0	-1.6	-0.8
Max	+1.3	+1.6	+1.3

The statistics of the 10 monthly averages of the average daily difference of the two data sets (Narod-LEMI) were:

	X	Y	Z
Average	-0.0	+0.2	+0.0
Std.dev	+0.4	+0.3	+0.2
Min	-0.5	-0.2	-0.2
Max	+0.9	+0.8	+0.4

Operations

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

Data from the Narod, LEMI and GSM-90 variometers were acquired on a computer at the observatory and were automatically retrieved to Geoscience Australia via a radio link every 3 to 6 minutes.

Habits varied between the 5 project team members who carried out the weekly calibrations. Some left the equipment (somewhat magnetic) transportation boxes at the Recorder House (65 m from the absolute pier), some in the Comparison House, and some half way between. Also absolutes timing was incorrectly set in some cases and known to be up to a minute in error. This was probably caused by a lack of communication between team members causing some to be unaware of the state of the system, in particular the removal of GPS timing from the non-acquisition computer in the Recorder House.

Until late 2010, it was common practice to enter the Narod and LEMI variometer huts in sequence to confirm that the systems were in good working order. This corrupted the data on both variometers for a few minutes each week. During 2010 data processing, the corrupted Narod data were removed and replaced by the LEMI data for those times, except on 2010-01-19 when the LEMI was not operational. The Narod data 2011-01-19T01:36:47 to 01:37:13 were replaced by constant values.

The distribution of Canberra 2010 data is described in Table 6.4. Data losses are identified in Table A.6.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011
ISGI, France	preliminary	real time
ISGI, France	preliminary	daily
GeoForschungsZentrum, Germany	preliminary	3-hourly
University of Oulu, Finland	preliminary	hourly
K indices		
IPS Radio and Space Services		weekly
University of Newcastle		weekly
British Geological Survey		weekly
CLS, CNES, France		weekly
ISGI, France		weekly
Royal Observatory of Belgium		weekly
GeoForschungsZentrum, Germany		semi-monthly
Principal magnetic storms and rapid variations		
WDC for Solar-Terrestrial Physics		monthly
WDC for Geomagnetism		monthly
Observatori de l'Ebre, Spain		monthly

Table 6.4. Distribution of Canberra 2010 data.

Significant events

2010-01-16 09:50:26 CN1 system failure. PPM stopped at 06:17:3.61 and restarted at 09:18:23.56 before all data ceased at 09:50:26

2010-01-18 No power from battery box - remove variometer battery box and return to HQ for repair

2010-01-19 00:08 Re-conditioned battery box installed onto LEMI system. Battery box had under-over voltage cut-off installed and new battery prior to installation.
CN1: 19/01/10 00:21:23 - CLK I 0 Correction 1263860483 31132715 C 3 s 993250844 R 0 s - 3153
Retrieve last three minutes of available data from day 016 (getObs CN1 016)

2010-02-14 13:04 Telemetry ceases

2010-02-15 00:01 Telemetry re-started

2010-02-23 22:36 update ISGI ftp server from ftp-isgi.cetp.ipsl.fr to ftp-isgi.latmos.ipsl.fr (194.254.40.44) for RT and daily one-minute data delivery.

2010-02-25 (Thursday) Looked for contamination at CNB following sudden BL change on Tuesday.
Error was a 1-hour time setting error on HP. There was an additional 53.7 s error today as well.
Control computer 01:05:30 HP 02:05:31
Also noticed that LJW (and most others) leave transportation box etc. in comparison hut and also use Control computer for time - today it was 53.7 s slow.
Control computer 01:09:36, 1194 was 12:10:30.
On ga-cnb-mag1 *ntpdate galah*->offset 53.762138s, then at 01:36:41 was close to talking clock 1194.

2010-04-14 Ativo visits to fix power problems in MagCal and inspecting asbestos on control hut. Located and removed some badly damaged cables (chewed by rats). Could not replace power cables as they were stuck into the wall insulation. Will need to install cable in duct beneath magcal control cable duct. Asbestos confirmed on control hut, removal is now on the agenda with Sally Peterson.

2010-04-20 Ativo in MAGCAL to replace faulty electrical wiring between E and W rooms of building.

2010-05-28 Ativo removing asbestos awning on control hut this morning.

2010-07-05 Network switch and fibre-converter in ATWS hut stopped due to inverter failure. Transferred these two devices to mains power as a temporary repair until a new inverter can be installed.
02:27 LEMI Hut: installed a 2nd ceramic element and switched both ceramics to position 1 (always on)
~02:40 replace 2 light-globes in ppm-room.of primary (NAROD) variometer hut

2010-07-09 Install Uni Bath MT lightning monitoring equipment in old seismic pit with sensors to west of pit

2010-07-21 Ativo scheduled to visit to install lazer-lite roof on control hut porch - using network keys.

2010-08-03 05:00 adjusted CNB and CN1 baselines to CNB/+-2nT CN1/+-5 nT, with agreement at 2009/10.

2010-09-03 16:35 NZ earthquake, apparent in CN1/ASP/LRM magnetic records

2010-09-14 02:24 Secondary Variometer (LEMI) Hut: Switch one ceramic element from "on" to "controlled"
Now one ceramic is "ON", one is "controlled" and 2 lights are "controlled". Internal door latch needs repair.

2010-09-29 17:18 earthquake noise on CN1 system Mag 7.2 Irian Jaya.

2010-11-06,07 High Speed Car Rally in Kowen Forest in vicinity of observatory.

2010-11-09 22:20 Lost contact with GPS clock on CN1. restarted GdapClock.
12/11/10 00:21:52 - CLK I 0 Correction 1289521312 815059156 C 0 s 55550546 R 0 s 1313
12/11/10 00:22:34 - CLK I 0 Correction 1289521354 815668241 C 0 s 29864 R 0 s 1327

2010-11-21 Probable power problems at Canberra Observatory.
Probable power off 09:54, power back on 15:56
09:54 CN1 data files stop recording PPM data, associated BLV jump in A and C channel
10:20 CNB room temperature starts dropping
13:36 CNB data stops
15:56 CN1 PPM data re-starts; preceded by BLV jump in ABC channels
CNB data restarts - problems with Z channel until 16:03

2010-11-30 Uni Bath ADU lightning equipment may have disk problems on /mtdata/data

2010-12-02 Time jump in CN1 data on PPM channel, 06:06:33 - 06:03:13

2010-12-06 Uni Bath ADU lightning monitor not responding to ping
23:25 LJW checks vault - ADU has power and all looks O.K. network switch is showing fault light. Power off then on to network switch. This gets is going again.

2010-12-21 22:40 contamination on both CNB and CN1 - ATIVO personnel are at the observatory.

Annual mean values

The annual mean values for Canberra are set out in Table 6.5 and displayed with the secular variation in Figure 6.2.

Hourly mean values

Plots of the hourly mean values for Canberra 2010 data are shown in Figure 6.3.

K indices

K indices for Canberra have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. Canberra K indices contribute to the global Kp and aa indices, the southern hemisphere Ks index, and all their derivatives. K indices measured in 2010 are listed in Table 6.6. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 6.7. Principal magnetic storms observed at Canberra are listed in Table 6.8, storm sudden commencements in Table 6.9 and solar flare effects Table 6.10.

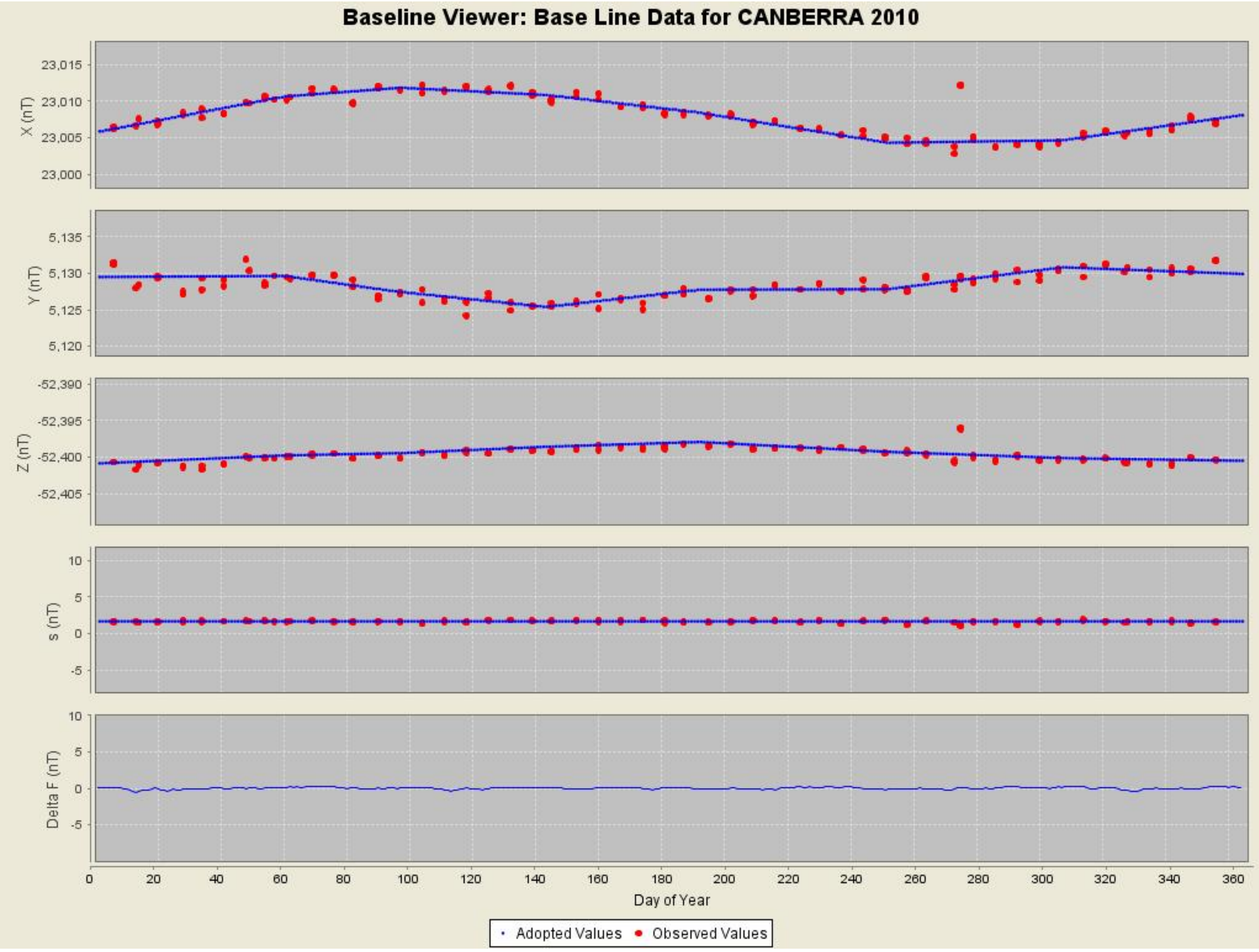
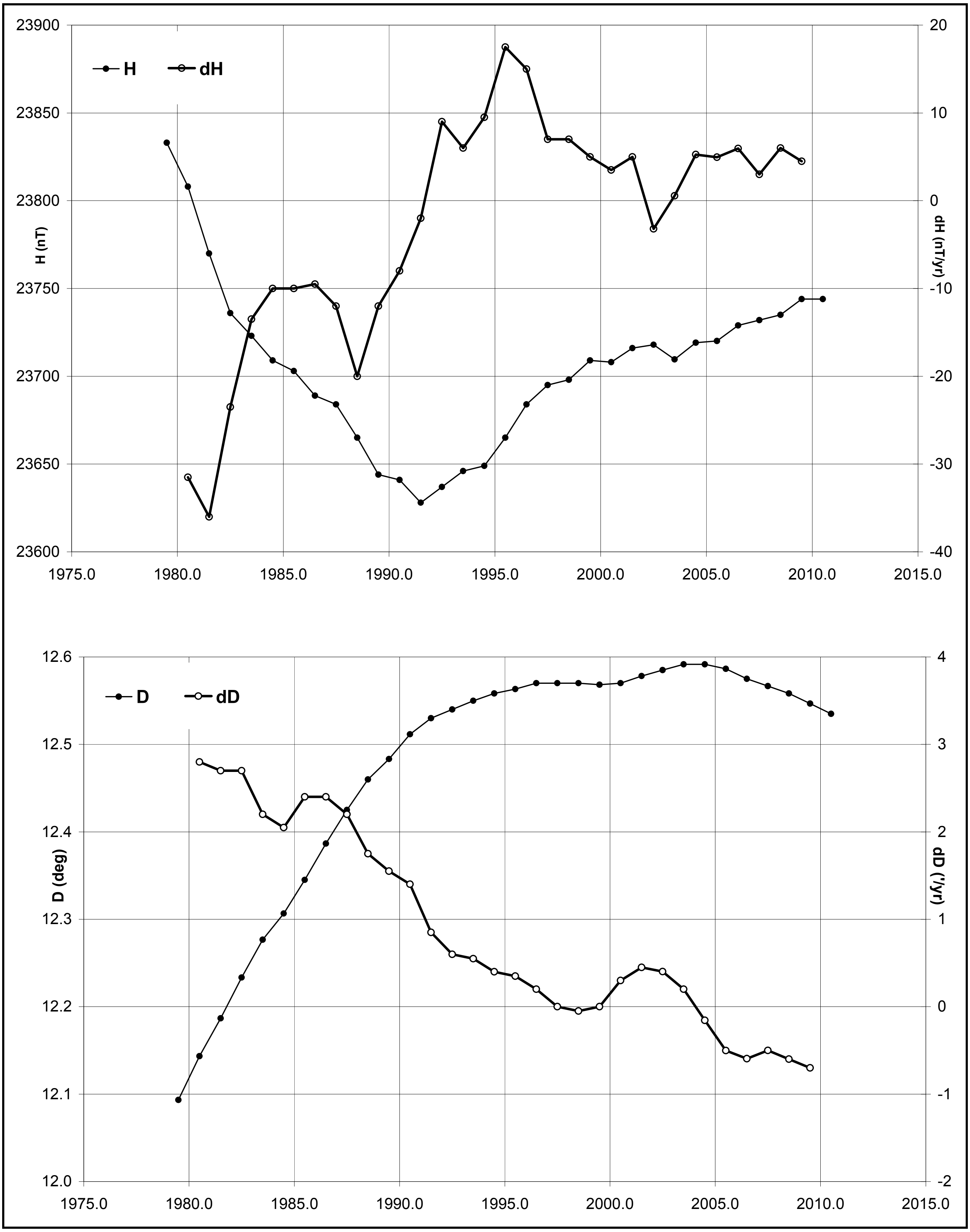


Figure 6.1. Canberra 2010 baseline plots.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)	
1979.5	A	12	05.6	-66	05.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	08.6	-66	06.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	09.1	23770	23234	5018	-53771	58791	DFI
1982.5	A	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	DFI
1983.5	A	12	16.6	-66	11.3	23723	23180	5044	-53756	58758	DFI
1984.5	A	12	18.4	-66	11.7	23709	23164	5054	-53741	58739	DFI
1985.5	A	12	20.7	-66	11.6	23703	23155	5067	-53726	58723	DFI
1986.5	A	12	23.2	-66	12.1	23689	23137	5081	-53716	58707	DFI
1987.5	A	12	25.5	-66	12.0	23684	23129	5096	-53699	58690	DFI
1988.5	A	12	27.6	-66	12.8	23665	23107	5106	-53690	58674	DFI
1989.5	A	12	29.0	-66	13.8	23644	23085	5111	-53683	58659	DFI
1990.5	A	12	30.7	-66	13.6	23641	23079	5121	-53667	58643	DFI
1991.5	A	12	31.8	-66	13.9	23628	23066	5126	-53652	58624	DFI
1992.5	A	12	32.4	-66	12.8	23637	23073	5132	-53625	58603	DFI
1993.5	A	12	33.0	-66	11.6	23646	23081	5138	-53597	58581	DFI
1994.5	A	12	33.5	-66	10.8	23649	23083	5142	-53571	58559	DFI
1995.5	A	12	33.8	-66	09.2	23665	23098	5148	-53540	58537	DFI
1996.5	A	12	34.2	-66	07.4	23684	23116	5154	-53507	58514	ABZ
1997.5	A	12	34.2	-66	06.1	23695	23127	5157	-53476	58491	ABZ
1998.5	A	12	34.2	-66	05.2	23698	23130	5157	-53444	58463	ABZ
1999.5	A	12	34.1	-66	03.7	23709	23140	5159	-53403	58429	ABZ
2000.5	A	12	34.2	-66	02.9	23708	23139	5160	-53367	58396	ABZ
2001.5	A	12	34.7	-66	01.5	23716	23146	5164	-53327	58362	ABZ
2002.5	A	12	35.1	-66	00.5	23718	23148	5168	-53291	58331	ABZ
2003.5	A	12	35.5	-66	00.3	23710	23139	5169	-53264	58303	ABZ
2004.5	A	12	35.5	-65	58.8	23719	23149	5171	-53225	58271	ABZ
2005.5	A	12	35.2	-65	57.9	23720	23150	5169	-53190	58240	ABZ
2006.5	A	12	34.5	-65	56.5	23729	23160	5166	-53151	58207	ABZ
2007.5	A	12	34.0	-65	55.5	23732	23164	5164	-53118	58179	ABZ
2008.5	A	12	33.5	-65	54.7	23735	23167	5161	-53088	58152	ABZ
2009.5	A	12	32.8	-65	53.4	23744	23177	5158	-53057	58128	ABZ
2010.5	A	12	32.1	-65	52.9	23744	23178	5153	-53035	58107	ABZ
1979.5	Q	12	05.5	-66	05.3	23844	23315	4995	-53775	58824	DFI
1980.5	Q	12	08.6	-66	06.8	23813	23280	5010	-53769	58806	DFI
1981.5	Q	12	11.4	-66	08.3	23783	23246	5022	-53767	58792	DFI
1982.5	Q	12	14.1	-66	10.1	23749	23210	5033	-53766	58778	DFI
1983.5	Q	12	16.5	-66	10.7	23734	23191	5046	-53753	58760	DFI
1984.5	Q	12	18.5	-66	11.1	23719	23174	5056	-53739	58741	DFI
1985.5	Q	12	20.7	-66	11.1	23713	23164	5070	-53724	58724	DFI
1986.5	Q	12	23.2	-66	11.6	23697	23146	5083	-53714	58709	DFI
1987.5	Q	12	25.5	-66	11.6	23690	23136	5097	-53698	58691	DFI
1988.5	Q	12	27.7	-66	12.2	23675	23118	5109	-53687	58676	DFI
1989.5	Q	12	29.1	-66	13.0	23657	23098	5114	-53680	58662	DFI
1990.5	Q	12	30.8	-66	12.8	23653	23092	5125	-53663	58645	DFI
1991.5	Q	12	31.8	-66	12.9	23645	23082	5130	-53647	58627	DFI
1992.5	Q	12	32.5	-66	12.1	23649	23085	5135	-53622	58605	DFI
1993.5	Q	12	33.0	-66	11.1	23655	23090	5140	-53594	58583	DFI
1994.5	Q	12	33.6	-66	10.2	23661	23095	5145	-53568	58561	DFI
1995.5	Q	12	33.9	-66	08.7	23675	23108	5150	-53537	58538	DFI
1996.5	Q	12	34.2	-66	07.2	23689	23121	5155	-53506	58515	ABZ
1997.5	Q	12	34.2	-66	05.6	23703	23135	5159	-53474	58492	ABZ
1998.5	Q	12	34.3	-66	04.8	23706	23137	5159	-53443	58464	ABZ
1999.5	Q	12	34.1	-66	03.2	23716	23148	5161	-53400	58430	ABZ
2000.5	Q	12	34.3	-66	02.2	23718	23149	5162	-53365	58398	ABZ
2001.5	Q	12	34.7	-66	00.9	23726	23156	5167	-53324	58364	ABZ
2002.5	Q	12	35.1	-65	59.8	23730	23159	5171	-53289	58334	ABZ
2003.5	Q	12	35.6	-65	59.5	23723	23152	5172	-53261	58306	ABZ
2004.5	Q	12	35.5	-65	58.3	23728	23157	5173	-53223	58273	ABZ
2005.5	Q	12	35.2	-65	57.4	23730	23159	5171	-53188	58242	ABZ
2006.5	Q	12	34.5	-65	56.1	23736	23166	5167	-53149	58208	ABZ
2007.5	Q	12	34.0	-65	55.3	23737	23168	5165	-53117	58180	ABZ
2008.5	Q	12	33.5	-65	54.4	23739	23171	5162	-53087	58153	ABZ
2009.5	Q	12	32.8	-65	53.3	23746	23179	5159	-53056	58128	ABZ
2010.5	Q	12	32.1	-65	52.6	23749	23183	5154	-53034	58108	ABZ
1979.5	D	12	05.6	-66	06.9	23816	23287	4990	-53782	58819	DFI

1980.5	D	12	08.4	-66	07.8	23792	23260	5004	-53770	58798	DFI
1981.5	D	12	11.1	-66	10.3	23750	23215	5013	-53776	58787	DFI
1982.5	D	12	13.7	-66	12.4	23710	23172	5022	-53773	58769	DFI
1983.5	D	12	16.6	-66	12.3	23706	23163	5040	-53760	58754	DFI
1984.5	D	12	18.4	-66	12.7	23691	23146	5049	-53745	58735	DFI
1985.5	D	12	20.5	-66	12.4	23690	23142	5064	-53729	58719	DFI
1986.5	D	12	23.3	-66	12.9	23675	23123	5079	-53717	58703	DFI
1987.5	D	12	25.5	-66	12.6	23674	23120	5094	-53701	58688	DFI
1988.5	D	12	27.5	-66	13.8	23647	23091	5102	-53693	58670	DFI
1989.5	D	12	29.0	-66	15.5	23615	23057	5105	-53690	58654	DFI
1990.5	D	12	30.5	-66	14.8	23619	23059	5116	-53671	58639	DFI
1991.5	D	12	31.6	-66	15.5	23600	23038	5119	-53658	58618	DFI
1992.5	D	12	32.3	-66	14.1	23615	23052	5127	-53630	58600	DFI
1993.5	D	12	33.0	-66	12.7	23628	23064	5134	-53601	58578	DFI
1994.5	D	12	33.4	-66	11.8	23633	23068	5138	-53574	58555	DFI
1995.5	D	12	33.8	-66	10.0	23652	23086	5145	-53542	58533	DFI
1996.5	D	12	34.2	-66	07.9	23676	23108	5152	-53508	58512	ABZ
1997.5	D	12	34.1	-66	06.9	23683	23115	5154	-53479	58488	ABZ
1998.5	D	12	34.2	-66	06.4	23678	23110	5153	-53450	58459	ABZ
1999.5	D	12	34.1	-66	04.6	23692	23124	5156	-53407	58427	ABZ
2000.5	D	12	34.2	-66	04.2	23685	23117	5155	-53372	58392	ABZ
2001.5	D	12	34.6	-66	02.7	23695	23126	5159	-53331	58358	ABZ
2002.5	D	12	35.2	-66	01.6	23700	23130	5165	-53296	58328	ABZ
2003.5	D	12	35.4	-66	01.5	23688	23118	5163	-53266	58295	ABZ
2004.5	D	12	35.3	-65	59.8	23702	23132	5166	-53229	58267	ABZ
2005.5	D	12	35.2	-65	58.9	23704	23135	5165	-53194	58236	ABZ
2006.5	D	12	34.6	-65	57.2	23717	23148	5164	-53153	58204	ABZ
2007.5	D	12	34.1	-65	55.9	23725	23157	5162	-53119	58177	ABZ
2008.5	D	12	33.6	-65	55.1	23728	23160	5160	-53089	58151	ABZ
2009.5	D	12	32.8	-65	53.7	23740	23173	5157	-53058	58127	ABZ
2010.5	D	12	32.1	-65	53.4	23736	23170	5151	-53036	58105	ABZ

Table 6.5. Canberra annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 6.2.



H
dH
H (nT)
dH (nT/yr)
23900
23850
23800
23750
23700
23650
23600
20
10
0
-10
-20
-30
-40
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
2015.0
D
dD
D (deg)
dD ('/yr)
12.6
12.5
12.4
12.3
12.2
12.1
12.0
4
3
2
1
0
-1
-2
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
2015.0

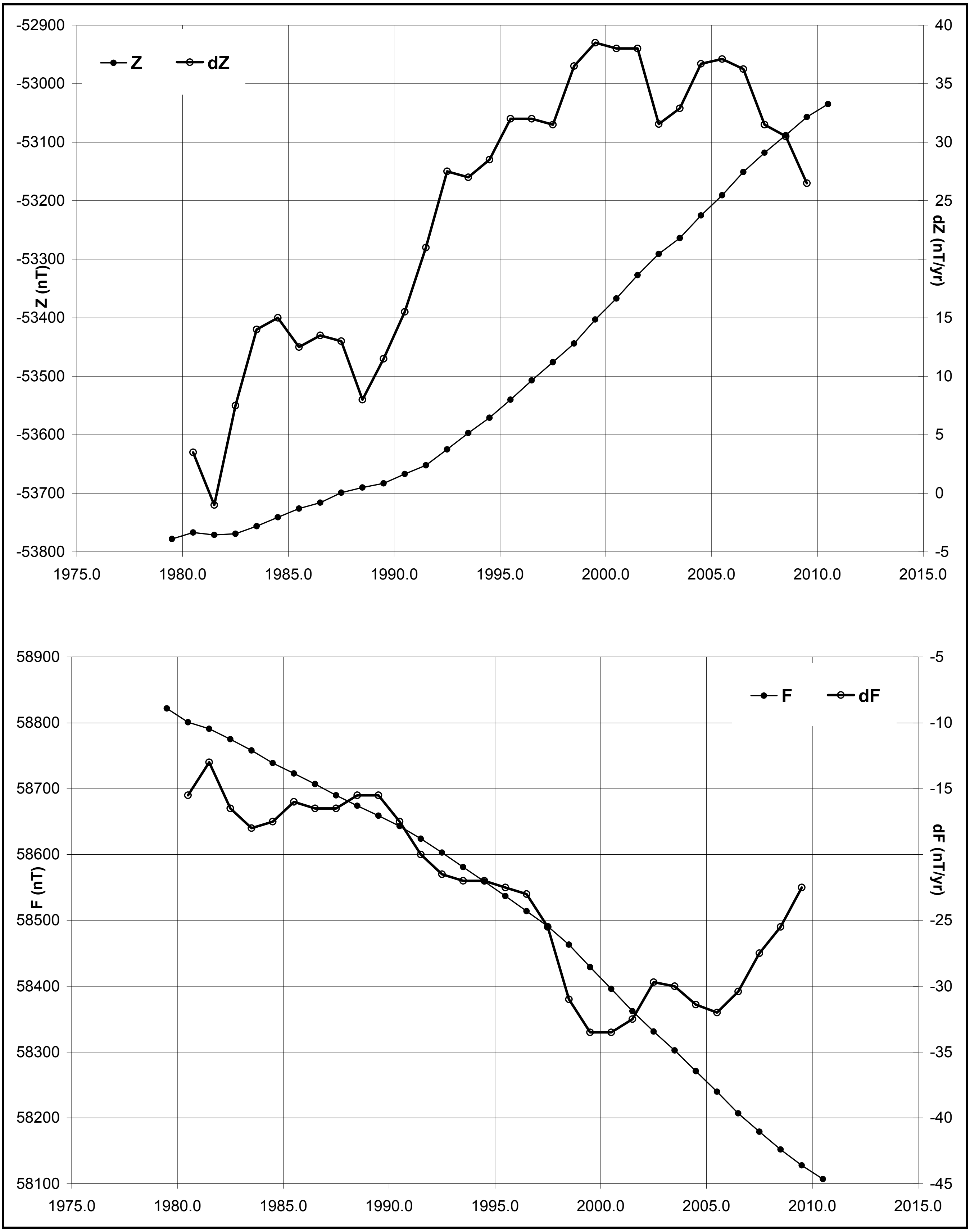


Figure 6.2. Canberra annual mean values and secular variation (all days) for H, D, Z and F.

Day	January			February			March			April			May			June		
01	0000	0002	2	0133	3323	18	2111	2111	10	2222	4222	18	0101	1200	5	2222	2331	17
02	0111	1011	6	2222	2213	16	0103	2212	11	1143	3322	19	0135	4443	24	1110	1211	8
03	1213	2101	11	3223	3211	17	1013	3312	14	1121	3321	14	2345	4332	26	1114	4112	15
04	1121	1011	8	1100	0001	3	1321	3201	13	3232	3233	21	2124	3322	19	3324	2010	15
05	0121	1100	6	1100	1200	5	0012	2011	7	2356	5532	31	2211	2220	12	1220	0011	7
06	0000	0000	0	0001	3411	10	1010	1012	6	3445	4443	31	0223	2221	14	0102	1111	7
07	0100	0011	3	2110	1112	9	1331	1000	9	3245	4322	25	2222	3221	16	1102	2010	7
08	0010	0000	1	2102	1002	8	1110	0100	4	3222	2112	15	0122	2101	9	1000	0010	2
09	0011	0101	4	0012	1100	5	0011	2101	6	1102	2110	8	0000	0010	1	0100	0010	2
10	1022	1211	10	1111	0011	6	1211	3321	14	1100	0000	2	1101	1221	9	1211	1001	7
11	1233	3211	16	2212	3201	13	1223	2120	13	1111	3432	16	1211	1100	7	0011	1100	4
12	0220	0122	9	1220	1101	8	1322	3311	16	3332	3321	20	1113	3100	10	0000	0000	0
13	2221	2212	14	1100	0111	5	0011	0210	5	0000	1001	2	0000	0010	1	1222	1111	11
14	1102	2010	7	0001	3002	6	0011	3101	7	1111	0122	9	0000	0210	3	0012	0000	3
15	1110	0122	8	2223	2243	20	1000	1110	4	2321	2100	11	0001	1000	2	0123	1212	12
16	1111	1000	5	2222	0112	12	0120	2001	6	1101	0110	5	0100	0110	3	3333	3331	22
17	1110	1000	4	1100	0012	5	1321	0001	8	0010	0010	2	1112	2220	11	1132	1111	11
18	0321	2201	11	0001	2321	9	1100	1111	6	0000	0001	1	0123	2110	10	1101	1210	7
19	1000	0001	2	1111	1122	10	1011	0111	6	1212	1010	8	0112	2311	11	1001	0010	3
20	1001	3333	14	0101	0101	4	1231	3210	13	0011	3201	8	2122	3211	14	0001	0000	1
21	1222	2110	11	0000	1001	2	0101	0000	2	0111	3210	9	1110	1111	7	1020	0011	5
22	0111	1011	6	1212	2212	13	0000	0000	0	0100	0122	6	0011	0000	2	0111	1100	5
23	1112	2101	9	1000	0001	2	1010	1000	3	2211	1011	9	0000	0000	0	0011	0010	3
24	1112	2100	8	0101	0100	3	0000	3300	6	1202	2010	8	0000	0000	0	0001	2210	6
25	1110	2012	8	0000	0102	3	1002	2220	9	1000	0000	1	1112	2202	11	0101	2123	10
26	1001	0001	3	1100	0000	2	0111	2002	7	0001	0000	1	1212	1100	8	2334	2222	20
27	0011	0001	3	0000	0011	2	1211	0000	5	1001	0101	4	0001	0000	1	3433	3112	20
28	0101	1210	6	1131	1102	10	1222	3111	13	1110	1001	5	2223	4122	18	2222	1211	13
29	0111	0012	6				1001	2201	7	2311	0111	10	1254	3422	23	1232	2123	16
30	1211	1212	11				1201	1122	10	0101	2100	5	1142	2342	19	4443	3213	24
31	2111	2212	12				0112	0112	8				2333	4222	21			

Day	July			August			September			October			November			December		
01	1223	2321	16	0111	1111	7	0100	1122	7	0100	0000	1	0232	2012	12	0000	0110	2
02	1132	2111	12	1112	3200	10	1123	1310	12	0000	0000	0	1111	1000	5	0010	0001	2
03	1102	2111	9	1312	2345	21	0101	0000	2	0101	0000	2	1121	2110	9	0001	0000	1
04	0012	1100	5	5435	5554	36	0000	0000	0	0010	1001	3	0002	1101	5	0121	1010	6
05	0001	2100	4	2311	2111	12	0000	0002	2	1222	1111	11	0011	1100	4	0000	0001	1
06	1000	0000	1	1211	3211	12	1112	2101	9	0012	3110	8	0111	1100	5	0111	1110	6
07	0000	1100	2	1011	0110	5	1113	2322	15	0112	2001	7	0000	0111	3	0032	2211	11
08	0000	0000	0	0001	0010	2	2212	3321	16	1202	0101	7	0022	3211	11	2221	1221	13
09	1112	1100	7	2222	2222	16	1002	2301	9	1002	1101	6	0101	1000	3	0101	1001	4
10	0000	0000	0	1121	1102	9	0000	0000	0	1001	2111	7	0000	0113	5	1111	0010	5
11	0000	2100	3	2232	2211	15	0000	0000	0	1235	5433	26	2224	4223	21	0110	1000	3
12	0000	1000	1	0011	2000	4	0000	0000	0	1323	3311	17	2323	3201	16	0010	2322	10
13	0000	0000	0	1100	0100	3	1000	1100	3	1221	1111	10	0111	2121	9	2321	1223	16
14	0102	2103	9	0001	1200	4	0233	2322	17	1000	0001	2	1111	1322	12	1322	4323	20
15	3122	3210	14	1102	2101	8	2103	0001	7	1112	2211	11	2323	2113	17	2221	2211	13
16	0012	1000	4	1221	1220	11	0111	1231	10	1110	2222	11	2122	3311	15	2222	0210	11
17	0000	0000	0	1101	2210	8	1333	2211	16	2233	2121	16	1211	1011	8	2110	1121	9
18	0000	0000	0	1101	2000	5	2111	1110	8	1112	1123	12	0222	2121	12	0220	2111	9
19	0000	0100	1	0002	1000	3	1211	1000	6	3332	1111	15	0101	1000	3	0111	0102	6
20	1021	1101	7	0000	1100	2	1101	1210	7	1001	3111	8	0232	1011	10	2432	3222	20
21	1101	0110	5	0001	1100	3	1322	0001	9	1100	1110	5	1112	2122	12	0001	1101	4
22	0002	1110	5	0000	0000	0	1100	0001	3	0121	2133	13	1123	2212	14	0001	0100	2
23	0121	2211	10	0011	1113	8	1232	2222	16	2234	5424	26	2232	2321	17	0011	1012	6
24	1110	0210	6	3334	4323	25	2223	3423	21	3433	4332	25	1222	2232	16	2101	1100	6
25	1111	2221	11	3324	3312	21	2212	1100	9	0122	3122	13	1211	1110	8	1112	2321	13
26	0110	0011	4	3333	2210	17	0011	3311	10	2122	1221	13	1000	0000	1	1111	0022	8
27	2434	3332	24	2334	3323	23	0101	2321	10	1111	2111	9	0011	1233	11	1110	0011	5
28	3234	3221	20	2333	3121	18	2244	3310	19	0011	3101	7	3331	2221	17	1222	4531	20
29	1223	3101	13	0000	0000	0	1111	1100	6	1100	2200	6	0111	2011	7	1111	2110	8
30	1113	1211	11	0000	0000	0	0001	0000	1	0002	1201	6	0111	1110	6	1122	1321	13
31	1101	2300	8	0010	0001	2				0223	3121	14				1112	1211	10

Table 6.6. Canberra 2010 K indices and daily K sums.

K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	986	1023	583	253	56	18	1	0	0	0	0
Mean sum	9.0										

Table 6.7. Frequency distribution of Canberra 2010 K indices and the annual mean daily K sum.

UT Start			**SSC amplitudes**			**Maximum 3hr K indices**		**Storm Ranges**			**UT End**	
Date	**Time**	**Type**	**D(')**	**H(nT)**	**Z(nT)**	**Day (3hr periods)**	**K**	**D(')**	**H(nT)**	**Z(nT)**	**Date**	**Time**
2010-04-05	08:26		2.22	33.5	8.65	5(4)	6	26.0	134.8	78.9	2010-04-06	02:00
2010-08-03	17:40		2.28*	19.2	1.89	3(8), 4(1,4,5,6,7)	5	22.6	171.9	61.6	2010-08-05	05:00
2010-10-11	05:22	...				11(4,5)	5	16.7	100.2	28.9	2010-10-11	23:00

Table 6.8. Principal magnetic storms observed at Canberra in 2010.

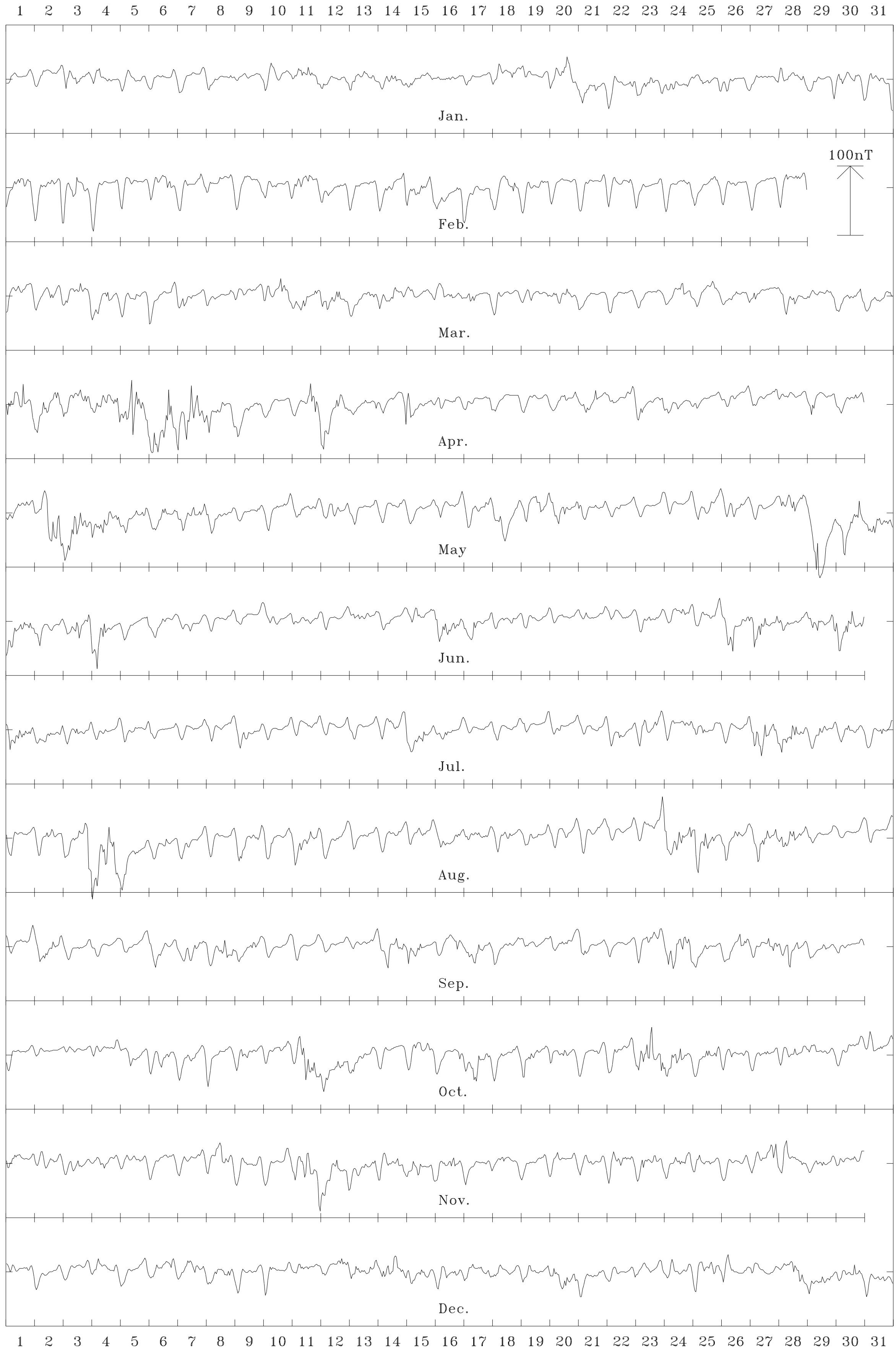
UT		**Type**	**Quality**	**Chief movement (nT)**		
Date	**Time**	**ssc/ssc***	**A,B,C**	**H(X)**	**D(Y)**	**Z**
2010-01-01	23:26	ssc*	B	-7.42	14.32*	-6.38
2010-01-10	15:37	ssc	C	11.75	0.99	2.39
2010-04-05	08:26	ssc	B	33.5	15.35	8.65
2010-04-11	13:04	ssc	A	18.05	4.74	2.5
2010-05-28	02:58	ssc	A	19.45	12.25	1.34
2010-08-03	17:40	ssc*	A	19.2	15.93*	1.89
2010-08-04	10:20	ssc*	A	85.72	-17.07*	18.3
2010-10-30	10:13	ssc	A	11.23	1.49	1.94
2010-11-08	07:52	ssc	B	15.17	2.03	2.52
2010-11-10	17:44	ssc	B	8.93	3.49	1.72
2010-12-19	21:31	ssc	C	4.55	-10.73	5.6

Table 6.9. Storm sudden commencements observed at Canberra in 2010.

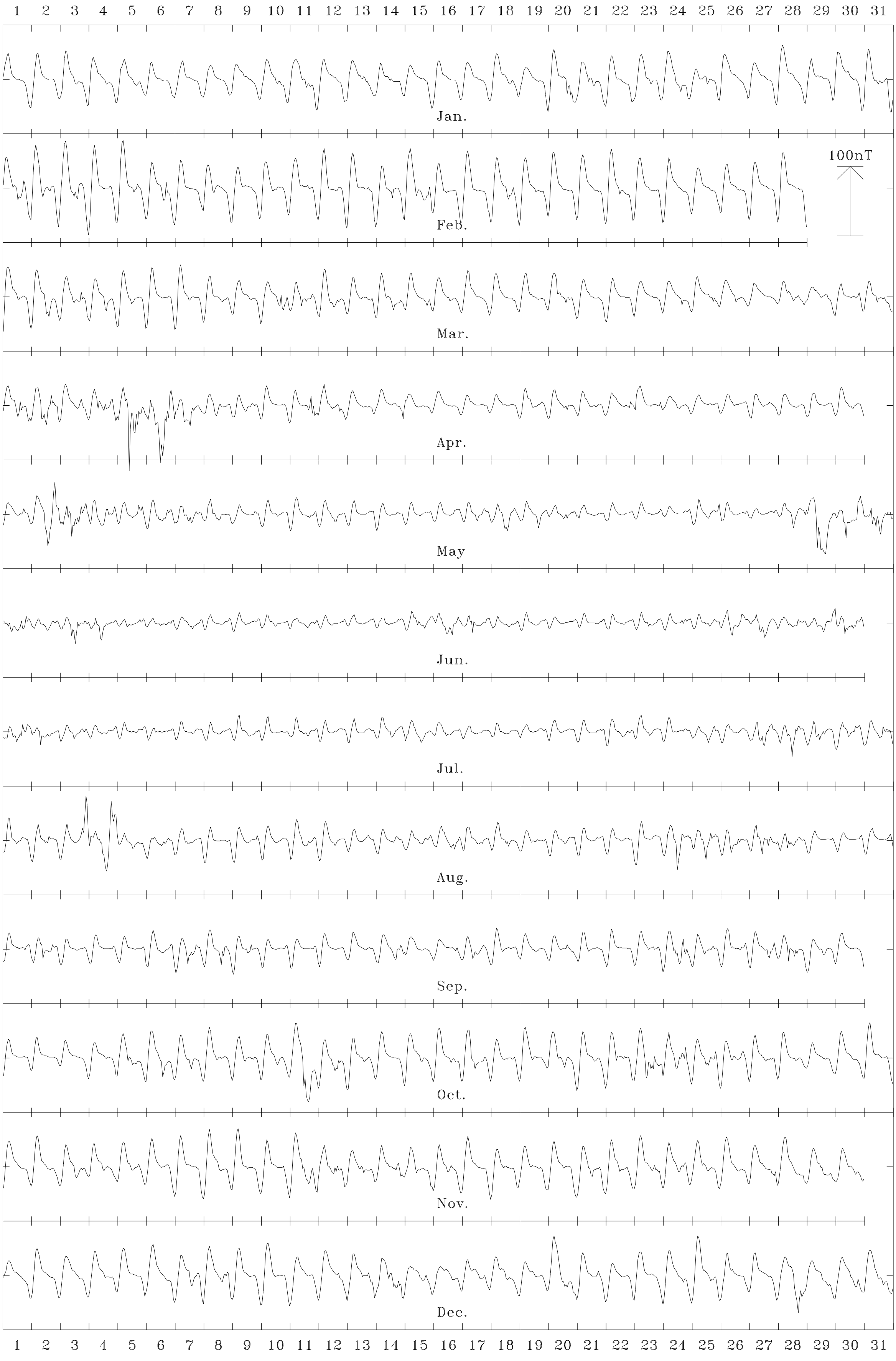
UT	**Movement**			**Amplitude (nT)**			**Confirmation**
Date	**Start**	**Max**	**End**	**H(X)**	**D(Y)**	**Z**	
2010-02-07	02:30	02:38	02:54	16.3	1.5	5.29	solar
2010-02-07	04:51	04:54	05:00	2.03	0.6	0.37	solar
2010-06-12	00:55	01:02	01:08	1.36	0.24	0.83	solar

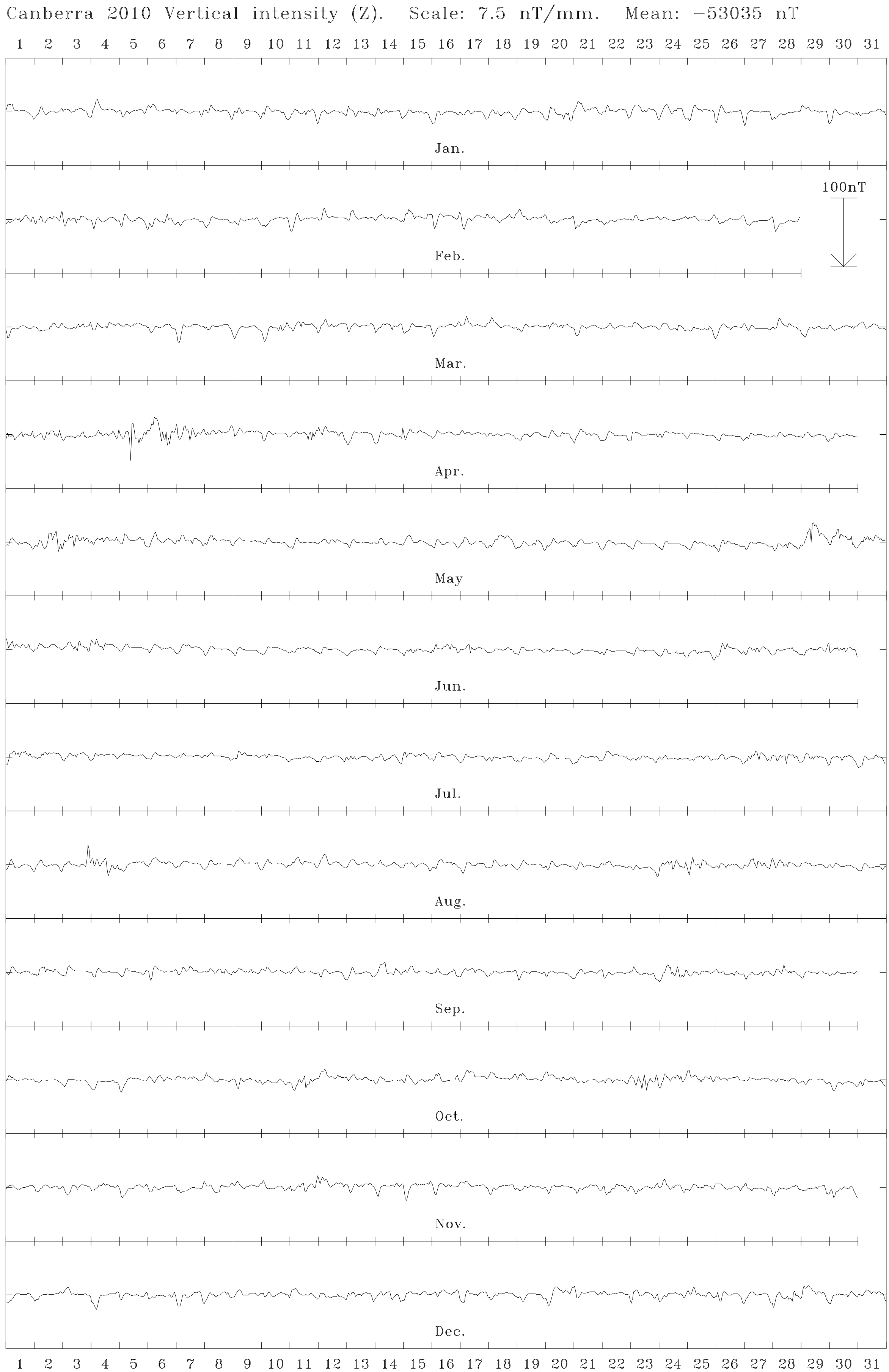
Table 6.10. Solar flare effects observed at Canberra in 2010.

Canberra 2010 North component (X). Scale: 7.5 nT/mm. Mean: 23178 nT



Canberra 2010 East component (Y). Scale: 7.5 nT/mm. Mean: 5153 nT




Canberra 2010 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53035 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
100nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

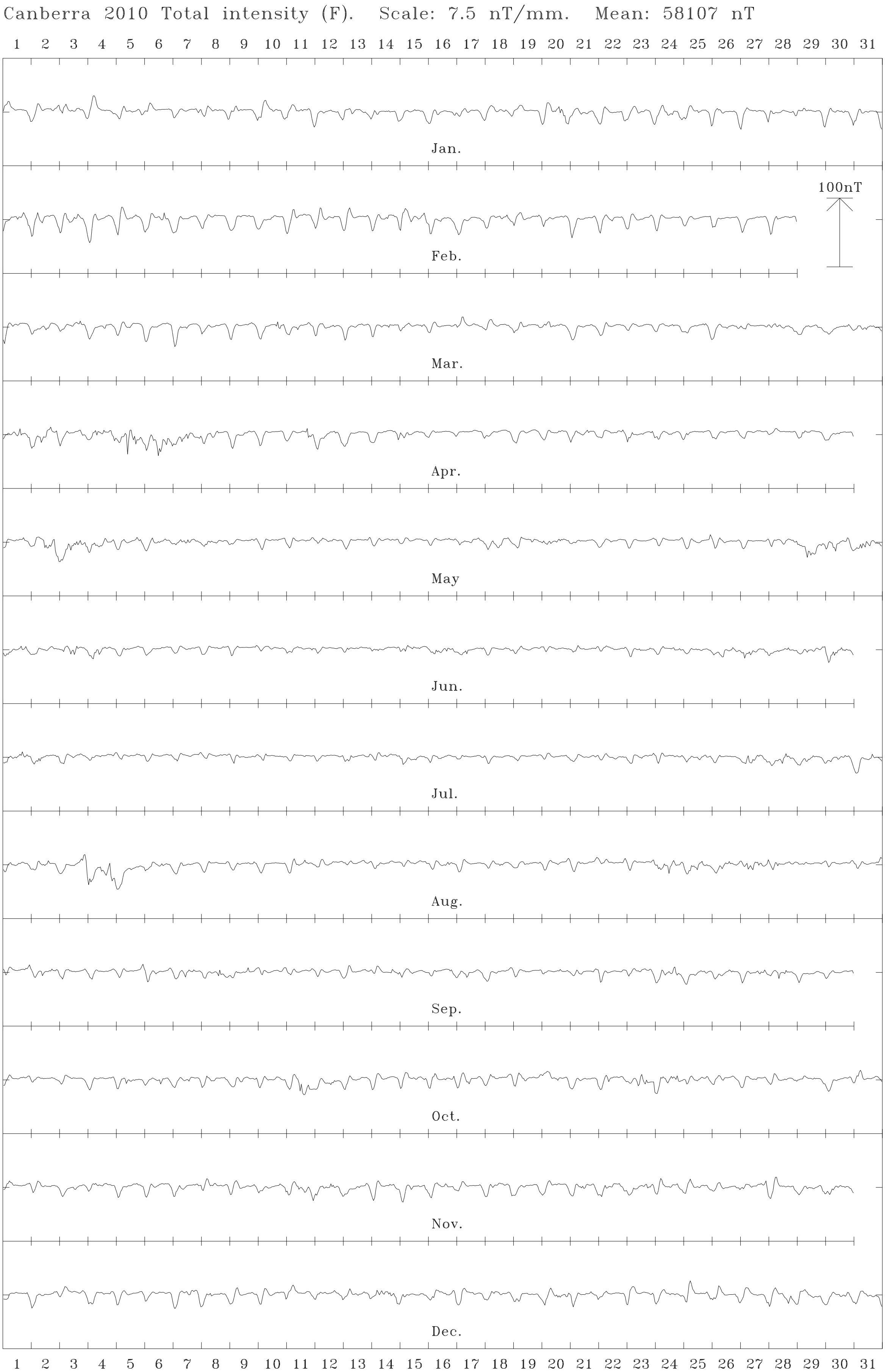


Figure 6.3. Canberra 2010 hourly mean values in X, Y, Z and F.

7. Macquarie Island

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.

The observatory comprises:

- an office in the station's Science Building;
- a Variometer House 100 m south of the office;
- an Absolute House about 30 m further south, and;
- a PPM House between the Variometer and Absolute Houses.

The area around the observatory is used by elephant seals and other native wildlife. Power to the huts is routed underground and data telemetry is via a wireless link to the station local area network. The Absolute and Variometer Houses are enclosed within non-magnetic protective fences.

IAGA code:	MCQ
Commenced operation:	1952
Geographic latitude:	54° 30' S
Geographic longitude:	158° 57' E
Geomagnetic latitude:	-59.65°
Geomagnetic longitude:	244.13°
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
Observers:	B. Quinton (to 2010-03-31) A. Gibbs (from 2010-04-01)

Table 7.1. Key observatory data.

Variometers

Two variometer systems operated at Macquarie Island throughout 2010, one referred to as MCQ the other as MQ2. The MCQ system consisted of a Narod Geophysics Limited 3-component ring-core fluxgate and an Elsec 820 proton precession magnetometer.

The MQ2 system comprised a Danish Meteorological Institute suspended 3-axis linear-core fluxgate and a GEM Systems GSM-90 total-field instrument. The details of the variometers used during 2010 are described in Table 7.2.

The MCQ fluxgate variometer electronics was 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 so that the three mutually orthogonal components recorded were of approximately equal magnitudes. At Macquarie Island the magnetic field is approximately 11° off vertical and each of the three orthogonal sensors makes an angle of approximately 55° with the magnetic vector (this orientation is referred to as ABC).

The GSM-90 total-field variometer 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-90 electronics was located in an insulated box on the floor in the SW corner of the sensor room of the Variometer House.

The MQ2 fluxgate variometer sensor was mounted on the NE pillar of the sensor room of the Variometer House and aligned magnetic NW, NE and vertical (this orientation is referred to as ABZ). The MQ2 fluxgate electronics was mounted in an insulated box situated on the floor in the SW corner of the sensor room.

The temperature of the sensor room of the Variometer House was controlled by a heating system. The temperature varied within a range of 7° through the year.

The Elsec 820 total-field variometer 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.

The data acquisition system was situated in the ante-room of the Variometer House. A single data-acquisition computer acquired data from both the MCQ and MQ2 variometer systems. Backup power was provided by two separate systems. An Uninterruptible Power Supply located in the office powered the MCQ fluxgate variometer (Narod) and the Elsec total-field variometer. A 12V battery box situated in the ante-room of the Variometer House powered the acquisition computer, the GPS clock, the MQ2 fluxgate variometer (DMI) and the GSM-90 total-field variometer.

3-component variometer:	Narod (MCQ)
Serial number:	9305-1
Type:	ring-core fluxgate
Orientation:	A, B, C
Acquisition interval:	1 s
Resolution:	0.025 nT
3-component variometer:	DMI FGE (MQ2)
Serial number:	E0307/S0262
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.3 nT
A/D converter:	ADAM 4017 module (±10V)
Total-field variometer:	GEM Systems GSM-90 (MQ2)
Serial number:	4081418/42176
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Total-field variometer:	Elsec 820 M3 (MCQ)
Serial number:	140
Type:	Proton precession
Acquisition interval:	10 s
Resolution:	0.1 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	ANARESAT

Table 7.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

Definitive 1-minute data for 2010 were derived from the DMI 3-axis linear-core fluxgate variometer (MQ2 system) and Elsec 820 total-field variometer (MCQ system). Reported data provided to INTERMAGNET in real-time during 2010 were derived from the MCQ system (Narod Geophysics Limited 3-component ring-core fluxgate and Elsec 820 proton magnetometer). The reasons for adopting DMI variometer and Elsec 820 for the definitive data will be explained in *Baselines* below.

DI fluxgate:	DMI (Primary)
Serial number:	DI0045
Theodolite:	Zeiss 020B
Serial number:	393911
Resolution:	0.1’
D correction:	0.15’
I correction:	-0.10’
DI fluxgate:	DMI (Secondary)
Serial number:	DI0040
Theodolite:	Zeiss 020B
Serial number:	394742
Resolution:	0.1’
D correction:	0.0’
I correction:	-0.10’
Total-field magnetometer:	GEM Systems GSM-90 (Primary)
Serial number:	5091720/52453
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Total-field magnetometer:	Austral (Secondary)
Serial number:	525
Type:	Proton precession
Resolution:	1 nT

Table 7.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Absolute instruments

The principal absolute magnetometers used at Macquarie Island and their adopted corrections for 2010 are described in Table 7.3.

Magnetic absolute measurements were performed nominally weekly in the Absolute House. DIM observations were made on the principal pier AE with a DMI Declination-Inclination magnetometer (DI0045) mounted on a Ziess 020B (393911) theodolite.

PPM observations were performed on pier AW with a GEM Systems GSM-90 Overhauser magnetometer (5091720) with sensor 52453. A Hewlett-Packard H4300 personal digital assistant computer was used to communicate with the GSM-90 magnetometer.

Pier differences of

$\Delta X = -2.6$ nT $\Delta Y = +5.1$ nT $\Delta Z = +4.2$ nT $\Delta F = -4.1$ nT

were applied to adjust observations performed on pier AW to be equivalent to observations on the principal pier AE.

A Declination-Inclination magnetometer (DMI DI0040 on Zeiss 020B 394742) and an Austral PPM (Aust525) were available as back-up absolute instruments and were used occasionally throughout the year in addition to the primary instruments.

The absolute instruments at Macquarie Island were compared against travelling reference instruments on 20 March 2009 (see Hitchman *et al.*, 2010). There is no instrument comparison in 2010, so the adopted instrument corrections from the 2009 comparisons have been applied to all Macquarie Island 2010 final data.

At 2010 mean magnetic field values (X= 10808 nT, Y= 6576 nT, Z= -62951 nT), these D, I and F corrections translate to corrections of:

$\Delta X = -1.6$ nT $\Delta Y = -1.0$ nT $\Delta Z = -0.4$ nT

Baselines

Baseline variations for the two vector variometers and two scalar variometers during 2010 have been crosschecked. It has been discovered that the Narod, DMI and GSM-90 instruments in the Variometer House all have noticeable baseline drifts between 3-7 March and 17-21 May due to external contamination. The contamination source is possibly the waste bins located 30 m east of the Variometer House. Elsec 820 data in the PPM House and absolute observations in the Absolute House were not contaminated as these two houses are located further away from the waste bins. The details of baseline variations for each of the instruments are:

1. Narod fluxgate in the Variometer House

There were 5 visible sudden baseline jumps during 2010. The Y channel had the maximum baseline jump of 8.64 nT.

2010-01-19	X -0.60 nT, Y-7.15 nT, Z-1.96 nT
2010-01-29	X +0.96 nT, Y + 8 nT, Z +2 nT
2010-02-23	Y -7.59 nT
2010-03-14	Y +8.15 nT
2010-12-10	X -2.44 nT, Y-8.64 nT, Z-3.36 nT

2. DMI fluxgate in the Variometer House

Baselines were generally stable during 2010 except 3-7 March and 17-21 May. However, baseline residuals (calculated from absolute observations) for X, Y, Z channels drifted from 3-7 March, with Z drifting most and changing 4 nT. They then stabilised for a few weeks. From 17-21 May, baseline residuals again drifted with Z drifting most and changing 3 nT. Baseline drifts also occurred in the Narod and GSM-90 instruments housed in the same Variometer House.

3. GSM-90 in the Variometer House

Baseline residuals drifted up to 3 nT from 3-7 March and 17-21 May, and remained stable after 21 May.

4. Elsec 820 total-field variometer in the PPM House

The Elsec 820 baseline was stable through 2010, varying within a 2 nT range.

Final DMI baselines were adopted by applying piecewise linear baseline drifts to observed baseline residuals from the weekly absolute observations.

The standard deviations of the differences between the weekly absolute observations and the final adopted variometer model and data using the DMI vector variometer were:

	σ		σ
X	0.9 nT	D	11"
Y	0.8 nT	I	03"
Z	0.5 nT	F	0.5 nT

Throughout the year there was about 2 nT of variation in the difference between F measured with the DMI vector variometer and F measured with the Elsec 820 scalar variometer.

Observed and adopted baseline values in X, Y and Z are shown in Figure 7.1.

Operations

The magnetic observers at Macquarie Island in 2010 were members of the Australian National Antarctic Research Expedition and were supported jointly by the Australian Government Antarctic Division and Geoscience Australia. The duties of the magnetic observer included maintaining the equipment, performing absolute observations to calibrate the variometers, transcribing the observations and emailing them to Geoscience Australia, maintaining the integrity of the observatory and reporting any changes to Geoscience Australia. During 2010, the role of magnetic observer was filled by the ANARE communications technical officers: Brett Quinton until 2010-03-31 and then by Adrian Gibbs from 2010-04-01.

The MCQ (Narod) vector variometer produced 8 samples per second which were filtered and output as 1-second data. The MQ2 (DMI) vector variometer was sampled once per second. Both the GSM-90 and Elsec 820 scalar variometers produced 10-second samples. All variometer data were recorded on an acquisition PC running QNX and the Geophysical Data Acquisition Platform (GDAP) software. Acquisition timing control was provided by a Garmin GPS clock mounted on the roof of the Variometer House. Timing corrections are listed in *Significant events* below.

Data were transmitted every 5 to 10 minutes to Geoscience Australia. "Reported" quality real-time 1-minute data were provided to INTERMAGNET throughout 2010 from the MCQ variometer system. Definitive 2010 1-minute data (and derived data products such as hourly and annual mean values) were subsequently sourced from the DMI vector variometer and the Elsec 820 scalar variometer.

There was about 37 days of Elsec 820 data loss primarily due to power failure. The data gaps were filled with GSM-90 data, thus reducing the annual data loss to 262 minutes. There was 282 minutes of vector variometer data loss due to a power failure. Data losses are identified in Table A.7.

The distribution of Macquarie Island 2010 data is described in Table 7.4.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011

Table 7.4. Distribution of Macquarie Island 2010 data.

Significant events

2010-01-04 scheduled telemetry outage 03:00 - 05:00 due to electrical maintenance work

2010-01-08 02:43 - 03:26 seal-fence repairs around observatory buildings

2010-01-15 22:30 -22:45 Satellite outage due to equipment maintenance

2010-01-19 08:49:08 baseline jumps in Narod RCF ABC=(-132, 218, 167) counts, XYZ = (0.6, 7.15, 1.96) nT

2010-02-01 Brett Quinton advises that the construction of new helipads inside the magnetic quiet zone at MCQ began around 29 January. Emails with Tony Foy (AAD Asset Manager) suggest there are 4 pads planned that would be 75-80m from the absolute hut. They would be used between May and August 2010 in connection with the Parks and Wildlife rabbit baiting program, and then be decommissioned. Discussions with Tony have resulted in him indicating that he may be able to move the pads slightly further away from the observatory.

2010-01-29 just after absolute obs (02:00 - 03:00), at 04:37:08, Narod variometer shifted X +0.96 nT, y + 8nT and Z +2nT. there is a shift occurred at 04:05:41 ~ 46. No correction applied.

2010-02-03 Brett advises that there will be some brief contamination to the geomag zone this morning at Macca, from 2215 3/2/10UTC. We will be removing a large volume of built-up sand around the micro pulsation enclosure, which has formed a nice ramp for seal entry.

2010-02-16 Send two new compact flash cards via postal service

2010-02-19 Brett advises that there may be a brief contamination in the magnetic quiet zone shortly, for 5-10 minutes (from 0045UTC 19/2/2010). "I will be performing a CF card swap on the Japanese MAGDAS experiment, and since their built-in LCD screen has failed, I will need to take in a VGA cable to briefly connect to your KVM. 0045-0100UTC will cover it."

2010-02-23 Narod baseline jumped EY 2010/02/23 23:49:30 - 7.59

2010-03-09 Narod variometer baseline shifted.

2010-04-06 Adrian Gibbs started routine obs and Brett's last obs was on 2010-03-31

2010-04-27 13:17 Narod and E820 data stopped.

2010-05-30 08:16:15 - CLK I 0 Correction 1275207375
494083718 C 0 s 436135987 R 0 s -1734

2010-06-28 Absolute Hut heater failed sometime after previous week's observations Spare heater installed. The faulty heater was sent to electricians (MCQ).

2010-07-01 Adrian Gibbs advised that the electricians have said that the element is burnt out in the original heater - could we have a new element sent down? There should be a ship coming down in several weeks. Chopper movements in June 2010 are attached at the end of the file.

2010-07-26 between 04:30-04:54 26 July, 15 minutes data loss. Three data files were generated. Probably associated with power cut.

04:52:46 - CLK I 0 Correction 1280119966
107786089 C 1 s 98264894 R 0 s -3536

06:20:16 - CLK I 0 Correction 1280125216
192177787 C 0 s 138433744 R 0 s -2161

2010-07-27 between 06:26 to 06:35 27 July (UT), - 10 minutes data loss - power cut

06:37:30 - CLK I 0 Correction 1280212650
582908793 C 0 s 528988056 R 0 s -2805

2010-07-28 Adrian Gibbs tested battery box twice around 2205 UTC. The volts in the battery box dropped straight to about 2 volts after the battery charger was disconnected. PC stopped and data loss from 22:02 - 22:07 28 July 2010.

22:07:42 - CLK I 0 Correction 1280354862
887422015 C 1 s 831539884 R 0 s -2502

2010-07-29 AG was up there today just to check on battery with his Leatherman around 0115 UTC for 5mins or so.

2010-08-01 AG changed 12V battery between 23:52:30 - 00:02:41 2 August. 10 minutes data loss. the old battery was power PC Sonic Model PS-12180NB 12V 18AH

2010-08-02 00:04:30 - CLK I 0 Correction 1280707470
588327086 C 0 s 529349532 R 0 s -2638

2010-08-07 00:40:20 - CLK I 0 Correction 1281141620 986125932 C 0 s 287381323 R 0 s -2414

00:51:47 - CLK I 0 Correction 1281142307 697470401 C 0 s -286904735 R 0 s -2647

2010-08-19 Adrian G is in the field from 19 - 26 Aug. contact Troy Metcalfe if needed.

2010-09-26 13:13 (approx) E820 PPM data stops

2010-09-28 04:25 slay and restart GdapE820 - this gets PPM data flowing again

2010-08-29 06:50:16 - CLK I 0 Correction 1283064616 316304614 C 0 s -107978530 R 0 s -1531

06:53:47 - CLK I 0 Correction 1283064827 424141190 C 0 s 108062456 R 0 s -1533

2010-09 VI editor not working on MCQ acquisition computer

2010-09-02 22:50:09 - CLK I 0 Correction 1283467809 329167109 C 0 s -389078689 R 0 s -2261

22:51:45 - CLK I 0 Correction 1283467905 718894971 C 0 s 389111979 R 0 s -2409

2010-09-20 05:20:16 - CLK I 0 Correction 1284960016 125626398 C 0 s 274190071 R 0 s -2359

05:23:53 - CLK I 0 Correction 1284960233 850707206 C 0 s -274185493 R 0 s -2400

2010-10-05 03:25 electrician in hut with magnetic clothing etc - short disturbance to data

2010-10-07 Power failure to Science building/variometer. Restored ~20:10 UTC. However power failure (~06:30???) left mq2 (DMI and GSM90) on battery box for some time, until battery exhausted then system stopped; mcq (Narod and Elsec820) on UPS 240V stopped sooner than mq2. It took me (PGC) some time to realise what had happened.

20:10:12 - CLK I 0 Correction 1286482212 34337408 C 0 s 970406402 R 0 s -4690

2010-10-08 01:30 Adrian reset UPS ("hit on button") and mcq started working, although unix/machview bug couldn't read file (F data started some time before NGL data - cause error, although OK on DOS version).

2010-10-08 ~20:23 no E820 data - probably its buffer filled up and needs configuration after power failed/restarted.

2010-10-13 00:05 - 00:13 noise on system - Adrian and carpenter inspecting hut

2010-10-13 Adrian G resets E820 PPM. - it runs for about 30 minutes then stops. stop and restart driver. E820 stops about 30 minutes later. 22:49 stop and restart driver

2010-10-20 02:01 stop and restart E820 driver, check E820 operations in qtalk

2010-10-24 23:38 stop and restart E820 driver. Retune E820 and restart again

2010-10-27 00:19:58 - 01:18:04 Narod was down due to UPS power was off for checking the size of UPS batteries There are 16 Century PS1270 batteries in the Linx800 UPS. They are 12v 7 Ah with 5mm spade terminals and are 1500mm L x 65mm W x 95 MM high DC Volts was only 105 V.

2010-10-27 22:40 stop and restart GdapE820

2010-11-01 04:09 and 04:11 (approx) stop and restart GdapE820

2010-12-22 02:45 E820 PPM intermittent spikes for next 24 hours

2010-12-23 02:40-02:50 change over powerhouse. 02:50 E820 PPM problems stop (correlates with return to normal power)

2010-12-24 E820 spiking intermittently. 22:24 stop GdapE820 and retune instrument and restart

2010-12-31 0030 to 0035 UTC (1130 to 1135 Macca Time) there was as incursion into the mag zone by the Honda buggy.

Annual mean values

The annual mean values for Macquarie Island are set out in Table 7.5 and displayed with the secular variation in Figure 7.2.

Hourly mean values

Plots of the hourly mean values for Macquarie Island 2010 data are shown in Figure 7.3.

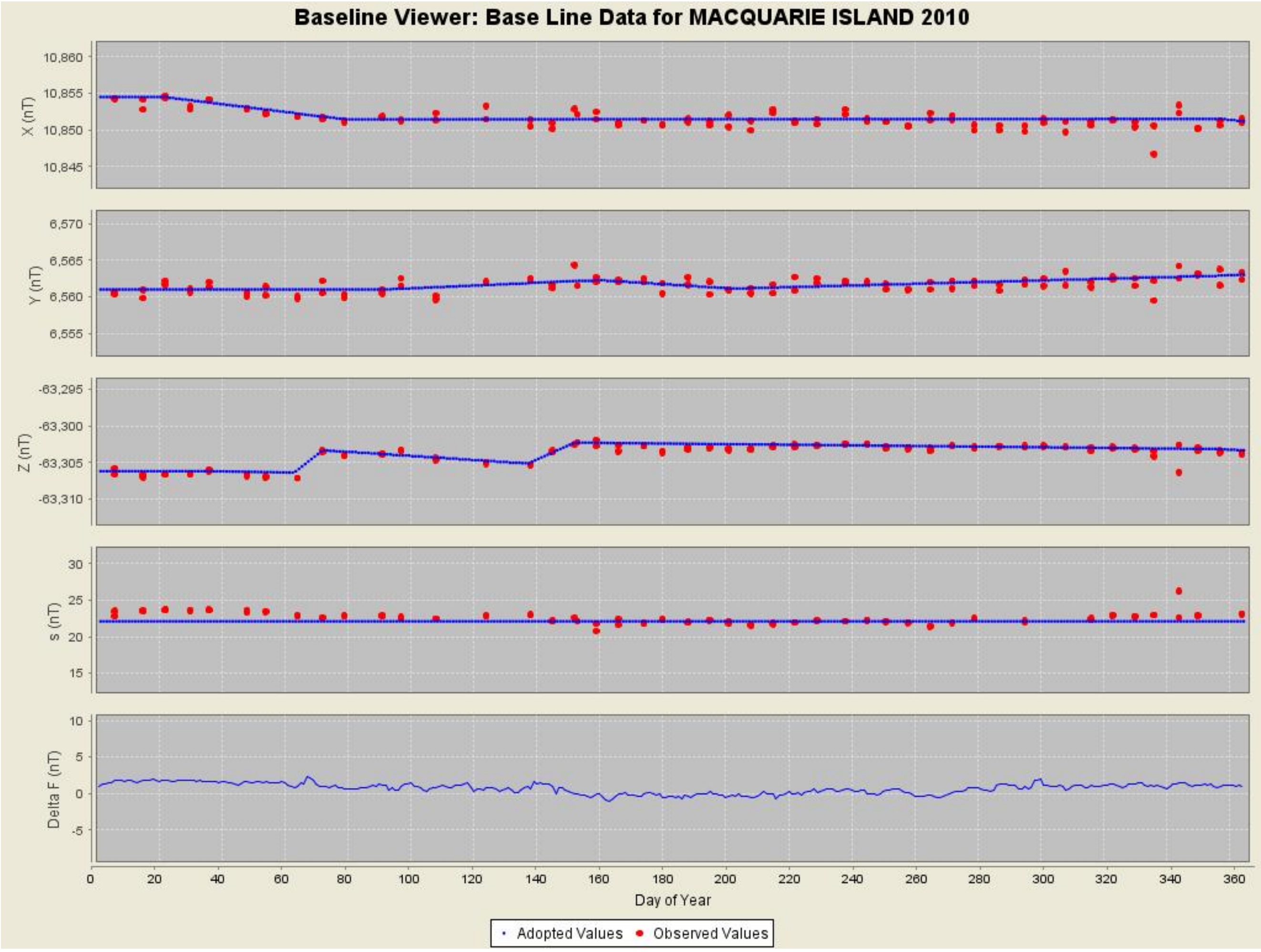
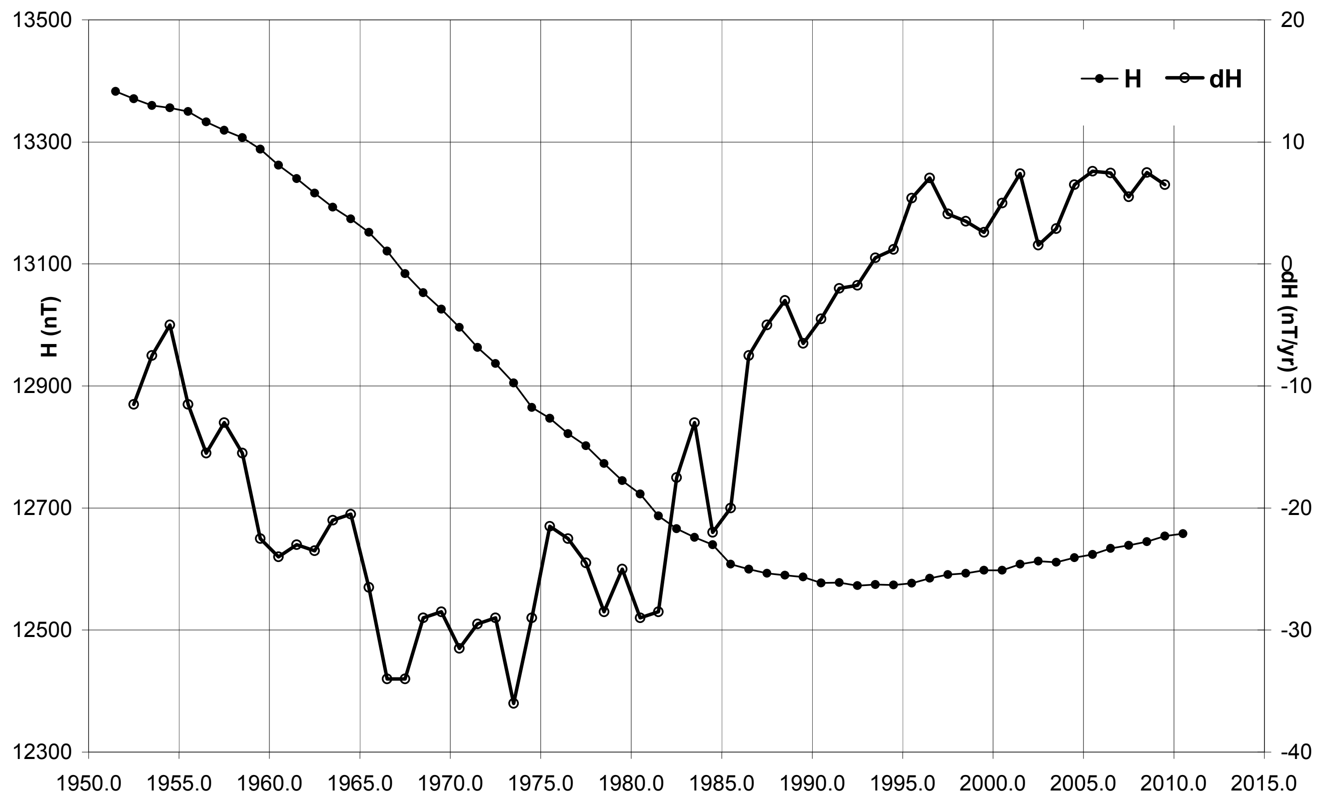


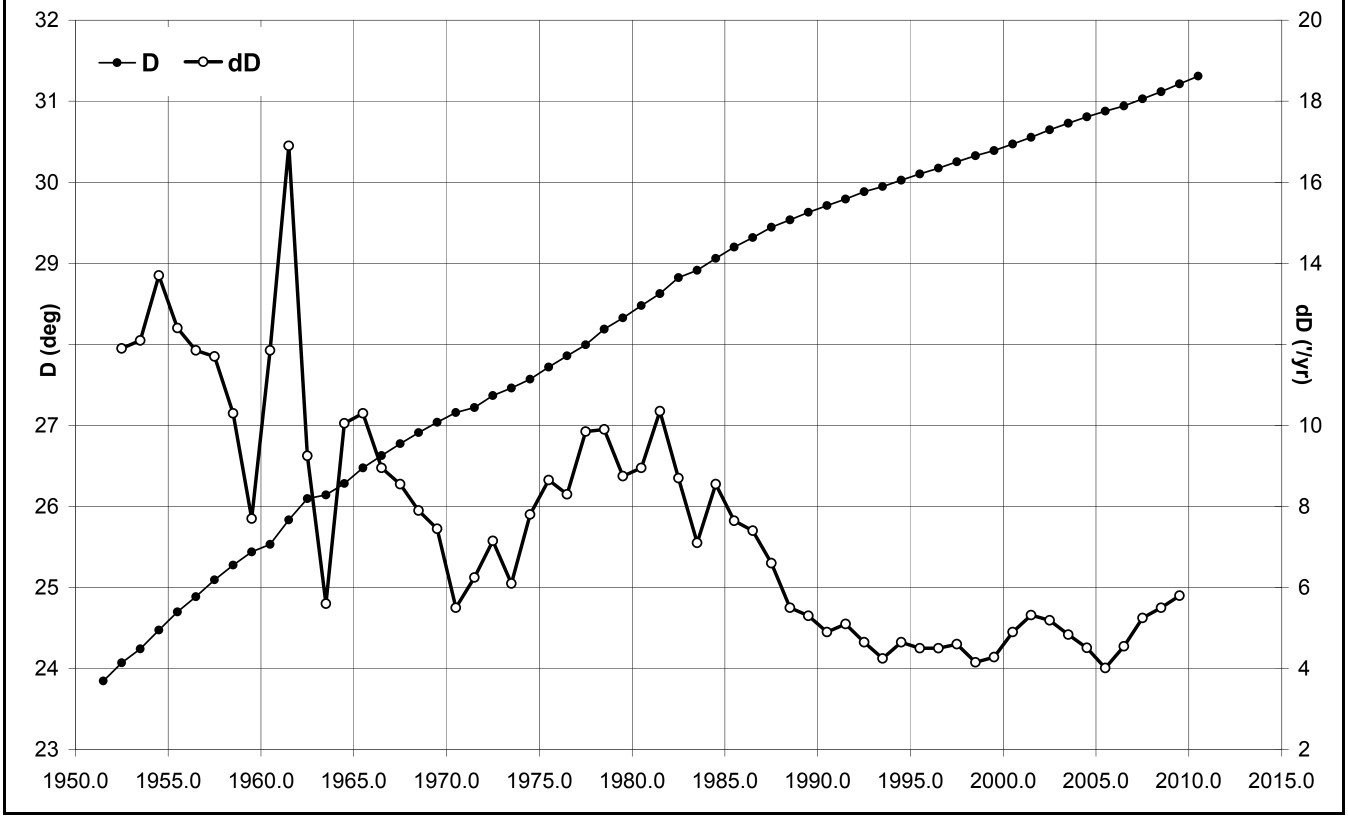
Figure 7.1. Macquarie Island 2010 baseline plots.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)	
1991.5	A	29	47.7	-78	48.9	12553	10893	6237	-63482	64711	XYZ
1992.5	A	29	53.1	-78	48.3	12557	10888	6257	-63450	64681	XYZ
1993.5	A	29	57.2	-78	48.1	12558	10880	6270	-63428	64659	ABC
1994.5	A	30	02.2	-78	48.3	12549	10863	6281	-63404	64634	ABC
1995.5	A	30	06.6	-78	47.5	12559	10864	6300	-63376	64608	ABC
1996.5	A	30	11.0	-78	46.4	12574	10870	6322	-63353	64589	ABC
1997.5	A	30	15.4	-78	45.9	12580	10866	6339	-63336	64573	ABC
1998.5	A	30	20.0	-78	45.8	12579	10857	6353	-63320	64557	ABC
1999.5	A	30	23.6	-78	45.2	12586	10856	6367	-63294	64534	ABC
2000.5	A	30	28.4	-78	45.0	12585	10847	6382	-63268	64507	ABC
2001.5	A	30	33.5	-78	44.1	12595	10846	6404	-63231	64473	ABC
2002.5	A	30	39.1	-78	43.5	12600	10840	6424	-63198	64442	ABC
2003.5	A	30	44.6	-78	44.0	12585	10817	6433	-63174	64416	ABC
2004.5	A	30	49.0	-78	42.7	12602	10823	6456	-63134	64380	ABC
2005.5	A	30	53.3	-78	42.1	12607	10819	6472	-63104	64352	ABC
2006.5	A	30	57.0	-78	40.8	12625	10828	6493	-63063	64315	ABC
2007.5	A	31	01.9	-78	40.2	12631	10823	6511	-63035	64288	ABZ
2008.5	A	31	07.3	-78	39.5	12637	10818	6532	-63005	64260	ABZ
2009.5	A	31	12.9	-78	38.4	12651	10820	6556	-62973	64231	ABZ
2010.5	A	31	19.0	-78	38.2	12651	10808	6576	-62951	64210	ABZ
1951.5		23	50.8	-78	17.6	13383	12241	5411	-64589	65961	HDZ
1952.5		24	04.2	-78	17.8	13371	12208	5453	-64550	65920	HDZ
1953.5		24	14.6	-78	18.2	13360	12182	5486	-64533	65901	HDZ
1954.5		24	28.4	-78	18.4	13356	12156	5533	-64535	65903	HDZ
1955.5		24	42.0	-78	18.6	13350	12129	5579	-64520	65887	HDZ
1956.5		24	53.2	-78	19.3	13333	12095	5611	-64506	65870	HDZ
1957.5		25	05.7	-78	19.8	13319	12062	5649	-64482	65843	HDZ
1958.5		25	16.6	-78	20.1	13307	12033	5682	-64456	65815	HDZ
1959.5		25	26.3	-78	20.9	13288	12000	5708	-64436	65792	HDZ
1960.5		25	32.0	-78	22.0	13262	11967	5716	-64414	65765	HDZ
1961.5		25	50.0	-78	22.5	13240	11917	5769	-64359	65707	HDZ
1962.5		26	05.8	-78	23.3	13216	11869	5814	-64321	65665	HDZ
1963.5		26	08.5	-78	24.2	13193	11843	5813	-64294	65634	HDZ
1964.5		26	17.0	-78	24.7	13174	11812	5834	-64249	65586	HDZ
1965.5		26	28.6	-78	25.5	13152	11773	5864	-64214	65547	HDZ
1966.5		26	37.6	-78	26.7	13121	11729	5881	-64175	65503	HDZ
1967.5		26	46.5	-78	28.5	13084	11681	5894	-64166	65486	HDZ
1968.5		26	54.7	-78	29.7	13053	11639	5908	-64132	65447	HDZ
1969.5		27	02.3	-78	30.8	13026	11602	5921	-64099	65409	HDZ
1970.5		27	09.6	-78	32.1	12996	11563	5932	-64078	65383	HDZ
1971.5		27	13.3	-78	33.3	12963	11527	5930	-64032	65331	HDZ
1972.5		27	22.1	-78	34.4	12937	11489	5947	-64008	65302	HDZ
1973.5		27	27.6	-78	35.8	12905	11451	5951	-63985	65273	HDZ
1974.5		27	34.3	-78	37.6	12865	11404	5955	-63956	65237	HDZ
1975.5		27	43.2	-78	38.2	12847	11373	5976	-63926	65204	HDZ
1976.5		27	51.6	-78	39.1	12822	11336	5992	-63891	65165	HDZ
1977.5		27	59.8	-78	39.9	12802	11304	6010	-63861	65132	HDZ
1978.5		28	11.3	-78	41.1	12773	11258	6034	-63838	65103	HDZ
1979.5		28	19.6	-78	42.3	12745	11219	6047	-63807	65067	HDZ
1980.5		28	28.8	-78	43.0	12723	11183	6067	-63768	65025	HDZ
1981.5		28	37.5	-78	44.5	12687	11136	6078	-63735	64985	HDZ
1982.5		28	49.5	-78	45.4	12666	11097	6107	-63711	64958	HDZ
1983.5		28	54.9	-78	45.7	12652	11075	6117	-63674	64919	HDZ
1984.5		29	03.7	-78	46.1	12640	11049	6140	-63650	64893	HDZ
1985.5		29	12.0	-78	47.4	12608	11006	6151	-63619	64856	XYZ
1986.5		29	19.0	-78	47.5	12600	10986	6169	-63590	64826	XYZ
1987.5		29	26.8	-78	47.8	12593	10966	6191	-63584	64819	XYZ
1988.5		29	32.2	-78	47.8	12590	10954	6207	-63560	64795	XYZ
1989.5		29	37.8	-78	47.8	12587	10941	6223	-63552	64786	XYZ
1990.5		29	42.8	-78	48.0	12577	10923	6234	-63519	64752	XYZ
1991.5		29	47.6	-78	47.6	12578	10915	6250	-63487	64721	XYZ
1992.5		29	53.0	-78	47.5	12573	10901	6264	-63447	64681	XYZ
1993.5	Q	29	56.9	-78	47.2	12575	10896	6277	-63427	64661	ABC
1994.5	Q	30	01.5	-78	47.0	12574	10887	6292	-63403	64637	ABC
1995.5	Q	30	06.2	-78	46.5	12577	10881	6308	-63377	64613	ABC
1996.5	Q	30	10.5	-78	45.9	12585	10879	6326	-63356	64594	ABC

1997.5	Q	30	15.2	-78	45.4	12591	10876	6344	-63336	64576	ABC
1998.5	Q	30	19.7	-78	45.1	12593	10870	6359	-63321	64562	ABC
1999.5	Q	30	23.5	-78	44.6	12598	10867	6373	-63293	64535	ABC
2000.5	Q	30	28.3	-78	44.3	12598	10858	6389	-63266	64509	ABC
2001.5	Q	30	33.3	-78	43.4	12608	10857	6409	-63229	64474	ABC
2002.5	Q	30	38.9	-78	42.8	12613	10851	6429	-63196	64442	ABC
2003.5	Q	30	43.7	-78	42.6	12611	10841	6444	-63170	64417	ABC
2004.5	Q	30	48.5	-78	41.8	12619	10838	6463	-63134	64383	ABC
2005.5	Q	30	52.7	-78	41.3	12624	10835	6479	-63106	64356	ABC
2006.5	Q	30	56.6	-78	40.3	12634	10836	6496	-63064	64317	ABC
2007.5	Q	31	01.8	-78	39.8	12639	10830	6515	-63038	64293	ABZ
2008.5	Q	31	07.1	-78	39.1	12645	10826	6535	-63008	64265	ABZ
2009.5	Q	31	12.8	-78	38.3	12654	10822	6558	-62974	64233	ABZ
2010.5	Q	31	18.7	-78	37.8	12658	10815	6579	-62952	64212	ABZ
1993.5	D	29	58.5	-78	50.0	12521	10846	6256	-63429	64654	ABC
1994.5	D	30	03.3	-78	50.2	12514	10831	6267	-63408	64632	ABC
1995.5	D	30	07.8	-78	49.4	12522	10830	6285	-63376	64601	ABC
1996.5	D	30	11.9	-78	47.4	12556	10852	6316	-63350	64583	ABC
1997.5	D	30	16.0	-78	47.3	12555	10843	6328	-63334	64566	ABC
1998.5	D	30	21.0	-78	47.7	12543	10824	6338	-63320	64550	ABC
1999.5	D	30	24.3	-78	46.4	12564	10836	6358	-63297	64532	ABC
2000.5	D	30	29.0	-78	46.7	12554	10819	6368	-63273	64507	ABC
2001.5	D	30	34.6	-78	46.0	12560	10813	6389	-63238	64473	ABC
2002.5	D	30	40.0	-78	44.8	12574	10816	6413	-63198	64437	ABC
2003.5	D	30	46.6	-78	46.8	12534	10769	6413	-63186	64418	ABC
2004.5	D	30	50.2	-78	45.0	12559	10783	6437	-63136	64374	ABC
2005.5	D	30	55.2	-78	44.3	12565	10779	6456	-63102	64341	ABC
2006.5	D	30	58.1	-78	42.0	12601	10805	6484	-63059	64305	ABC
2007.5	D	31	02.9	-78	41.2	12610	10803	6504	-63031	64280	ABZ
2008.5	D	31	07.9	-78	40.3	12622	10804	6525	-62999	64251	ABZ
2009.5	D	31	13.2	-78	38.8	12643	10813	6553	-62970	64226	ABZ
2010.5	D	31	19.8	-78	39.4	12628	10787	6566	-62947	64201	ABZ

Table 7.5. Macquarie Island annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 7.2.


H
dH
H (nT)
dH (nT/yr)
13500
13300
13100
12900
12700
12500
12300
20
10
0
-10
-20
-30
-40
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
2015.0


D
dD
D (deg)
dD ('/yr)
32
31
30
29
28
27
26
25
24
23
20
18
16
14
12
10
8
6
4
2
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
2015.0

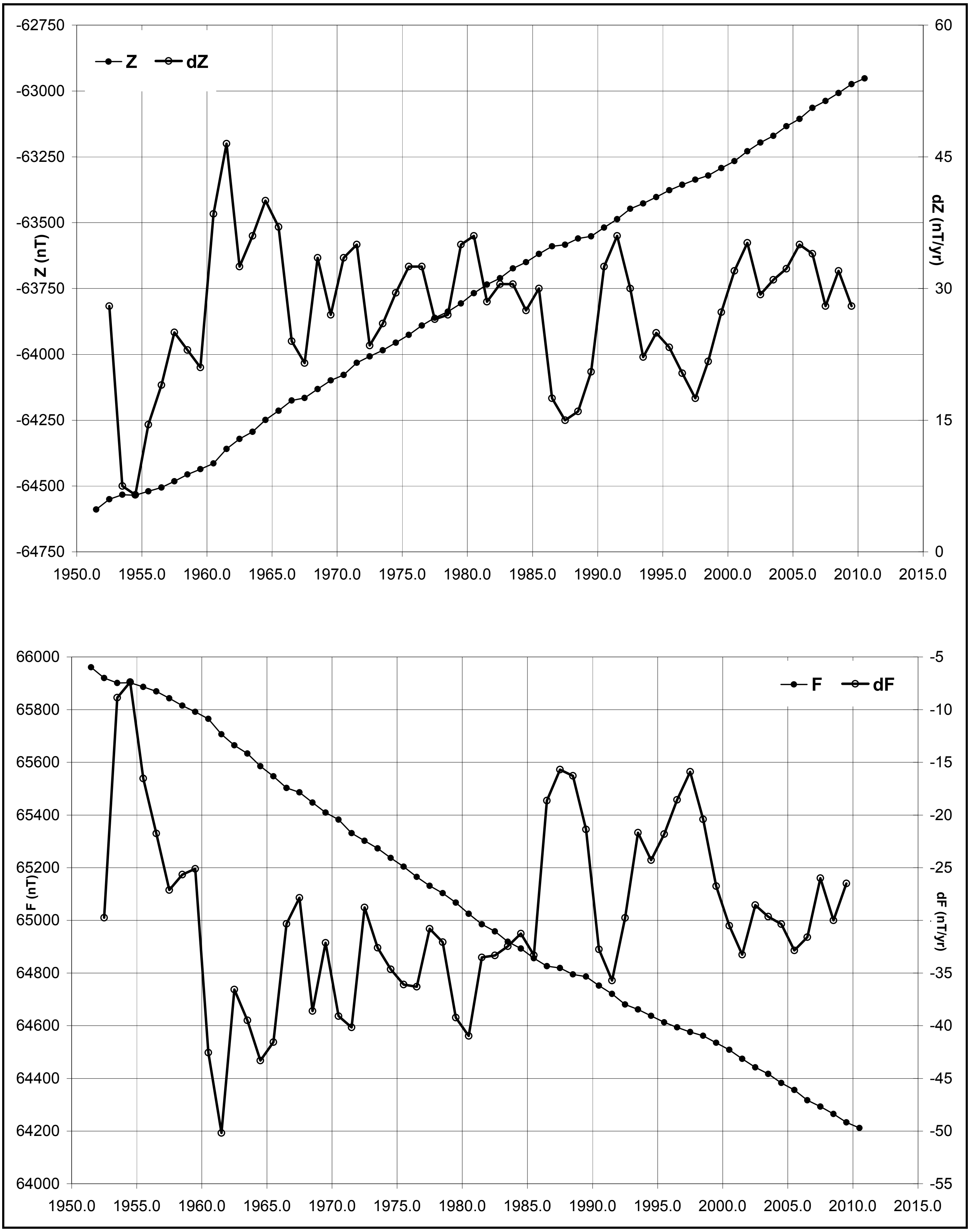
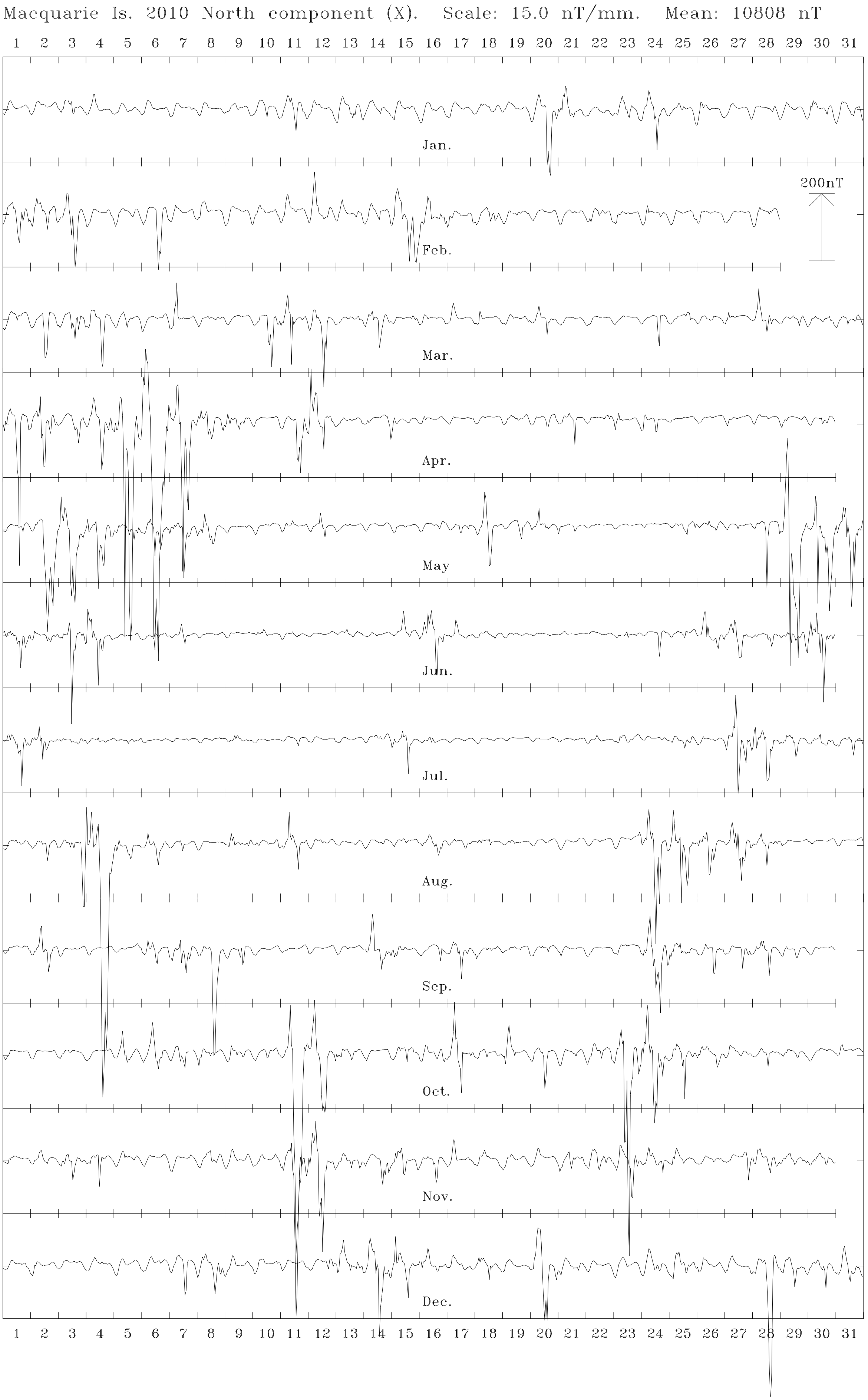
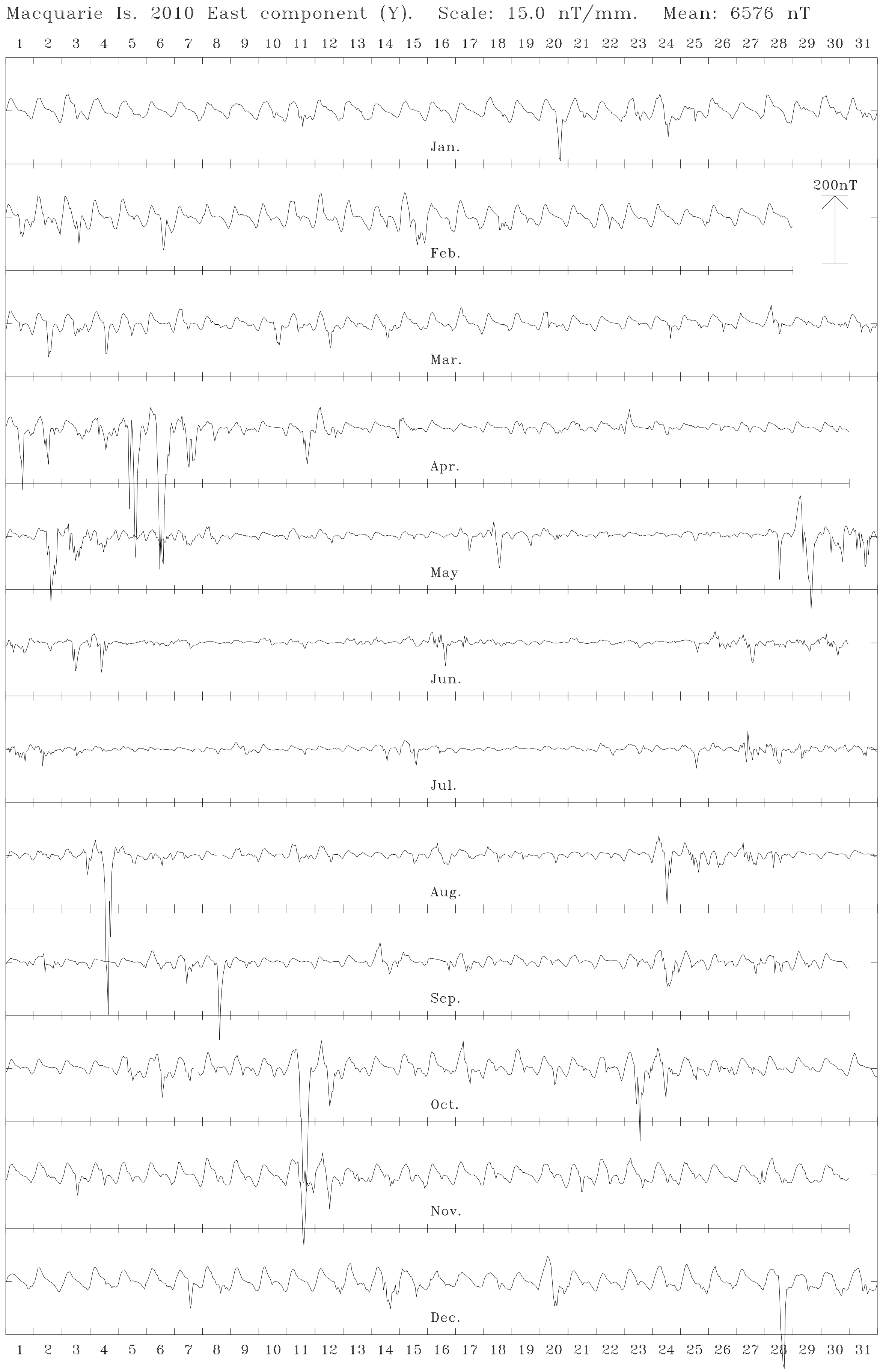


Figure 7.2. Macquarie Island annual mean values and secular variation (quiet days) for H, D, Z and F.


Macquarie Is. 2010 North component (X). Scale: 15.0 nT/mm. Mean: 10808 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
200nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Macquarie Is. 2010 East component (Y). Scale: 15.0 nT/mm. Mean: 6576 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
200nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

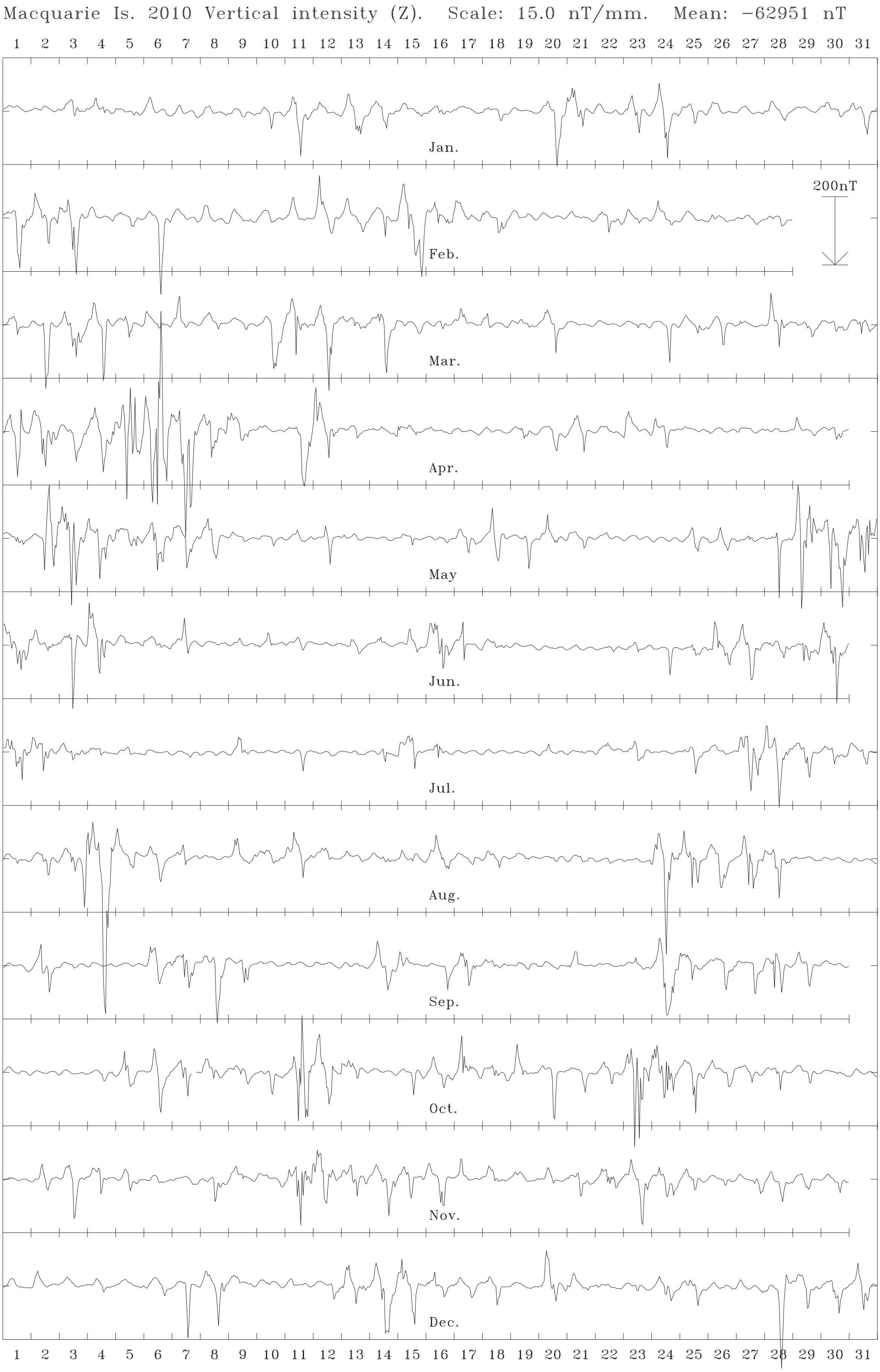

Macquarie Is. 2010 Vertical intensity (Z). Scale: 15.0 nT/mm. Mean: −62951 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
200nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Figure 7.3. Macquarie Island 2010 hourly mean values in X, Y, Z and F.

8. Mawson

The magnetic observatory is part of the Mawson scientific research station in MacRobertson 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 comprises:

- the Variometer House, and;
- the Absolute House;

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

In 1955 the Mawson observatory commenced recording magnetic variations with a 3-component analogue magnetograph. The observatory has continuously recorded the geomagnetic field at Mawson since that time. In December 1985 the magnetic observatory was converted to digital recording. It was accepted as an INTERMAGNET observatory at the start of 2006. It is operated by Geoscience Australia as part of the Australian National Antarctic Research Expeditions.

IAGA code:	MAW		
Commenced operation:	1955		
Geographic latitude:	67°	36'	14" S
Geographic longitude:	62°	52'	45" E
Geomagnetic latitude:	-73.06°		
Geomagnetic longitude:	111.94°		
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		
Observers:	E. Curtis		

Table 8.1. Key observatory data.

Variometers

The variometers used during 2010 are described in Table 8.2. The DMI sensor was located in the recording (eastern) room of the Variometer House. Two of the orthogonal sensors were horizontal and oriented so that they were each at an angle of 45° to the direction of the horizontal component of the magnetic field at the time of installation. The third sensor was aligned vertically. The Narod and total-field sensors were located within the sensor (western) room. Two of the Narod orthogonal sensors were horizontal and oriented so that they were each at an angle of 45° to the direction of the horizontal component of the magnetic field at the time of installation. The third sensor was aligned vertically. The Narod magnetometer produced eight samples per second that were Gaussian filtered and output as 1-second data on the second.

The Overhauser magnetometer was configured for 10-second sampling. During a maintenance visit to Mawson during February and March 2011, the 2010 Overhauser variometer magnetometer was replaced and returned to GA. The returned parts were GSM-90 electronics 3091319 and sensor 42175. This indicates that the sensors for the variometer and absolute GSM-90 magnetometers (42175 and 42187) have been incorrectly reported prior to 2010, probably from December 2006.

There were many variometer failures during the year starting at 2010-05-15, with evidence indicating that the Narod variometer, DMI variometer, GSM-90 variometer and acquisition computer were at fault!

The GSM-90 variometer failed on 2010-07-07. Eventually a cracked capacitor in the power supply section was replaced and it was returned to service 2010-08-16. (This GSM-90 and sensor were subsequently replaced during a maintenance visit in 2011 as a precaution.)

The Narod variometer failed irrecoverably on 2010-06-23. The sensor was removed later in 2010 and returned to GA (arriving March 2011) for connector modification and pairing with a modern version of the Narod electronics. The Narod electronics and cable were removed at a different time and returned to GA (arriving at GA May 2011).

The DMI variometer had problems 2010-06-24, 2010-07-28, 2010-10-12 and 2010-10-13, sometimes at the same time as problems with other instruments.

Suspecting the acquisition computer, acquisition was switched to the spare computer on 2010-10-15 using a new Compact Flash card.

3-component variometer:	Narod (MAW)
Serial number:	9004-1
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.025 nT
3-component variometer:	DMI FGE (MW2)
Serial number:	E0291/S0244
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.3 nT
A/D converter:	ADAM 4017 module (±10V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	3091319/42175
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS16 clock
Communications:	ANARESAT

Table 8.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

During a maintenance visit in February 2011, both acquisition computers were used (with new Compact Flash cards), recording both the DMI variometer and an upgraded Narod variometer, and a replaced GSM-90 variometer. At the time of writing this report (May 2011) the above problems had not recurred, although the new Narod variometer and its acquisition system were losing about 50 isolated 1-second records per day for unknown reasons.

The Variometer House also housed two acquisition computers, each having its own 12V battery power supply and GPS clock, and sharing a keyboard and screen using a KVM switch; an Ethernet radio link; and an uninterruptible power supply (used for 240V devices). During 2010, only one computer was used at any one time, recording all variometer data.

Sensor and the electronics temperatures of both fluxgate magnetometers were monitored by in-built dual temperature systems.

DI fluxgate:	DMI (Primary)
Serial number:	D26035
Theodolite:	Zeiss 020B
Serial number:	311542
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
DI fluxgate:	DMI (Secondary)
Serial number:	DI0022
Theodolite:	Zeiss 020B
Serial number:	353758
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081417/42187
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 8.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Temperature regulation during 2010, as in previous years, was not ideal. The heating system (a regulated heater in each sensor room) was inefficient and inadequate. Although there have been attempts to build a controlled heater for a small volume around each magnetometer sensor and each magnetometer electronics within a coarsely controlled low-temperature room environment for many of GA’s observatories, there has been little progress.

There was little correlation between the weekly temperature readings in the Narod sensor room and any of the DMI and Narod sensor and electronics recordings.

Using the nominal temperature parameters

$$\text{temperature} = 0.2\times\text{counts} - 273°\text{C}$$

the temperature of the DMI sensor fell from +12ºC at the start of 2010 to +2ºC in April and rose to 16ºC by the end of 2010. Generally the 24-hour temperature range was less than 1ºC, but was as high as 4ºC. (Average range was 0.6ºC±0.5ºC.)

The DMI electronics temperature followed a very similar pattern, ranging from +2ºC to 17ºC, with a 24-hour range as high as 8ºC. (Average range of 1.0ºC±1.0ºC.)

There was a high correlation between the DMI sensor and electronics (which were in the same room). There would be difficulty separating the sensor and electronics temperature effects in the data.

The Narod temperatures were digitised as 8-bit only. The sensor and electronics temperatures of the Narod variometer were unexpectedly similar in nature, although the two are in different rooms with different heaters. The Narod data indicated a temperature a range from +15ºC to +1ºC in April.

The DMI variometer temperature data were explainable and so the DMI data were preferred to the Narod data whenever they were available for the production of final data.

Temperature control of the variometers remains a priority in order to improve data quality.

The DMI variometer was used as the primary source of definitive data for Mawson during 2010 (with data gaps filled using Narod data where possible, although in 2010 no infill was possible). Real-time data were distributed using the Narod data early in the year. Real-time data distributed from 2010-08-10 01:16 until the end of 2010 used DMI magnetometer data.

Spike filters were used to eliminate sharp spikes in the Narod variometer data. The spike parameters required a spike to have a “spike level” at least 2 nT and 10 times the average of the following minute. Between 6 and 27 s of data per day were rejected. In the case of DMI variometer data, filtering seemed to be unnecessary although it usefully indicated periods of corrupted data which required more thorough attention. A spike filter was not useful for the scalar data as it eliminated apparently valid data during daily auroral zone activity. Consequently spike filters were not applied to either the DMI or scalar data.

As there were two variometers in use at Mawson, it was possible to compare them to gain some estimate of the limitations of the observatory data. Both variometers were calibrated using the same set of absolute measurements. The Narod variometer data were not considered to be well compensated for temperature changes, and there were significant temperature changes. The following results using 2009 data should take these factors into account. For various periods, there appeared to be a difference of about ±2 nT per annum, ±1 nT per week, ±0.5 nT per day, ±0.05nT per minute. Apart from temperature, possible influences are inaccuracies in scale values and variometer orientation.

There was also an annual difference of about 1 nT between the absolute F measurements in the Absolute House and the variometer F measurements. The difference follows a regular seasonal curve – it is either a real physical effect or some calibration problem with one or both GSM-90 instruments (e.g. temperature coefficient). This difference shows in the annual FCheck for definitive data.

The scalar variometer GSM-90 performed satisfactorily throughout much of 2010, although was unavailable from 2010-07-07 to 2010-08-16 while a fault in the power supply remained unresolved.

The meteorological temperature at Mawson during 2010 varied from a minimum -33ºC (2010-07-07) to a maximum of +6ºC (2010-12-18). Daily minimum temperatures varied from -33ºC to +1ºC (average -15±8ºC); daily maximum temperatures varied from -28ºC to +6ºC (average -9±8ºC); daily temperature range varied from 0ºC to 17ºC (average 6±3ºC). The daily maximum wind gust varied from 17 to 189 km/h (average 83±29 km/h). The maximum daily maximum wind gust was 189 km/h in October. The minimum daily maximum wind gust was 17 km/h in October. Almost every day was windy due to either blizzard or katabatic conditions.

Absolute instruments

The principal absolute magnetometers used at Mawson and their adopted corrections for 2010 are described in Table 8.3. The GSM-90 sensor 42187 was used. Hitchman *et al.* (2010) indicated that sensor 42175 was used for absolutes, but this seems to be incorrect. As noted in *Variometers* above, it appears that the sensors were reported incorrectly from December 2006.

The DIM derived sensor-orientation angles δ and ε appeared to be stable until June 2010. Thereafter, these angles (especially the horizontal angle δ) appeared to vary during the pair of weekly observations, and δ slowly drifted from -6' in September to -10' in December. Several attempts were made to find the cause of the variation during the pairs of weekly observations (it was thought that the cause was sensor hysteresis), but during annual processing it appeared that the problem may have been a loose sensor. Otherwise the DIM performed well.

The absolute GSM-90 performed well. The difference between the sets of 12 absolute GSM-90 readings and DMI vector variometer had an annual average standard deviation of 0.27 nT. The difference between the sets of 12 absolute GSM-90 readings and GSM-90 scalar variometer had an annual average standard deviation of 0.13 nT.

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 Mawson absolute instruments for 2010, as was the case for 2009, as no new evidence about corrections was gathered. At the 2010 mean magnetic field values at Mawson these D, I and F corrections translate to corrections of:

$\Delta X = 0.0$ nT $\Delta Y = 0.0$ nT $\Delta Z = 0.0$ nT

Instrument corrections were applied while reducing absolute observations to determine baselines and, accordingly, these corrections have been applied to all Mawson 2010 final data.

Baselines

An automated procedure which fits a linear spline curve to the baseline residuals was used to derive final baseline parameters for the Narod and DMI variometers.

The standard deviations of the differences between the adopted variometer model and data using DMI variometer (used for definitive data), and the absolute observations, were:

	σ		σ
X	1.0 nT	D	11"
Y	0.9 nT	I	4"
Z	0.7 nT	F	0.6 nT

(Using 89 observations on 45 days and excluding a pair of observations on 2010-04-21.)

Observed and adopted baseline values in X, Y and Z are shown in Figure 8.1.

For comparison, the standard deviations between the adopted variometer model and data using Narod variometer, and the absolute observations, were:

	σ		σ
X	0.9 nT	D	10"
Y	1.2 nT	I	5"
Z	0.5 nT	F	0.5 nT

(Using 44 observations on 22 days and excluding a pair of observations on 2010-04-21. The Narod failed in June 2010.)

Operations

The 2010 Mawson observer was jointly employed by Geoscience Australia and the Australian Antarctic Division. He was a member of the Australian National Antarctic Research Expedition. Mawson personnel change over each summer with varying periods of overlap. Ewan Curtis took over responsibility for the observatory from Dave Gillies in late November (nominally 25th) 2009 and handed over responsibility to Ian Phillips in late February/early March (nominally 1st March) 2011.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. In 2010 the observers performed absolute observations weekly and forwarded them by email to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

During 2010 data were recorded on a QNX acquisition computer which was directly connected to the station's radio network hub. Data were retrieved to Geoscience Australia using *rsync* over *ssh* at least every 12 minutes, but normally every 6 minutes. (Data from the alternate variometer system were also retrieved every 6 minutes, interleaved with the primary variometer.)

There were many electronic problems during 2010 which remain unexplained. They included a blown fuse in a telemetry link, a blown capacitor in the variometer GSM-90, the hard failure of the Narod variometer, and intermittent problems in the acquisition computer, DMI, Narod, and GSM-90 variometers. The computer was replaced but returned to service successfully in 2011. The GSM-90 variometer was repaired and successfully returned to service, although replaced in 2011 for data security. The Narod was removed from service and replaced in 2011 with a modern version of the Narod magnetometer. The DMI variometer was left in service and its problems have not reappeared.

Real-time data were processed automatically at Geoscience Australia then distributed, usually within a 2 to 15-minute delay. The QNX acquisition computer used a GPS clock (both pulse-per-second and absolute-time-code) to set the system time. The clock was checked from Geoscience Australia regularly to ensure it was working. If not, it was reset remotely or, if necessary, the computer was re-booted.

On the following 13 occasions, there were corrections in excess of 10 ms:

2010-03-22	04:13:06 +0.762s System reboot as Clock program failed
2010-06-23	04:24:18 +1.393s System reboot in unsuccessful attempt to recover Narod (and GSM-90) data
2010-06-24	04:14:54 +0.670s System reboot in attempt to recover Narod DMI and GSM-90 data
2010-07-08	03:23:36 +0.710s System reboot in attempt to recover DMI and GSM-90 data
2010-07-08	10:21:48 +1.025s System reboot in attempt to recover DMI and GSM-90 data
2010-08-30	03:45:06 +1.029s System reboot as Clock program failed
2010-10-11	04:27:06 +0.352s System reboot as Clock program failed
2010-10-12	22:37:42 +0.934s System reboot as Clock program failed
2010-10-13	01:56:53 +1.100s System reboot in attempt to resolve widespread system failure
2010-10-13	04:22:06 +1.243s System reboot in attempt to resolve widespread system failure
2010-10-13	06:02:30 +0.344s System reboot in attempt to resolve widespread system failure
2010-10-13	22:39:08 +0.277s System reboot in attempt to resolve widespread system failure
2010-10-15	06:32:27 +108.8 day Switched to alternate computer – first boot for years?

There were 7 corrections between 1and 2 ms on:

- June 23
- November 17, 17, 26
- December 4, 8, 12

and 1 correction between 2 and 10 ms on:

- November 12

The rate of the system clock was adjusted to better than 1ppm before the computer was switched on on 2010-10-15. Thereafter it was about 17ppm.

In earlier years static-electricity sparks (originating from very dry blown snow during the severe blizzards that are common at

Mawson) occasionally halted the acquisition computer. Whether any of the problems in 2010 could be attributed to blizzards is unknown.

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

During 2010, the INTERMAGNET filter was applied to convert 1-second vector real-time and final data to 1-minute data (except as noted below). A box filter (±30seconds from the minute mark) was applied to scalar data. Until 2010-08-23 01:29, a -1 s time correction was applied to the scalar data as recorded to align them better with the vector data. After that time, data acquisition parameters made that same correction at the time of recording, and further altered the instrument triggering to better align the data with the 10-second time marks.

The distribution of Mawson 2010 data is described in Table 8.4. Data losses are identified in Table A.8.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2011

Table 8.4. Distribution of Mawson 2010 data.

Significant events

2010-03-21 GdapClock failed
21/03/10 09:20:01 - CLK W 0 Lost contact with Gm16 RESET

2010-03-22 04:11:30 shutdown
22/03/10 04:13:06 - CLK I 0 Correction 1269231186 781885664 C 0 s 762080876 R 0 s -791
22/03/10 04:13:48 - CLK I 0 Correction 1269231228 782040240 C 0 s -19588 R 0 s -687

2010-04-21 Changes to the heater configuration (one light turned permanently on)

2010-04-29 Ewan's comment is that temperature has recovered somewhat after heater configuration changes
The obs from last week stands out - it may be valid though if the change was temperature related.

2010-05-15 Narod ceased being recorded at about 16:40.

2010-05-17 Found that Narod was still producing some binary output, restarting GdapNGL didn't work, but sensing a Ctrl-C to it using qtalk then restarting GdapNGL started data coming in.
Continuing segmentation faults causing a failure in real-time data delivery.

2010-05-19 NGL data stopped about 06:35. Same symptoms as a few days ago.

2010-05-20 GdapNGL restarted after qtalk/CtrlC at about 00:48

2010-06-16 Tested ppmtcor parameter to get phase right between vector and scalar data.
It seems that -.75s or -1s gives better results.

2010-06-23 NGL data stopped about 01UT. Tried at ~04:10 to stop/restart GdapNGL, qtalk to NGL and ^C to reset it. Some data came out, but stopped very quickly.
The GSM90 data is also sparse.
Tried reboot on computer, no improvement.
Asked Ewan to power down/up the NGL

2010-06-24 04:13 shutdown - there was no NGL since yesterday and now no DMI data either.
(GSM90 was coming in although it was intermittent for several hours yesterday)
Result: several seconds of NGL data then none, and DMI data resumed (with GSM-90)

2010-07-07 PPM data stops about 14:56, DMI data stops about 16:52

2010-07-08 Qtalk to PPM - no response, qtalk to DMI - seems OK
restart serial drivers - no improvement
reboot computer DMI restarts, but there is a short period of 2 samples per second with alternate samples having a value of 0.

2010-07-09 Ewan cycles power on Narod - no improvement
Checks GSM-90 with PDA - no response. DMI, battery boxes and UPS are working.
Later checks with GSM-90 variometer confirmed there is no response from the electronics.

2010-07-28 09:14 MW2 ceases delivering data
23:14 slay GdapAdam, check /dev/ser8 with qtalk, restart GdapAdam -> MW2 restarted

2010-08-10 Changed XgetObsRsync.TailSub to recode "mw2" variometer to "maw" Oracle data.
No change to variometer acquisition, all mw2 rawhdata files still intact - just data loaded into Oracle MAW from 01:16 will be mw2/DMI data and not the non-exisitent maw/NGL data.

2010-08-16 News from Ewan - Dan found/replaced a cracked capacitor in the power supply in the GSM-90.
Restarted the driver at end of 2010-08-16 and the variometer F data commenced again.
Hysteresis tests on DIM showed a change of 2.8 nT between readings, but they were not correlated to the hysteresis settings.

2010-08-23 01:27 changed GSM-90 driver to version 2, partly to overcome data losses starting yesterday.
GdapGSM90 -P20 -d/dev/ser1 -ttfi -C10 -TT49 & changed to
GdapGSM90 -P20 -d/dev/ser1 -ttfi -C10 -TT49 -b -w 1.00 -l 2.50 -l 1.00 -q ab & then soon after changed to
GdapGSM90 -P20 -d/dev/ser1 -ttfi -C10 -TT49 -b -w 1.00 -l 4.00 -l 1.00 -q ab &
Note now quality "a" and "b" accepted, and long polarise used, and DELAYS implemented to get F at the 10s.

2010-08-28 28/08/10 13:40:01 - CLK W 0 Lost contact with Gm16 RESET

2010-08-30 ga-maw-mag1 # GdapClock -v5 -L/tmp/ -P50 -c600 -mGM_GPS16 -i3 -p0x2f8 -d/dev/ser2 >/dev/null 2>&1 &
[1] 555294734
ga-maw-mag1 # tail -f /tmp/Mon.log
30/08/10 03:23:48 - CLK I 0 Power Up 2138564
30/08/10 03:36:00 - CLK I 0 Started
30/08/10 03:36:00 - CLK I 0 Power Up 2138565
03:43 shutdown
30/08/10 03:44:02 - CLK I 0 Started
30/08/10 03:45:06 - CLK I 0 Correction 1283139906 48205584 C 1 s 28838980 R 0 s -828
30/08/10 03:45:48 - CLK I 0 Correction 1283139948 48358164 C 0 s -8503 R 0 s -785

2010-10-09 04:00 clock failed
Also over weekend processing system failures (Oracle problems etc) caused data not to be loaded

	and some h files including h10281??.mw2 were corrupted at sun-geomag end of the line.
2010-10-11	04:25 shutdown to fix clock 11/10/10 04:27:06 - CLK I 0 Correction 1286771226 372119210 C 0 s 352099415 R 0 s -763 11/10/10 04:27:48 - CLK I 0 Power Down 2144618 1 0 -13266 11/10/10 04:27:48 - CLK I 0 Correction 1286771268 372274784 C 0 s -13266 R 0 s -843
2010-10-12	DMI data ceased at 20:52:42. System running O.K. Slay and restart GdapAdam 22:18:50 - data recommences Stops again at 22:20:26 Slay and restart GdapAdam 22:32:20 - stops again after about 1 minute reboot about 22:38 12/10/10 22:37:42 - CLK I 0 Correction 1286923062 952750550 C 0 s 933929427 R 0 s -795 12/10/10 22:38:24 - CLK I 0 Correction 1286923104 952905126 C 0 s -16825 R 0 s -793
2010-10-13	~01:55 shutdown again after many driver restarts to try and fix "stopping vector data" - it doesn't seem to be a problem with the DMI - perhaps a memory fault?
2010-10-13	22:35 Reboot system - gets DMI data running, but still no PPM data.
2010-10-15	06:15-06:30 (approx) Acquisition computer changed to spare. PPM restarted O.K. after cycling power
2010-11-10	06:50 lost contact with GPS clock
2010-11-10	at 23:59:16 restarted GdapClock 12/11/10 00:04:52 - CLK I 0 Correction 1289520292 406722234 C 0 s -9545118 R 0 s 16222 12/11/10 00:05:34 - CLK I 0 Correction 1289520334 398044510 C 0 s 366515 R 0 s 16291
2010-12-20	Power failure caused blown fuse in wireless radio telemetry link - fuse replaced

Annual mean values

The annual mean values for Mawson are set out in Table 8.5 and displayed with the secular variation in Figure 8.2.

Hourly mean values

Plots of the hourly mean values for Mawson 2010 data are shown in Figure 8.3.

K indices

Table 8.6 shows Mawson K indices for 2010. They have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. K indices were scaled from preliminary data from the Narod variometer until 2010-06-22 (with missing data filled with DMI data 2010-05-15 to 10-05-20), and preliminary data from the DMI variometer from 2010-06-23 until the end of 2010. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 8.7.

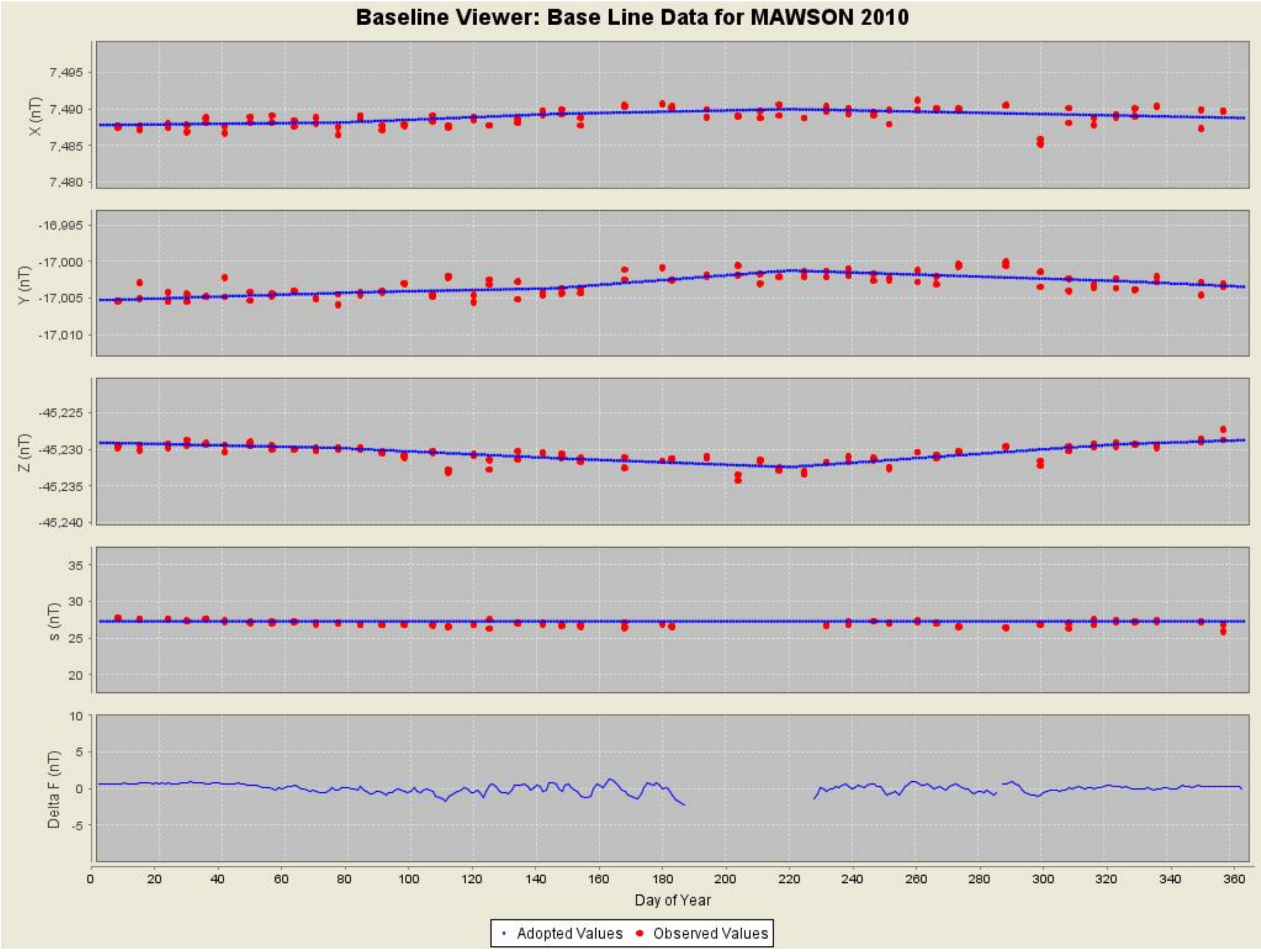
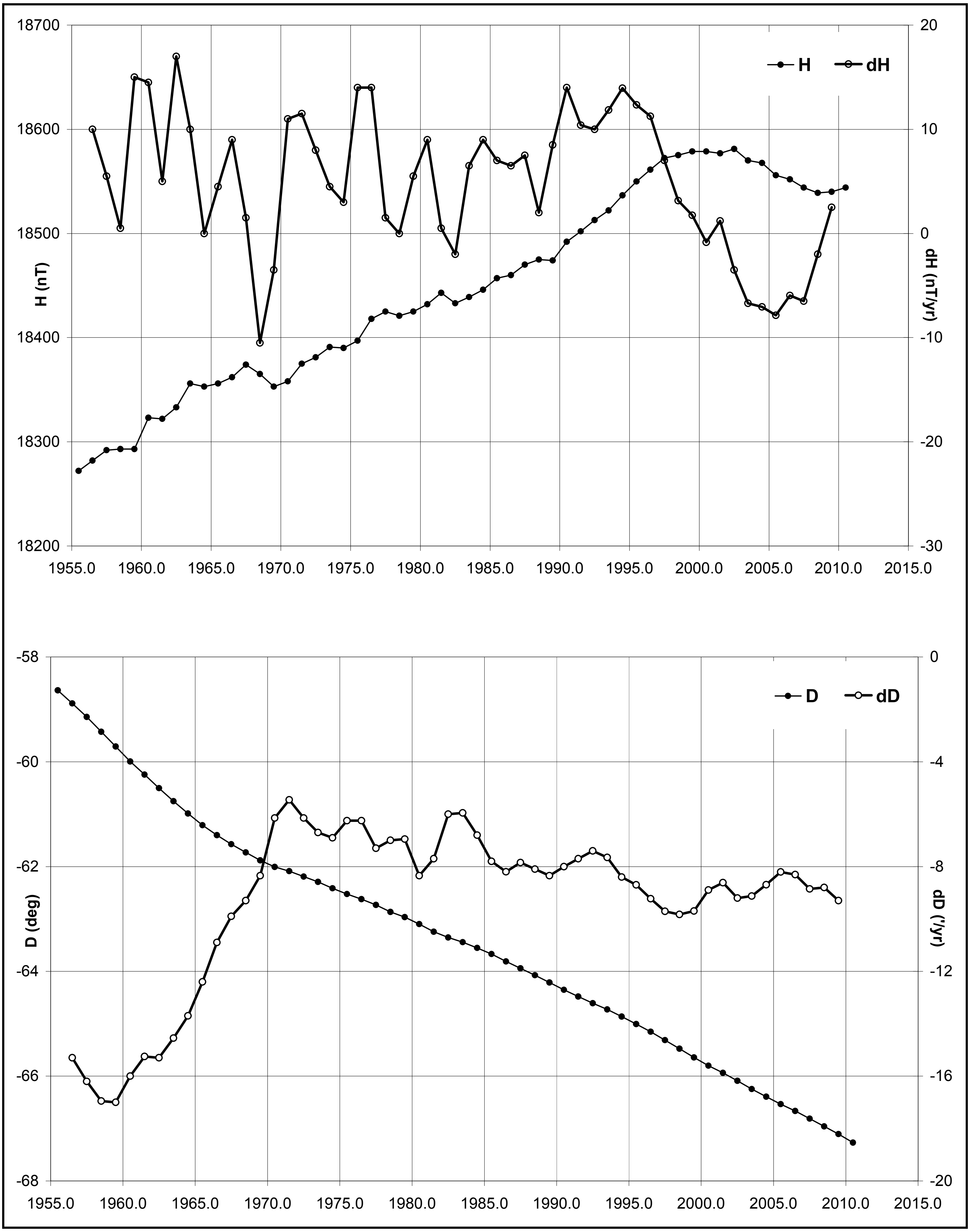


Figure 8.1. Mawson 2010 baseline plots.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)	
1955.5		-58	38.1	-69	33.3	18272	9510	-15602	-49012	52307	DHZ
1956.5		-58	53.2	-69	32.5	18282	9447	-15652	-49006	52305	DHZ
1957.5		-59	08.7	-69	31.1	18292	9381	-15703	-48974	52279	DHZ
1958.5		-59	25.6	-69	30.3	18293	9305	-15750	-48940	52247	DHZ
1959.5		-59	42.6	-69	28.5	18293	9227	-15796	-48860	52172	DHZ
1960.5		-59	59.6	-69	25.2	18323	9163	-15867	-48800	52127	DHZ
1961.5		-60	14.6	-69	23.1	18322	9094	-15906	-48707	52039	DHZ
1962.5		-60	30.1	-69	21.1	18333	9027	-15956	-48650	51990	DHZ
1963.5		-60	45.2	-69	17.6	18356	8968	-16016	-48562	51915	DHZ
1964.5		-60	59.2	-69	15.4	18353	8901	-16050	-48460	51819	DHZ
1965.5		-61	12.6	-69	13.1	18356	8840	-16087	-48368	51734	DHZ
1966.5		-61	24.0	-69	09.6	18362	8790	-16122	-48235	51612	DHZ
1967.5		-61	34.4	-69	07.2	18374	8747	-16159	-48168	51553	DHZ
1968.5		-61	43.8	-69	05.2	18365	8698	-16175	-48060	51449	DHZ
1969.5		-61	53.0	-69	03.4	18353	8649	-16187	-47954	51346	DHZ
1970.5		-62	00.5	-69	00.4	18358	8616	-16210	-47840	51241	DHZ
1971.5		-62	05.3	-68	56.4	18375	8602	-16237	-47719	51135	DHZ
1972.5		-62	11.4	-68	53.1	18381	8575	-16258	-47600	51026	DHZ
1973.5		-62	17.6	-68	49.7	18391	8551	-16282	-47486	50923	DHZ
1974.5		-62	24.8	-68	47.2	18390	8516	-16299	-47380	50824	DHZ
1975.5		-62	31.4	-68	44.0	18397	8488	-16322	-47269	50723	DHZ
1976.5		-62	37.3	-68	40.0	18418	8470	-16355	-47157	50626	DHZ
1977.5		-62	43.9	-68	36.9	18425	8442	-16377	-47051	50530	DHZ
1978.5		-62	51.9	-68	35.5	18421	8402	-16393	-46986	50468	DHZ
1979.5		-62	57.9	-68	32.9	18425	8375	-16412	-46890	50380	DHZ
1980.5		-63	05.8	-68	29.8	18432	8340	-16437	-46784	50284	DHZ
1981.5		-63	14.6	-68	27.1	18443	8303	-16468	-46705	50215	DHZ
1982.5		-63	21.2	-68	25.5	18433	8267	-16475	-46616	50128	DHZ
1983.5		-63	26.6	-68	22.3	18439	8244	-16494	-46503	50025	DHZ
1984.5		-63	33.1	-68	19.3	18446	8216	-16515	-46404	49936	DHZ
1985.5		-63	40.2	-68	17.0	18457	8186	-16542	-46342	49882	DHZ
1986.5		-63	48.7	-68	15.1	18460	8147	-16565	-46276	49822	XYZ
1987.5		-63	56.6	-68	12.5	18470	8113	-16593	-46198	49753	XYZ
1988.5		-64	04.4	-68	10.7	18475	8078	-16616	-46142	49703	XYZ
1989.5		-64	12.8	-68	09.7	18474	8037	-16634	-46099	49663	XYZ
1990.5		-64	21.1	-68	06.4	18492	8004	-16670	-46015	49592	XYZ
1991.5		-64	28.8	-68	04.2	18502	7971	-16697	-45957	49542	XYZ
1992.5	A	-64	36.9	-68	02.8	18499	7930	-16712	-45894	49482	XYZ
1993.5	A	-64	44.2	-68	00.7	18506	7898	-16736	-45830	49426	XYZ
1994.5	A	-64	52.9	-67	59.4	18511	7858	-16760	-45794	49394	XYZ
1995.5	A	-65	00.9	-67	56.7	18532	7828	-16798	-45741	49352	XYZ
1996.5	A	-65	09.8	-67	54.5	18548	7791	-16833	-45698	49319	XYZ
1997.5	A	-65	19.4	-67	53.0	18560	7749	-16865	-45670	49297	XYZ
1998.5	A	-65	29.1	-67	52.4	18561	7702	-16887	-45648	49278	XYZ
1999.5	A	-65	39.0	-67	51.5	18561	7653	-16910	-45618	49250	XYZ
2000.5	A	-65	48.2	-67	50.6	18566	7610	-16935	-45594	49230	XYZ
2001.5	A	-65	56.2	-67	49.8	18567	7571	-16953	-45565	49203	XYZ
2002.5	A	-66	05.8	-67	49.3	18568	7524	-16975	-45546	49185	ABZ
2003.5	A	-66	15.6	-67	50.7	18546	7466	-16976	-45546	49177	ABZ
2004.5	A	-66	24.1	-67	49.6	18549	7426	-16998	-45514	49149	ABZ
2005.5	A	-66	33.0	-67	50.1	18535	7376	-17004	-45499	49129	ABZ
2006.5	A	-66	40.8	-67	49.3	18536	7338	-17022	-45472	49105	ABZ
2007.5	A	-66	49.2	-67	49.2	18533	7295	-17037	-45460	49093	ABZ
2008.5	A	-66	58.1	-67	49.4	18528	7249	-17051	-45454	49085	ABZ
2009.5	A	-67	06.6	-67	48.9	18533	7209	-17073	-45448	49082	ABZ
2010.5	A	-67	16.8	-67	49.5	18531	7157	-17093	-45466	49097	ABZ
1992.5	Q	-64	36.5	-68	01.7	18513	7938	-16724	-45885	49479	XYZ
1993.5	Q	-64	43.6	-67	59.4	18522	7908	-16749	-45819	49422	XYZ
1994.5	Q	-64	51.8	-67	57.4	18537	7874	-16781	-45779	49389	XYZ
1995.5	Q	-65	00.4	-67	55.3	18550	7838	-16813	-45731	49350	XYZ
1996.5	Q	-65	09.2	-67	53.5	18561	7799	-16843	-45692	49318	XYZ
1997.5	Q	-65	18.9	-67	52.0	18572	7757	-16875	-45663	49295	XYZ
1998.5	Q	-65	28.6	-67	51.3	18575	7710	-16900	-45642	49277	XYZ
1999.5	Q	-65	38.5	-67	50.2	18579	7663	-16925	-45611	49250	XYZ
2000.5	Q	-65	48.0	-67	49.6	18579	7616	-16946	-45585	49225	XYZ

2001.5	Q	-65	56.3	-67	48.9	18577	7574	-16963	-45555	49198	XYZ
2002.5	Q	-66	05.2	-67	48.2	18581	7532	-16986	-45540	49185	ABZ
2003.5	Q	-66	14.7	-67	48.7	18570	7480	-16997	-45532	49174	ABZ
2004.5	Q	-66	23.5	-67	48.1	18568	7436	-17014	-45503	49146	ABZ
2005.5	Q	-66	32.1	-67	48.4	18557	7389	-17022	-45488	49127	ABZ
2006.5	Q	-66	39.9	-67	48.1	18552	7349	-17035	-45465	49105	ABZ
2007.5	Q	-66	48.7	-67	48.4	18544	7302	-17046	-45455	49092	ABZ
2008.5	Q	-66	57.6	-67	48.6	18539	7256	-17060	-45450	49085	ABZ
2009.5	Q	-67	06.3	-67	48.4	18540	7213	-17080	-45447	49083	ABZ
2010.5	Q	-67	16.2	-67	48.5	18544	7165	-17104	-45460	49097	ABZ
1992.5	D	-64	39.6	-68	05.2	18466	7904	-16689	-45907	49482	XYZ
1993.5	D	-64	45.9	-68	03.0	18476	7877	-16713	-45847	49430	XYZ
1994.5	D	-64	55.3	-68	01.9	18476	7831	-16734	-45804	49390	XYZ
1995.5	D	-65	01.7	-67	58.8	18504	7812	-16774	-45752	49353	XYZ
1996.5	D	-65	11.1	-67	56.2	18525	7775	-16814	-45707	49318	XYZ
1997.5	D	-65	20.4	-67	55.0	18534	7733	-16844	-45682	49299	XYZ
1998.5	D	-65	30.9	-67	54.8	18530	7680	-16864	-45665	49282	XYZ
1999.5	D	-65	41.0	-67	53.9	18528	7630	-16884	-45626	49245	XYZ
2000.5	D	-65	49.7	-67	52.6	18543	7593	-16917	-45614	49239	XYZ
2001.5	D	-65	56.4	-67	51.6	18547	7561	-16935	-45583	49212	XYZ
2002.5	D	-66	07.6	-67	51.2	18540	7504	-16953	-45552	49180	ABZ
2003.5	D	-66	17.4	-67	53.2	18510	7443	-16947	-45556	49173	ABZ
2004.5	D	-66	26.0	-67	52.1	18517	7403	-16972	-45530	49152	ABZ
2005.5	D	-66	35.4	-67	53.4	18492	7347	-16970	-45516	49129	ABZ
2006.5	D	-66	42.6	-67	51.6	18504	7316	-16997	-45482	49102	ABZ
2007.5	D	-66	50.0	-67	50.7	18512	7282	-17019	-45463	49087	ABZ
2008.5	D	-66	59.2	-67	51.0	18506	7235	-17034	-45461	49084	ABZ
2009.5	D	-67	07.3	-67	49.9	18520	7200	-17063	-45454	49082	ABZ
2010.5	D	-67	17.8	-67	51.2	18508	7143	-17074	-45475	49097	ABZ

Table 8.5. Mawson annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 8.2.


H
dH
H (nT)
dH (nT/yr)
D
dD
D (deg)
dD ('/yr)

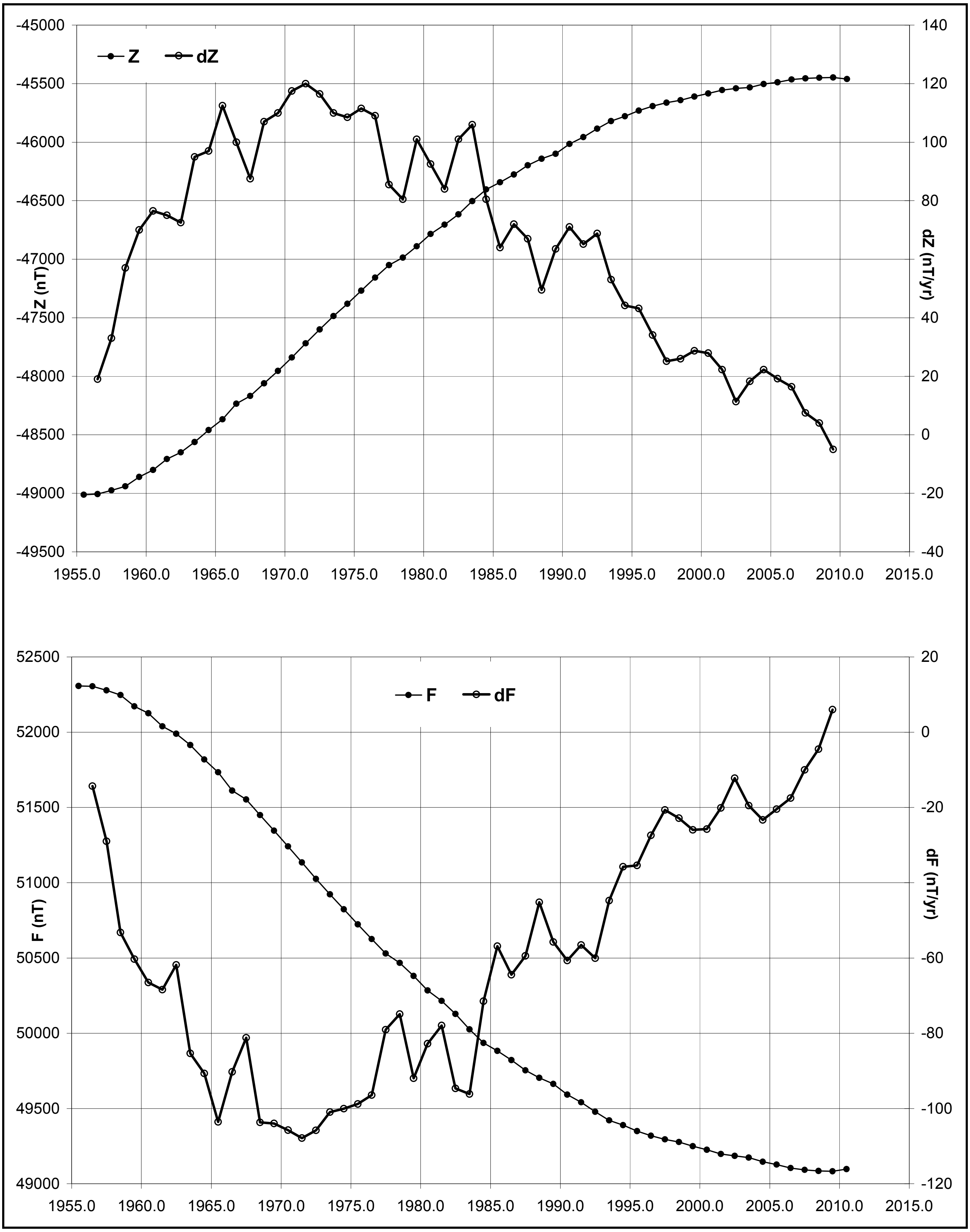


Figure 8.2. Mawson annual mean values and secular variation (quiet days) for H, D, Z and F.

Day	January			February			March			April			May			June		
01	2100	0102	6	4333	4346	30	2211	2213	14	5532	5426	32	3211	1231	14	7544	3266	37
02	2001	2013	9	5433	3335	29	1101	3325	16	5455	3365	36	3213	6577	34	5533	3265	32
03	2313	3303	18	5333	3353	28	4422	3454	28	5322	3655	31	6654	3576	42	4444	3256	32
04	2222	1102	12	5320	1134	19	3642	2334	27	5442	3467	35	5444	3265	33	6744	3254	35
05	3211	2221	14	3310	2223	16	1122	3213	15	5467	5665	44	3433	4475	33	3432	1145	23
06	4431	1112	17	2312	4644	26	5210	1334	19	6653	4747	42	2454	3465	33	4323	1135	22
07	2110	0122	9	3220	0135	16	4441	1023	19	6454	4577	42	3443	3466	33	2222	2224	18
08	4310	0111	11	5522	1002	17	1310	0143	13	7544	3257	37	5542	2154	28	2121	1111	10
09	0111	1111	7	4311	1233	18	1111	1223	12	5432	2244	26	5300	0131	13	3221	1114	15
10	3111	2211	12	3422	1144	21	4221	3556	28	3210	3034	16	3300	2222	14	4423	2113	20
11	3333	3343	25	3332	2124	20	6444	3253	31	3310	4656	28	4322	2255	25	5322	2214	21
12	4322	2244	23	4542	2324	26	6653	2365	36	6642	1345	31	2321	3204	17	2100	0012	6
13	6642	3334	31	4431	1254	24	4220	1154	19	2122	1115	15	4121	0012	11	1131	2244	18
14	4422	3143	23	4422	3015	21	6323	3355	30	3421	1228	23	1120	0122	9	3321	1135	19
15	2211	2256	21	5543	4556	37	2000	0242	10	6432	2111	20	4422	1102	16	3223	3336	25
16	2211	1003	10	3332	1245	23	3221	2115	17	1412	1111	12	3211	0242	15	6654	3364	37
17	2221	1112	12	4431	1016	20	4532	2216	25	3221	0055	18	4531	2355	28	5454	2245	31
18	2211	2223	15	2102	3543	20	5410	1025	18	4321	1023	16	5334	3333	27	3453	2221	22
19	2001	1111	7	4412	2222	19	2011	1235	15	3332	2244	23	2122	2334	19	2111	1224	14
20	2122	4846	29	1100	0100	3	3331	2330	18	3221	2355	23	6443	3326	31	2110	0114	10
21	3432	3202	19	1000	1122	7	2220	0013	10	3343	3223	23	5331	1111	16	3231	0121	13
22	2411	2124	17	4522	2234	24	0000	0000	0	2222	2164	21	1232	0001	9	1221	1234	16
23	4342	3224	24	4331	1002	14	1110	0012	6	7542	2135	29	3010	1002	7	3201	2132	14
24	3443	3343	27	3321	1154	20	2000	3335	16	5321	2231	19	0000	0010	1	0010	0264	13
25	3222	2115	18	5311	1144	20	3421	1243	20	3321	0114	15	1111	2216	15	4222	1334	21
26	4422	2223	21	5210	0000	8	2211	2005	13	3000	2200	7	1211	2134	15	4664	3356	37
27	3111	1113	12	0110	0120	5	4410	0100	10	4220	1211	13	2110	1201	8	4644	3366	36
28	4422	3234	24	0120	1001	5	1542	1214	20	1111	1114	11	2321	3226	21	4534	2353	29
29	3311	1003	12				3211	2146	20	5521	1144	23	6642	2365	34	3544	3247	32
30	4412	2234	22				5321	0265	24	3211	1224	16	5563	3477	40	6764	3367	42
31	5222	2234	22				5421	1435	25				4554	4476	39			

Day	July			August			September			October			November			December		
01	3544	4575	37	4222	2125	20	2110	0135	13	4300	0103	11	2122	2113	14	4201	1243	17
02	5454	3255	33	3443	2235	26	4333	3344	27	2000	0000	2	1122	2222	14	5421	0014	17
03	4412	3455	28	4432	2377	32	5211	0013	13	2300	0110	7	4521	2354	26	2100	0033	9
04	4333	3232	23	7646	6678	50	2100	1024	10	0010	0013	5	4321	2200	14	2212	2021	12
05	1333	1234	20	5432	3334	27	2201	0116	13	3323	2321	19	1102	2223	13	1100	0014	7
06	4311	0012	12	3433	1343	24	4432	2265	28	3122	4552	24	2100	1134	12	2221	1214	15
07	2100	0---	-	2222	2103	14	5434	3435	31	2111	2214	14	3200	1042	12	3222	3354	24
08	--00	1235	-	3111	0011	8	3322	6555	31	6432	1112	20	2111	2333	16	3422	3463	27
09	3323	2254	24	5543	4354	33	1002	3314	14	4321	1232	18	3411	1112	14	3312	2103	15
10	2000	0000	2	4422	2226	24	3221	0001	9	2001	2235	15	2000	0255	14	2111	1112	10
11	0100	1205	9	6442	3354	31	2130	0001	7	2333	5553	29	3324	4455	30	4321	1013	15
12	3110	0035	13	4321	2115	19	1120	0013	8	5453	344-	-	5553	3356	35	1220	1335	17
13	4110	0003	9	3431	1123	18	2100	0231	9	----	----	-	5332	2264	27	5542	2355	31
14	3111	3226	19	2110	1233	13	2332	3366	28	2210	0003	8	3322	3466	29	3534	5566	37
15	7443	3335	32	5412	2135	23	6224	0005	19	3212	1133	16	4533	1215	24	5433	4343	29
16	3132	4124	20	4332	2353	25	3210	2372	20	4320	2366	26	4422	3311	20	4433	2334	26
17	1000	0004	5	3421	1355	24	2334	2254	25	3533	2156	28	2432	2144	22	5411	2344	24
18	2000	0101	4	2321	1101	11	3321	0223	16	5310	0265	22	4432	3244	26	2522	2224	21
19	3000	0000	3	3311	2134	18	2210	1114	12	5541	2115	24	2211	1001	8	4322	0113	16
20	3311	0124	15	1000	0224	9	4210	0121	11	5322	2143	22	1332	1123	16	3655	3335	33
21	2220	0111	9	2110	0004	8	3442	1002	16	4311	2213	17	5212	2344	23	3322	2222	18
22	4322	2312	19	2000	0003	5	2200	0023	9	1322	2225	19	4323	3333	24	1101	2202	9
23	2532	2221	19	2010	0012	6	3332	1133	19	3534	5567	38	3443	3554	31	3211	1000	8
24	1110	0135	12	4454	4456	36	4444	3447	34	5534	3476	37	4332	3453	27	2331	3321	18
25	4212	2335	22	4644	4456	37	5443	2145	28	4433	3264	29	3432	3222	21	5413	2353	26
26	5432	1134	23	5554	3355	35	4122	2265	24	4422	2465	29	2100	1141	10	3211	3143	18
27	7545	3367	40	2554	3537	34	4112	2366	25	3322	2153	21	1111	2375	21	4210	0224	15
28	544-	----	-	4453	3245	30	3344	2243	25	2122	1142	15	4422	2355	27	3323	5532	26
29	2444	3225	26	3112	1003	11	2522	1101	14	4421	2113	18	2422	2252	21	4322	2241	20
30	3432	2346	27	3000	0001	4	1101	1104	9	1102	1212	10	4221	2233	19	1011	3334	16
31	4312	4213	20	0120	0004	7				1322	3112	15				4333	3222	22

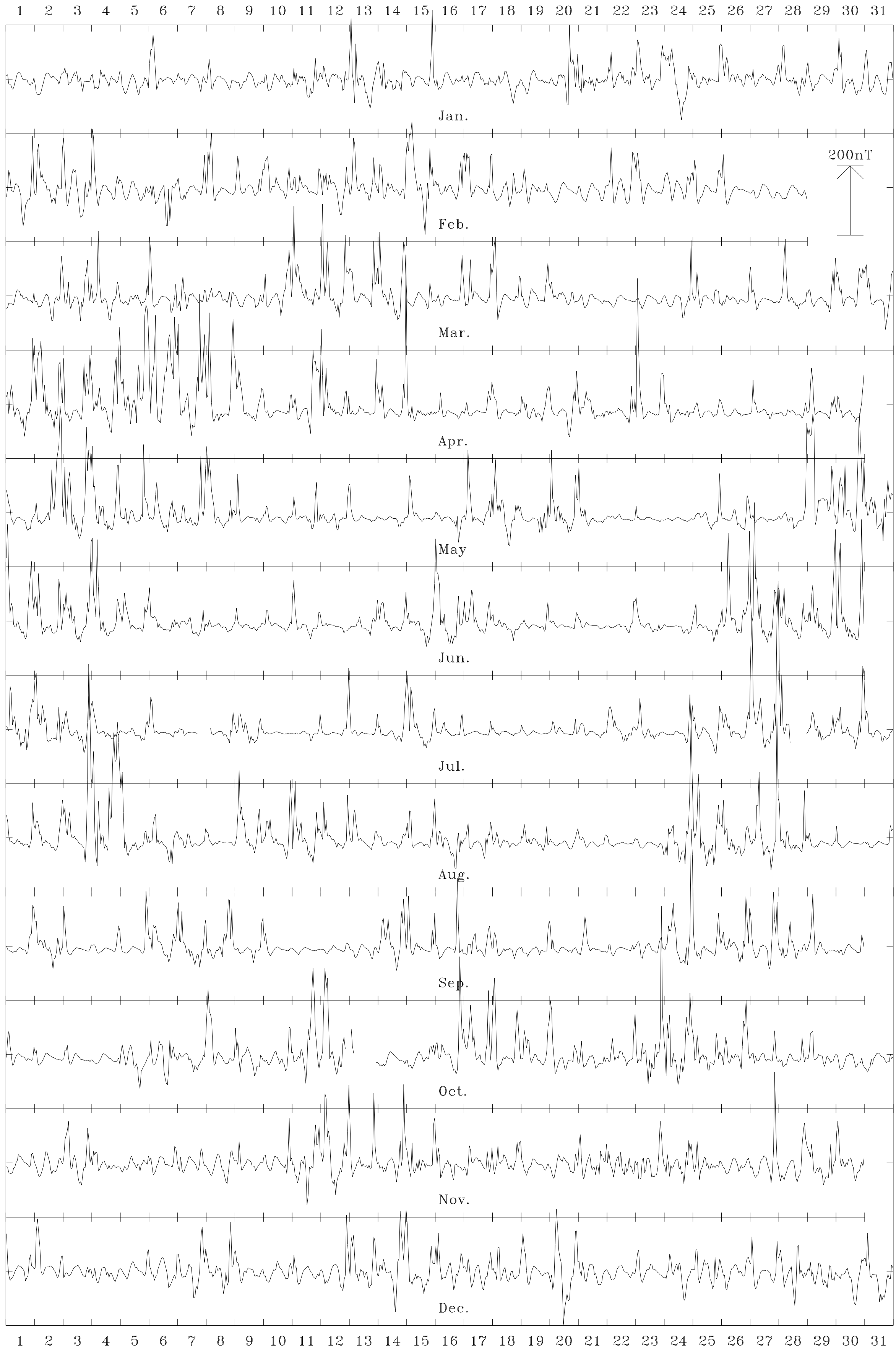
Table 8.6. Mawson 2010 K indices and daily K sums.

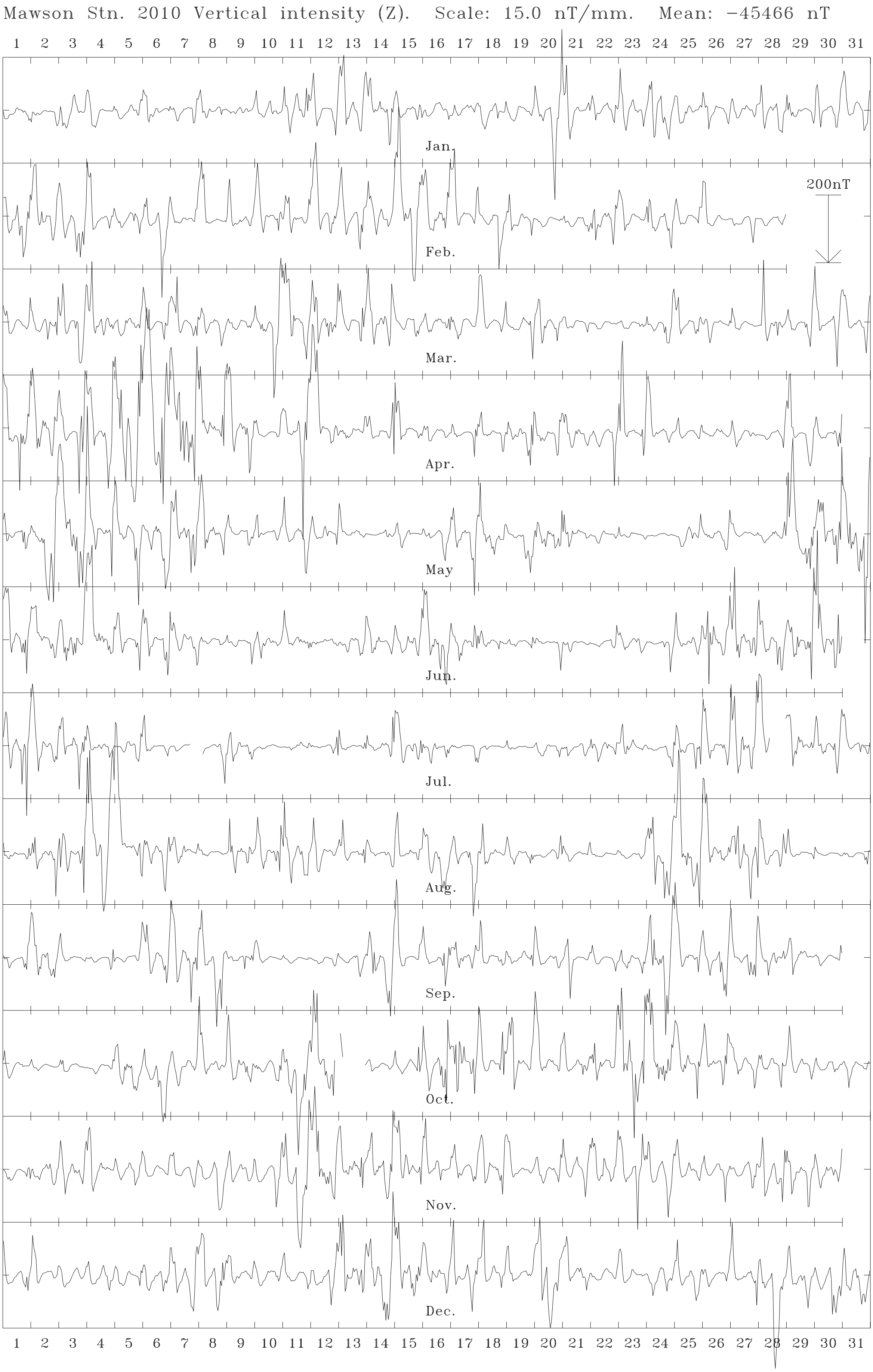
K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	339	555	655	554	403	249	108	35	3	0	19
Mean sum	20.1										

Table 8.7. Frequency distribution of Mawson 2010 K indices and the annual mean daily K sum.

Mawson Stn. 2010 North component (X). Scale: 15.0 nT/mm. Mean: 7158 nT

Mawson Stn. 2010 East component (Y). Scale: 15.0 nT/mm. Mean: −17093 nT




Mawson Stn. 2010 Vertical intensity (Z). Scale: 15.0 nT/mm. Mean: −45466 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
200nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

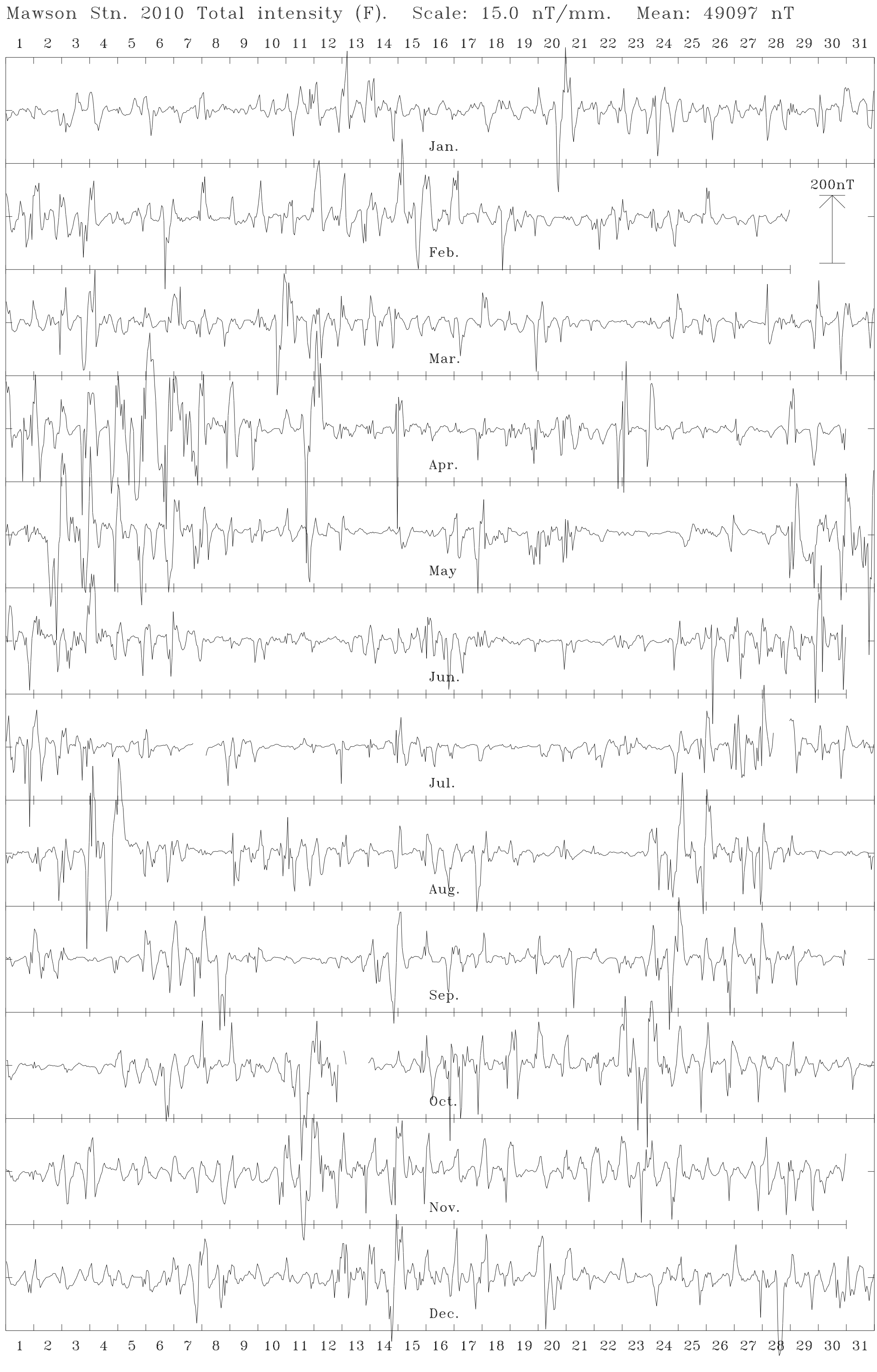


Figure 8.3. Mawson 2010 hourly mean values in X, Y, Z and F.

9. Casey

Casey is situated on the Antarctic coast in Wilkes Land 3880 km south of Perth. It is the nearest Australian Antarctic research station to Australia. The magnetic Absolute Hut is about 120 m south of the tank house, the nearest 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.

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 station, including near the Variometer and Absolute Huts.

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 Hopgood (2001, 2002, 2004a, 2004b).

Variometers

The variometers used during 2010 are described in Table 9.2.

Absolute instruments

The principal absolute magnetometers used at Casey in 2010 are described in Table 9.3.

Baselines

Preparation of definitive Casey data sets has been deferred until a later time. Baselines for data acquired in 2010 will be derived and reported in a later report.

Operations

The 2010 Casey observers were jointly employed by Geoscience Australia and the Australian Antarctic Division. They were members of the Australian National Antarctic Research Expedition. Casey personnel change over each summer with varying periods of overlap.

The observers were responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. In 2010, the observers performed absolute observations weekly and forwarded them by email to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

Data were recorded on a QNX acquisition computer which was directly connected to the station's radio network hub. Data were retrieved to Geoscience Australia using *rsync* over *ssh* at least every 10 minutes. These near real-time data were processed automatically at Geoscience Australia then distributed to registered recipients, usually within a 2 to 8-minute delay.

The QNX acquisition computer used a GPS clock (both pulse-per-second and absolute-time-code) to set the system time. The clock was checked from Geoscience Australia regularly to ensure it was working. If not, it was reset remotely or, if necessary, the computer was re-booted.

The distribution of Casey 2010 data is described in Table 9.4.

IAGA code:	CSY
Commenced operation:	1999
Geographic latitude:	66° 17' S
Geographic longitude:	110° 32' E
Geomagnetic latitude:	-76.01°
Geomagnetic longitude:	184.67°
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
Observers:	T. Bolton (to 2010-12-06) T. Crews (from 2010-12-15)

Table 9.1. Key observatory data.

3-component variometer:	DMI FGE
Serial number:	E0199/S0160
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.3 nT
A/D converter:	ADAM 4017 module (±10V)
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081423/42189
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	ANARESAT

Table 9.2. Magnetic variometers used in 2010. See Appendix C for a schematic of their configuration.

DI fluxgate:	DMI
Serial number:	DI0047
Theodolite:	Zeiss 020B
Serial number:	352229
Resolution:	0.1’
D correction:	0.15’
I correction:	-0.20’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	810881/31960
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Total-field magnetometer:	Geometrics G816 (backup)
Serial number:	766
Type:	Proton precession
Resolution:	1 nT
Correction:	1.5 nT

Table 9.3. Absolute magnetometers and their adopted corrections for 2010. Corrections are applied in the sense Standard = Instrument + correction.

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily

Table 9.4. Distribution of Casey 2010 data.

Significant events

2010-03-09 Inspection of absolute and variometer hut by electrician around time of absolute observations

2010-03-31 08:18-08:24 telemetry interruption due to Sun interference to satellite

2010-04-13 Two extra ceramic heater elements installed into previously empty slots on absolute hut heater. The new elements are under the control of the thermostat, not always on.

2010-06-28 10-15 min scheduled interruption to ANARESAT telemetry 00:00

2010-07-06 10 minute scheduled interruption starting at 13:00

2010-11-05 11-12 10 minute telemetry outage due to scheduled maintenance

2010-11-09 22:25 lost contact with GPS clock. restarted GPS as follows
12/11/10 00:21:37 - CLK I 0 Started
12/11/10 00:25:40 - CLK I 0 Correction 1289521540
709669181 C 0 s 72377807 R 0 s -39025
12/11/10 00:26:22 - CLK I 0 Correction 1289521582
707642469 C 0 s 12954 R 0 s -39162

2010-12-05 07:25 lost contact with GPS clock. restarted GdapClock 2010-12-06 02:01 without success.
Reboot 2010-12-06 02:15.
06/12/10 02:16:11 - CLK I 0 Started
06/12/10 02:16:26 - CLK W 0 UTC inconsistent
1291601786
0 22 972075974 1291601786 285689286 22
972075974
06/12/10 02:17:12 - CLK I 0 Correction 1291601832
106358806 C 0 s -205762561 R 0 s -38720
06/12/10 02:17:54 - CLK I 0 Power Down 4305339
1
0 24693
06/12/10 02:17:54 - CLK I 0 Correction 1291601874
104345068 C 0 s 24693 R 0 s -38780

2010-12-15 First absolute observation by Trevor Crews (TC), the 2011 observer (DOY 349)

Data losses

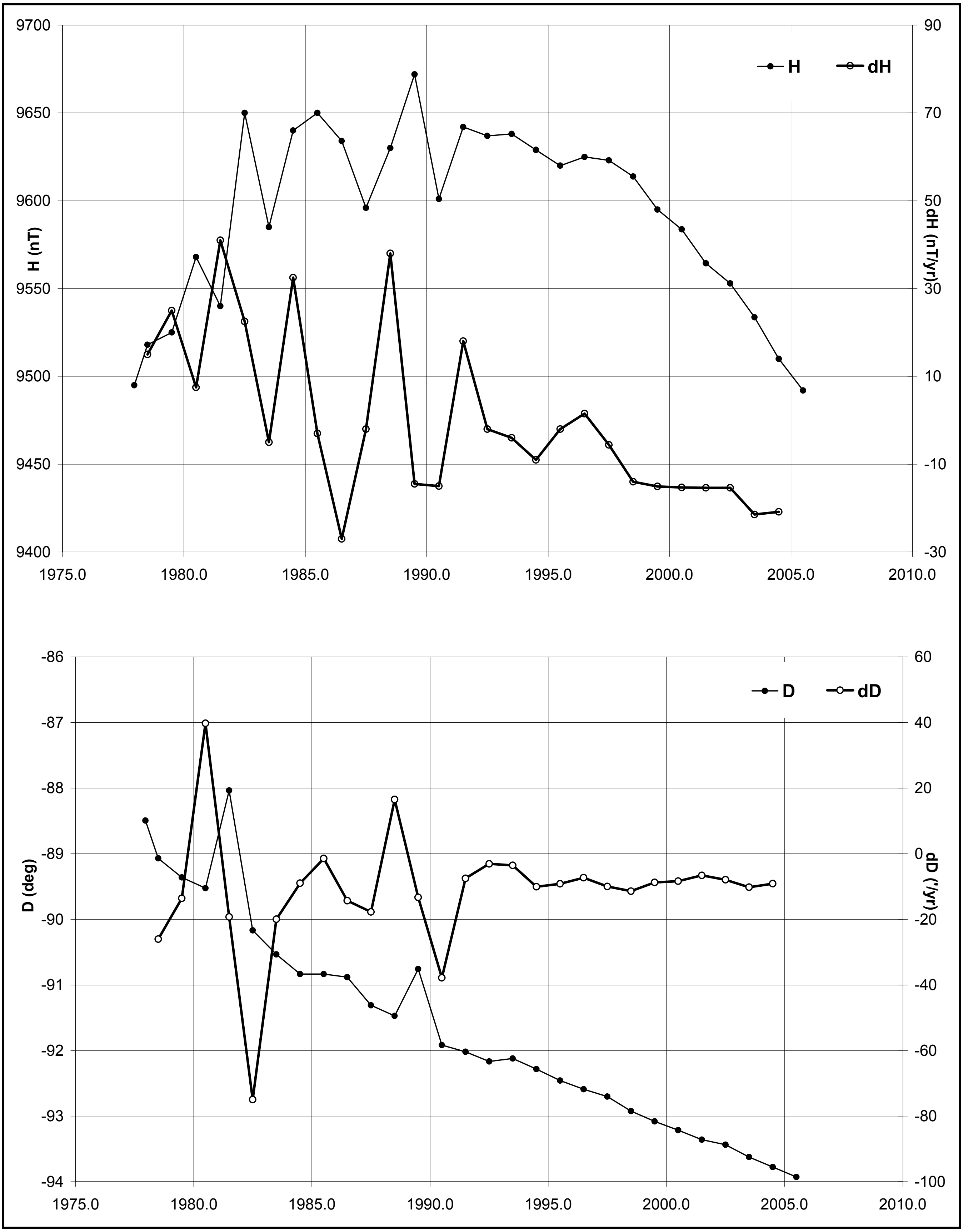
Data losses for 2010 will be reported in a later report.

Annual mean values

The annual mean values for Casey are set out in Table 9.5 and displayed with the secular variation in Figure 9.1.

Year	**Days**	**D** (°	’)	**I** (°	’)	**H** (nT)	**X** (nT)	**Y** (nT)	**Z** (nT)	**F** (nT)	**Elements**
1977.96	AB	-88	29.6	-81	38.7	9495	250	-9492	-64650	65344	DHZ
1978.5	AB	-89	4.3	-81	36.2	9518	154	-9516	-64488	65187	DHZ
1979.5	AB	-89	21.6	-81	35.7	9525	106	-9524	-64469	65169	DHZ
1980.5	AB	-89	31.5	-81	33.9	9568	79	-9568	-64528	65233	DHZ
1981.5	AB	-88	2.1	-81	32.0	9540	327	-9534	-64083	64789	DHZ
1982.5	AB	-90	10.0	-81	28.4	9650	-28	-9650	-64400	65120	DHZ
1983.5	AB	-90	32.0	-81	31.5	9585	-89	-9585	-64326	65037	DHZ
1984.5	AB	-90	50.0			9640	-140	-9639			DHZ
1985.5	AB	-90	50.0	-81	25.9	9650	-140	-9649	-64067	64790	DHZ
1986.5	AB	-90	52.9	-81	27.2	9634	-148	-9633	-64101	64821	DHZ
1987.5	AB	-91	18.6	-81	29.1	9596	-219	-9593	-64097	64811	DHZ
1988.5	AB	-91	28.4	-81	27.2	9630	-248	-9627	-64086	64805	DHZ
1989.5	AB	-90	45.5	-81	23.5	9672	-128	-9671	-63887	64615	DHZ
1990.5	AB	-91	55.0	-81	27.4	9601	-321	-9596	-63920	64637	DHZ
1991.5	QM	-92	1.2	-81	25.0	9642	-340	-9636	-63881	64605	XYZ
1992.5	QM	-92	10.0	-81	25.0	9637	-364	-9630	-63848	64571	XYZ
1993.5	QM	-92	7.3	-81	25.0	9638	-357	-9631	-63852	64576	XYZ
1994.5	QM	-92	17.1	-81	25.3	9629	-384	-9621	-63824	64547	XYZ
1995.5	QM	-92	27.5	-81	25.6	9620	-413	-9611	-63807	64528	XYZ
1996.5	QM	-92	35.4	-81	25.3	9625	-435	-9615	-63804	64526	XYZ
1997.5	QM	-92	42.1	-81	25.2	9623	-454	-9612	-63774	64496	XYZ
1998.5	Q	-92	55.4	-81	25.7	9614	-490	-9601	-63777	64497	XYZ
1999.5	Q	-93	4.9	-81	26.5	9595	-516	-9581	-63762	64480	XYZ
2000.5	Q	-93	12.9	-81	27.0	9584	-537	-9568	-63749	64465	XYZ
2001.5	Q	-93	21.6	-81	27.9	9564	-561	-9548	-63729	64443	XYZ
2002.5	Q	-93	26.1	-81	28.3	9553	-572	-9536	-63708	64421	XYZ
2003.5	Q	-93	37.5	-81	29.4	9534	-603	-9514	-63713	64422	XYZ
2004.5	Q	-93	46.5	-81	30.5	9510	-626	-9489	-63691	64397	XYZ
2005.5	Q	-93	55.7	-81	31.3	9492	-650	-9469	-63682	64385	XYZ
1998.5	A	-92	55.4	-81	25.7	9615	-490	-9602	-63785	64505	XYZ
1999.5	A	-93	4.8	-81	26.4	9599	-516	-9585	-63772	64490	XYZ
2000.5	A	-93	13.2	-81	27.0	9587	-538	-9571	-63759	64476	XYZ
2001.5	A	-93	21.6	-81	27.9	9566	-561	-9549	-63733	64447	XYZ
2002.5	A	-93	29.4	-81	28.4	9553	-582	-9535	-63719	64432	XYZ
2003.5	A	-93	39.5	-81	29.5	9535	-608	-9515	-63730	64440	XYZ
2004.5	A	-93	47.0	-81	30.4	9512	-628	-9491	-63701	64408	XYZ
2005.5	A	-93	56.5	-81	31.4	9492	-652	-9470	-63694	64397	XYZ
1998.5	D	-92	58.2	-81	25.8	9615	-498	-9601	-63805	64526	XYZ
1999.5	D	-93	10.7	-81	26.6	9599	-532	-9583	-63796	64514	XYZ
2000.5	D	-93	13.6	-81	27.0	9588	-539	-9572	-63771	64487	XYZ
2001.5	D	-93	19.4	-81	27.8	9570	-555	-9553	-63746	64460	XYZ
2002.5	D	-93	37.4	-81	28.8	9549	-603	-9529	-63747	64458	XYZ
2003.5	D	-93	47.4	-81	30.2	9525	-629	-9503	-63764	64472	XYZ
2004.5	D	-93	47.8	-81	30.5	9513	-630	-9491	-63719	64425	XYZ
2005.5	D	-93	57.2	-81	31.5	9494	-654	-9471	-63715	64419	XYZ

Table 9.5. Casey annual mean values. Until 1990 these were calculated using the monthly average values of regular absolute observations, denoted by AB. From 1991 they were gained using data from the AAD’s fluxgate variometer that was calibrated through regular absolute observations. Until 1997 the means were calculated over the five quietest days at Mawson station, denoted QM. From 1998 monthly means were calculated over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month, denoted A, Q and D respectively. Plots of these data with secular variation in H, D, Z and F are shown in Figure 9.1.


9700
9650
9600
9550
9500
9450
9400
H (nT)
90
70
50
30
10
-10
-30
dH (nT/yr)
H
dH
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
-86
-87
-88
-89
-90
-91
-92
-93
-94
D (deg)
60
40
20
0
-20
-40
-60
-80
-100
dD ('/yr)
D
dD
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0

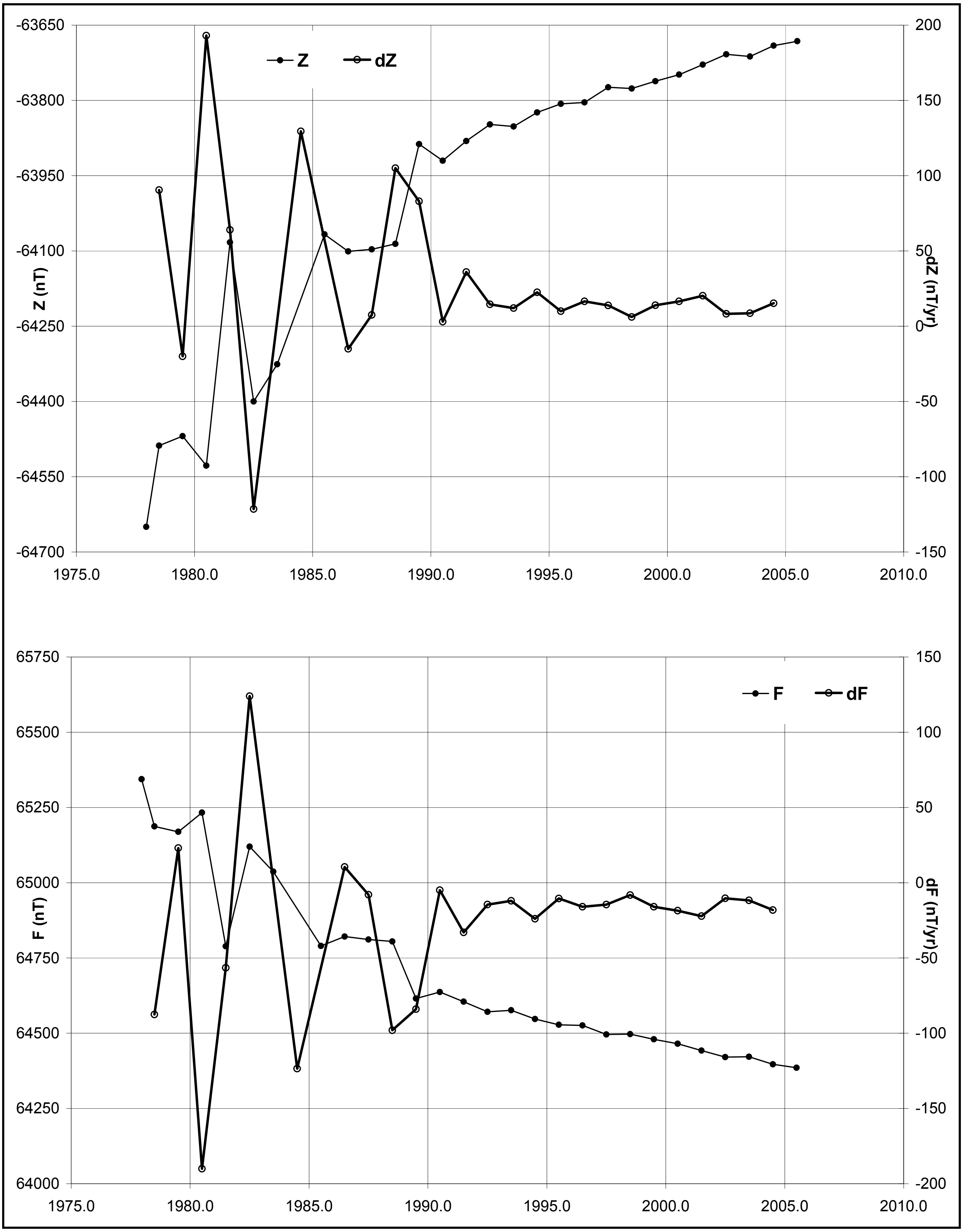


Figure 9.1. Casey annual mean values and secular variation for H, D, Z and F (using all days until 1992.5 and quiet days from 1993.5).

Appendix A. Data losses

Date	**Interval (hh:mm)**	**Data loss (minutes)**
Vector data		
2010-07-16	04:12 – 07:09	178
2010-11-21	03:42 –	
2010-11-22	05:59	1578
2010-11-24	00:06 – 00:08	3
Scalar data		
2010-07-16	05:00 – 06:38	99
2010-11-18	06:48 –	
2010-11-24	00:08	8241

Table A.1. Kakadu data losses.

Date	**Interval (hh:mm)**	**Data loss (minutes)**
Vector data		
2010-01-01	01:01 – 02:00	60
2010-01-04	01:03 – 01:09	7
2010-01-12	04:14 – 04:26	13
2010-01-12	07:33 – 07:36	4
2010-01-14	02:20 – 03:20	61
2010-03-15	01:42 – 02:42	61
2010-04-07	21:31 –	
2010-04-08	00:00	150
2010-04-08	21:43 –	
2010-04-09	00:10	148
2010-04-11	22:00 –	
2010-04-12	00:10	131
2010-04-12	22:56 – 23:30	35
2010-04-12	23:59 –	
2010-04-13	02:00	122
2010-04-14	01:15 – 01:40	26
2010-04-14	21:00 –	
2010-04-15	02:00	301
2010-04-15	21:05 – 21:09	5
2010-04-15	23:59 –	
2010-04-16	01:00	62
2010-05-07	05:40 – 05:41	2
2010-05-11	19:15 – 21:30	136
2010-05-15	01:58 – 02:17	20
2010-05-23	23:55 – 23:55	1
2010-05-27	23:35 –	
2010-05-28	01:06	92
2010-05-28	02:43 – 02:43	1
2010-05-31	00:22 – 00:25	4
2010-06-05	07:39 – 07:42	4
2010-06-05	08:39 – 08:42	4
2010-06-06	00:35 – 00:38	4
2010-06-06	01:04 – 01:08	5
2010-06-09	04:45 –	
2010-06-10	00:30	1186
2010-06-19	00:17 – 00:51	35
2010-10-13	22:00 –	
2010-10-14	08:00	601
2010-10-14	23:06 – 23:06	1
2010-10-16	01:46 – 01:52	7
2010-10-16	01:55 – 02:00	6
2010-10-16	04:31 – 04:34	4
2010-10-16	04:49 – 04:51	3
2010-10-16	04:56 – 05:30	35
2010-10-17	07:23 – 07:26	4
2010-10-18	00:49 – 00:52	4
2010-10-18	01:49 – 01:57	9
2010-10-19	04:02 – 04:02	1
2010-10-19	04:45 – 04:49	5
2010-11-08	05:52 – 05:55	4
2010-11-09	00:03 – 00:04	2
2010-11-09	00:35 – 00:58	24
2010-11-09	22:00 – 22:38	39
2010-11-09	23:59 –	
2010-11-11	03:00	1622
2010-12-30	00:01 – 00:03	3
Scalar data		
2010-01-04	01:05 – 01:05	1
2010-04-07	21:31 – 23:59	149
2010-04-08	21:44 –	
2010-04-09	00:09	146
2010-04-11	22:02 –	
2010-04-12	00:59	178
2010-04-12	22:57 – 23:29	33
2010-04-13	00:00 – 01:59	120
2010-04-14	01:17 – 01:25	9
2010-04-14	21:01 –	
2010-04-15	01:59	299
2010-04-16	00:00 – 00:59	60
2010-05-07	05:41 – 05:41	1
2010-05-27	23:36 – 23:59	24
2010-05-31	00:23 – 00:24	2
2010-06-09	04:46 –	
2010-06-10	00:29	1184
2010-10-11	23:04 – 23:05	2
2010-10-13	22:01 –	
2010-10-14	07:59	599
2010-10-16	01:56 – 01:59	4
2010-10-16	03:48 – 06:08	141
2010-11-08	02:52 – 02:52	1
2010-11-09	00:04 – 00:04	1
2010-11-09	00:36 – 00:40	5
2010-11-09	00:43 – 00:57	15
2010-11-10	00:00 –	
2010-11-11	02:59	1620

Table A.2. Charters Towers data losses.

Date	**Interval (hh:mm)**	**Data loss (minutes)**
Vector data		
2010-01-19	12:24 – 12:32	9
2010-01-23	06:18 – 08:47	150
2010-01-24	16:02 – 16:05	4
2010-06-05	02:55 – 02:56	2
2010-06-05	03:32 – 03:34	3
Scalar data		
2010-01-01	00:00 –	
2010-01-27	09:00	37981
2010-01-27	09:04 – 09:05	2
2010-01-27	09:08 – 09:08	1
2010-01-27	09:13 – 09:15	3
2010-01-27	09:20 – 09:20	1
2010-01-27	09:27 – 09:28	2
2010-01-27	09:37 – 09:40	4
2010-01-27	09:44 – 09:50	7
2010-01-27	10:05 – 10:05	1
2010-01-28	23:14 – 23:31	18
2010-01-30	00:00 – 23:59	1440
2010-02-09	00:00 – 23:59	1440
2010-02-11	22:21 – 22:29	9
2010-02-11	22:34 – 22:34	1
2010-02-11	23:31 – 23:31	1

2010-02-12	00:00 –		
2010-02-27		13:31	22412
2010-02-27	14:22 –	14:23	2
2010-02-27	14:26 –	14:28	3
2010-02-27	14:38 –	14:38	1
2010-02-28	09:51 –	09:51	1
2010-02-28	10:01 –		
2010-03-10		10:27	14427
2010-03-10	10:32 –		
2010-03-11		19:00	1949
2010-03-11	19:14 –	19:15	2
2010-03-11	20:11 –	20:20	10
2010-03-15	00:00 –	23:59	1440
2010-03-16	06:27 –	06:28	2
2010-03-17	05:18 –	05:33	16
2010-03-17	05:35 –		
2010-03-24		06:50	10156
2010-03-24	11:12 –	11:24	13
2010-03-24	11:31 –	11:32	2
2010-03-24	20:31 –	20:37	7
2010-03-24	20:42 –	20:44	3
2010-03-24	20:46 –	20:56	11
2010-03-24	20:58 –	21:00	3
2010-03-24	21:09 –	21:11	3
2010-03-24	21:15 –		
2010-03-28		06:02	4848
2010-03-28	10:52 –	10:56	5
2010-03-30	00:00 –		
2010-03-31		03:07	1628
2010-03-31	03:10 –	03:13	4
2010-04-01	12:36 –	12:42	7
2010-04-01	14:05 –	14:05	1
2010-04-01	14:07 –	14:08	2
2010-04-01	14:47 –	14:48	2
2010-04-01	14:51 –	14:56	6
2010-04-01	15:25 –	15:33	9
2010-04-01	16:07 –	16:10	4
2010-04-01	16:59 –	17:03	5
2010-04-01	21:15 –	21:16	2
2010-04-01	21:22 –	21:22	1
2010-04-01	21:26 –	21:26	1
2010-04-01	21:29 –	21:30	2
2010-04-01	21:35 –	21:37	3
2010-04-01	21:43 –	21:43	1
2010-04-01	21:45 –	21:46	2
2010-04-01	22:05 –	22:10	6
2010-04-01	22:16 –	22:24	9
2010-04-02	00:29 –	00:35	7
2010-04-02	04:39 –	04:46	8
2010-04-02	05:27 –	05:39	13
2010-04-02	05:46 –	05:52	7
2010-04-02	06:09 –	06:32	24
2010-04-02	06:38 –	06:39	2
2010-04-02	07:26 –	07:27	2
2010-04-02	08:10 –	08:10	1
2010-04-02	08:19 –	08:20	2
2010-04-02	08:22 –	08:31	10
2010-04-02	08:35 –	08:37	3
2010-04-02	09:46 –	09:46	1
2010-04-02	09:51 –	09:59	9
2010-04-02	10:41 –	10:45	5
2010-04-02	10:53 –	11:02	10
2010-04-02	11:18 –	11:19	2
2010-04-02	11:21 –	11:26	6
2010-04-02	12:02 –	12:04	3
2010-04-02	12:06 –	13:01	56
2010-04-02	14:27 –	14:32	6
2010-04-02	15:27 –	15:29	3
2010-04-02	15:31 –	15:32	2
2010-04-02	15:34 –	15:34	1
2010-04-02	15:46 –	15:47	2
2010-04-02	15:59 –	15:59	1
2010-04-02	16:03 –	16:32	30
2010-04-02	19:06 –	19:28	23
2010-04-02	20:23 –	20:34	12
2010-04-03	02:45 –	02:48	4
2010-04-03	05:15 –	05:20	6
2010-04-03	09:02 –	09:16	15
2010-04-03	09:21 –	09:23	3
2010-04-03	11:16 –	11:28	13
2010-04-03	14:29 –	14:34	6
2010-04-03	14:36 –	14:36	1
2010-04-03	14:39 –	14:44	6
2010-04-03	17:30 –	17:32	3
2010-04-03	17:34 –	18:05	32
2010-04-03	18:56 –	19:11	16
2010-04-03	19:20 –	19:29	10
2010-04-03	19:53 –	20:19	27
2010-04-03	20:21 –	20:21	1
2010-04-03	20:23 –	20:23	1
2010-04-03	20:32 –	20:33	2
2010-04-04	18:02 –	18:28	27
2010-04-04	18:40 –	18:41	2
2010-04-04	18:45 –	18:45	1
2010-04-04	19:01 –	19:04	4
2010-04-04	19:10 –	19:10	1
2010-04-04	19:13 –	19:13	1
2010-04-04	19:30 –	19:30	1
2010-04-04	19:33 –	19:42	10
2010-04-04	19:48 –	19:55	8
2010-04-04	20:45 –	21:45	61
2010-04-04	22:30 –	22:36	7
2010-04-05	00:04 –	00:12	9
2010-04-05	00:15 –	00:18	4
2010-04-05	00:44 –	00:44	1
2010-04-05	00:49 –	01:07	19
2010-04-05	01:21 –	01:21	1
2010-04-05	15:54 –	15:55	2
2010-04-05	17:47 –	17:49	3
2010-04-05	20:56 –	21:02	7
2010-04-05	21:07 –	21:08	2
2010-04-05	21:13 –	21:20	8
2010-04-08	18:23 –		
2010-04-10		23:47	3205
2010-04-11	00:12 –	00:13	2
2010-04-11	00:15 –	01:11	57
2010-04-11	01:16 –	02:19	64
2010-04-11	02:26 –	02:39	14
2010-04-11	04:06 –	04:49	44
2010-04-11	07:44 –	07:45	2
2010-04-11	08:16 –	08:16	1
2010-04-11	08:18 –	08:25	8
2010-04-11	08:29 –	08:30	2
2010-04-11	09:51 –	11:41	111
2010-04-11	11:43 –	11:48	6
2010-04-11	13:21 –	13:24	4
2010-04-11	13:28 –	21:19	472
2010-04-11	21:22 –	21:23	2
2010-04-11	21:25 –	21:30	6
2010-04-11	21:38 –	21:40	3
2010-04-11	21:53 –	22:08	16
2010-04-11	22:16 –	22:30	15
2010-04-11	22:34 –	22:39	6
2010-04-11	22:42 –	22:45	4
2010-04-11	22:48 –	22:52	5
2010-04-11	23:08 –	23:16	9
2010-04-12	00:01 –	07:59	479
2010-04-12	09:55 –	10:54	60

2010-04-12	10:56 – 10:57	2
2010-04-12	11:15 – 12:45	91
2010-04-12	12:50 – 12:50	1
2010-04-12	13:05 – 13:06	2
2010-04-12	13:14 –	
2010-04-14	23:59	3526
2010-04-15	00:56 – 01:10	15
2010-04-15	02:48 – 03:06	19
2010-04-15	04:14 – 04:22	9
2010-04-15	04:24 – 11:52	449
2010-04-15	11:57 –	
2010-04-16	22:32	2076
2010-04-16	22:58 – 23:12	15
2010-04-16	23:14 – 23:14	1
2010-04-17	00:00 –	
2010-04-29	23:59	18720
2010-05-02	07:20 – 07:21	2
2010-05-02	07:23 – 07:23	1
2010-05-03	15:21 – 15:35	15
2010-05-03	16:08 – 16:40	33
2010-05-03	17:31 – 17:45	15
2010-05-03	18:08 – 18:13	6
2010-05-03	18:16 – 18:16	1
2010-05-04	01:25 – 01:39	15
2010-05-04	12:55 – 13:15	21
2010-05-04	13:18 – 13:20	3
2010-05-04	13:45 – 13:52	8
2010-05-04	13:55 – 14:30	36
2010-05-04	23:03 – 23:04	2
2010-05-04	23:57 –	
2010-05-05	00:03	7
2010-05-05	03:23 – 03:33	11
2010-05-05	03:38 – 03:40	3
2010-05-05	21:34 – 21:36	3
2010-05-05	21:38 –	
2010-05-06	00:00	143
2010-05-06	00:02 – 00:02	1
2010-05-06	04:51 – 04:51	1
2010-05-06	04:53 – 06:01	69
2010-05-06	06:51 – 06:51	1
2010-05-06	09:03 – 09:05	3
2010-05-06	09:13 – 09:13	1
2010-05-06	10:32 – 15:43	312
2010-05-06	20:17 – 20:31	15
2010-05-07	01:25 – 01:28	4
2010-05-07	04:06 – 04:07	2
2010-05-07	05:50 – 06:11	22
2010-05-07	06:13 – 06:13	1
2010-05-07	06:55 – 06:55	1
2010-05-07	06:57 – 06:58	2
2010-05-07	07:01 – 07:08	8
2010-05-07	07:10 – 07:19	10
2010-05-07	07:23 – 07:55	33
2010-05-07	08:03 – 08:04	2
2010-05-07	08:15 – 08:15	1
2010-05-07	11:21 – 11:22	2
2010-05-07	11:26 – 11:26	1
2010-05-07	15:06 – 15:08	3
2010-05-07	15:10 – 15:11	2
2010-05-07	15:13 – 15:19	7
2010-05-07	20:25 – 20:26	2
2010-05-07	20:31 – 20:34	4
2010-05-07	20:39 – 20:53	15
2010-05-07	20:57 – 21:03	7
2010-05-07	21:08 – 21:12	5
2010-05-07	21:59 –	
2010-05-08	04:17	379
2010-05-08	06:13 – 06:16	4
2010-05-08	07:01 – 07:04	4
2010-05-08	09:59 – 12:13	135
2010-05-08	22:48 –	
2010-05-09	00:21	94
2010-05-09	01:01 – 01:20	20
2010-05-09	02:14 – 02:22	9
2010-05-09	02:24 – 02:33	10
2010-05-09	09:00 – 09:06	7
2010-05-10	01:43 – 01:52	10
2010-05-11	04:10 – 04:17	8
2010-05-11	04:21 – 04:54	34
2010-05-11	04:57 – 05:24	28
2010-05-11	06:23 – 06:28	6
2010-05-11	06:37 – 07:20	44
2010-05-11	07:22 – 07:22	1
2010-05-11	07:25 – 07:25	1
2010-05-11	07:27 – 07:27	1
2010-05-11	07:31 – 07:35	5
2010-05-11	07:53 – 07:53	1
2010-05-11	08:14 – 08:36	23
2010-05-11	20:31 – 20:31	1
2010-05-12	00:53 – 01:01	9
2010-05-12	01:06 – 01:15	10
2010-05-12	02:37 – 02:49	13
2010-05-12	02:57 – 04:16	80
2010-05-12	04:18 – 04:21	4
2010-05-12	04:46 – 04:53	8
2010-05-12	05:26 – 05:27	2
2010-05-12	05:30 – 05:31	2
2010-05-12	05:35 – 05:36	2
2010-05-12	10:37 – 11:34	58
2010-05-12	18:39 – 18:44	6
2010-05-12	18:46 – 18:49	4
2010-05-12	18:54 – 18:57	4
2010-05-12	19:05 – 19:07	3
2010-05-12	19:09 – 19:10	2
2010-05-12	19:46 – 19:47	2
2010-05-12	20:00 – 20:35	36
2010-05-12	20:39 – 20:40	2
2010-05-12	21:01 – 21:03	3
2010-05-12	22:18 – 23:01	44
2010-05-13	00:59 – 01:01	3
2010-05-13	01:17 – 01:19	3
2010-05-13	01:27 – 01:27	1
2010-05-13	01:35 – 01:35	1
2010-05-13	01:40 – 01:40	1
2010-05-13	01:46 – 01:47	2
2010-05-13	03:38 – 03:43	6
2010-05-13	03:46 – 03:46	1
2010-05-13	16:54 – 16:54	1
2010-05-13	16:57 – 17:06	10
2010-05-13	18:04 – 19:05	62
2010-05-14	00:17 – 00:18	2
2010-05-14	00:20 – 01:22	63
2010-05-14	02:52 – 03:00	9
2010-05-14	06:41 – 08:10	90
2010-05-14	08:47 – 09:04	18
2010-05-14	11:27 – 11:28	2
2010-05-14	17:18 – 17:29	12
2010-05-14	18:32 – 19:50	79
2010-05-15	00:00 – 23:59	1440
2010-05-16	04:46 – 04:47	2
2010-05-16	05:21 – 05:24	4
2010-05-16	05:31 – 05:33	3
2010-05-16	05:35 – 05:41	7
2010-05-16	05:43 – 05:46	4
2010-05-16	05:49 – 05:58	10
2010-05-16	07:48 – 08:01	14
2010-05-16	08:06 – 08:06	1
2010-05-16	08:22 – 08:56	35

2010-05-16	10:42 – 10:44	3
2010-05-16	11:20 – 11:44	25
2010-05-16	11:52 – 13:00	69
2010-05-16	20:05 – 20:13	9
2010-05-16	20:15 – 20:30	16
2010-05-16	20:36 – 20:36	1
2010-05-16	20:48 – 21:12	25
2010-05-16	21:24 – 21:26	3
2010-05-16	21:29 – 21:29	1
2010-05-16	21:32 – 21:32	1
2010-05-16	22:36 – 22:44	9
2010-05-16	22:50 – 22:58	9
2010-05-16	23:00 – 23:01	2
2010-05-16	23:16 – 23:17	2
2010-05-17	07:36 – 07:37	2
2010-05-17	13:24 – 13:24	1
2010-05-17	13:37 – 13:48	12
2010-05-17	13:58 – 13:59	2
2010-05-17	14:04 – 14:12	9
2010-05-18	01:27 – 01:27	1
2010-05-18	01:30 – 01:50	21
2010-05-18	06:36 – 10:40	245
2010-05-18	13:32 – 13:39	8
2010-05-18	13:47 – 13:49	3
2010-05-18	15:36 – 15:39	4
2010-05-18	16:37 – 16:37	1
2010-05-18	16:46 – 16:46	1
2010-05-18	16:49 – 17:16	28
2010-05-18	17:18 – 17:20	3
2010-05-18	17:24 – 17:24	1
2010-05-18	17:26 – 17:26	1
2010-05-18	17:34 – 17:35	2
2010-05-18	18:37 – 18:38	2
2010-05-18	20:56 – 20:56	1
2010-05-18	22:03 – 22:03	1
2010-05-18	22:15 – 22:21	7
2010-05-18	22:24 – 22:24	1
2010-05-18	22:32 –	
2010-05-23	00:13	5862
2010-05-24	05:27 – 05:30	4
2010-05-24	05:58 – 05:58	1
2010-05-24	06:00 – 06:32	33
2010-05-24	06:36 – 06:36	1
2010-05-24	06:38 – 06:41	4
2010-05-24	06:43 – 06:45	3
2010-05-24	14:17 – 14:17	1
2010-05-24	14:39 – 14:39	1
2010-05-24	21:40 –	
2010-05-28	00:11	4472
2010-05-28	00:28 – 01:29	62
2010-05-28	01:31 –	
2010-06-04	00:48	10038
2010-06-05	02:36 – 02:36	1
2010-06-05	03:33 – 03:34	2
2010-06-27	16:29 – 16:34	6

Table A.3. Learmonth data losses.

Date	**Interval (hh:mm)**	**Data loss (minutes)**
Vector data		
2010-01-10	22:47 – 22:49	3
2010-01-12	23:39 – 23:43	5
2010-01-19	03:18 – 03:19	2
2010-01-19	03:30 – 03:32	3
2010-01-19	03:41 – 03:43	3
2010-01-20	03:07 – 03:09	3
2010-01-20	03:11 – 03:12	2
2010-01-20	04:10 – 04:12	3
2010-03-10	05:57 – 05:58	2
2010-04-17	03:47 – 05:41	115
2010-08-26	00:31 – 04:00	210
2010-11-09	00:00 – 00:10	11
Scalar data		
2010-01-01	00:36 – 00:36	1
2010-01-01	03:11 – 03:11	1
2010-01-01	06:20 – 06:20	1
2010-01-01	06:58 – 06:58	1
2010-01-01	07:18 – 07:18	1
2010-01-01	07:27 – 07:27	1
2010-01-01	07:53 – 07:53	1
2010-01-01	09:39 – 09:39	1
2010-01-01	12:05 – 12:05	1
2010-01-01	13:02 – 13:02	1
2010-01-01	13:10 – 13:10	1
2010-01-01	13:24 – 13:24	1
2010-01-01	13:27 – 13:27	1
2010-01-01	13:30 – 13:30	1
2010-01-01	13:43 – 13:43	1
2010-01-01	13:52 – 13:52	1
2010-01-01	13:57 – 13:57	1
2010-01-01	14:11 – 14:11	1
2010-01-01	14:39 – 14:39	1
2010-01-01	14:44 – 14:44	1
2010-01-01	14:52 – 14:52	1
2010-01-01	15:16 – 15:16	1
2010-01-01	15:36 – 15:36	1
2010-01-01	15:44 – 15:44	1
2010-01-01	16:02 – 16:02	1
2010-01-01	16:30 – 16:31	2
2010-01-01	16:41 – 16:41	1
2010-01-01	16:45 – 16:45	1
2010-01-01	16:54 – 16:54	1
2010-01-01	16:56 – 16:56	1
2010-01-01	17:10 – 17:10	1
2010-01-01	17:13 – 17:13	1
2010-01-01	17:32 – 17:32	1
2010-01-01	17:41 – 17:42	2
2010-01-01	19:51 – 19:51	1
2010-01-01	19:53 – 19:53	1
2010-01-01	20:18 – 20:18	1
2010-01-01	20:21 – 20:21	1
2010-01-01	21:07 – 21:07	1
2010-01-01	21:44 – 21:44	1
2010-01-01	22:03 – 22:03	1
2010-01-01	22:37 – 22:37	1
2010-01-01	22:41 – 22:41	1
2010-01-01	22:55 – 22:55	1
2010-01-01	23:21 – 23:21	1
2010-01-01	23:46 – 23:46	1
2010-01-02	00:03 – 00:03	1
2010-01-02	00:12 – 00:12	1
2010-01-02	00:47 – 00:47	1
2010-01-02	00:50 – 00:50	1
2010-01-02	01:10 – 01:10	1
2010-01-02	01:25 – 01:25	1
2010-01-02	01:31 – 01:31	1
2010-01-02	01:39 – 01:40	2
2010-01-02	02:42 – 02:42	1
2010-01-02	03:30 – 03:30	1
2010-01-02	03:37 – 03:37	1
2010-01-02	03:44 – 03:44	1
2010-01-02	03:46 – 03:47	2
2010-01-02	04:17 – 04:17	1
2010-01-02	04:50 – 04:50	1

2010-01-02	07:54 – 07:54	1
2010-01-02	08:28 – 08:28	1
2010-01-02	09:47 – 09:47	1
2010-01-02	10:51 – 10:51	1
2010-01-02	11:16 – 11:16	1
2010-01-02	11:22 – 11:22	1
2010-01-02	11:41 – 11:42	2
2010-01-02	12:40 – 12:40	1
2010-01-02	13:05 – 13:05	1
2010-01-02	13:19 – 13:19	1
2010-01-02	13:21 – 13:21	1
2010-01-02	14:07 – 14:07	1
2010-01-02	15:09 – 15:09	1
2010-01-02	18:40 – 18:41	2
2010-01-02	19:33 – 19:33	1
2010-01-02	19:48 – 19:48	1
2010-01-02	21:12 – 21:12	1
2010-01-02	21:23 – 21:23	1
2010-01-02	22:13 – 22:13	1
2010-01-02	22:51 – 22:51	1
2010-01-02	23:09 – 23:09	1
2010-01-02	23:24 – 23:24	1
2010-01-02	23:37 – 23:37	1
2010-01-02	23:56 – 23:56	1
2010-01-02	23:58 – 23:58	1
2010-01-03	00:23 – 00:23	1
2010-01-03	00:56 – 00:56	1
2010-01-03	01:12 – 01:12	1
2010-01-03	01:52 – 01:52	1
2010-01-03	02:00 – 02:00	1
2010-01-03	05:23 – 05:23	1
2010-01-03	11:44 – 11:44	1
2010-01-03	11:46 – 11:46	1
2010-01-03	11:51 – 11:51	1
2010-01-03	11:54 – 11:54	1
2010-01-03	12:41 – 12:41	1
2010-01-03	13:12 – 13:12	1
2010-01-03	13:16 – 13:16	1
2010-01-03	13:26 – 13:26	1
2010-01-03	14:27 – 14:27	1
2010-01-03	14:46 – 14:46	1
2010-01-03	15:07 – 15:07	1
2010-01-03	15:14 – 15:14	1
2010-01-03	15:37 – 15:37	1
2010-01-03	16:09 – 16:09	1
2010-01-03	16:30 – 16:30	1
2010-01-03	16:41 – 16:42	2
2010-01-03	17:13 – 17:14	2
2010-01-03	17:24 – 17:25	2
2010-01-03	17:57 – 17:57	1
2010-01-03	18:10 – 18:10	1
2010-01-03	18:27 – 18:27	1
2010-01-03	18:29 – 18:29	1
2010-01-03	18:43 – 18:43	1
2010-01-03	18:45 – 18:45	1
2010-01-03	18:59 – 18:59	1
2010-01-03	19:01 – 19:01	1
2010-01-03	19:03 – 19:03	1
2010-01-03	19:05 – 19:05	1
2010-01-03	19:11 – 19:12	2
2010-01-03	19:34 – 19:34	1
2010-01-03	19:47 – 19:47	1
2010-01-03	19:59 – 19:59	1
2010-01-03	20:04 – 20:04	1
2010-01-03	20:22 – 20:22	1
2010-01-03	20:36 – 20:36	1
2010-01-03	21:01 – 21:01	1
2010-01-03	21:05 – 21:05	1
2010-01-03	21:26 – 21:26	1
2010-01-04	03:33 – 03:33	1
2010-01-04	03:55 – 03:55	1
2010-01-04	05:22 – 05:22	1
2010-01-04	05:35 – 05:35	1
2010-01-04	06:25 – 06:25	1
2010-01-04	07:20 – 07:20	1
2010-01-04	09:06 – 09:06	1
2010-01-04	13:49 – 13:49	1
2010-01-04	14:05 – 14:05	1
2010-01-04	14:13 – 14:13	1
2010-01-04	15:00 – 15:00	1
2010-01-04	15:56 – 15:56	1
2010-01-04	16:17 – 16:17	1
2010-01-04	16:57 – 16:57	1
2010-01-04	17:09 – 17:09	1
2010-01-04	17:19 – 17:19	1
2010-01-04	17:25 – 17:25	1
2010-01-04	17:47 – 17:47	1
2010-01-04	17:58 – 17:58	1
2010-01-04	18:19 – 18:19	1
2010-01-04	18:25 – 18:26	2
2010-01-04	18:58 – 18:58	1
2010-01-04	19:29 – 19:29	1
2010-01-04	20:21 – 20:21	1
2010-01-04	20:24 – 20:24	1
2010-01-04	20:37 – 20:37	1
2010-01-04	20:41 – 20:41	1
2010-01-04	21:09 – 21:09	1
2010-01-04	21:51 – 21:51	1
2010-01-04	22:11 – 22:11	1
2010-01-04	22:52 – 22:52	1
2010-01-04	23:03 – 23:03	1
2010-01-04	23:18 – 23:18	1
2010-01-05	01:09 – 01:09	1
2010-01-05	02:08 – 02:08	1
2010-01-05	03:55 – 03:55	1
2010-01-05	04:09 – 04:09	1
2010-01-05	04:40 – 04:40	1
2010-01-05	06:35 – 06:35	1
2010-01-05	08:31 – 08:31	1
2010-01-05	08:56 – 08:56	1
2010-01-05	11:15 – 11:15	1
2010-01-05	14:17 – 14:17	1
2010-01-05	14:35 – 14:35	1
2010-01-05	15:46 – 15:46	1
2010-01-05	16:56 – 16:56	1
2010-01-05	18:53 – 18:53	1
2010-01-05	21:19 – 21:19	1
2010-01-06	07:19 – 07:20	2
2010-01-06	07:25 – 07:25	1
2010-01-06	07:31 – 07:34	4
2010-01-06	09:11 – 09:11	1
2010-01-10	22:48 – 22:48	1
2010-01-11	05:17 – 05:17	1
2010-01-12	23:40 – 23:40	1
2010-01-13	00:26 – 00:26	1
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2010-01-14	06:06 – 06:06	1
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2010-07-09	18:39 – 18:39	1
2010-07-14	23:03 – 23:03	1
2010-07-16	23:42 – 23:42	1
2010-07-21	11:40 – 11:40	1
2010-07-22	17:16 – 17:16	1
2010-07-23	05:12 – 05:12	1
2010-07-26	06:05 – 06:05	1
2010-08-01	03:21 – 03:21	1
2010-08-02	05:25 – 05:25	1
2010-08-03	04:44 – 04:44	1
2010-08-04	13:54 – 13:54	1
2010-08-04	15:51 – 15:51	1
2010-08-05	01:19 – 01:19	1
2010-08-05	03:35 – 03:35	1
2010-08-05	06:15 – 06:15	1
2010-08-05	06:29 – 06:29	1
2010-08-05	16:29 – 16:29	1
2010-08-05	17:39 – 17:39	1
2010-08-05	18:32 – 18:32	1
2010-08-05	22:58 – 22:58	1
2010-08-06	05:10 – 05:10	1
2010-08-06	10:24 – 10:24	1
2010-08-06	16:09 – 16:09	1
2010-08-06	17:18 – 17:18	1
2010-08-07	15:23 – 15:23	1
2010-08-07	22:37 – 22:37	1
2010-08-08	23:48 – 23:48	1
2010-08-09	18:31 – 18:31	1
2010-08-10	09:57 – 09:57	1
2010-08-10	17:05 – 17:05	1
2010-08-10	23:03 – 23:03	1
2010-08-10	23:13 – 23:13	1
2010-08-11	04:19 – 04:19	1
2010-08-11	06:08 – 06:08	1
2010-08-11	06:36 – 06:36	1
2010-08-11	17:36 – 17:36	1
2010-08-12	03:01 – 03:01	1
2010-08-12	07:23 – 07:23	1
2010-08-13	20:05 – 20:05	1
2010-08-14	03:49 – 03:49	1
2010-08-14	05:57 – 05:57	1
2010-08-15	17:52 – 17:52	1
2010-08-15	20:01 – 20:01	1
2010-08-16	06:40 – 06:40	1
2010-08-21	06:02 – 06:02	1
2010-08-26	00:32 – 03:59	208
2010-08-27	23:57 – 23:57	1
2010-08-30	15:43 – 15:43	1
2010-09-02	02:31 – 02:31	1
2010-09-18	01:00 – 01:00	1
2010-10-08	22:38 – 22:38	1
2010-10-09	13:44 – 13:44	1
2010-10-11	12:33 – 12:33	1
2010-10-17	09:32 – 09:32	1
2010-11-02	15:44 – 15:44	1
2010-11-02	16:12 – 16:12	1
2010-11-05	01:17 – 01:17	1
2010-11-09	00:01 – 00:09	9
2010-11-09	00:11 – 00:11	1
2010-11-09	02:20 – 02:20	1
2010-11-09	02:41 – 02:41	1
2010-11-09	04:32 – 04:32	1
2010-11-09	04:35 – 04:35	1
2010-11-09	05:34 – 05:34	1
2010-11-09	06:17 – 06:17	1
2010-11-09	07:02 – 07:02	1
2010-11-09	14:27 – 14:27	1
2010-11-09	16:39 – 16:39	1
2010-11-10	01:57 – 01:58	2
2010-11-10	11:34 – 11:34	1
2010-11-10	13:01 – 13:01	1
2010-11-10	13:27 – 13:27	1
2010-11-10	14:47 – 14:47	1
2010-11-10	18:47 – 18:47	1
2010-11-11	05:20 – 05:20	1
2010-11-11	09:29 – 09:29	1
2010-11-11	10:21 – 10:21	1
2010-11-11	17:14 – 17:14	1
2010-11-12	02:34 – 02:34	1
2010-11-12	05:07 – 05:07	1
2010-11-12	05:18 – 05:18	1
2010-11-12	06:39 – 06:39	1

2010-11-12	06:45 – 06:45	1
2010-11-12	06:55 – 06:55	1
2010-11-12	06:58 – 06:58	1
2010-11-12	10:12 – 10:12	1
2010-11-12	15:12 – 15:12	1
2010-11-12	15:19 – 15:19	1
2010-11-12	15:39 – 15:39	1
2010-11-12	18:51 – 18:51	1
2010-11-12	18:54 – 18:54	1
2010-11-12	19:10 – 19:10	1
2010-11-12	20:00 – 20:00	1
2010-11-12	20:14 – 20:14	1
2010-11-12	21:11 – 21:11	1
2010-11-12	22:35 – 22:35	1
2010-11-12	23:04 – 23:04	1
2010-11-13	02:24 – 02:24	1
2010-11-13	02:54 – 02:54	1
2010-11-13	04:00 – 04:00	1
2010-11-13	09:18 – 09:18	1
2010-11-13	12:10 – 12:10	1
2010-11-13	12:35 – 12:35	1
2010-11-13	13:14 – 13:14	1
2010-11-13	13:16 – 13:16	1
2010-11-13	17:28 – 17:28	1
2010-11-13	17:33 – 17:33	1
2010-11-13	20:18 – 20:18	1
2010-11-13	21:12 – 21:12	1
2010-11-14	00:36 – 00:36	1
2010-11-14	00:38 – 00:38	1
2010-11-14	02:13 – 02:13	1
2010-11-14	03:28 – 03:28	1
2010-11-14	05:07 – 05:07	1
2010-11-14	05:09 – 05:09	1
2010-11-14	07:37 – 07:37	1
2010-11-14	07:49 – 07:49	1
2010-11-14	10:25 – 10:25	1
2010-11-14	10:54 – 10:54	1
2010-11-14	11:36 – 11:36	1
2010-11-14	13:38 – 13:38	1
2010-11-14	14:00 – 14:00	1
2010-11-14	20:29 – 20:29	1
2010-11-14	20:32 – 20:32	1
2010-11-14	20:39 – 20:39	1
2010-11-14	21:22 – 21:23	2
2010-11-15	01:33 – 01:34	2
2010-11-15	01:40 – 01:40	1
2010-11-15	02:05 – 02:05	1
2010-11-15	05:27 – 05:27	1
2010-11-15	06:55 – 06:55	1
2010-11-15	09:35 – 09:35	1
2010-11-15	09:44 – 09:44	1
2010-11-15	13:21 – 13:21	1
2010-11-15	13:25 – 13:25	1
2010-11-15	15:28 – 15:28	1
2010-11-15	16:24 – 16:24	1
2010-11-15	21:40 – 21:40	1
2010-11-15	23:23 – 23:23	1
2010-11-15	23:48 – 23:48	1
2010-11-15	23:50 – 23:50	1
2010-11-16	00:47 – 00:47	1
2010-11-16	04:43 – 04:43	1
2010-11-16	05:25 – 05:25	1
2010-11-16	07:47 – 07:47	1
2010-11-16	10:23 – 10:23	1
2010-11-16	10:39 – 10:39	1
2010-11-16	12:08 – 12:08	1
2010-11-16	15:26 – 15:26	1
2010-11-16	17:07 – 17:07	1
2010-11-16	19:05 – 19:05	1
2010-11-16	19:22 – 19:22	1
2010-11-17	00:04 – 00:05	2
2010-11-17	00:57 – 00:57	1
2010-11-17	01:12 – 01:12	1
2010-11-17	01:15 – 01:15	1
2010-11-17	04:08 – 04:08	1
2010-11-17	04:14 – 04:14	1
2010-11-17	04:34 – 04:34	1
2010-11-17	05:43 – 05:43	1
2010-11-17	07:03 – 07:03	1
2010-11-17	07:17 – 07:17	1
2010-11-17	08:09 – 08:09	1
2010-11-17	10:19 – 10:19	1
2010-11-17	10:47 – 10:48	2
2010-11-17	11:44 – 11:44	1
2010-11-17	14:36 – 14:36	1
2010-11-17	17:09 – 17:09	1
2010-11-17	18:29 – 18:29	1
2010-11-17	19:13 – 19:13	1
2010-11-17	19:32 – 19:32	1
2010-11-17	19:40 – 19:40	1
2010-11-17	20:14 – 20:14	1
2010-11-17	20:46 – 20:46	1
2010-11-17	22:54 – 22:54	1
2010-11-17	23:24 – 23:24	1
2010-11-17	23:49 – 23:49	1
2010-11-18	03:48 – 03:48	1
2010-11-18	04:22 – 04:22	1
2010-11-18	06:24 – 06:24	1
2010-11-18	07:26 – 07:26	1
2010-11-18	10:26 – 10:26	1
2010-11-18	12:58 – 12:58	1
2010-11-18	17:59 – 17:59	1
2010-11-18	19:03 – 19:03	1
2010-11-18	20:47 – 20:47	1
2010-11-18	21:40 – 21:40	1
2010-11-19	09:51 – 09:51	1
2010-11-19	15:48 – 15:48	1
2010-11-19	17:15 – 17:15	1
2010-11-19	17:26 – 17:26	1
2010-11-19	18:38 – 18:38	1
2010-11-19	20:08 – 20:08	1
2010-11-19	21:17 – 21:17	1
2010-11-19	22:12 – 22:12	1
2010-11-19	22:21 – 22:21	1
2010-11-20	00:29 – 00:29	1
2010-11-20	02:59 – 02:59	1
2010-11-20	03:24 – 03:24	1
2010-11-20	05:31 – 05:31	1
2010-11-20	06:03 – 06:03	1
2010-11-20	07:08 – 07:08	1
2010-11-20	12:25 – 12:25	1
2010-11-20	12:47 – 12:47	1
2010-11-20	19:09 – 19:09	1
2010-11-20	20:40 – 20:40	1
2010-11-20	21:49 – 21:49	1
2010-11-20	22:57 – 22:57	1
2010-11-21	01:21 – 01:21	1
2010-11-21	01:39 – 01:39	1
2010-11-21	02:48 – 02:48	1
2010-11-21	03:36 – 03:36	1
2010-11-21	04:48 – 04:48	1
2010-11-21	10:07 – 10:07	1
2010-11-21	11:01 – 11:01	1
2010-11-21	12:01 – 12:01	1
2010-11-21	12:03 – 12:03	1
2010-11-21	12:11 – 12:11	1
2010-11-21	14:25 – 14:25	1
2010-11-21	16:31 – 16:31	1

2010-11-21	17:27 – 17:27	1
2010-11-21	18:26 – 18:26	1
2010-11-21	23:58 – 23:58	1
2010-11-22	00:33 – 00:33	1
2010-11-22	02:33 – 02:33	1
2010-11-22	05:36 – 05:36	1
2010-11-22	06:26 – 06:26	1
2010-11-22	08:09 – 08:09	1
2010-11-22	11:06 – 11:06	1
2010-11-22	14:35 – 14:35	1
2010-11-22	15:11 – 15:11	1
2010-11-22	19:05 – 19:05	1
2010-11-22	19:20 – 19:20	1
2010-11-22	19:46 – 19:46	1
2010-11-22	20:26 – 20:26	1
2010-11-23	01:23 – 01:23	1
2010-11-23	03:24 – 03:24	1
2010-11-23	12:18 – 12:18	1
2010-11-23	13:22 – 13:22	1
2010-11-23	15:18 – 15:18	1
2010-11-23	16:25 – 16:25	1
2010-11-23	20:55 – 20:55	1
2010-11-23	22:28 – 22:28	1
2010-11-23	23:39 – 23:39	1
2010-11-24	03:13 – 03:13	1
2010-11-24	04:25 – 04:25	1
2010-11-24	04:52 – 04:52	1
2010-11-24	06:11 – 06:11	1
2010-11-24	08:17 – 08:17	1
2010-11-24	10:38 – 10:38	1
2010-11-24	11:21 – 11:21	1
2010-11-25	00:54 – 00:54	1
2010-11-25	01:18 – 01:18	1
2010-11-25	06:02 – 06:02	1
2010-11-25	07:05 – 07:05	1
2010-11-25	09:15 – 09:15	1
2010-11-25	17:16 – 17:16	1
2010-11-25	17:40 – 17:40	1
2010-11-25	18:04 – 18:04	1
2010-11-25	19:43 – 19:43	1
2010-11-25	21:32 – 21:32	1
2010-11-26	02:49 – 02:49	1
2010-11-26	05:05 – 05:05	1
2010-11-26	06:45 – 06:45	1
2010-11-26	12:50 – 12:50	1
2010-11-26	13:28 – 13:28	1
2010-11-26	16:28 – 16:28	1
2010-11-26	17:49 – 17:49	1
2010-11-26	18:11 – 18:11	1
2010-11-27	01:17 – 01:17	1
2010-11-27	02:12 – 02:12	1
2010-11-27	04:23 – 04:23	1
2010-11-27	05:25 – 05:25	1
2010-11-27	05:42 – 05:42	1
2010-11-27	06:55 – 06:55	1
2010-11-27	10:07 – 10:07	1
2010-11-27	17:05 – 17:05	1
2010-11-27	19:26 – 19:26	1
2010-11-27	20:16 – 20:16	1
2010-11-27	20:59 – 20:59	1
2010-11-28	01:03 – 01:03	1
2010-11-28	03:59 – 03:59	1
2010-11-28	05:15 – 05:15	1
2010-11-28	07:38 – 07:38	1
2010-11-28	09:02 – 09:02	1
2010-11-28	11:27 – 11:27	1
2010-11-28	18:11 – 18:11	1
2010-11-28	20:14 – 20:14	1
2010-11-28	21:24 – 21:24	1
2010-11-28	21:34 – 21:34	1
2010-11-28	23:19 – 23:19	1
2010-11-28	23:41 – 23:41	1
2010-11-29	03:00 – 03:00	1
2010-11-29	03:13 – 03:13	1
2010-11-29	03:33 – 03:33	1
2010-11-29	03:53 – 03:53	1
2010-11-29	06:45 – 06:45	1
2010-11-29	14:06 – 14:06	1
2010-11-29	14:20 – 14:20	1
2010-11-29	15:28 – 15:28	1
2010-11-29	16:26 – 16:26	1
2010-11-29	21:47 – 21:47	1
2010-11-29	22:18 – 22:18	1
2010-11-30	00:08 – 00:08	1
2010-11-30	03:19 – 03:19	1
2010-11-30	11:24 – 11:24	1
2010-11-30	11:56 – 11:56	1
2010-11-30	12:40 – 12:40	1
2010-11-30	14:02 – 14:02	1
2010-11-30	15:39 – 15:39	1
2010-11-30	16:56 – 16:56	1
2010-11-30	17:22 – 17:22	1
2010-11-30	17:29 – 17:29	1
2010-11-30	21:14 – 21:14	1
2010-12-01	00:59 – 00:59	1
2010-12-01	02:28 – 02:28	1
2010-12-01	03:57 – 03:57	1
2010-12-01	05:23 – 05:23	1
2010-12-01	05:29 – 05:29	1
2010-12-01	09:21 – 09:21	1
2010-12-01	12:25 – 12:25	1
2010-12-01	12:55 – 12:55	1
2010-12-01	15:01 – 15:01	1
2010-12-01	17:28 – 17:28	1
2010-12-01	21:01 – 21:01	1
2010-12-02	01:43 – 01:43	1
2010-12-02	03:00 – 03:00	1
2010-12-02	03:38 – 03:38	1
2010-12-02	03:50 – 03:50	1
2010-12-02	09:43 – 09:43	1
2010-12-02	20:45 – 20:45	1
2010-12-03	01:09 – 01:09	1
2010-12-03	03:40 – 03:40	1
2010-12-03	04:27 – 04:27	1
2010-12-03	05:35 – 05:35	1
2010-12-03	10:35 – 10:35	1
2010-12-03	10:44 – 10:44	1
2010-12-03	10:48 – 10:48	1
2010-12-03	13:26 – 13:26	1
2010-12-03	14:39 – 14:39	1
2010-12-03	18:45 – 18:45	1
2010-12-03	19:35 – 19:35	1
2010-12-04	03:25 – 03:25	1
2010-12-04	04:00 – 04:00	1
2010-12-04	05:27 – 05:27	1
2010-12-04	06:23 – 06:23	1
2010-12-04	16:13 – 16:13	1
2010-12-04	16:22 – 16:22	1
2010-12-04	16:49 – 16:49	1
2010-12-04	21:40 – 21:40	1
2010-12-05	01:22 – 01:22	1
2010-12-05	05:07 – 05:07	1
2010-12-05	08:21 – 08:21	1
2010-12-05	12:20 – 12:20	1
2010-12-05	17:47 – 17:47	1
2010-12-05	22:32 – 22:32	1
2010-12-05	23:13 – 23:13	1
2010-12-06	15:15 – 15:15	1

2010-12-06	16:42 – 16:42	1
2010-12-06	19:57 – 19:57	1
2010-12-07	01:50 – 01:50	1
2010-12-07	04:59 – 04:59	1
2010-12-07	07:02 – 07:02	1
2010-12-07	09:19 – 09:19	1
2010-12-07	14:09 – 14:09	1
2010-12-07	15:12 – 15:12	1
2010-12-07	17:45 – 17:45	1
2010-12-07	18:45 – 18:45	1
2010-12-07	19:46 – 19:46	1
2010-12-07	19:56 – 19:56	1
2010-12-08	03:16 – 03:16	1
2010-12-08	04:38 – 04:38	1
2010-12-08	11:42 – 11:42	1
2010-12-08	14:47 – 14:47	1
2010-12-08	15:00 – 15:00	1
2010-12-08	16:40 – 16:40	1
2010-12-08	21:42 – 21:42	1
2010-12-09	00:40 – 00:40	1
2010-12-09	01:15 – 01:15	1
2010-12-09	09:05 – 09:05	1

Table A.4. Alice Springs data losses.

Date	Interval (hh:mm)	Data loss (minutes)
Vector data		
2010-06-27	11:59 –	
2010-06-28	02:14	856
2010-09-21	03:30 – 04:10	41
Scalar data		
2010-03-22	08:51 – 08:51	1
2010-06-27	12:00 –	
2010-06-28	02:21	862
2010-06-28	18:20 –	
2010-06-30	02:45	1946

Table A.5. Gnangara data losses.

Date	Interval (hh:mm)	Data loss (minutes)
Vector data		
Nil		
Scalar data		
2010-11-21	13:38 – 15:57	140

Table A.6. Canberra data losses.

Date	Interval (hh:mm)	Data loss (minutes)
Vector data		
2010-02-03	22:23 – 22:51	29
2010-04-05	08:59 – 09:05	7
2010-05-30	08:10 – 08:14	5
2010-07-26	04:31 – 04:51	21
2010-07-26	06:16 – 06:18	3
2010-07-27	06:26 – 06:35	10
2010-07-28	22:03 – 22:06	4
2010-08-01	23:52 –	
2010-08-02	00:03	12
2010-10-07	16:39 – 20:05	207
Scalar data		
2010-05-30	08:11 – 08:13	3
2010-07-26	04:32 – 04:50	19
2010-07-26	06:17 – 06:17	1
2010-07-27	06:27 – 06:34	8
2010-07-28	22:04 – 22:06	3
2010-08-01	23:53 –	
2010-08-02	00:02	10
2010-09-07	13:28 – 13:28	1
2010-10-07	16:40 – 20:11	212
2010-12-18	04:10 – 04:11	2
2010-12-19	00:51 – 00:52	2
2010-12-20	09:17 – 09:17	1

Table A.7. Macquarie Island data losses.

Date	Interval (hh:mm)	Data loss (minutes)
Vector data		
2010-03-22	04:11 – 04:14	4
2010-06-23	04:22 – 04:24	3
2010-06-24	03:24 – 04:14	51
2010-07-07	16:51 –	
2010-07-08	03:25	635
2010-07-08	10:19 – 10:21	3
2010-07-28	09:13 – 23:14	842
2010-08-30	03:43 – 03:44	2
2010-10-11	04:25 – 04:26	2
2010-10-12	20:52 – 22:52	121
2010-10-12	23:20 – 23:36	17
2010-10-12	23:39 – 23:41	3
2010-10-12	23:43 – 23:48	6
2010-10-13	00:05 – 01:10	66
2010-10-13	01:13 – 01:16	4
2010-10-13	01:20 – 01:28	9
2010-10-13	01:33 – 01:56	24
2010-10-13	03:53 – 04:21	29
2010-10-13	04:23 – 05:26	64
2010-10-13	05:31 – 06:02	32
2010-10-13	06:08 – 22:38	991
2010-10-15	06:10 – 06:33	24
Scalar data		
2010-03-22	04:12 – 04:12	1
2010-05-15	17:33 – 17:33	1
2010-05-15	18:53 – 18:53	1
2010-05-15	18:57 – 18:57	1
2010-05-15	19:38 – 19:38	1
2010-05-19	07:48 – 07:48	1
2010-05-19	08:07 – 08:07	1
2010-05-19	08:12 – 08:12	1
2010-05-19	08:19 – 08:19	1
2010-05-19	08:23 – 08:23	1
2010-05-19	08:26 – 08:26	1
2010-05-19	08:32 – 08:32	1
2010-05-19	08:35 – 08:35	1
2010-05-19	08:40 – 08:40	1
2010-05-19	08:45 – 08:45	1
2010-05-19	08:47 – 08:50	4
2010-05-19	08:52 – 08:52	1
2010-05-19	08:58 – 08:58	1
2010-05-19	09:02 – 09:04	3
2010-05-19	09:07 – 09:07	1
2010-05-19	09:09 – 09:09	1
2010-05-19	09:12 – 09:12	1
2010-05-19	09:16 – 09:16	1
2010-05-19	09:30 – 09:30	1
2010-05-19	09:34 – 09:34	1
2010-05-19	09:37 – 09:37	1
2010-05-19	09:39 – 09:40	2
2010-05-19	09:48 – 09:48	1

2010-05-19	09:56 – 09:56	1
2010-05-19	10:00 – 10:00	1
2010-05-19	10:09 – 10:09	1
2010-05-19	10:18 – 10:18	1
2010-05-19	10:29 – 10:29	1
2010-05-19	10:31 – 10:31	1
2010-05-19	10:33 – 10:33	1
2010-05-19	10:38 – 10:39	2
2010-05-19	10:59 – 11:00	2
2010-05-19	11:12 – 11:12	1
2010-05-19	11:14 – 11:15	2
2010-05-19	11:18 – 11:18	1
2010-05-19	11:20 – 11:21	2
2010-05-19	11:32 – 11:32	1
2010-05-19	11:34 – 11:35	2
2010-05-19	11:38 – 11:38	1
2010-05-19	11:47 – 11:47	1
2010-05-19	12:06 – 12:08	3
2010-05-19	12:11 – 12:11	1
2010-05-19	12:18 – 12:20	3
2010-05-19	12:28 – 12:28	1
2010-05-19	12:31 – 12:33	3
2010-05-19	12:36 – 12:36	1
2010-05-19	12:43 – 12:43	1
2010-05-19	12:47 – 12:47	1
2010-05-19	12:49 – 12:49	1
2010-05-19	12:52 – 12:54	3
2010-05-19	13:02 – 13:03	2
2010-05-19	13:13 – 13:13	1
2010-05-19	13:23 – 13:23	1
2010-05-19	13:32 – 13:32	1
2010-05-19	13:38 – 13:39	2
2010-05-19	13:47 – 13:47	1
2010-05-19	13:50 – 13:52	3
2010-05-19	13:55 – 13:56	2
2010-05-19	13:58 – 13:58	1
2010-05-19	14:08 – 14:09	2
2010-05-19	14:20 – 14:20	1
2010-05-19	14:28 – 14:28	1
2010-05-19	14:36 – 14:36	1
2010-05-19	14:47 – 14:47	1
2010-05-19	14:50 – 14:50	1
2010-05-19	14:58 – 14:58	1
2010-05-19	15:02 – 15:02	1
2010-06-23	02:04 – 02:04	1
2010-06-23	03:11 – 03:11	1
2010-06-23	03:13 – 03:14	2
2010-06-23	03:24 – 03:24	1
2010-06-23	03:30 – 03:30	1
2010-06-23	03:40 – 03:43	4
2010-06-23	03:46 – 03:50	5
2010-06-23	03:52 – 03:52	1
2010-06-23	03:56 – 03:56	1
2010-06-23	03:58 – 03:58	1
2010-06-23	04:00 – 04:00	1
2010-06-23	04:03 – 04:06	4
2010-06-23	04:08 – 04:09	2
2010-06-23	04:12 – 04:12	1
2010-06-23	04:15 – 04:15	1
2010-06-23	04:17 – 04:19	3
2010-06-23	04:21 – 04:28	8
2010-06-23	04:30 – 05:11	42
2010-06-23	05:14 – 05:20	7
2010-06-23	05:22 – 05:27	6
2010-06-23	05:29 – 05:40	12
2010-06-23	05:42 – 05:43	2
2010-06-23	05:46 – 05:49	4
2010-06-23	05:51 – 05:54	4
2010-06-23	05:56 – 05:56	1
2010-06-23	05:58 – 06:04	7
2010-06-23	06:06 – 06:06	1
2010-06-23	06:08 – 06:08	1
2010-06-23	06:10 – 06:10	1
2010-06-23	06:14 – 06:14	1
2010-06-23	06:41 – 06:41	1
2010-06-23	06:44 – 06:44	1
2010-06-23	06:49 – 06:49	1
2010-06-23	06:56 – 06:56	1
2010-06-23	07:09 – 07:09	1
2010-06-23	07:18 – 07:18	1
2010-06-23	07:21 – 07:21	1
2010-06-23	07:23 – 07:23	1
2010-06-23	07:28 – 07:29	2
2010-06-23	07:32 – 07:34	3
2010-06-23	07:36 – 07:37	2
2010-06-23	07:39 – 07:41	3
2010-06-23	07:45 – 07:45	1
2010-06-23	07:48 – 07:48	1
2010-06-23	07:50 – 07:53	4
2010-06-23	07:55 – 07:55	1
2010-06-23	07:57 – 07:59	3
2010-06-23	08:01 – 08:01	1
2010-06-23	08:04 – 08:04	1
2010-06-23	08:06 – 08:06	1
2010-06-23	08:10 – 08:11	2
2010-06-23	08:18 – 08:18	1
2010-06-23	08:24 – 08:25	2
2010-06-23	08:27 – 08:27	1
2010-06-23	08:31 – 08:33	3
2010-06-23	08:35 – 08:35	1
2010-06-23	08:37 – 08:37	1
2010-06-23	08:40 – 08:41	2
2010-06-23	08:43 – 08:43	1
2010-06-23	08:45 – 08:45	1
2010-06-23	08:48 – 08:48	1
2010-06-23	08:51 – 08:56	6
2010-06-23	08:59 – 08:59	1
2010-06-23	09:07 – 09:07	1
2010-06-23	09:11 – 09:11	1
2010-06-23	09:17 – 09:17	1
2010-06-23	09:19 – 09:19	1
2010-06-23	09:21 – 09:21	1
2010-06-23	09:23 – 09:23	1
2010-06-23	09:26 – 09:27	2
2010-06-23	09:29 – 09:30	2
2010-06-23	09:32 – 09:32	1
2010-06-23	09:34 – 09:38	5
2010-06-23	09:40 – 09:40	1
2010-06-23	09:44 – 09:45	2
2010-06-23	09:49 – 09:53	5
2010-06-23	09:55 – 09:56	2
2010-06-23	09:58 – 09:58	1
2010-06-23	10:01 – 10:05	5
2010-06-23	10:07 – 10:13	7
2010-06-23	10:15 – 10:15	1
2010-06-23	10:17 – 10:20	4
2010-06-23	10:23 – 10:25	3
2010-06-23	10:28 – 10:28	1
2010-06-23	10:30 – 10:31	2
2010-06-23	10:34 – 10:37	4
2010-06-23	10:39 – 10:39	1
2010-06-23	10:41 – 10:53	13
2010-06-23	10:55 – 10:58	4
2010-06-23	11:00 – 11:00	1
2010-06-23	11:02 – 11:05	4
2010-06-23	11:08 – 11:10	3
2010-06-23	11:12 – 11:13	2
2010-06-23	11:15 – 11:18	4

2010-06-23	11:20 – 11:21	2
2010-06-23	11:25 – 11:28	4
2010-06-23	11:30 – 11:40	11
2010-06-23	11:42 – 11:44	3
2010-06-23	11:46 – 11:51	6
2010-06-23	11:53 – 11:53	1
2010-06-23	11:56 – 11:56	1
2010-06-23	12:00 – 12:01	2
2010-06-23	12:03 – 12:03	1
2010-06-23	12:05 – 12:11	7
2010-06-23	12:13 – 12:19	7
2010-06-23	12:24 – 12:25	2
2010-06-23	12:28 – 12:28	1
2010-06-23	12:30 – 12:30	1
2010-06-23	12:35 – 12:38	4
2010-06-23	12:43 – 12:44	2
2010-06-23	12:54 – 12:54	1
2010-06-23	13:09 – 13:09	1
2010-06-23	13:15 – 13:15	1
2010-06-23	13:22 – 13:22	1
2010-06-23	14:39 – 14:39	1
2010-06-23	14:55 – 14:55	1
2010-06-23	15:03 – 15:03	1
2010-06-23	15:06 – 15:06	1
2010-06-23	15:19 – 15:19	1
2010-06-23	15:38 – 15:38	1
2010-06-23	16:42 – 16:42	1
2010-06-23	23:53 – 23:53	1
2010-06-24	00:07 – 00:08	2
2010-06-24	00:30 – 00:30	1
2010-06-24	01:47 – 01:47	1
2010-06-24	01:57 – 01:57	1
2010-06-24	02:19 – 02:19	1
2010-06-24	02:31 – 02:31	1
2010-06-24	02:49 – 02:49	1
2010-06-24	03:02 – 03:02	1
2010-06-24	03:25 – 03:25	1
2010-06-24	03:31 – 03:31	1
2010-06-24	03:37 – 03:37	1
2010-06-24	03:51 – 03:51	1
2010-06-24	03:55 – 03:55	1
2010-06-24	03:57 – 03:57	1
2010-06-24	04:07 – 04:07	1
2010-06-24	04:13 – 04:14	2
2010-06-24	04:24 – 04:24	1
2010-07-07	00:00 –	
2010-08-16	23:51	59032
2010-08-17	15:40 – 15:40	1
2010-08-22	06:56 – 06:56	1
2010-08-22	07:01 – 07:01	1
2010-08-22	07:34 – 07:34	1
2010-08-22	07:40 – 07:41	2
2010-08-22	07:54 – 07:54	1
2010-08-22	07:57 – 07:58	2
2010-08-22	08:11 – 08:12	2
2010-08-22	08:19 – 08:19	1
2010-08-22	08:24 – 08:24	1
2010-08-22	08:28 – 08:28	1
2010-08-22	08:49 – 08:49	1
2010-08-22	08:53 – 08:53	1
2010-08-22	09:06 – 09:06	1
2010-08-22	09:08 – 09:09	2
2010-08-22	09:18 – 09:18	1
2010-08-22	09:24 – 09:24	1
2010-08-22	09:29 – 09:31	3
2010-08-22	09:33 – 09:35	3
2010-08-22	09:38 – 09:38	1
2010-08-22	09:41 – 09:43	3
2010-08-22	09:48 – 09:50	3
2010-08-22	09:55 – 09:56	2
2010-08-22	10:11 – 10:11	1
2010-08-22	10:18 – 10:18	1
2010-08-22	10:27 – 10:27	1
2010-08-22	11:10 – 11:10	1
2010-08-22	14:28 – 14:28	1
2010-08-22	14:30 – 14:30	1
2010-08-22	14:33 – 14:34	2
2010-08-22	14:36 – 14:36	1
2010-08-22	14:58 – 14:58	1
2010-08-22	15:05 – 15:05	1
2010-08-22	15:11 – 15:11	1
2010-08-22	15:14 – 15:14	1
2010-08-22	15:19 – 15:19	1
2010-08-22	15:30 – 15:30	1
2010-08-22	15:39 – 15:39	1
2010-08-22	15:41 – 15:42	2
2010-08-22	15:57 – 15:57	1
2010-08-22	16:39 – 16:39	1
2010-08-22	16:41 – 16:41	1
2010-08-22	16:43 – 16:43	1
2010-08-22	16:56 – 16:56	1
2010-08-22	17:14 – 17:14	1
2010-08-22	17:21 – 17:23	3
2010-08-22	17:25 – 17:25	1
2010-08-22	17:32 – 17:32	1
2010-08-22	17:53 – 17:53	1
2010-08-22	18:05 – 18:05	1
2010-08-22	18:08 – 18:08	1
2010-08-22	18:11 – 18:11	1
2010-08-22	18:13 – 18:16	4
2010-08-22	18:19 – 18:19	1
2010-08-22	18:22 – 18:22	1
2010-08-22	18:24 – 18:24	1
2010-08-22	18:30 – 18:30	1
2010-08-22	18:39 – 18:40	2
2010-08-22	18:52 – 18:52	1
2010-08-22	18:56 – 18:56	1
2010-08-22	18:59 – 18:59	1
2010-08-22	19:05 – 19:05	1
2010-08-22	19:07 – 19:08	2
2010-08-22	19:20 – 19:20	1
2010-08-22	19:24 – 19:24	1
2010-08-22	19:26 – 19:27	2
2010-08-22	19:33 – 19:33	1
2010-08-22	19:35 – 19:35	1
2010-08-22	19:38 – 19:39	2
2010-08-22	19:42 – 19:42	1
2010-08-22	19:50 – 19:55	6
2010-08-22	20:05 – 20:05	1
2010-08-22	20:08 – 20:08	1
2010-08-22	20:12 – 20:12	1
2010-08-22	20:15 – 20:15	1
2010-08-22	20:17 – 20:20	4
2010-08-22	20:22 – 20:22	1
2010-08-22	20:25 – 20:25	1
2010-08-22	20:33 – 20:34	2
2010-08-22	20:38 – 20:39	2
2010-08-22	20:47 – 20:47	1
2010-08-22	20:50 – 20:50	1
2010-08-22	20:54 – 20:54	1
2010-08-22	21:06 – 21:06	1
2010-08-22	21:11 – 21:11	1
2010-08-22	21:31 – 21:31	1
2010-08-22	21:34 – 21:34	1
2010-08-22	21:42 – 21:42	1
2010-08-22	21:45 – 21:45	1
2010-08-22	22:06 – 22:07	2
2010-08-22	22:21 – 22:21	1

2010-08-22	22:25 – 22:25	1
2010-08-22	22:36 – 22:36	1
2010-08-22	22:41 – 22:41	1
2010-08-22	22:50 – 22:50	1
2010-08-22	23:10 – 23:10	1
2010-08-22	23:12 – 23:12	1
2010-08-22	23:16 – 23:16	1
2010-08-22	23:19 – 23:19	1
2010-08-22	23:23 – 23:23	1
2010-08-22	23:28 – 23:28	1
2010-08-23	00:15 – 00:15	1
2010-08-23	00:20 – 00:20	1
2010-08-23	01:29 – 01:29	1
2010-08-30	03:44 – 03:44	1
2010-10-11	04:26 – 04:26	1
2010-10-12	18:33 – 18:33	1
2010-10-12	20:53 – 20:53	1
2010-10-12	21:21 – 21:21	1
2010-10-12	21:34 – 21:34	1
2010-10-12	21:45 – 21:45	1
2010-10-12	21:48 – 21:48	1
2010-10-12	21:51 – 21:51	1
2010-10-12	21:57 – 21:57	1
2010-10-12	22:01 – 22:01	1
2010-10-12	22:03 – 22:03	1
2010-10-12	22:08 – 22:08	1
2010-10-12	22:13 – 22:13	1
2010-10-12	22:21 – 22:21	1
2010-10-12	22:26 – 22:26	1
2010-10-12	22:31 – 22:36	6
2010-10-12	22:41 – 22:41	1
2010-10-12	23:20 – 23:20	1
2010-10-12	23:26 – 23:27	2
2010-10-12	23:32 – 23:32	1
2010-10-12	23:39 – 23:40	2
2010-10-12	23:44 – 23:44	1
2010-10-12	23:46 – 23:47	2
2010-10-13	00:05 – 00:05	1
2010-10-13	00:07 – 00:07	1
2010-10-13	00:23 – 00:25	3
2010-10-13	00:32 – 00:32	1
2010-10-13	00:38 – 00:38	1
2010-10-13	00:44 – 00:44	1
2010-10-13	00:46 – 00:48	3
2010-10-13	00:55 – 00:55	1
2010-10-13	01:01 – 01:01	1
2010-10-13	01:05 – 01:05	1
2010-10-13	01:14 – 01:14	1
2010-10-13	01:21 – 01:23	3
2010-10-13	01:34 – 01:34	1
2010-10-13	01:48 – 01:49	2
2010-10-13	01:52 – 01:52	1
2010-10-13	01:55 – 01:56	2
2010-10-13	03:54 – 03:54	1
2010-10-13	03:59 – 03:59	1
2010-10-13	04:01 – 04:01	1
2010-10-13	04:05 – 04:06	2
2010-10-13 2010-10-15	04:16 – 06:32	3017
2010-12-22	19:29 – 19:29	1
2010-12-22	19:31 – 19:32	2

Table A.8. Mawson data losses.

Date	Interval (hh:mm)	Data loss (minutes)
Reported in a later report		

Table A.9. Casey data losses.

Observatory	Vector		Scalar	
	(minutes)	(%)	(minutes)	(%)
Kakadu	1759	0.33	8340	1.59
Charters Towers	5054	0.96	4594	0.87
Learmonth	168	0.03	152911	29.09
Alice Springs	362	0.07	1402	0.27
Gnangara	897	0.17	2809	0.53
Canberra	0	0.00	140	0.03
Macquarie Island	298	0.06	262	0.05
Mawson	2932	0.56	62702	11.93
Total	**11470**	**0.27**	**233160**	**5.55**

Table A.10. Summary of 2010 data losses from Australian observatories.

Appendix B. Backup data

Date	Interval (hh:mm)		Data infilled (mm:ss)
2010-01-05	02:13	02:14	1:20
2010-01-13	01:10	01:14	3:45
2010-01-27	01:49	01:49	0:15
2010-02-09	01:40	01:42	1:20
2010-02-17	00:31	00:32	1:10
2010-02-23	00:25	00:28	2:30
2010-03-02	00:35	00:36	0:40
2010-03-09	00:47	00:48	0:40
2010-03-23	01:07	01:10	2:05
2010-03-30	01:22	01:22	0:25
2010-04-06	03:47	03:48	0:45
2010-04-13	01:48	01:49	0:50
2010-04-20	02:54	02:55	0:20
2010-04-20	03:20	03:22	2:05
2010-04-27	02:49	02:52	2:07
2010-05-11	02:14	02:14	0:25
2010-05-18	02:10	02:11	0:25
2010-05-24	02:10	02:11	1:10
2010-06-01	02:44	02:45	1:00
2010-06-08	02:55	02:56	0:50
2010-06-29	02:17	02:19	2:05
2010-07-05	02:29	02:36	7:30
2010-07-13	01:47	01:50	2:55
2010-07-27	04:44	04:45	0:25
2010-08-11	03:12	03:13	0:45
2010-08-17	04:28	04:29	0:55
2010-08-24	02:43	02:47	4:10
2010-09-07	02:58	02:59	1:15
2010-09-14	02:26	02:28	2:05
2010-09-20	03:08	03:08	0:25
2010-09-21	00:24	00:26	2:30
2010-10-01	02:24	02:26	1:55
2010-10-12	01:28	01:28	0:50
2010-10-26	00:53	00:54	0:30
2010-11-09	01:14	01:15	1:05
2010-11-21	09:00	21:00	720:01
2010-12-21	22:43	22:45	2:30

Table B.1. Canberra CN1 variometer data used for infill of CNB variometer during 2010.

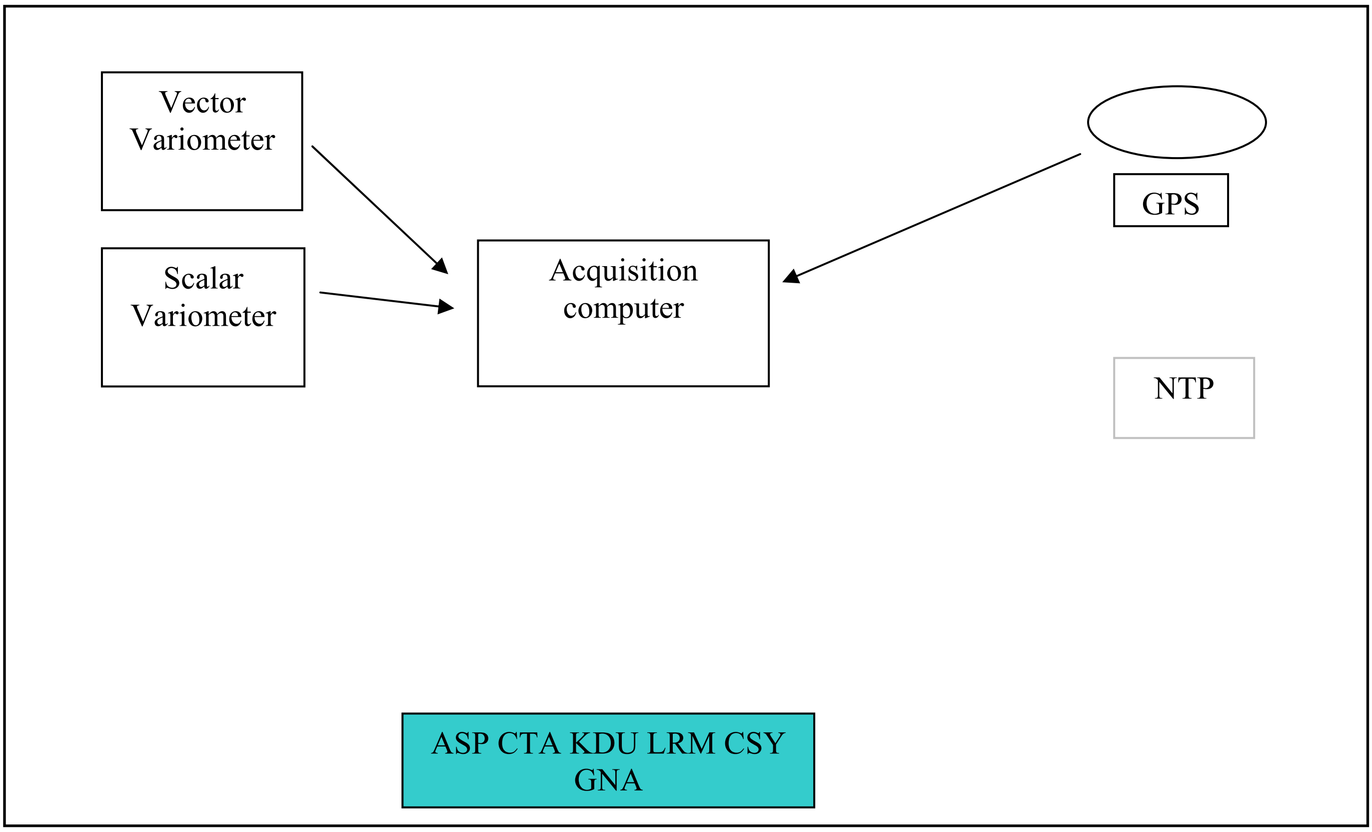
Date	Interval (hh:mm)	Data infilled (minutes)
Nil		

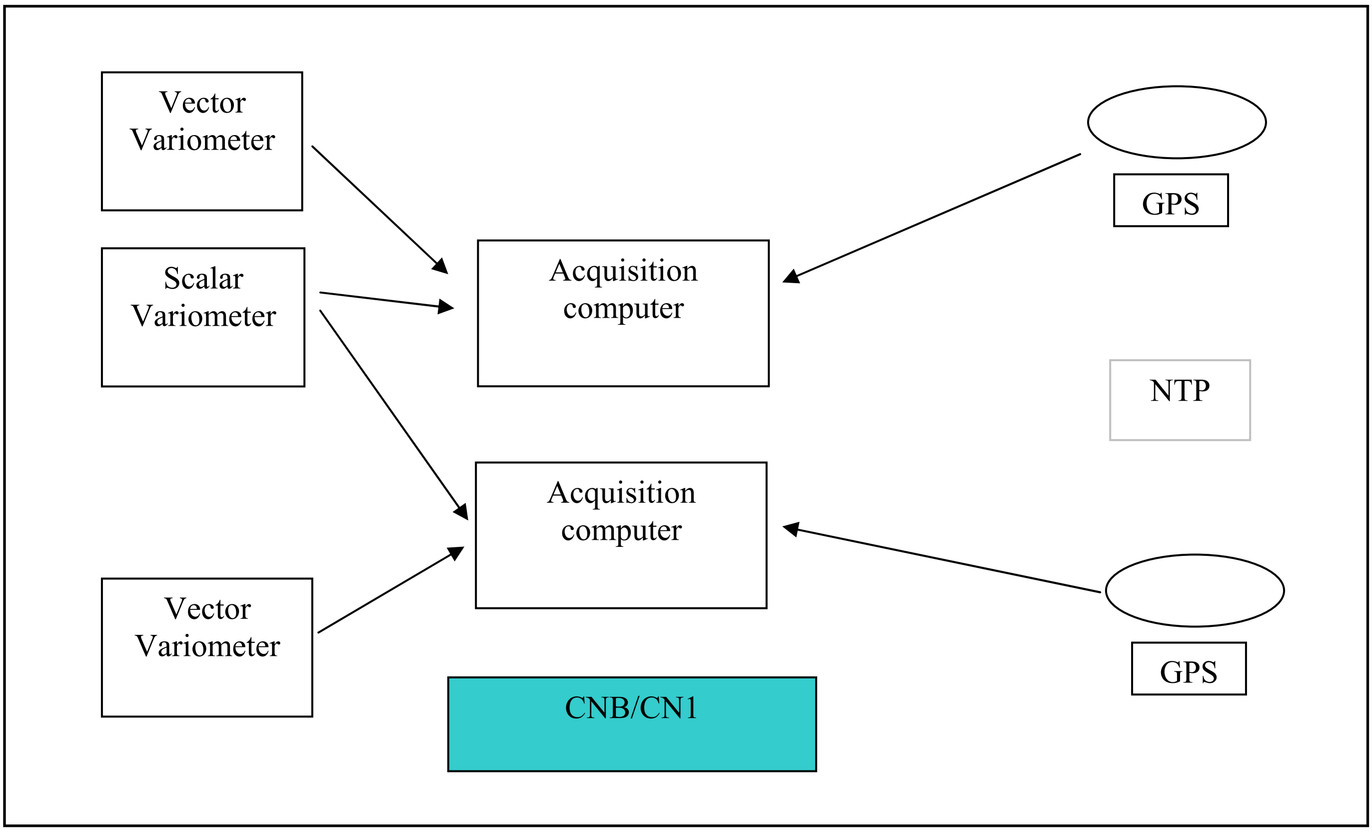
Table B.2. Macquarie Island MCQ vector variometer data used for infill of MQ2 vector variometer during 2010.

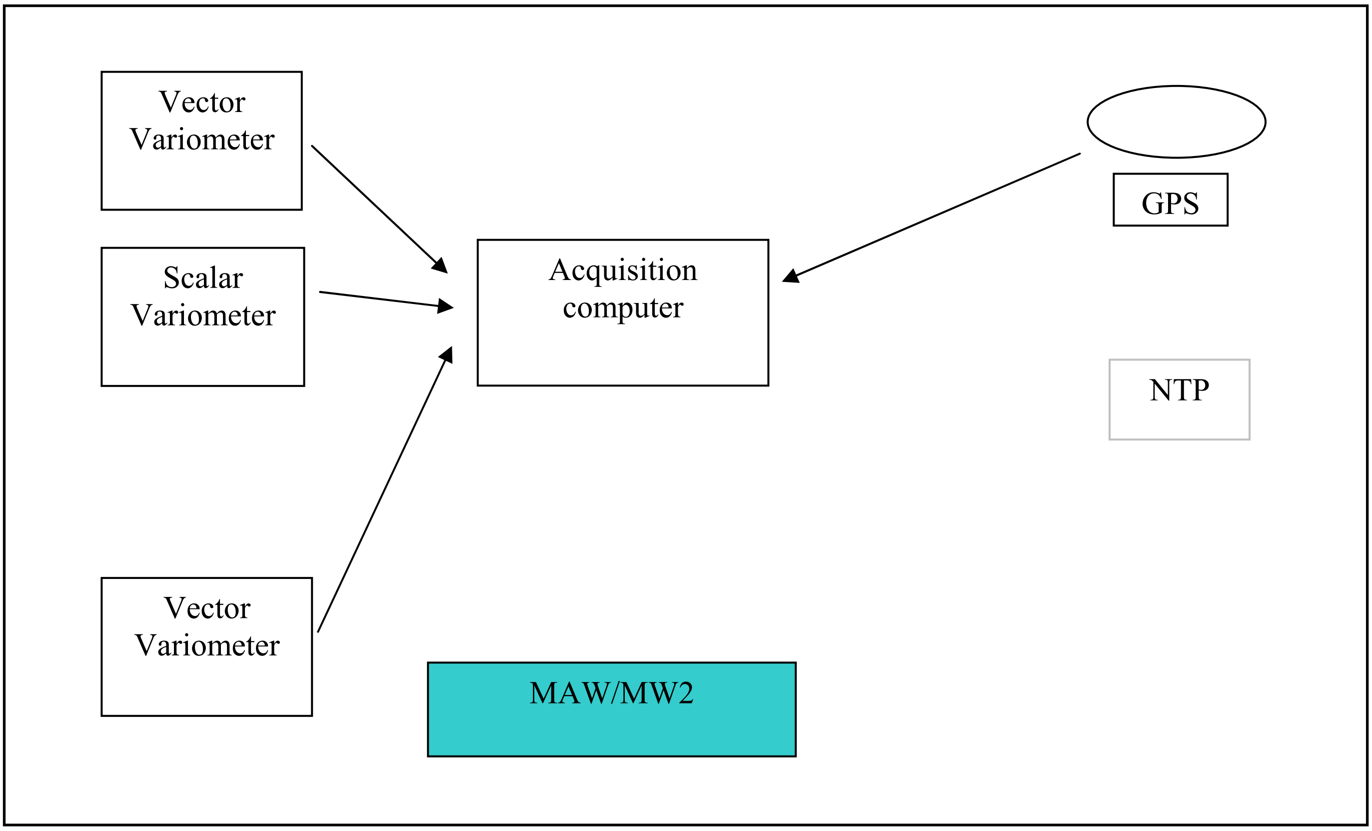
Date	Interval (hh:mm)	Data infilled (minutes)
Nil		

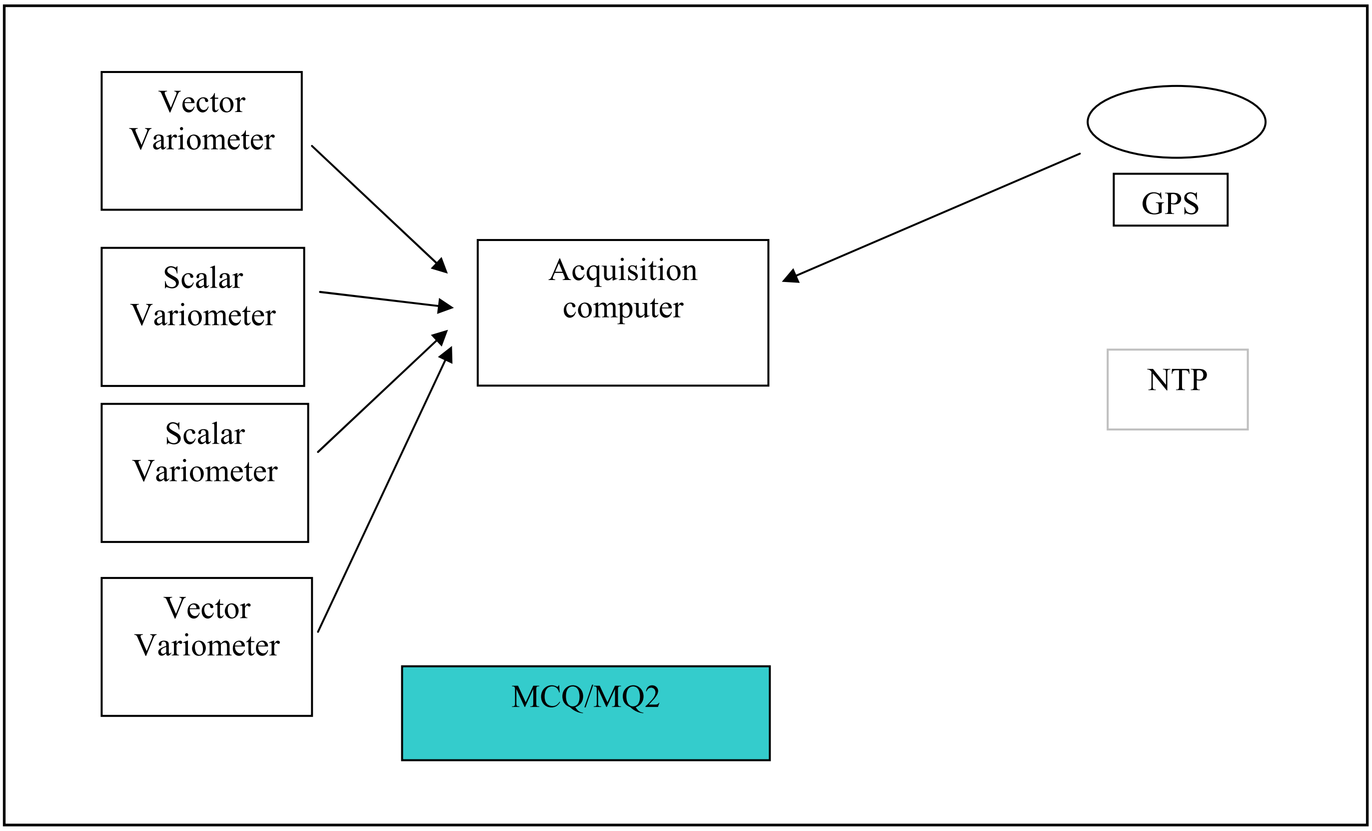
Table B.3. Mawson MAW (Narod) vector variometer data used for infill of MW2 (DMI) vector variometer during 2010.

Appendix C. Variometer configurations






Vector Variometer
Scalar Variometer
Vector Variometer
Acquisition computer
GPS
NTP
MAW/MW2


Vector Variometer
Scalar Variometer
Scalar Variometer
Vector Variometer
Acquisition computer
GPS
NTP
MCQ/MQ2

References

Crosthwaite, P.G., 1992, Calibration of X, Y, Z, F type variometers, *Australian Geological Survey Organisation*, *Geomagnetism Note,* **1992/24**.

Crosthwaite, P.G., 1994, Using F in X, Y, Z, F type variometers, *Australian Geological Survey Organisation, Geomagnetism Note*, **1994/16**.

Hattingh, M., Loubser, L. and Nagtegaal, D., 1989, Computer K-index estimation by a new linear-phase, robust, non-linear smoothing method, *Geophysical Journal International*, **99**, 533–547.

Hitchman, A.P., Crosthwaite, P.G., Hopgood, P.A., Lewis, A.M. and Wang, L., 2008, Australian Geomagnetism Report 2006, Geoscience Australia Record **2008/2**, *Geoscience Australia*.

Hitchman, A.P., Crosthwaite, P.G., Lewis, A.M., Torr, G. and Wang, L., 2009, Australian Geomagnetism Report 2007, Geoscience Australia Record **2009/1**, *Geoscience Australia*.

Hitchman, A.P., Crosthwaite, P.G., Lewis, A.M., Torr, G. and Wang, L., 2010a, Australian Geomagnetism Report 2008, Geoscience Australia Record **2010/22**, *Geoscience Australia*.

Hitchman, A.P., Crosthwaite, P.G., Lewis, A.M. and Wang, L., 2010b, Australian Geomagnetism Report 2009, Geoscience Australia Record **2010/45**, *Geoscience Australia*.

Hopgood, P.A. (Editor), 1999, Australian Geomagnetism Report 1995, *Australian Geological Survey Organisation*.

Hopgood, P.A. (Editor), 2000, Australian Geomagnetism Report 1996, *Australian Geological Survey Organisation*.

Hopgood, P.A. (Editor), 2001, Australian Geomagnetism Report 1999, *Geoscience Australia*.

Hopgood, P.A. (Editor), 2002, Australian Geomagnetism Report 2000, *Geoscience Australia*.

Hopgood, P.A. (Editor), 2004a, Australian Geomagnetism Report 2001, *Geoscience Australia*.

Hopgood, P.A. (Editor), 2004b, Australian Geomagnetism Report 2002, *Geoscience Australia*.

Hopgood, P.A. and McEwin, A.J. (Editors), 1997, Australian Geomagnetism Report 1994, *Australian Geological Survey Organisation*.

Lewis, A.M., 2010, Gingin and Gnangara Geomagnetic Observatories visit, August 2010, *Geoscience Australia*, *Geomagnetism Note,* **2010/11**.

Lewis, A.M. and Pownall, D., 2010, Charters Towers Geomagnetic Observatory maintenance visit, November 2010, *Geoscience Australia*, *Geomagnetism Note,* **2010/12**.

Lewis, A.M. and Wang, L., 2010, Gnangara, Learmonth and Gingin Geomagnetic Observatories maintenance visit, June 2010, *Geoscience Australia*, *Geomagnetism Note,* **2010/10**.

McEwin, A.J. and Hopgood, P.A. (Editors), 1994, Australian Geomagnetism Report 1993, *Australian Geological Survey Organisation.*

St-Louis, B. (Editor), 2008, INTERMAGNET Technical Reference Manual, Version 4.4, 86pp., *INTERMAGNET*.

Staff

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Andrew Lewis	GA Level 5	Project Manager; Australian Geomagnetic Reference Field model; Charters Towers and Gnangara observatories (to 2010-06-30); Charters Towers, Learmonth, Gnangara and Gingin observatories (from 2010-07-01)
Adrian Hitchman	GA Level 5/6	Project Leader; Gingin observatory (to 2010-06-30); Casey observatory (from 2010-07-01)
Glen Torr	GA Level 3	Observatory and system scientific and technical support; Kakadu, Learmonth and Casey observatories; retired 2010-06-30
Liejun Wang	GA Level 5	Information management; compass calibrations; Alice Springs and Macquarie Island observatories (to 2010-06-30); Kakadu, Alice Springs and Macquarie Island observatories (from 2010-07-01)
Jim Whatman	GA Level 4	Technical support

Table 3. Canberra-based staff.

Name	Organisation/Company	Observatory
Tim Bolton	AAD	Casey (to 2010-12-06)
Trevor Crews	AAD	Casey (from 2010-12-15)
Ewan Curtis	AAD	Mawson
Shaun Evans	GA Data Acquisition Facility	Alice Springs
Adrian Gibbs	AAD	Macquarie Island (from 2010-04-01)
Owen Giersch	IPS	Learmonth
John Kennewell	IPS	Learmonth
Emily Lindsay	IPS	Learmonth
Chris Lord	IPS	Learmonth
Owen McConnel	GA	Gnangara, technical support
Jack Millican		Charters Towers (to 2010-09-22)
Stephen Pryde	Pryde Electronic Repairs	Gnangara
Brett Quinton	AAD	Macquarie Island (to 2010-03-31)
Andy Ralph	Kakadu Culture Camp	Kakadu
Warren Serone	GA Data Acquisition Facility	Alice Springs
Brad Stevenson	Bradley Stevenson Sales and Service	Charters Towers (from 2010-11-12)

Table 4. Observatory-based staff.