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by

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Summary

During 2007, 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 Macquarie Island, Casey and Mawson observatory operations were a joint responsibility of Geoscience Australia and the Australian Antarctic Division.

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 regular 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 and USA. 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.

During May and June 2007 the magnetic repeat stations at Vanimo and Kavieng, Papua New Guinea, and Noumea, New Caledonia, were re-occupied and data collected to monitor the secular variation at those stations.

The Indonesian observatories at Tangerang and Tondano were upgraded by Geoscience Australia under an AusAID grant in 2001. The project included the purchase of instrumentation and the training of staff from Indonesia's national meteorological and geophysical organisation, Badan Meteorologi and Geofisika (BMG). Some data were received at Geoscience Australia from the Tondano observatory in 2007; however, no data were received from Tangerang observatory.

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 and repeat stations operated by Geoscience Australia during the 2007 calendar year.

Acronyms and abbreviations

AAD	Australian Antarctic Division
ACRES	Australian Centre for Remote Sensing
ACT	Australian Capital Territory
A/D	analogue to digital
ADAS	analogue data acquisition system
AGR	Australian Geomagnetism Report
AGRF	Australian Geomagnetic Reference Field
AGSO	Australian Geological Survey Organisation
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
CLS	Collecte Localisation Satellites, France
CNB	Canberra magnetic observatory
CNES	Centre National d'Etudes Spatiales, France
CODATA	Committee on Data for Science and Technology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSY	Casey magnetic observatory
CTA	Charters Towers magnetic observatory
D	Magnetic Declination (variation)
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
I	Magnetic Inclination (dip)
INTER-MAGNET	International Real-time Magnetic observatory Network
IAGA	International Association of Geomagnetism and Aeronomy
IGRF	International Geomagnetic Reference Field
IGY	International Geophysical Year (1957-58)
IPGP	Institut de Physique du Globe de Paris, France
IPS	IPS Radio and Space Services
ISGI	International Service of Geomagnetic Indices, France
K	kennziffer (German: logarithmic index; code no.) – 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
QHM	quartz horizontal magnetometer
RAAF	Royal Australian Air Force
RCF	ring-core fluxgate
SC	sudden commencement
sfe	solar flare effect
ssc	sudden storm commencement
UPS	uninterruptible power supply
UT[C]	Universal Time [Coordinated]
VSAT	Very Small Aperture Terminal
WDC	World Data Centre
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);
- Casey (CSY), Australian Antarctic Territory, and;
- Mawson (MAW), Australian Antarctic Territory.

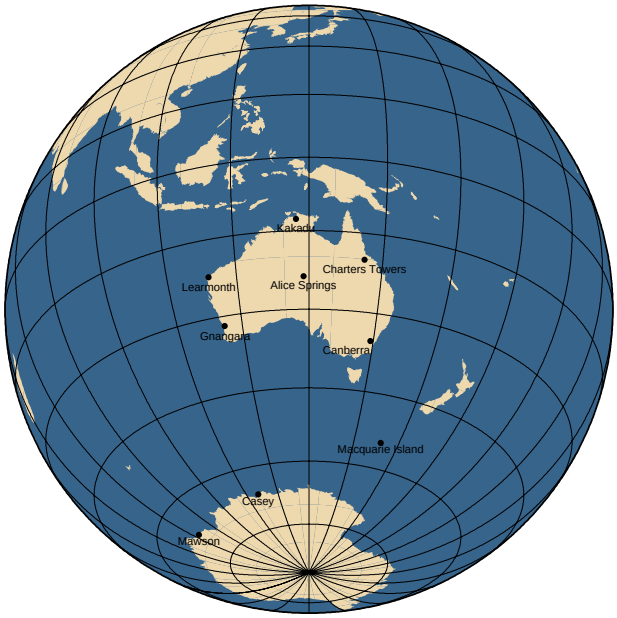


Figure 1. The Geoscience Australia geomagnetic observatory network.

Antarctic operations

Geoscience Australia supports 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, 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.

Regional observatories

Between 1998 and 2001, Geoscience Australia contributed to an AusAID project to upgrade geomagnetic observatories at Tangerang (TNG) near Jakarta on Java and Tondano (TND) near Manado on Sulawesi operated by Indonesia's Badan Meteorologi dan Geofisika (BMG). The project included the cost of instrumentation and the training of BMG staff at Geoscience Australia.

As a result of this project it is possible to transmit absolute observation and variometer data to Geoscience Australia from these observatories for routine processing. Some data were received in this way from Tondano observatory in 2007, however no data were received from Tangerang.

The Indonesian data complement data gained during repeat station occupations to enhance Australian Geomagnetic Reference Field (AGRF) models.

Magnetometer calibration

Canberra magnetic observatory hosts the Geoscience Australia Magnetometer Calibration Facility. Built in 1999, in collaboration with the Department of Defence, it consists of a Finnish/Ukrainian-designed 3-axis coil system which is used to calibrate observatory variometers and clients' 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 automatically processed 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 to IPS Radio and Space Services, Sydney, where they are used for space weather analysis and forecasting. Preliminary 1-minute time series are available in near real-time on the Geoscience Australia website. They are also sent to the Edinburgh INTERMAGNET geomagnetic information node (GIN) and made available on the INTERMAGNET website.

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 World Data Center A (WDC-A).

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 (by e-mail) 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.

Preliminary monthly mean values from all Australian observatories are provided in support of the Ørsted satellite project. 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

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 '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, 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 Canberra are provided semi-monthly to the GeoForschungsZentrum, Potsdam, Germany, for the derivation of global geomagnetic activity indicators such as the 'planetary' Kp index.

K indices for Canberra are also provided to:

- University of Newcastle, Australia;
- CLS, CNES (French Space Agency), Toulouse, France;
- Royal Observatory of Belgium, Brussels, and;
- Geomagnetism Research Group of the British Geological Survey.

K indices from 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.

All routine K index information is transmitted by e-mail.

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.

Storms and rapid variations

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

- WDC-A, Boulder, USA;
- WDC-C2, 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, or in which Geoscience Australia had significant involvement. 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.

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 (www.ga.gov.au/geomag).

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 by telephone line or network connection.

Recording intervals and mean values

The standard sample intervals at Australian observatories are 1 second for vector data and 10 seconds for scalar data. One-minute values are generated from the 1-second data using the INTERMAGNET filter (St-Louis, 2008). Hourly mean values are computed from minutes 00^m to 59^m, e.g. the hourly mean value labelled 01^h, is the mean of the 1-minute values from 01^h00^m to 01^h59^m inclusive. Daily means are the average of hourly mean values 00^h to 23^h when all hourly means in the day exist.

Monthly means are computed for the 5 International Quiet Days, the 5 International Disturbed Days and all days in the month over as many days that exist in each of the subsets. Annual means are computed from the monthly means for a Quiet Day mean, a Disturbed Day mean and an all day mean, over as many months for which Quiet, Disturbed or all day means exist.

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:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} S_{XA} & S_{XB} & S_{XC} \\ S_{YA} & S_{YB} & S_{YC} \\ S_{ZA} & S_{ZB} & S_{ZC} \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix} + \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix} + \begin{pmatrix} Q_X \\ Q_Y \\ Q_Z \end{pmatrix} \left(T - T_S\right) + \begin{pmatrix} q_X \\ q_Y \\ q_Z \end{pmatrix} \left(t - t_S\right) + \begin{pmatrix} D_X \\ D_Y \\ D_Z \end{pmatrix} \left(\tau - \tau_0\right)$$

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;
- Ts and ts 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 – DIM) 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 except Canberra used an external GPS clock to maintain timing accuracy throughout 2007. Canberra observatory changed from ntpd to GPS-based timing in August 2007.

ADAM A/D converters are used to convert analogue data 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.

During 2007, a Geoscience Australia QNX-based data-acquisition system was installed at Casey magnetic observatory. It operated in parallel with the Australian Antarctic Division's EDA FM105B variometer which acquires data using the AAD Analogue Data Acquisition System (ADAS).

Observatory data are retrieved to Canberra automatically via telephone and network links 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.

Variometers

The variometers used during 2007 are described in Table 1.2.

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. The data connections between the acquisition computer and both the ADAM A/D and the PPM variometer were via fibre-optic modems and several metres of fibre-optic cable to isolate any damage from lightning entering the system through any one piece of equipment. The fibre-cable connecting the ADAM A/D to the computer was removed in March while investigating a data-link failure. The fibre-cable connecting the PPM to the computer was transferred to the ADAM A/D in December, leaving no fibre in the PPM data-link thereafter.

IAGA code:	KDU
Commenced operation:	05 March 1995
Geographic latitude:	12° 41' 10.9" S
Geographic longitude:	132° 28' 20.5" E
Geomagnetic latitude:	-21.81°
Geomagnetic longitude:	205.69°
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.

3-component variometer:	DMI FGE
Serial number:	E0198/S0183
Type:	suspended; linear 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:	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:	2400b TCP/IP

Table 1.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

DI fluxgate:	Bartington MAG-01H
Serial number:	B0622H
Theodolite:	Zeiss 020B
Serial number:	359142
Resolution:	0.1’
D correction:	0.05’
I correction:	-0.05’
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 2007. 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.

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 housed the variometer electronics, was maintained at about 23°C using a temperature control unit with both heating and cooling capability. The temperature of the DMI FGE magnetometer electronics ranged from 25.7°C to 30.2°C during the year, at an average of 27.7°C±0.7°C. The typical daily range of the DMI fluxgate electronics temperature varied from less than 0.25°C in April to 1.5°C in December.

The DMI sensor temperature ranged from 25.9°C to 33.9°C during the year, with an average of 30.2°C±1.9°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. The average daily temperature variations of the sensor were about 0.25°C.

The meteorological temperature at nearby Jabiru in 2007 varied from a minimum temperature of 11°C in June to a maximum temperature of 40°C in November. The average daily minimum temperature was 23°C and the average daily maximum temperature 35°C. The daily temperature range was 12±3°C, and the least and greatest daily temperature ranges were 2°C and 21°C.

The correlation between temperature and FCheck behaviour was not as apparent as in previous years. (See the discussion in Baselines below).

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. The time corrections were logged automatically. The logged time corrections in excess of 1 ms during 2007 were:

2007-02-20	00:51:53	6.689s	computer installed
2007-02-20	00:56:32	6.686s	computer installed/restart
2007-02-22	00:50:28	0.715s	System restart/reconfigured
2007-03-14	05:24:40	0.555s	System restart
2007-03-19	00:49:59	1.341s	power failed? /System restart

(Various logged corrections from 2007-11-09 to 2007-12-04 were to a computer in preparation or during installation, but not collecting data.)

2007-12-04	01:33:22	0.101s	System maintenance
2007-12-04	04:14:58	1.156s	System restart
2007-12-04	04:34:36	0.102s	System maintenance

One-second variometer data sometimes contained signatures from monsoonal electrical storms and there was some data corruption due to oscillations of the suspended fluxgate sensor caused by waves from significant regional earthquakes.

Spikes caused by monsoonal electrical storms (mainly October-February) were not removed from the 1-second definitive data. The effects of earthquakes on days-of-year:

023, 028, 068, 091, 125, 157, 167,182, 232, 349(2)

were not removed from the 1-second definitive data.

These artefacts should have little effect on the filtered 1-minute data.

Absolute instruments

The principal absolute magnetometers used at Kakadu and their adopted corrections for 2007 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. This method was used at Kakadu throughout the year.

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 D and I corrections applied in 2007 were determined through instrument comparisons performed during maintenance and calibration visits in November 2004, May 2006, September 2006, and December 2007, and can be traced through comparisons to B0806H/100856, B0610H/160459, and comparisons at the 2004 IAGA Workshop at Kakioka. The F correction was measured by instrument comparisons and frequency comparisons at Canberra before the instrument was deployed, and during the December 2007 visit. These corrections were applied during the determination of baselines.

At the 2007 mean magnetic field values at Kakadu the D, I, and F corrections translate to corrections of:

ΔX = -0.5 nT ΔY = +0.5 nT ΔZ = -0.5 nT

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

Baselines

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

	σ		σ
X	0.7 nT	D	5"
Y	0.8 nT	I	4"
Z	0.8 nT	F	0.5 nT

The baselines aligned with the 2006 baselines to within:

-0.8 nT for X -1.0 nT for Y -0.3 nT for Z.

It was not necessary to apply drifts to any channel in 2007.

Observations made between 23 May and 22 July, and also on 27 November, were excluded from baseline determinations. The observer appeared to have magnetically contaminated the results with a can of insect repellent to protect himself from wasps.

The DMI FGE magnetometer maintained stable baselines throughout the year, except for the frequent transitions between two metastable states. It is suspected that observation errors, and insufficient training, may be responsible for some decline in baseline stability compared to previous years.

From late in 2004, the DMI FGE variometer has shown frequent shifts amounting to 1 nT in F, sometimes several times per day. The shift always had the same character: a slow onset and decay of about 5 minutes; always of the same magnitude and sign, and was semi-stable in either the shifted or un-shifted state. It has previously been deduced from occasional sets of absolute observations in early 2005 that straddled a shift, that no component was shifted by more than 1 nT, indicating that the problem was not serious. The shifts began when the GSM-90 variometer and new computer were installed during the November 2004 maintenance visit. Although the pre-GSM-90 data (Geometrics 856) was noisier and such shifts not so obvious, no similar shifts were apparent before the visit. The source of this problem has not yet been resolved.

FCheck had two meta-stable states differing by about 1 nT as a result of this problem. There were two phases during the year:

- January to August, there was no dominant state, although the low state was somewhat preferred in January and the high state somewhat preferred was preferred in March and June;
- September to December, the low state was dominant and FCheck was much more stable.

During 2007 the difference between the KDU absolute and variometer GSM-90 magnetometers was consistent to within ±0.5 nT. No seasonal variation was noticeable during the year.

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 Andy Ralph, the local observer. On these visits the operation of the observatory was also checked. Completed absolute observation forms were posted to Geoscience Australia where they were reduced 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. Fortunately the DMI FGE magnetometer baselines appear to have been exceptionally stable throughout 2007, as they have been in previous years, and the fewer than normal number of observations did not seem to affect the quality of the final data.

There were many problems encountered processing the absolute observations during 2007 and some observations were disregarded. Although the observer demonstrated competence performing observations, he appeared to be insufficiently trained particularly in the observance of personal magnetic decontamination. This training deficiency was addressed during the December maintenance visit.

A computer power-supply failure on 9 February caused loss of data for more than 10 days. The data-acquisition computer was replaced on 20 February. Due to a configuration error the vector variometer then operated in low-resolution (10V) mode for about 2 days. On 22 February at 00:53UT it was remotely reconfigured and thereafter operated in normal resolution (5V) mode.

There was extensive monsoonal flooding in the district in March which prevented physical access and damaged all landline data communications to the observatory from 3 until 13 March. Data from this period were recovered when communications were restored on 14 March. It appears that during an inspection on 13 March some cables were dislodged and vector variometer data were lost until the problem was rectified on 21 March.

Andrew Lewis and Jim Whatman from GA visited the observatory from 3 to 7 December to:

- Check the condition of the observatory, and tidy equipment and the Control House in general;
- check reference mark azimuths;
- confirm variometer baselines;
- re-measure the pier difference between the primary and external observation piers A and E;
- install a 12V battery power-supply box and use it to power as much of the variometer system as possible;
- replace the data acquisition computer;
- replace batteries in UPS, absolute battery box and Bartington DIM;
- undertake absolute instrument comparisons and tests, and;
- provide refresher training for the local observer.

The instrument correction to the KDU absolute instrument B0622H/359142 agreed within 0.05’ of the adopted correction.

The pier difference between Pier A and E was consistent with measurements in 2003, 2004, and 2006.

A round of angles was not possible at Pier E due to heavy vegetation. A round of angles at Pier A indicated the possibility of a shift of 0.1’ in the azimuth of the primary mark AW relative to Pier E and other reference marks. Any shift has not been accounted for in data in this report.

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.

Data losses at Kakadu in 2007 are identified in Table A.1.

Significant events

2007-02-09 23:40 Acquisition system failed

2007-02-12 No response from acquisition computer, although router is O.K.
Inspection by Andy Ralph indicates computer failed (See 2007-03-?? Below for details.)

2007-02-15 Despatch replacement computer via Australia Post from GA to KDU

2007-02-20 00:50 Andy Ralph installed replacement computer
00:55 accidental reboot
Magnetometers and GPS are working O.K.
modem tested O.K. and left unplugged
Did not notice that ADAM was incorrectly configured in 10V mode rather than 5V mode

2007-02-22 00:49 AML remotely reconfigured ADAM to 5V mode and restarted the computer

2007-03-03 No real-time data from 16:40 UT due to flooding and communications outage.

2007-03 The computer that failed on 2007-02-09 arrived at GA for inspection. The computer was undamaged, but its external power supply had failed.

2007-03-13 Receding floodwaters allow Andy Ralph access to KDU to check system.
PPP modem connected to system

modem connection is unreliable (probably due to noisy water-damaged telephone line).
DDS modem and router re-set, but DDS line still not working. Fault lodged with Telstra

2007-03-14 Data connection ok again.
Earlier modem tests probably failed when Telstra was using or repairing the phone lines.
However the Adam is not reachable since 2007-03-13T01:00, and cannot revive it by restarting the driver or restarting the system (shutdown at 05:23).
Andy is not available to trouble shoot.
Suspect plug may have been dislodged when Andy checked system yesterday 2007-03-13

2007-03-21 Andy Ralph visited KDU and connected DMI variometer direct to ser8 bypassing fibre optic (lightning protection) interface, and seemed ok.
The removed equipment will be returned for testing.
PPP MODEM DISCONNECTED.

2007-08-01 Owen McConnel visited KDU.
Investigated potential absolute observation pier contamination and found

- plastic chair/table/umbrella outside Absolute Shelter apparently non-magnetic, umbrella ok > 1m, and
- metal broom inside shelter (20nT on DIM in D mode at its stored location) and
- a metal can fly-spray inside shelter!

Will inform Andy Ralph of the results.

2007-09-16 Andy Ralph attended KDU to reboot seismic computer for Terry Smith.

2007-09-19 Andy Ralph attended KDU to reattach communications link to phone line - apparently disconnected on 2007-09-16 by mistake.

2007-12-04 Andrew Lewis and Jim Whatman at KDU
installed 12V battery box
~2007-12-03T23:40 replaced 240V computer with 12V computer previously removed from KDU after 2007-02-09
replaced GPS pulse stretcher, and attached to new computer
~01:00 swapped over GSM90 then DMI to new computer
disconnected GSM90 fibre-optic (lightning protection) cable, and connecting that fibre-optic cable to the DMI, with DMI/ADAM485-232 end fibre-optic modem to UPS, computer-end fibre-optic modem to 12V battery box.
Some DMI data loss (30-60m) when power supply failed during power rearrangements.

2007-12-06 Some contamination to data ~05:00 during maintenance on instrument sensor vaults.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 1.4. Distribution of 2007 data.

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 2007 data are shown in Figure 1.3.

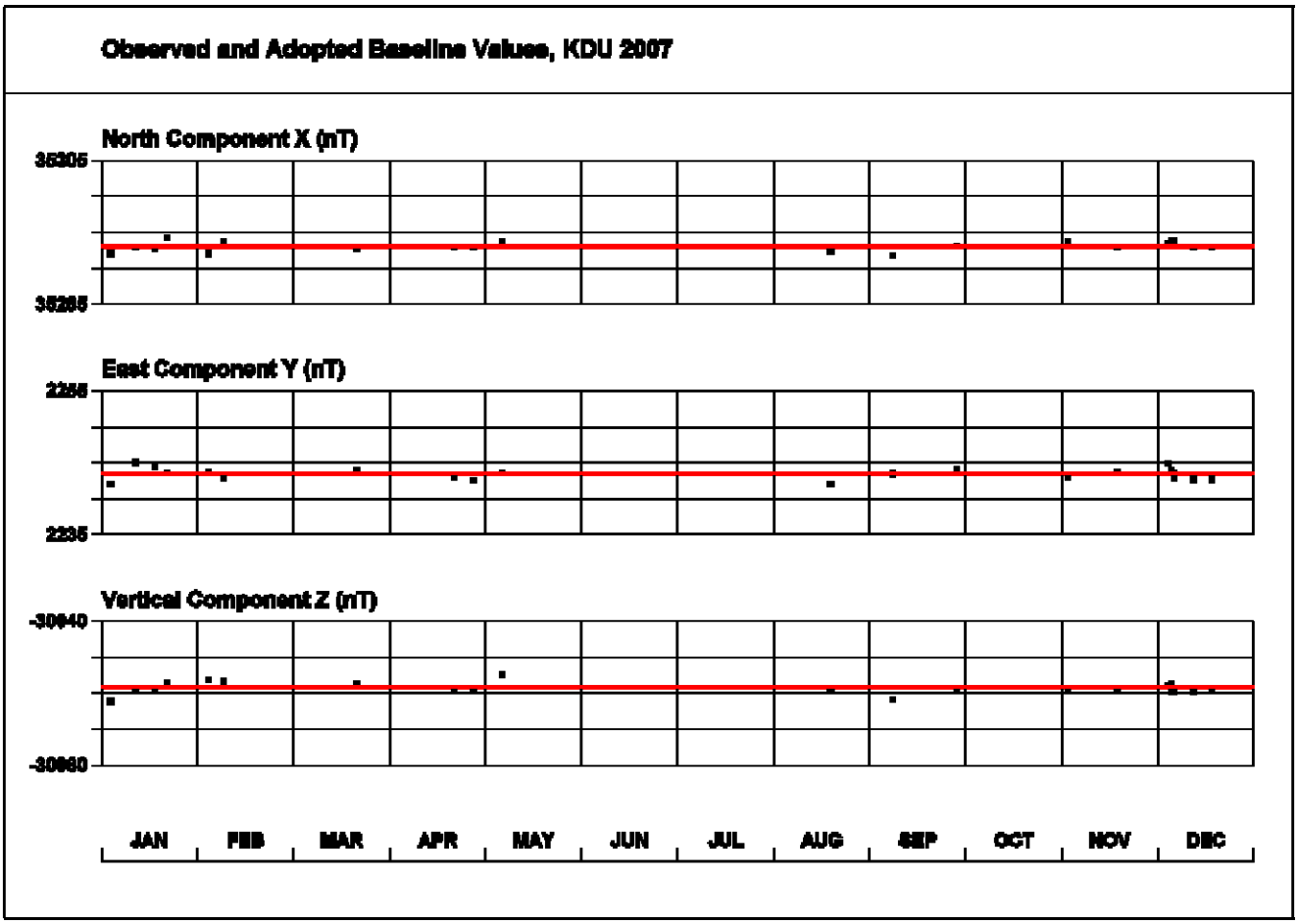


Figure 1.1. Kakadu baseline plots.

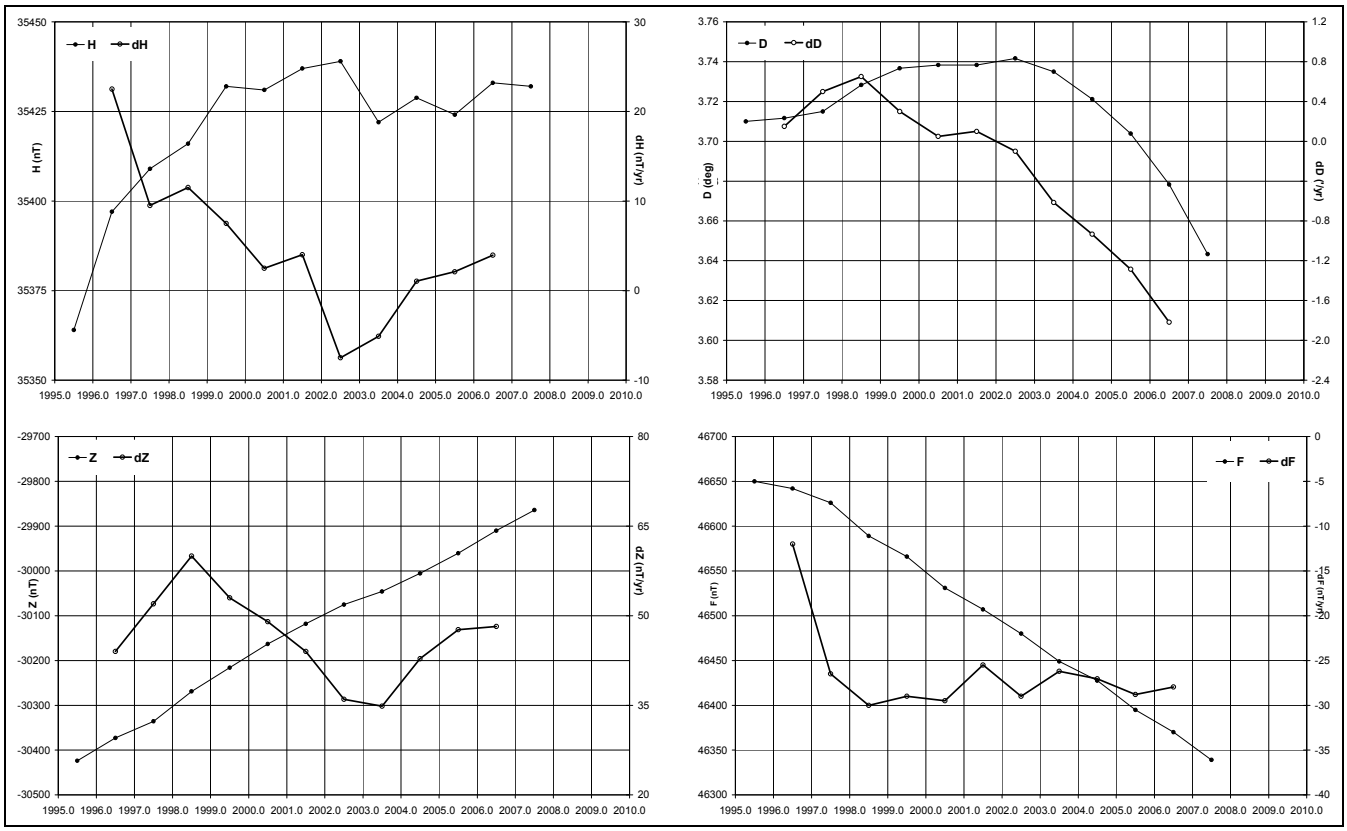
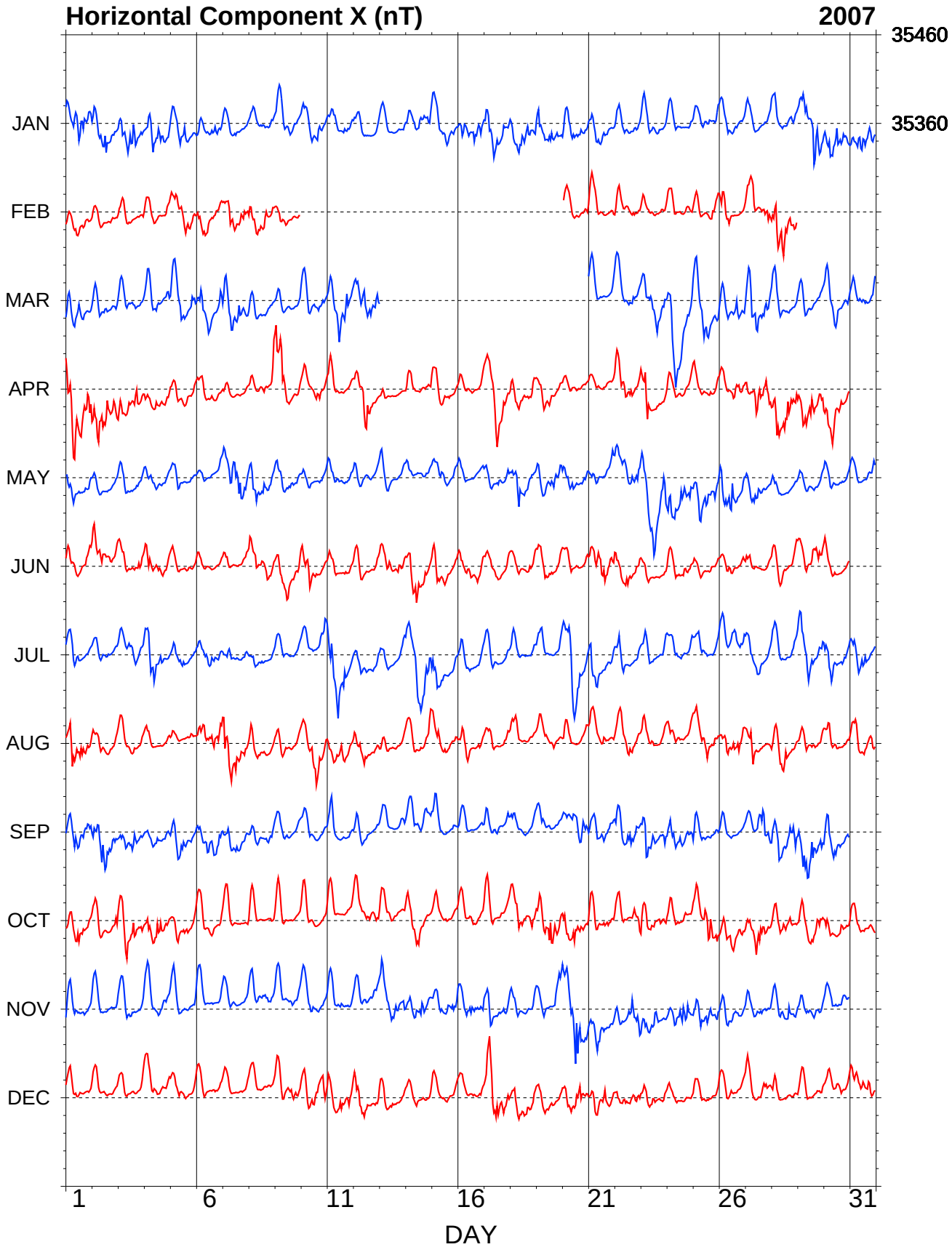


Figure 1.2. Annual mean values and secular variation (all days) for H, D, Z and F measured at Kakadu.

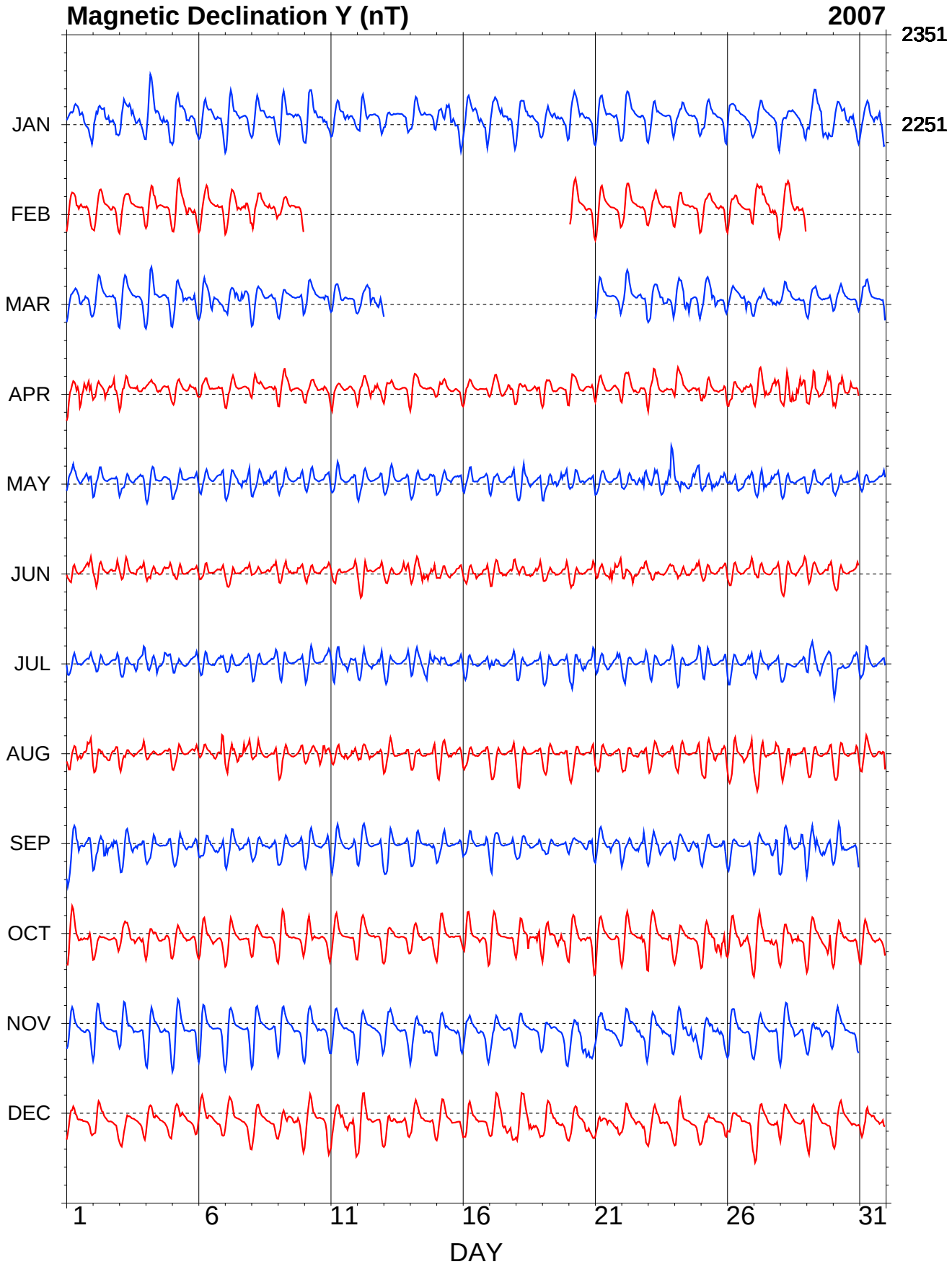
Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABZ
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABZ
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABZ
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	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	7.6	35432	35361	2252	-29864	46339	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	7.3	35438	35367	2253	-29864	46344	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	8.0	35423	35351	2251	-29865	46332	ABZ

Table 1.5. Annual mean values calculated using the 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.

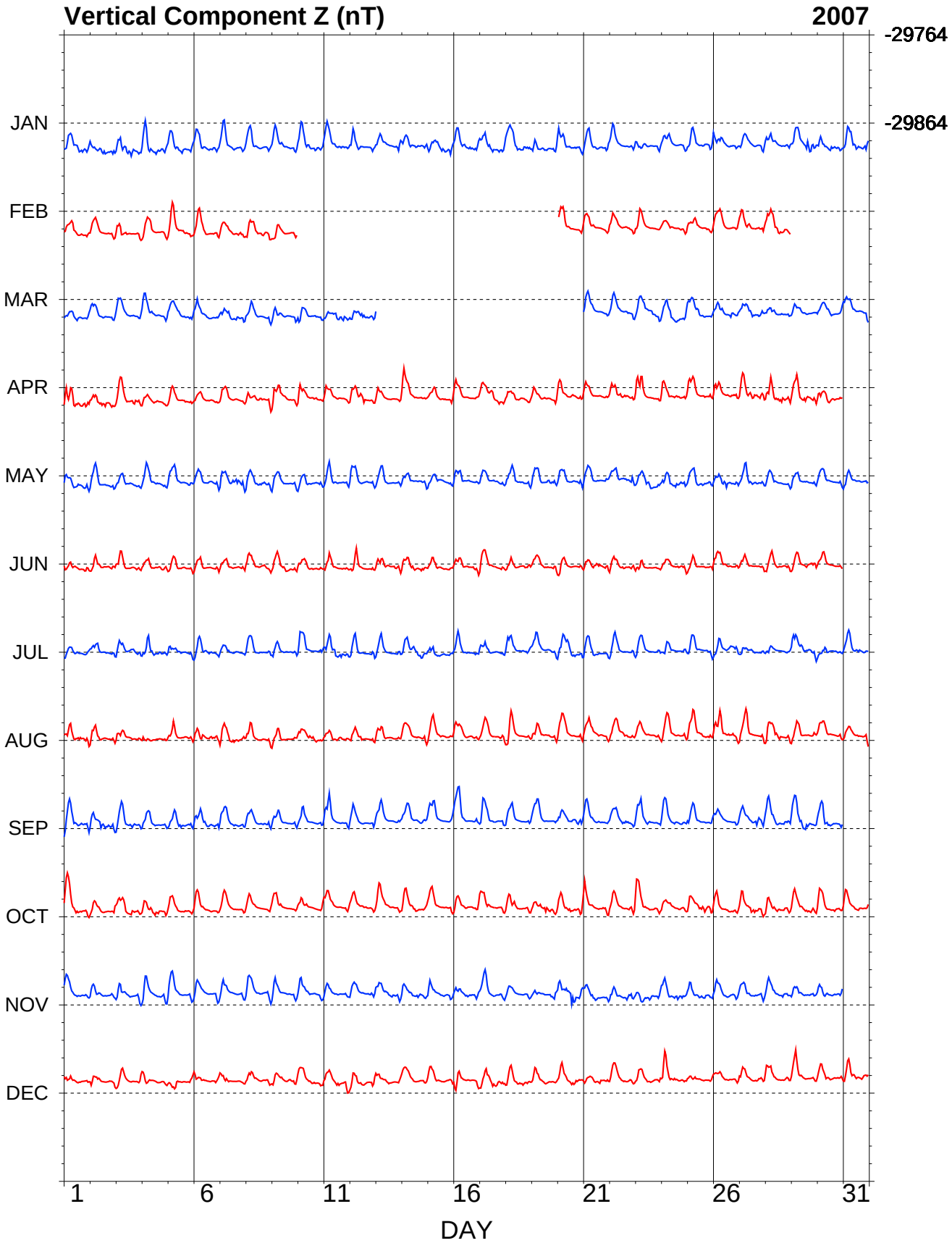
KDU - Hourly Mean Values



KDU - Hourly Mean Values



KDU - Hourly Mean Values



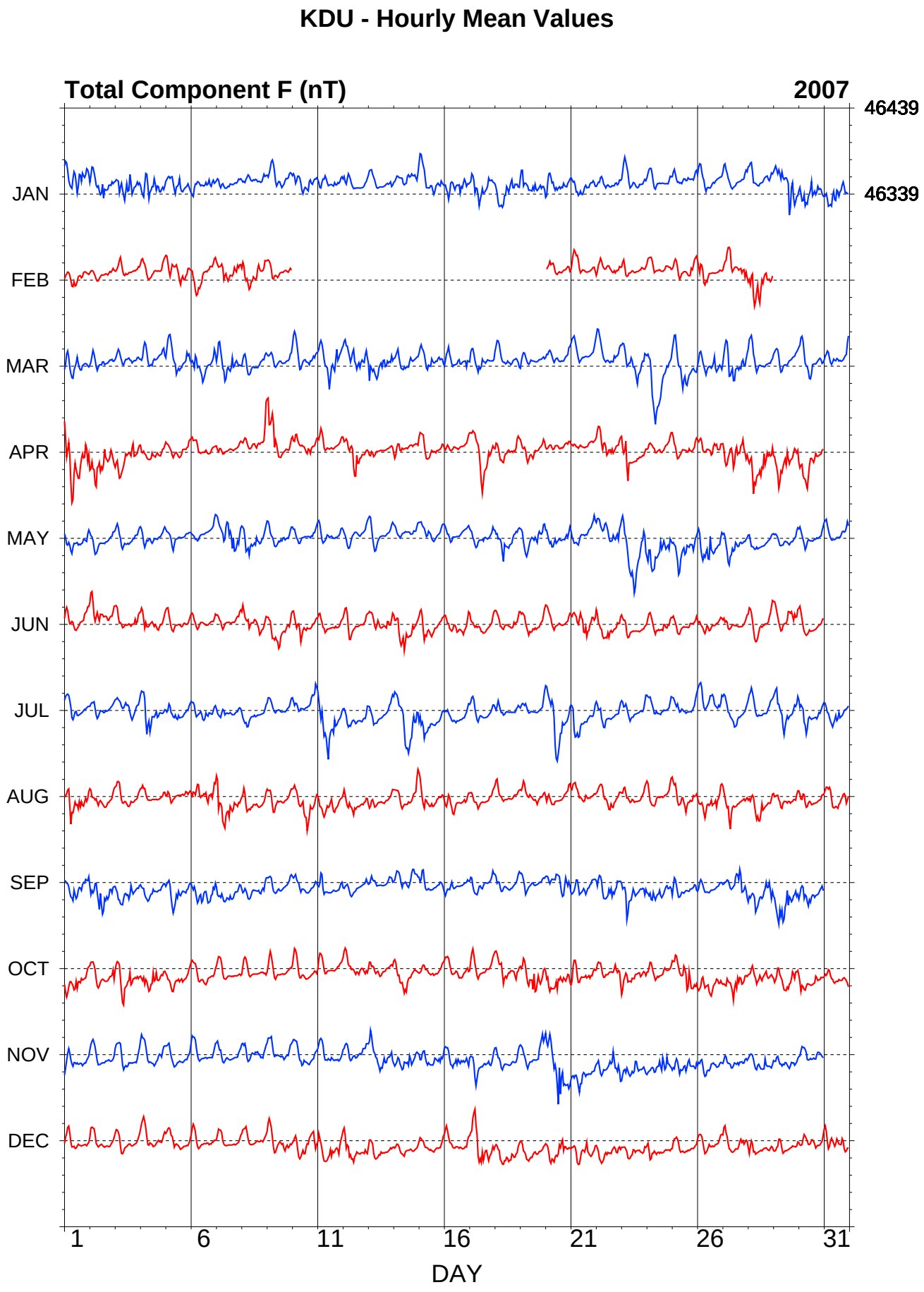


Figure 1.3. Hourly mean values in X, Y, Z and F measured at Kakadu.

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 city 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).

Variometers

The variometers used during 2007 are described in Table 2.2. The DMI FGE fluxgate sensor was installed on a marble plate which rests on concrete blocks in the mine tunnel. Before installation its scale-values, relative sensor alignments and temperature sensitivities were determined at the Canberra magnetometer calibration facility. 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.

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.

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 electronics) were housed in an air-conditioned (for cooling) room in an adjacent arm of the tunnel.

Timing was derived from a Garmin GPS 16 clock. This clock was installed on 3 May 2006 and superseded timing based on the data-acquisition computer clock. Although noted in the Charters Towers *Significant events* in the 2006 Australian Geomagnetism Report (Hitchman *et al*., 2008), this change was not reported in Table 2.2 of that report.

Data files were telemetered from Charters Towers to Geoscience Australia through a network with a maximum delay of 10 minutes. The variometer and recording systems were powered by 240VAC mains, backed up by a PowerTech UPS with sufficient capacity to power the system for up to four hours.

Absolute instruments

Variometers were calibrated by weekly absolute observations using a DIM and PPM on Pier C in the Absolute Shelter. The principal absolute magnetometers used and their adopted corrections for 2007 are described in Table 2.3.

Before 31 December 2006, the absolute instruments were corrected to the Canberra Observatory reference, with corrections for D, I, and F of zero. From 00:00 on 01 January 2007, they were corrected to the international reference. At the 2007 mean magnetic-field values at Charters Towers the D, I, and F corrections in Table 2.3 translate to corrections of:

ΔX = -2.17 nT ΔY =-0.29 nT ΔZ = -1.85 nT ΔH = -2.19 nT

Consequently, there is a shift equal to the new instrument corrections in the 1-second data between 23:59:59 2006-12-31 and 00:00:00 2007-01-01. In the 1-minute data, this shift is not apparent as these data were derived from the 1-second data using the INTERMAGNET filter.

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

IAGA code:	CTA
Commenced operation:	June 1983
Geographic latitude:	20° 05' 25" S
Geographic longitude:	146° 15' 51" E
Geomagnetic latitude:	-27.80°
Geomagnetic longitude:	221.02°
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

Table 2.1. Key observatory data.

3-component variometer:	DMI FGE (Version G)
Serial number:	E0227/S0210
Type:	non-suspended; linear 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

Table 2.2. Magnetic variometers used in 2007. 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 2007. Corrections are applied in the sense Standard = Instrument + correction.

Baselines

During 2007 the X, Y and Z fluxgate variometer baseline drifts were within a 6, 9 and 6 nT range, respectively.

On 10 March, the variometer baselines jumped suddenly between 04:11:28 and 04:11:29. The offsets for X , Y and Z were:

dX = -1.48 nT, dY = -0.64 nT, dZ = 0.0 nT.

A second sudden baseline jump occurred on 01 October, between 01:16:09 and 10:16:10. The offsets for X, Y and Z were:

dX = -3.71 nT, dY = 9.24 nT, dZ = -1.92 nT.

With drift corrections applied to the baselines, the standard deviations in the difference between absolute observations and the adopted final variometer model were:

	σ		σ
X	0.8 nT	D	11"
Y	1.7 nT	I	4"
Z	0.6 nT	F	0.3 nT

With drift corrections applied, FCheck varied within a 2 nT envelope. This is not unreasonably high as the baseline was calibrated against the absolute PPM and DIM, where the absolute PPM may have had 2 nT variations throughout 2007 (as the difference between the absolute PPM and variometer PPM varied within about 2 nT).

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

Operations

The local observer performed most routine operations during the year, including:

- weekly absolute observations;
- weekly temperature measurements in tunnel;
- mailing the observation sheet and log sheet to GA.

Data losses at Charters Towers in 2007 are identified in Table A.2.

Significant events

2007-02-15 Second set of absolute PPM readings failed - possibly absolute battery box battery problems

2007-02-17 Variometer PPM stops operating 12:02:13 (there were storms in CTA at this time)

2007-02-19 04:30 Jack in tunnel investigating variometer PPM problem
04:50 Jack in tunnel again, try absolute PPM, try PPM in ser5 - O.K.
Reboot system ~05:04 - all O.K. (PC had temporarily lost the use of ser7)

2007-03-01 First obs with new batteries in absolute battery box.

2007-04-22 Lost communications with GPS Clock 15:40

2007-04-23 restart GdapClock at 05:51 LJW and Jonathon Griffin at CTA for maintenance visit 23 - 27 Apr

2007-04-24 restart GdapClock at 01:17 again but still not working
- called and left message for LJW at CTA to restart computer
- ntpdate -q time gave 14ms correction (192.55.112.40) at 01:17
- LJW calls in - requests a remote reboot.
Reboot at 02:19

2007-05-22 last good GdapClock time correction at 06:01 shutdown to enable GdapClock at 01:26:40; prior to shutdown pips seemed to show reasonably good timing (line delay prevented accurate appraisal but seemed good to a few tenths of a second) After startup, 01:28:12 correction was 1.011s (included CMOS 1s variability). Tried GdapClockTest2 to see if anything was happening, and there seemed to be some ticking - but didn't test the system correctly and no resolution of this problem at this stage. PGC

2007-07-23 01:46 baseline updated

2007-09-05 19:00-24:00 Head temperature anomaly

2007-09-27 Cor Var X = -2.85 # Xvar = 31512.45
Cor Var Y = -1.22 # Yvar = 4201.15
Cor Var Z = -4.79 # Zvar = -37572.30

2007-10-04 absolute obs indicated a large base line shift, in comparison to the 27 Sep observations above. waiting for next obs for confirmation
Cor Var X = -5.35 # Xvar = 31515.59
Cor Var Y = 10.87 # Yvar = 4213.15
Cor Var Z = -6.11 # Zvar = -37569.97
Found out baseline jumped during 01:16:09 to 01:16:10. unknown reason.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 2.4. Distribution of 2007 data.

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 2007 data are shown in Figure 2.3.

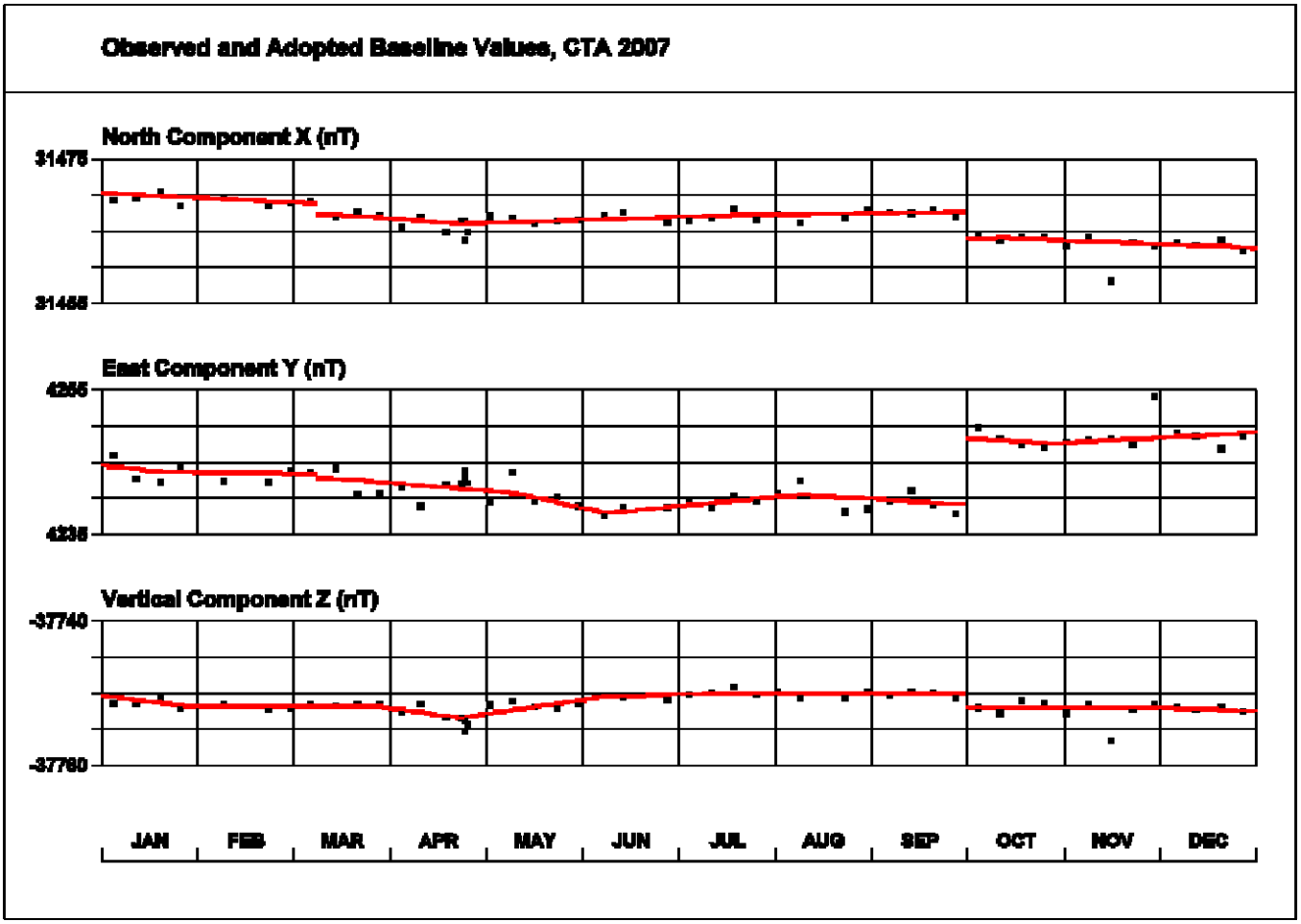


Figure 2.1. Charters Towers baseline plots.

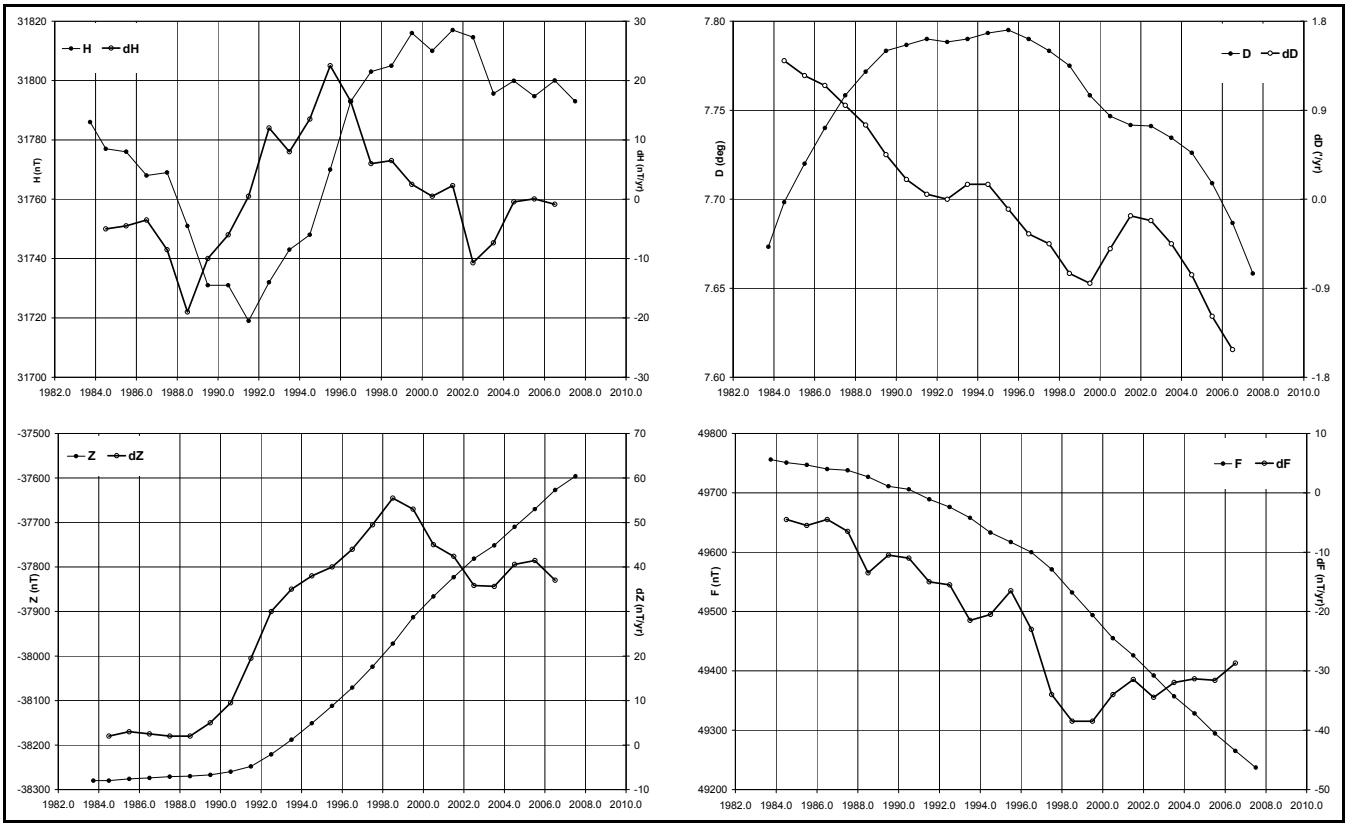


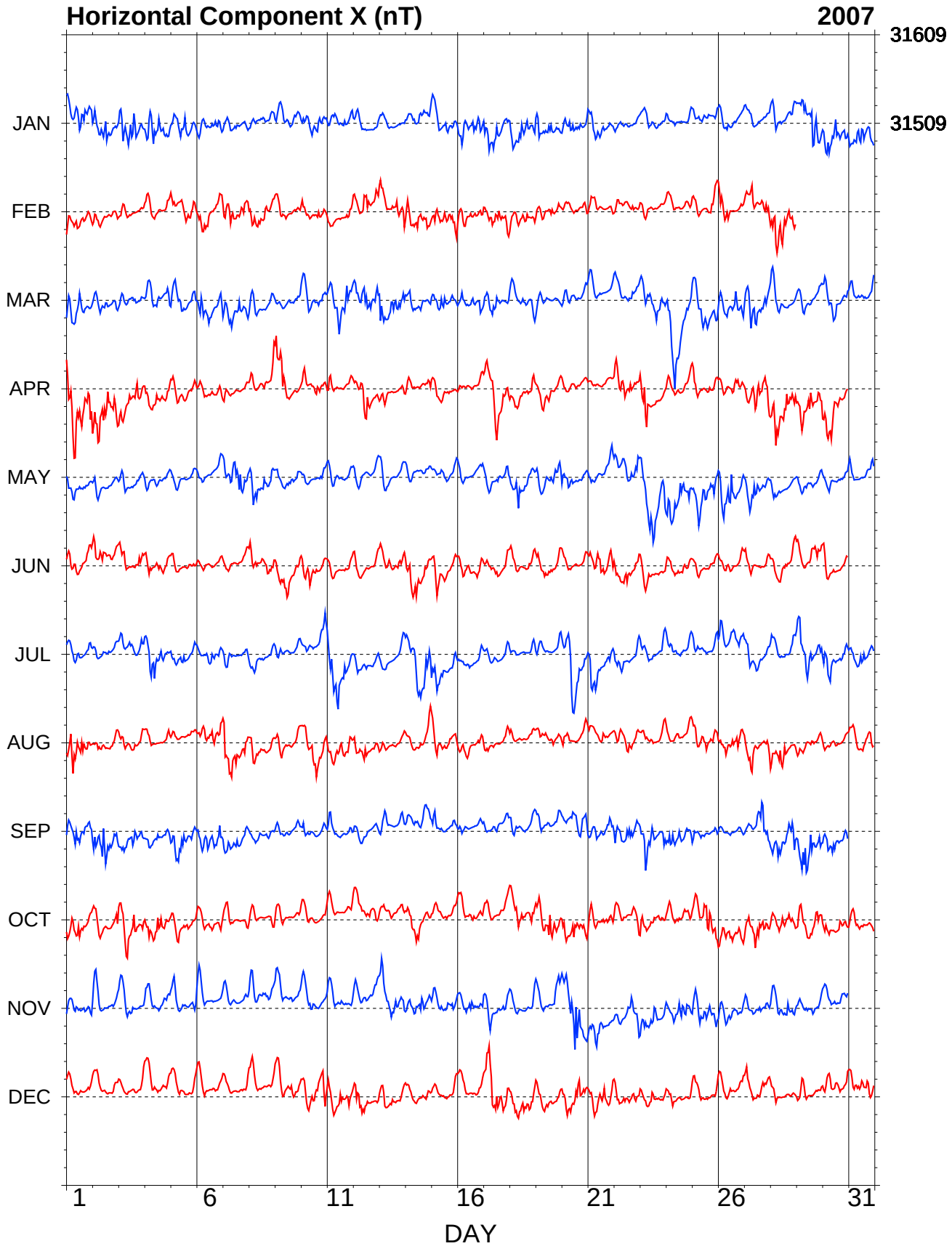
Figure 2.2. Annual mean values and secular variation (all days) for H, D, Z and F measured at Charters Towers.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
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
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
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

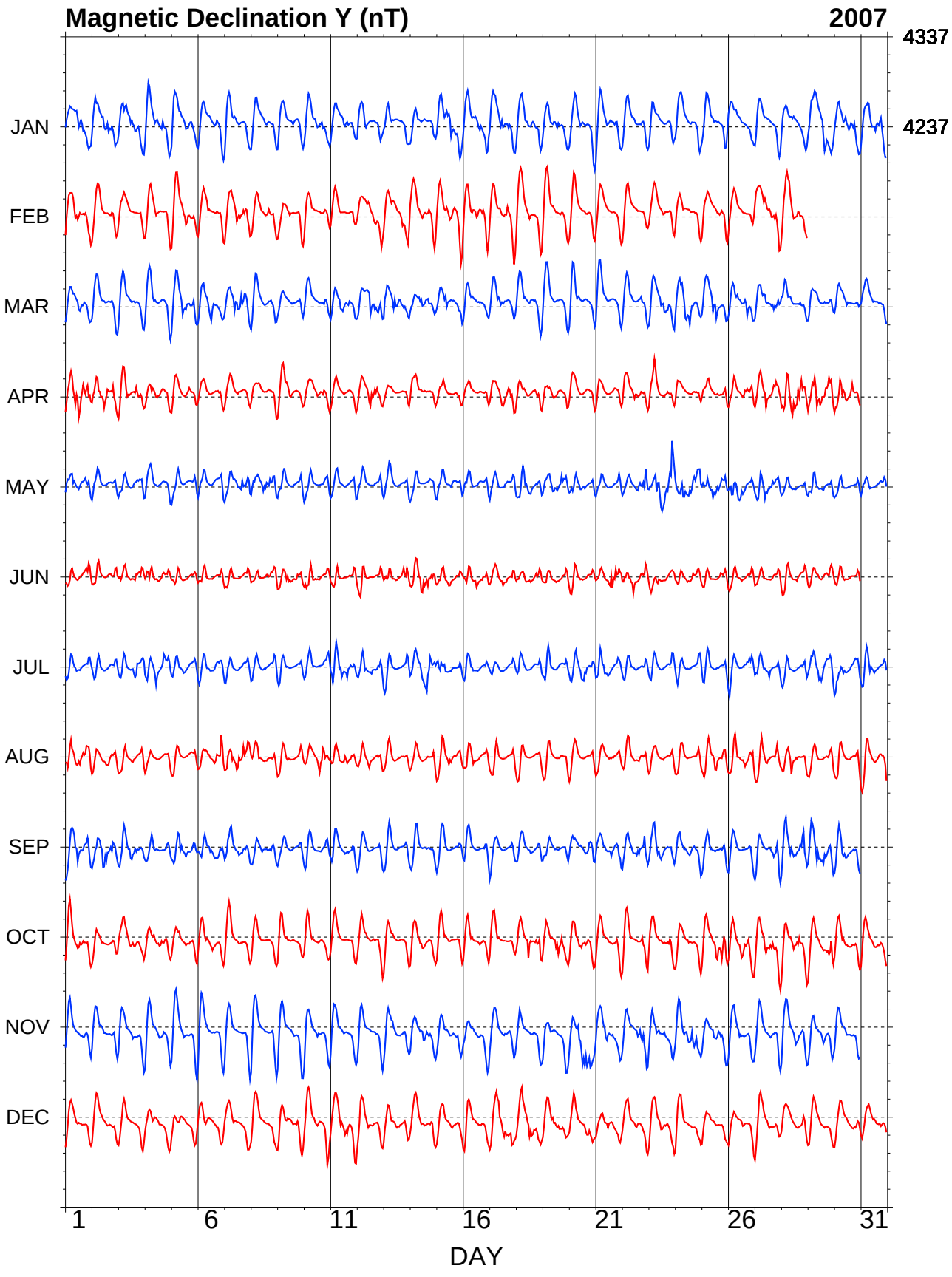
1999.5	D	7	45.5	-50	1.0	31797	31506	4293	-37916	49484	XYZ
2000.5	D	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	ABZ
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABZ
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABZ
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABZ
2004.5	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

Table 2.5. Annual mean values calculated using the 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 the text.

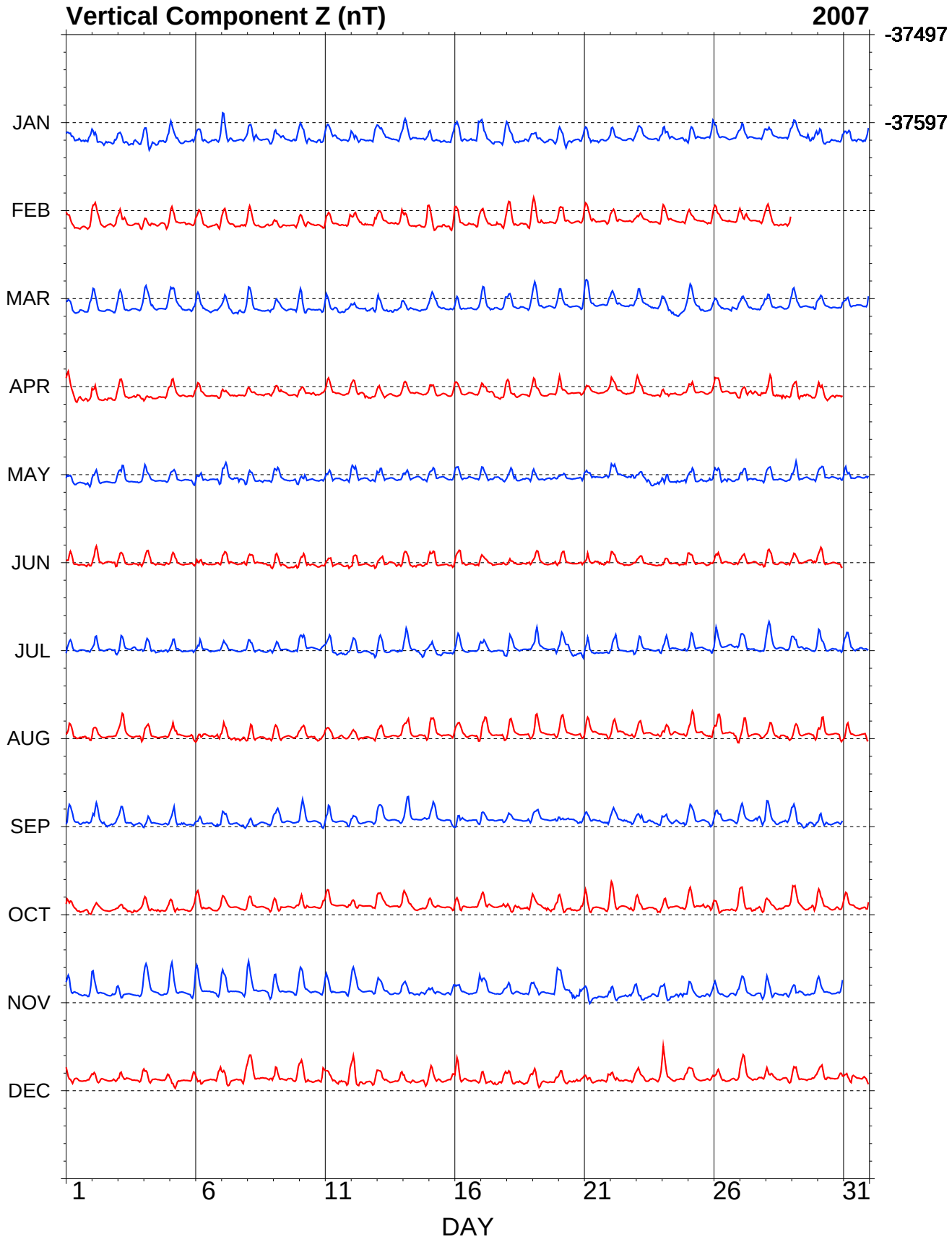
CTA - Hourly Mean Values



CTA - Hourly Mean Values



CTA - Hourly Mean Values



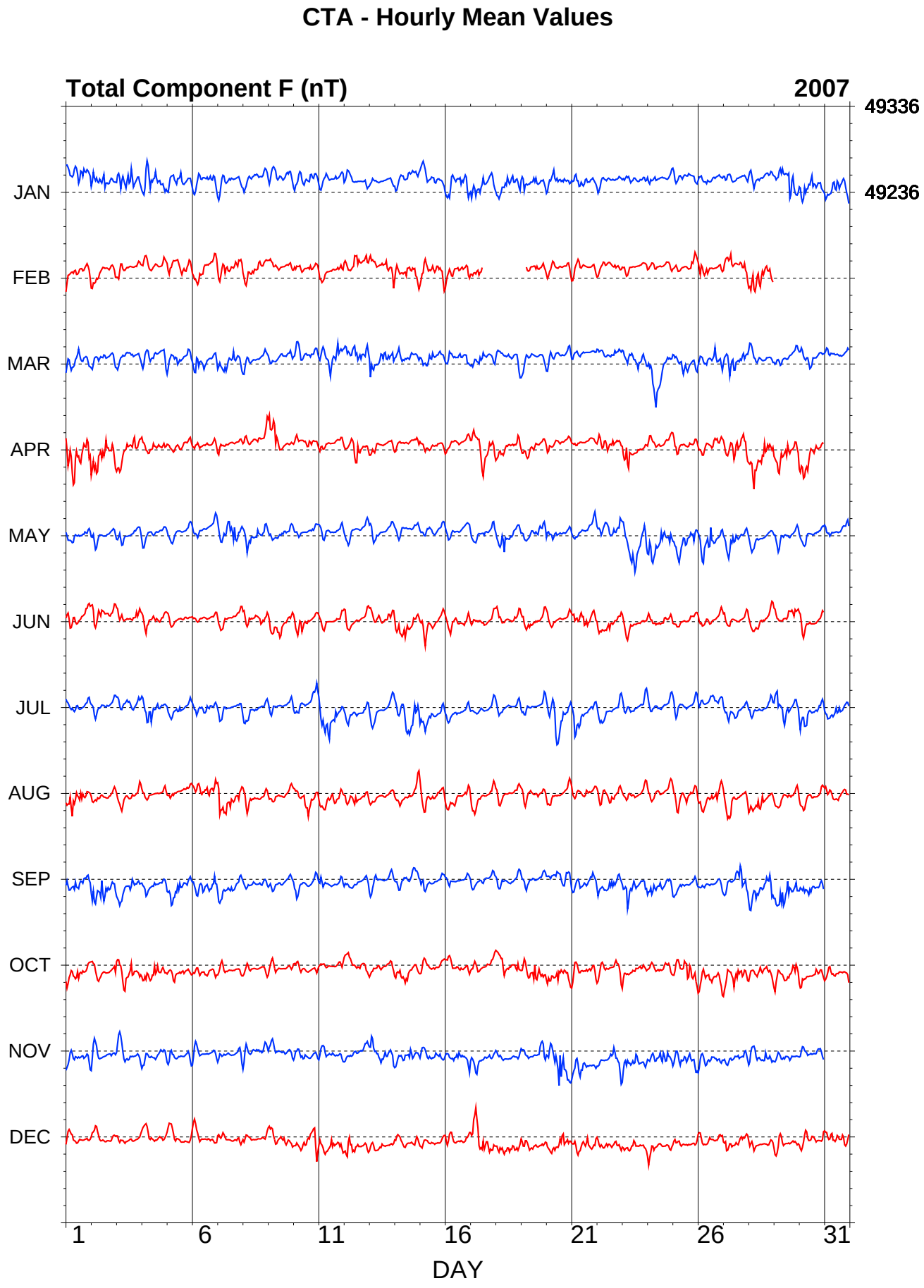


Figure 2.3. Hourly mean values in X, Y, Z and F measured at Charters Towers.

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 collocated with the Learmonth Solar Observatory, which is jointly staffed by IPS Radio and Space Services and the US 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.

Variometers

The variometers used during 2007 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.

An underground cable conduit carried analogue data from the magnetometer sensors to the central vault, and 12 V power and digital data from the central vault to the RSTN building. The variometer and recording system were powered by 240 VAC mains power. The equipment was protected from power outages and surges by an uninterruptible power supply.

Throughout 2007, the variometer PPM was unstable. The problems were manifested in the data as sudden jumps with magnitudes of up to several nanoTesla. Some of the jumps are reported in the "Significant Events" section below. There were also several short periods of rapid drift evident in the FCheck data; most, but not all, of these were also probably caused by PPM instabilities. The problems with the variometer PPM remain in the final PPM data. The variometer PPM failed completely in early 2008 and was replaced in April 2008.

Absolute instruments

The principal absolute magnetometers used at Learmonth and their adopted corrections for 2007 are described in Table 3.3.

No absolute instrument comparisons were made at LRM during 2007. Comparisons were last made on 10 and 11 April 2006 using travelling reference instruments B0610H/160459 and GSM90_003985/11690. Instrument differences were measured as 0.0', -0.1', 0.3 nT in D, I and F respectively in the sense (Travelling reference instruments) - (Learmonth instruments). 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 2007 mean magnetic field values at Learmonth these D, I, and F corrections translate to corrections of:

ΔX = -2.6 nT ΔY = 0.0 nT ΔZ = -1.7 nT

These corrections have been applied to all LRM 2007 final data.

IAGA code:	LRM
Commenced operation:	November 1986
Geographic latitude:	22° 13' 19" S
Geographic longitude:	114° 06' 03" E
Geomagnetic latitude:	-32.18°
Geomagnetic longitude:	186.55°
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:	not recorded
Observers:	A. Brockman (until 28 January) O. Giersch (from 29 January)

Table 3.1. Key observatory data.

3-component variometer:	DMI FGE
Serial number:	E0271/S0237
Type:	suspended; linear 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:	708729/21889
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:	IPS dedicated data line to Sydney then via the Internet to Canberra

Table 3.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

DI fluxgate:	Bartington MAG-01H
Serial number:	B0702H
Theodolite:	Zeiss 020B
Serial number:	312714
Resolution:	0.1’
D correction:	0.0’
I correction:	-0.2’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091316/761100
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 3.3. Absolute magnetometers and their adopted corrections for 2007. Corrections are applied in the sense Standard = Instrument + correction.

Baselines

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

	σ		σ
X	1.3 nT	D	11"
Y	1.6 nT	I	5"
Z	0.9 nT	F	0.6 nT

On 10 March, the solar and magnetic observatories were shut down to mitigate possible damage associated with an approaching tropical cyclone. On 12 March, after the cyclone had passed, observatory operations recommenced. On restarting the vector variometer, a baseline jump was evident and, for a period of about 20 days, rapid baseline drift occurred, particularly in the X component. Throughout the year there was a range of about 6 nT in the difference between F derived from the fluxgate data (final data model with drifts applied) and the variometer PPM.

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

Operations

Absolute observations were performed weekly by Dr Alan Brockman (until 28 January) and Mr Owen Giersch (from 29 January). Observational data were sent via the postal service to Geoscience Australia, where they were processed. Both observers were officers of IPS Radio and Space Service.

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.

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.

Data losses at Learmonth in 2007 are identified in Table A.3.

Significant events

2007-01-08 Crane work on IPS 28ft dish 23:30 - 24:00

2007-01-09 Crane work on IPS 28 ft dish 00:00 - 00:30

2007-01-21 Variometer PPM steps up and back several times ~20:00 causing FCheck anomalies

2007-01-29 Owen Giersch assumes role of observer-in- charge

2007-02-02 (or earlier) Alan Brockman now IPS Officer-in-Charge (since John Kennewell retired). Alan had been doing obs for 6 months prior to Owen Giersch taking over.

2007-03-10 23:00 mains power stopped for at least 48 hours while Cyclone Jacob passes near Exmouth

2007-03-12 Alan Brockman restarted system - battery box charger was getting very hot. No telemetry or telephone communications yet. There were no flooding or structural problems caused by the cyclone. Variometer has baseline jump and rapid drifts on re-start.

2007-03-13 No GPS clock - since 04:40 11 Mar 2007. Current time was a bit fast (<1s) at 2007-03-13 23:28. Could not get GPS to work and parameters for ser2 port on acquisition PC seem incorrect reset ser2 port parameters but still could not get GPS to work. Shut down GdapClock and "ntpdate time" about 23:50 - correction -0.487s. Started ntpd about 23:50.

2007-03-14 ntpd offset < 1ms by 00:51. Owen checked GPS and replaced the battery - GPS started working and at 04:40 there was a correction of -426ms. ntpd was only shut down a minute or two before GdapClock started corrections.

2007-03-16 Owen bypassed GPS battery-charger and connected the GPS direct to computer power outlet. Short period of data loss ~06:10 to make connection and re-power the computer.

2007-03-18 FCheck problems

2007-03-21 FCheck problems

2007-03-23 Absolute PPM sensor cable failure - no observation done this week. Small jump in FCheck 08:20, unknown reason

2007-03-24 3nT FCheck drift over 12 hrs, unknown cause

2007-03-25 Small jump in FCheck 20:40, unknown reason

2007-04-02 replacement 5m absolute PPM cable arrives

2007-04-03 First observation with new PPM cable

2007-04-05 to 15 Owen Giersch away, Alan may do observation

2007-04-25 No data from 05:03 UT onwards

2007-04-26 Data telemetry re-starts about 05UT - no data loss. Caused by system problem at LRM.

2007-05-18 06:50 Update preliminary baselines (XYZ drift)

2007-06-28 11:50 FCheck step

2007-07-10 05:30 - update preliminary baseline (XYZ drift)

2007-08 Problems with power and absolute PPM mean several absolute observations were missed.

2007-08-27 Absolute PPM problems resolved

2007-08-29 06:34 Update preliminary baseline parameters (XYZ drift)

2007-09-18 21:07 F channel changed by ~1.25nT No obvious reason.

2007-09-21 No observers on site until 05 October.

2007-11-08 18:24:20 variometer PPM jump

2007-11-30 Update preliminary baselines (FV parameter changed from 24 to 19 (approx 03:20UT)

2007-12-13 00:12 Update preliminary baselines (XYZ drifts)

2007-12-17 Absolute PDA battery failure. Prepare a replacement battery. Owen away from observatory until mid January.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 3.4. Distribution of 2007 data.

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 2007 data are shown in Figure 3.3.

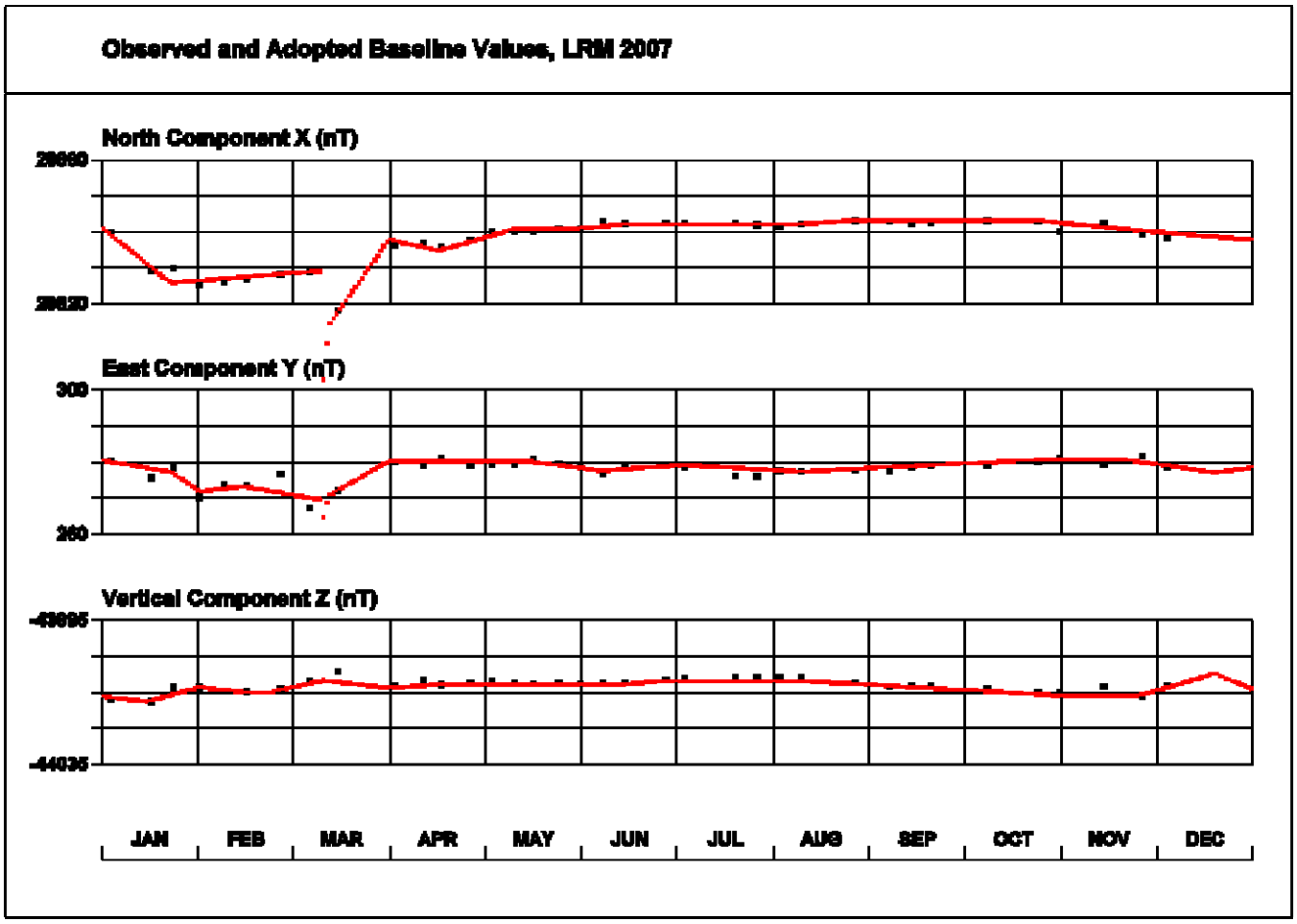


Figure 3.1. Learmonth baseline plots.

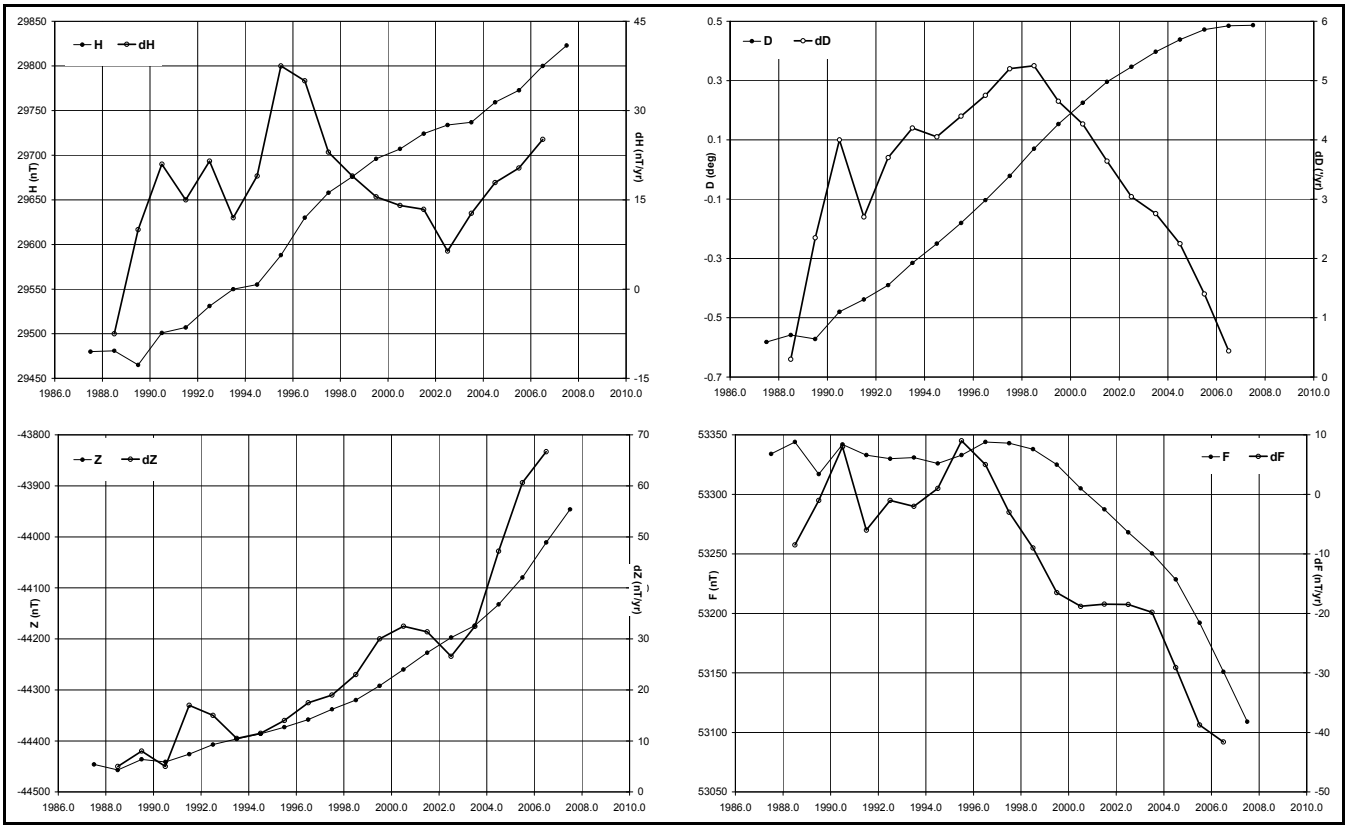
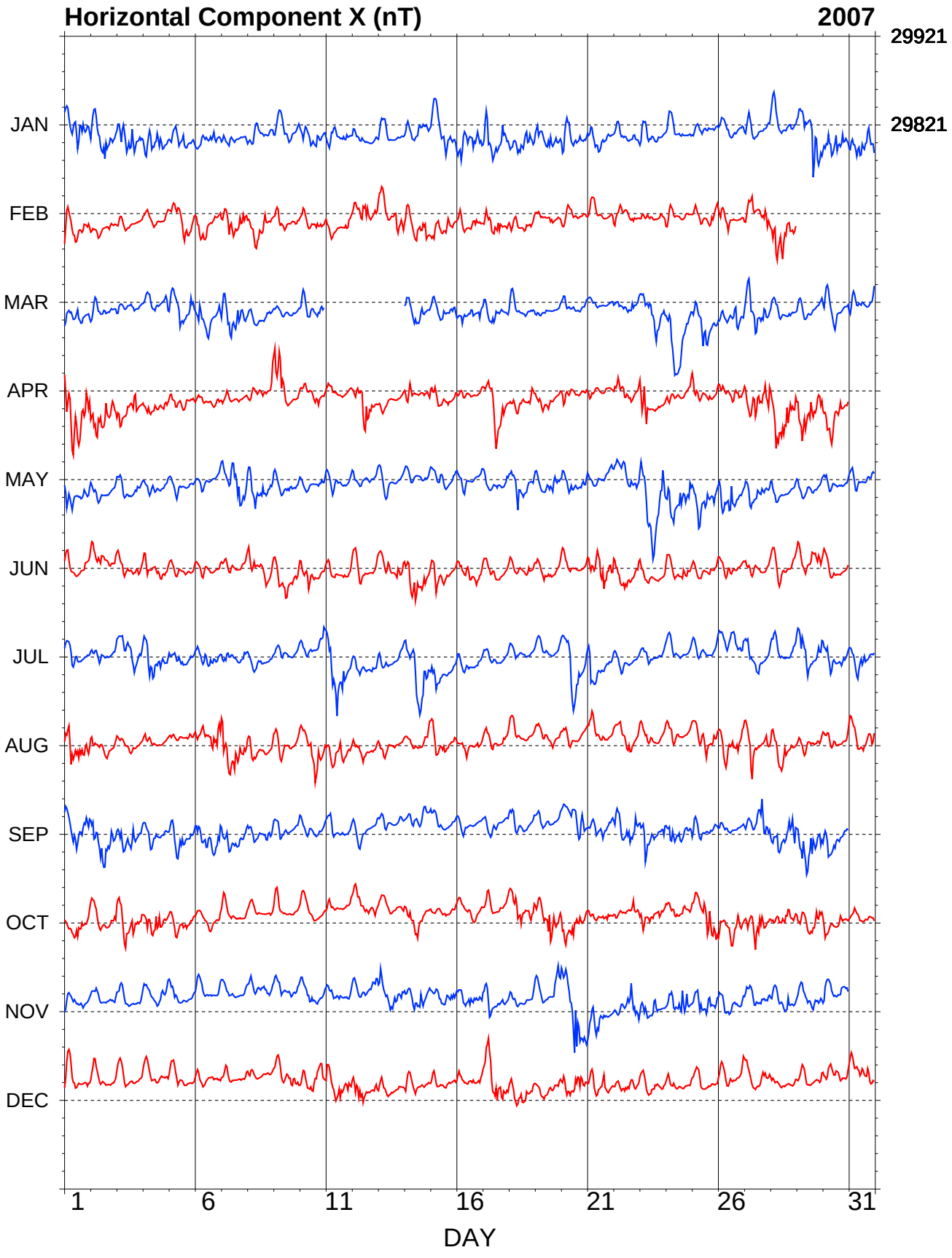


Figure 3.2. Annual mean values and secular variation (all days) for H, D, Z and F measured at Learmonth.

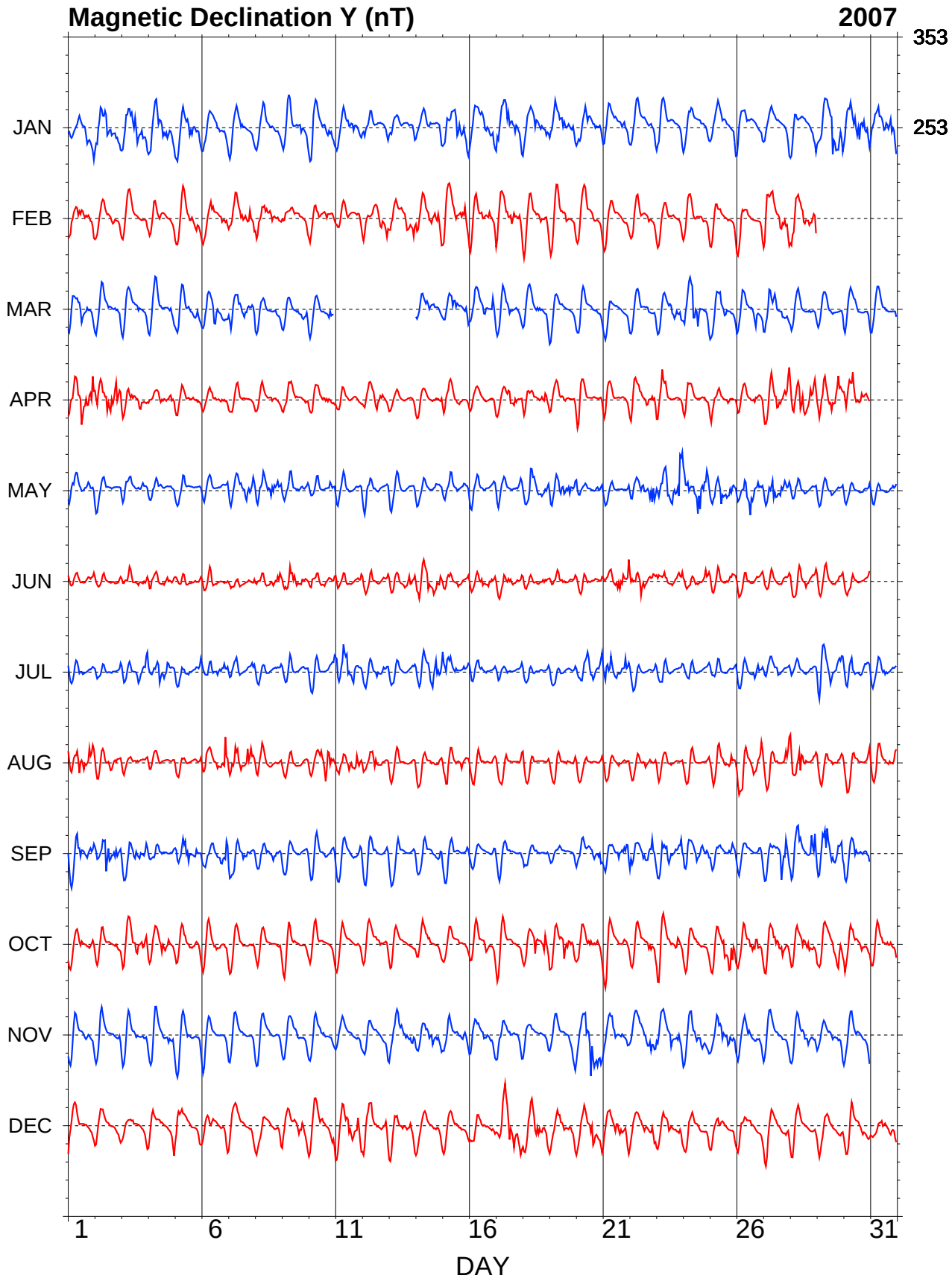
Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441	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
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
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

Table 3.5. Annual mean values calculated using the 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.

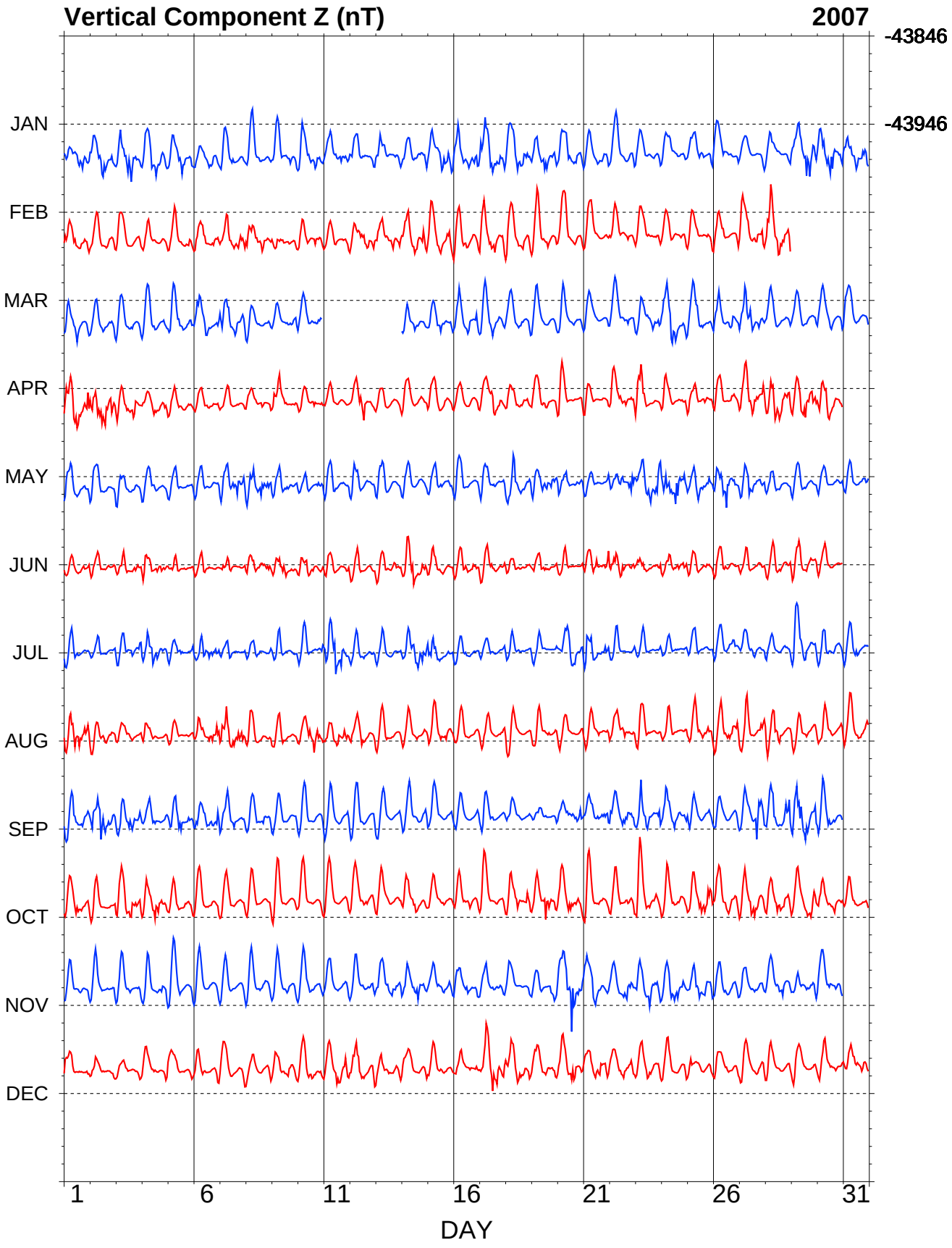
LRM - Hourly Mean Values



LRM - Hourly Mean Values



LRM - Hourly Mean Values



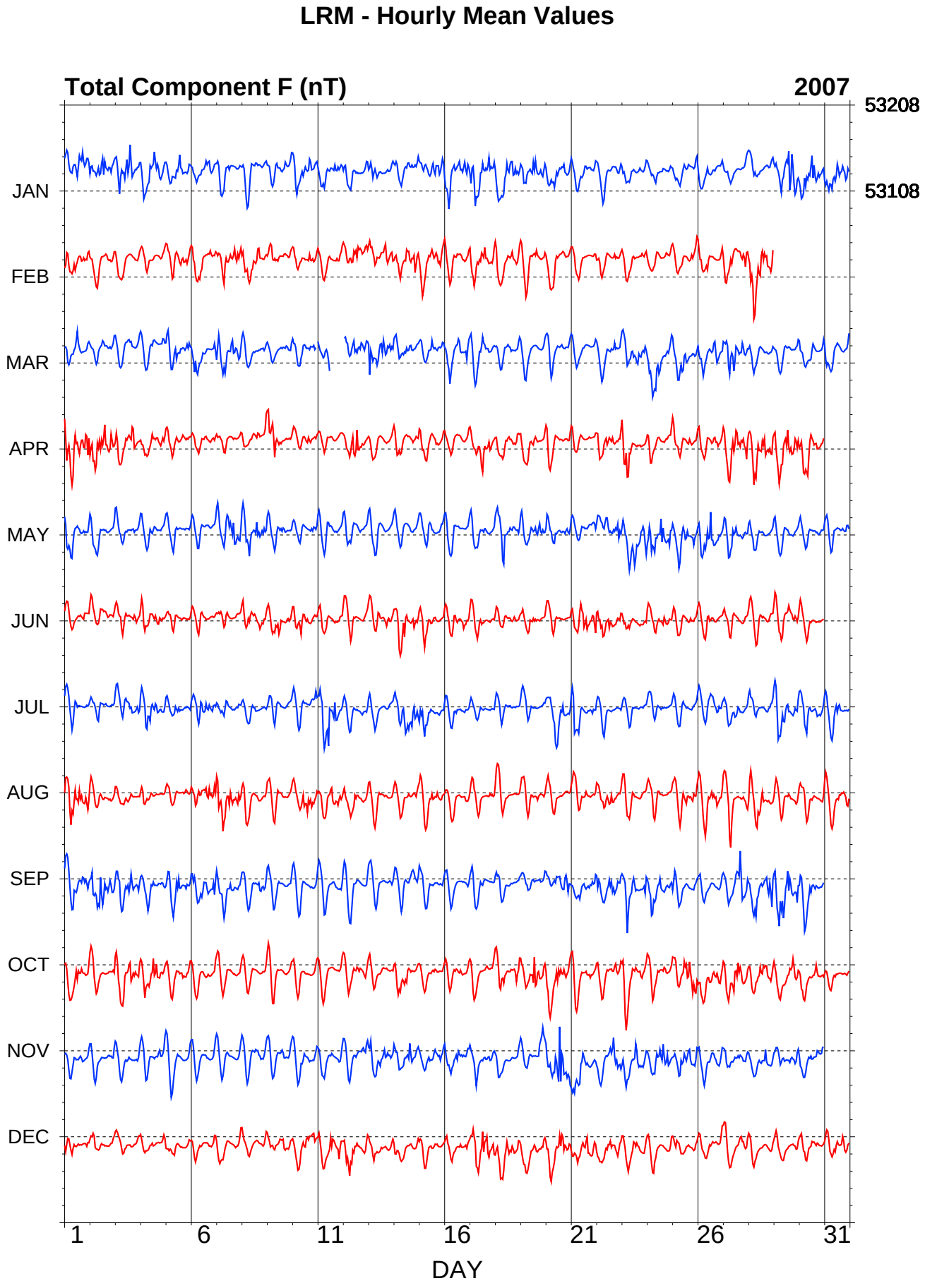


Figure 3.3. Hourly mean values in X, Y, Z and F measured at Learmonth.

4. Alice Springs

The Alice Springs magnetic observatory is located approximately 10 km south of Alice Springs in the Northern Territory, on the Sustainable Ecosystems Centre for Arid Zone Research operated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). 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 roofed Absolute Shelter, 80 m southeast of the Control House, which encloses a concrete observation pier (Pier G), the top of which 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 are housed.

Variometers

The variometers used during 2007 are described in Table 4.2.

The recording and variometer electronic control equipment were housed in the Control House. The DMI fluxgate sensor was housed in the eastern underground vault and the PPM sensor in the northern vault. The fluxgate vault was insulated inside with foam. Both vaults were covered with soil to minimize diurnal temperature fluctuations.

Absolute instruments

The principal absolute magnetometers used at Alice Springs and their adopted corrections for 2007 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.

Instrument comparisons, using the reference absolute instruments B0610H/160459 and GSM90_003985/11690, were performed at the Alice Springs observatory during May 2005. No comparisons were carried out in 2007. The adopted difference between the Alice Springs instruments and the International average (as defined by observations at IAGA instrument workshops) is given in Table 4.3. At the 2007 mean magnetic field values at Alice Springs these D, I, and F corrections 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 2007 final data.

Baselines

The standard deviations in the 2007 weekly absolute observations from the final adopted variometer model and data were:

	σ		σ
X	0.9 nT	D	9"
Y	1.3 nT	I	3"
Z	0.6 nT	F	0.9 nT

During 2007, the daily average FCheck fell within the range -2.2 nT to 2.3 nT. Observed and adopted baseline values in X, Y and Z are shown in Figure 4.1.

IAGA code:	ASP		
Commenced operation:	June 1992		
Geographic latitude:	23°	45'	39.6" S
Geographic longitude:	133°	53'	00.0" E
Geomagnetic latitude:	-32.67°		
Geomagnetic longitude:	208.24°		
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.

3-component variometer:	DMI FGE
Serial number:	E0306/S0261
Type:	suspended; linear 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:	VSAT

Table 4.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

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:	2101216/306403
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.5 nT
Period in use:	until 22 November
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081422/01504
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period in use:	from 5 December

Table 4.3. Absolute magnetometers and their adopted corrections for 2007. Corrections are applied in the sense Standard = Instrument + correction.

Operations

In 2007, absolute observations were performed weekly by Warren Serone and Shaun Evans. Both the observers were Alice Springs-based officers of the Australian Centre for Remote Sensing (ACRES) of Geoscience Australia. ACRES has an office approximately 500 m from the observatory site. The operation of the observatory is checked twice weekly by Mr Serone. In 2007, magnetic data were downloaded to Geoscience Australia head office in Canberra by VSAT connection every 5 minutes.

Data losses at Alice Springs in 2007 are identified in Table A.4.

Significant events

2007-01-18 System failure ~05UT. Shaun checks hut ~23UT - Acquisition PC not responding to reboot. Cannot communicate with satellite modem either.

2007-01-24 New computer connected ~04:00 and functioning - data retrieved via PPP Sat Modem still not accessible, normal network not available. XgetObsGNA now gets both GNA and ASP via ga-cnb-mag1 (Control Hut) computer.

2007-01-25 Data stops at 04:10, probably caused by installation of a surge filter on the telephone line

2007-01-29 Surge filter removed from telephone line

2007-02-19 Satellite router re-installed, telemetry switched back to 5 minutes via satellite (from 1 hour via PPP modem)

2007-02-19 PPM data loss is slowly getting worse.

2007-03-15 00:24. BLV adjusted.

2007-05-04 Updated blv file with new drifts.

2007-08-23 AML at observatory - remove redundant modem, check and clean up control and absolute hut. Check vaults and azimuth marks, re-scribe azimuth mark B.

2007-09-20 09:33 Update baseline parameters

2007-10-08 00:40 Update blv file with new drifts (X) - taking effect from DOY 208.08

2007-11-22 Absolute GSM90_2101216 fails during observations by SDE. Instrument returned to GA for testing - faulty sensor 306403

2007-11-29 GSM90_4081422/01504 freighted to ASP as replacement absolute instrument

2007-12-05 First absolute observation using GSM90_4081422/01504 PPM

2007-12-12 Multiple reboots - reason uknown 22:22 BLV adjusted.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
WDC-C2	preliminary	real time
WDC-C2	preliminary	daily
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 4.4. Distribution of 2007 data.

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 2007 data are shown in Figure 4.3.

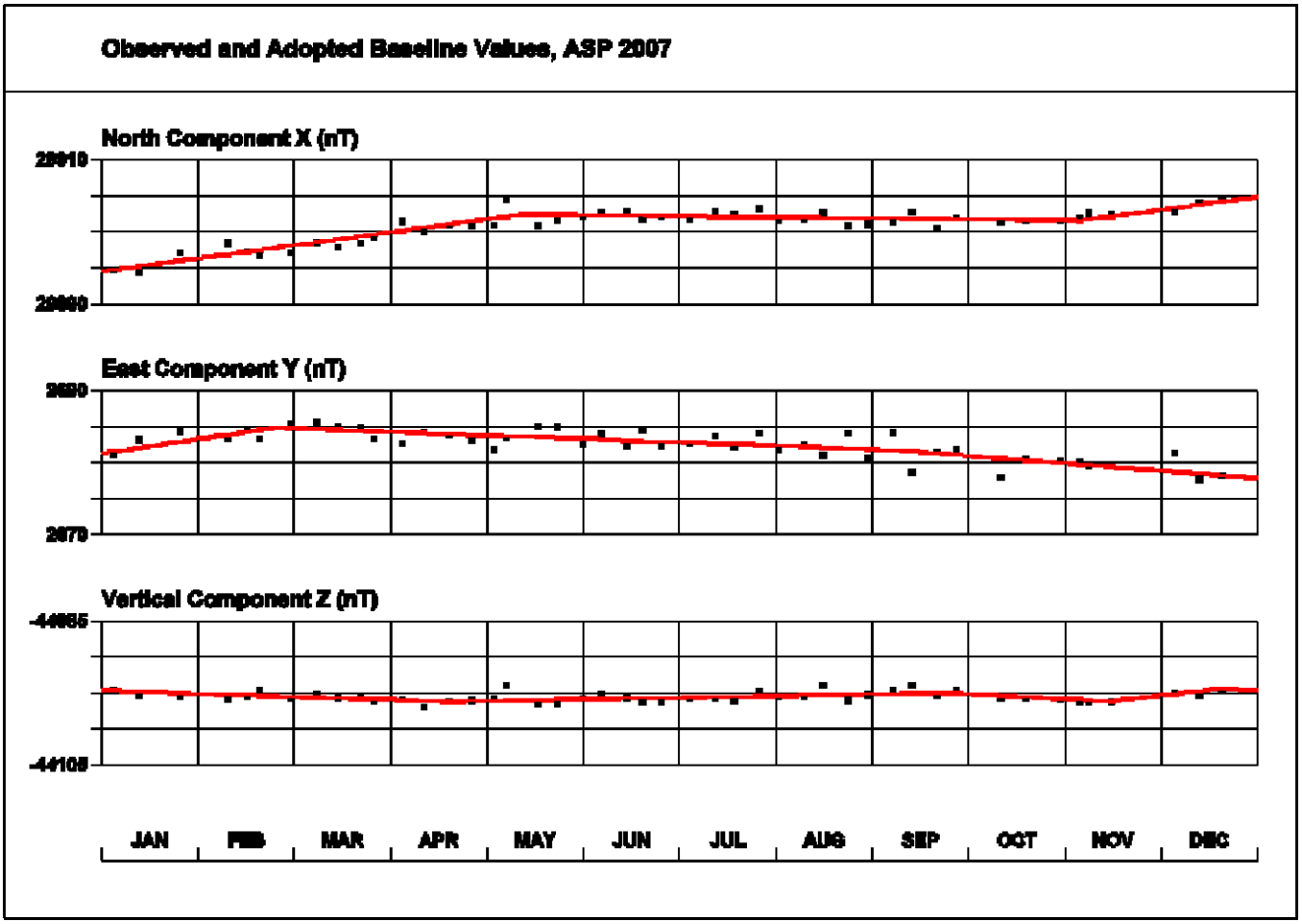


Figure 4.1. Alice Springs baseline plots.

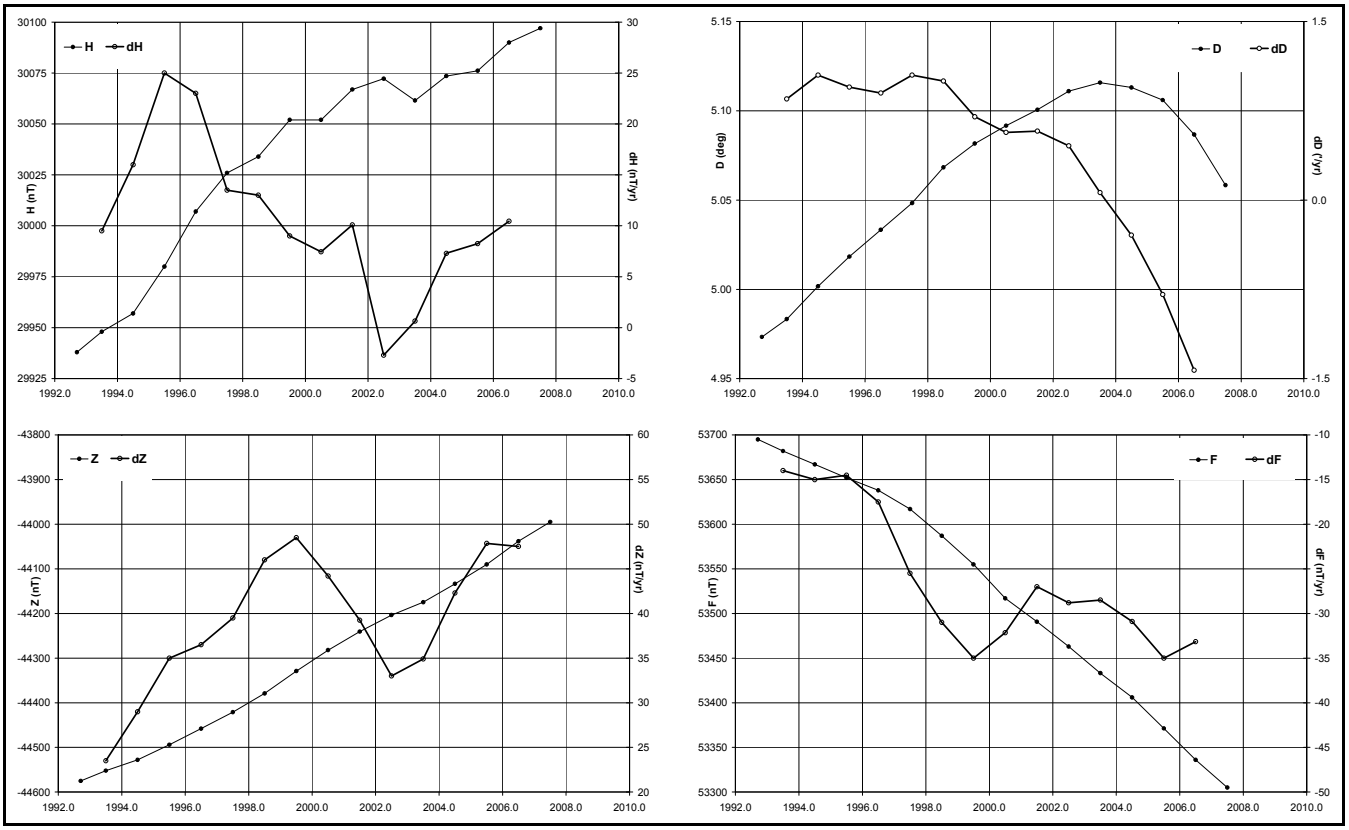
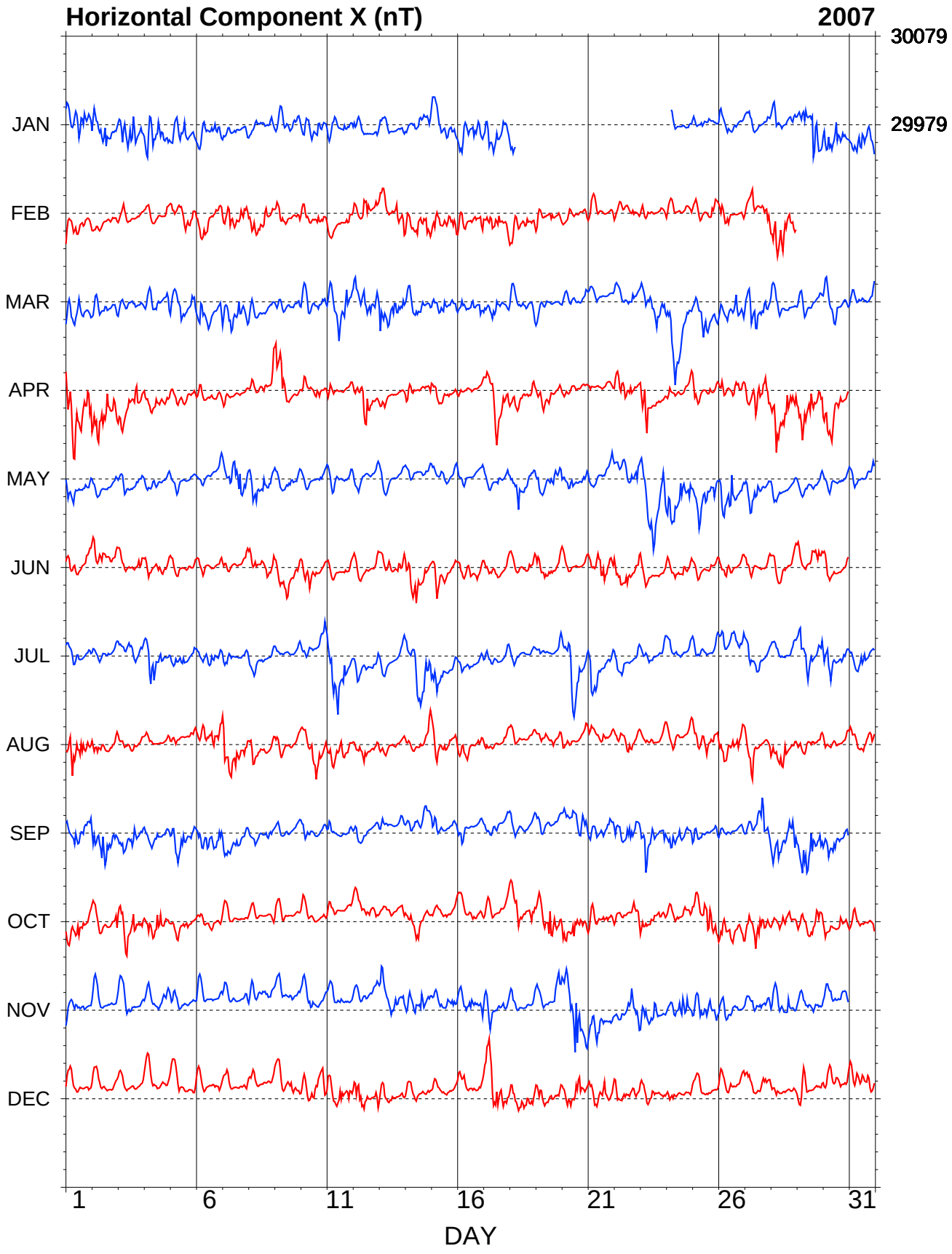


Figure 4.2. Annual mean values and secular variation (all days) for H, D, Z and F measured at Alice Springs.

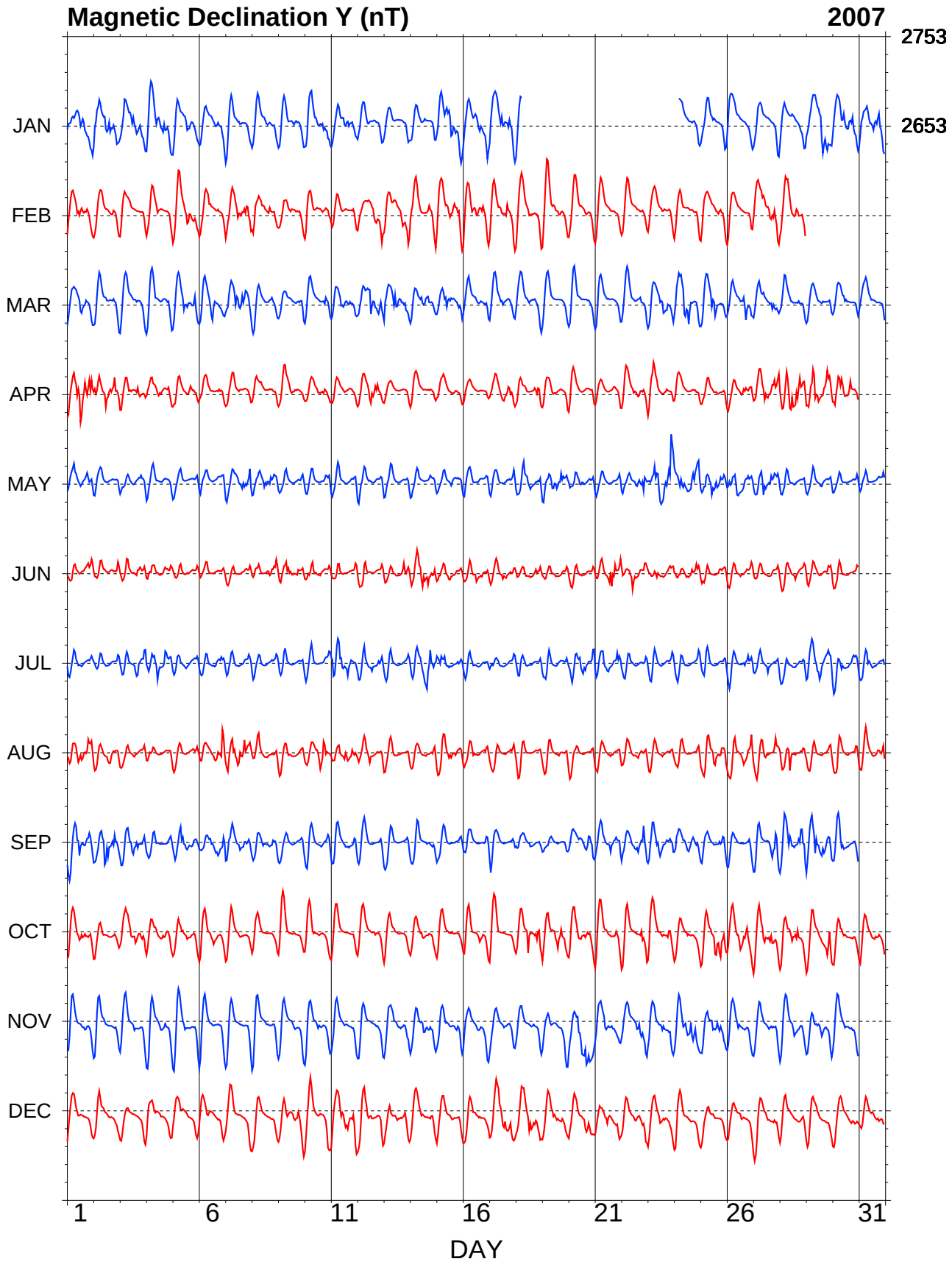
Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1992.708	A	4	58.4	-56	06.8	29938	29825	2595	-44575	53695	XYZ
1993.5	A	4	59.0	-56	05.5	29948	29835	2601	-44552	53682	XYZ
1994.5	A	5	00.1	-56	04.1	29957	29843	2612	-44528	53667	XYZ
1995.5	A	5	01.1	-56	01.7	29980	29865	2623	-44494	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
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
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

Table 4.5. Annual mean values calculated using the 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.

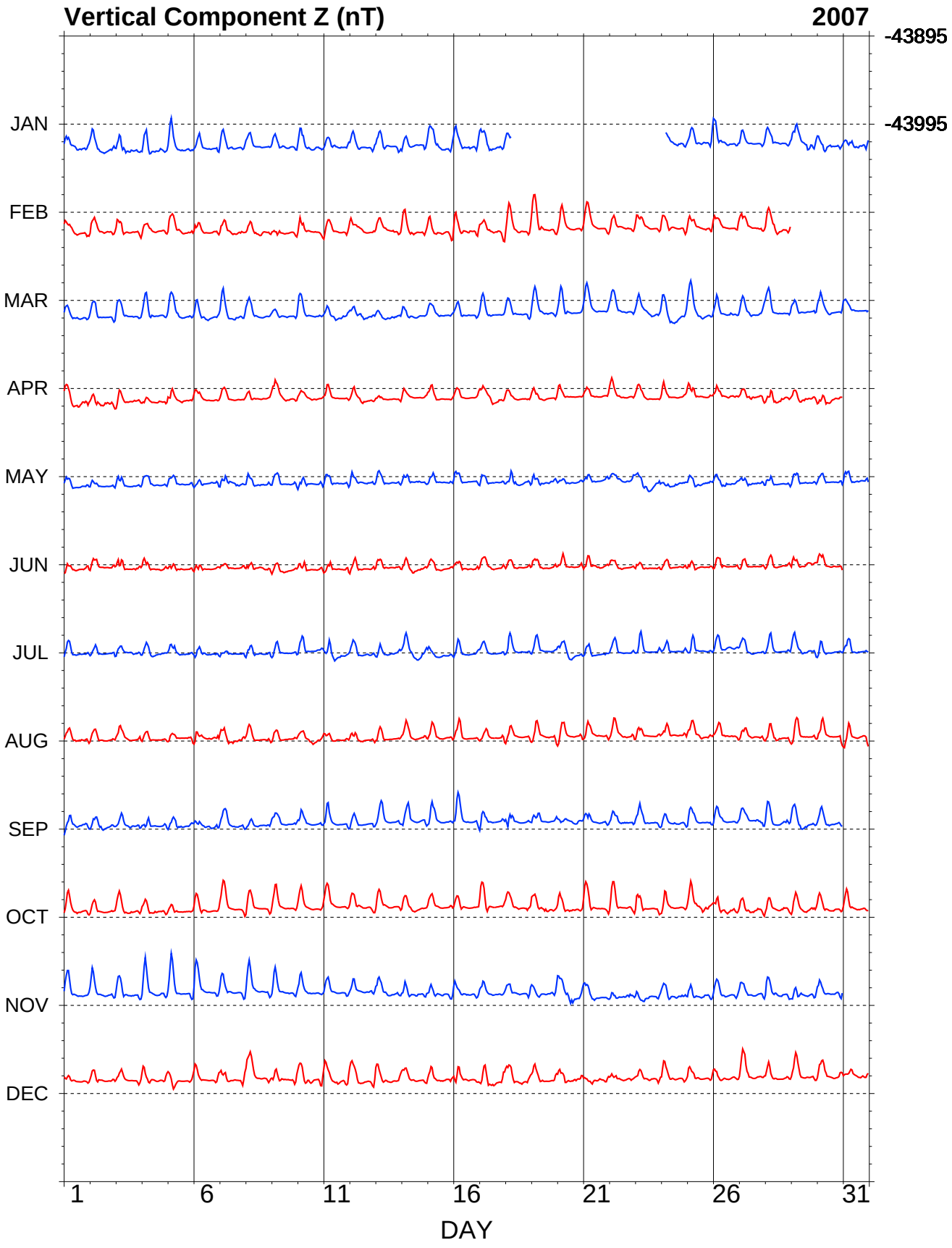
ASP - Hourly Mean Values



ASP - Hourly Mean Values



ASP - Hourly Mean Values



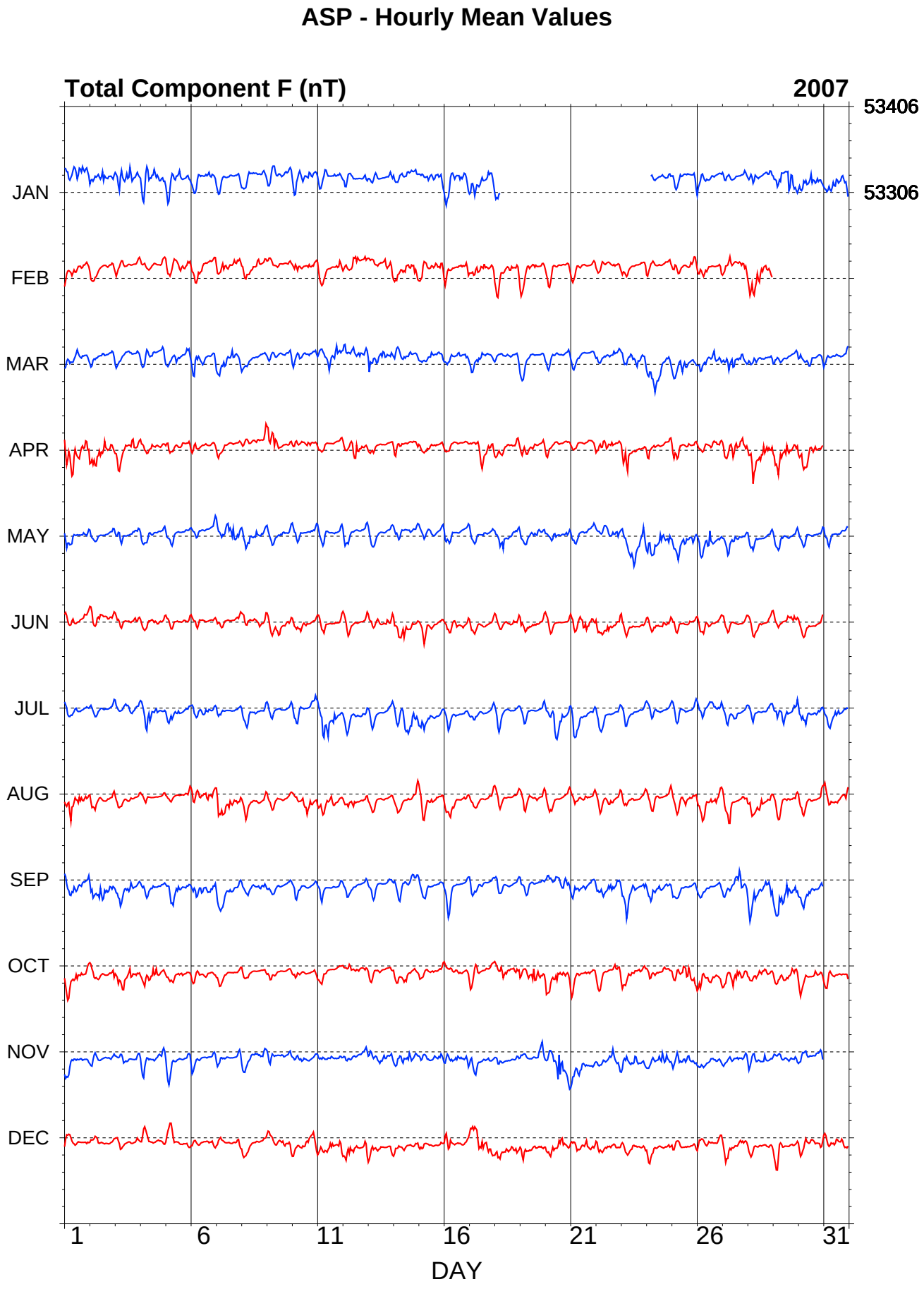


Figure 4.3. Hourly mean values in X, Y, Z and F measured at Alice Springs.

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 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.

Variometers

The variometers used during 2007 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 variometer had in-built sensors to monitor both sensor and electronics temperatures.

The acquisition PC was accessible via a modem for remote control and data retrieval. The telephone and equipment was protected from lightning and powered through a UPS. The acquisition PC clock was synchronised to the 1-second pulse from a GPS clock, but the time code from the GPS was not used. Timing errors were normally less than 0.1 s.

As the variometers were below the ground, the diurnal temperature changes were small. The standard temperature was 20°C. Both the fluxgate sensor and electronics temperatures varied from about 15°C in winter to about 30°C in summer. The maximum rate of change of temperature was 0.15°C/day. Temperature fluctuations in the PPM sensor vault 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 2007 are described in Table 5.3.

At the 2007 mean magnetic field values at Gnangara 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 2007 final data.

IAGA code:	GNA
Commenced operation:	June 1957
Geographic latitude:	31° 46' 48" S
Geographic longitude:	115° 56' 48" E
Geomagnetic latitude:	-41.65°
Geomagnetic longitude:	188.93°
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
Observers:	G. van Reeken (until 30 January) S. Pryde (from 30 January)

Table 5.1. Key observatory data.

3-component variometer:	EDA FM105B
Serial number:	2877/2887
Type:	linear 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:	Telephone line

Table 5.2. Magnetic variometers used in 2007. 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 2007. Corrections are applied in the sense Standard = Instrument + correction.

Baselines

There appeared to be a seasonal variation in X, Y and Z baselines; however, because it appeared to lag the seasonal temperature variation (by about 54 days), there did not seem to be a direct correlation with temperature. Consequently no temperature coefficients were applied to the vector variometer data.

The standard deviations in the 2007 weekly absolute observations from the final adopted variometer model and data were:

	σ		σ
X	1.0 nT	D	13"
Y	1.5 nT	I	4"
Z	0.6 nT	F	0.6 nT

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM varied between -2.0 nT and 1.0 nT.

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

Operations

The observatory was operated by contracted observers G. van Reeken (until 30 January) and S. Pryde (from 30 January), with technical assistance from O. McConnel, a Perth-based Geoscience Australia staff member.

Data were transmitted to Geoscience Australia via modem every 3 hours and were then processed, stored in a database and distributed to data repositories. Throughout 2007, K indices for Gnangara were derived using a computer-assisted method based on the IAGA-accepted LRNS algorithm. K indices were distributed weekly.

Absolute observations were performed fortnightly until 30 June and weekly thereafter. The stainless steel security door on the Absolute Hut was left open in the same position during observations.

During recent years the residential area near the observatory has grown. Although this currently poses no threat to the observatory in a technical sense, there is a growing vandalism problem. Over the years considerable amounts of data have been lost as a consequence of intruders, vandalism and break-ins. However, no data were lost for this reason in 2007.

Data losses at Gnangara in 2007 are identified in Table A.5.

Significant events

2007-01-28 Alarm triggered during electrical storm - Security Monitoring contacted Owen

2007-01-30 to 31 Visit by AML. Observer change-over from Hans Van Reeken to Stephen Pryde. Instrument comparisons, rounds of angles, instrument checks.

2007-02-01 Security reed switch on absolute hut door relocated by Owen McConnel to ensure it always closes when the door is shut.

2007-02-04 Fcheck anomaly ~19:30-20:00

2007-02-07 First solo observation from Stephen Pryde

2007-02-11 GPS Clock failure 01:40

2007-02-12 Slay and restart GdapClock 01:36 - no improvement. Reboot 01:48

2007-02-21 Stephen visits observatory for observation but aborts due to trouble levelling the theodolite (No security guard for this visit)

2007-02-23 Observation - first time Stephen has arranged a security guard.

2007-02-28 GPS clock stops working at 05:50

2007-03-01 Slay and restart GPS clock - no luck 01:38:40 reboot system, GPS clock now working

2007-04-25 00:10 Security Monitors reported alarm system power failure. Security patrol sent to investigate.

2007-04-26 Stephen Pryde visits to check for problems - system had stopped due to problems with power at powerpole. He gets it running again by increasing current draw by switching on all the lights in the vault. Restart computer and G856 PPM. We should get the power company to clean up insulators on the power pole. Stephen finds that the lights must be left on in the vault maintain power. AML contacts Owen and suggests he talk to Stephen before contacting power company.

2007-04-27 Owen visits site to inspect power problems and calls power company. System is not running

2007-04-30 Power company reports that they visited site on 27 Apr. System is still not running. SP visits observatory and gets the system running at 05:32. Re-start at 05:38

2007-05-04 Updated blv file with new drifts.

2007-05-13 Lost contact with GPS clock 15:45

2007-05-14 Stop GdapClock 05:29:32 Restart GdapClock 05:31:02,no improvement, 05:38 reboot system - all O.K.

2007-07-26 Signs installed at observatory (doors and boundary fence). Eastern side fence has been cut

2007-09-05 04:39 Update baseline parameters (Y and Z drift)

2007-10-02 07:45 Lost contact with GPS CLOCK

2007-10-03 Changed rc.acquisition to include GdapAdjustClockRate 838059307 Could not correct GPS clock easily, SHUTDOWN at 02:43. Correction +223ms at 02:45:19, Rate -325

2007-10-15 Data telemetry stopped 02:02. Problem with telephone line?

2007-10-16 SP reset modem, telemetry worked again. Seems to have been temporary change in BL while investigating. Problem with wasps and termites in vault noted.

2007-11-01 14:00 UT telemetry stops.

2007-11-02 SP resets modem during absolute observation visit. OMcC investigates problem - tried swapping modems without success. Reboot at 06:15 with original modem with success. However lost connection shortly afterwards - theory is that the Chubb security swiped the line on exit and re-arming the security system. That may be the cause of the system hanging up. Could re-visit the ppp script at GNA to put modem initialisation inside the re-try loop.

2007-12-12 23:00 BLV adjusted

2007-12-27 pest control treatment for termites around variometer vault

Data distribution

Recipient	Status	Sent
1-minute values		
INTERMAGNET	preliminary	3-hourly
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly
K indices		
IPS Radio and Space Services		weekly
ISGI, France		weekly
Principal magnetic storms and rapid variations		
WDC-A		monthly
WDC-C2		monthly
Observatori de l'Ebre, Spain		monthly

Table 5.4. Distribution of 2007 data.

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 2007 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 from Gnangara contribute to the global am index and its derivatives. K indices measured in 2007 are listed in Table 5.6.

Principal magnetic storms observed at Gnangara are listed in Table 5.7 and other rapid variation phenomena in Table 5.8.

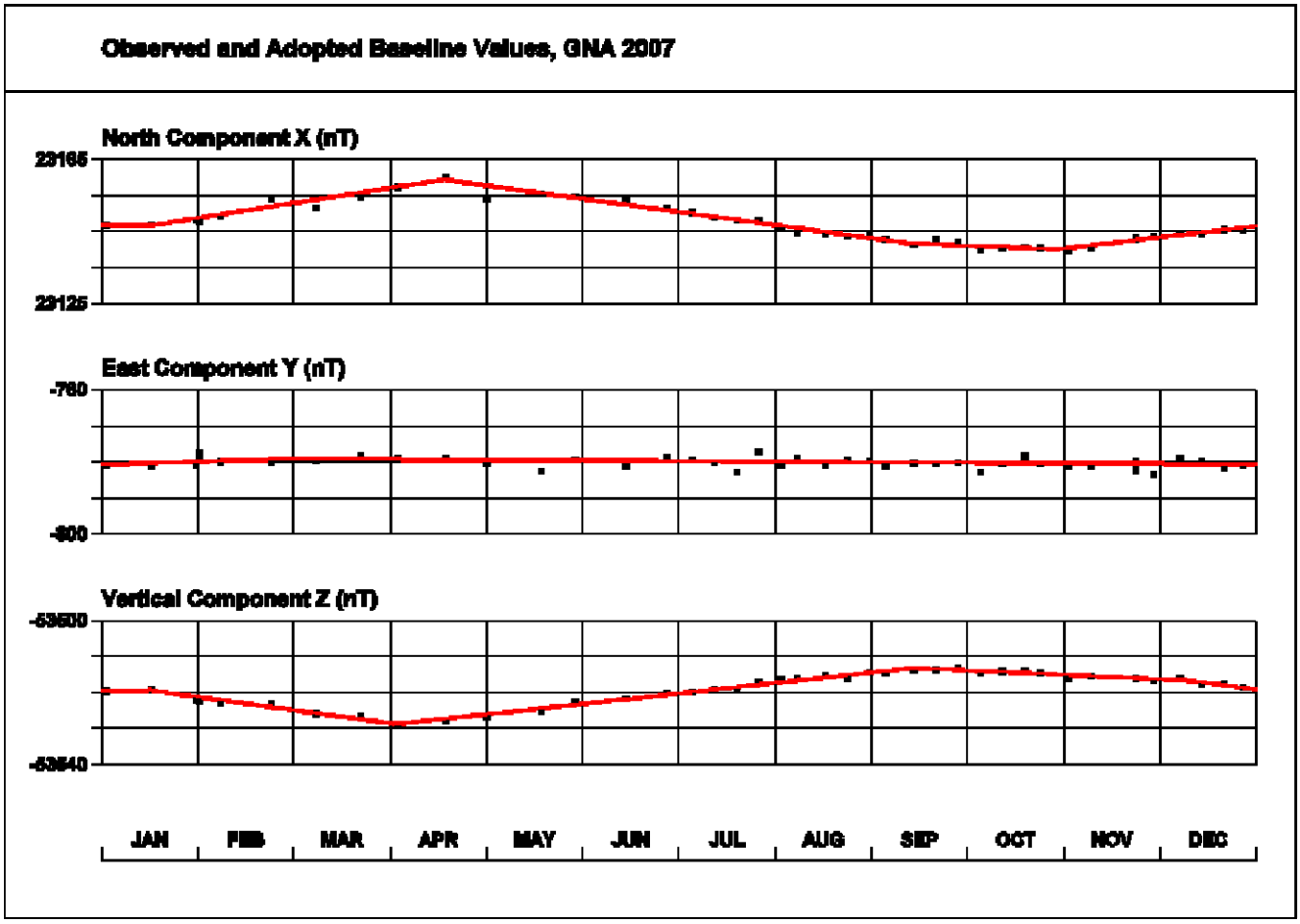


Figure 5.1. Gnangara baseline plots.

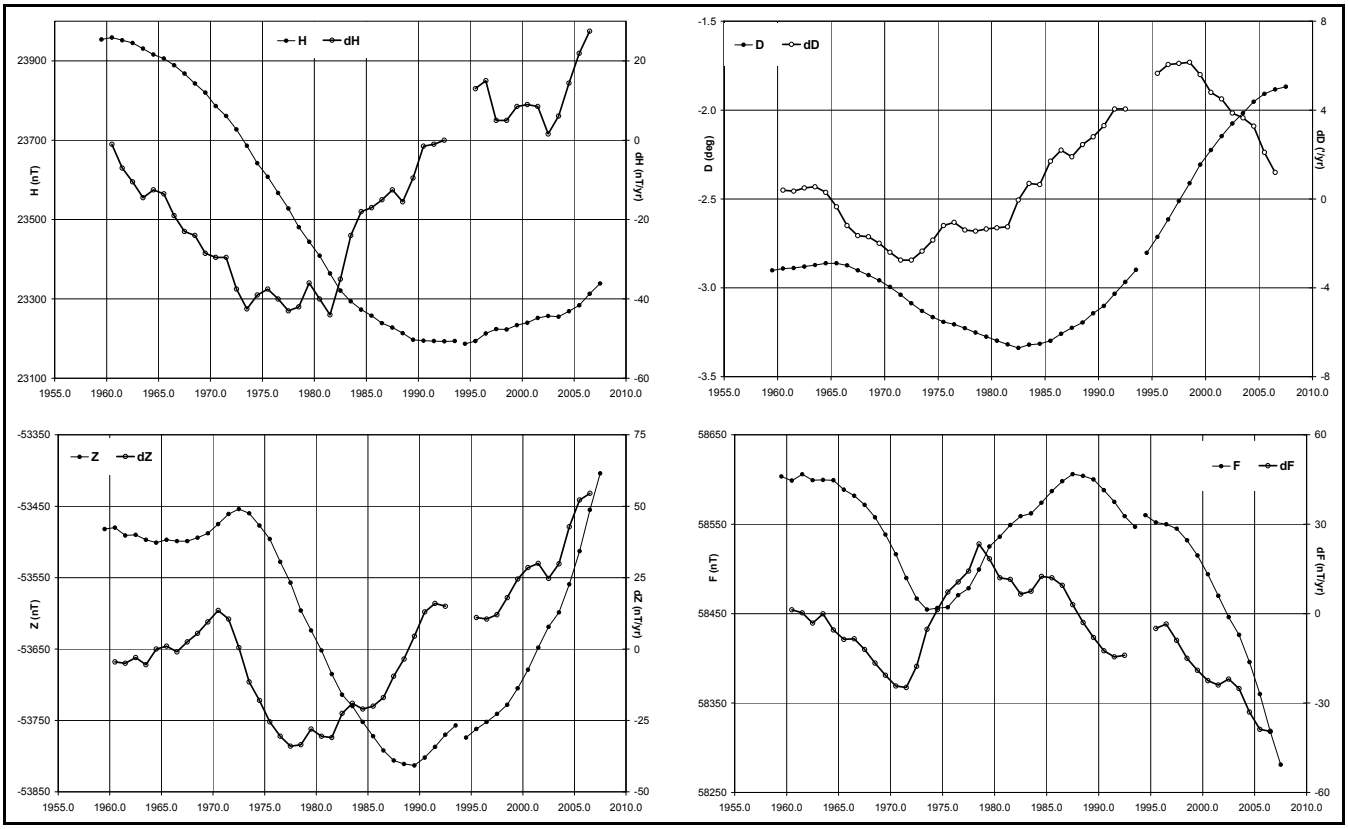


Figure 5.2. Annual mean values and secular variation (quiet days) for H, D, Z and F measured at Gnangara.

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
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
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

Table 5.5. Annual mean values calculated using the 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).

Day	January			February			March			April			May			June		
01	1123	4323	19	2222	2132	16	2222	3211	15	4333	5444	30	2231	2231	16	1111	1121	9
02	4325	5333	28	2110	1221	10	1011	1021	7	3335	4342	27	1000	0100	2	1121	0111	8
03	3323	4433	25	2001	0001	4	0000	1210	4	2222	1331	16	0001	1231	8	2110	0232	11
04	3233	3322	21	2101	0002	6	1111	1021	8	3113	2232	17	1001	1110	5	2211	2221	13
05	2113	3322	17	2211	2222	14	2213	2232	17	2011	1211	9	0000	0000	0	0000	0111	3
06	1110	2321	11	2222	0221	13	2324	4212	20	1111	1110	7	0000	0001	1	0100	0000	1
07	1001	2001	5	3233	3242	22	3223	3333	22	0000	1100	2	1022	3433	18	0000	0010	1
08	1011	1111	7	3222	2322	18	2111	0220	9	0010	1112	6	2222	3322	18	2220	1233	15
09	0121	1221	10	2221	0122	12	0000	1121	5	3342	1001	14	1111	1111	8	1222	2122	14
10	2223	2322	18	2100	0221	8	1210	0231	10	1102	2221	11	1000	0131	6	2221	2021	12
11	2222	2332	18	0110	0022	6	0013	3432	16	1211	1002	8	0011	1000	3	0000	0211	4
12	2111	0101	7	1003	3323	15	2112	4343	20	2213	4320	17	1100	0001	3	1000	0011	3
13	0000	0100	1	3211	1334	18	4234	4333	26	2000	0000	2	0100	0000	1	0001	2231	9
14	0000	2122	7	3223	3433	23	3212	3322	18	0110	1002	5	1000	0230	6	2224	2333	21
15	1222	4332	19	2222	2331	17	2223	3232	19	2111	2210	10	0111	1010	5	2222	2211	14
16	1311	3333	18	1111	3232	14	2201	3223	15	0000	0000	0	1101	0011	5	1211	3221	13
17	4333	3342	25	2212	4312	17	1122	2221	13	0113	3442	18	0100	1123	8	1212	3111	12
18	3233	3322	21	2002	2222	12	1001	2211	8	1101	2333	14	1233	3332	20	1111	0331	11
19	2212	3323	18	1000	1201	5	1011	0000	3	1111	2211	10	2223	3332	20	1111	1210	8
20	2213	1223	16	0000	0201	3	1000	1121	6	1000	0101	3	2212	1121	12	1111	0000	4
21	2112	2221	13	1000	0000	1	0000	0000	0	1000	0110	3	1100	0102	5	0113	4333	18
22	1111	1221	10	1000	1121	6	0000	0211	4	1223	2332	18	1123	3243	19	2324	2213	19
23	1101	1101	6	1000	1121	6	1012	3322	14	3431	0100	12	3335	4346	31	2231	1122	14
24	0001	0211	5	1000	0111	4	3335	4222	24	2111	0121	9	3333	4544	29	2211	1330	13
25	0001	1101	4	1100	0332	10	3213	3212	17	2110	----	-	1224	3333	21	1100	0221	7
26	1000	1101	4	3321	0001	10	1111	2531	15	----	----	-	2334	4421	23	1101	1121	8
27	1100	1012	6	0132	2433	18	2223	2333	20	----	----	-	3234	3431	23	1100	0110	4
28	2100	1122	9	3333	3333	24	3112	1211	12	----	----	-	2211	1001	8	1101	3111	9
29	2233	6654	31				1000	1001	3	----	----	-	0100	2111	6	1111	2233	14
30	3333	4343	26				3112	2000	9	----	-321	-	0000	0001	1	1210	0000	4
31	2223	3442	22				0011	1112	7				1000	0121	5			

Day	July			August			September			October			November			December		
01	0012	1001	5	4334	4332	26	1124	2233	18	2113	2212	14	1100	0211	6	2001	0012	6
02	0010	0100	2	2121	3320	14	3324	4332	24	1010	1023	8	1111	0001	5	1111	1111	8
03	0101	3323	13	1111	2201	9	2223	4422	21	2232	4333	22	1001	2010	5	1000	0000	1
04	3324	3431	23	1000	0001	2	2111	2022	11	2223	3321	18	1010	1321	9	2010	1012	7
05	1210	3022	11	0000	0020	2	1233	3231	18	2111	2110	9	1011	1001	5	3121	1102	11
06	1111	2322	13	0022	2325	16	2112	2334	18	0012	2101	7	0000	1101	3	1001	1121	7
07	1100	0123	8	3333	4433	26	3122	3221	16	2000	2101	6	1000	0000	1	1100	0011	4
08	1100	1111	6	2210	1101	8	1112	1220	10	0000	0002	2	(0)000	1112	(5)	0110	0001	3
09	0100	0010	2	1011	1010	5	0001	0001	2	0000	1001	2	1101	2102	8	2100	2232	12
10	0001	1013	6	1012	4543	20	1000	0220	5	0000	1000	1	2121	2101	10	1222	2234	18
11	3445	2421	25	3221	3331	18	0000	1100	2	0000	0011	2	1102	1002	7	4333	3343	26
12	1221	2121	12	1114	1120	11	0001	1000	2	0111	1221	9	1001	0133	9	3322	2112	16
13	0000	0011	2	1000	0100	2	0000	0011	2	0000	1002	3	3323	3232	21	2211	2221	13
14	1013	4553	22	0000	1012	4	1000	1222	8	2112	2101	10	3222	3322	19	1122	0121	10
15	3323	1121	16	1212	3211	13	3110	0121	9	1000	1201	5	3211	3233	18	1102	1112	9
16	1111	1120	8	1112	1121	10	1111	0021	7	1001	3210	8	1111	3222	13	1110	0111	6
17	1001	0010	3	1000	0022	5	0000	1002	3	1000	0001	2	2121	2221	13	2344	5333	27
18	0110	0000	2	1000	0000	1	2000	1000	3	1234	2243	21	1000	0201	4	3223	4433	24
19	0000	0000	0	0000	2211	6	1101	1001	5	3222	4332	21	1000	1034	9	2222	2122	15
20	1124	4323	20	1000	0001	2	1112	3332	16	3222	2321	17	2224	6532	26	3322	3532	23
21	3332	3232	21	1000	2101	5	2121	3233	17	1211	1132	12	3333	3321	21	2222	3331	18
22	1111	0000	4	0101	2220	8	3222	3342	21	2100	0333	12	1112	2453	19	2111	3322	15
23	0000	0110	2	0000	1010	2	2443	2323	23	2112	2231	14	3121	3221	15	2212	2212	14
24	0000	1000	1	0000	0000	0	2322	3322	19	1001	2211	8	2112	2432	17	2111	0111	8
25	0000	0000	0	1003	3231	13	2111	0233	13	2003	4553	22	2123	2432	19	0011	1000	3
26	0000	1332	9	1111	2333	15	1011	0010	4	3222	3431	20	2112	2112	12	0001	2101	5
27	1211	2101	9	3232	2152	20	0002	1544	16	2113	3423	19	1111	1211	9	2211	1122	12
28	1000	0001	2	2234	3121	18	3242	2344	24	2103	3421	16	0011	2311	9	2100	1111	7
29	2433	4233	24	1010	2121	8	3343	4433	27	2011	3354	19	0001	2212	8	1010	0012	5
30	3331	1231	17	1221	1011	9	2232	2231	17	2211	1312	13	1001	1221	8	2011	2210	9
31	1122	3101	11	1011	1233	12				2011	3221	12				0112	2222	12

Table 5.6. K indices and daily K sums measured at Gnangara in 2007.

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
2007-01-01	09:47	ssc	1.08	12.27	7.06	2(4,5)	5	17.2	56.8	120.3	2007-01-02	21:00
2007-01-29	05:00	...				29(5,6)	6	11.2	58.1	76.2	2007-01-30	21:00
2007-05-21	23:20	...				23(8)	6	29.2	118.2	181.0	2007-05-28	09:58
2007-07-14	07:23	...				14(6,7)	5	13.8	75.6	86.1	2007-07-15	21:27
2007-11-19	18:10	...				20(5)	6	20.8	115.9	126.3	2007-11-21	17:00

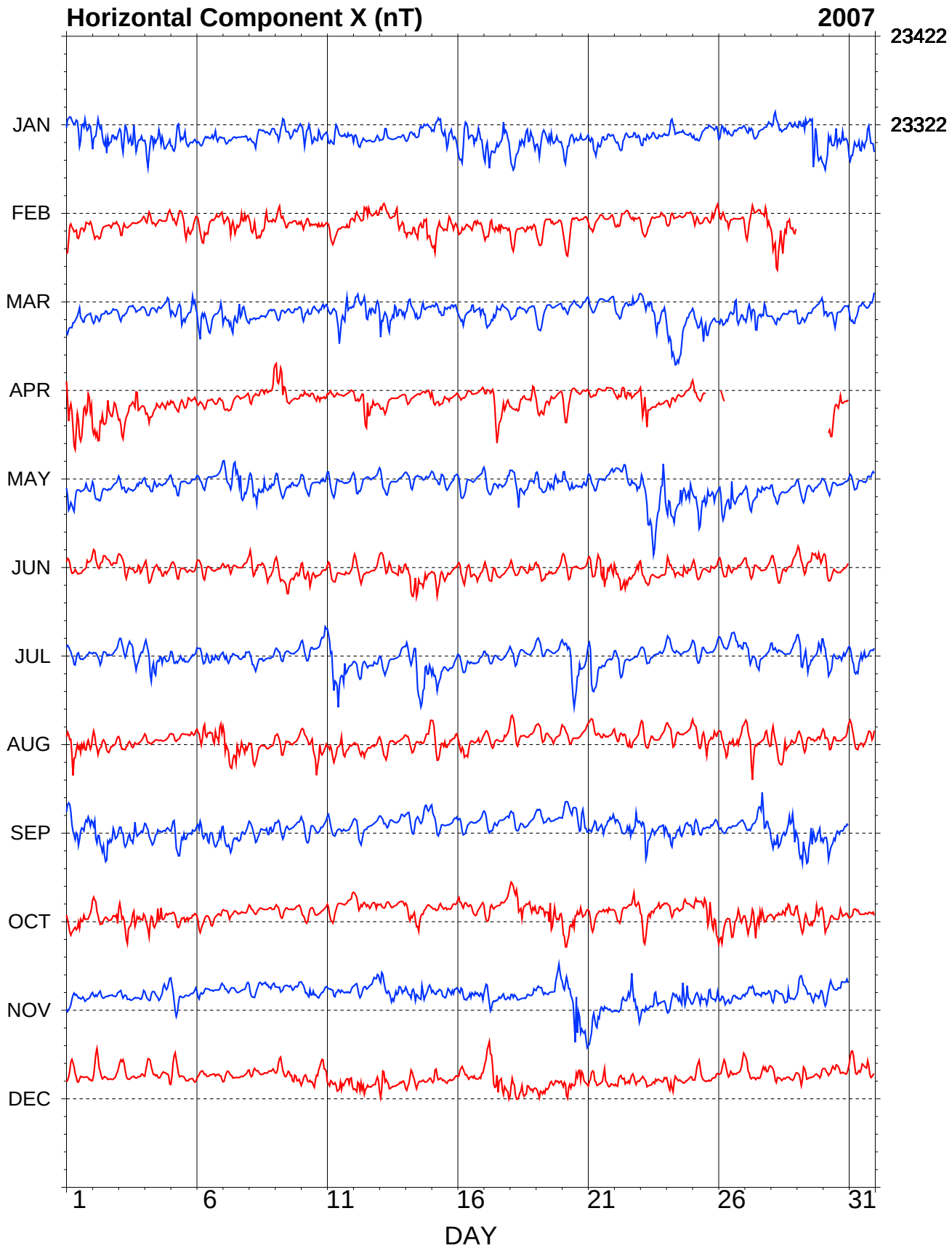
Table 5.7. Principal magnetic storms observed at Gnangara in 2007.

UT		Type	Quality	Chief movement (nT)		
Date	Time	ssc/ssc*	A,B,C	H(x)	D(y)	Z
2007-01-01	09:47	ssc	c	12.27	7.37	7.06
2007-01-14	12:45	ssc*	b	5.02	10.37*	5.04*
2007-01-14	20:23	ssc	a	5.3	9.44	6.62
2007-09-27	11:52	ssc	b	11.35	2.55	4.53
2007-10-25	11:35	ssc	a	25.92	5.44	10.44

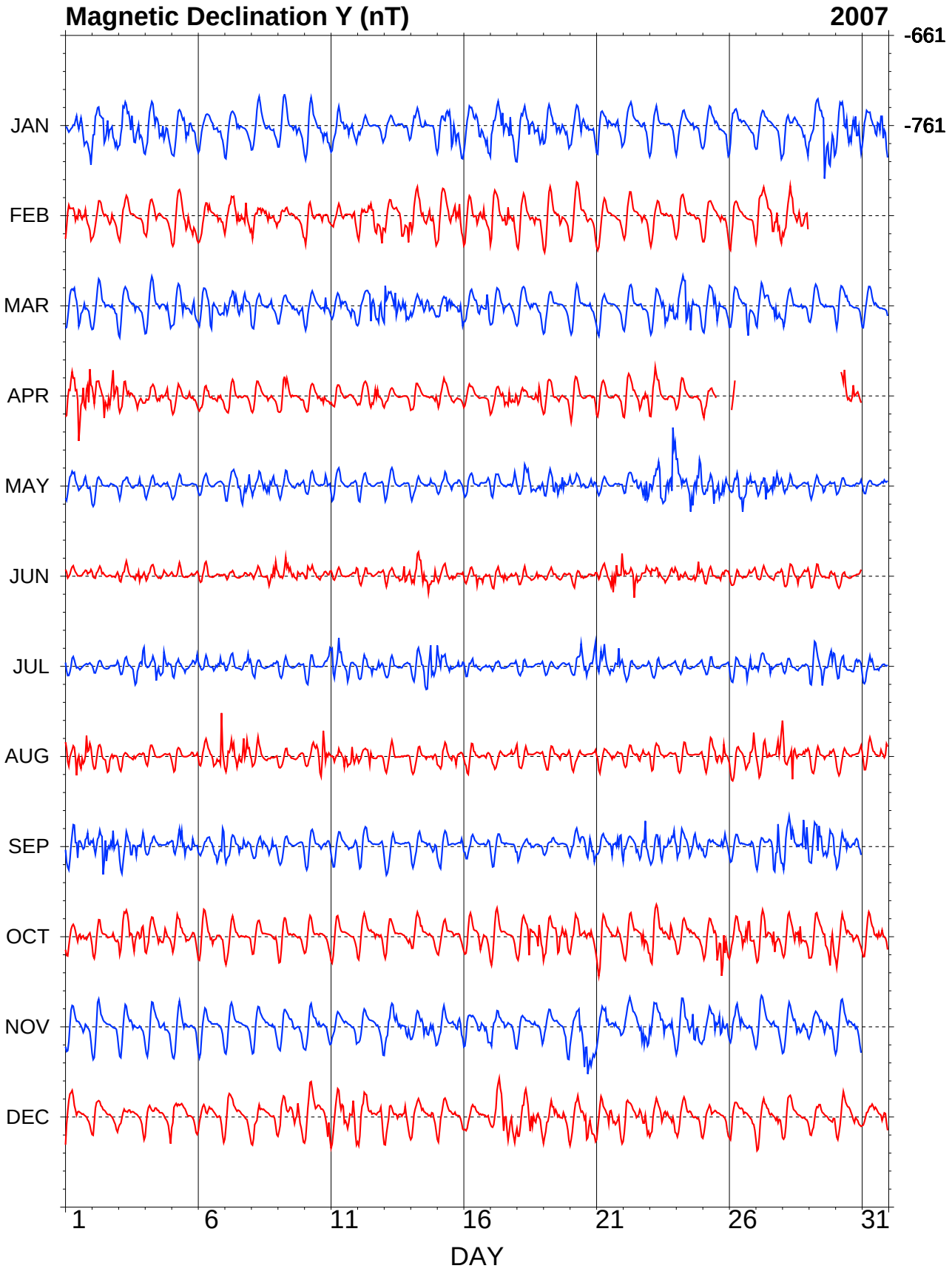
UT	Movement			Amplitude (nT)			Confirmation
Date	Start	Max	End	H(x)	D(y)	Z	
Nil							

Table 5.8. Sudden storm commencements and solar flare effects observed at Gnangara in 2007.

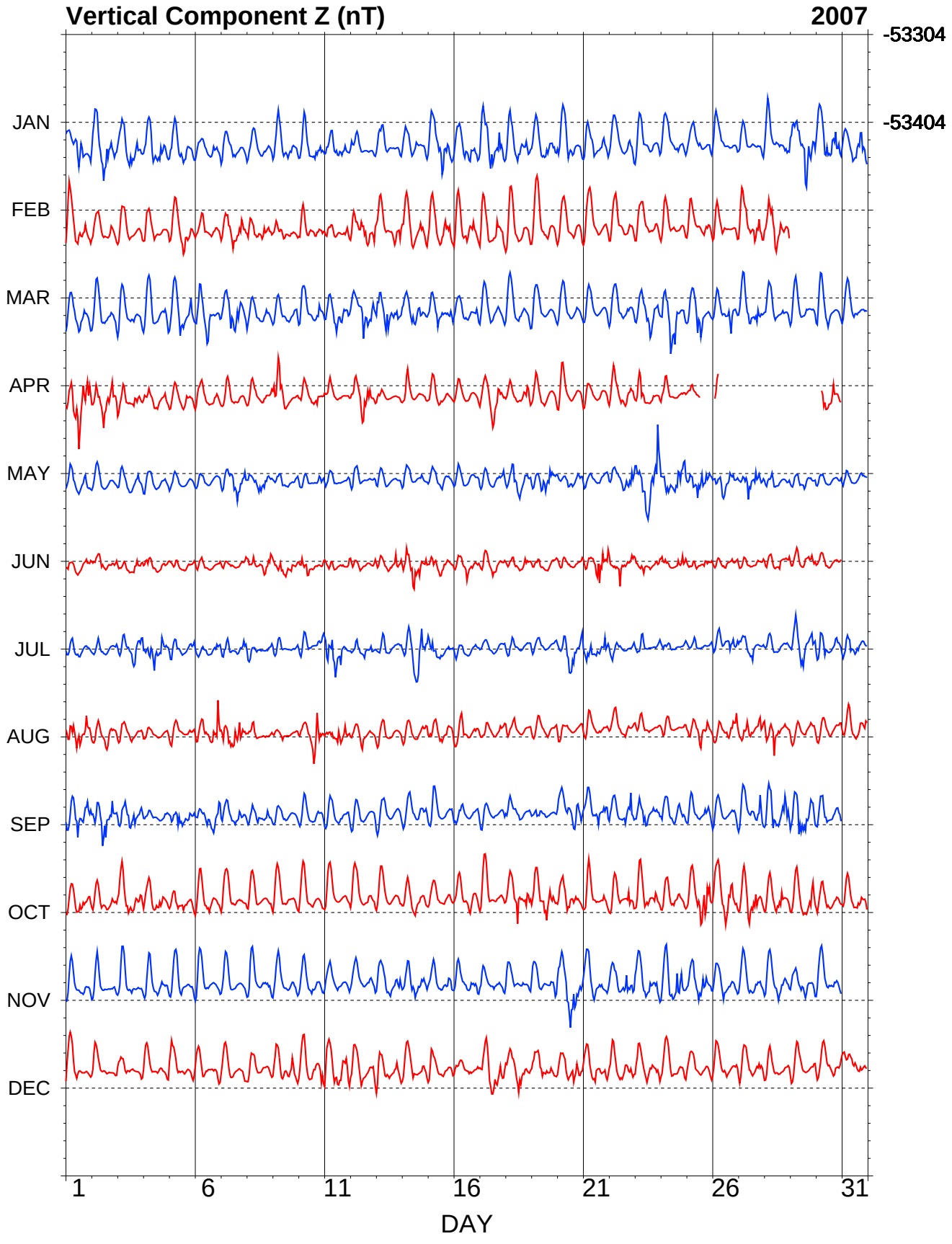
GNA - Hourly Mean Values



GNA - Hourly Mean Values



GNA - Hourly Mean Values



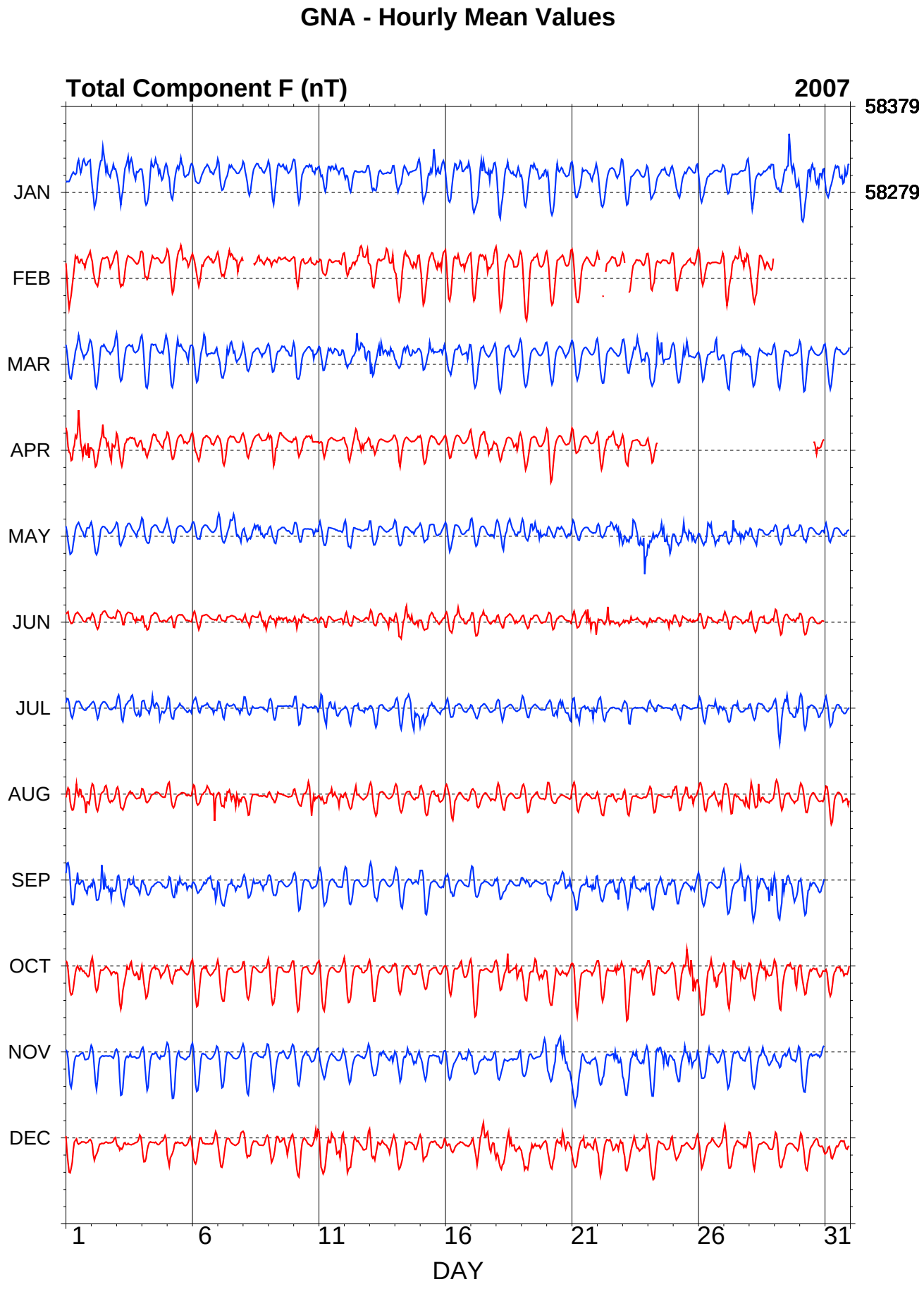


Figure 5.3. Hourly mean values in X, Y, Z and F measured at Gnangara.

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:

- a Recorder House;
- a Variometer House 85 m NW of the Recorder House;
- a Secondary Variometer House some 70 m to the west of the Recorder House;
- an Absolute House 60 m NE of the Recorder House;
- a Comparison House 12 m west of the Absolute House;
- a Test House some 210 m north of the Recorder House;
- the Geoscience Australia Magnetometer Calibration Facility some 100 m SE of the Recorder House;
- a sheltered external observation site;
- four azimuth pillars, and;
- two seismic vaults.

Variometers

The variometers used during 2007 are described in Table 6.2.

During 2007, the principal variometer, a Narod ring-core fluxgate, operated on a pier in the eastern room of the Variometer House. Total-intensity variations were monitored in the western room of the Variometer House. A LEMI 3-component fluxgate variometer, housed in the Secondary Variometer House, served as a backup instrument.

Timing for the primary variometer data was ntpd-based until 7 August when a Trimble Acutime GPS clock began operation. The 2006 Australian Geomagnetism Report (Hitchman *et al*., 2008) incorrectly reported that a GPS clock had provided timing during 2006 when timing had actually been by ntpd.

Absolute instruments

The principal absolute magnetometers used at Canberra and their adopted corrections for 2007 are described in Table 6.3.

The absolute instruments used at Canberra also served as the Australian observatory reference instruments. Intercomparison of various DIMs at the 11th IAGA workshop in Kakioka, Japan, resulted in corrections to D of 0.0’ and I of -0.15’ for the DI0048. International comparison via a travelling reference PPM to other nations’ PPMs and frequency standards has shown that no F correction is necessary.

At the 2007 mean magnetic field values at Canberra these D, I, and F corrections translate to corrections of:

ΔX = -3.0 nT ΔY = -0.7 nT ΔZ = -1.4 nT

These corrections have been applied to Canberra 2007 final data.

Baselines

Without any correction, the Narod baseline drifts were in the range of 9 nT, 10 nT and 3 nT in X, Y and Z during 2007. Drift patterns of three channels have very similar seasonal dependence to those of previous years.

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

IAGA code:	CNB
Commenced operation:	1978
Geographic latitude:	35° 18' 52.6" S
Geographic longitude:	149° 21' 45.4" E
Geomagnetic latitude:	-42.44°
Geomagnetic longitude:	226.94°
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:	L. Wang

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 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:	ntpd (until 7 August) Trimble Acutime GPS clock (from 7 August)
Communications:	radio link

Table 6.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

DI fluxgate:	DMI
Serial number:	DI0048
Theodolite:	Zeiss 020B
Serial number:	353756
Resolution:	0.1’
D correction:	0.0’
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 2007. Corrections are applied in the sense Standard = Instrument + correction.

	σ		σ
X	0.6 nT	D	11"
Y	1.2 nT	I	2"
Z	0.3 nT	F	0.2 nT

There was less than 1.0 nT variation throughout the year in the FCheck.

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

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 RCF variometer were acquired on a computer at the observatory and were automatically retrieved to head office via a telemetry link every 10 minutes. The temperature in Variometer House varied between 24.8°C and 26.5°C throughout the year.

Data losses at Canberra in 2007 are identified in Table A.6. When required, data from the backup LEMI variometer were used to in fill gaps in the primary variometer record. Data acquired from the LEMI for this purpose are identified in Table B.1.

Significant events

2007-01-17 Network Failure - Fibre-Optic converter power supply - no data telemetry

07:44 baseline (Z) shifted up ~ 5 nT

2007-01-18 FO Converter power supply replaced 23:00

18:42 baseline (Z) shifted down ~ 5nT (shifted Z @-4.47 nT from 07:46 17 Jan 2007 - 18:36 18 Jan 2008 at final dataset)

2007-02-15 Commence 3 hourly data delivery to Potsdam for Real-time Kp index calculations

2007-02-20 01:00 - 02:30 telemetry interruption, upgrades in computer room.

Afternoon thunderstorms - spikes on data

2007-02-22 LEMI data has steps during the day in A, B, C and sensor temperature

2007-02-27 01:00 LEMI data corruption - LJW in hut re-arranging equipment

2007-03-08 Testing local NTP using LEMI ga-cnb-mag3 as server, CTL ga-cnb-mag1 as client caused clock error on LEMI computer about 02:06 - 02:31 (-1271s correction later applied). The configuration worked on computers at Symonston, and should not have effected the server computer! Further tests cannot use NGL or LEMI computers. (server 127.127.1.0 fudge 127.127.1.0 stratum 3)

2007-03-27 Attempted to install Trimble Acutime s/n 260033496 p/n 28530-01 with BNC extender cable to Narod for 1s pulse, using Powerbox PUP30-12-N 100-240VAC 0.8A 47-63Hz 11-13 VDC 2.7A 30W s/n 155959 week 9746 with Trimble cable #3, and 42 ms pulse stetcher 20070301 (battery CB1270 12V &Ah)

Test in Control Hut were marginal. Slay ntp on ga-cnb-mag2 ~03:11, tried Clock. OK. Take out ntpd from rc.local, install Trimble in rc.acquisition (using -r -48000); nglRW failed for unknown reasons. Then everything including clock, two pulse stretchers, ser2 seemed to fail. Disconnect clock and restart ntpd. It may be that the battery was very low, power supply consequently blew, and low voltage explains some of the other faults!!??

Reverted to previous setup but CNB variometer environment altered with old comparison hut wooden rack installed - still the installation needs to be tidied to
1) remove numerous 12V PS with one battery box
2) separate 240V power from data cables in conduits
3) remove unused cables cluttering conduits
4) replace discky 4 outlet power board if still required

2007-03-29 04:40 UT time: added "X-Protective-Marking" in email headers.

2007-04-13 ~01:40 CN1 shutdown as Adam data had multiple and invalid data records per second on several occasions, with many spikes etc. System clearly misbehaving, cause unknown (acquisition, Adam?)

2007-04-14 ACT forestry (phone number 62050204) informed about the Subaru Rally in Kowen forest on the weekend from 1 - 3 June. Gates to the forest will be locked up from 28 May to 3 June.

2007-04-28 Backward time jump in CN1 @ 13:20

2007-05-17 05UT Radio link down during ATWS installation

2007-05-31 Installed GdapAdjustClockRate, and modified clock rate from standard to 838095345; residual rate ~-500ppb. Not installed in startup scripts at this stage.

2007-06-20 12:30 - 24:00 Radio link down due to power surge protector failure in the external radio box at CMO

2007-06-21 00:00 - 02:24 Radio link down due to power surge protector failure in the external radio box at CMO

2007-07-03 50m N-S, E-W MT system set up out from Control hut for OEMD equipment testing.

2007-07-10 Cold reboot of Narod RCF ~01:50 (causing about 1 minute data loss)

2007-07-13 Slay ntpd and restart ntpd at 02:37 to see if data improves.

2007-07-16 Radio link upgrades cause interruption to telemetry 01:15

2007-07-17 ~04:30-04:40 install Trimble GPS 260033496 Cable#3, Pulse stretcher 20070301 using power supply Powertech MP-3240 100-240V 47-63Hz 12V 4A N17413; ~08:15 slay ntpd, start (rc.clock) GdapClock using Trimble NOTE rc.clock needs to be merged into rc.acquisition instead of rc.local having ntpd. GdapClock failed at about 12:05

2007-07-18 shutdown to try and get clock working at ~00:16; shutdown ... ~00:24 Should be back to ntpd now - cannot get any response (serial or PPS) from the Trimble.

2007-08-07 During AAD training, noticed that the 240 plug to power supply of GPS wasn't making good contact at the power supply end. ~01:33, slay ntpd, change clock rate to 838054112 and start GdapClock

07/08/07 01:34:21 - CLK I 0 Correction:

1186450461 174792012 C 0 s 6758453 R 0 s 213

07/08/07 01:35:46 - CLK I 0 Correction:

1186450546 181394998 C 0 s 10382 R 0 s 250

GPS CLOCK back in use and NOT NTPD. Still require some changes to complete the transiton GSM90 905926 Failed - no serial communication to device

2007-08-14 Absolute GSM90 failed to operate last week, and 003985 also failed this week - appears to be broken

	wires in RS232 connector Connected the pps from GPS pulse stretcher to Narod. While testing, nglRW -d/dev/ser5 could not read data at 9600 properly. Some baud rates <9600 baud gave some very poor and incomplete data Reconnecting to ser8 worked ok - something is wrong, but I didn't resolve the problem...PGC.
2007-08-17	Timejumps in CN1 data - repeated data for F rather than erroneous data. It could be that a network connection CN1-CNB was lost during storms that were around at the time, and that MachR reopened the Resource Manager F file and started at the beginning of the buffer, so duplicationg already recorded data.
2007-09-05	Japanese researchers visited the observatory
2007-09-06	23:20 stop e-mail RT delivery to ISGI, FTP delivery continues unchanged.
2007-09-16	20:50 Lost contact with GPS on CN1
2007-09-17	Could not resurrect CN1 GPS by restarting GdapClock. shutdown CN1 at 01:46; 01:48:07 Correction CN1 48ms. Made adjustments to CN1 /etc/rc.d/ rc.ports and rc.acquisition; rc.ports now starts serial driver for ser1, ser2, and ser5-8 as 3 processes rc.acquisition now calls GdapAdjustClockRate then GdapClock -r 0
2007-10-22	01:26: updated baseline
2007-11-23	Magcal UPS stopped working due to operated Circuit Breaker. Restored CB and all OK.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
ISGI, France	preliminary	real time
ISGI, France	preliminary	daily
GeoForschungsZentrum, Germany	preliminary	3-hourly
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly
K indices		
IPS Radio and Space Services		weekly
University of Newcastle		weekly
British Geological Survey		weekly
CLS, CNES, France		weekly
ISGI, France		weekly
Centre de Physique du Globe, Belgium		weekly
GeoForschungsZentrum, Germany		semi-monthly
Observatori de l'Ebre, Spain		monthly
Principal magnetic storms and rapid variations		
WDC-A		monthly
WDC-C2		monthly

Table 6.4. Distribution of 2007 data.

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 2007 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 2007 are listed in Table 6.6.

Principal magnetic storms observed at Canberra are listed in Table 6.7 and other rapid variation phenomena in Table 6.8.

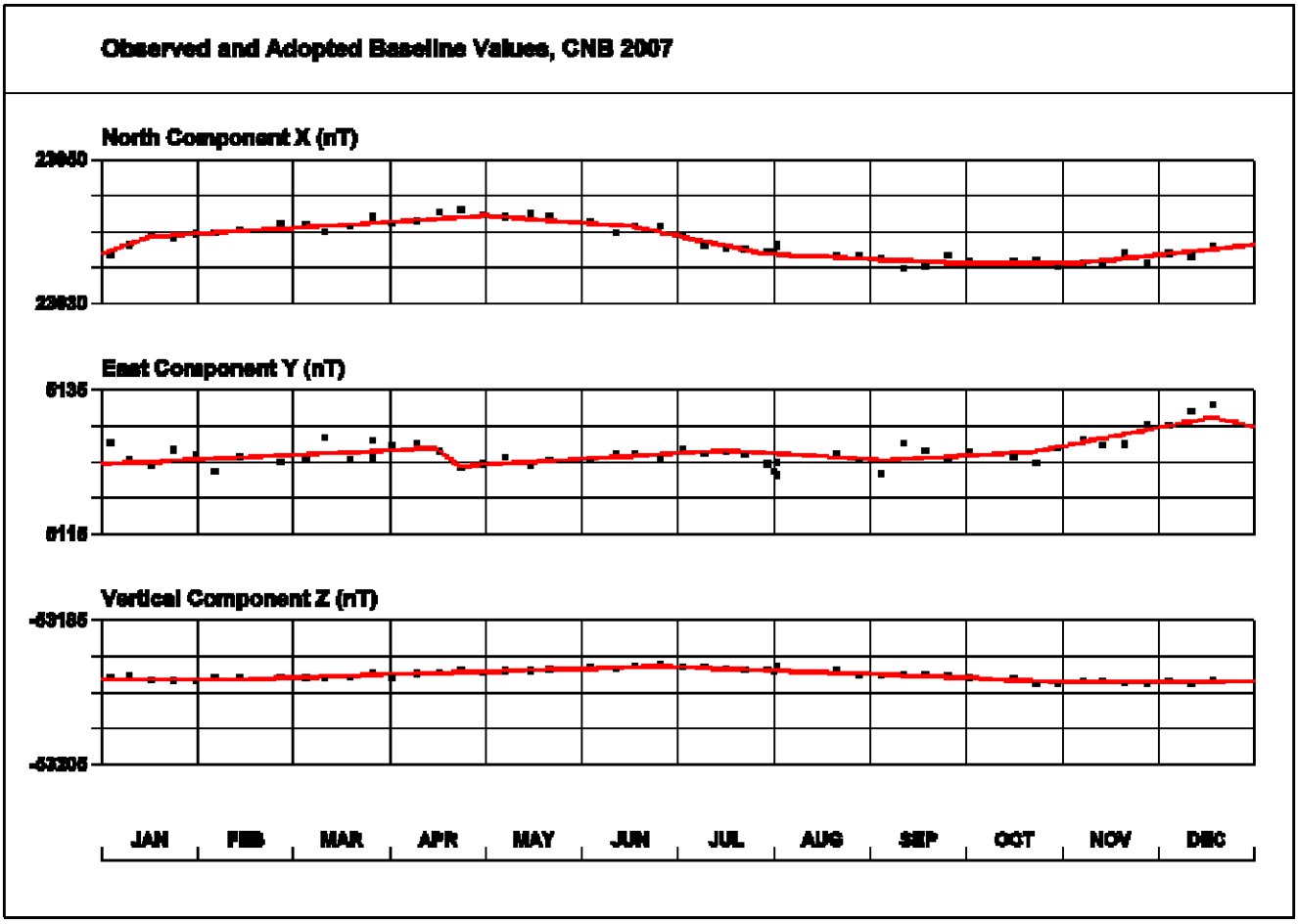


Figure 6.1. Canberra baseline plots.

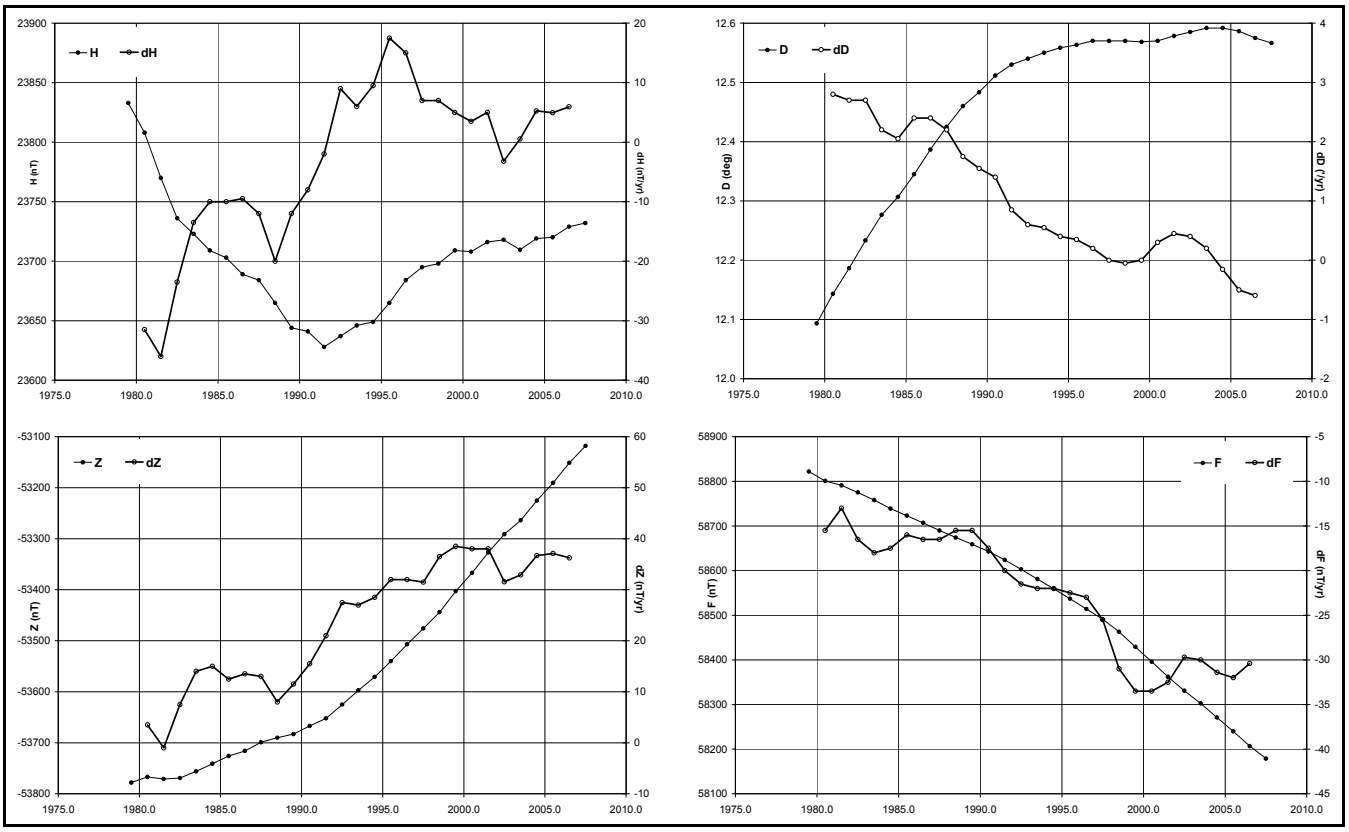


Figure 6.2. Annual mean values and secular variation (all days) for H, D, Z and F measured at Canberra.

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
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
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

Table 6.5. Annual mean values calculated using the 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.

Day	January			February			March			April			May			June		
01	1013	4323	17	2233	2222	18	2223	3211	16	3444	4334	29	1231	2221	14	1112	1122	11
02	4334	4323	26	0111	1201	7	0011	2011	6	3444	4333	28	0000	0100	1	2222	0111	11
03	3334	4423	26	1111	0000	4	0000	1100	2	2333	1421	19	0011	1110	5	1111	1231	11
04	2233	4322	21	1202	0002	7	0111	1011	6	2223	2123	17	0002	1000	3	1212	2211	12
05	2223	3111	15	2212	3212	15	2123	3121	15	1111	1200	7	0001	0000	1	0000	0000	0
06	2221	2211	13	1222	1111	11	2334	4212	21	0111	2110	7	0000	0000	0	0000	0000	0
07	1111	2001	7	2233	3232	20	3233	4422	23	1000	1000	2	0022	3422	15	0000	0000	0
08	1111	1011	7	2222	2311	15	1112	1010	7	0011	1102	6	2333	3211	18	2121	1222	13
09	0131	2221	12	2332	0111	13	1101	1121	8	4443	2000	17	1221	1101	9	0223	3111	13
10	1223	2311	15	2100	0211	7	1120	1121	9	1102	2211	10	0000	0021	3	2132	1010	10
11	2331	2222	17	1100	0012	5	1123	3332	18	1211	1000	6	0001	1000	2	0000	0100	1
12	2101	0101	6	1002	3213	12	2223	4232	20	1223	4220	16	1100	0001	3	0000	0000	0
13	0000	0000	0	2222	2334	20	5344	3333	28	0000	0000	0	0001	0000	1	0012	2231	11
14	0010	2111	6	3223	3222	19	2223	3211	16	0110	1001	4	1001	0120	5	2325	2332	22
15	1233	4322	20	1223	3221	16	1233	3222	18	1112	2100	8	0111	2000	5	2212	2200	11
16	1422	3323	20	1111	2212	11	2311	2123	15	0000	1000	1	0000	0000	0	1211	3110	10
17	3233	3222	20	1322	3302	16	2223	2210	14	0134	3341	19	0000	1111	4	1112	2110	9
18	2233	3313	20	2002	2211	10	0101	2101	6	1101	2222	11	1143	2222	17	0111	0220	7
19	2322	3212	17	2101	2201	9	0111	0001	4	1012	2100	7	2223	2321	17	1122	1100	8
20	2123	1212	14	0101	0101	4	1000	1101	4	1100	1100	4	2112	1111	10	1112	0000	5
21	1222	2111	12	0100	0000	1	0001	0000	1	0000	0000	0	1101	0112	7	0113	4333	18
22	1111	1111	8	0100	0101	3	0011	0211	6	2223	2322	18	1123	2233	17	2234	2112	17
23	1112	1101	8	1000	1000	2	0113	4322	16	4441	0200	15	2355	4345	31	1131	1111	10
24	0010	0111	4	1010	0000	2	2354	4211	22	1111	0011	6	4332	4433	26	1111	1220	9
25	0012	1111	7	1100	1221	8	2224	4111	17	1211	2200	9	1333	3332	21	0000	0210	3
26	1011	1101	6	2422	0001	11	1222	2422	17	1001	2210	7	2335	4311	22	0002	1010	4
27	0101	1011	5	1133	2332	18	2333	2222	19	1113	3333	18	2234	2311	18	1010	0100	3
28	1321	1011	10	2444	3222	23	2212	1100	9	2434	4433	27	2201	0000	5	1012	3101	9
29	1232	5533	24				1100	1002	5	3344	4333	27	0111	2101	7	0011	2232	11
30	3333	4332	24				2213	3000	11	3343	2311	20	1111	1100	6	1211	0000	5
31	2333	3332	22				0002	1101	5				1100	0111	5			

Day	July			August			September			October			November			December		
01	0012	0000	3	3343	4333	26	1124	2222	16	1113	3201	12	1211	0211	9	1111	0011	6
02	0011	0100	3	0121	2210	9	2335	4221	22	1121	1012	9	0012	0001	4	0121	1011	7
03	0102	3412	13	0111	2100	6	1223	3212	16	1232	4222	18	0001	2000	3	0000	0010	1
04	2335	2330	21	1000	0000	1	1222	2011	11	1323	3221	17	1001	2211	8	1011	1012	7
05	1111	3010	8	0000	0010	1	1243	3121	17	1121	1100	7	1112	1001	7	2121	1111	10
06	0112	2210	9	0122	2324	16	1212	2224	16	0002	2110	6	0000	1000	1	0100	0111	4
07	1110	0111	6	4443	4333	28	2322	3211	16	1101	2000	5	0000	0001	1	1110	0000	3
08	1110	1001	5	1321	1100	9	1212	1210	10	0000	0000	0	1110	1112	8	0010	0001	2
09	0000	0000	0	1012	1000	5	0001	0100	2	0010	1000	2	1101	2201	8	1110	1211	8
10	0001	1012	5	0023	3331	15	0001	0100	2	0000	0000	0	2222	2100	11	0222	2224	16
11	3454	2410	23	2223	3221	17	0000	1100	2	0000	0000	0	0111	1001	5	3332	3333	23
12	1131	2010	9	1224	2110	13	0001	1000	2	0121	1221	10	0001	1122	7	2332	2012	15
13	0000	0001	1	1100	0000	2	0100	0010	2	0011	1011	5	3323	3223	21	1212	2111	11
14	1124	3443	22	1100	2001	5	0000	1212	6	1222	2101	11	2222	3312	17	1222	1111	11
15	3333	2111	17	2212	3211	14	2111	0101	7	0011	1200	5	1211	2211	11	1112	0011	7
16	0112	1100	6	1123	1010	9	0110	0010	3	0101	2200	6	1122	3212	14	0121	0101	6
17	0002	0000	2	1001	0010	3	0001	2001	4	0000	0000	0	2131	2101	11	3444	4333	28
18	1000	0000	1	0000	0000	0	1001	1000	3	1234	2134	20	1100	0201	5	2324	4323	23
19	0000	0000	0	0001	2200	5	0111	1000	4	2222	5321	19	1110	1023	9	2332	2122	17
20	0234	4313	20	0100	0000	1	1112	3232	15	3233	2210	16	2234	6432	26	2232	3433	22
21	2432	3121	18	0101	2101	6	1121	2223	14	1211	1112	10	2344	3221	21	2322	2321	17
22	0111	0000	3	0102	2210	8	2222	3332	19	1200	0222	9	0222	2442	18	1212	3222	15
23	0011	1110	5	0001	1000	2	2443	2113	20	2112	2110	10	2232	3221	17	1223	2201	13
24	0001	1000	2	0000	0000	0	2321	3212	16	1001	2201	7	2123	3332	19	1111	1001	6
25	0000	1000	1	1013	3220	12	1121	1122	11	1114	4433	21	2233	2322	19	0010	1000	2
26	0000	1321	7	1121	2233	15	1111	1000	5	2223	3321	18	2213	2011	12	0012	2101	7
27	1322	3100	12	2332	2131	17	1002	1544	17	1214	3312	17	1111	1101	7	1221	2122	13
28	1001	0001	3	2324	3121	18	2333	1233	20	2213	3311	16	0111	2301	9	1200	0100	4
29	2423	4123	21	1110	2110	7	3344	4323	26	1111	2233	14	0101	2211	8	0011	1011	5
30	3332	1221	17	1320	1001	8	2233	2221	17	2221	1202	12	0012	1111	7	1011	2100	6
31	1023	2101	10	1112	1122	11				1012	2111	9				0212	2122	12

Table 6.6. K indices and daily K sums measured at Canberra in 2007.

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**
2007-01-29	05:00	...				29(5,6)	5	11.3	79.3	30.3	2007-01-30	21:00
2007-05-21	23:41	...				23(3,4,8),26(4)	5	23.0	104.3	45.7	2007-05-28	09:30
2007-11-19	18:10	...				20(5)	6	16.5	122.2	35.8	2007-11-21	21:00

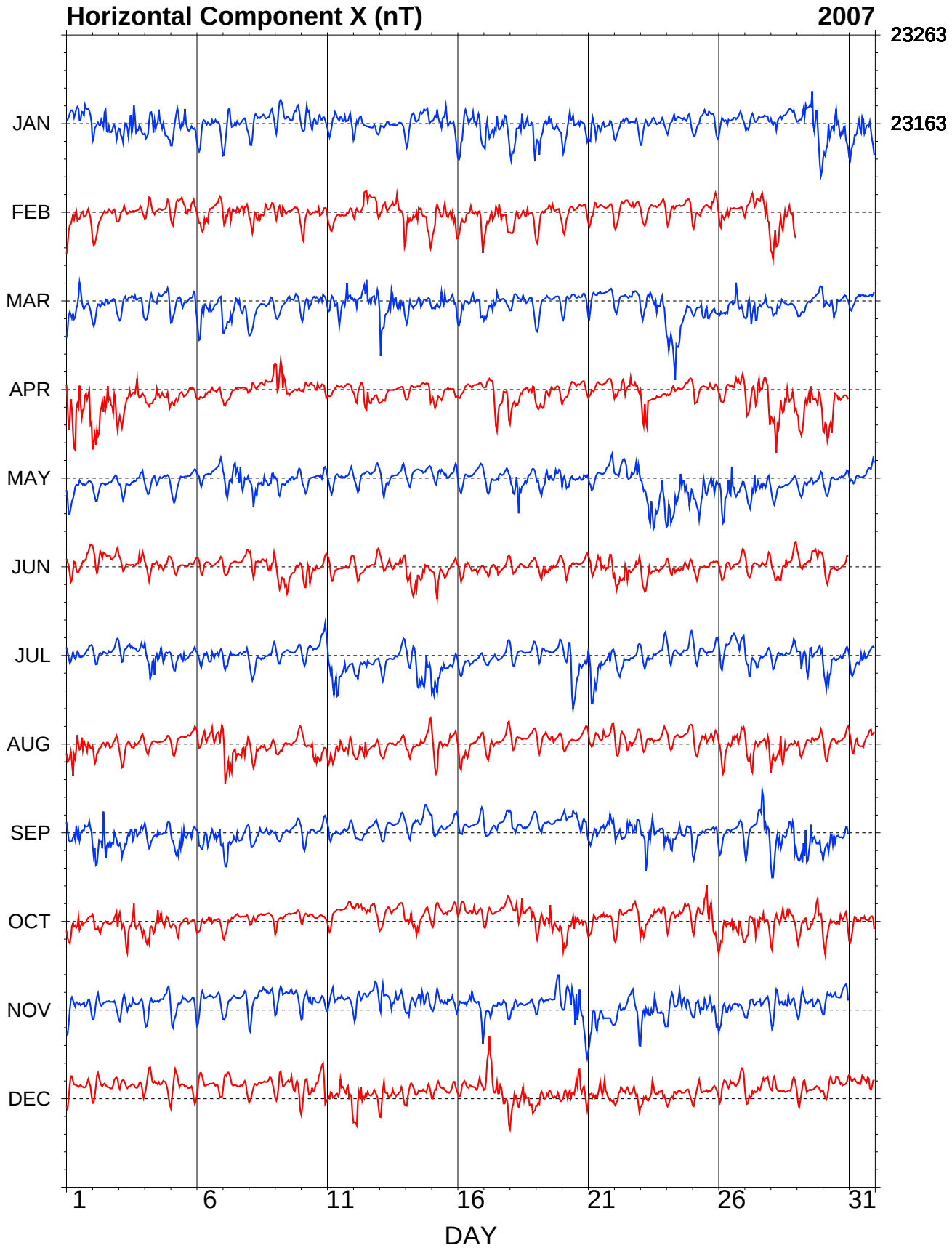
Table 6.7. Principal magnetic storms observed at Canberra in 2007.

UT		Type	Quality	Chief movement (nT)		
Date	**Time**	**ssc/ssc***	**A,B,C**	**H(x)**	**D(y)**	**Z**
2007-09-20	10:11	ssc	b	16.16	3.44	2.3
2007-09-27	11:51	ssc	b	16.21	1.28	3.08
2007-10-25	11:35	ssc	a	36.42	4.11	7.71

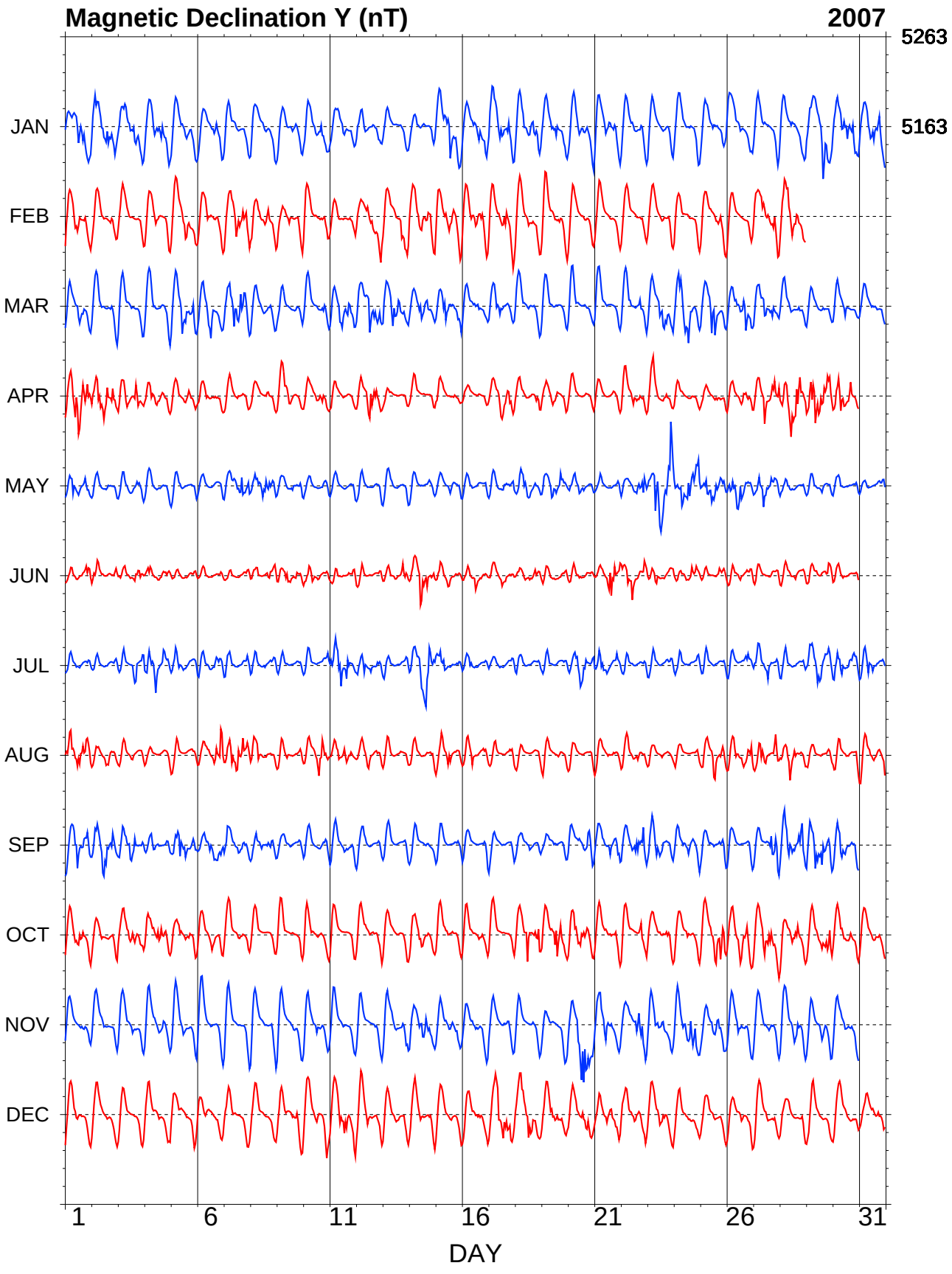
UT	Movement			Amplitude (nT)			Confirmation
Date	**Start**	**Max**	**End**	**H(x)**	**D(y)**	**Z**	
Nil							

Table 6.8. Sudden storm commencements and solar flare effects observed at Canberra in 2007.

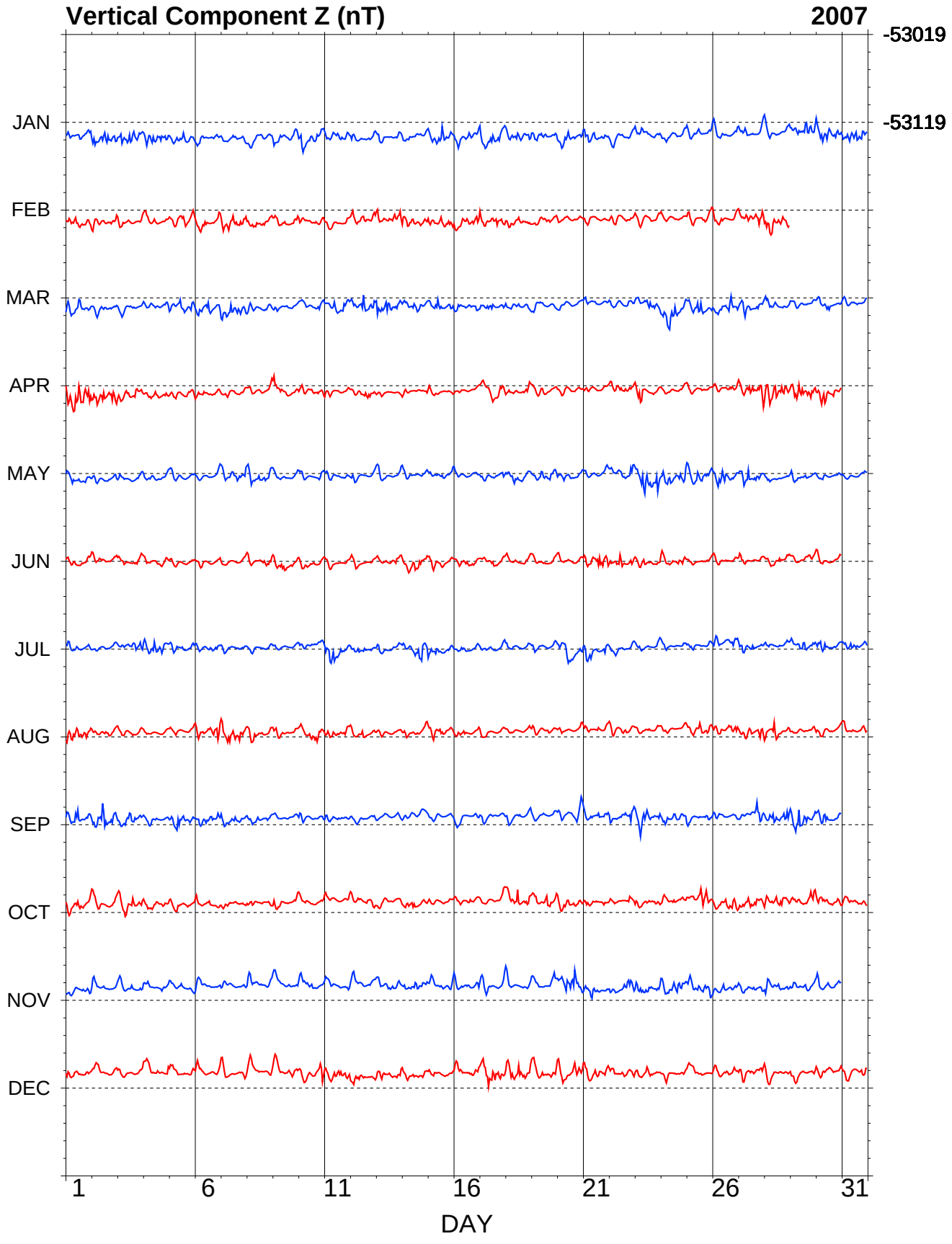
CNB - Hourly Mean Values



CNB - Hourly Mean Values



CNB - Hourly Mean Values



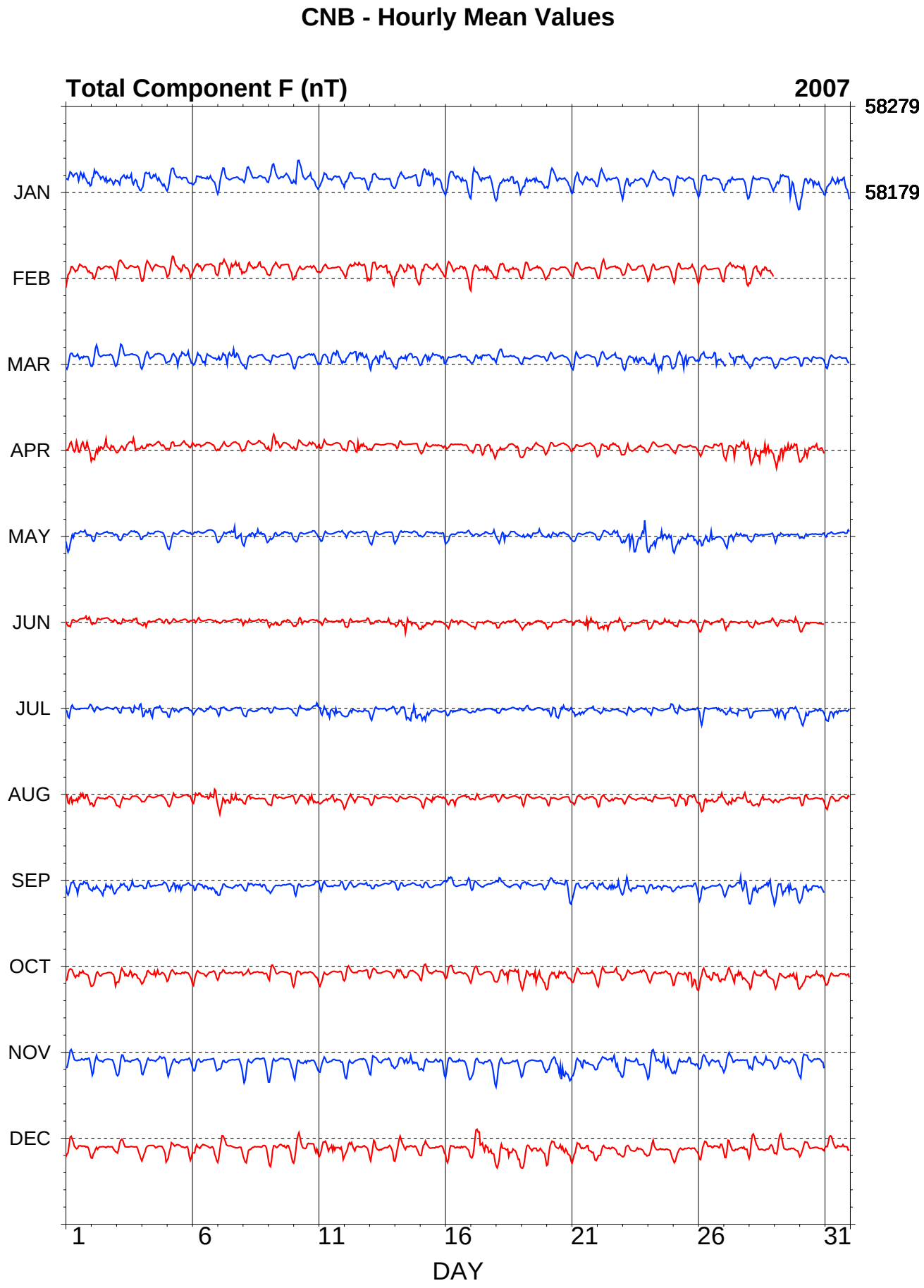


Figure 6.3. Hourly mean values in X, Y, Z and F measured at Canberra.

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:	-59.82°
Geomagnetic longitude:	244.11°
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:	J. Wruck (until 17 April) C. Clarke (from 18 April)

Table 7.1. Key observatory data.

Variometers

The variometers used during 2007 are described in Table 7.2. Two variometer systems were in operation throughout the year, one referred to as MCQ, the other as MQ2. The MCQ system consisted of a Narod Geophysics Limited 3-component ring-core fluxgate and a GEM Systems GSM-90. The MQ2 system comprised a Danish Meteorological Institute suspended 3-axis linear-core fluxgate and an Elsec 820 proton magnetometer.

The MCQ 3-component vector variometer sensor was mounted on a marble base in 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 A,B,C. The electronic console of the MCQ variometer was situated in the ante-room of the Variometer House. The MCQ scalar variometer sensor and electronics were located in the sensor room of the Variometer House. The temperature of the Variometer House was controlled with a heating system.

The MQ2 3-component vector variometer was housed in the instrument room of the Variometer House and aligned magnetic NW, NE and vertical. The MQ2 total-field scalar variometer was located in 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 separated systems. An Uninterruptible Power Supply located in the office powered the MCQ vector variometer (Narod) and the MQ2 scalar variometer (Elsec PPM). A 12 V battery box situated in the ante-room of the Variometer House provided power for the acquisition computer, the GPS clock, the MQ2 vector variometer (DMI) and the MCQ scalar variometer, (GSM-90 PPM).

Comparison of 2007 data from the MCQ and MQ2 systems indicated that superior baseline stability was obtained from the MQ2 vector variometer (DMI suspended fluxgate) and the MCQ scalar variometer (GEM GSM-90). This can be explained, at least in part, by the more stable temperature regime experienced by both the MQ2 vector variometer and the MCQ scalar variometer when compared to annual temperature variations experienced by the alternative variometer equipment. Accordingly, definitive 1-minute data for 2007 were derived from the MQ2 vector variometer (DMI) and the MCQ scalar variometer (GSM-90).

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 fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.3 nT
A/D converter:	ADAM 4017 module (±10V)
Period of use:	from 5 April
Total-field variometer:	GEM Systems GSM-90 (MCQ)
Serial number:	4081418/42176
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Total-field variometer:	Elsec 820 M3 (MQ2)
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:	real-time telemetry

Table 7.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

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 2007. Corrections are applied in the sense Standard = Instrument + correction.

Absolute instruments

The principal absolute magnetometers used at Macquarie Island and their adopted corrections for 2007 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. PPM observations were performed on pier AW. A Hewlett Packard H4300 hand-held computer was used to communicate with the GSM-90 magnetometers.

A pier difference of:

X = -2.6 nT, Y = +5.1 nT, Z = +4.2 nT (F = -4.1 nT)

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

A Declination Inclination magnetometer and an Austral PPM were available as back-up absolute instruments and were used occasionally throughout the year, in addition to the primary instruments.

The Macquarie Island total field absolute instrument, GSM90_5091720/52453, was compared with the Australian reference instrument, GSM90_905926/21867, at Canberra on 21 February 2006. The Macquarie Island DIM, DI0045/393911, was compared to the Australian reference, DI0048/353756, at Canberra observatory on 13 and 27 Dec 2005. These instrument comparisons yield the corrections to international standards listed in Table 7.3. At the 2007 mean magnetic field values at Macquarie Island these D, I, and F corrections translate to corrections of:

ΔX = -1.9 nT ΔY = -0.5 nT ΔZ = -0.4 nT

These corrections have been applied to all Macquarie Island 2007 final data.

Baselines

The standard deviations of the differences between the weekly absolute observations and the final adopted variometer model and data using the MQ2 vector variometer were:

	σ		σ
X	0.6 nT	D	11"
Y	0.7 nT	I	2"
Z	0.2 nT	F	0.2 nT

The drifts applied to the X, Y, and Z baselines amounted to less than 5 nT throughout 2007. Throughout the year there was about 4 nT of variation in the difference between F measured with the MQ2 vector variometer and the MCQ 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 2007 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, maintaining the integrity of the observatory and reporting any changes to Geoscience Australia.

During 2007, the role of magnetic observer at Macquarie Island was filled by the ANARE communications technical officers: Jodi Wruck, from 6 April 2006 until 17 April 2007 and Christopher Clarke from 18 April 2007.

The MCQ (Narod) vector variometer produced 8 samples per second which were averaged and output as 1-second data. The MQ2 (DMI) vector variometer was sampled once per second. Both the MCQ and MQ2 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. Data were transmitted every 5 to 10 minutes to Geoscience Australia. "Reported" quality real-time 1-minute data was provided to INTERMAGNET throughout 2007 from the MCQ variometer system. Definitive 2007 1-minute data (and derived data products such as hourly and annual mean values) where sourced from the MQ2 vector variometer and the MCQ scalar variometer. Acquisition timing control was provided by a dedicated Garmin GPS clock mounted on the variometer building.

Data losses for the MQ2 vector variometer and MCQ scalar variometer at Macquarie Island in 2007 are identified in Table A.7. When required, data from the MCQ vector variometer were used to in fill gaps in the MQ2 vector variometer record. Data acquired for this purpose are identified in Table B.2.

Significant events

2007-01-06	MCQ vector system data loss ~19:40 to 23:59 Unknown cause.
2007-01-23	05:18 stop the third GDAP MACHR process (mq1) on QNX acquisition PC
2007-01-25	Jodi checks batteries in LINX UPS (no stoppage). Replace two batteries.
2007-02-13	22:00 AGAD communications upgrade - no telemetry for up to 3 hours.
2007-02-15	JCB forklift in magnetic quiet zone 03:00 -03:30 UT.
2007-03	Station resupply 18 x 12V 7AH batteries (16 for UPS, 2 for absolute battery box); 4 outlet non-magnetic heater + ceramic and bulb elements; DMI DIM DI0040/394742

2007-04-03 05:20-05:40 Japanese SERC MAGDAS system in variometer hut has memory card replaced

2007-04-13 03:30 Data contamination (probably during new observer training)

2007-04-16 04:50 Data contamination

2007-04-27 First observation by new observer Christopher Clarke "CRC"

2007-05 Lock on PPM hut door replaced with magnetic steel barrel bolt!

2007-05-13 22:43:11 MCQ (Narod) fluxgate and MQ2 (E820) PPM stop working.

2007-05-14 01:45 Narod re-started, E820 continues to malfunction. Reset GdapE820 and CRC resets E820. Functioning by about 02:50

2007-05-15 04:10 - 06:50 Narod and E820 stopped as LINX800 UPS batteries replaced.

2007-05-18 06:35 Update MCQ preliminary baselines (X and Z drift)

2007-05-29 02:00 - 05:00 JCB forklift working on riometer in quiet zone.

2007-06-05 CRC rebooted acquisition sys while resolving a network problem.

2007-06-27 No telemetry 07:30 - 20:15 Fibre optic cable problems

2007-07-11 00:52 - 01:02 motorbike in magnetic quiet zone

2007-08-24 Absolute hut heater faulty - removed from hut for repair

2007-08-29 06:26 Update preliminary MCQ baseline parameters (X drift)

2007-08-30 Absolute hut heater repaired and re-installed.

2007-09-10 CRC away from station for about 10 days from today

2007-11-04 15:52 lost connection to GPS Clock

2007-11-05 05:29 Re-start GdapClock GPS clock program

2007-12-01 03:35:48 Sudden change in MCQ (Narod) fluxgate baselines over a period of 1 second. Most change in B and C channels

2007-12-12 23:50 fix BLV jump in MCQ preliminary baseline parameters; 23:58 update MCQ Y and Z drift in preliminary baseline parameters.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 7.4. Distribution of 2007 data.

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 2007 data are shown in Figure 7.3.

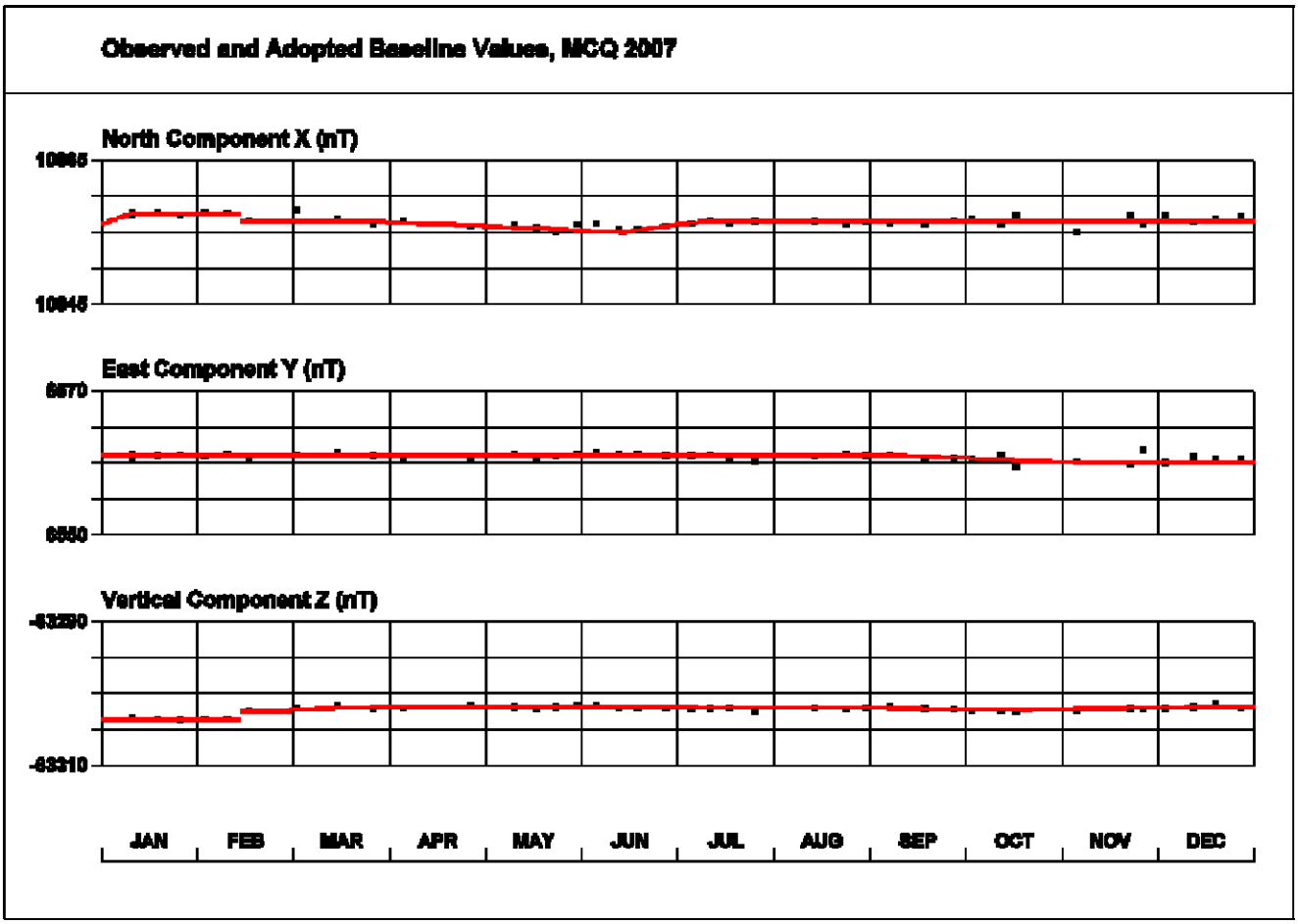


Figure 7.1. Macquarie Island baseline plots.

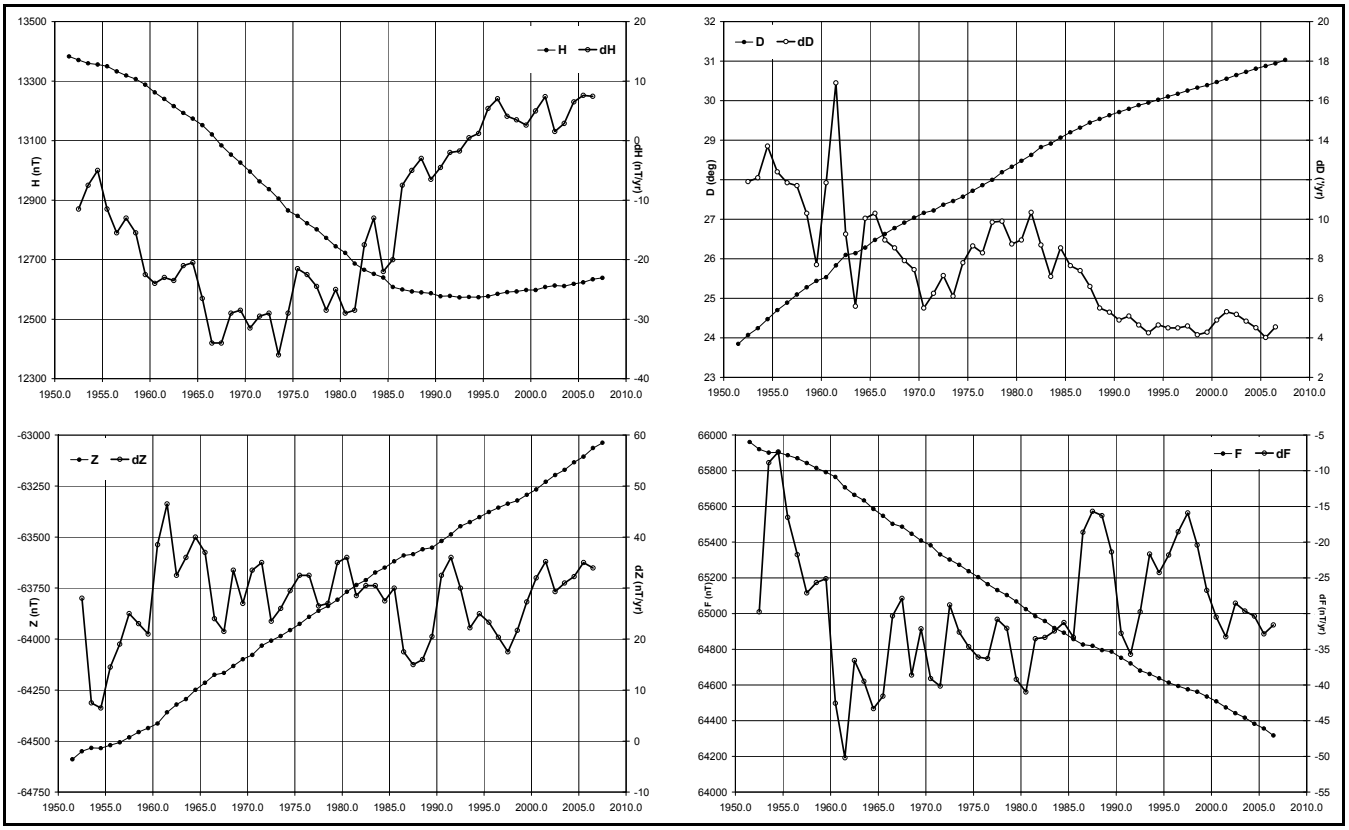


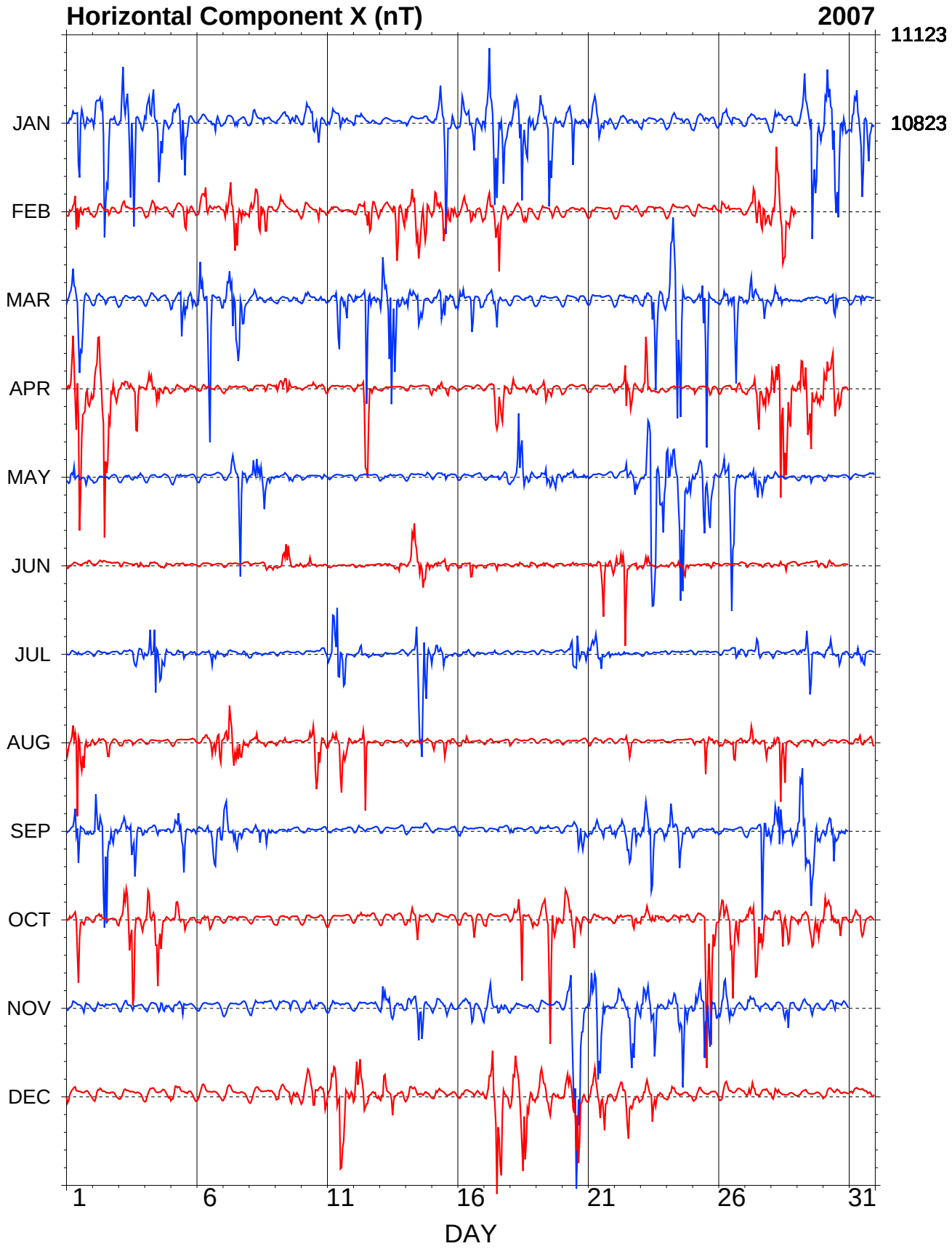
Figure 7.2. Annual mean values and secular variation (quiet days) for H, D, Z and F measured at Macquarie Island.

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
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

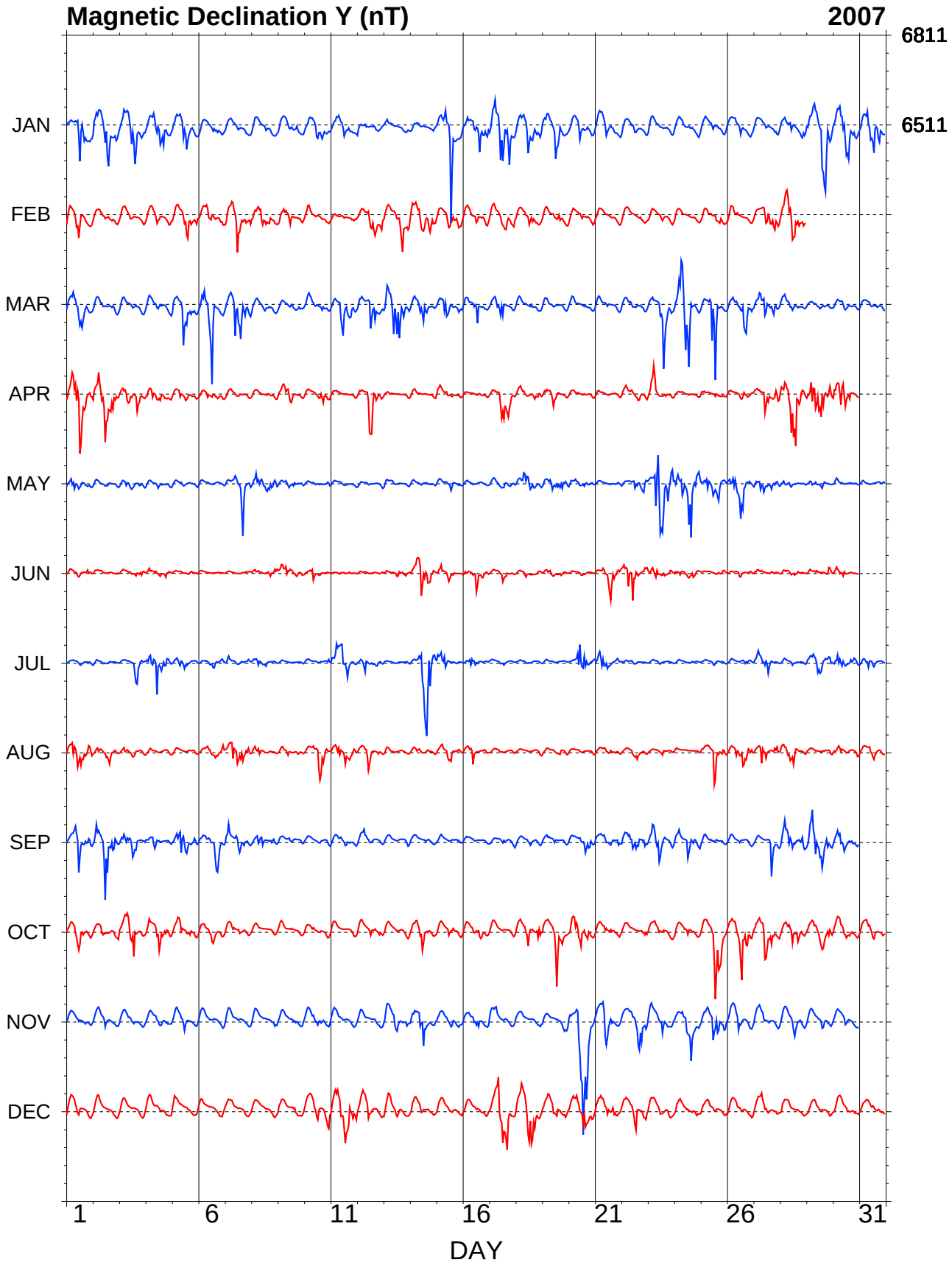
2000.5	Q	30	28.3	-78	44.3	12598	10858	6389	-63266	64509	ABC
2001.5	Q	30	33.3	-78	43.4	12608	10857	6409	-63229	64474	ABC
2002.5	Q	30	38.9	-78	42.8	12613	10851	6429	-63196	64442	ABC
2003.5	Q	30	43.7	-78	42.6	12611	10841	6444	-63170	64417	ABC
2004.5	Q	30	48.5	-78	41.8	12619	10838	6463	-63134	64383	ABC
2005.5	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
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

Table 7.5. Annual mean values calculated using the 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.

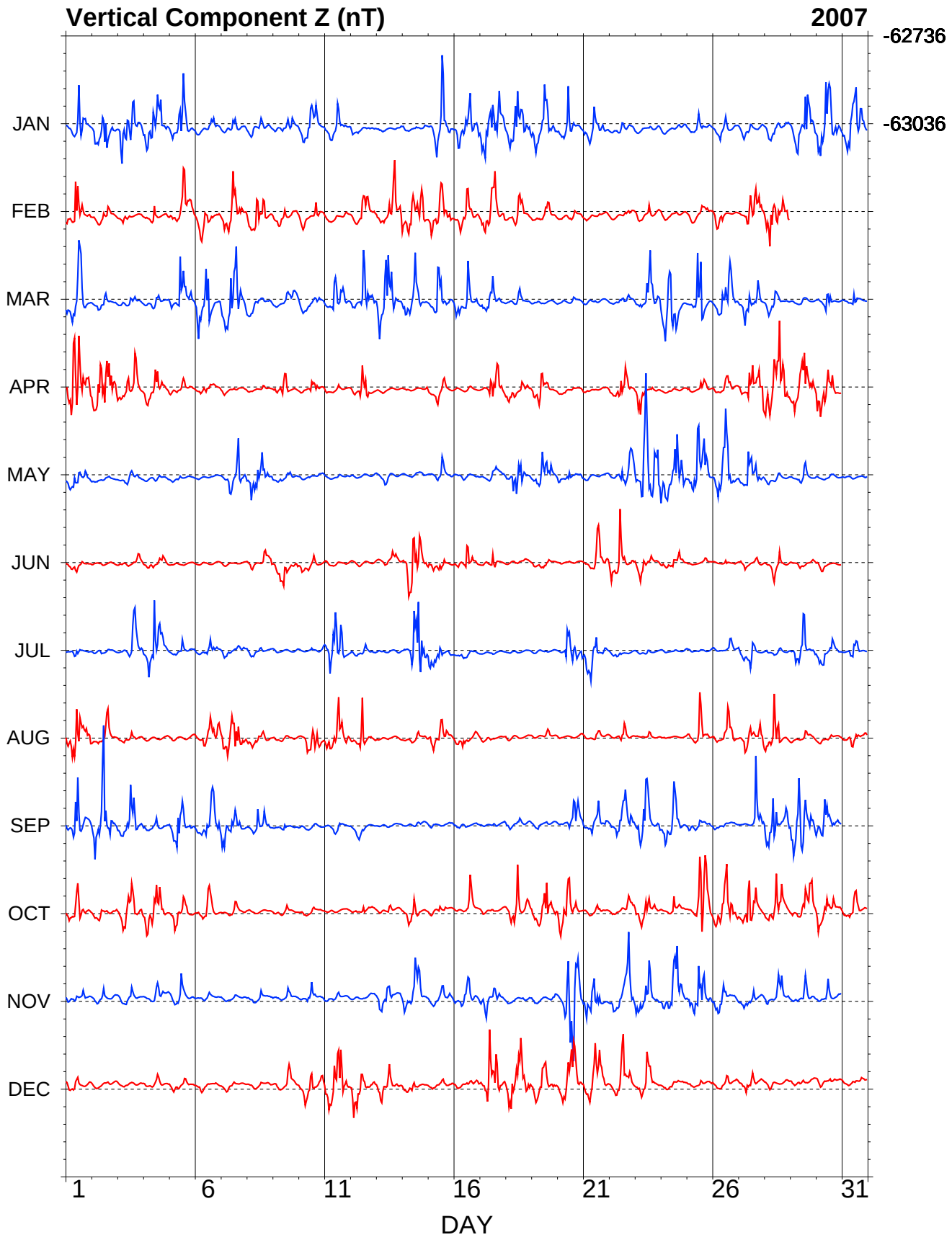
MCQ - Hourly Mean Values



MCQ - Hourly Mean Values



MCQ - Hourly Mean Values



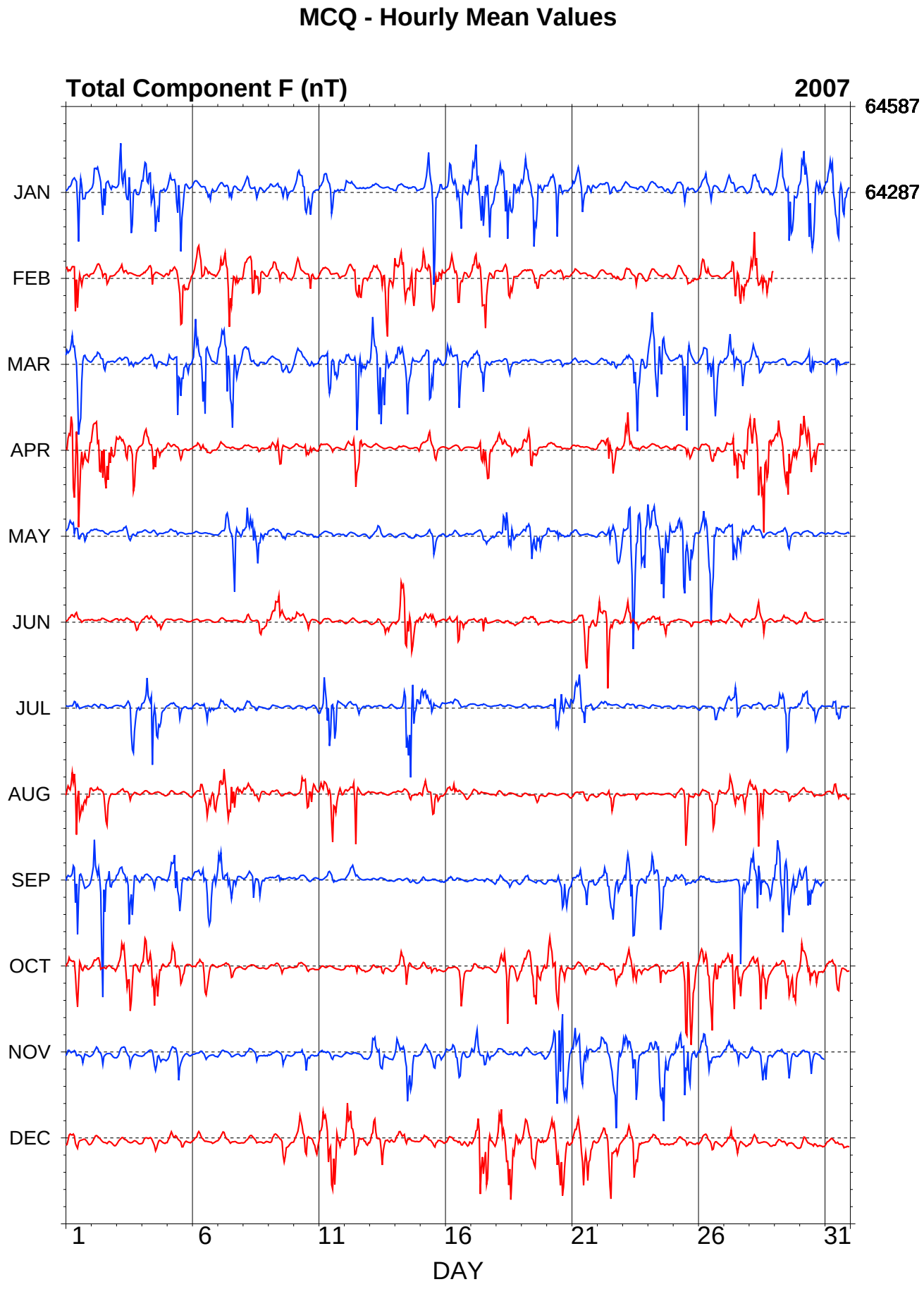


Figure 7.3. Hourly mean values in X, Y, Z and F measured at Macquarie Island.

8. Casey

Casey is situated 3880 km south of Perth and is the Australian Antarctic research station nearest to Australia. The magnetic Absolute Hut is about 120 m south of the tank house, the structure of the modern Casey Station nearest to it. The old Casey station, in use until the late 1980s, lies about 1 km to the northeast of the present Casey.

The crystalline rocks of Casey have unusually high concentrations of magnetic minerals producing high magnetic gradients in and around the Absolute Hut.

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 2007 are described in Table 8.2.

No usable magnetic-field data were obtained from Casey in 2006. During the year it became evident that a periodic signal of unknown origin was present in the total-field variations synthesized from the X, Y and Z data recorded by the ADAS system. This signal had approximately a 40 nT amplitude and 30-minute period. Absolute observations indicated it was not a natural field variation. Further investigation is necessary to ascertain the source of the signal. The ADAS system is still operational at Casey.

A new magnetic variometer installed in May 2007 provides an independent source of magnetic-field data. Analysis of the two datasets for the period in which they overlap may help to identify the problem with the ADAS data.

Absolute instruments

The principal absolute magnetometers used at Casey in 2007 are described in Table 8.3.

Baselines

As the new variometer system became operational midway through the year, baselines for data acquired in 2007 will be derived and reported in conjunction with the full year of 2008 data.

Operations

The 2007 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 2007, the observers performed absolute observations weekly and forwarded them by e-mail to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

During 2007, 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.

IAGA code:	CSY
Commenced operation:	1999
Geographic latitude:	66° 17' S
Geographic longitude:	110° 32' E
Geomagnetic latitude:	-76.28°
Geomagnetic longitude:	184.12°
K 9 index lower limit:	N/A
Principal pier:	Pier A
Pier elevation (top):	40 m AMSL
Principal reference mark:	Trig station G11
Reference mark azimuth:	307° 41' 02"
Reference mark distance:	464 m
Observers:	I. Phillips (until late November) D. Matejic (from late November)

Table 8.1. Key observatory data.

3-component variometer:	EDA FM105B
Serial number:	9004-1
Type:	linear fluxgate
Orientation:	X, Y, Z
Acquisition interval:	10 s
Resolution:	0.2 nT
Data acquisition system:	ADAS
3-component variometer:	DMI FGE
Serial number:	E0199/S0160
Type:	suspended; linear fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.3 nT
A/D converter:	ADAM 4017 module (±10V)
Period of use:	from 14 May
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081423/42189
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	from 14 May
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	ANARESAT

Table 8.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

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.

The new variometer system installed in May supersedes the existing EDA fluxgate system. It comprises a 3-component suspended fluxgate variometer and an Overhauser total-field variometer, as described in Table 8.2.

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:	0.01 nT
Correction:	1.5 nT

Table 8.3. Absolute magnetometers and their adopted corrections for 2007. Corrections are applied in the sense Standard = Instrument + correction.

Significant events

2007-02-23 No data telemetry - AAD hard disk failure at Kingston

2007-05-03 Comms established between GA and Gdap PC in variometer hut (no magnetometers yet)

2007-05-11 System installed and running, fluxgate not yet aligned or unlocked.

2007-05-14 Fluxgate aligned and unclamped, thermostat and heater re-positioned

2007-05-15 00:57 Reboot to change from 5V to 10V ADAM

2007-05-20 14:03 - 16:40 ANARESAT outage

2007-06-27 No telemetry 07:30 - 20:15 Fibre problems

2007-07-06 Variometer hut cleared of snow and equipment checked

2007-07-18 New heater installed in absolute hut. Heater controller set to 10C

2007-08-29 GPS Clock lost contact - 11:50

2007-08-30 Restart GdapClock 01:08 no success. shutdown 01:25:40 01:27:13 correction +408ms

2007-09-17 Despatch 24V battery charger #98521A Model BVW24125 100-240VAC 50-60Hz .8-.35A 29.4VDC 1.25A EndOfCharge 27.6V Rev. D Type 00-03N

Data losses

Data losses for 2007 will be reported in conjunction with those for 2008.

Annual mean values

The annual mean values for Casey are set out in Table 8.4 and displayed with the secular variation in Figure 8.1.

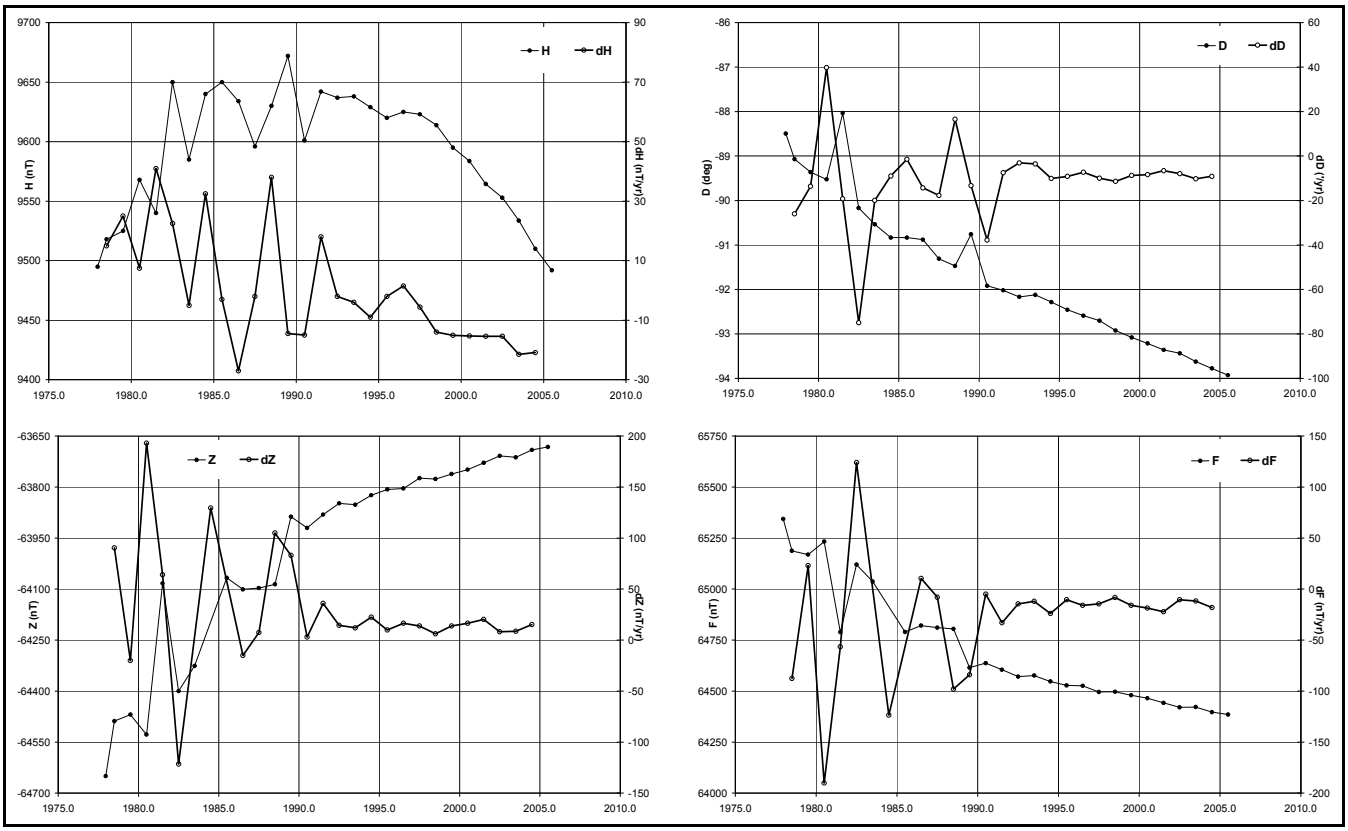


Figure 8.1. Annual mean values and secular variation for H, D, Z and F (using all days until 1992.5 and quiet days from 1993.5) measured at Casey.

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
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 8.4. 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 8.1.

9. 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 three-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.

Variometers

The variometers used during 2007 are described in Table 9.2. 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 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.

The Variometer House also housed a GPS clock, a data acquisition computer, an Ethernet radio link and a standby power supply.

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

Temperature control in the variometer house appeared to fail at about 2007-02-06T19:00. There were no wild fluctuations in instrument-temperature recordings as one might expect, but rather long-period variations. The weekly room-temperature measurements were not consistent with the instrument-temperature recordings. They indicated a reduction in room temperature but not to the low levels indicated by the instrument-temperature recordings. Reports from Mawson in early 2008 indicated that the heater in the eastern (DMI sensor) room was not working and the heater in the western (NGL sensor) room was working. This situation could not be reconciled with the temperature data. If the instrument-temperature recordings and the temperature models are correct, it appears that the NGL sensor and electronics temperatures (in different rooms, one heated, one not) had almost parallel temperature traces and plummeted to below -10°C during the year. If this is true it might explain some curious instrument behaviour and data losses during the year as the equipment is not rated to below 0°C.

During normal operation, the temperature within the sensor rooms would be maintained close to 10°C by fast-cycle heaters and monitored by a Doric Trendicator digital thermometer with its sensor on a disused pier.

The meteorological temperature at Mawson during 2007 varied from a minimum -29°C in September to a maximum of +4°C in January. The smoothed daily minimum/maximum temperatures varied from -20°C /-14°C during the coldest period of September, to -2°C /+3°C during the warmest periods January and December. The average daily maximum wind gust was about 90 km/hr. The maximum wind gust was 207 km/hr in October. Almost every day was windy due to either blizzard or katabatic conditions.

The Narod variometer was used as the source of real-time data for MAW during 2007. The DMI variometer was used as the primary source of FINAL data for MAW during 2007 (with data gaps filled in using Narod data).

IAGA code:	MAW
Commenced operation:	1955
Geographic latitude:	67° 36' 14" S
Geographic longitude:	62° 52' 45" E
Geomagnetic latitude:	-73.09°
Geomagnetic longitude:	110.69°
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:	I. McLean (until November) R. Bali (from November)

Table 9.1. Key observatory data.

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 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:	3091319/42187
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	stable from 9 July
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS16 clock
Communications:	ANARESAT

Table 9.2. Magnetic variometers used in 2007. See Appendix C for a schematic of their configuration.

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:	4081417/42175
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 9.3. Absolute magnetometers and their adopted corrections for 2007. Corrections are applied in the sense Standard = Instrument + correction.

There were severe problems with temperature regulation during 2007. The Narod temperatures are digitised as 8-bit only and there were numerous transitions between 8-bit ranges because of the large temperature range. The lack of an F variometer for much of the year, the apparent large temperature effects on the data when there was an F variometer for comparison, the large variation in baselines judged by absolute measurements, and the difficulty establishing significant temperature coefficients from a variometer with similarly significant underlying baseline drifts made the Narod data less reliable than the DMI data.

The scalar variometer GSM-90 4081417 (sensor 42174) was removed as a variometer in November 2006 to replace a non-functioning absolute instrument. A replacement GSM-90 3091319 (sensor 42187, cable 3091319) was despatched as a replacement at the end of January 2007 for the final voyage of the summer to Mawson – it arrived in March. Comparisons on 30 March at Mawson indicated that there was no convincing instrument difference between these two scalar instruments. Although the plan was to return GSM-90 4081417 to the variometer and use GSM-90 3091319 as the absolute instrument, GSM-90 3091319 was mistakenly installed as a variometer on 11 April. Over the following months and many attempts, only intermittent data were acquired from the variometer GSM-90 3091319. Ian McLean eventually found a fault in the RF output transistor and replaced it with a similar 3W 2SC1947; useful variometer data were acquired from GSM-90 3091319 from 9 July onwards.

Absolute instruments

The principal absolute magnetometers used at Mawson and their adopted corrections for 2007 are described in Table 9.3.

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 2007. At the 2007 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 2007 final data.

Baselines

The standard deviations between the adopted variometer model and data, and the absolute observations, were:

	σ		σ
X	1.0 nT	D	12"
Y	1.1 nT	I	4"
Z	0.4 nT	F	0.4 nT

Observed and adopted baseline values in X, Y and Z are shown in Figure 9.1.

Operations

The 2007 Mawson observers were jointly employed by Geoscience Australia and the Australian Antarctic Division. They were members of the Australian National Antarctic Research Expedition. Mawson 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 2007, the observers performed absolute observations weekly and forwarded them by e-mail to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

During 2007, 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.

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.

During 2007, adjustments to the acquisition timing exceeded 10 ms on the following occasions (the period of loss of time accurate time corrections is also noted):

2007-01-17 02:16:53	+22ms	GPS failed 2007-01-16 14:00
2007-03-07 01:39:24	-21ms	GPS failed 2007-03-03 12:11
2007-03-20 01:51:08	+808ms	System restart 2007-03-20 01:49 GPS failed 2007-03-19 00:10
2007-04-02 03:12:57	+69ms	GPS failed 2007-03-21 20:10
2007-04-13 05:25:32	+118ms	System restart
2007-06-14 01:10:54	+23ms	GPS failed 2007-06-10 19:31
2007-06-26 23:07		reconnect to GPS clock
(Lost connection 2007-06-25 12:50 - no further information available.)		
2007-07-18 01:56:12	+906ms	System restart GPS failed 2007-07-17 04:10
(2007-07-25 03:42:33	-1ms	GPS failed 2007-07-2419:30)
2007-09-13 02:15:54	+734ms	System configuration
2007-09-13 03:08:08	+161ms	System configuration GPS failed2007-09-12 07:20 See Significant events
2007-09-25 03:52:24	+28ms	GPS failed2007-09-24 ??:??
2007-10-25 01:36:24	+47ms	GPS failed 2007-10-24 11:02

2007-10-26 01:32:19	+648ms	System restart
2007-11-14 02:12:26	+748ms	GPS fixed itself! System restart 2007-11-14 01:47 GPS failed 2007-11-13 20:20 See Significant events

The recorder room also housed an uninterruptible power supply and 12V battery power supplies.

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. There were no losses attributed to blizzards in 2007.

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 2007, the INTERMAGNET-filter was applied to convert 1-second real-time and FINAL data to 1-minute data (except as noted below).

Some data from the DMI variometer were included in FINAL data that were not compliant with the INTERMAGNET filtering requirement. These were 2 minutes of data on each of 2007-03-20, 2007-07-18, 2007-09-13, 2007-10-26 and 2007-11-14, at system restarts. In addition, 193 minutes of (INTERMAGNET filtered) data on 2007-04-12 to 2007-04-13, and 1 minute of data on each of 2007-03-20 and 2007-09-13, were included from the Narod variometer to fill a data gap on the DMI variometer.

Data losses at Mawson in 2007 are identified in Table A.9.

Significant events

2007-02-09	to 2007-02-10? Baseline changes due to fire detector tests and replacement.
2007-03-19	Spike on Narod temperature channels.
2007-03-20	01:25 GPS restart did not fix timing problem. 01:49 Reboot computer.
2007-03-21	to 2007-03-22 Narod temperature problems
2007-04-11	GSM90 driver started after replacement GSM90 variometer installed
2007-04-12	GSM90 variometer intermittent. Tests show that data connection is ok, 13.0V, but S and N is 108 0000. F produces only 'c' quality data e.g. 12000 c.
2007-04-12	22:04 DMI/Adam driver for MW2 failed
2007-04-13	01:13 DMI/Adam driver for MW2 restarted - MW2 data began to arrive
2007-04-13	05:23 Restart MAW/MW1 computer - too many problems occurring with all variometers
2007-04-27	04:59 GdapGSM90 restarted with 30 sec sampling - changed previously from default 10s to 20s sampling on 2007-04-24 (and probably from 2s to 3.5s mode). Last 10s 06:53, first 20s 17:07 ?
2007-04-30	08:25 Changes in variometer hut - probably placement of DMI sensor storage box - changed baselines
2007-06-18	~03:00 restarted GSM90 driver - seems to be working at the moment!
2007-06-19	switched GSM90 to ser1 - no improvement
2007-06-27	No telemetry 07:30 - 20:15 Fibre problems
2007-07-09	Variometer GSM90 returned to device on ser1 – 2W RF output transistor failed/replaced with 3W 2SC1947 by Ian.McLean
2007-07-18	System restart 01:54 to correct timing problem ~03:40 restarted *GdapGSM90* to run on ser1 - device was transferred to here for testing earlier, and later *stty baud=9600 < /dev/ser1*. *rc.acquisition* modified to use ser1 at correct baud rate.
2007-08-01	Noticed that the h data file had many missing periods, usually only a few seconds. ~06:34 *slay GdapNGL*, *qtalk ^C* to /dev/ser5, then restart GdapNGL to get data at about 06:34:36 to try and fix data losses that developed today.
2007-08-07	Ian confirmed that "The GSM90 in the variometer building is 3091319."
2007-09-13	Attempted to check out GPS problem, copied across GdapAdjustClockRate and then ...
2007-09-13	RECONFIG /tmp -> /log directory! Accidentally mv /tmp (by inserting a space into /tmp/filename) and then the system linked a new /tmp to /dev/shmem and I couldn't get rid of it to put the original directory back again. This lead to many problems shutdown 02:13, and had +734ms correction, but GdapClock had been stopped for a while by then at ~03:00 accidentally "rtc hw" and later when GdapClock started there was a +161ms correction However made several changes rc.local changed to record to /log/cron.log rc.acqusition GdapClock ... -L/log/ ... EndDay to delete files from /tmp and /log CheckTimeCorrections to access /log rather than /tmp crontab changed to record to /log epoch getObsGPSDCN has directory for MAW set to /log rather than /tmp I hope it all goes ok next reboot. I also removed and reinserted cron from rc.sysinit - it should be back to normal! MAY NOT BE ABLE TO crontab -e any more because of weird /tmp - fix is to "crontab -l > file" then "vi file" the "crontab file"
2007-09-16	Clean up of Absolute Hut - removed DIM carry case and many metal objects including magnetic magnifying glass etc. No change in baseline observed.
2007-09-24	08:42 Removed DMI transportation box from the variometer hut - significant change to MAW, smaller change to MW2 variometer
2007-??-??	Internal door-lock in variometer building failed to reopen when closed. It was removed.
2007-10-05	Replaced door-lock in variometer building.
2007-10-25	20:26 short (~30s) intermittent data losses from Narod and GSM90 variometers begin
2007-10-26	01:27 Reboot acquisition computer to resolve data losses without success. 01:41 Reset Narod magnetometer to resolve data losses without success.
2007-??-??	?? tightened feet on theodolite to fix wavering mark problem.
2007-11-14	01:30 GPS restart did not fix timing problem. 01:47:35 System restart. 35s data loss, did not fix timing problem. 02:12 GPS came good by itself!
2007-11-20	Ian McLean departed Mawson, Roselin Bali assumes responsibility for observatory operations.

Data distribution

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	definitive	2008
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 9.4. Distribution of 2007 data.

Annual mean values

The annual mean values for Mawson are set out in Table 9.5 and displayed with the secular variation in Figure 9.2.

Hourly mean values

Plots of the hourly mean values for Mawson 2007 data are shown in Figure 9.3.

K indices

Table 9.6 shows Mawson K indices for 2007. 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.

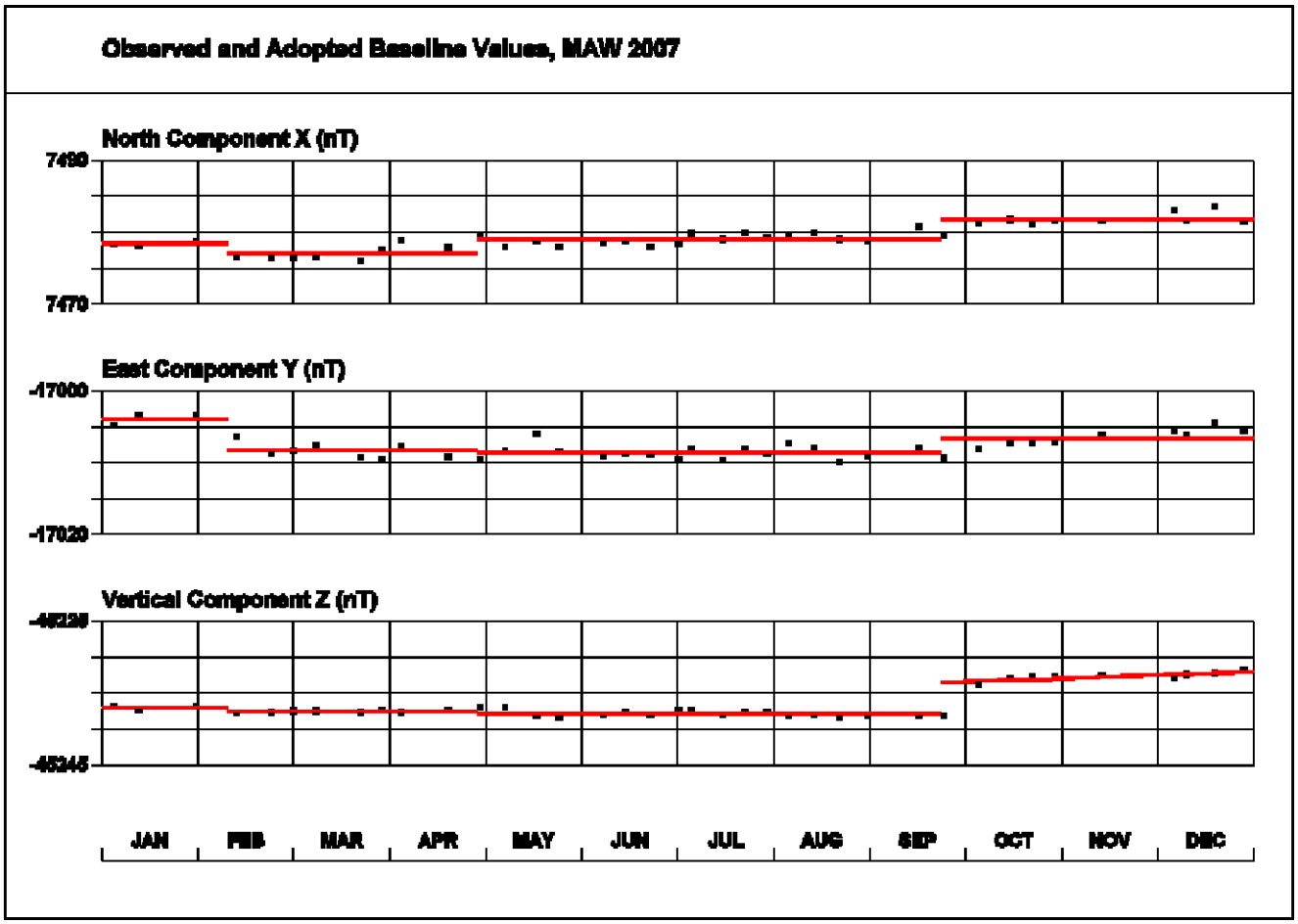


Figure 9.1. Mawson baseline plots.

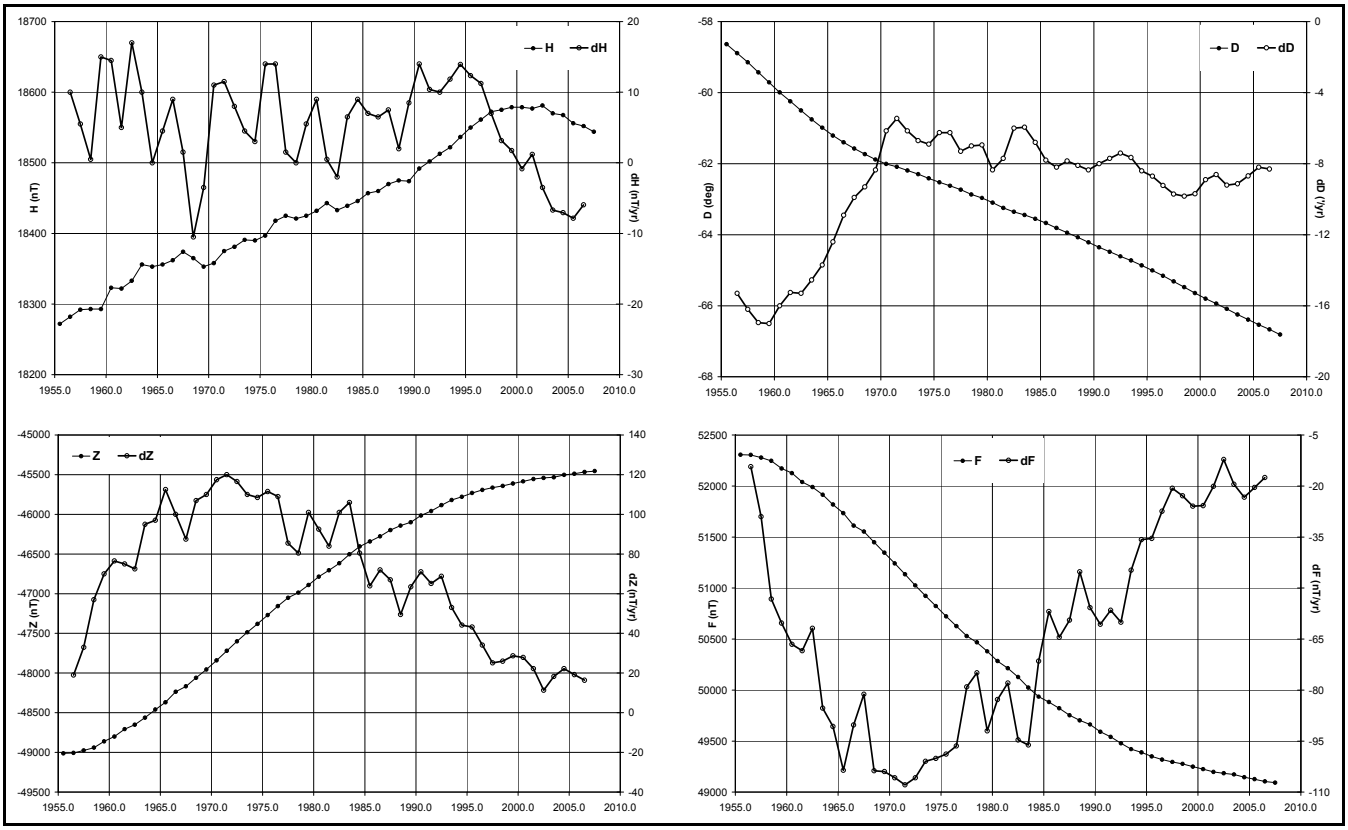


Figure 9.2. Annual mean values and secular variation (quiet days) for H, D, Z and F measured at Mawson.

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
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
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

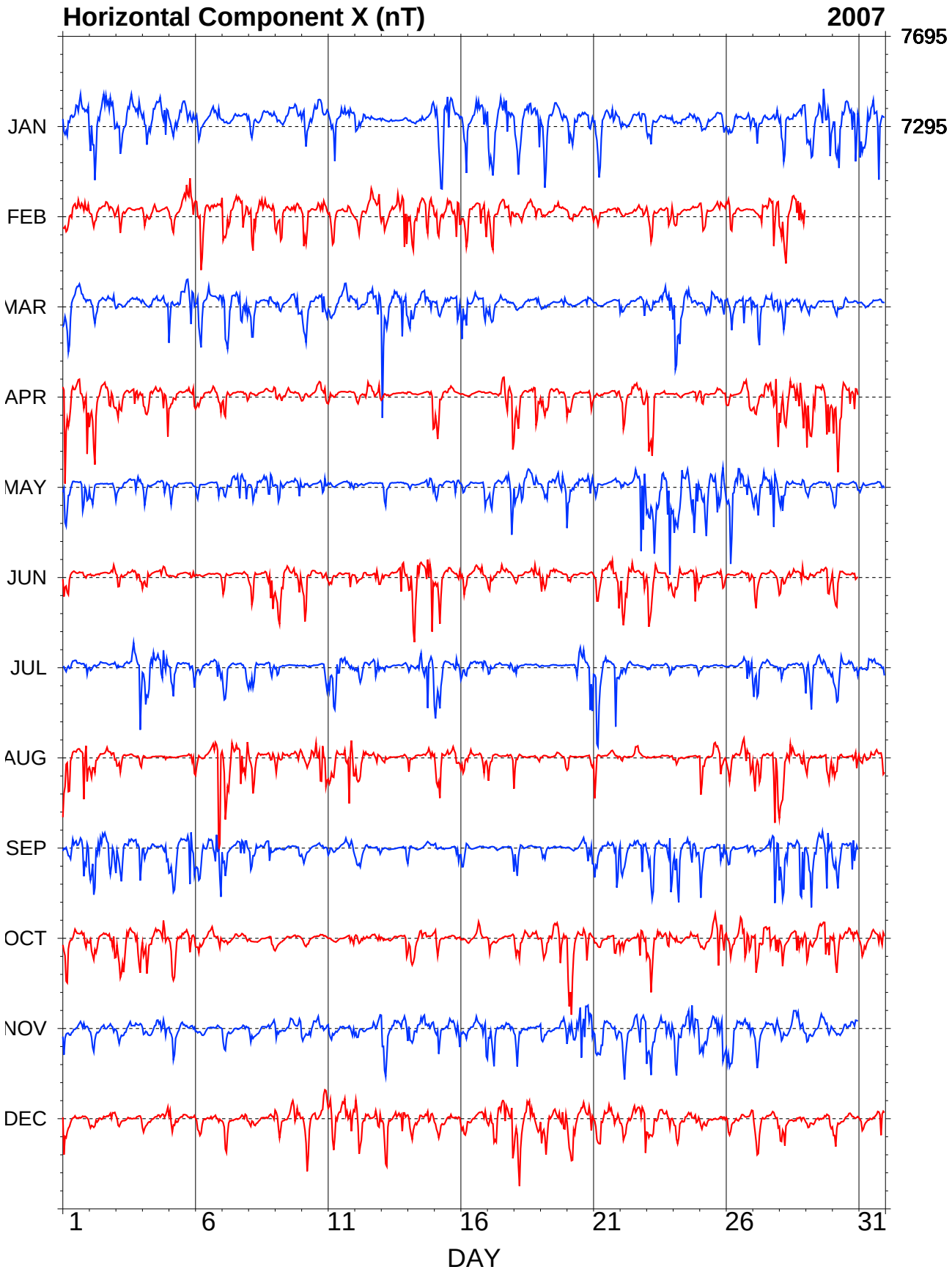
Table 9.5. Annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 9.2.

Day	January			February			March			April			May			June		
01	4322	4323	23	6343	3235	29	6553	3423	31	7655	3467	43	6632	3345	32	4312	1133	18
02	6545	5455	39	3332	2224	21	2331	1125	18	6744	4476	42	3420	1104	15	2222	0014	13
03	4545	4345	34	3321	2000	11	2110	0114	10	4432	1433	24	4111	2253	19	4322	1235	22
04	3544	4566	37	4312	1013	15	1122	2135	17	4443	3365	32	4300	2133	16	4322	2642	25
05	3433	4455	31	3322	3344	24	6233	3365	31	4232	1235	22	4300	0003	10	2110	0144	13
06	4311	2353	22	3653	3333	29	4644	3214	28	4212	1235	20	3200	0024	11	1200	0013	7
07	2210	1113	11	6533	3365	34	5544	3566	38	4410	1123	16	3232	3526	26	4211	0012	11
08	3311	0244	18	4633	3325	29	4431	1232	20	2010	1202	8	2444	4464	32	3422	2356	27
09	1221	2232	15	5452	0244	26	2200	1355	18	3432	1115	20	2433	3234	24	4444	3234	28
10	3433	4333	26	5421	1354	25	4422	2365	28	3202	2325	19	3100	1155	16	5533	2133	25
11	4553	4333	30	3410	0045	17	4323	3443	26	3322	1001	12	2101	2145	16	3211	0154	17
12	5322	1201	16	3312	3325	22	2332	4355	27	3222	3334	22	1221	0001	7	2211	1144	16
13	2000	0000	2	5333	3446	31	8554	4466	42	2010	0001	4	1311	0201	9	3121	1353	19
14	1222	3024	16	5454	3563	35	5444	4334	31	1210	1126	14	1113	0244	16	4564	3556	38
15	4554	5432	32	5443	3476	36	2343	3336	27	5532	2210	20	3212	1253	19	3553	3214	26
16	3533	4335	29	4443	3346	31	6432	2226	27	1000	0000	1	2212	1005	13	4432	3343	26
17	6554	5465	40	4432	3366	31	3432	3233	23	0221	4567	27	3421	2246	24	3332	3223	21
18	4653	4447	37	4122	2354	23	2122	1314	16	6422	2266	30	4345	4333	29	4213	2233	20
19	3633	4344	30	1112	2320	12	2112	1223	14	4342	2114	21	3455	3455	34	4333	2211	19
20	4443	3256	31	1200	1114	10	1100	0032	7	4310	1015	15	6343	2245	29	3221	1112	13
21	3553	3352	29	3210	1002	9	0111	1002	6	3210	0123	12	3310	1122	13	1444	4436	30
22	3122	2243	19	2100	1244	14	4110	1234	16	4413	3346	28	2222	4377	29	5554	3335	33
23	4432	1113	19	3320	1145	19	2321	3426	23	7663	2200	26	6465	4358	41	6553	2154	31
24	2010	2122	10	4310	0012	11	6543	4233	30	2212	2114	15	5455	4476	40	4433	2254	27
25	1212	1125	15	4410	1353	21	3324	4225	25	3310	2221	14	4555	3674	39	2221	1134	16
26	2222	1015	15	3422	0000	11	2332	3523	23	4221	3344	23	4655	4465	39	1120	2123	12
27	3300	2135	17	1243	2363	24	3553	4344	31	3433	3467	33	5543	3565	36	4422	1224	21
28	4422	2244	24	5564	4456	39	3442	2243	24	6554	5567	43	5533	3024	25	5223	2144	23
29	5443	6657	40				2310	1102	10	5653	3476	39	2211	1223	14	3222	2265	24
30	4554	4456	37				3322	3001	14	6665	3444	38	3422	2113	18	4532	1113	20
31	6554	4575	41				1331	1022	13				2121	0154	16			

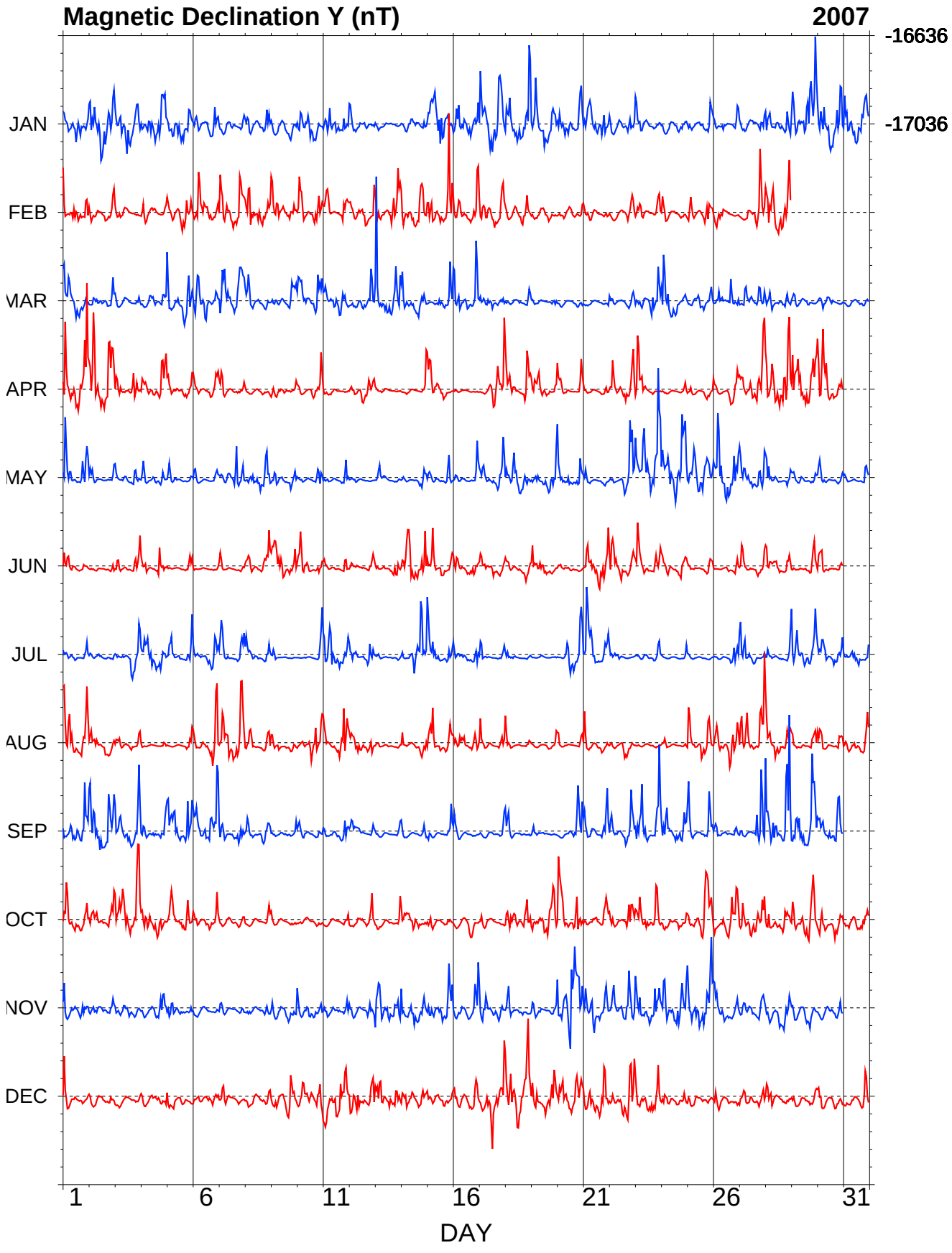
Day	July			August			September			October			November			December		
01	3223	2124	19	7564	3266	39	4233	3375	30	4533	3345	30	5211	1243	19	5311	1113	16
02	2222	2003	13	4353	3433	28	6644	4465	39	3332	1246	24	2211	2024	14	2112	1132	13
03	2221	2436	22	2321	2204	16	5443	4337	33	6454	4366	38	3112	2011	11	1101	1002	6
04	4555	4454	36	2011	0004	8	3453	3235	28	5534	3553	33	2000	2354	16	2010	0122	8
05	3432	2146	25	1000	0015	7	5444	2375	34	3433	3253	26	3422	1004	16	4321	2101	14
06	4323	3365	29	4002	3457	25	4433	3657	35	3331	2215	20	1000	1113	7	2221	3133	17
07	5422	1155	25	5654	4576	42	4432	3553	29	2221	1123	14	3210	0003	9	2411	0032	13
08	5321	0144	20	3533	3255	29	4442	2355	29	1000	0004	5	2110	0033	10	2110	0014	9
09	3213	0010	10	4232	1114	18	1121	2103	11	3100	0021	7	4211	2214	17	3311	2354	22
10	0030	0005	8	2222	4766	31	3201	1132	13	1000	0021	4	4222	2333	21	1543	3244	26
11	5565	3334	34	5454	2476	37	2000	1254	14	0000	0034	7	4212	2124	18	3553	3566	36
12	4453	2344	29	6332	3233	25	3321	1003	13	2121	0046	16	3100	1234	14	4443	2245	28
13	2211	1211	11	1210	0001	5	2011	0004	8	1121	1015	12	5533	3244	29	3533	3242	25
14	3123	4474	28	4000	1234	14	3001	0124	11	5333	3202	21	5433	3333	27	3422	2243	22
15	6453	3254	32	5542	1355	30	3111	0134	14	3301	1022	12	3422	3365	28	3222	2213	17
16	4332	2234	23	4334	2254	27	4210	0010	8	1121	1320	11	3323	2256	26	4221	1145	20
17	4122	1123	16	4210	1144	17	0010	0115	8	3100	0000	4	5443	2333	27	3455	5436	35
18	3221	0011	10	5110	0023	12	5410	0002	12	3434	2253	26	5511	2101	16	6555	5566	43
19	1000	0000	1	1000	0113	6	2232	2000	11	3433	4476	34	4220	1124	16	4443	3355	31
20	0125	4327	24	4110	0004	10	0211	2366	21	6643	2464	35	5435	6656	40	4443	3754	34
21	3743	2174	31	5111	1222	15	5322	1236	24	2322	3255	24	5544	4355	35	4443	3573	33
22	4331	1101	14	2011	3232	14	5442	2364	30	4311	2454	24	3423	3555	30	2323	3366	28
23	2211	1135	16	1111	0013	8	4663	3267	37	5423	3253	27	5443	3355	32	5333	2335	27
24	1000	0004	5	2300	0001	6	5542	4445	33	2211	1213	13	5533	3555	34	2322	2113	16
25	2110	1111	8	5210	3264	23	6322	1265	27	2113	4665	28	5444	3557	37	2211	2212	13
26	0001	1354	14	3432	3545	29	3332	0134	19	4343	3665	34	5444	2234	28	3211	2103	13
27	5432	2114	22	6353	4277	37	2102	1576	24	3534	3535	31	2422	2244	22	3422	2224	21
28	3310	1116	16	7535	3255	35	6653	2377	39	3412	3544	26	2222	3334	21	4421	2232	20
29	6543	3336	33	4221	2145	21	4654	4476	40	5222	3476	31	2212	2333	18	2221	1114	14
30	4443	2234	26	3422	0045	20	5544	3365	35	3432	2343	24	1111	2133	13	3312	2222	17
31	3234	3215	23	3313	1245	22				2222	2244	20				1201	2264	18

Table 9.6. K indices and daily K sums measured at Mawson in 2007.

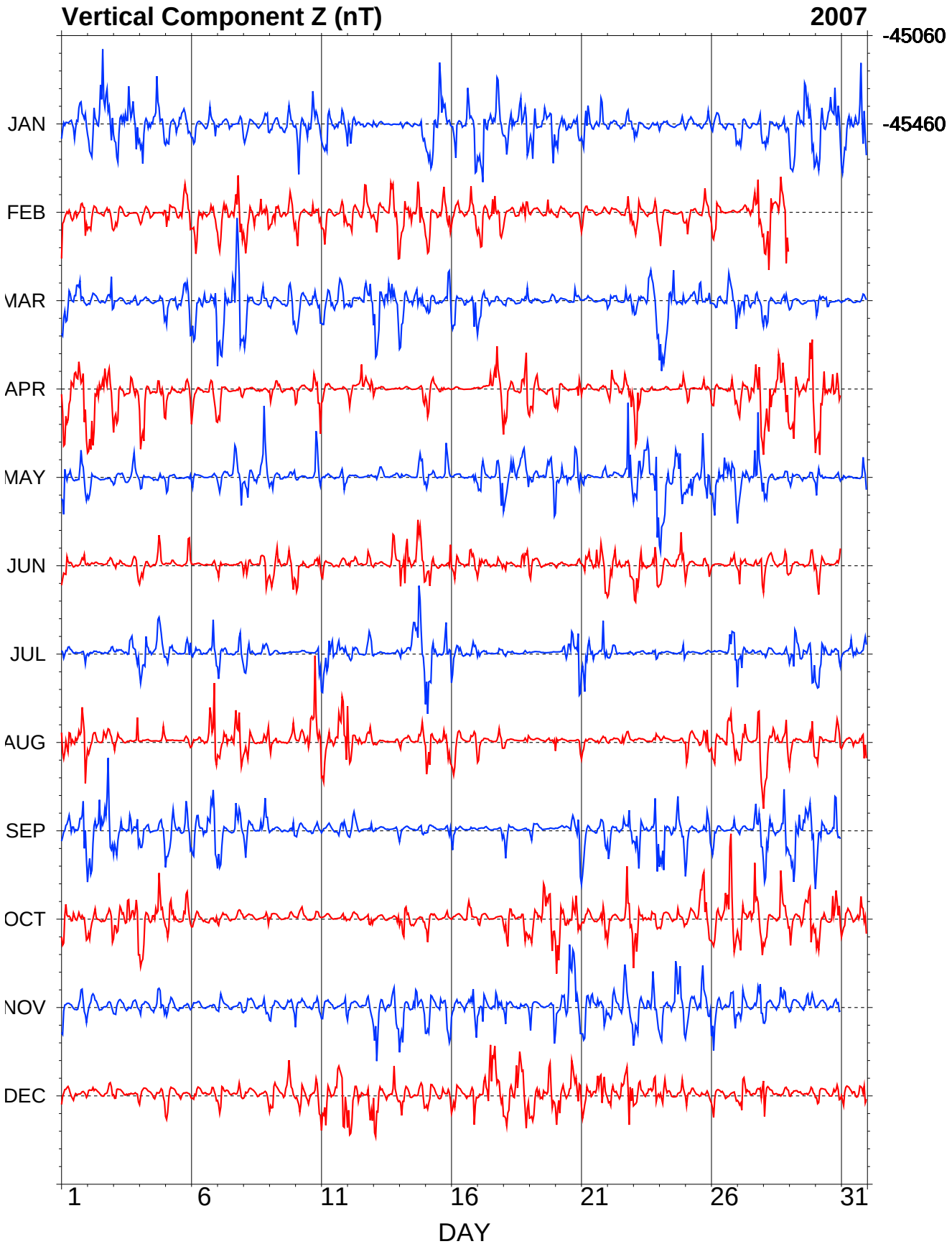
MAW - Hourly Mean Values



MAW - Hourly Mean Values



MAW - Hourly Mean Values



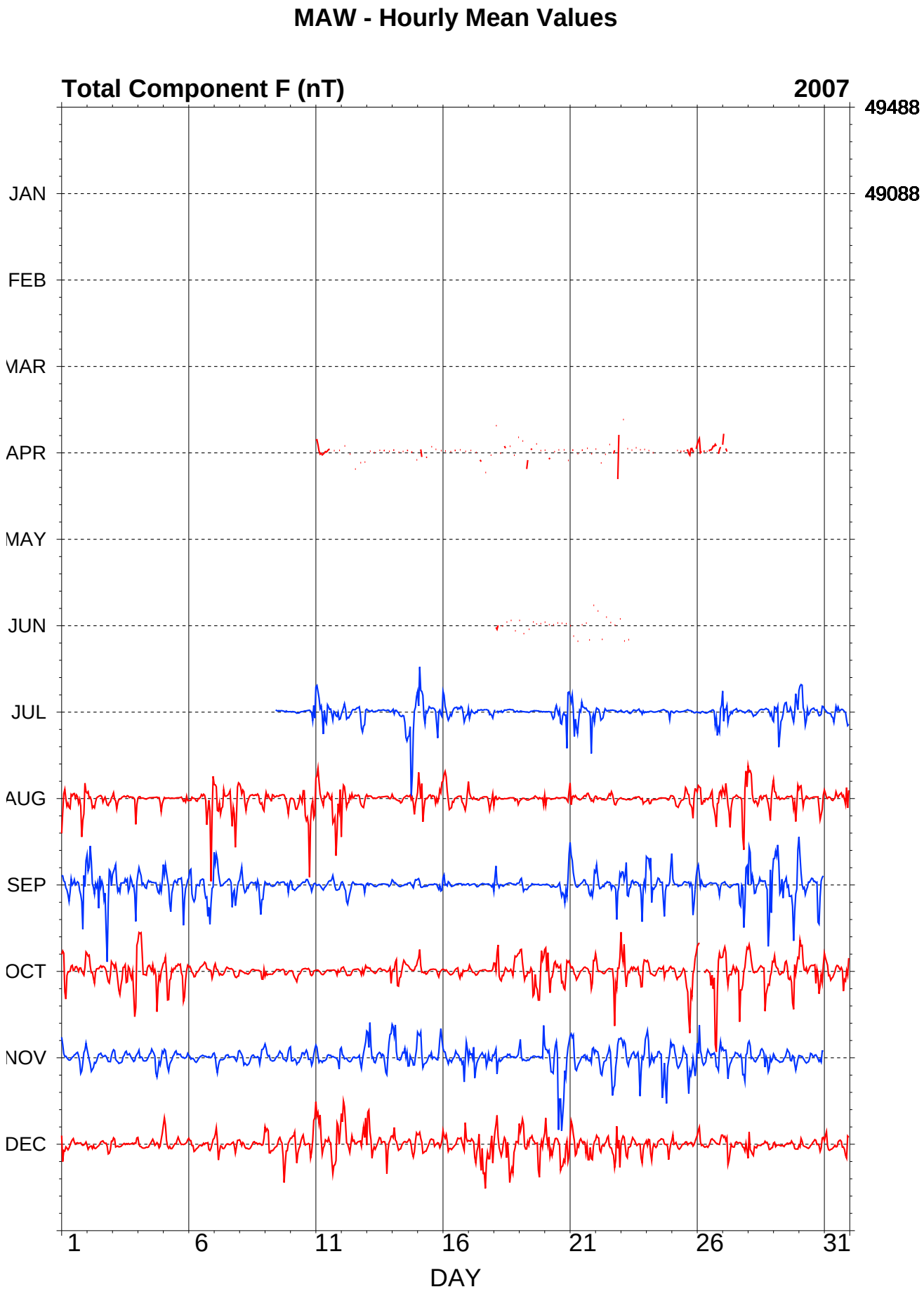


Figure 9.3. Hourly mean values in X, Y, Z and F measured at Mawson.

10. Repeat stations

Geoscience Australia maintains a network of fifteen repeat stations throughout Australia, its offshore islands, and the southwest Pacific region. The repeat stations are usually occupied at intervals of about two years to determine the secular variation of the magnetic field. During each three-to-four day occupation the magnetic field is monitored continuously with portable on-site three-component and total-field magnetic variometers.

Variometers

The variometers used during 2007 are described in Table 10.1.

The magnetometers, acquisition and recording system were all powered by either 12 V DC batteries and solar panels or 240 V AC mains power, depending on the location. Preliminary data processing and analysis were done on-site using a laptop computer.

3-component variometer:	Narod
Serial number:	2506-1
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.01 nT
Total-field variometer:	GEM Systems GSM-90
Serial number:	810882/81315
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

Table 10.1. Magnetic variometers used in 2007.

Absolute instruments

The principal absolute magnetometers used at repeat stations and their adopted corrections for 2007 are described in Table 10.2. The GSM-90 was also used for total field surveys around each station.

DI fluxgate:	DMI
Serial number:	DI0050
Theodolite:	Zeiss 020B
Serial number:	308887
Resolution:	0.1’
D correction:	-0.2’
I correction:	-0.2’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	003985/11690
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 10.2. Absolute magnetometers and their adopted corrections for 2007. Corrections are applied in the sense Standard = Instrument + correction.

Operations

The variometer recordings were calibrated to observatory standard using a campaign of absolute magnetic observations made during each station occupation. Usually about 24 sets of absolute observations are made on the primary repeat station during the three days of the occupations. Vector field differences between the primary and secondary stations at each site were also measured. Azimuths to prominent features from both primary and secondary stations were checked and total-field gradient surveys around each station were undertaken.

The normal or quiet level of the magnetic field at each repeat station was determined by analysing the calibrated on-site variometer record with reference to the quiet level of the magnetic field derived from suitable observatory data.

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

Station occupations

The repeat stations at Vanimo (VAN) and Kavieng (KAV) in Papua New Guinea, and Noumea (NOU) in New Caledonia, were re-occupied during May – June 2007. Figure 10.1 shows the location of the repeat stations and the Australian permanent magnetic observatories.

The adopted normal field values at the time of the 2007 occupations and the average secular variation over the interval between the two most recent station occupations are shown in Tables 10.3 and 10.4. All available data from the stations are plotted in Figure 10.2.

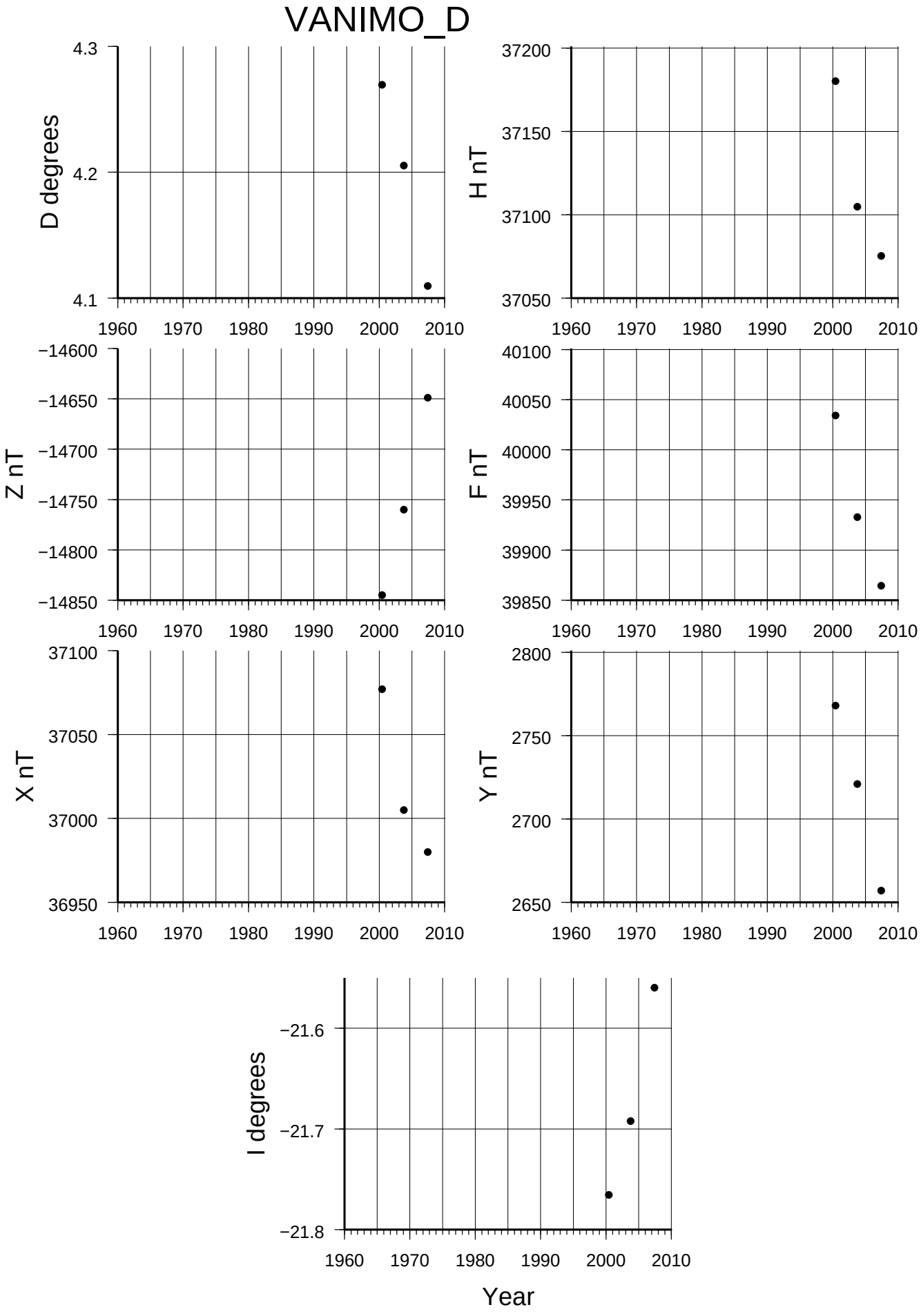
Figure 10.1. Repeat stations occupied in 2007 (blue dots) and the Australian magnetic observatory network (black squares).

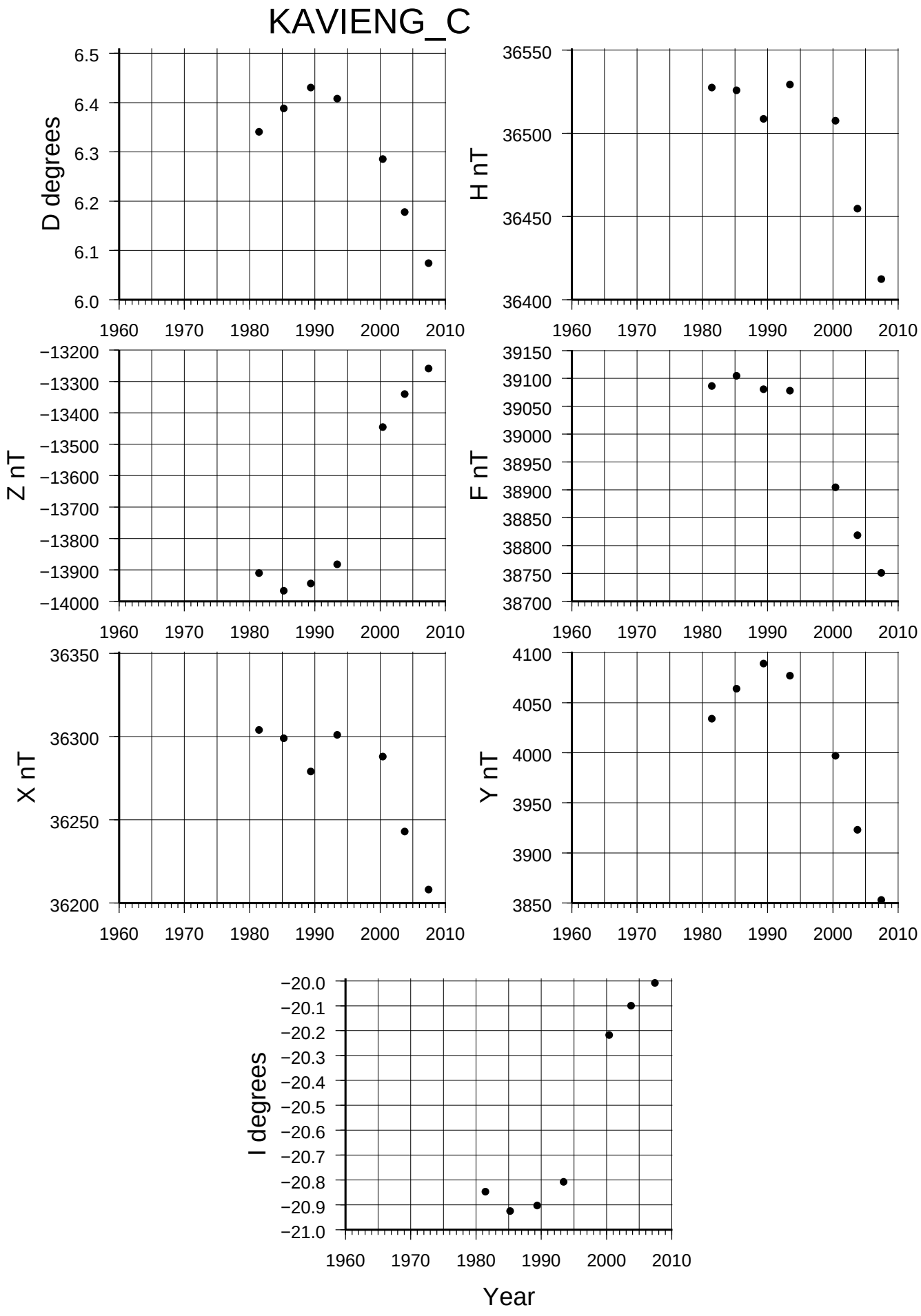
Station (site)	Date	D		I		H	X	Y	Z	F
		(°	’)	(°	’)	(nT)	(nT)	(nT)	(nT)	(nT)
Vanimo (D)	2007-05-25	04	06.9	-21	33.8	37075	36979	2660	-14651	39864
Kavieng (C)	2007-05-31	06	04.5	-20	00.4	36412	36205	3853	-13258	38751
Noumea (B)	2007-06-07	12	32.0	-47	54.4	32056	31292	6956	-35485	47820

Table 10.3. Adopted main field values at the time of the 2007 station occupations.

Station (site)	Last occupation	ΔD (‘/yr)	ΔI (‘/yr)	ΔH (nT/yr)	ΔX (nT/yr)	ΔY (nT/yr)	ΔZ (nT/yr)	ΔF (nT/yr)
Vanimo (D)	2003-10-08	-1.5	2.1	-8	-7	-17	30	-19
Kavieng (C)	2003-10-03	-1.7	1.5	-12	-10	-19	23	-19
Noumea (B)	2003-10-14	-1.0	0.1	-21	-19	-14	25	-33

Table 10.4. Average secular variation between the two most recent occupations.


VANIMO_D
D degrees
4.3
4.2
4.1
H nT
37200
37150
37100
37050
Z nT
−14600
−14650
−14700
−14750
−14800
−14850
F nT
40100
40050
40000
39950
39900
39850
X nT
37100
37050
37000
36950
Y nT
2800
2750
2700
2650
I degrees
−21.6
−21.7
−21.8
1960
1970
1980
1990
2000
2010
Year


KAVIENG_C
D degrees
H nT
Z nT
F nT
X nT
Y nT
I degrees
Year

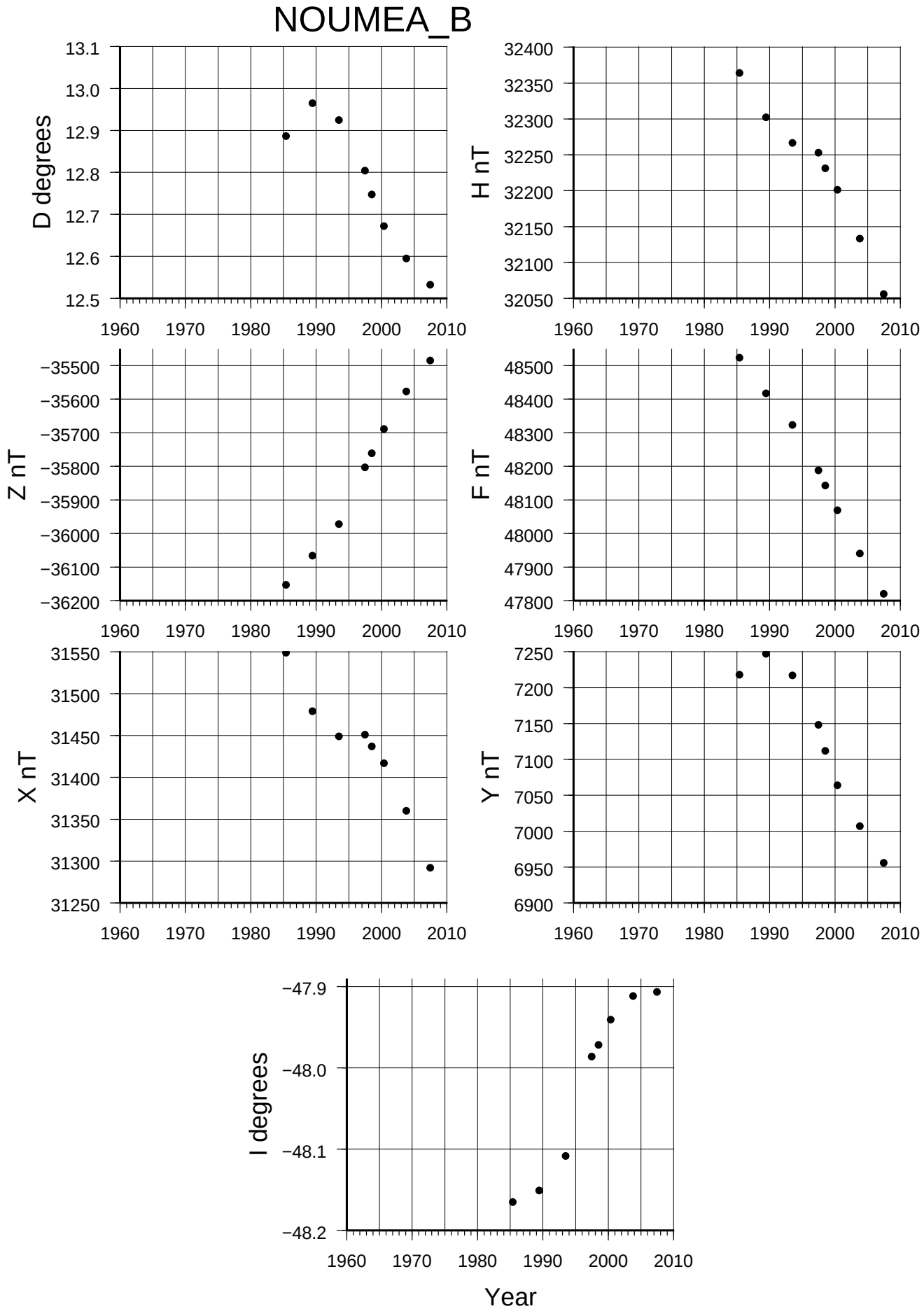


Figure 10.2. Adopted main-field values at time of repeat station occupations.

Appendix A. Data losses

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-02-09	XYZ	23:50 –	14469
2007-02-20		00:58	
2007-02-09	F	23:51 –	14460
2007-02-20		00:50	
2007-02-20	F	00:55 – 00:55	1
2007-02-22	XYZ	00:48 – 00:50	3
	F	00:49 – 00:49	1
2007-03-13	XYZ	01:01 –	11480
2007-03-21		00:20	
2007-03-14	F	05:23 – 05:24	2
2007-03-19	F	00:47 – 00:49	3
2007-12-04	F	00:52 – 01:01	10
	XYZ	01:06 – 01:06	1
	F	01:17 – 01:17	1
	XYZ	03:45 – 04:14	30
	F	04:14 – 04:14	1
2007-12-06	F	04:54 – 05:06	13
2007-12-09	F	07:24 – 07:24	1

Table A.1. Kakadu data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-01-09	XYZ	23:11 - 23:12	2
2007-02-17	F	12:03 - 23:59	717
2007-02-18	F	00:00 - 23:59	1440
2007-02-19	F	00:00 - 05:06	307
	XYZ	04:18 - 04:19	2
	XYZ	04:26 - 04:26	1
	XYZ	04:49 - 04:52	4
	XYZ	05:04 - 05:07	4
2007-04-13	XYZ	02:11 - 02:13	3
	F	02:11 - 02:13	3
	XYZ	07:22 - 07:24	3
	F	07:22 - 07:24	3
2007-04-23	F	07:00 - 07:01	2
2007-04-24	XYZ	02:18 - 02:21	4
	F	02:19 - 02:19	1
2007-05-24	XYZ	01:26 - 01:27	2
	F	01:27 - 01:27	1
2007-06-07	XYZ	03:26 - 03:26	1
	F	03:26 - 03:26	1
	XYZ	03:43 - 03:47	5
	F	03:44 - 03:48	5
2007-06-16	F	04:49 - 05:06	18
	F	05:33 - 05:44	12

Table A.2. Charters Towers data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-02-02	XYZ	01:50 - 01:52	3
	F	01:51 - 01:51	1
2007-03-10	XYZ	22:23 - 23:59	97
	F	22:24 - 23:59	96
2007-03-11	XYZ	00:00 - 23:59	1440
	F	11:34 - 23:59	746
2007-03-12	XYZ	00:00 - 23:59	1440
	F	00:00 - 01:22	83
2007-03-13	XYZ	00:00 - 23:59	1440
2007-03-16	XYZ	04:45 - 05:51	7
	F	05:46 - 05:50	5
2007-11-22	F	22:37 - 22:37	1
	F	22:42 - 22:42	1
2007-11-26	XYZ	06:25 - 06:30	6

Table A.3. Learmonth data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-01-18	XYZ	05:51 - 23:59	1089
	F	05:52 - 23:59	1088
2007-01-19	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-01-20	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-01-21	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-01-22	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-01-23	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-01-24	XYZ	00:00 - 03:59	240
	F	00:00 - 03:58	239
	XYZ	04:01 - 04:02	2
2007-01-28	F	05:11 - 05:11	1
2007-03-01	F	13:52 - 13:52	1
2007-03-02	F	15:32 - 15:32	1
2007-03-03	F	00:18 - 00:20	3
	F	00:30 - 00:32	3
	F	11:31 - 11:31	1
2007-03-15	F	08:36 - 08:36	1
2007-03-27	F	01:00 - 01:00	1
2007-06-06	XYZ	11:35 - 11:39	5
2007-06-15	F	21:10 - 21:10	1
	F	21:12 - 21:12	1
	F	21:25 - 21:25	1
	F	21:42 - 21:43	2
	F	21:56 - 21:56	1
	F	22:15 - 22:15	1
	F	22:17 - 22:17	1
	F	22:32 - 22:32	1
	F	22:41 - 22:42	2
	F	22:46 - 22:46	1
	F	22:49 - 22:49	1
2007-06-16	F	00:15 - 00:15	1
	F	01:34 - 01:34	1
	F	01:40 - 01:40	1
2007-07-09	F	20:30 - 20:30	1
2007-07-10	F	00:46 - 00:46	1
	F	00:49 - 00:49	1
	F	21:03 - 21:04	2
	F	21:39 - 21:39	1
	F	22:12 - 22:12	1
	F	22:15 - 22:15	1
	F	22:55 - 22:55	1
	F	23:02 - 23:02	1
	F	23:29 - 23:29	1
	F	23:32 - 23:32	1
	F	23:35 - 23:35	1
2007-07-11	F	00:50 - 00:50	1
	F	01:19 - 01:20	2
	F	02:16 - 02:16	1
	F	17:15 - 17:15	1
2007-07-19	F	21:15 - 21:18	4
	F	21:22 - 21:23	2
	F	21:26 - 21:26	1
	F	21:49 - 21:49	1
2007-07-21	F	22:21 - 22:21	1

	F	22:36 - 22:36	1
2007-08-16	F	22:39 - 22:39	1
	F	22:42 - 22:42	1
2007-09-12	XYZ	11:18 - 11:45	28
	XYZ	17:41 - 18:03	23
	F	17:42 - 17:54	13
	F	17:57 - 18:02	6
	XYZ	18:05 - 18:19	15
	F	18:06 - 18:18	13
2007-12-15	XYZ	08:10 - 08:13	4
	XYZ	09:44 - 09:53	10
2007-12-31	F	17:25 - 17:25	1
	F	18:41 - 18:41	1

Table A.4. Alice Springs data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-01-01	XYZ	05:39 - 05:40	2
2007-02-04	F	19:25 - 19:53	29
2007-02-05	F	04:50 - 04:50	1
2007-02-07	F	15:51 - 16:06	16
	F	16:14 - 16:16	3
	F	16:53 - 16:53	1
	F	20:49 - 20:49	1
	F	21:00 - 21:01	2
	F	21:43 - 21:45	3
	F	21:56 - 22:01	6
	F	22:11 - 22:26	16
	F	23:31 - 23:37	7
2007-02-08	F	00:18 - 10:01	584
2007-02-09	F	06:58 - 07:13	16
	F	22:33 - 22:50	18
	F	23:02 - 23:02	1
	F	23:04 - 23:33	30
2007-02-10	F	06:15 - 06:19	5
	F	07:53 - 07:54	2
	F	07:59 - 07:59	1
	F	08:18 - 08:18	1
	F	09:08 - 09:09	2
	F	09:17 - 09:20	4
2007-02-12	XYZ	01:48 - 01:50	3
	F	01:49 - 01:49	1
2007-02-21	F	09:16 - 09:20	5
	F	09:26 - 09:26	1
	F	13:44 - 13:46	3
	F	23:47 - 23:51	5
	F	23:55 - 23:59	5
2007-02-22	F	00:00 - 00:30	31
	F	01:08 - 01:11	4
	F	01:25 - 01:25	1
	F	02:15 - 05:08	174
	F	05:27 - 05:28	2
	F	06:35 - 07:53	79
	F	08:37 - 08:46	10
	F	10:31 - 11:26	56
2007-02-23	F	02:15 - 06:20	246
2007-02-24	F	06:21 - 07:23	63
	F	07:57 - 08:19	23
	F	08:34 - 08:35	2
	F	09:11 - 09:37	27
2007-02-25	F	04:39 - 05:08	30
	F	05:19 - 05:19	1
	F	05:24 - 05:25	2
	F	05:27 - 05:28	2
2007-02-26	F	00:08 - 00:08	1
2007-03-01	XYZ	01:37 - 01:39	3
	F	01:38 - 01:38	1
2007-04-24	F	04:33 - 04:34	2
	F	06:08 - 06:11	4
	F	06:30 - 06:30	1
	F	07:49 - 07:58	10
	F	08:09 - 08:11	3
	F	08:23 - 08:23	1
	F	08:34 - 08:34	1
	F	08:46 - 08:46	1
	F	08:48 - 08:48	1
	F	08:51 - 08:54	4
	F	09:12 - 23:59	888
2007-04-25	F	00:00 - 23:59	1440
	XYZ	13:02 - 23:59	658
2007-04-26	XYZ	00:00 - 01:59	120
	XYZ	03:03 - 03:20	18
	XYZ	06:02 - 23:59	1078
	F	00:00 - 23:59	1440
2007-04-27	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-04-28	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-04-29	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2007-04-30	XYZ	00:00 - 05:32	333
	XYZ	05:35 - 05:38	4
	F	00:00 - 13:45	826
2007-05-07	XYZ	08:23 - 08:38	16
2007-05-14	XYZ	05:37 - 05:39	3
	F	05:38 - 05:38	1
2007-09-09	F	09:56 - 09:56	1
2007-10-03	XYZ	02:43 - 02:45	3
	F	02:44 - 02:44	1
2007-10-12	XYZ	01:58 - 02:06	9
2007-10-16	XYZ	02:05 - 02:39	35
2007-11-02	XYZ	06:14 - 06:18	5
	F	06:15 - 06:15	1
2007-11-07	XYZ	05:36 - 05:45	10
2007-11-08	XYZ	02:34 - 03:00	27
2007-12-27	XYZ	02:35 - 02:43	9
	XYZ	03:01 - 03:05	5

Table A.5. Gnangara data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-03-27	F	02:35 - 05:02	148
2007-04-12	F	00:59 - 01:00	2
2007-07-18	F	00:16 - 00:16	1
	F	00:24 - 00:24	1
2007-09-05	F	00:19 - 00:21	3

Table A.6. Canberra data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-06-05	XYZ	02:39-02:41	3
	F	02:40-02:40	1
2007-07-10	XYZ	00:53-00:55	3
	F	00:54-00:54	1

Table A.7. Macquarie Island data losses from the MQ2 vector variometer and MCQ scalar variometer.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
Reported in 2008			

Table A.8. Casey data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2007-01-01	F	00:00 - 23:59	1440
2007-01-02	F	00:00 - 23:59	1440
2007-01-03	F	00:00 - 23:59	1440
2007-01-04	F	00:00 - 23:59	1440
2007-01-05	F	00:00 - 23:59	1440
2007-01-06	F	00:00 - 23:59	1440
2007-01-07	F	00:00 - 23:59	1440
2007-01-08	F	00:00 - 23:59	1440
2007-01-09	F	00:00 - 23:59	1440
2007-01-10	F	00:00 - 23:59	1440
2007-01-11	F	00:00 - 23:59	1440
2007-01-12	F	00:00 - 23:59	1440
2007-01-13	F	00:00 - 23:59	1440
2007-01-14	F	00:00 - 23:59	1440
2007-01-15	F	00:00 - 23:59	1440
2007-01-16	F	00:00 - 23:59	1440
2007-01-17	F	00:00 - 23:59	1440
2007-01-18	F	00:00 - 23:59	1440
2007-01-19	F	00:00 - 23:59	1440
2007-01-20	F	00:00 - 23:59	1440
2007-01-21	F	00:00 - 23:59	1440
2007-01-22	F	00:00 - 23:59	1440
2007-01-23	F	00:00 - 23:59	1440
2007-01-24	F	00:00 - 23:59	1440
2007-01-25	F	00:00 - 23:59	1440
2007-01-26	F	00:00 - 23:59	1440
2007-01-27	F	00:00 - 23:59	1440
2007-01-28	F	00:00 - 23:59	1440
2007-01-29	F	00:00 - 23:59	1440
2007-01-30	F	00:00 - 23:59	1440
2007-01-31	F	00:00 - 23:59	1440
2007-02-01	F	00:00 - 23:59	1440
2007-02-02	F	00:00 - 23:59	1440
2007-02-03	F	00:00 - 23:59	1440
2007-02-04	F	00:00 - 23:59	1440
2007-02-05	F	00:00 - 23:59	1440
2007-02-06	F	00:00 - 23:59	1440
2007-02-07	F	00:00 - 23:59	1440
2007-02-08	F	00:00 - 23:59	1440
2007-02-09	F	00:00 - 23:59	1440
2007-02-10	F	00:00 - 23:59	1440
2007-02-11	F	00:00 - 23:59	1440
2007-02-12	F	00:00 - 23:59	1440
2007-02-13	F	00:00 - 23:59	1440
2007-02-14	F	00:00 - 23:59	1440
2007-02-15	F	00:00 - 23:59	1440
2007-02-16	F	00:00 - 23:59	1440
2007-02-17	F	00:00 - 23:59	1440
2007-02-18	F	00:00 - 23:59	1440
2007-02-19	F	00:00 - 23:59	1440
2007-02-20	F	00:00 - 23:59	1440
2007-02-21	F	00:00 - 23:59	1440
2007-02-22	F	00:00 - 23:59	1440
2007-02-23	F	00:00 - 23:59	1440
2007-02-24	F	00:00 - 23:59	1440
2007-02-25	F	00:00 - 23:59	1440
2007-02-26	F	00:00 - 23:59	1440
2007-02-27	F	00:00 - 23:59	1440
2007-02-28	F	00:00 - 23:59	1440
2007-03-01	F	00:00 - 23:59	1440
2007-03-02	F	00:00 - 23:59	1440
2007-03-03	F	00:00 - 23:59	1440
2007-03-04	F	00:00 - 23:59	1440
2007-03-05	F	00:00 - 23:59	1440
2007-03-06	F	00:00 - 23:59	1440
2007-03-07	F	00:00 - 23:59	1440
2007-03-08	F	00:00 - 23:59	1440
2007-03-09	F	00:00 - 23:59	1440
2007-03-10	F	00:00 - 23:59	1440
2007-03-11	F	00:00 - 23:59	1440
2007-03-12	F	00:00 - 23:59	1440
2007-03-13	F	00:00 - 23:59	1440
2007-03-14	F	00:00 - 23:59	1440
2007-03-15	F	00:00 - 23:59	1440
2007-03-16	F	00:00 - 23:59	1440
2007-03-17	F	00:00 - 23:59	1440
2007-03-18	F	00:00 - 23:59	1440
2007-03-19	F	00:00 - 23:59	1440
2007-03-20	F	00:00 - 23:59	1440
2007-03-21	F	00:00 - 23:59	1440
2007-03-22	F	00:00 - 23:59	1440
2007-03-23	F	00:00 - 23:59	1440
2007-03-24	F	00:00 - 23:59	1440
2007-03-25	F	00:00 - 23:59	1440
2007-03-26	F	00:00 - 23:59	1440
2007-03-27	F	00:00 - 23:59	1440
2007-03-28	F	00:00 - 23:59	1440
2007-03-29	F	00:00 - 23:59	1440
2007-03-30	F	00:00 - 23:59	1440
2007-03-31	F	00:00 - 23:59	1440
2007-04-01	F	00:00 - 23:59	1440
2007-04-02	F	00:00 - 23:59	1440
2007-04-03	F	00:00 - 23:59	1440
2007-04-04	F	00:00 - 23:59	1440
2007-04-05	F	00:00 - 23:59	1440
2007-04-06	F	00:00 - 23:59	1440
2007-04-07	F	00:00 - 23:59	1440
2007-04-08	F	00:00 - 23:59	1440
2007-04-09	F	00:00 - 23:59	1440
2007-04-10	F	00:00 - 23:58	143
2007-04-11	F	13:29 - 16:58	210
	F	18:02 - 22:13	252
	F	23:02 - 23:59	58
2007-04-12	F	00:00 - 03:13	194
	F	04:04 - 08:08	245
	F	08:57 - 12:55	239
	F	13:39 - 17:52	254
	F	18:37 - 22:14	218
	F	22:22 - 22:22	1
	F	22:48 - 22:48	1
	F	22:52 - 23:59	68
2007-04-13	F	00:00 - 02:55	176
	F	03:31 - 03:31	1
	F	03:36 - 07:23	228
	F	08:09 - 12:08	240
	F	13:00 - 16:39	220
	F	17:32 - 20:55	204
	F	21:49 - 23:59	131
2007-04-14	F	00:00 - 01:33	94
	F	02:25 - 05:58	214
	F	06:49 - 10:18	210
	F	11:09 - 14:23	195
	F	15:19 - 18:46	208
	F	19:38 - 23:15	218
2007-04-15	F	00:07 - 03:47	221
	F	04:37 - 08:29	233
	F	09:16 - 12:48	213
	F	13:36 - 17:14	219

	F	18:00 - 21:54	235	F	03:10 - 03:24	15
	F	22:37 - 23:59	83	F	03:26 - 04:00	35
2007-04-16	F	00:00 - 02:25	146	F	04:05 - 04:26	22
	F	03:08 - 07:09	242	F	04:28 - 04:42	15
	F	07:51 - 11:34	224	F	04:44 - 04:59	16
	F	12:18 - 16:29	252	F	05:01 - 05:02	2
	F	17:11 - 21:25	255	F	05:08 - 05:32	25
	F	22:06 - 23:59	114	F	05:38 - 05:55	18
2007-04-17	F	00:00 - 02:09	130	F	05:57 - 05:58	2
	F	02:47 - 07:13	267	F	06:01 - 06:14	14
	F	07:51 - 11:44	234	F	06:18 - 06:36	19
	F	12:22 - 16:17	236	F	06:38 - 06:39	2
	F	16:55 - 21:14	260	F	06:41 - 06:44	4
	F	21:57 - 23:59	123	F	06:46 - 06:58	13
2007-04-18	F	00:00 - 01:57	118	F	07:05 - 07:29	25
	F	02:37 - 06:14	218	F	07:32 - 07:48	17
	F	06:52 - 10:39	228	F	07:50 - 08:00	11
	F	11:25 - 14:59	215	F	08:07 - 08:23	17
	F	15:43 - 19:09	207	F	08:32 - 09:01	30
	F	19:54 - 23:18	205	F	09:04 - 09:16	13
2007-04-19	F	00:02 - 03:24	203	F	09:18 - 09:19	2
	F	04:11 - 07:34	204	F	09:27 - 09:27	1
	F	08:21 - 11:46	206	F	09:29 - 09:53	25
	F	12:36 - 15:55	200	F	09:55 - 09:56	2
	F	16:42 - 20:03	202	F	09:58 - 10:10	13
	F	20:49 - 23:59	191	F	10:12 - 10:14	3
2007-04-20	F	00:00 - 00:13	14	F	10:17 - 10:31	15
	F	00:59 - 04:33	215	F	10:33 - 10:35	3
	F	05:20 - 08:49	210	F	10:41 - 10:58	18
	F	09:37 - 13:18	222	F	11:01 - 11:03	3
	F	14:04 - 17:51	228	F	11:06 - 11:17	12
	F	18:35 - 22:20	226	F	11:20 - 11:22	3
	F	23:02 - 23:59	58	F	11:26 - 11:42	17
2007-04-21	F	00:00 - 02:46	167	F	11:52 - 12:23	32
	F	03:26 - 07:28	243	F	12:28 - 12:47	20
	F	08:09 - 11:43	215	F	12:59 - 13:23	25
	F	12:24 - 15:59	216	F	13:26 - 13:28	3
	F	16:38 - 20:18	221	F	13:30 - 13:41	12
	F	20:56 - 23:59	184	F	13:44 - 13:46	3
2007-04-22	F	00:00 - 00:30	31	F	13:48 - 14:02	15
	F	01:09 - 05:05	237	F	14:13 - 14:39	27
	F	05:46 - 09:23	218	F	14:41 - 14:43	3
	F	10:02 - 13:28	207	F	14:45 - 15:11	27
	F	14:08 - 17:32	205	F	15:16 - 15:17	2
	F	18:14 - 21:42	209	F	15:20 - 15:34	15
	F	22:23 - 23:59	97	F	15:47 - 16:13	27
2007-04-23	F	00:00 - 01:49	110	F	16:16 - 16:25	10
	F	02:30 - 05:51	202	F	16:33 - 16:50	18
	F	06:31 - 09:52	202	F	16:52 - 16:54	3
	F	10:34 - 13:56	203	F	17:06 - 17:32	27
	F	14:35 - 18:01	207	F	17:35 - 17:51	17
	F	18:43 - 22:12	210	F	17:55 - 17:57	3
	F	22:51 - 23:59	69	F	18:02 - 18:22	21
2007-04-24	F	00:00 - 02:17	138	F	18:34 - 18:56	23
	F	02:59 - 06:22	204	F	18:58 - 18:59	2
	F	06:54 - 22:49	956	F	19:02 - 19:03	2
	F	22:51 - 23:07	17	F	19:06 - 19:18	13
	F	23:09 - 23:23	15	F	19:23 - 19:45	23
	F	23:25 - 23:59	35	F	19:59 - 20:27	29
2007-04-25	F	00:01 - 00:15	15	F	20:34 - 20:52	19
	F	00:17 - 00:29	13	F	21:00 - 21:15	16
	F	00:34 - 00:54	21	F	21:19 - 21:20	2
	F	00:58 - 01:18	21	F	21:22 - 21:36	15
	F	01:20 - 01:46	27	F	21:51 - 22:19	29
	F	01:50 - 02:08	19	F	22:23 - 22:37	15
	F	02:10 - 02:26	17	F	22:46 - 23:06	21
	F	02:28 - 02:47	20	F	23:10 - 23:23	14
	F	02:50 - 03:04	15	F	23:30 - 23:43	14
	F	03:06 - 03:08	3	F	23:45 - 23:50	6

2007-04-26	F	00:03 - 00:29	27		F	23:31 - 23:33	3
	F	00:36 - 00:53	18		F	23:37 - 23:38	2
	F	00:55 - 00:56	2		F	23:43 - 23:59	17
	F	01:06 - 01:34	29	2007-04-27	F	00:00 - 00:02	3
	F	01:36 - 01:36	1		F	00:04 - 00:06	3
	F	01:38 - 01:47	10		F	00:10 - 00:22	13
	F	01:55 - 02:12	18		F	00:35 - 01:04	30
	F	02:14 - 02:15	2		F	01:10 - 01:28	19
	F	02:27 - 02:50	24		F	01:30 - 01:31	2
	F	02:52 - 02:53	2		F	01:33 - 01:34	2
	F	02:57 - 03:01	5		F	01:37 - 01:50	14
	F	03:03 - 03:15	13		F	02:02 - 02:22	21
	F	03:22 - 03:38	17		F	02:26 - 02:39	14
	F	03:42 - 03:44	3		F	02:44 - 02:46	3
	F	03:53 - 04:17	25		F	02:48 - 02:58	11
	F	04:20 - 04:22	3		F	03:00 - 03:03	4
	F	04:24 - 04:37	14		F	03:16 - 03:41	26
	F	04:52 - 05:22	31		F	03:47 - 04:02	16
	F	05:30 - 05:56	27		F	04:04 - 04:08	5
	F	05:59 - 06:18	20		F	04:11 - 04:30	20
	F	06:31 - 06:56	26		F	04:44 - 23:59	1156
	F	06:58 - 06:59	2	2007-04-28	F	00:00 - 23:59	1440
	F	07:02 - 07:12	11	2007-04-29	F	00:00 - 23:59	1440
	F	07:18 - 07:30	13	2007-04-30	F	00:00 - 23:59	1440
	F	07:32 - 07:34	3	2007-05-01	F	00:00 - 23:59	1440
	F	07:46 - 08:12	27	2007-05-02	F	00:00 - 23:59	1440
	F	08:20 - 08:44	25	2007-05-03	F	00:00 - 23:59	1440
	F	08:47 - 08:59	13	2007-05-04	F	00:00 - 23:59	1440
	F	09:05 - 09:07	3	2007-05-05	F	00:00 - 23:59	1440
	F	09:14 - 09:34	21	2007-05-06	F	00:00 - 23:59	1440
	F	09:36 - 09:37	2	2007-05-07	F	00:00 - 23:59	1440
	F	09:39 - 09:41	3	2007-05-08	F	00:00 - 23:59	1440
	F	09:50 - 10:15	26	2007-05-09	F	00:00 - 23:59	1440
	F	10:25 - 10:49	25	2007-05-10	F	00:00 - 23:59	1440
	F	10:51 - 11:02	12	2007-05-11	F	00:00 - 23:59	1440
	F	11:19 - 12:13	55	2007-05-12	F	00:00 - 23:59	1440
	F	12:26 - 12:56	31	2007-05-13	F	00:00 - 23:59	1440
	F	12:58 - 13:15	18	2007-05-14	F	00:00 - 23:59	1440
	F	13:27 - 13:52	26	2007-05-15	F	00:00 - 23:59	1440
	F	13:55 - 14:07	13	2007-05-16	F	00:00 - 23:59	1440
	F	14:19 - 14:46	28	2007-05-17	F	00:00 - 23:59	1440
	F	14:48 - 15:03	16	2007-05-18	F	00:00 - 23:59	1440
	F	15:09 - 15:23	15	2007-05-19	F	00:00 - 23:59	1440
	F	15:26 - 15:28	3	2007-05-20	F	00:00 - 23:59	1440
	F	15:38 - 16:06	29	2007-05-21	F	00:00 - 23:59	1440
	F	16:09 - 16:21	13	2007-05-22	F	00:00 - 23:59	1440
	F	16:33 - 16:57	25	2007-05-23	F	00:00 - 23:59	1440
	F	16:59 - 17:04	6	2007-05-24	F	00:00 - 23:59	1440
	F	17:06 - 17:18	13	2007-05-25	F	00:00 - 23:59	1440
	F	17:20 - 17:21	2	2007-05-26	F	00:00 - 23:59	1440
	F	17:32 - 18:00	29	2007-05-27	F	00:00 - 23:59	1440
	F	18:03 - 18:11	9	2007-05-28	F	00:00 - 23:59	1440
	F	18:14 - 18:25	12	2007-05-29	F	00:00 - 23:59	1440
	F	18:27 - 18:28	2	2007-05-30	F	00:00 - 23:59	1440
	F	18:42 - 19:13	32	2007-05-31	F	00:00 - 23:59	1440
	F	19:20 - 19:54	35	2007-06-01	F	00:00 - 23:59	1440
	F	19:56 - 20:08	13	2007-06-02	F	00:00 - 23:59	1440
	F	20:10 - 20:12	3	2007-06-03	F	00:00 - 23:59	1440
	F	20:22 - 20:46	25	2007-06-04	F	00:00 - 23:59	1440
	F	20:50 - 21:02	13	2007-06-05	F	00:00 - 23:59	1440
	F	21:14 - 21:44	31	2007-06-06	F	00:00 - 23:59	1440
	F	21:46 - 21:47	2	2007-06-07	F	00:00 - 23:59	1440
	F	21:49 - 22:00	12	2007-06-08	F	00:00 - 23:59	1440
	F	22:02 - 22:05	4	2007-06-09	F	00:00 - 23:59	1440
	F	22:15 - 22:48	34	2007-06-10	F	00:00 - 23:59	1440
	F	22:51 - 22:55	5	2007-06-11	F	00:00 - 23:59	1440
	F	22:57 - 23:12	16	2007-06-12	F	00:00 - 23:59	1440
	F	23:14 - 23:14	1	2007-06-13	F	00:00 - 23:59	1440
	F	23:17 - 23:29	13	2007-06-14	F	00:00 - 23:59	1440

2007-06-15	F	00:00 - 23:59	1440
2007-06-16	F	00:00 - 23:59	1440
2007-06-17	F	00:00 - 23:59	1440
2007-06-18	F	00:00 - 02:38	159
	F	04:21 - 08:04	224
	F	08:33 - 12:01	209
	F	12:29 - 16:07	219
	F	16:34 - 20:08	215
	F	20:33 - 23:59	207
2007-06-19	F	00:00 - 00:03	4
	F	00:30 - 03:54	205
	F	04:20 - 08:58	279
	F	09:25 - 12:48	204
	F	13:16 - 16:43	208
	F	17:10 - 20:39	210
	F	21:04 - 23:59	176
2007-06-20	F	00:00 - 00:43	44
	F	01:07 - 04:35	209
	F	04:59 - 08:22	204
	F	08:47 - 12:20	214
	F	12:44 - 16:16	213
	F	16:41 - 20:02	202
	F	20:28 - 23:49	202
2007-06-21	F	00:14 - 03:36	203
	F	04:02 - 07:25	204
	F	07:51 - 11:11	201
	F	11:36 - 14:54	199
	F	15:20 - 18:42	203
	F	19:06 - 22:24	199
	F	22:49 - 23:59	71
2007-06-22	F	00:00 - 02:09	130
	F	02:33 - 06:07	215
	F	06:31 - 10:13	223
	F	10:36 - 14:22	227
	F	14:44 - 18:41	238
	F	19:02 - 22:54	233
	F	23:16 - 23:59	44
2007-06-23	F	00:00 - 03:14	195
	F	03:35 - 07:30	236
	F	07:50 - 23:59	970
2007-06-24	F	00:00 - 23:59	1440
2007-06-25	F	00:00 - 23:59	1440
2007-06-26	F	00:00 - 23:59	1440
2007-06-27	F	00:00 - 23:59	1440
2007-06-28	F	00:00 - 23:59	1440
2007-06-29	F	00:00 - 23:59	1440
2007-06-30	F	00:00 - 23:59	1440
2007-07-01	F	00:00 - 23:59	1440
2007-07-02	F	00:00 - 23:59	1440
2007-07-03	F	00:00 - 23:59	1440
2007-07-04	F	00:00 - 23:59	1440
2007-07-05	F	00:00 - 23:59	1440
2007-07-06	F	00:00 - 23:59	1440
2007-07-07	F	00:00 - 23:59	1440
2007-07-08	F	00:00 - 23:59	1440
2007-07-09	F	00:00 - 10:21	622
2007-07-18	F	01:55 - 03:43	109
2007-08-01	F	05:44 - 05:44	1
2007-09-13	F	02:14 - 02:14	1
2007-10-25	F	20:27 - 20:27	1
	F	20:30 - 20:31	2
	F	21:17 - 21:17	1
	F	21:19 - 21:19	1
	F	21:28 - 21:28	1
	F	21:32 - 21:32	1
	F	21:37 - 21:37	1
	F	21:54 - 21:55	2
	F	21:57 - 21:57	1
	F	21:59 - 22:00	2
	F	22:03 - 22:18	16
	F	22:20 - 22:22	3
	F	22:25 - 22:26	2
	F	22:29 - 22:29	1
	F	22:31 - 22:31	1
	F	22:33 - 22:36	4
	F	22:40 - 22:40	1
	F	22:43 - 22:43	1
	F	22:45 - 22:45	1
	F	22:48 - 22:48	1
	F	22:50 - 22:51	2
	F	22:54 - 22:54	1
	F	22:56 - 22:56	1
	F	22:59 - 22:59	1
	F	23:01 - 23:01	1
	F	23:06 - 23:09	4
	F	23:15 - 23:16	2
	F	23:21 - 23:21	1
	F	23:23 - 23:23	1
	F	23:30 - 23:35	6
	F	23:40 - 23:40	1
	F	23:42 - 23:43	2
	F	23:47 - 23:47	1
	F	23:49 - 23:49	1
	F	23:51 - 23:52	2
	F	23:55 - 23:55	1
2007-10-26	F	00:00 - 00:01	2
	F	00:03 - 00:07	5
	F	00:09 - 00:09	1
	F	00:11 - 00:15	5
	F	00:17 - 00:20	4
	F	00:22 - 00:23	2
	F	00:25 - 00:28	4
	F	00:33 - 00:33	1
	F	00:35 - 00:36	2
	F	00:39 - 00:39	1
	F	00:41 - 00:42	2
	F	00:44 - 00:44	1
	F	00:48 - 00:48	1
	F	00:51 - 01:01	11
	F	01:04 - 01:06	3
	F	01:10 - 01:11	2
	F	01:14 - 01:14	1
	F	01:17 - 01:18	2
	F	01:20 - 01:20	1
	F	01:25 - 01:27	3
	XYZ	01:27 - 01:27	1
	F	01:30 - 01:33	4
	F	01:35 - 01:38	4
	F	01:40 - 01:40	1
	F	01:42 - 01:42	1
	F	01:44 - 01:44	1
	F	01:47 - 01:51	5
	F	01:53 - 01:55	3
	F	01:59 - 01:59	1
	F	02:03 - 02:03	1
	F	02:07 - 02:08	2
	F	02:11 - 02:13	3
	F	02:16 - 02:17	2
	F	02:19 - 02:19	1
	F	02:24 - 02:24	1
	F	02:28 - 02:30	3
	F	02:34 - 02:36	3
	F	02:44 - 02:48	5
	F	02:50 - 02:50	1
	F	02:52 - 02:52	1
	F	02:54 - 02:57	4
	F	03:00 - 03:02	3
	F	03:05 - 03:09	5

	F	03:11 - 03:12	2
	F	03:14 - 03:14	1
	F	03:17 - 03:30	14
	F	03:32 - 03:33	2
	F	03:35 - 03:39	5
	F	03:42 - 04:31	50
	F	04:34 - 04:51	18
	F	04:53 - 05:12	20
	F	05:14 - 05:27	14
	F	05:29 - 05:36	8
	F	05:38 - 05:42	5
	F	05:44 - 05:49	6
	F	05:51 - 05:51	1
	F	05:55 - 06:07	13
	F	06:09 - 06:19	11
	F	06:21 - 06:25	5
	F	06:27 - 06:27	1
	F	06:30 - 06:30	1
	F	06:32 - 06:40	9
	F	06:42 - 06:43	2
	F	06:45 - 06:49	5
	F	06:51 - 06:58	8
	F	07:00 - 07:36	37
	F	07:38 - 07:40	3
	F	07:42 - 07:43	2
	F	07:50 - 07:53	4
	F	07:56 - 07:56	1
	F	08:01 - 08:01	1
	F	08:05 - 08:06	2
	F	08:08 - 08:08	1
	F	08:10 - 08:13	4
	F	08:15 - 08:18	4
	F	08:22 - 08:24	3
	F	08:30 - 08:30	1
	F	08:38 - 08:38	1
	F	08:40 - 08:40	1
2007-11-14	F	01:48 - 01:48	1

Table A.9. Mawson data losses.

Observatory	**XYZ**		**F**	
	(minutes)	**(%)**	**(minutes)**	**(%)**
Kakadu	25983	4.94	14493	2.76
Charters Towers	31	0.01	2510	0.48
Learmonth	4433	0.84	933	0.18
Alice Springs	8616	1.64	8619	1.64
Gnangara	6661	1.27	10470	1.99
Canberra	0	0.00	444	0.03
Macquarie Island	6	0.00	2	0.00
Mawson	1	0.00	267998	50.99
Total	**45731**	**1.09**	**305469**	**7.26**

Table A.10. Summary of annual data losses. (Casey data loss for 2007 will be reported with the 2008 data and has been excluded from these statistics.)

Appendix B. Backup data

Date	Interval (hh:mm)	Data in filled (minutes)
2007-01-01	20:18 - 20:19	2
2007-01-03	18:50 - 18:52	3
2007-01-05	16:00 - 16:02	3
2007-01-07	15:35 - 15:36	2
2007-01-08	15:25 - 15:26	2
2007-01-10	17:11 - 17:12	2
2007-01-12	09:11 - 09:12	2
2007-01-13	12:41 - 12:42	2
2007-01-15	05:46 - 05:47	2
2007-01-17	00:04 - 00:05	2
2007-01-18	18:36 - 18:37	2
2007-01-19	10:17 - 10:18	2
2007-01-20	03:57 - 03:58	2
	06:06 - 06:07	2
	08:20 - 08:21	2
	10:31 - 10:32	2
	12:43 - 12:44	2
	14:56 - 14:57	2
	16:14 - 16:15	2
2007-01-21	09:34 - 09:35	2
2007-01-22	05:33 - 05:34	2
2007-01-23	07:50 - 07:51	2
2007-01-24	10:05 - 10:06	2
2007-01-25	14:47 - 14:48	2
2007-01-26	20:49 - 20:50	2
2007-01-28	04:00 - 04:02	3
2007-01-29	10:01 - 10:02	2
2007-01-30	17:15 - 17:17	3
2007-01-31	17:05 - 17:06	2
2007-02-01	10:45 - 10:46	2
2007-02-02	19:11 - 19:12	2
2007-02-03	16:16 - 16:17	2
2007-02-04	16:04 - 16:05	2
2007-02-05	14:35 - 14:36	2
2007-02-06	19:20 - 19:22	3
2007-02-08	02:40 - 02:41	2
2007-02-09	02:30 - 02:31	2
2007-02-10	06:01 - 06:02	2
2007-02-11	04:35 - 04:36	2
2007-02-12	03:10 - 03:11	2
2007-02-13	11:40 - 11:42	3
2007-02-14	16:30 - 16:31	2
2007-02-15	10:10 - 10:12	3
2007-02-16	17:19 - 17:20	2
2007-02-18	03:10 - 03:12	3
2007-02-19	01:45 - 01:46	2
2007-02-20	05:15 - 05:17	3
2007-02-21	08:53 - 08:54	2
2007-02-22	14:50 - 14:52	3
2007-02-23	11:01 - 11:02	2
2007-02-24	15:15 - 15:16	2
2007-02-26	02:16 - 02:17	2
2007-02-27	10:45 - 10:47	3
2007-02-28	14:20 - 14:22	3
2007-03-01	12:59 - 13:00	2
2007-03-02	21:36 - 21:37	2
2007-03-03	20:05 - 20:07	3
2007-03-04	13:48 - 13:49	2
2007-03-05	22:19 - 22:20	2
2007-03-07	03:09 - 03:10	2
	20:33 - 20:35	3
2007-03-08	18:43 - 18:44	2
2007-03-09	11:58 - 11:59	2
2007-03-10	08:55 - 08:56	2
2007-03-11	07:08 - 07:09	2
2007-03-12	00:19 - 00:20	2
	21:14 - 21:15	2
2007-03-13	19:24 - 19:25	2
2007-03-14	17:26 - 17:27	2
2007-03-15	15:29 - 15:30	2
2007-03-16	12:28 - 12:29	2
2007-03-17	11:46 - 11:47	2
2007-03-18	00:07 - 00:08	2
2007-03-19	04:18 - 04:19	2
2007-03-20	01:14 - 01:15	2
	19:47 - 19:48	2
2007-03-21	15:24 - 15:25	2
2007-03-22	10:58 - 11:00	3
2007-03-23	11:24 - 11:26	3
2007-03-24	03:22 - 03:23	2
	21:42 - 21:44	3
2007-03-25	17:21 - 17:22	2
2007-03-26	09:20 - 09:21	2
2007-03-27	03:30 - 04:07	38
	04:12 - 04:13	2
	04:15 - 04:16	2
	02:35 - 05:00	146
2007-06-12	08:36 - 08:37	2
2007-06-20	09:09 - 09:10	2
2007-06-22	04:33 - 04:34	2
2007-06-24	15:09 - 15:10	2
2007-06-27	23:06 - 23:07	2
2007-06-29	14:42 - 14:43	2
2007-07-01	11:16 - 11:17	2
2007-07-03	11:33 - 11:34	2
2007-07-04	03:05 - 03:06	2
	20:49 - 20:50	2
2007-07-06	00:52 - 00:52	1
2007-07-07	08:33 - 08:35	3
2007-07-08	03:52 - 03:54	3
2007-07-10	01:51 - 01:53	3
2007-07-11	00:16 - 00:19	4
2007-07-12	20:55 - 20:56	2
2007-07-18	00:15 - 00:16	2
	00:23 - 00:24	2
2007-08-02	04:29 - 04:35	6
2007-08-14	04:23 - 04:52	30
2007-12-03	23:59 - 23:59	1
2007-12-04	00:00 - 00:02	2

Table B.1. Canberra CN1 variometer data used for in fill of CNB variometer during 2007.

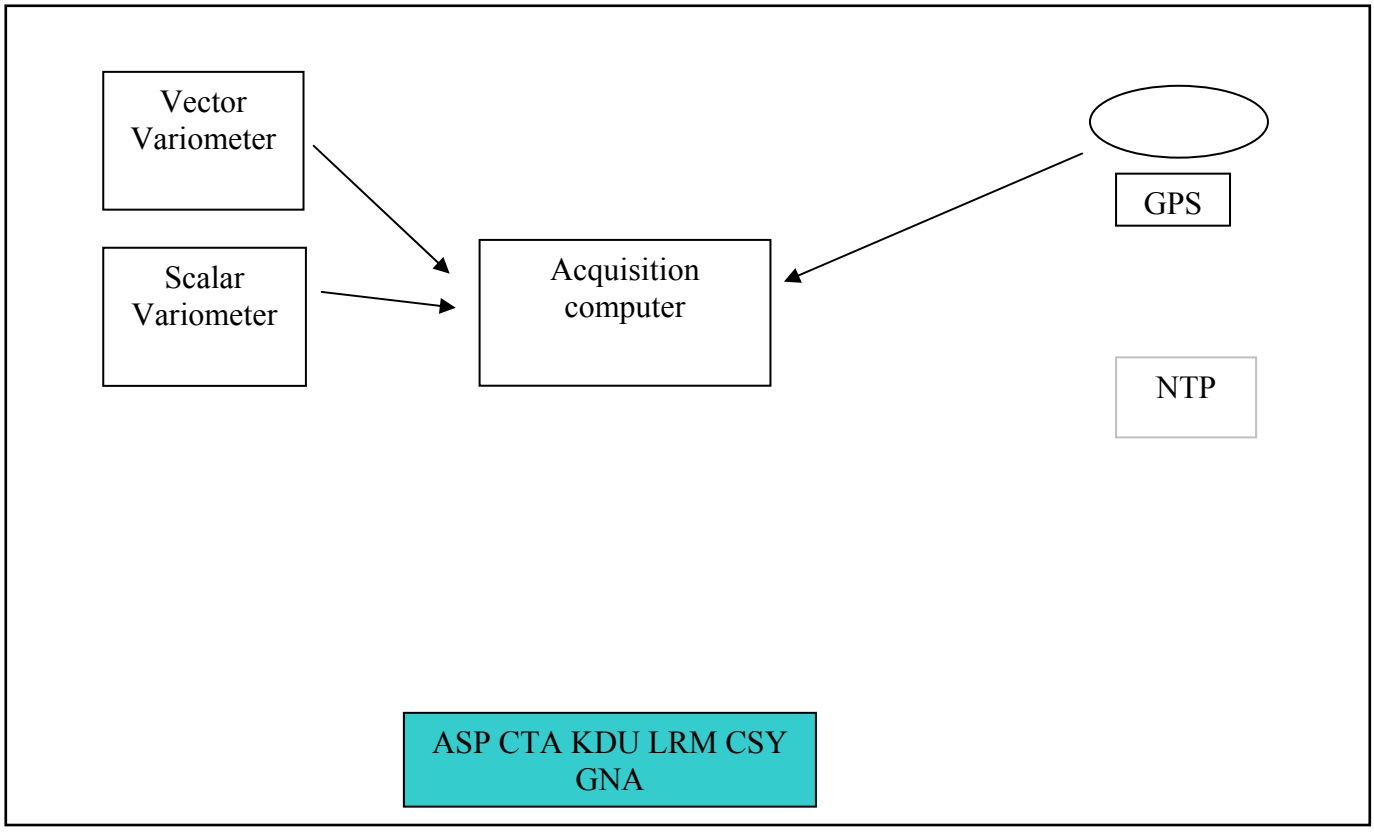
Date	Interval (hh:mm)	Data in filled (minutes)
2007-10-13	02:22 - 02:25	4

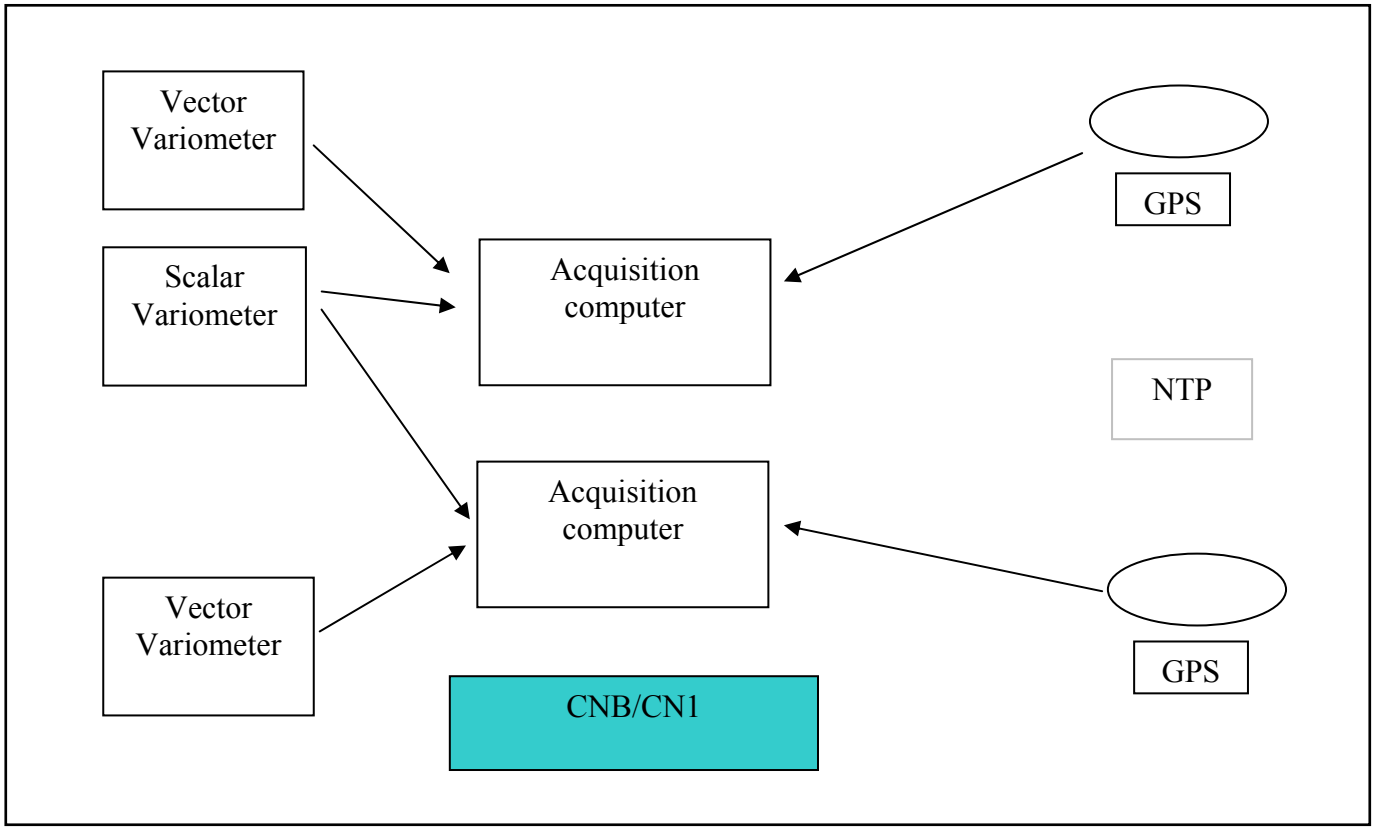
Table B.2. Macquarie Island MCQ vector variometer data used for in fill of MQ2 vector variometer during 2007.

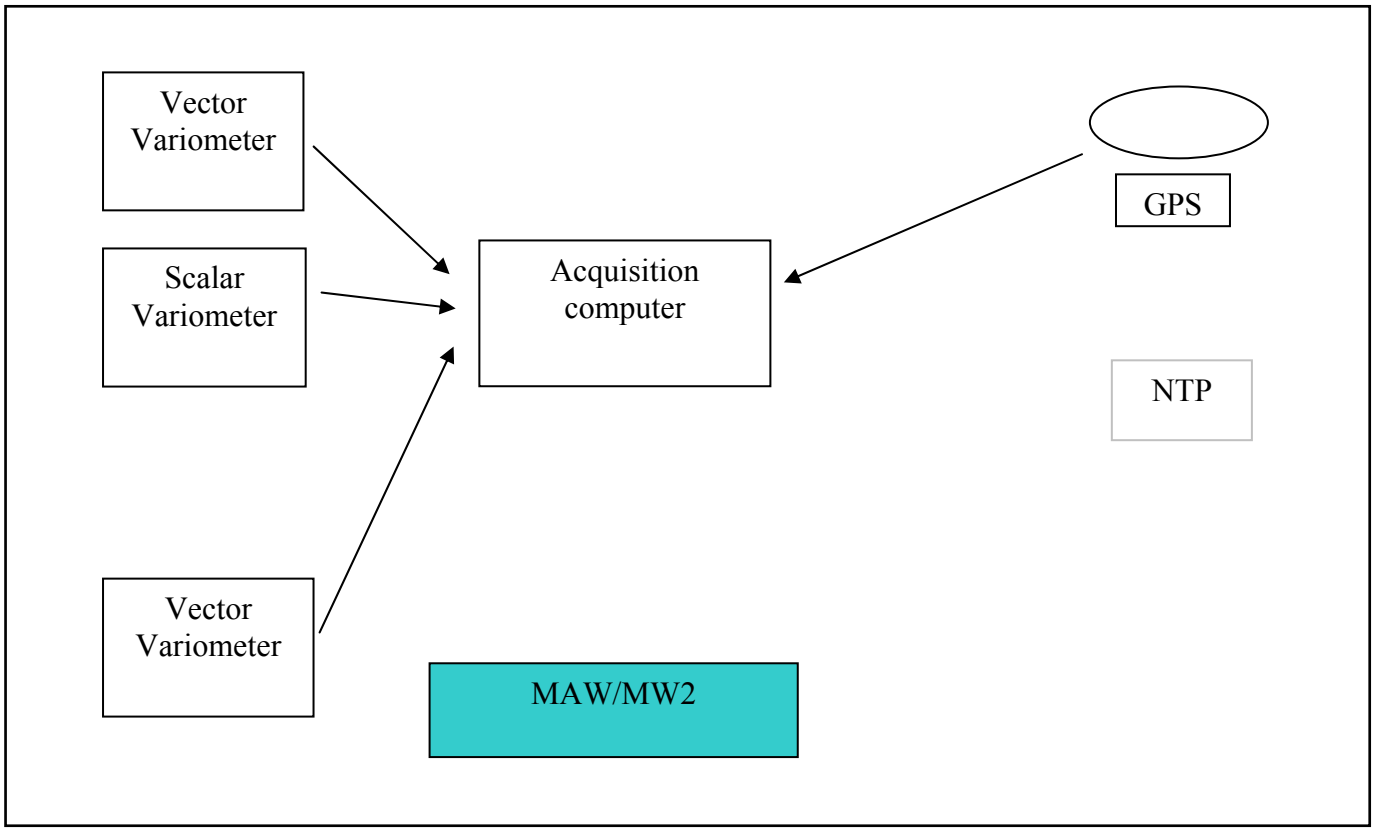
Date	Interval (hh:mm)	Data in filled (minutes)
2007-03-20	01:48 - 01:49	2
2007-04-12	22:04 - 23:59	116
2007-04-13	00:00 - 01:14	75
	05:23 - 05:24	2
2007-07-18	01:54 - 01:55	2
2007-09-13	02:13 - 02:14	2
2007-10-26	01:26 - 01:26	1
	01:28 - 01:28	1
2007-11-14	01:47 - 01:48	2

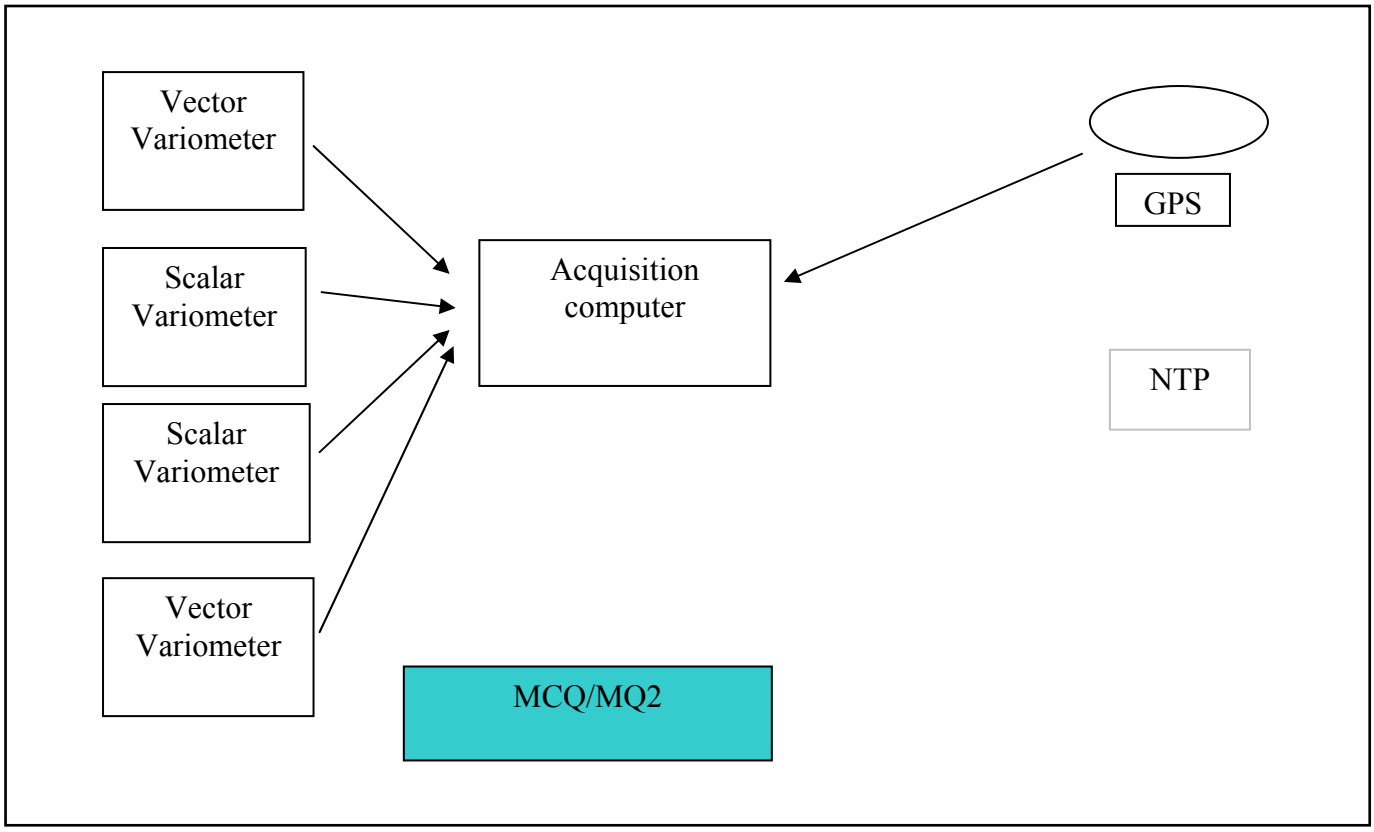
Table B.3. Mawson MAW vector variometer data used for in fill of MW2 vector variometer during 2007.

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

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*.

Observatory maintenance reports

Lewis, A.M., 2007, Gnangara Geomagnetic Observatory maintenance visit and observer change over, January 2007, *Geoscience Australia*, *Geomagnetism Note,* **2007/10**.

Lewis, A.M. and J.W. Whatman, 2007, Kakadu Geomagnetic Observatory maintenance visit, December 2007, *Geoscience Australia*, *Geomagnetism Note,* **2007/15**.

Wang, L., 2007, Gnangara Geomagnetic Observatory one-day visit, November 2007, *Geoscience Australia*, *Geomagnetism Note,* **2007/13**.

Wang, L. and J. Griffin, 2007, Charters Towers Geomagnetic Observatory maintenance visit, April 2007, *Geoscience Australia*, *Geomagnetism Note,* **2007/11**.

Other reports

Lewis, A.M., 2007, Geomagnetic conjugate point experiment, August 2007, *Geoscience Australia*, *Geomagnetism Note,* **2007/12**.

Lewis, A.M., 2007, Magnetic observations on Darwin Airport compass swing bay, *Geoscience Australia*, *Geomagnetism Note,* **2007/14**.

Staff

Name	Classification	Responsibility
Peter Crosthwaite	GA Level 5	Digital acquisition, system and software development and maintenance; Kakadu, Mawson and Casey observatories
Andrew Lewis	GA Level 5	Repeat station surveys; Learmonth and Macquarie Island observatories; Australian Geomagnetic Reference Field Model
Adrian Hitchman	GA Level 5	Project Leader; Gnangara and Alice Springs observatories
Peter Hopgood	GA Level 6	Research
Glen Torr	GA Level 3	Observatory and system scientific support
Liejun Wang	GA Level 4	Information management; Canberra and Charters Towers observatories
Jim Whatman	GA Level 4	Technical support

Table 2. Canberra-based staff.

Name	Organisation	Observatory
Roselin Bali	AAD	Mawson (from mid-November)
Alan Brockman	IPS	Learmonth (until 28 January)
Christopher Clarke	AAD	Macquarie Island (from 18 April)
Shaun Evans	ACRES, GA	Alice Springs
Owen Giersch	IPS	Learmonth (from 29 January)
Owen McConnel	GA	Gnangara, technical support
Ian McLean	AAD	Mawson (until mid-November)
Daniel Matejic	AAD	Casey (from late-November)
Jack Millican		Charters Towers
Ian Phillips	AAD	Casey (until late-November)
Stephen Pryde	Pryde Electronic Repairs	Gnangara (from 30 January)
Andy Ralph	Kakadu Culture Camp	Kakadu
Warren Serone	ACRES, GA	Alice Springs
Gerard van Reeken		Gnangara (until 29 January)
Jodi Wruck	AAD	Macquarie Island (until 17 April)

Table 3. Observatory-based staff.