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by

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Summary

During 2006 Geoscience Australia operated nine geomagnetic observatories in Australia, the sub-Antarctic, and the 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 January 2006 the magnetic repeat station at Hobart, Tasmania, was re-occupied and data collected to monitor the secular variation at that station.

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). Data were received for processing at Geoscience Australia from the Tondano observatory in 2006; 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 calendar year 2006.

Acronyms and abbreviations

AAD	Australian Antarctic Division
ACRES	Australian Centre for Remote Sensing
ACT	Australian Capital Territory
A/D	analogue to digital
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
ASP	Atmospheric and Space Physics (a program of the AAD)
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
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

The Geomagnetism Project of Geoscience Australia operates nine permanent geomagnetic observatories in Australia and the Australian Antarctic Territory, 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 and other southwest Pacific countries. Stations are occupied every two to four years to provide secular variation data at locations between the observatories.

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. 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. This continued in 2006, enabling assistance to be provided to the Indonesian geomagnetism program. Due to equipment failures and insufficient resources no data were received from Tangerang in 2006.

The Indonesian data will also complement data gained during repeat station occupations to enhance 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 large 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 agencies requiring the calibration of compasses and compass theodolites as well as the determination of magnetic signatures of other equipment.

Data distribution

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

Time series

Preliminary 1-second time series are provided in near real-time to IPS Radio and Space Services 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 and are sent to the Edinburgh INTERMAGNET GIN for inclusion 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 NOAA, these data are then obtained directly from INTERMAGNET by the NGDC, Boulder, and ingested into WDC-A.

Australian magnetic observatory data have been contributed to the INTERMAGNET project (see Trigg and Coles, 1994) since the first CD of definitive data was produced. 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.

Magnetic activity indices

Canberra (with its predecessors at Toolangi and Melbourne) and Hartland (with its predecessors at 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:

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

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 (LRNS) smoothing algorithm (Hattingh et al. 1989) to produce an estimate of the quiet or 'non-K' daily variation. This initial curve may be manipulated on a computer screen using a spline fitting technique to improve the estimate of the non-K variations. The estimated non-K variation for the day is 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). Continuing as a monthly report, in January 1990 (Vol. 38, No. 1) the series was renamed the *Australian Geomagnetism Report*. The monthly series was replaced by the 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).

Observatory	Data first on CD	Data first transmitted	Data transmission frequency
KDU	2000	Aug 2001	daily to 22 Sep, 2005 then real-time
CTA	2000	Aug 2001	daily to 01 Sep, 2005 then real-time
LRM	2005	23 Aug 2005	daily to 20 Jun, 2005 then real-time
ASP	1999	Dec 1999	daily
GNA	1994	early 1995	daily
CNB	1991	Oct 1994	daily to 01 Sep, 2005 then real-time
MCQ	2001	Jun 2002	daily to 02 Jun, 2005 then real-time
MAW	2005	24 Nov 2005	daily to 15 Dec, 2005 then real-time

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

Instrumentation

The basic system used at Australian observatories to monitor magnetic fluctuations comprises an orthogonal 3-component variometer and a total-field variometer.

The total-field data are primarily used as a check on the adopted variometer scale-values, temperature coefficients and drift-rates through a calculation of the difference between the direct total-field readings and those derived from the 3-component data. Additionally, should one channel of the 3-component variometer become unserviceable, the missing data may be synthesized from the remaining two channels and the total-field channel.

Observatory 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 interval at Australian observatories is 1 second for 3-component variometer data and 10 seconds for total-intensity data. The INTERMAGNET filter is applied to the 1-second data to generate 1-minute values. 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 hour means in the day existed.

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 in each of the subsets that existed.

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 existed.

Variometers

Vector variometer sensors at Australian observatories are orientated so the 3 measured components have a similar magnitude. In the typical configuration the two 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.

One of the benefits of this alignment 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 can be recovered using the scalar variometer data (Crosthwaite, 1992, 1994).

Data reduction

Using regular absolute observations, parameters are obtained that enable the calculation of the geographic X, Y and Z (and so H, D, I and F) components of the magnetic field through 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 a DI-fluxgate magnetometer (or Declination and Inclination Magnetometer – DIM) to measure the magnetic field direction and a PPM to measure the total-field intensity.

DIMs at Australian observatories use Elsec 810, Bartington MAG-01H and DMI Model G fluxgate sensors and electronics, mounted on Zeiss-Jena 020B and 010B non-magnetic theodolites.

The *offset method* of performing DIM observations is used at most observatories. This method involved setting the theodolite to the whole number of minutes nearest a null fluxgate output, resulting in a small non-zero output. Then a series of eight fluxgate vs. time readings is recorded without moving the theodolite. At some observatories the *null method* continues to be used.

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.

Absolute instruments used at Australian observatories are periodically compared with the reference magnetometers, sometimes through subsidiary travelling reference instruments. Inter-comparisons performed at the IAGA workshops on *Geomagnetic Observatory Instruments, Data Acquisition and Processing* relate the Australian reference magnetometers to international standards.

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 most Australian observatories use software built around the QNX operating system. During 2006, the last remaining DOS-based data-acquisition systems, at Gnangara and Alice Springs observatories, were replaced with QNX systems.

Data-acquisition timing is governed by the operating system clock in the acquisition computer. At most observatories the system clock is maintained to within 1 ms of UTC using a GPS clock. In some cases, Network Time Protocol Daemon (ntpd) is used, maintaining the system clock to within 10 ms of UTC. Ntpd is available as a backup at many observatories.

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.

At Casey, the Australian Antarctic Division's EDA FM105B variometer 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 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 consists of:

- a 3x3 m air-conditioned concrete-brick Control House, with concrete ceiling and aluminium cladding and roof, where all recording instrumentation and control equipment is 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 that are both about 100 m from Pier A at approximate true bearings of 27° and 238°;
- two 600 mm square underground vaults that house the variometer sensors, both located 50-60 m from the Control House, one to its SSW and one to its WSW (cables between the sensor vaults and the Control House are routed via underground conduits), and;
- a concrete slab, with tripod foot placements and a marker plate, used as an external reference site E (at a standard height of 1.6 m above the marker plate). The marker plate is 60 m, at a bearing of 331°, from the principal observation pier A.

Key data for the observatory are given in Table 1.1.

IAGA code:	KDU
Commenced operation:	05 March 1995
Geographic latitude:	12° 41' 10.9" S
Geographic longitude:	132° 28' 20.5" E
Geomagnetic latitude:	-21.85°
Geomagnetic longitude:	205.65°
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
Observers:	R. Lynch (until 19 February) A. Ralph (from 15 September)

Table 1.1 Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 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 sensor-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.

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.

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 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

The observatory was also protected from lightning by an ERICO System 3000 (Advanced Integrated Lightning Protection), consisting of a Dynasphere Air Termination unit, mast, and copper-coated steel rod, designed to protect an 80m radius area around the sphere. There were also lengths of copper ribbon and aluminium power cables buried in shallow trenches towards the Absolute Shelter, in the opposite direction, and from the Control Hut to and around both variometer sensor vaults, and a conducting loop around the Control Hut. All of these lightning protection components were connected together.

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 Z fluxgate sensor vertical, and the two horizontal fluxgate sensors each aligned at 45° to the declination at the time of installation. 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 magnetometer calibration facility.

Very little filtering has been applied to the 1-second variometer data in this report. Spikes caused by monsoonal electrical storms (mainly October-February) and corruption due to oscillations of the suspended fluxgate sensor caused by long-period surface waves from significant regional earthquakes remain in the data.

Absolute instruments

The principal absolute magnetometers used at Kakadu and their adopted corrections for 2006 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). 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 2006 were determined through instrument comparisons performed during maintenance and calibration visits in November 2004, May 2006, and September 2006, 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. These corrections were applied during the determination of baselines.

At the 2006 mean magnetic field values at Kakadu the D, I, and F corrections translate to corrections of:

$\Delta X = -0.5$ nT $\Delta Y = +0.5$ nT $\Delta Z = -0.5$ nT

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

Baselines

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

	σ		σ
X	0.6 nT	D	6"
Y	1.0 nT	I	4"
Z	0.9 nT	F	0.5 nT

The baselines aligned with the 2005 baselines to within 0.5 nT. Drifts of -1.5 nT per year and +1.5 nT per year were applied to the Y and Z channels respectively.

Although no observations were made on the standard Pier A during March through to August inclusive (due to the cyclone-damage to the Absolute Shelter), observations at external Pier E in May showed that there were no baseline differences between the May and September observations.

FCheck had two meta-stable states differing by about 1 nT. There were three phases during the year:

- January to May, the dominant state was the high state (about +1 nT);
- June to August, the low state was favoured;
- September to December, the low state was dominant and FCheck was much more stable.

During the latter phase, FCheck typically varied by ±0.05 nT daily, whereas it would often vary by ±0.5 nT daily during the earlier phases. If the change between the high and low state was removed, there was still a change of about 1 nT in FCheck during the year.

The variation appeared to be caused by a slow onset change in the DMI FGE magnetometer, taking a few minutes to start and end, and therefore difficult to identify. The change in any vector component appeared to be no more than 1 nT. (This problem has been described in a previous report.)

During 2006 the difference between the KDU absolute and variometer GSM-90 magnetometers was consistent to within ±0.5 nT. No seasonal variation was noticeable during that period. Most variation occurred from September onwards suggesting that there may be some error in the observation technique of the new observer, but this is yet to be investigated.

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

Operations

Rory Lynch, the local observer until February 2006, was trained in geomagnetic observations in late 2003 and began observations in January 2004. Due to other commitments, he was unable to make as many observations as is customary at geomagnetic observatories. Fortunately the DMI FGE magnetometer baselines appear to have been exceptionally stable throughout 2006 and the fewer than normal number of observations did not seem to affect the quality of the final data.

Following Rory Lynch's departure, another operator was trained but later declined to take up the position. In April a cyclone caused a tree to crush the roof of the Absolute Shelter. Repairs were not finished until June. Andy Ralph was trained on site in September and continued to be the local operator thereafter.

Liejun Wang visited the observatory in May and September for routine checks, calibrations, and training. Calibrations on Pier A were not possible in May, due to the cyclone damage; however calibrations were made on the external tripod reference site (Pier E). These calibrations and others made in September (and previous differences measured between Piers A and E) showed that no contamination of Pier A had occurred during repairs to the Absolute Shelter and that there was no baseline difference detectable from data collected during the May and September visits.

QNX system data timing was controlled by the 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. From 22 January, the time corrections were logged automatically. There were no logged time corrections in excess of 1ms from 22 January. The only likely large time correction may have occurred following a system restart on 6 January.

Although some lightning protection measures were incorporated in the original construction of the observatory, Kakadu has suffered frequent damage from lightning since its installation in 1995. Further lightning protection measures were taken in December 1998 and again in October 1999. Since then, although power and communications have frequently been interrupted, the observatory has survived serious damage from electrical storms.

When possible, absolute observations were performed weekly by 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.

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

The Control House containing the variometer electronics was maintained at a temperature of about 23°C. The temperature control unit combined both heating and cooling. The DMI FGE magnetometer electronics temperature was 27.6 ±0.7°C during the year. During October-November it rose as high as 30.7°C. The DMI fluxgate electronics temperatures had a typical daily variation of less than 0.25°C in January, when temperature control was at its best, and 1.5°C in October-November when temperature control was at its worst.

There were three phases of temperature stability during the year, tantalisingly similar in timing to the three phases of FCheck behaviour. No doubt there is some direct or indirect connection.

The DMI sensor, although buried underground, varied between 27.6°C and 33.5°C during the year, in accordance with the seasons in long periods, and probably with the barometric pressure systems in short periods. Daily variations were about 0.25°C.

The DMI FGE magnetometer maintained stable baselines throughout the year, except for the frequent transitions between the 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 stable in either the shifted or un-shifted state. The occasional sets of absolute observations in early 2005 that straddled a shift seemed to indicate that no component was shifted by more than 1nT, 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 been resolved.

Data losses at Kakadu in 2006 are identified in Table A.1.

Significant events

2006-02-19 Rory Lynch's last observation and observatory visit before leaving the area for new employment.

2006-05-15 to 05-19. Visit by LJW for normal maintenance and to train new observer. Discovered that a tree had fallen onto the Absolute Shelter, following Cyclone Monica Apr 17. The roof was crushed to just above Pier A, but the pier was not damaged. The Control Hut and variometer pits were not damaged.

Observations were made at the external tripod reference site Pier E to constrain baselines. Instrument comparisons and tests were made on Pier E.

Kristine Seeleither was trained as a new observer (later decided not to accept the position).

2006-05-17 06:00 Commence applying the INTERMAGNET filter to real-time delivery of 1-minute data.

05:30-06:15 Vehicles in area to clean up fallen trees.

2006-05-18 06:10-06:30 Removal of fallen tree from Absolute Shelter.

2006-06-03 to Jun 04, removal of trees overhanging Control Hut and Absolute Shelter.

2006-06-07 Builder (Tony Hergenhan) removed damaged roof from Absolute Shelter and repaired brickwork.

2006-06-13 Absolute Shelter repairs to brickwork and wooden structure completed, fallen trees removed with assistance from Rangers. Further tree removal may be required (consult Extreme Garden Care).

2006-06-19 Absolute Shelter repairs completed.

2006-07-05 Commence 1-second real-time data delivery to Ionospheric Prediction Service.

2006-09-13 to 09-18. Visit by LJW. Termite damage noted in the Control Hut. Pest treatment has been arranged through Regional Pest Control. Absolute Shelter appears in good condition following repairs. Pier differences between A and E suggest that no magnetic change has occurred to Pier A following repairs. Absolute observations on A, and corrected observations on E in May agree with previous observations in February, suggesting stable baselines from Feb to Sep.

2006-09-14 to 09-16. Andy Ralph's training observations, supervised by LJW, beginning his role as local observer.

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	2007
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 1.4. Distribution of 2006 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 2006 data are shown in Figure 1.3.

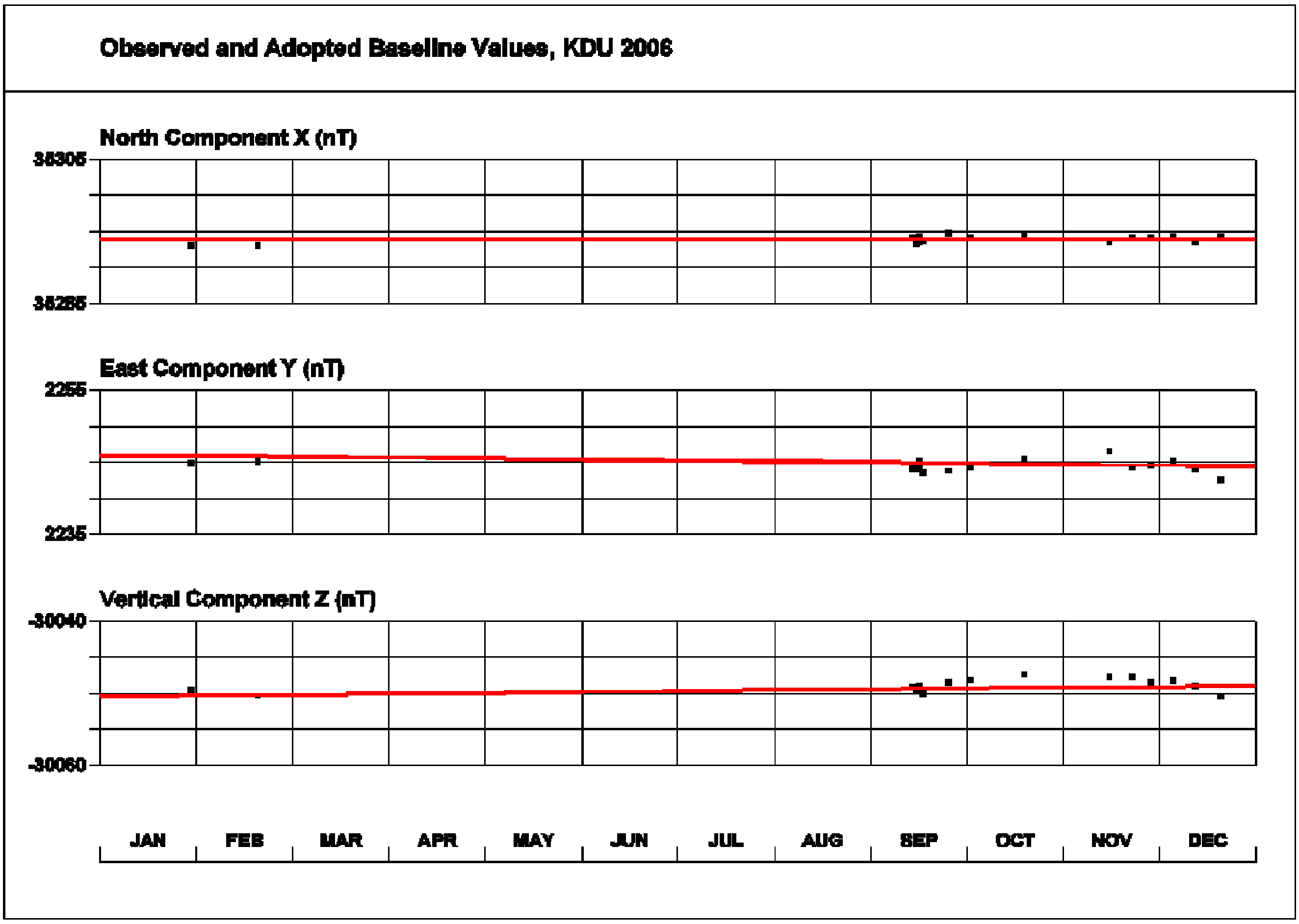


Figure 1.1. Kakadu baseline plots.

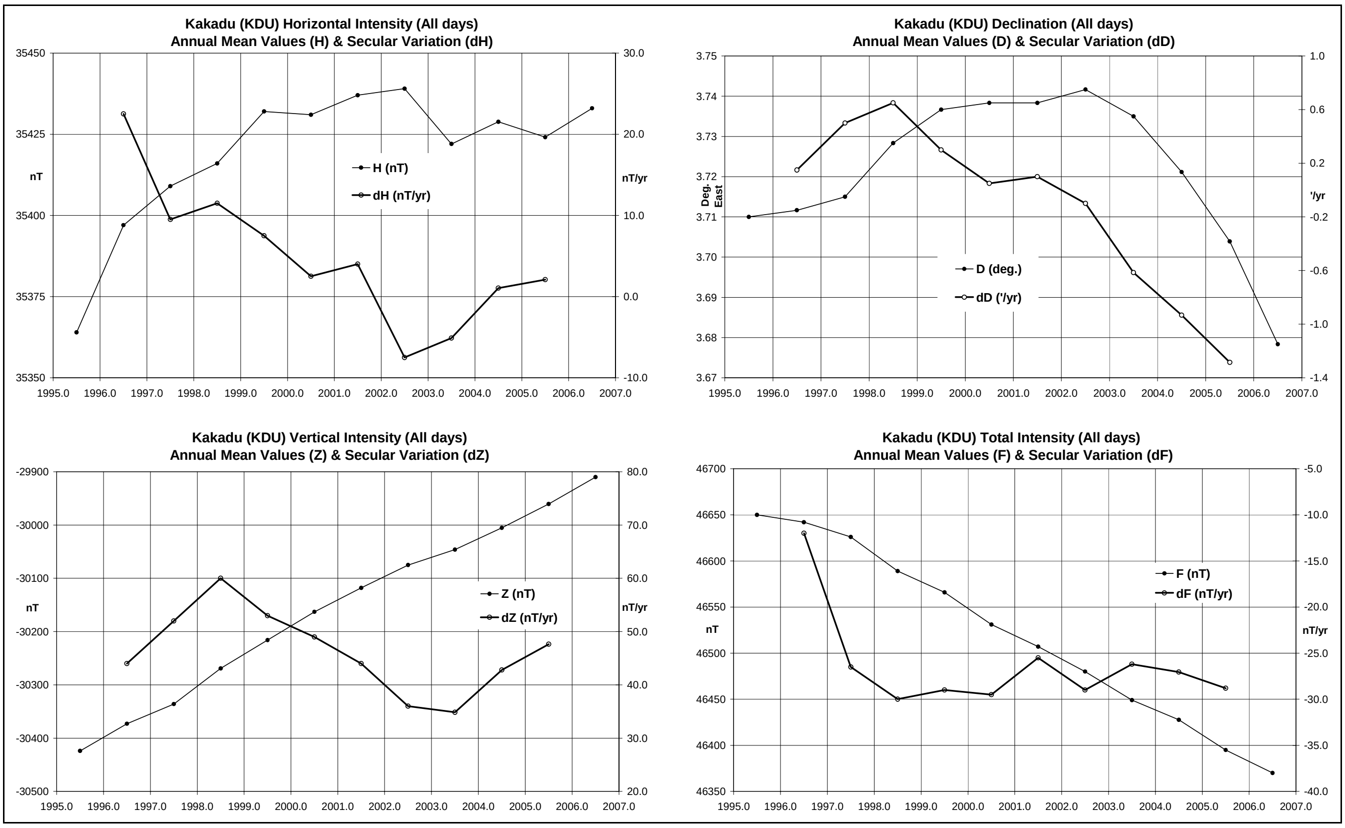
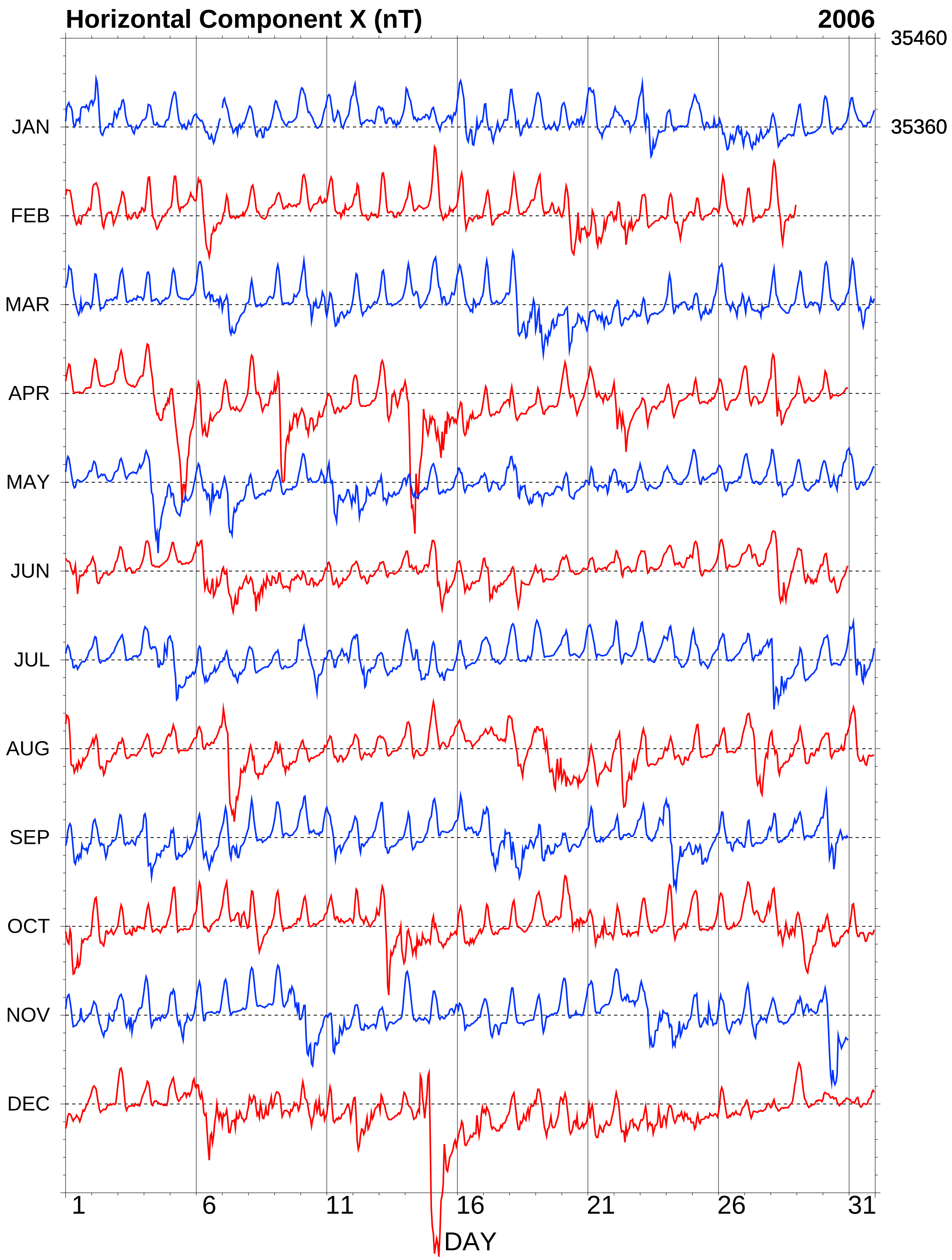


Figure 1.2. Annual mean values and secular variation for H, D, Z and F measured at Kakadu.

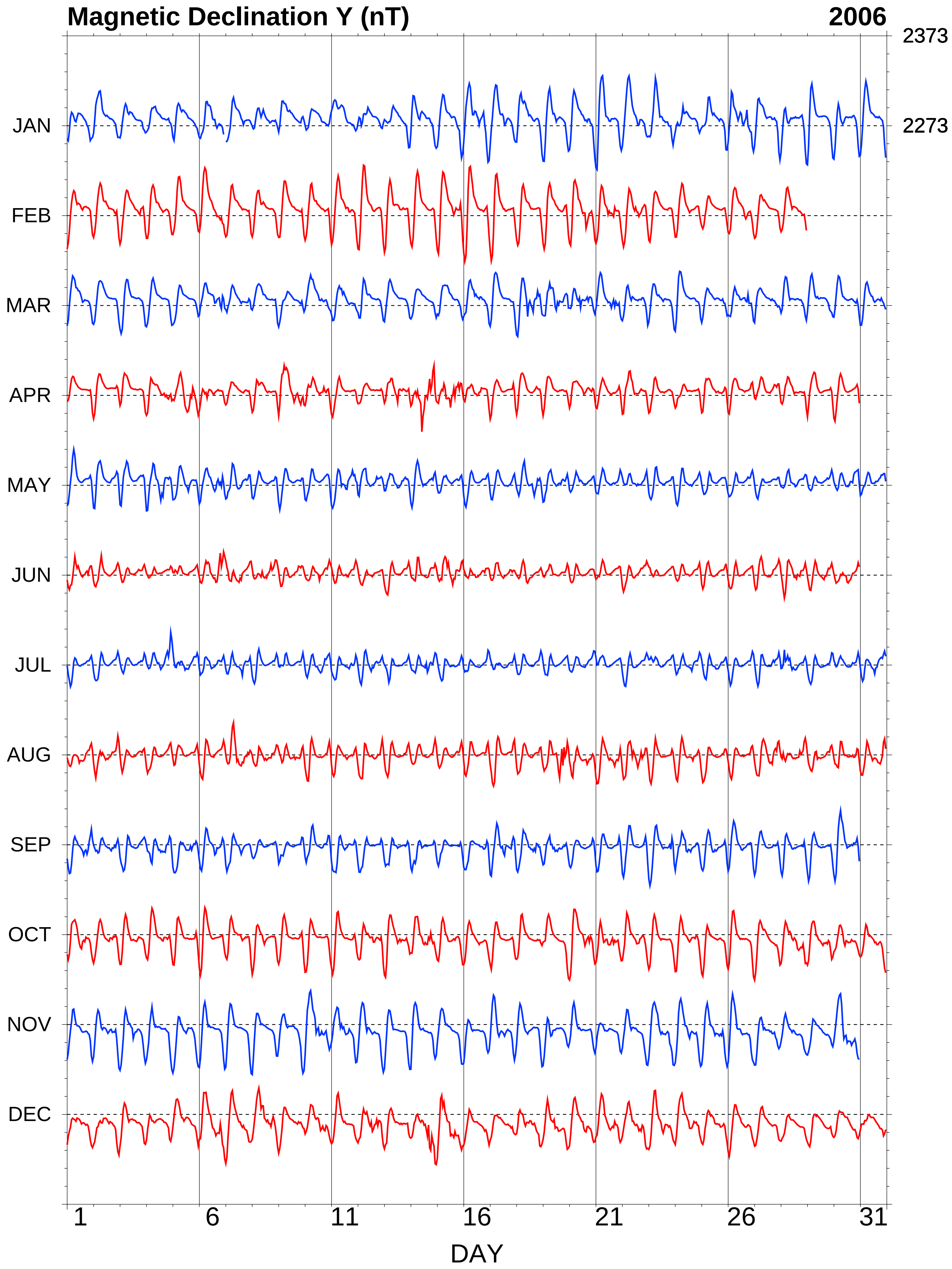
Year	**Days**	**D** (°	')	**I** (°	')	**H** (nT)	**X** (nT)	**Y** (nT)	**Z** (nT)	**F** (nT)	**Elements**
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABZ
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABZ
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABZ
1998.5	A	3	43.7	-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
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
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

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.

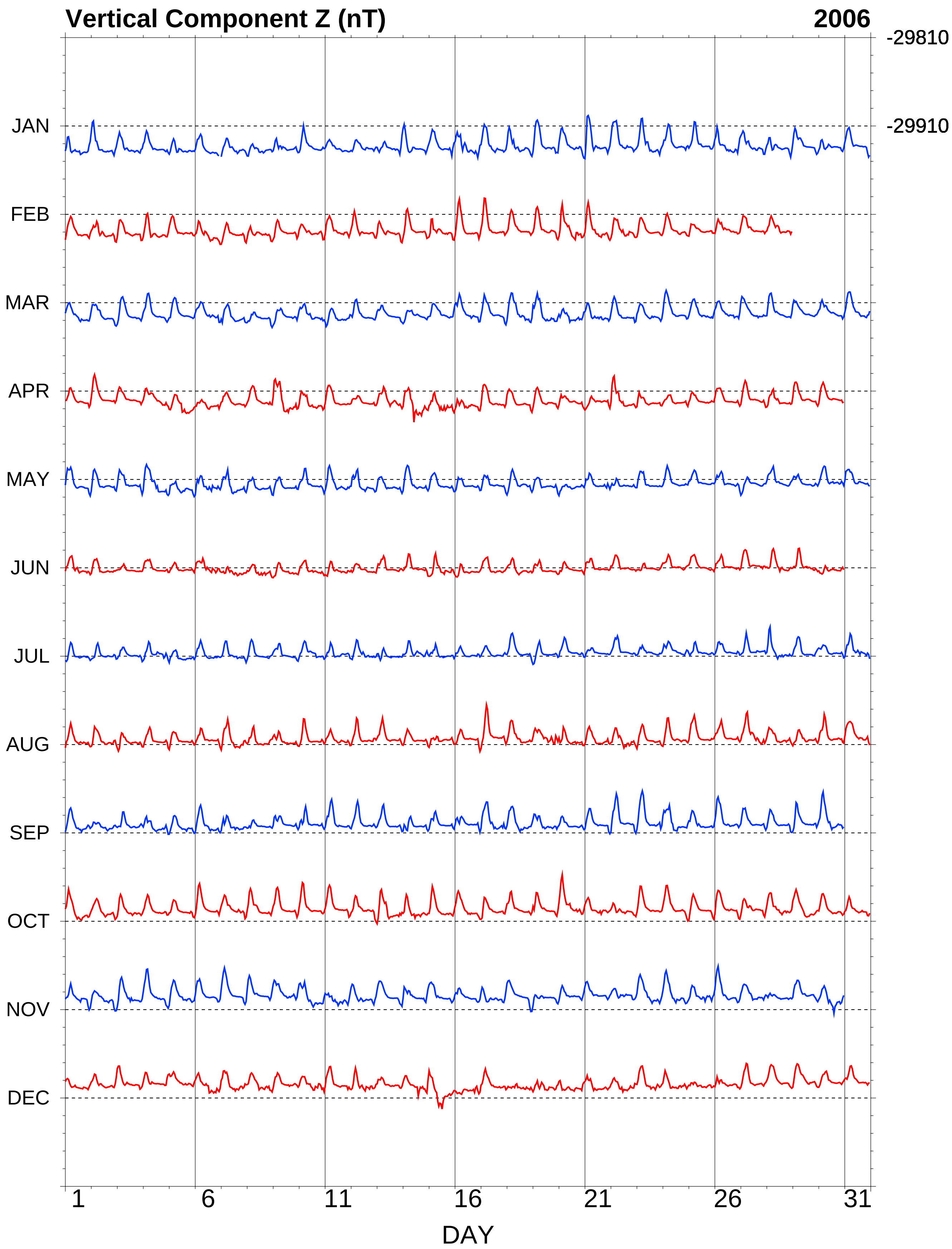
KDU - Hourly Mean Values



KDU - Hourly Mean Values



KDU - Hourly Mean Values



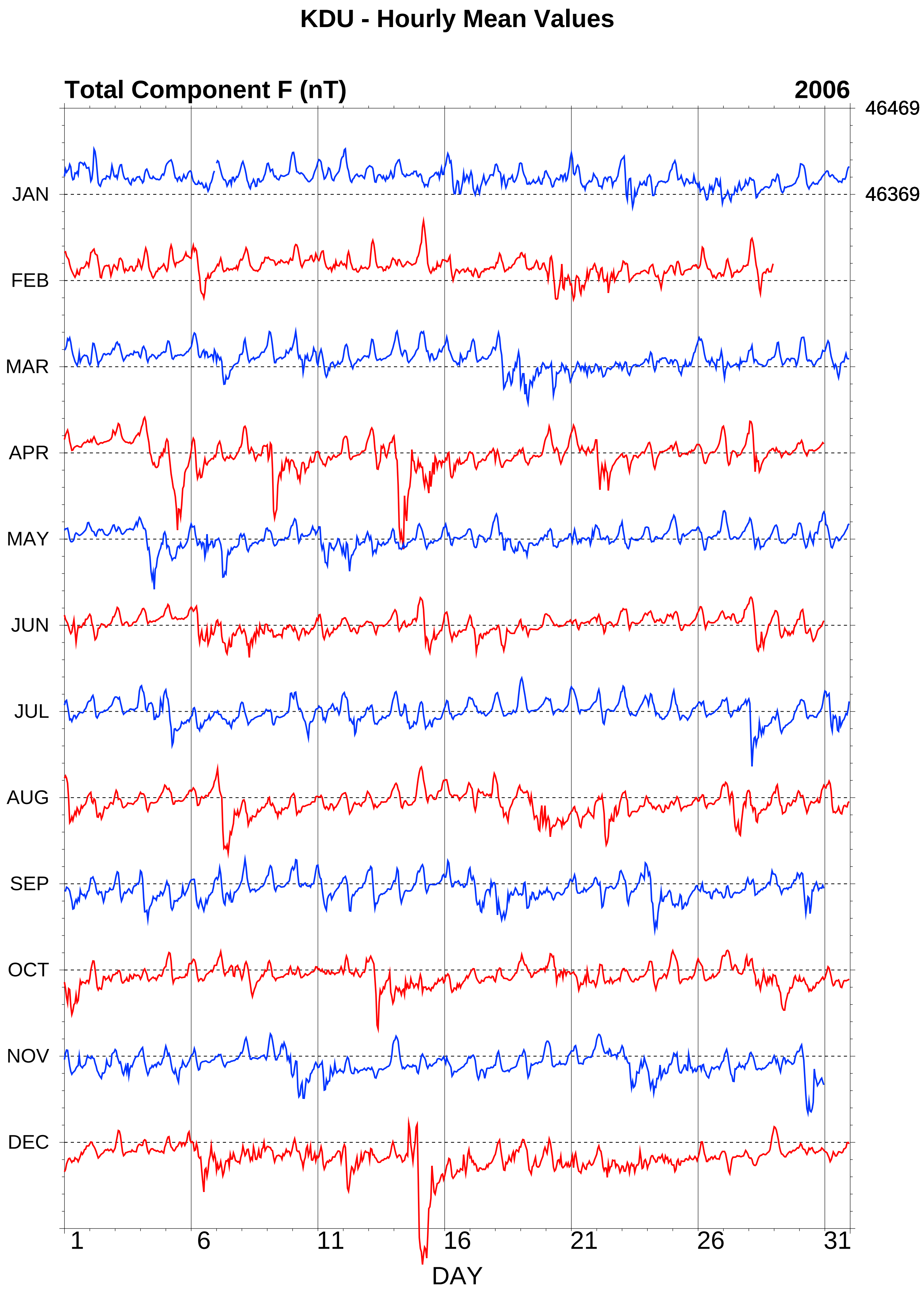


Figure 1.3. Hourly mean values in X, Y, Z and F measured at Kakadu.

2. Charters Towers

Charters Towers is approximately 120 km southwest of Townsville in north Queensland. The Charters Towers magnetic observatory is located at Towers Hill, 1.7 km southwest of the town centre, in an area leased to Geoscience Australia by the Charters Towers 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. A detailed history is given in Hopgood and McEwin (1997).

IAGA code:	CTA
Commenced operation:	June 1983
Geographic latitude:	20° 05' 25" S
Geographic longitude:	146° 15' 51" E
Geomagnetic latitude:	-27.84°
Geomagnetic longitude:	220.99°
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. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 are described in Table 2.2.

The DMI FGE fluxgate sensor was installed on a concrete block in the mine tunnel. Before installation its scale-values, relative sensor alignments and temperature sensitivities were determined at the magnetometer calibration facility at Canberra observatory.

The total-field variometer sensor was suspended from the ceiling of the tunnel. The digital output from this instrument was input directly to the acquisition computer. The PPM variometer served as both an FCheck and a backup, should any one of the channels of the fluxgate variometer become unserviceable.

Although not actively controlled, the temperature within the tunnel where the variometers were located varied very little over the year – from about 27°C in winter to about 29°C in summer. There was no discernible diurnal temperature variation in the tunnel. The control electronics associated with the variometers (with the exception of the DMI fluxgate magnetometer electronics) were housed in an air-conditioned (for cooling) room in an adjacent arm of the tunnel.

Time was taken from the acquisition computer system clock. The computer did not have an attached external GPS clock. On weekdays the PC clock was checked and set remotely from Geoscience Australia in Canberra.

Data files were telemetered from Charters Towers to Geoscience Australia through a network. The data transfer delay time was 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.

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:	Acquisition PC clock
Communications:	TCP/IP (until mid-May) VSAT link (after mid-May)

Table 2.2. Magnetic variometers.

Absolute instruments

Variometers were calibrated by weekly absolute observations on Pier C in the absolute shelter. The principal absolute magnetometers used and their adopted corrections for 2006 are described in Table 2.3.

At the 2006 mean magnetic field values at Charters Towers the D, I and F corrections translate to corrections of:

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

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

DI fluxgate:	DMI
Serial number:	DI0036
Theodolite:	Zeiss 020B
Serial number:	394050
Resolution:	0.1’
D correction:	0.00’
I correction:	0.00’
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 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Baselines

In 2006 the fluxgate variometer baseline drifts in X, Y and Z were within a 6, 10 and 4 nT range, respectively. The drifts were examined from an FCheck plot and, with reference to the PPM variometer, seem to have been mainly associated with fluxgate variometer baseline drifts.

At 21:45UT on 3 May, a steel rack inside the tunnel was moved, causing a variometer baseline jump. By examining the absolute observations and magnetogram, the jump value for X, Y and Z was determined to be:

dX = 4.3 nT, dY = 6.0 nT, dZ = 7.7 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	13"
Y	1.9 nT	I	4"
Z	0.7 nT	F	0.5 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 2006 (as the difference between 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 measurement in tunnel;
- mailing the observation-sheet and log-sheet to GA.

Data losses at Charters Towers in 2006 are identified in Table A.2.

Significant events

2006-01-02 01:00 With JMM's assistance, trying to fix the telemetry problems that have been occurring. Couldn't dynamically fix it using ifconfig en0/en1 up/down commands, but eventually talked JMM through using vi to change ref to en0->en1 and remove old reference to en1.

Rebooted yet again and had access for a while (other Telstra problems interfering as well). From now, there appears to be no functioning en0, but en1 is ok.

Problem seems to have started last Friday just after 00:00 UT when seismic/mag telemetry failed probably after lightning. Reboots failed to fix the problem on Monday (I think). When the line was fixed seismic came back but not mag.

Resultant missing data:

09 Jan 00:04 - 23:35

11 Jan 05:14 single point

12 Jan 01:02 single point

2006-02-14 Commenced real-time data delivery to IPS.

2006-03-31 Noticed that NTP at CTA had failed - added server 192.55.112.1 as well as 192.55.112.40 and restarted ntp, and it seemed to work.

2006-04-04 from 03:00 PC failed. no data from 03:00

2006-04-10 JMM replaced the QNX PC last Friday 7 Apr 2006, but no link to GA and no data came through. LM/PGC/JMM fiddled with cables etc. and eventually swapped the en1 cable to the only spare port in the hub, and voila - it came up and data started flowing. Between 03:36 and 03:50 I would say NTP corrected the time, although at 03:50 still no drift file entry had been made. At 03:30, CTA was 11.105s FAST.

There was also a problem with the "netstat -rn" output. It had 10.1.1.100 on lo0 strangely.

It appears that the hub port was damaged at the same time the computer was damaged last week. Also had to set up user "nobody" and script "pips" to get time pips for Jack.

faulty QNX returned to Canberra. S/N049CQ0096

2006-05-03 LM at CTA changed the network to VSAT. Lost some data about 07:00 (probably PGC testing the GPS clock). ntp probably won't work after the network changes so GM_GPS16 installed about 07:00, and worked ok (reboot required about 07:00 to reconnect to the system). IP changes soon to follow. ~21:45 BL change may be LM moving rack for VSAT installation

2006-05-04 Ethernet card for sat modem or something or other not compatible - VSAT will not be implemented yet, maybe in a week or so.

2006-05-04 Observations indicated a baseline shift. It may be due to a steel object (possibly a rack) inside the tunnel being moved. It happened at 21:45 03 May.

2006-05-17 06:00 commenced INTERMAGNET filtering of 1 minute RT data delivery

2006-07-05 00 commenced delivery of 1-second RT data to IPS

2006-08 plumbing repairs in tunnel are scheduled some time in August/September.

2006-11 modem sent to CTA

2006-12-03 ~23:30 Modem installed on ser1 and switched on for PPP connections

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	2007
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 2.4. Distribution of 2006 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 2006 data are shown in Figure 2.3.

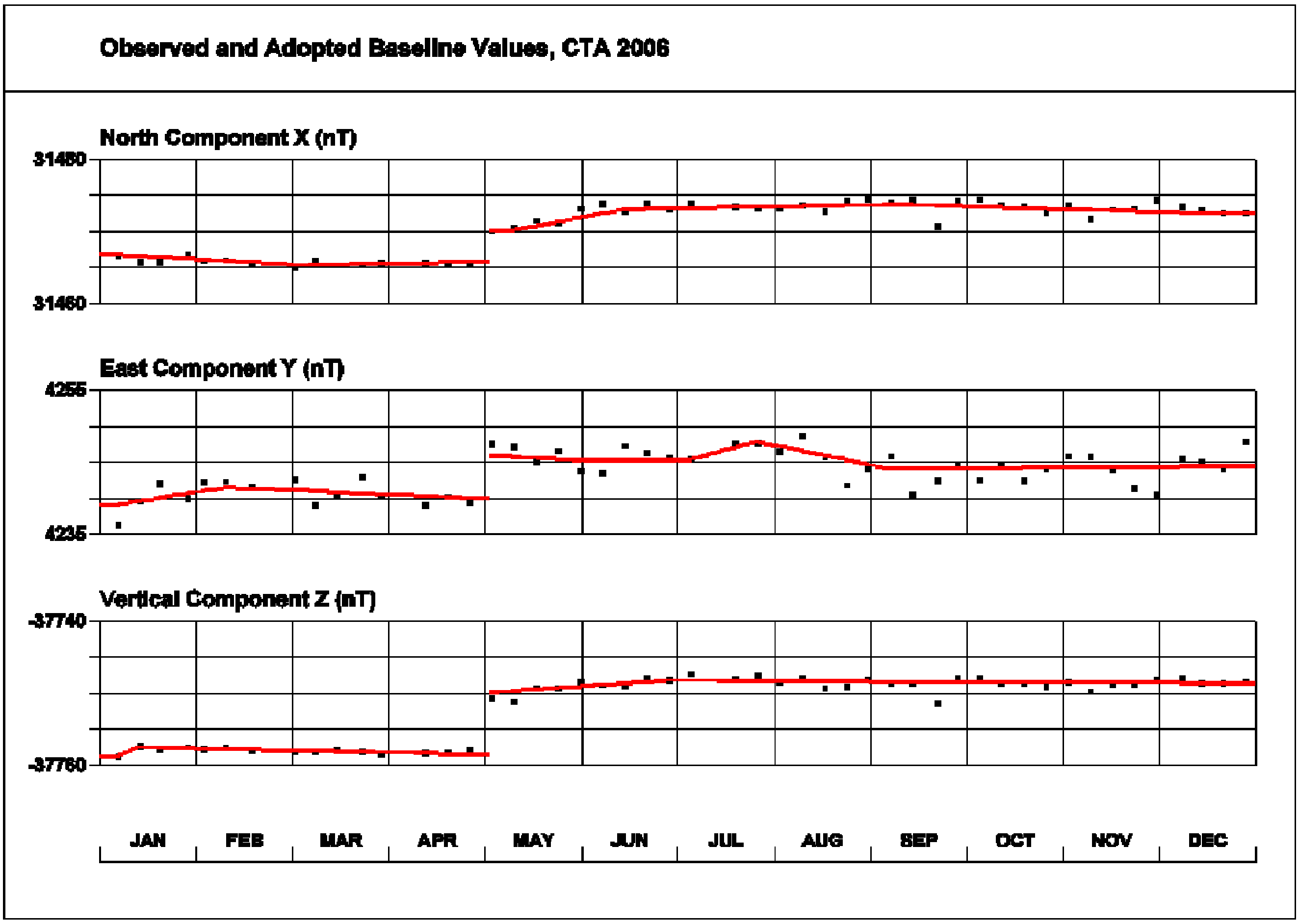


Figure 2.1. Charters Towers baseline plots.

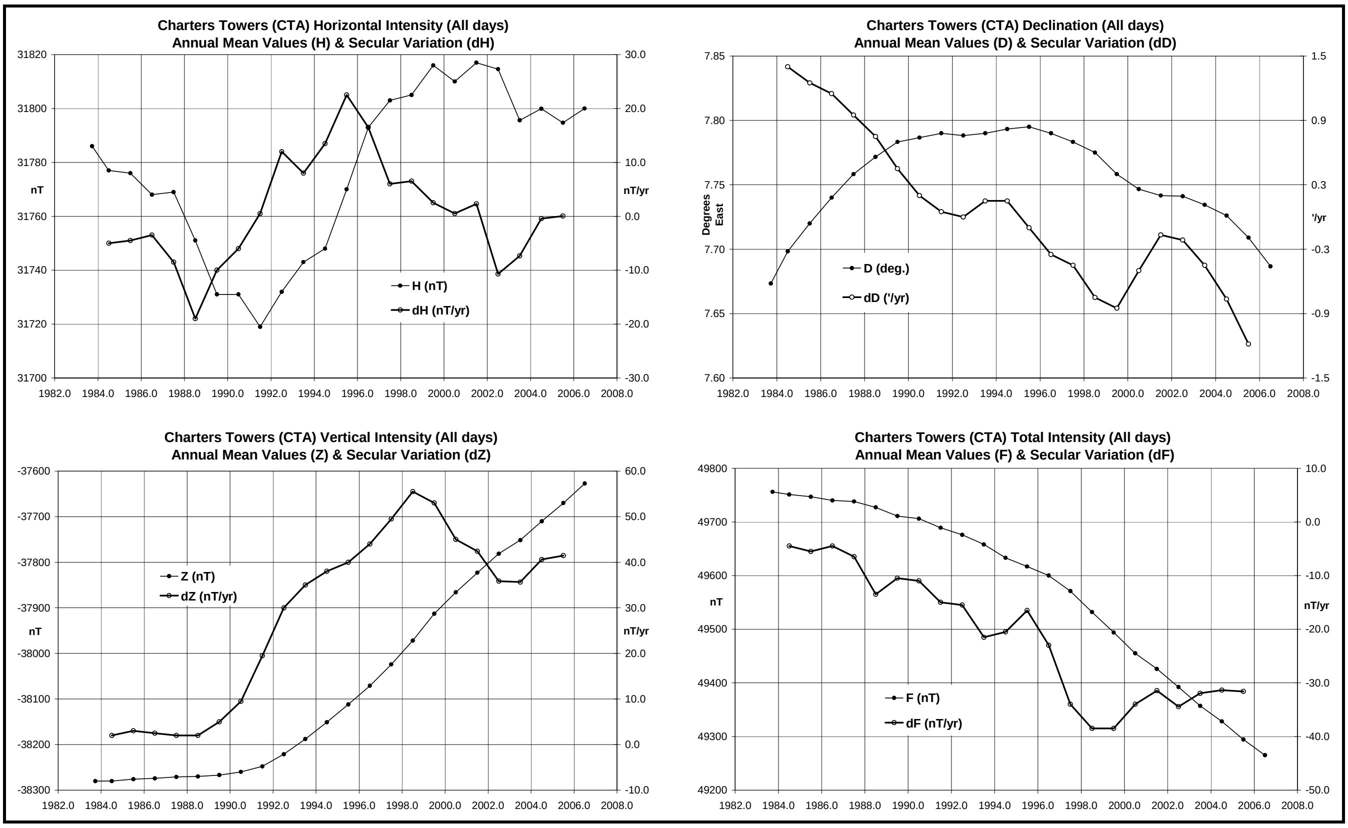


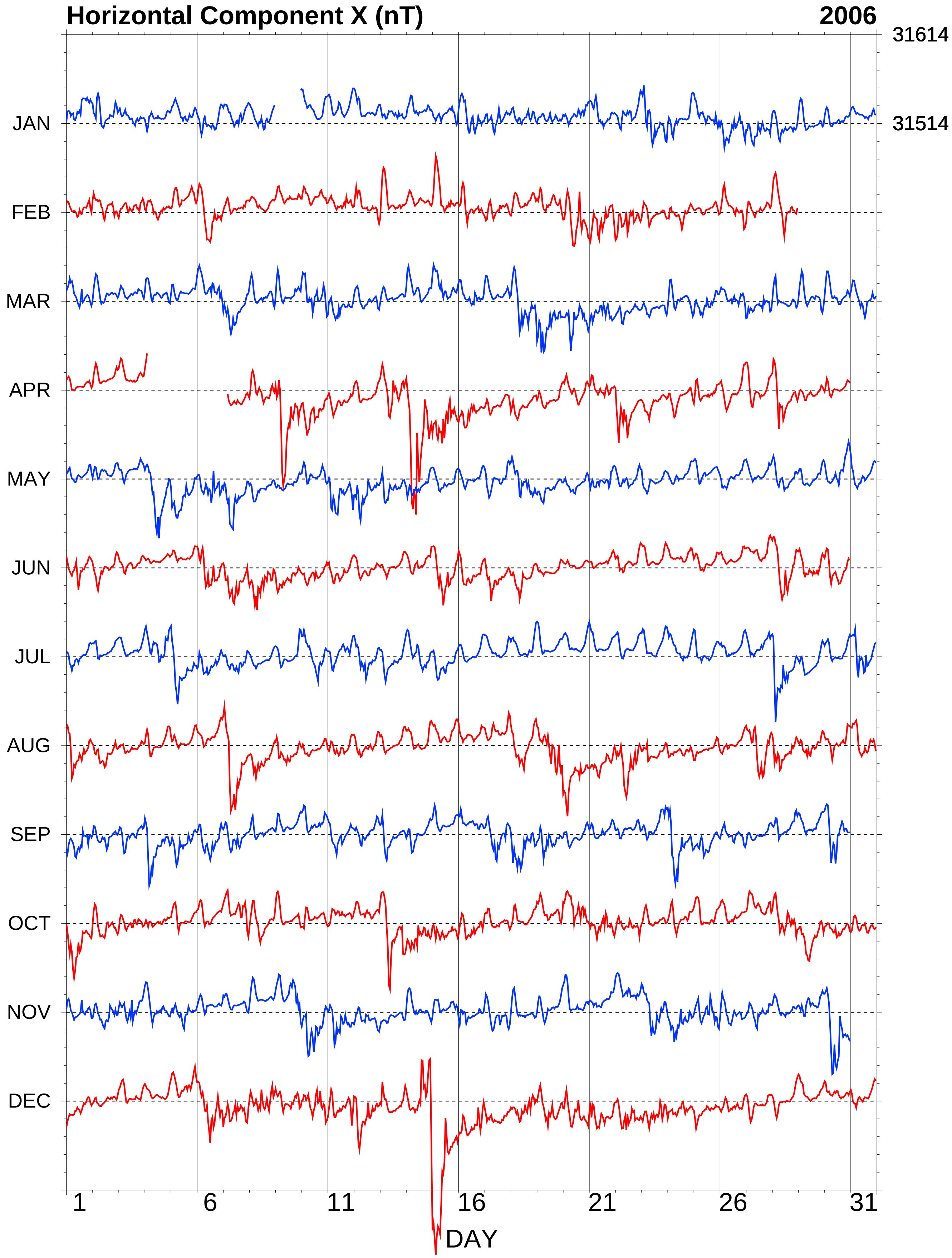
Figure 2.2. Annual mean values and secular variation for H, D, Z and F measured at Charters Towers.

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
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
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

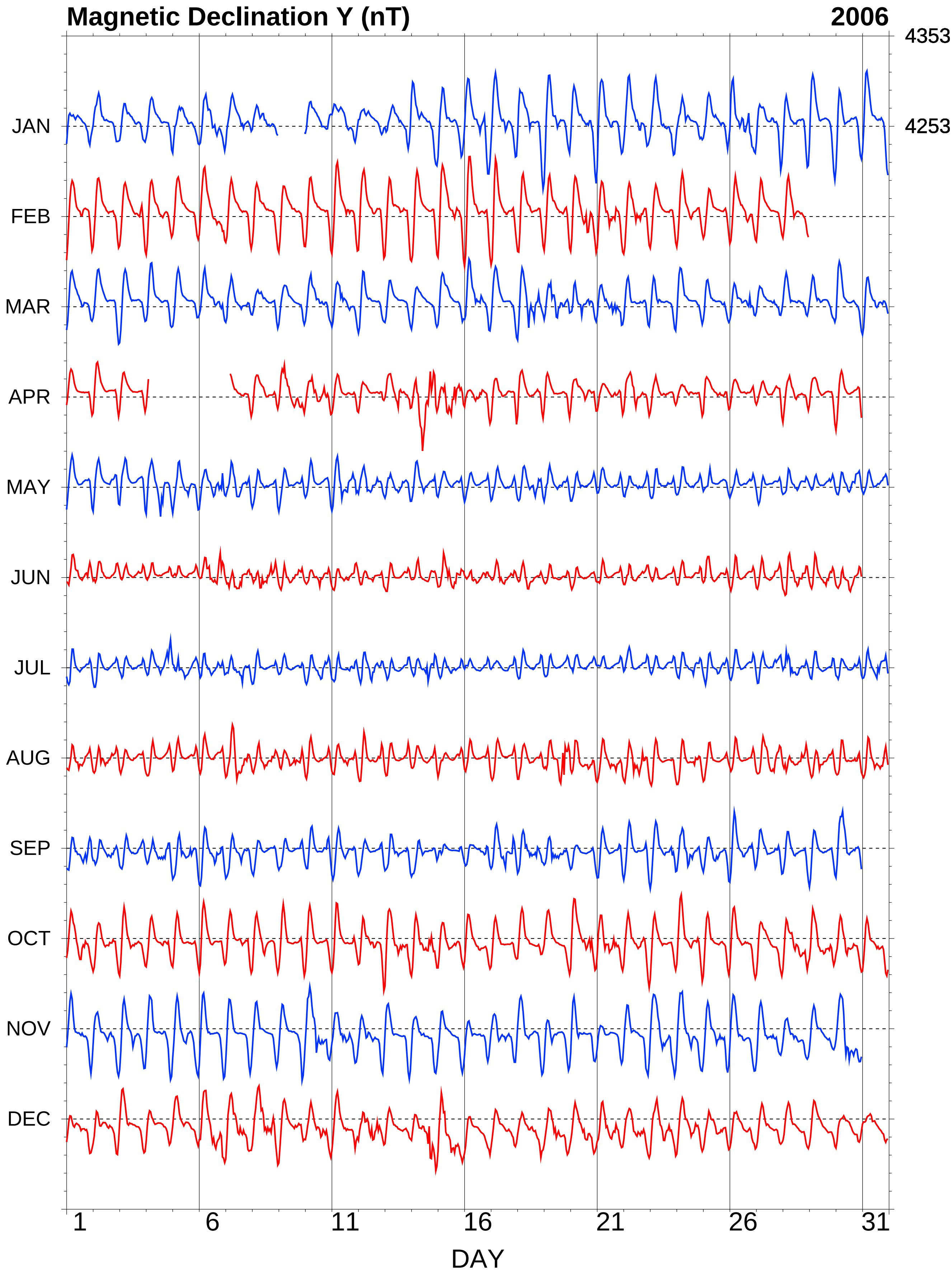
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABZ
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABZ
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABZ
2004.5	D	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	ABZ
2005.5	D	7	42.4	-49	51.3	31774	31487	4261	-37673	49283	ABZ
2006.5	D	7	41.2	-49	48.6	31787	31501	4252	-37629	49258	ABZ

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.

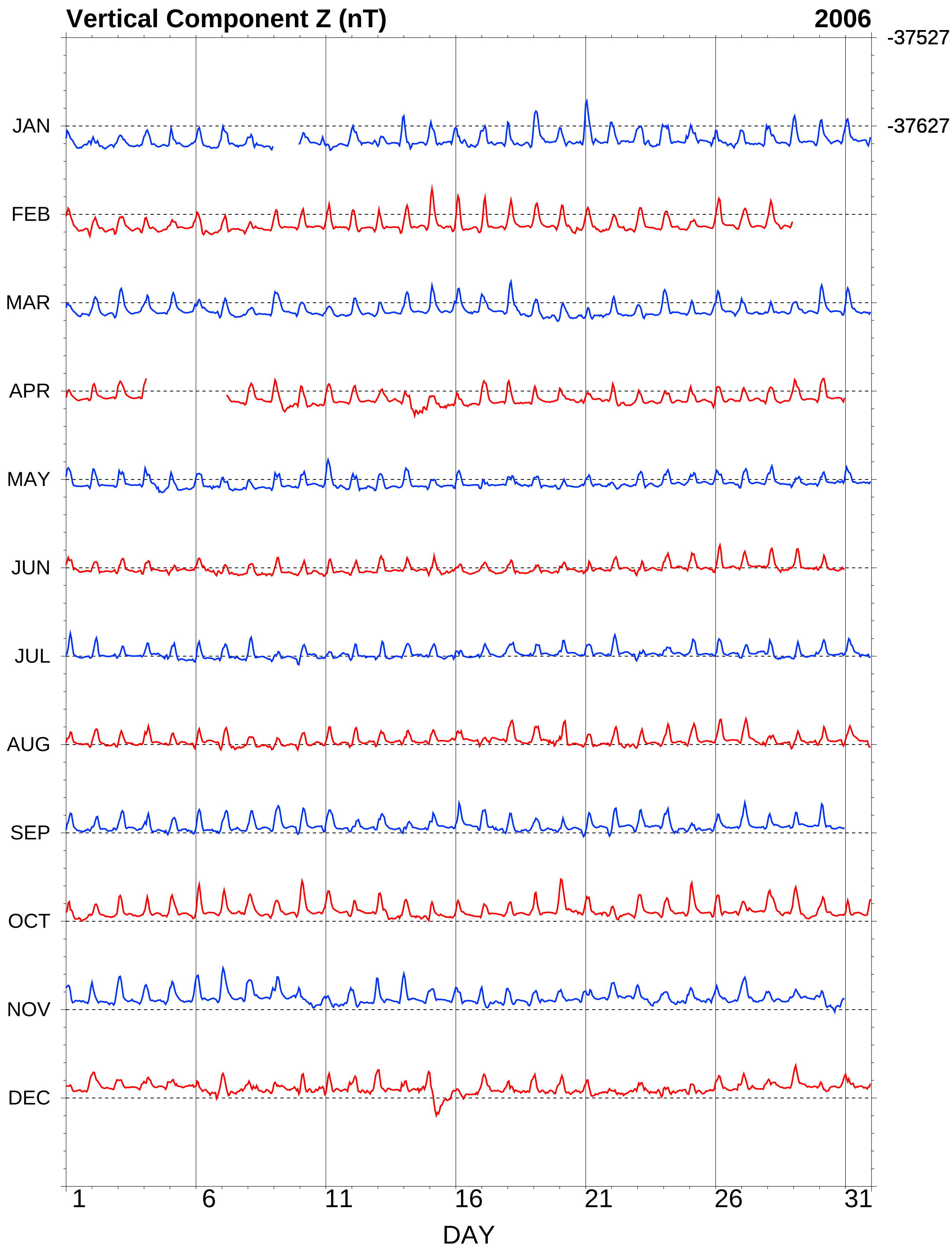
CTA - Hourly Mean Values



CTA - Hourly Mean Values



CTA - Hourly Mean Values



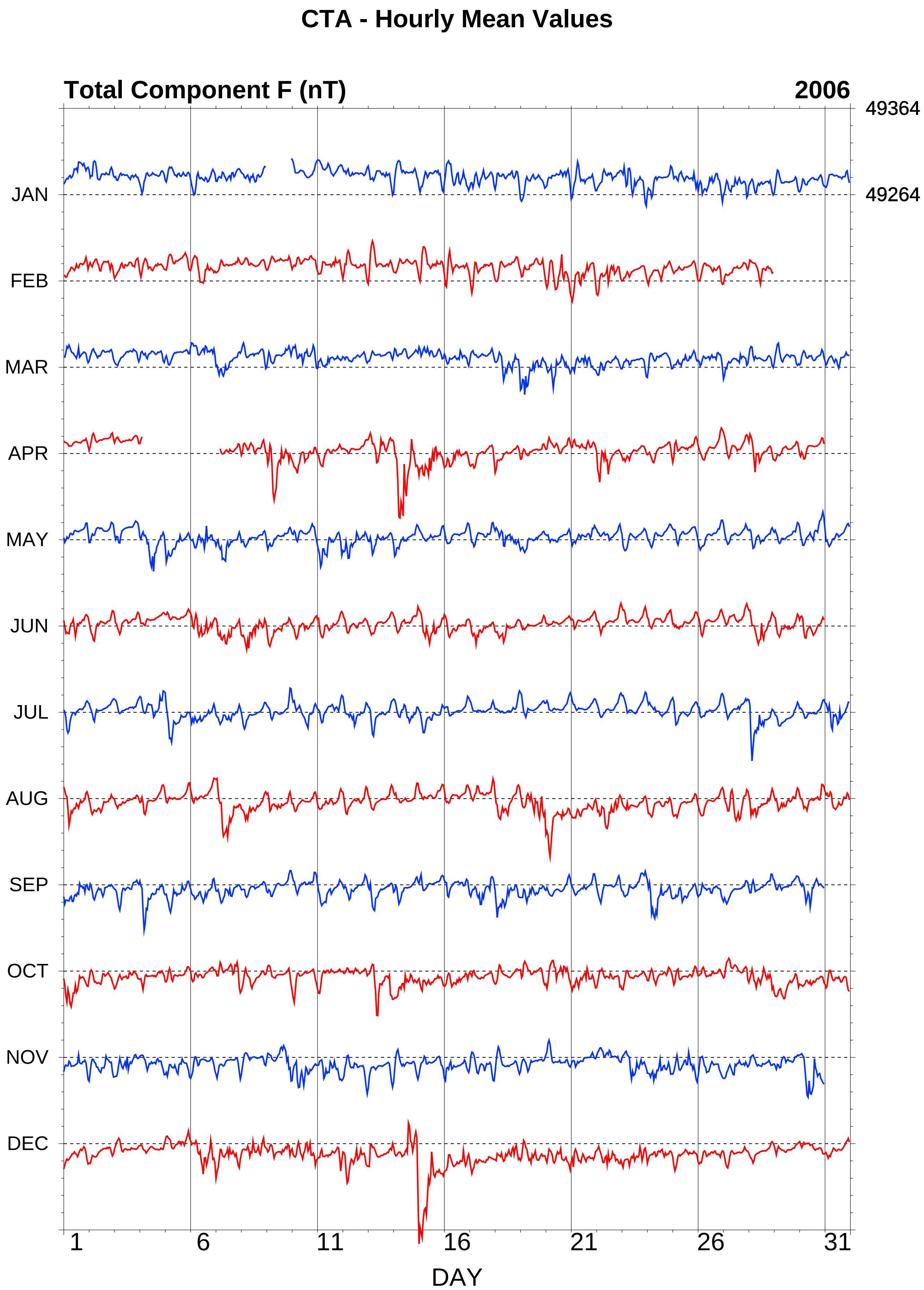


Figure 2.3. Hourly mean values in X, Y, Z and F measured at Charters Towers.

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 observatory consists of:

- three underground vaults located on IPS land, housing variometer sensors and control equipment;
- an Absolute Shelter located on RAAF land, and;
- an external station on RAAF land.

IAGA code:	LRM
Commenced operation:	November 1986
Geographic latitude:	22° 13' 19" S
Geographic longitude:	114° 06' 03" E
Geomagnetic latitude:	-32.22°
Geomagnetic longitude:	186.51°
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:	S. Pryde (until 29 June) A. Brockman (from 3 July)

Table 3.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 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. Until 22 November the fluxgate sensor was housed in a 600×600×800 mm underground concrete vault with the fluxgate electronics housed in another small underground plastic vault. The PPM sensor was located in a third underground polyethylene cylindrical vault (600 mm diameter) which was situated about 10 m from the fluxgate vault. All vaults were covered with local sand or gravel and some had foam insulation to minimize diurnal temperature fluctuations.

On 23 November the magnetometers and control electronics were moved into three new 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. The fluxgate sensor was moved into the northernmost vault with the control electronics in the central vault. A new GSM-90 total-field sensor was installed in the southernmost vault with its electronics in the central vault.

An underground cable conduit carries 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 are powered by 240 VAC mains power. The equipment is protected from power outages and surges by an uninterruptible power supply.

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:	Geometrics 856
Serial number:	50708
Type:	Proton precession
Acquisition interval:	10 s
Resolution:	0.1 nT
Period in use:	until 23 November
Total-field variometer:	GEM Systems GSM-90
Serial number:	708729/21889
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period in use:	from 23 November
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Accutime GPS clock
Communications:	IPS dedicated data line to Sydney then via the Internet to Canberra

Table 3.2. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at Learmonth and their adopted corrections for 2006 are described in Table 3.3.

Absolute instrument comparisons were made at LRM on 10 and 11 April 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 difference between the LRM instruments and the International average (as defined by observations at IAGA instrument workshops) is given in Table 3.3. At the 2006 mean magnetic field values at Learmonth these D, I, and F corrections translate to corrections of:

$\Delta X = -2.6$ nT $\Delta Y = 0.0$ nT $\Delta Z = -1.7$ nT

These corrections have been applied to all LRM 2006 final data.

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 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Baselines

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

	σ		σ
X	1.2 nT	D	29"
Y	4.3 nT	I	5"
Z	1.2 nT	F	1.2 nT

The X, Y, and Z baseline drifts amounted to less than 10 nT in any of these components throughout the year. There was about 5 nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM throughout the year.

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

Operations

Absolute observations were performed weekly by Mr Stephen Pryde (SP) (until 29 June) and Dr Alan Brockman (from 3 July). 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 the IPS 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 2006 are identified in Table A.3.

Significant events

2006-02-06	Data contamination 22:55 - 23:59
2006-02-07	Data contamination 00:00 - 06:35
2006-03	New observer, Stephen Pryde, is having problems with absolute observations
2006-03-14	Received absolute obs of 7 March from Stephen Pryde. results are ok.
2006-03-27	04:39 variometer PPM fails, 05:33 PPM re-starts, sampling at 30s intervals.
2006-03-31	Reboot LRM at ~00:45 to recover GPS clock which was not connecting. John Kennewell rebooted the computer 2 days before to try and get GdapIPS working again (maybe after fiddling to get the G856 working, as it had failed) PPM is now only every 30s. Restarting GdapClock did not work today, but the shutdown/restart worked, Time correction was 0.688 s.
2006-04-09	to 04-14 Maintenance visited to LRM by LJW Instrument comparisons, observer training, replace DIM battery 6v 1.3Ah C20. Remote reference station obs, check azimuths and instruments, PPM resets
2006-04-10	PPM still sampling at 30 second intervals fails at 20:52
2006-04-11	03:23 Variometer PPM re-starts at 30 sec sampling interval 19:23 Variometer PPM stops
2006-04-12	04:28 Variometer PPM restarts at 10 sec sampling interval
2006-05-08	05:21 Stephen Pryde reported that there was a vehicle about 30 meters from vault.
2006-05-17	06:00 commence INTERMAGNET filtering of 1 minute reported quality real time data delivery. Observer reports that a crane will be on site on 18-19 May.
2006-05-18	Data contamination 02:50 - 03:50
2006-05-19	A black snake found near the absolute hut, hence no obs done this week
2006-06-16	Observation received. Previous one was on 12 May.
2006-06-20	Stephen Pryde reports a problem with PDA cable
2006-06-22	replacement PDA cable sent
2006-06-26	Stephen Pryde will be departing as geomag observer on 29 June
2006-07-03	Alan Brockman commences as new geomagnetic observer - numerous problems with observations over the following months
2006-07-05	00:00 commence delivery of 1-second RT data to IPS (switch off 1 minute delivery to IPS)
2006-07-07	Received the faulty PDA cable
2006-07-14	01:46 - communication to LRM lost - appears en0 network port had stalled. John Kennewell powered off/on machine to reset the network port
2006-07-25	Expect a crane to be on site at LSO 26 July to perform some work on the 28ft antenna
2006-08-11	Three new variometer vaults completed
2006-11-06	Fire reduction work scheduled for vicinity of magnetometer vaults, data contamination 01:13 - 01:15
2006-11-21	to 27 Nov AML/JWW maintenance visit to re-locate variometers to new vaults
2006-11-23	Relocating magnetometers to new vaults - no data 01:00 - 23:59
2006-11-24	Installation in new vaults - no data 00:00 - 09:00

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 2006 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 2006 data are shown in Figure 3.3.

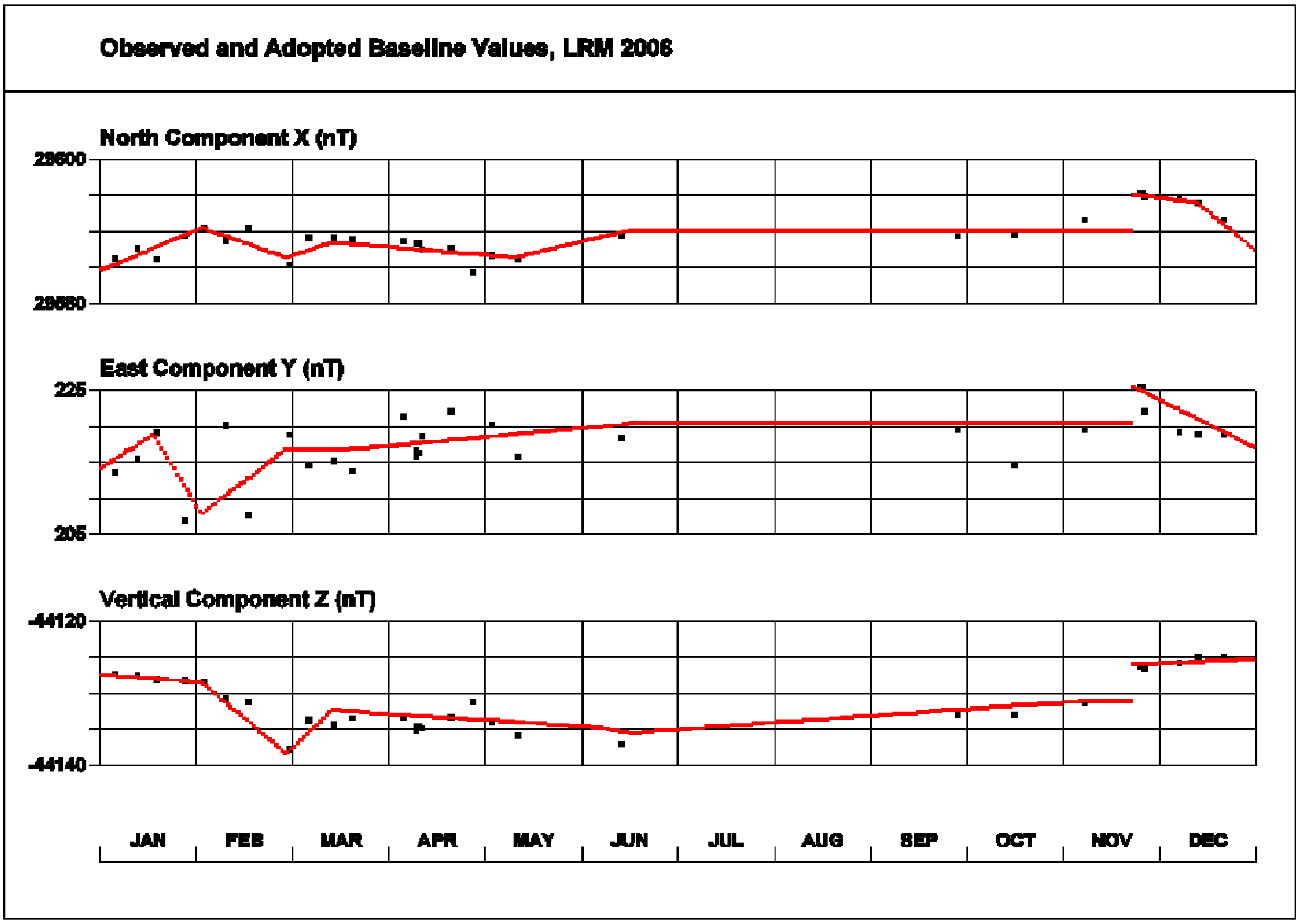


Figure 3.1. Learmonth baseline plots.

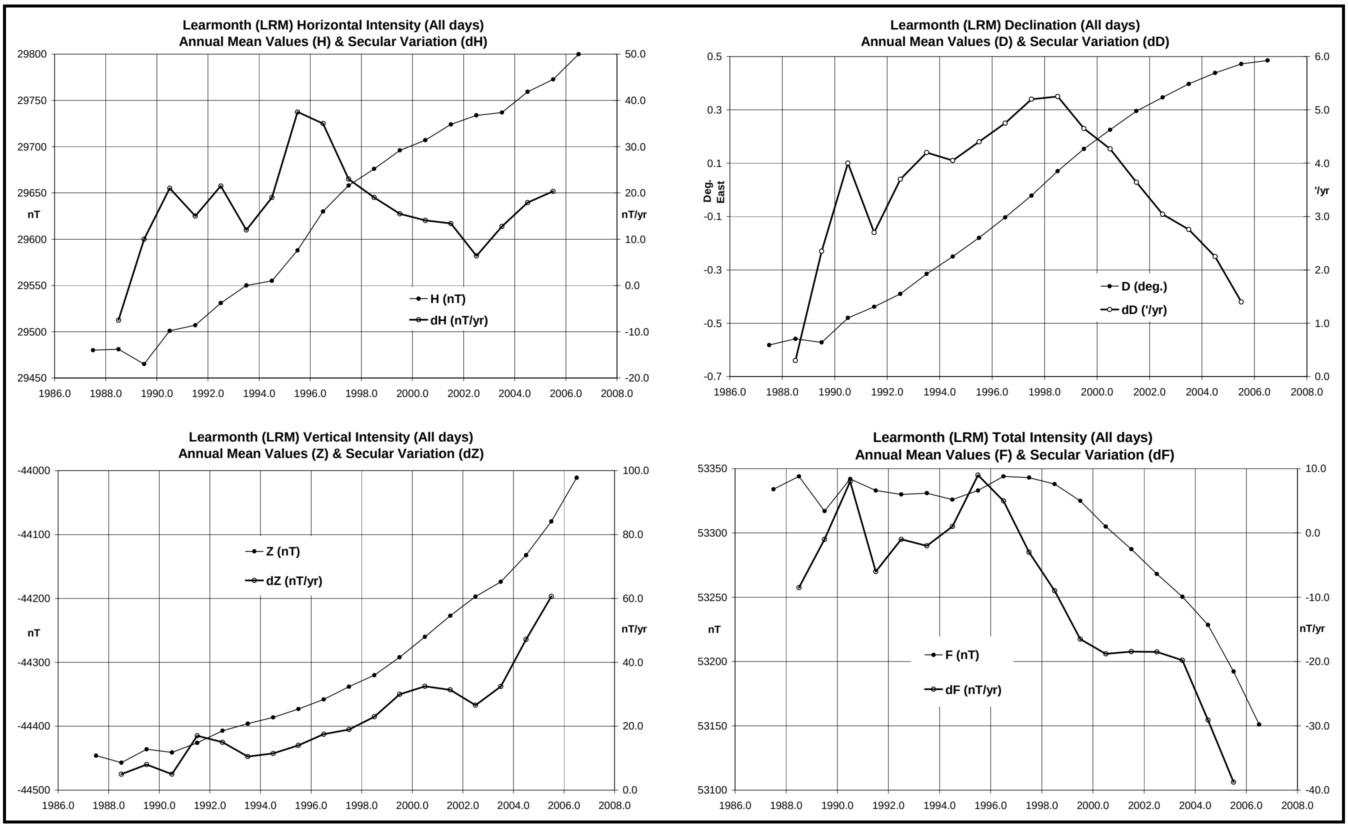
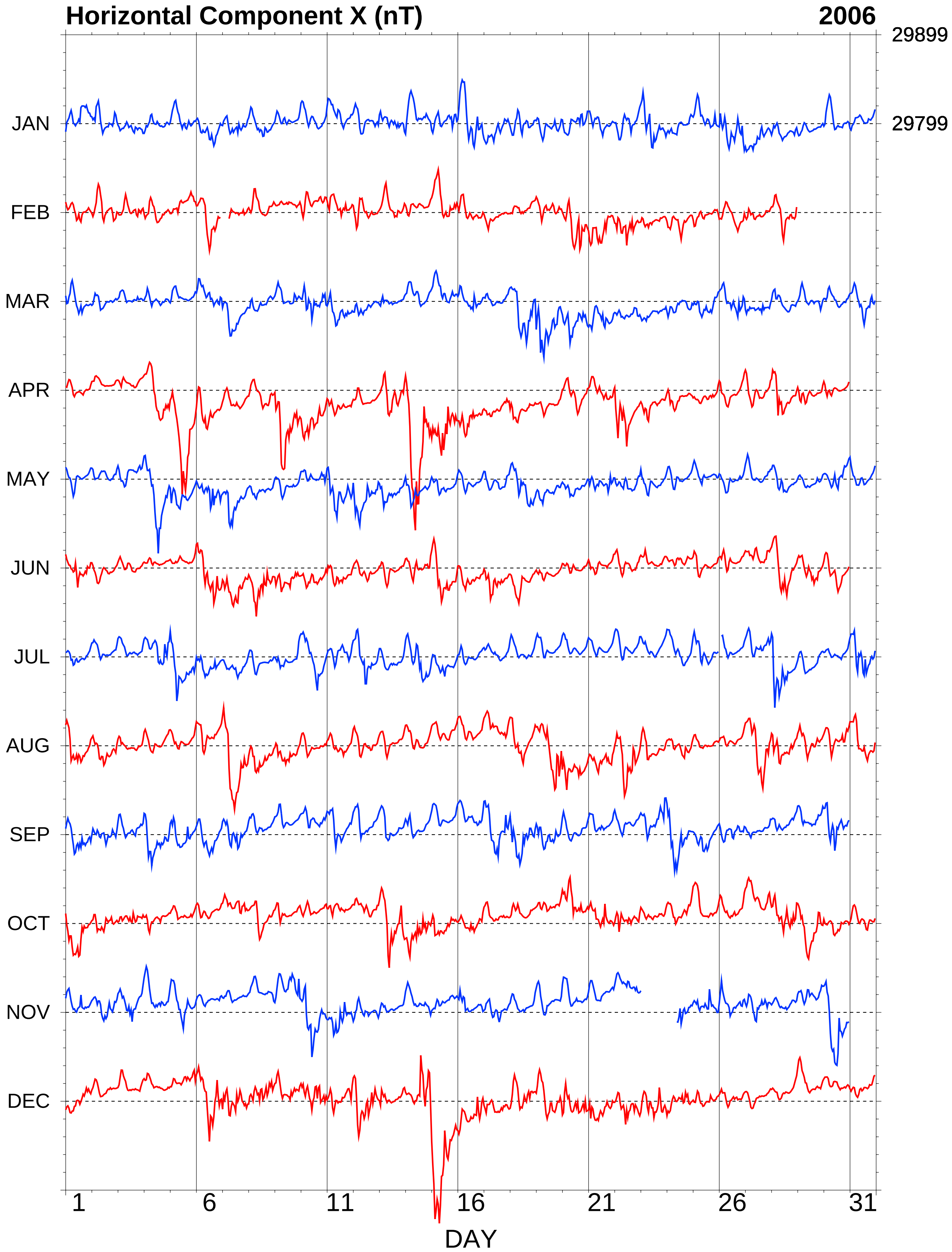


Figure 3.2. Annual mean values and secular variation for H, D, Z and F measured at Learmonth.

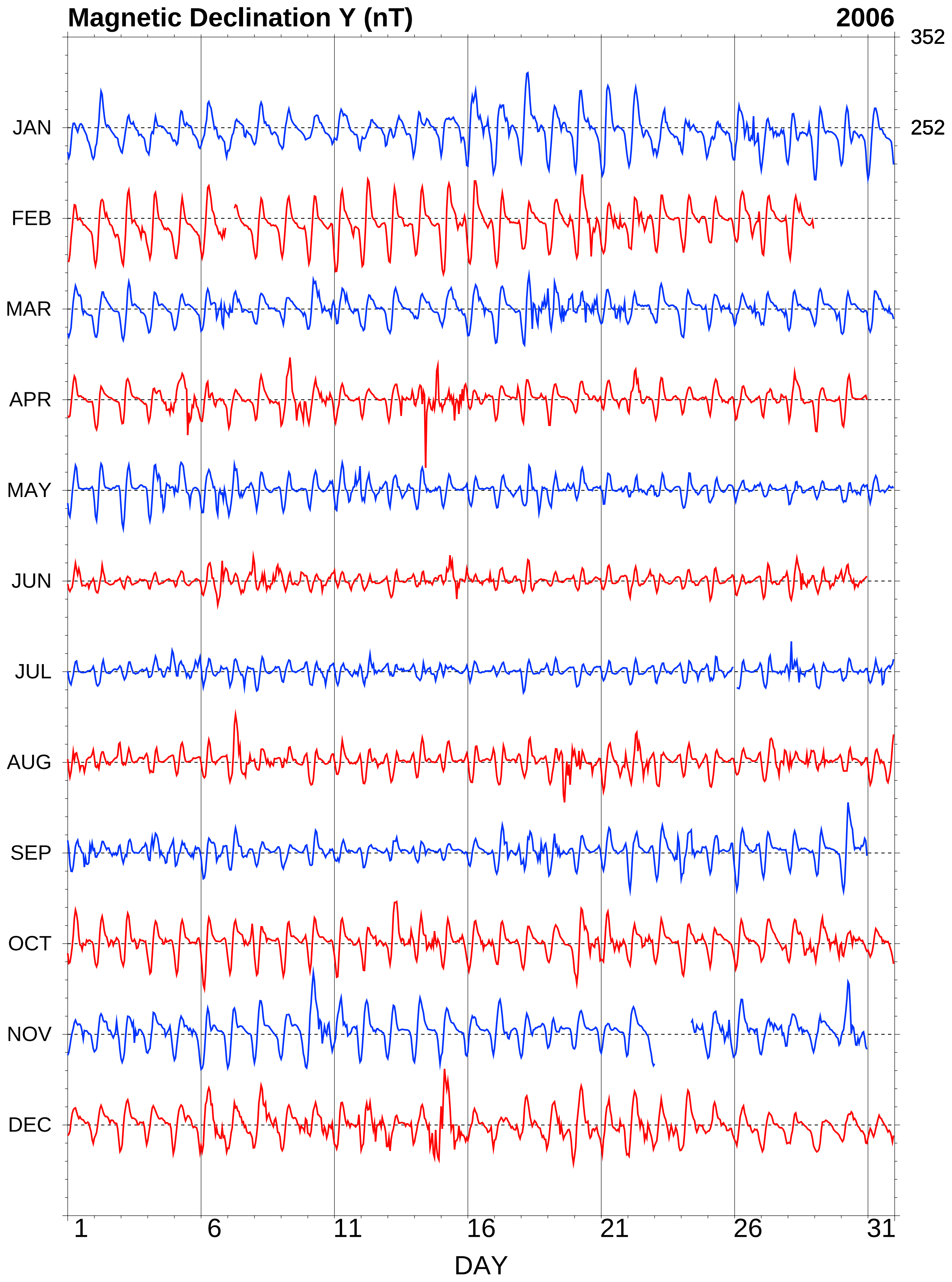
Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441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

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.

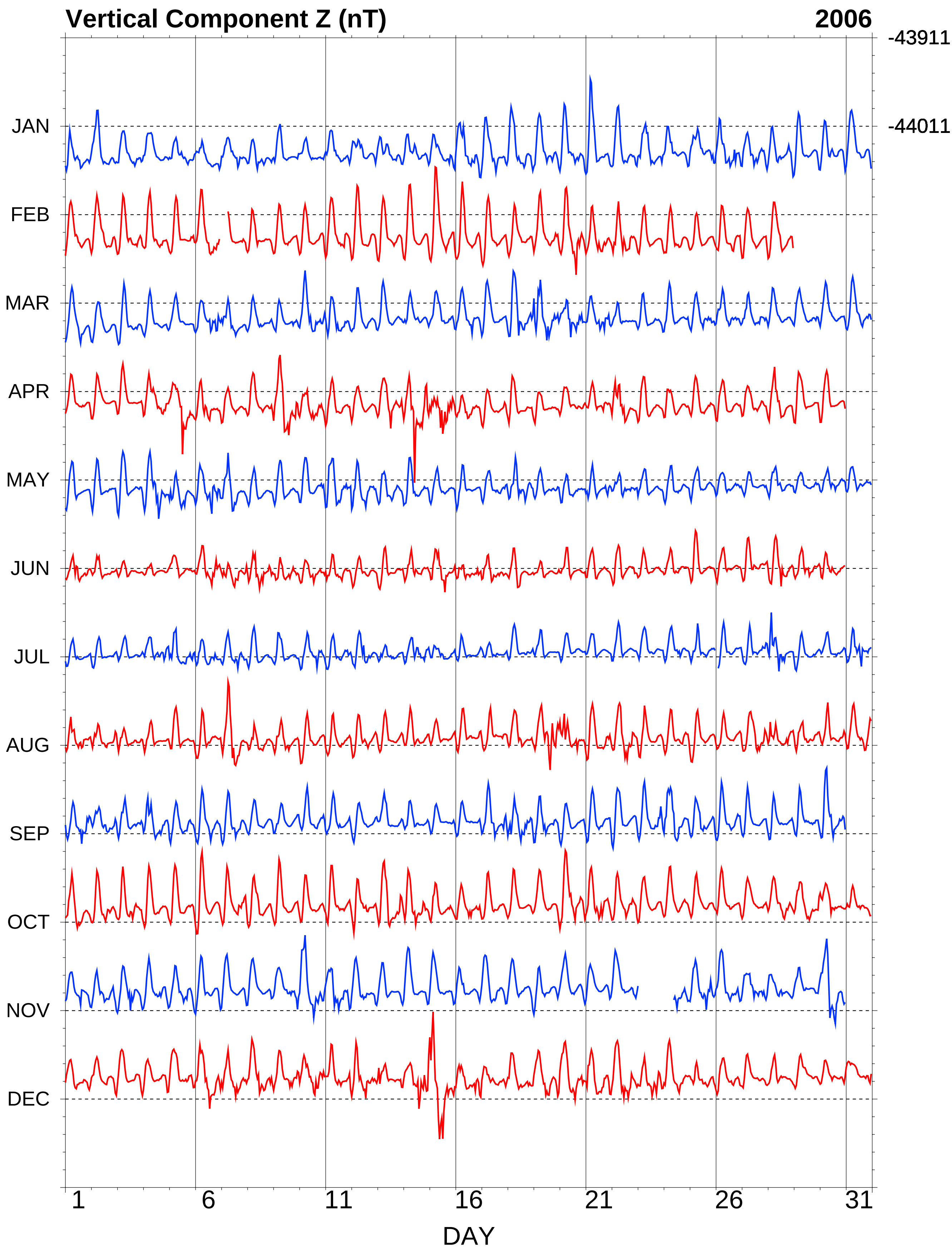
LRM - Hourly Mean Values



LRM - Hourly Mean Values



LRM - Hourly Mean Values



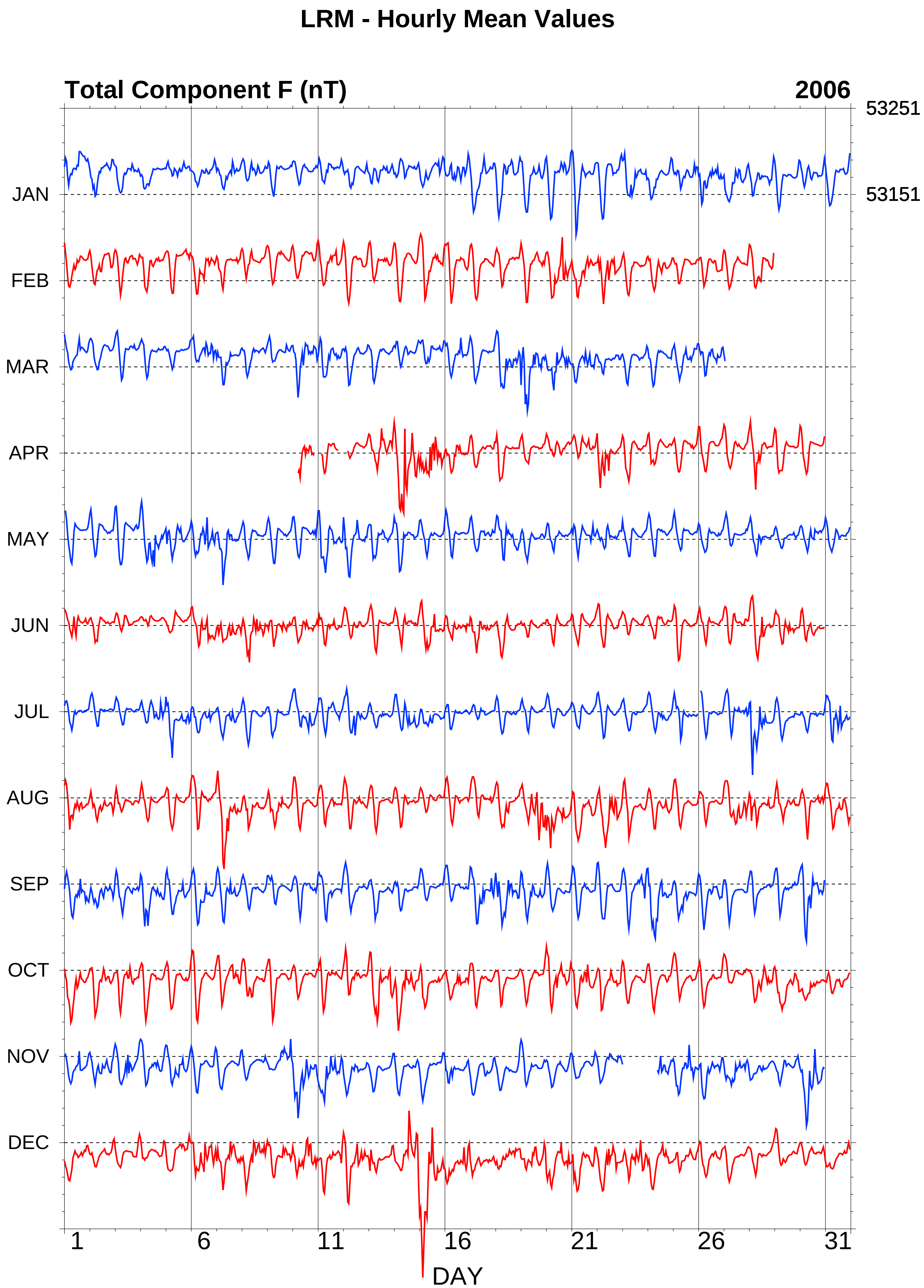


Figure 3.3. Hourly mean values in X, Y, Z and F measured at Learmonth.

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.

IAGA code:	ASP
Commenced operation:	June 1992
Geographic latitude:	23° 45' 39.6" S
Geographic longitude:	133° 53' 00.0" E
Geomagnetic latitude:	-32.71°
Geomagnetic longitude:	208.21°
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. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 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.

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 GPS clock
Communications:	VSAT link

Table 4.2. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at Alice Springs and their adopted corrections for 2006 are described in Table 4.3. A Hewlett Packard H4300 Personal Data Assistant 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 2006. 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 2006 mean magnetic field values at Alice Springs these D, I, and F corrections translate to corrections of:

$\Delta X = 0.2$ nT $\Delta Y = 0.0$ nT $\Delta Z = -0.3$ nT

These corrections have been applied to all Alice Springs 2006 final data.

DI fluxgate:	DMI
Serial number:	DI0052
Theodolite:	Zeiss 020B
Serial number:	313887
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	2101216/306403
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.4 nT

Table 4.3. Absolute magnetometers and their adopted corrections for 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Baselines

The standard deviations in the 2006 weekly absolute observations from the final adopted variometer model and data were:

	σ		σ
X	1.5 nT	D	9"
Y	1.3 nT	I	5"
Z	0.8 nT	F	1.0 nT

Throughout the year the baseline drift for X was 38 nT, Y was 17 nT and Z was 11 nT. These drifts changed gradually during the year due to seasonal variations in a manner comparable to the 2005 drifts. There was about 10 nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM for the period when PPM data were available.

Observed and adopted baseline values in X, Y and Z are shown in Figure 4.1.

Operations

In 2006 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 2006 magnetic data were downloaded to Geoscience Australia head office in Canberra by VSat connection every 10 minutes.

Data losses at Alice Springs in 2006 are identified in Table A.4.

Significant events

2006-03	VSAT dish installed during March.
2006-04-11	QNX computer sent to ASP (VSAT link up and modem responding to telnet) for installation
2006-04-20	Upgrade from DOS to QNX Gdap - commence real-time data at about 05:30
2006-05-10	01:40 UT Commence real-time data delivery to IPS
2006-05-17	06:00 commence INTERMAGNET filtering of 1 minute RT data delivery
2006-05-26	00:11 commence delivery of RT and daily data to WDC-C2 Kyoto University
2006-07-05	00:00 commence delivery of 1-second RT data to IPS
2006-07-20	01:30 changed IP address from 203.166.33.34 to 192.245.112.82 (only changed /etc/hosts then shutdown). Changeover worked smoothly except could only access through galah, not epoch.
2006-09-14	DIM sensor re-aligned and tightened before absolutes that day
2006-09-29	~0340 Comms failed - WS checked as ASP and seems ok, powered off/on modem and still no coms. Later - ASCS see VSAT modem and ASP as up, but cannot traceroute anywhere from DCN or epoch.
2006-10-09	Connected to ASP via MCQ and ftp'd data back to GA to date - still no real time

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	2007
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 4.4. Distribution of 2006 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 2006 data are shown in Figure 4.3.

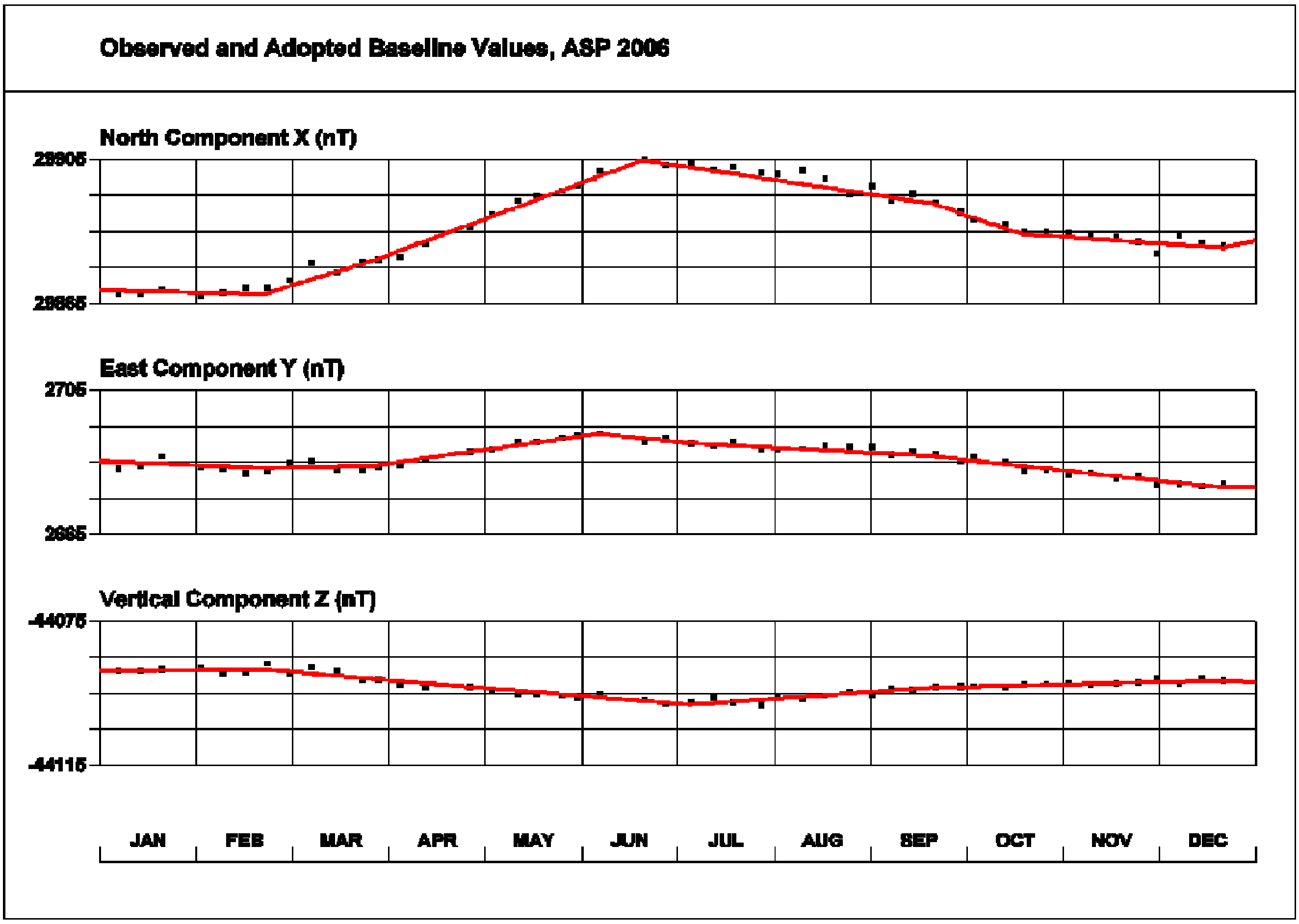


Figure 4.1. Alice Springs baseline plots.

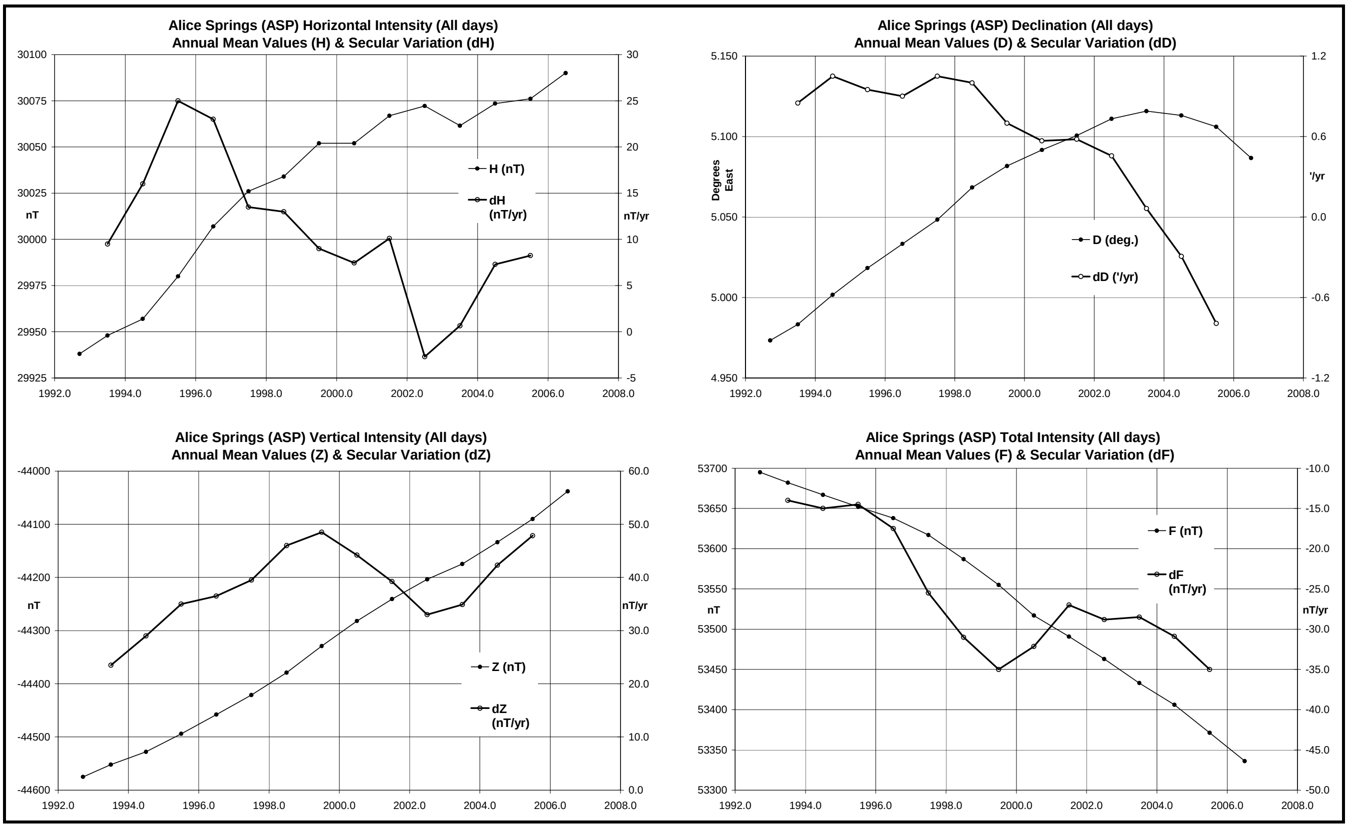
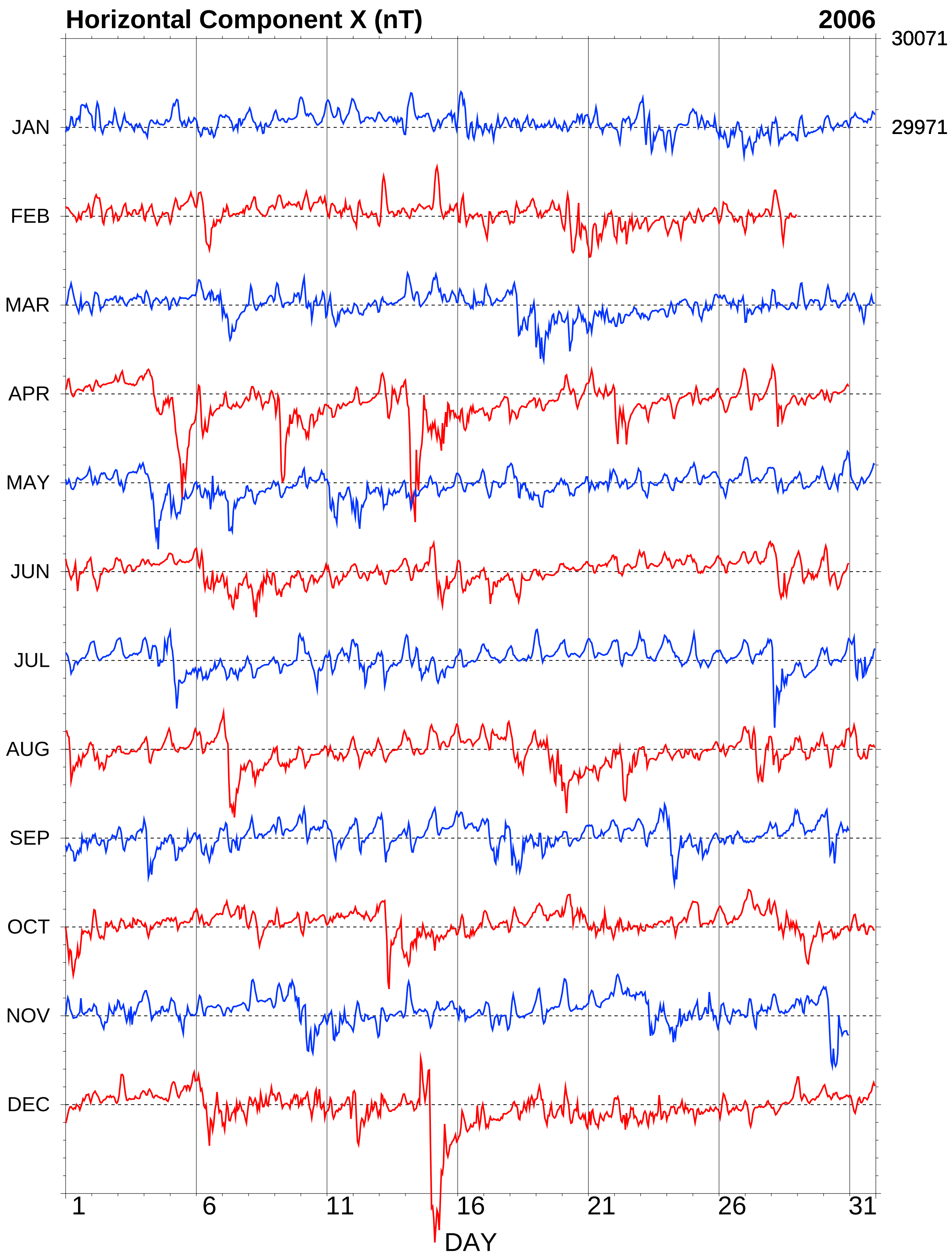


Figure 4.2. Annual mean values and secular variation for H, D, Z and F measured at Alice Springs.

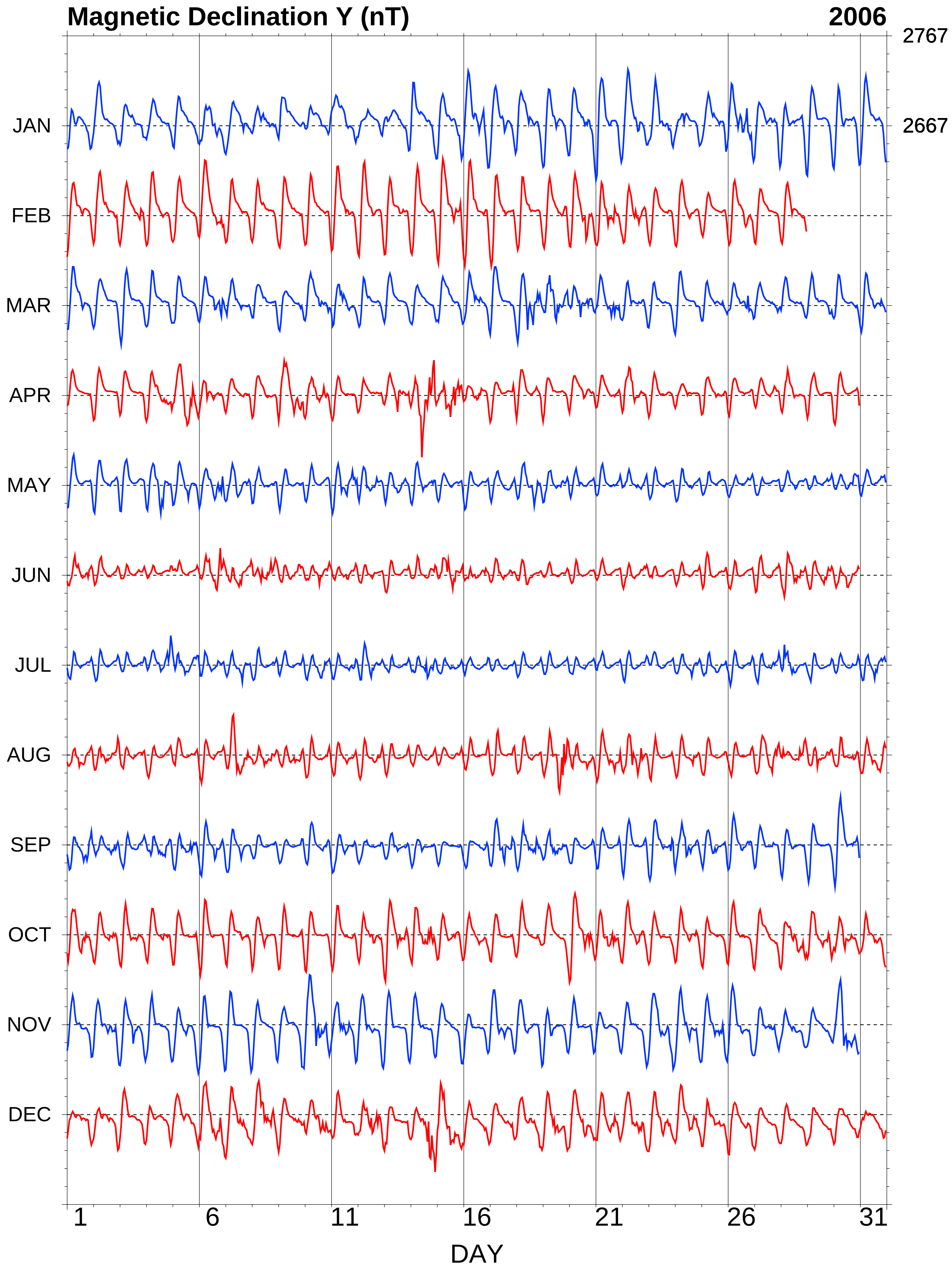
Year	Days	D (°	')	I (°	')	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
1992.708	A	4	58.4	-56	06.8	29938	29825	2595	-44575	53695	XYZ
1993.5	A	4	59.0	-56	05.5	29948	29835	2601	-44552	53682	XYZ
1994.5	A	5	00.1	-56	04.1	29957	29843	2612	-44528	53667	XYZ
1995.5	A	5	01.1	-56	01.7	29980	29865	2623	-44494	53652	XYZ
1996.5	A	5	02.0	-55	59.0	30007	29892	2633	-44458	53638	XYZ
1997.5	A	5	02.9	-55	56.6	30026	29910	2642	-44421	53617	XYZ
1998.5	A	5	04.1	-55	54.7	30034	29917	2653	-44379	53587	XYZ
1999.5	A	5	04.9	-55	51.9	30052	29934	2662	-44329	53555	XYZ
2000.5	A	5	05.5	-55	50.2	30052	29934	2667	-44282	53517	XYZ
2001.5	A	5	06.0	-55	48.0	30067	29948	2673	-44241	53491	XYZ
2002.5	A	5	06.7	-55	46.3	30072	29953	2679	-44204	53463	XYZ
2003.5	A	5	07.0	-55	45.8	30062	29942	2681	-44175	53433	XYZ
2004.5	A	5	06.6	-55	44.9	30073	29954	2680	-44134	53406	XYZ
2005.5	A	5	06.4	-55	42.0	30076	29957	2677	-44090	53371	ABZ
2006.5	A	5	05.2	-55	39.4	30090	29971	2668	-44038	53336	ABZ
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
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

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



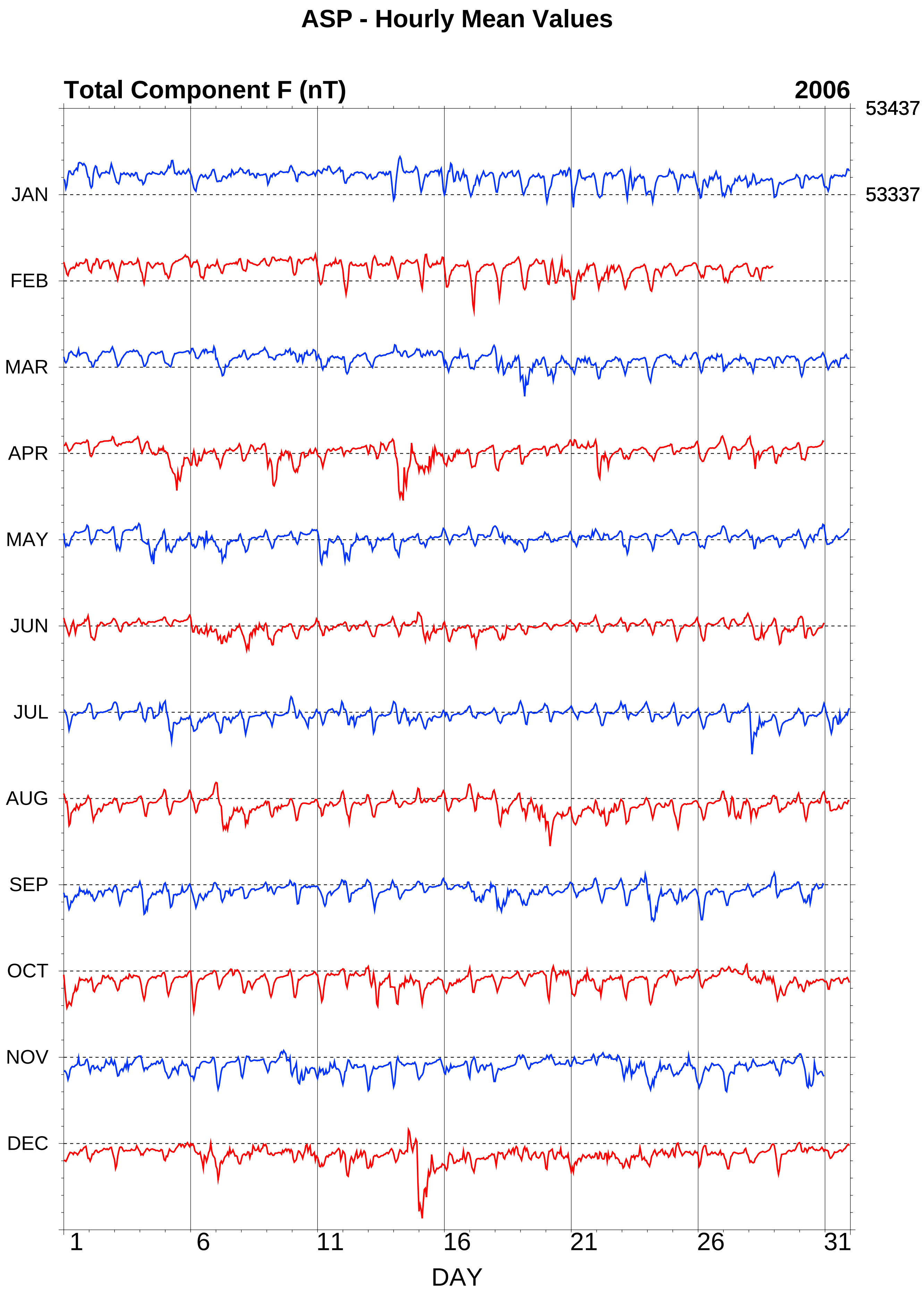


Figure 4.3. Hourly mean values in X, Y, Z and F measured at Alice Springs.

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 low natural magnetic gradients of less than 1 nT/m, although in places numerous artificial features have introduced higher gradients.

Variometers

The variometers used during 2006 are described in Table 5.2.

The fluxgate sensors were located at the eastern end of the vault, while the electronic equipment and acquisition PC were housed in 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 < 0.1°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 2006 are described in Table 5.3.

The Gnangara absolute magnetometers were periodically compared with instruments from the Canberra magnetic observatory that serve as a reference standard for the Australian observatory network.

The DMI declination-inclination magnetometer was compared with the Australian reference at Canberra observatory on 26 Feb 2004 and had corrections of: 0.0' and 0.0' in D and I. During 2005 and 2006, instrument comparisons were performed at Gnangara during service visits. Instrument corrections adopted for 2006 are shown in Table 5.3.

IAGA code:	GNA
Commenced operation:	June 1957
Geographic latitude:	31° 46' 48" S
Geographic longitude:	115° 56' 48" E
Geomagnetic latitude:	-41.70°
Geomagnetic longitude:	188.89°
K 9 index lower limit:	450 nT
Principal pier:	Pier B
Pier elevation (top):	60 m AMSL
Principal reference mark:	Pillar N
Reference mark azimuth:	315° 21' 42"
Reference mark distance:	70 m
Observer:	G. van Reeken

Table 5.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

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:	GPS clock
Communications:	Telephone line

Table 5.2. Magnetic variometers.

DI fluxgate:	DMI
Serial number:	DI0037
Theodolite:	Zeiss 020B
Serial number:	390444
Resolution:	0.1’
D correction:	-0.05’
I correction:	0.00’
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 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

The GEM Systems GSM-90 total-field magnetometer was compared at the Canberra magnetic observatory on 06 May 2003 and had a zero instrument correction. The correction was confirmed a travelling reference magnetometer during a service visit to Gnangara in April 2006. The instrument corrections adopted for 2006 is shown in Table 5.3.

At the 2006 mean magnetic field values at Gnangara these D, I, and F corrections translate to corrections of:

$\Delta X = 0.0$ nT $\Delta Y = -0.3$ nT $\Delta Z = 0.0$ nT

These corrections have been applied to all Gnangara 2006 final data.

Baselines

By observing an annual cycle in baselines similar to that in temperature, temperature coefficients (Q) for the X, Y and Z variometer channels were estimated to be

QX = 1.2 nT/°C QY = -0.5 nT/°C QZ = -1.0 nT/°C

The mean values (and standard deviations) of the differences between the absolute measurements and the derived values from the variometer data after drifts and temperature coefficients were applied are:

	σ		σ
X	1.1 nT	D	10"
Y	1.1 nT	I	4"
Z	0.7 nT	F	0.7 nT

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM varied between -2.4 nT and 1.3 nT.

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

Operations

Data were retrieved to Geoscience Australia via modem shortly after UT 0:00 daily and then were distributed to INTERMAGNET. Throughout 2006 K indices for Gnangara were derived using a computer assisted method developed at Geoscience Australia and based on the IAGA accepted LRNS algorithm. The K indices were distributed weekly.

Absolute observations were performed fortnightly. The stainless steel security door was left open in the same position during observations.

Over the last five years the residential area near the observatory has expanded. Although this currently poses no threat to the observatory in a technical sense, there is a recurring problem with vandalism. Over the years considerable amounts of data have been lost as a consequence of intruders, vandalism and break-ins, although it was not the case in 2006.

Data losses at Gnangara in 2006 are identified in Table A.5.

Significant events

2006-01-17 Owen reported that the person who broke into GNA and stole the instruments has been formally charged and appeared in court. Owen was recently contacted by the police and asked to sign an original copy of his statement.

2006-01-27 Modem answers but computer does not respond. Asked Owen to investigate 11:36 EDST. Owen managed to get computer to reboot after several attempts ~15:30 EDST 04:30UT but the computer is unreliable.

2006-02-02 Owen installed new battery box, data loss from 2:25 - 2:46 plus some contamination. Owen removed old power supply and will store it.

2006-02-07 Total field measurements recorded at absolute obs were very scattered. NB contacts Hans and asks about measurements and suggests to charge battery box. Found out that he put the battery box on charge, however this is the first time in 12 months, so the next obs will hpopefully be fine. Also Hans is planning to finish doing the absolute obs around the end of FY or christmas the most.

2006-03-07 Owen restarts acq computer at about 07UT by disconnecting/reconnecting power.

2006-03-09 Security monitors reported alarm on zone 4 at ~12UT (Tel: 131518, Ref: WZA6235)

2006-04-04 00:00 Hans rebooted the computer - appeared to have a System Disk failure. Reboot restarted data acquisition successfully. Noticed BL shift in the obs immediately afterwards! Equip may have moved in the vault while searching for power switch etc???

2006-04-08 LJW visted GNA (one-day) and did instrument comparison.

2006-06-18 3:59 Data transmission to GA stopped. Contacted Owen on 21st June. Unable to attend until 23rd. Unable to contact Hans. Sent an email.

2006-06-22 05:00 (approx-check) Hans attended observatory and restored data acquisition. time correction applied (33 ticks) at 05:14 AML

2006-08-14 Data acquisition stopped (PC failure - see below) Owen contacted by Network staff

2006-08-15 Owen visited GNA - boot disk failure again, at ~03:00 began installation of GDAP computer.

Finished installation a few hours later, and set automatic retrieval via ga-cnb-mag1 every 3 hours. ADAM/G856/GPS16 all working ok. Had troubles with the modem, but it came good for reasons unknown.

G856 had Energiser batteries which had seriously leaked but fortunately not destroyed the instrument. Old computer being returned to retrieve any missing data, along with the Trimble GPS clock.

Convert from MACQ DOS to Gdap QNX (with PPP networking). Data now retrieved to GA every 3 hrs. Previous to this it was daily)

2006-08-20 (Night of Sunday) Hole knocked in absolute hut wall - Security Monitoring (13 15 18) reported Zone 2 PIR (underground vault) was triggered at 4:56 WA time. AML requested visit by security officer. Owen attended site with police and security late in evening. (Chubb 13 15 98)

2006-09-05 Automatic notification that GPS clock had failed. Last Correction at 18:41 2006-09-04. at 2006-09-05 02:24, "pips" was a few tenths seconds after 1194 time. Could not get GdapClock to recognise clock. Shutdown jsut after data recorded for 02:41. System up by 02:42:08. GdapClock recognised GPS after that - first correction 2006-09-05 02:46:30 +450ms. Expect time correct to 200ms at least until shutdown, then 450ms slow for 3.5min.

2006-10-12 Security Monitoring activated by 'Zone 2 underground fault' motion detection at 2:12 local time (UT 18:12 on 11th/DOY 284). PAH rang 13-15-18 who was informed by Anthony that a patrol was sent and the site remained externally secure, ie

	no signs of forced entry etc. Data flow was not affected. No action taken.
2006-10-25	20:23pm LT Wed. Security Monitoring (Tel.13-15-18) advised (ref. WZA6235) that they did not receive a "closing signal" from GNA that indicates the alarm is not armed. WKG rang Owen (in the field) who advised the repairer was there that day fixing the hole in the absolute house wall and he failed to turn on alarm when leaving. He will be there again on 26th, and will try to remember to turn on the alarm.
2006-11-20	AML and JWW visit observatory Install new padlock on absolute, clean out absolute hut. inspect repairs-reboot QNX acquisition computer. Photograghs

Data distribution

Recipient	**Status**	**Sent**
1-minute values		
INTERMAGNET	preliminary	3-hourly
INTERMAGNET	definitive	2007
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 2006 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 2006 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 2006 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.

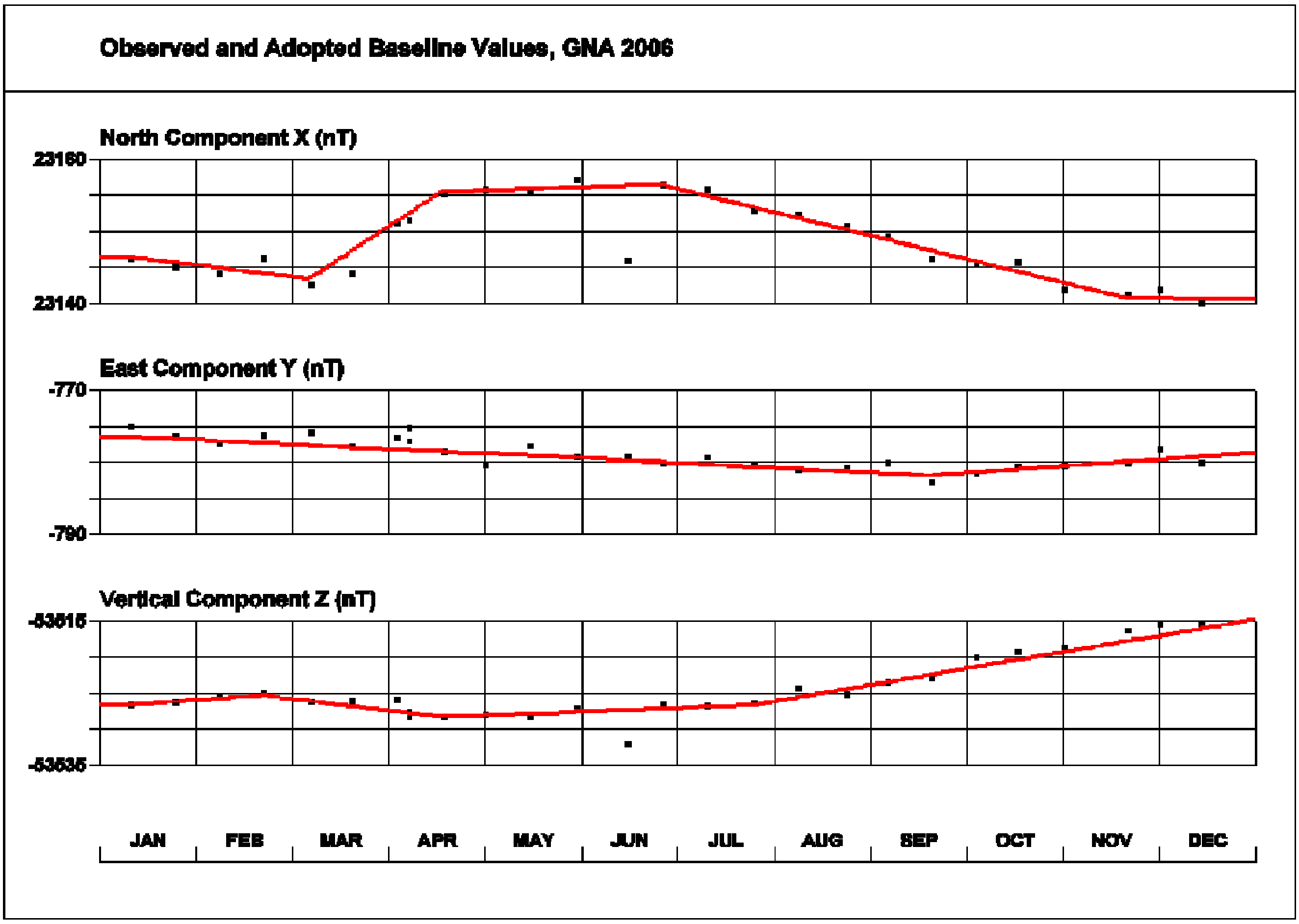


Figure 5.1. Gnangara baseline plots.

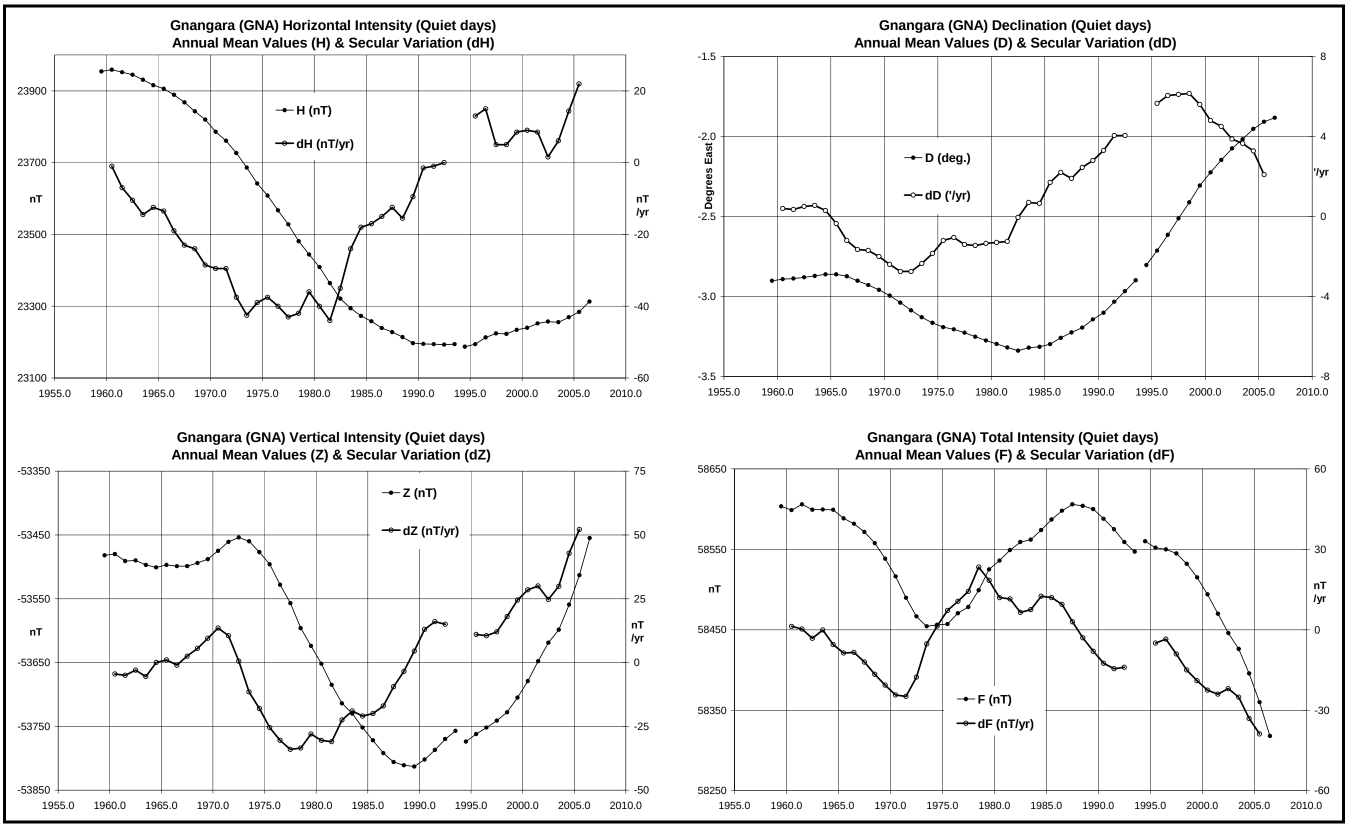


Figure 5.2. Annual mean values and secular variation for H, D, Z and F measured at Gnangara.

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
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
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

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	2112	3222	15	0111	2002	7	2112	4211	14	0000	0101	2	0000	0001	1	1223	2232	17
02	3232	1223	18	(1)112	1221	(11)	1010	1001	4	1000	0---	-	1010	1110	5	2321	0221	13
03	2111	1211	10	1111	1241	12	1100	111(0)	(5)	----	----	-	1000	0021	4	1211	2211	11
04	1110	1010	5	2122	1101	10	----	----	-	-112	2344	-	1023	5432	20	0000	0000	0
05	0011	2212	9	2011	0121	8	----	----	-	3224	7452	29	3222	3210	15	1000	0120	4
06	1121	2222	13	2222	3233	19	----	----	-	1232	3221	16	2112	5544	24	1233	3453	24
07	1111	2312	12	2110	1221	10	---1	3111	-	1010	1102	6	2343	3222	21	3233	3433	24
08	1112	2200	9	1011	1010	5	1001	2231	10	1101	2121	9	2112	1111	10	3344	3433	27
09	1100	0001	3	1011	1022	8	0100	0132	7	3343	4344	28	0001	0201	4	2122	3332	18
10	1000	1101	4	2100	0123	9	2333	4223	22	3233	2421	20	0000	0022	4	2111	3222	14
11	1001	1111	6	2110	2311	11	3134	2321	19	1111	1112	9	2333	3244	24	1111	3311	12
12	1111	0011	6	2221	2101	11	1111	2121	10	0000	0110	2	4332	3322	22	1001	2201	7
13	1010	1212	8	1100	2311	9	2100	0000	3	0214	5323	20	2223	2231	17	0000	0000	0
14	1001	1132	9	1110	0003	6	0001	2002	5	3456	4656	39	2222	1121	13	1001	2223	11
15	1100	1232	10	2123	3333	20	2222	2332	18	2235	4543	28	0112	1011	7	2334	5323	25
16	2222	3442	21	3222	1121	14	1212	2321	14	2113	3321	16	1000	0101	3	2221	2232	16
17	2222	3212	16	1111	2112	10	1001	1011	5	1111	1123	11	0100	1211	6	2232	2221	16
18	3223	1321	17	0100	1111	5	1125	4544	26	2100	0222	9	1122	1442	17	1123	1011	10
19	2012	2222	13	2221	2232	16	4435	4444	32	1000	0211	5	2321	1231	15	1100	00--	-
20	2111	3333	17	2233	5532	25	3235	3342	25	0112	2310	10	2213	0221	13	----	----	-
21	2212	2111	12	2224	3433	23	2312	3433	21	0101	2311	9	2111	0131	10	----	----	-
22	1111	3302	12	3223	4421	21	2121	1231	13	3234	2211	18	1101	1223	11	--11	1121	-
23	2233	3323	21	2111	1122	11	1110	1001	5	1221	0101	8	2210	1101	8	0000	0000	0
24	3221	2101	12	2012	2201	10	2001	0122	8	2112	0001	7	0121	1100	6	0000	1110	3
25	2122	1233	16	1010	0001	3	1112	2231	13	1100	2111	7	0100	0011	3	1101	0000	3
26	33--	----	-	1221	2323	16	2102	2342	16	1000	0010	2	0000	2020	4	1000	0000	1
27	--12	3222	-	2100	2001	6	3110	1313	13	1110	1121	8	0000	0000	0	0001	1122	7
28	2111	1131	11	1113	2112	12	1210	1221	10	2132	1111	12	1212	2101	10	2233	4232	21
29	2000	0001	3				1010	0132	8	1100	0000	2	0000	0021	3	2322	3231	18
30	1101	0120	6				1001	1011	5	0000	0000	0	0002	3231	11	2122	4320	16
31	0000	2200	4				1001	3231	11				1011	1111	7			

Day	July			August			September			October			November			December		
01	1100	1010	4	2234	4311	20	3122	3444	23	4333	3322	23	1101	3222	12	1002	1231	10
02	0010	0000	1	1223	2113	15	2111	3333	17	1122	3321	15	2011	2342	15	1000	2012	6
03	0000	0010	1	2100	1021	7	2121	2211	12	2212	3212	15	2114	4220	16	1110	0121	7
04	0112	3234	16	1000	0000	1	3433	2332	23	1001	1322	10	2221	1222	14	1000	0111	4
05	3343	2332	23	1100	0100	3	1123	2331	16	1000	2121	7	1122	2211	12	1002	1213	10
06	2222	1321	15	0011	1200	5	1112	4221	14	0011	1001	4	1000	1012	5	3224	4354	27
07	1112	3310	12	3345	4431	27	1121	3311	13	1000	2324	12	1000	0001	2	3332	4322	22
08	1010	0010	3	2333	2321	19	1100	1011	5	2122	2121	13	1000	0011	3	3444	3342	27
09	0000	0112	4	1113	3123	15	1100	0000	2	1110	0021	6	1000	2334	13	2110	1323	13
10	2101	3431	15	1000	0022	5	1011	1221	9	1000	0012	4	3434	5343	29	2212	4433	21
11	0111	2222	11	1211	2210	10	3322	2101	14	2110	2111	9	3233	4433	25	3222	2134	19
12	1324	4221	19	1111	2321	12	1122	1121	11	1001	3312	11	2112	2101	10	3333	5443	28
13	1111	2000	6	0000	00--	-	1222	2020	11	2244	3254	26	1010	0001	3	3211	1123	14
14	1113	4532	20	----	----	-	1113	1011	9	3223	3443	24	1101	1223	11	2112	5667	30
15	0111	2011	7	--00	0111	-	1000	0000	1	2223	2331	18	2111	1112	10	6655	5423	36
16	0000	0010	1	0000	1000	1	1000	1111	5	1111	3212	12	3110	0111	8	2222	1333	18
17	0000	1110	3	0020	1122	8	2113	4142	18	1101	1110	6	2101	3211	11	3111	1221	12
18	0000	0110	2	1232	2212	15	3234	4342	25	0001	0022	5	1011	1111	7	2112	2323	16
19	0000	0000	0	2113	6556	29	2233	3221	18	1001	1100	4	1111	1101	7	2224	4222	20
20	0100	0001	2	4421	1322	19	1010	0120	5	2233	4443	25	1010	2001	5	3122	5434	24
21	0000	0000	0	2122	2333	18	0001	1101	4	3223	3432	22	2000	1001	4	3333	3422	23
22	0010	0001	2	2234	4530	23	0000	0010	1	2221	3332	18	0012	2122	10	3234	3432	24
23	0001	1100	3	1220	0111	8	1111	1235	15	1001	1112	7	1133	4433	22	2132	4332	20
24	1121	3311	13	1100	1320	8	4334	4231	24	1121	2132	13	3334	3222	22	2122	3332	18
25	1110	1112	8	0000	0010	1	2114	3112	15	2111	1201	9	2122	3442	20	1131	2312	14
26	2100	0000	3	0000	0001	1	2211	2222	14	1011	2101	7	3212	3132	17	2111	2211	11
27	1000	2233	11	1112	3434	19	2111	0210	8	1001	1123	9	2223	2331	18	1010	0100	3
28	5434	3301	23	3331	2433	22	2111	1011	8	2123	4333	21	1102	2212	11	1000	0011	3
29	2001	0010	4	2123	2321	16	1010	1121	7	4232	3244	24	1212	1112	11	1001	0111	5
30	1100	0200	4	1012	1321	11	2333	2223	20	2224	2311	17	2334	5422	25	2102	1111	9
31	2222	4232	19	1131	2443	19				1000	2222	9				2010	0112	7

Table 5.6. K indices and daily K sums measured at Gnangara in 2006.

Commencement				SSC-amplitudes			Maximum 3hr K indices		Storm Ranges			End		
Mth	Day	Hr	Mn	D(')	H(nT)	Z(nT)	Day (3hr Periods)	K	D(')	H(nT)	Z(nT)	Mth	Day	Hr
Feb	20	05	58	...			20(5,6)	5	18.3	60.2	93.1	Feb	20	21
Mar	18	06	00	...			18(4,6),19(4),20(4)	5	17.0	86.7	111.3	Mar	20	21
Apr	05	09	00	...			5(5)	7	29.3	132.9	184.7	Apr	05	22
	14	03	00	...			14(4,6,8)	6	34.4	189.1	227.6		16	03
May	06	12	00	...			6(5,6)	5	19.7	119.1	83.1	May	08	14
Aug	19	10	57	...			19(5,8)	6	7.9	53.6	38.6	Aug	20	10
Dec	14	14	14	2.7	61.65	27.67	14(8)	7	26.3	191.1	165.6	Dec	15	17

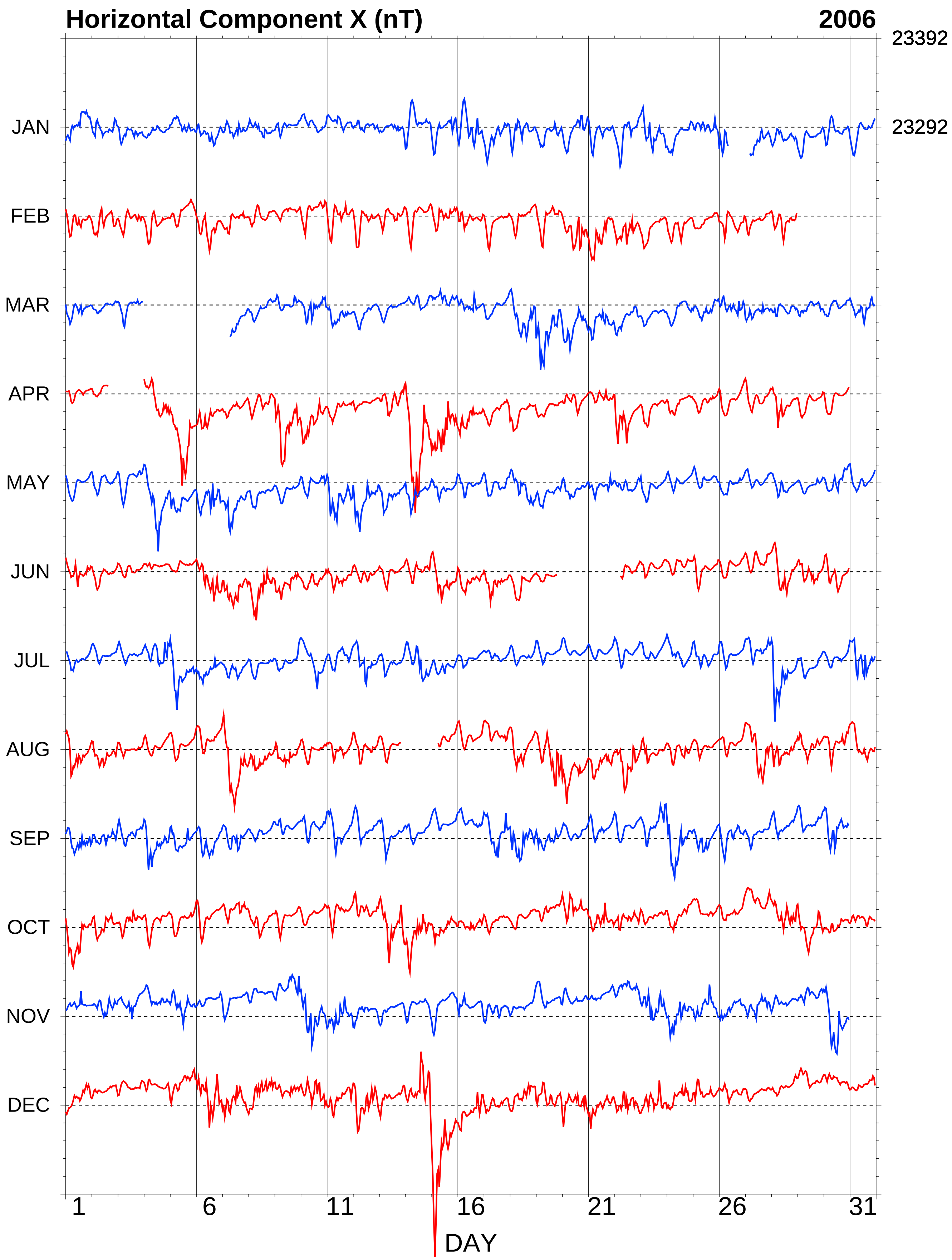
Table 5.7. Principal magnetic storms observed at Gnangara in 2006.

UT Date				Type & Quality		Chief movement (nT)		
Mth	Day	Hr	Mn	ssc/ssc*	A,B,C	H(x)	D(y)	Z
Jul	09	21	37	ssc	a	4.13	13.14	9.31
	27	13	53	ssc	a	9.68	5.68	6.8
Aug	17	07	21	ssc	a	12.31	18.12	13.74
Dec	14	14	14	ssc	a	61.65	18.23	27.67

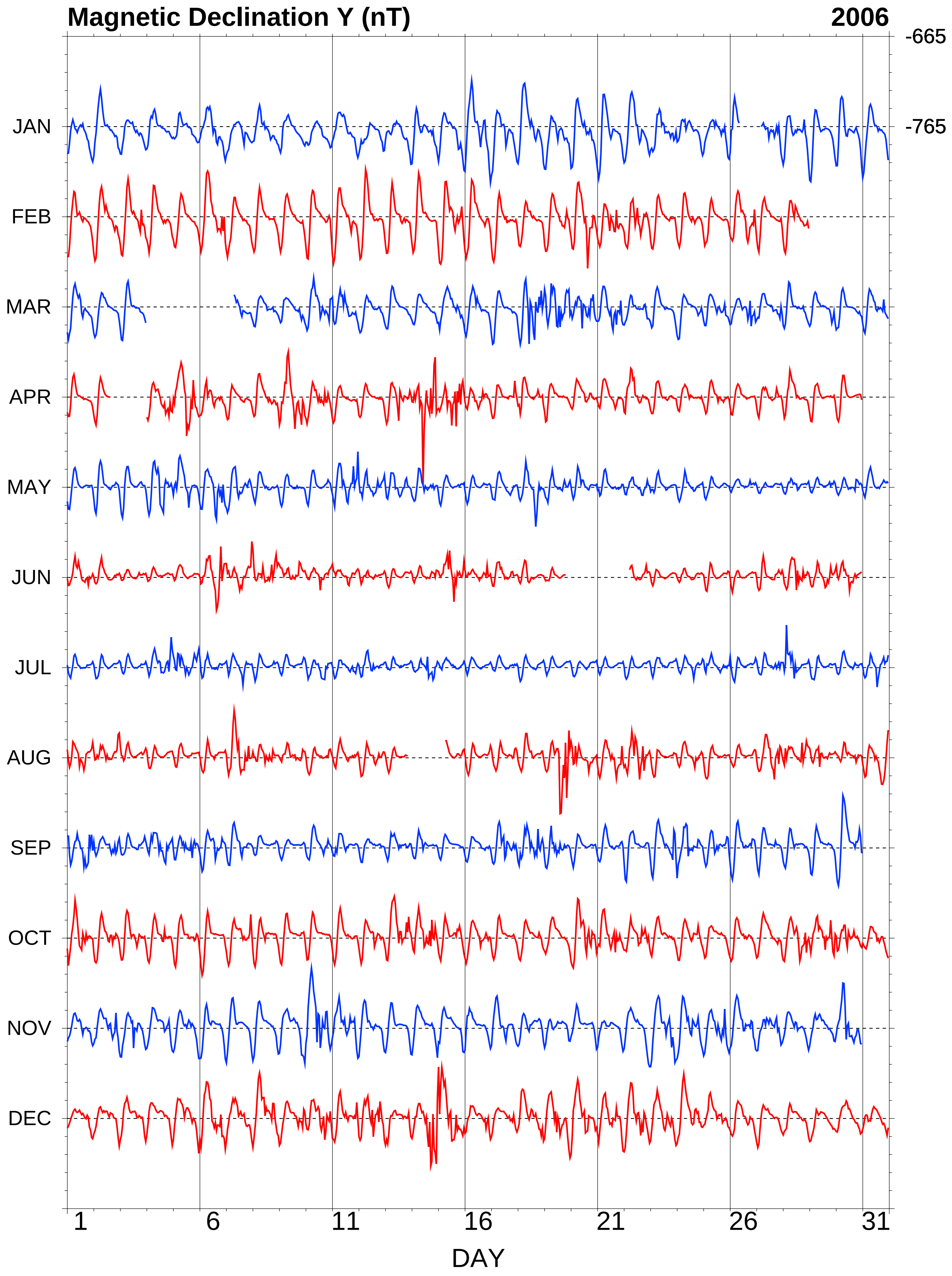
Mth	Day	UT of movement Start	Max	End	Amplitude (nT) H(x)	D(y)	Z	Confirmation
May	02	06:30	06:37	06:49	3.6	1.2	6.0	solar

Table 5.8. Sudden storm commencements and solar flare effects observed at Gnangara in 2006.

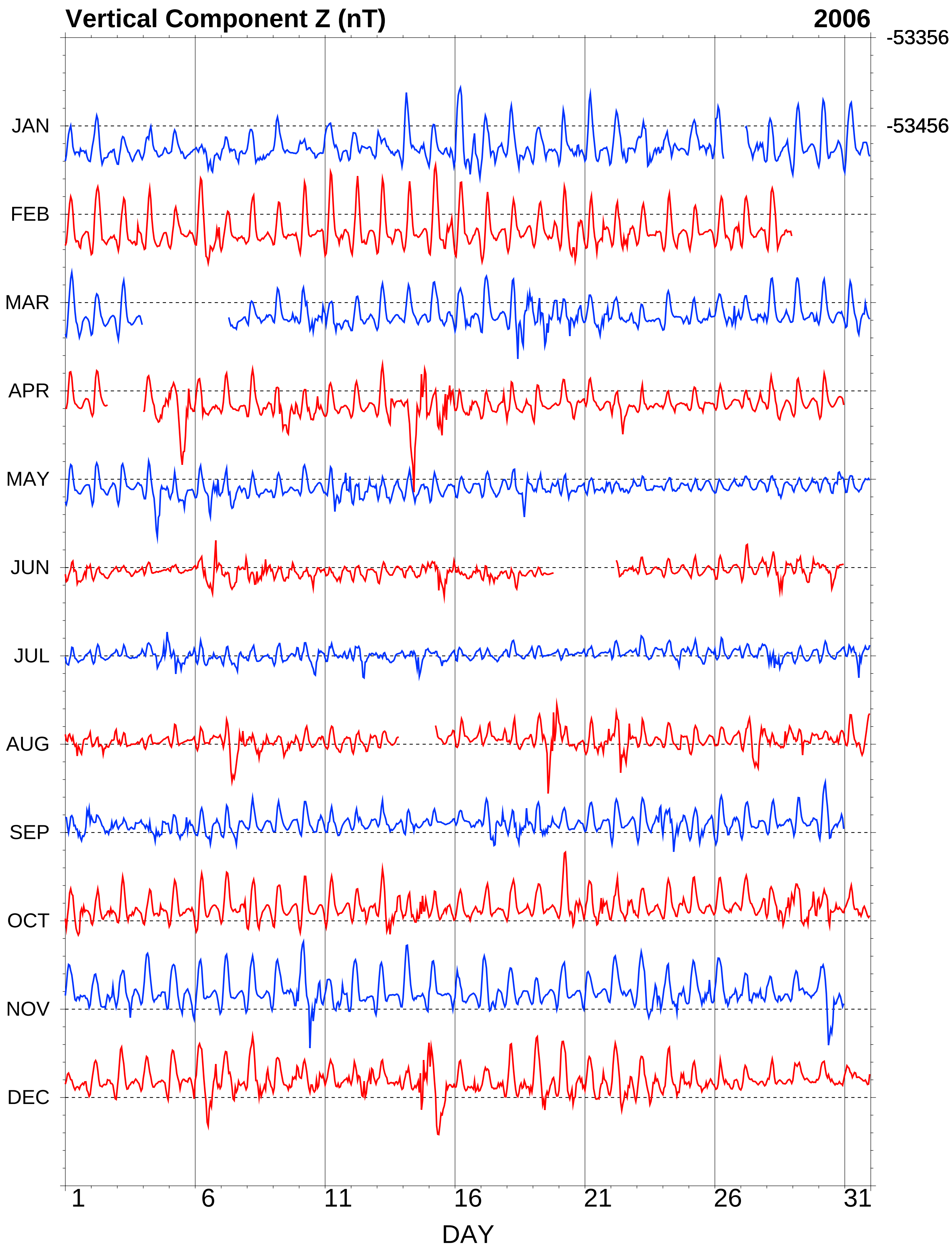
GNA - Hourly Mean Values



GNA - Hourly Mean Values



GNA - Hourly Mean Values



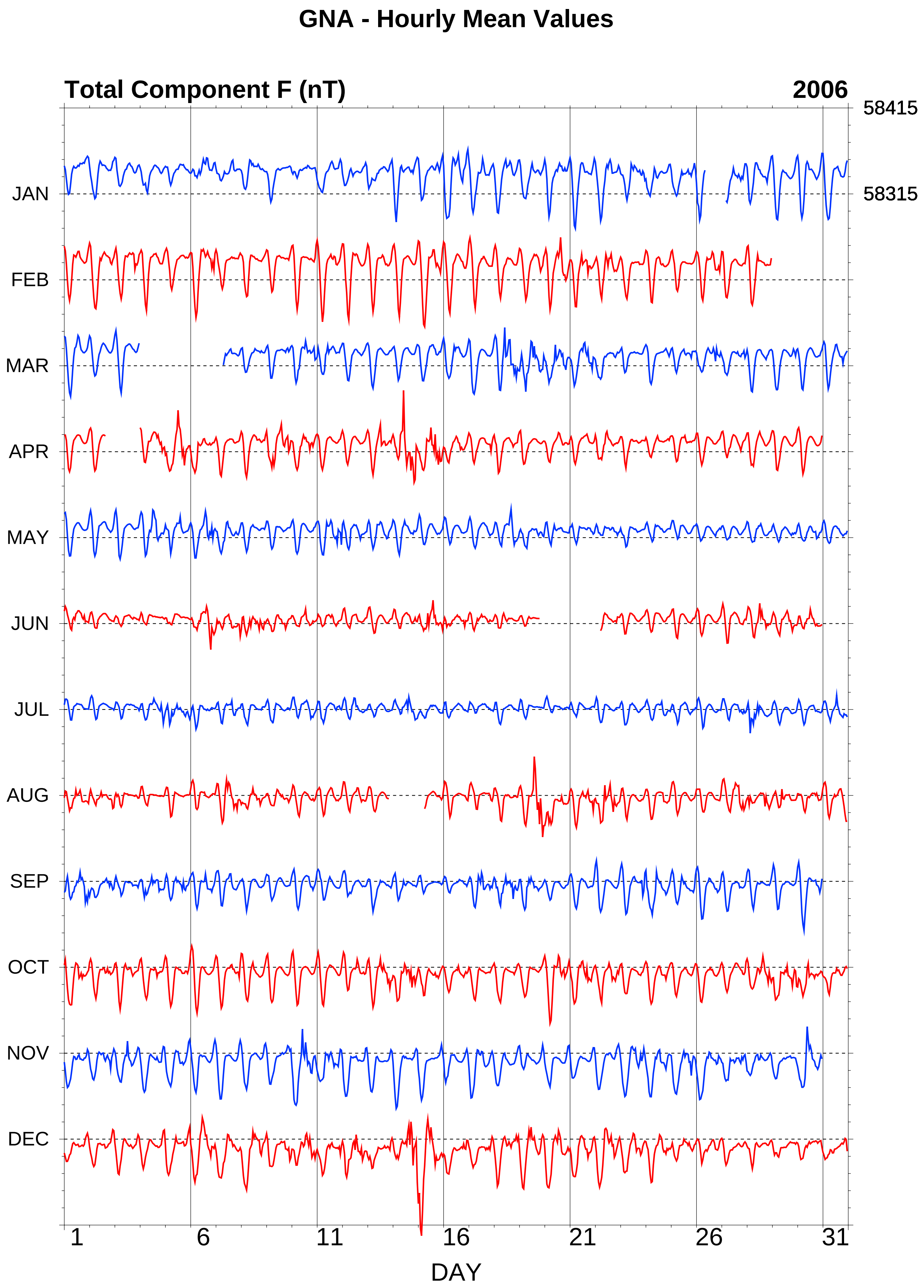


Figure 5.3. Hourly mean values in X, Y, Z and F measured at Gnangara.

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.

IAGA code:	CNB
Commenced operation:	1978
Geographic latitude:	35° 18' 52.6" S
Geographic longitude:	149° 21' 45.4" E
Geomagnetic latitude:	-42.48°
Geomagnetic longitude:	226.92°
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:	L. Wang

Table 6.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 are described in Table 6.2.

During 2006, 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.

3-component variometer:	Narod (Primary)
Serial number:	9004-2
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Resolution:	0.025 nT
3-component variometer:	LEMI (Secondary)
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:	Trimble GPS clock
Communications:	Radio link

Table 6.2. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at Canberra and their adopted corrections for 2006 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.

These instrument corrections have not been applied to the 2006 Canberra data as the uncertainty in the I correction is the same magnitude as the correction itself. The F and D corrections adopted corrections are zero.

At the 2006 mean magnetic field values at Canberra these D, I, and F corrections translate to corrections of:

$\Delta X = -3.0$ nT $\quad \Delta Y = -0.7$ nT $\quad \Delta Z = -1.4$ nT

These corrections have been applied to all Canberra 2006 final data.

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 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Baselines

Without any correction, the Narod baseline drifts were in the range of 8 nT, 9 nT and 3 nT in X, Y and Z during 2006. Drift patterns of three channels have very similar seasonal dependence to those of previous years.

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

	σ		σ
X	1.6 nT	D	11"
Y	1.2 nT	I	6"
Z	0.7 nT	F	0.3 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 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.

Data losses at Canberra in 2006 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

2006-02-13 23:12 Commenced real-time data delivery to ftp.ips.gov.au/incoming/mag/ga,gov.au.

2006-03-27 The LEMI (CN1) variometer failed - battery ran flat. Noticed the baselines changed several hours before power supply failed. It is a worry that the power failure caused a baseline shift.

2006-04-23 Week 17 - 13 April, both GNA and CNB K index were delivered through subscription application

2006-05-17 06:00 Commenced INTERMAGNET filtering of 1 minute RT data delivery.

2006-06-28 Fence construction work was carried out by ACT Forest at S-W corner of the outside of our observatory. The work takes about a week.

2006-06-30 Noticed GPS (CN1) had not locked for the past week or more.

Restarted GdapClock several times without success. Logs indicated GPS failed during 16 June, and no signal since then. CN1 system Clock was about 0.5s slow using pips. Restarted at about 02:25. Clock started up ok after restart. CN1 correction +1.029s after restart, and pips method of checking seemed to be ok.

2006-07-05 At 00:00 Commenced delivery of 1-second RT data to IPS (switch off 1 minute delivery to IPS)

2006-07-25 DIM B0610H/160459 reading on x10 scale varies about 0.010 from previous to next. There were not much variations on Narod data (k =1). Battery was charged over the weekend. See cnb06206.obs for more details.

2006-07-18 DIM B0610H/160459 reading on x10 scale was ok.

2006-08-01 DIM B0610H/160459 reading on x10 scale is normal today.

2006-08-15 The minute reading for North-Up(nu) was 34 in the first set of observations. The second set it was 40, so were the third and fourth set. Declination diff from this week obs between CNB absolute DMI and DIM B0610H/160459 is small.

2006-08-18 Commenced CNB data delivery to GeoForschungsZentrum Potsdam at every 3 hours at UT 03:00 for a test purpose.

2006-08-22 The minute reading for North-Np(nu) was 34 in the first set of observations. The second set it was 40, so were the third and fourth set. (see 15 Aug note). Declination diff from this week obs between CNB absolute DMI and DIM B0610H/160459 is small.

2006-08-28 Finished the delivery test to GeoForschungsZentrum Potsdam. The test went ok without any problem. Waiting for an instruction from Potsdam.

2006-08-29 AML and AAD trainees entered primary and secondary variometer hut (probably between 01 and 02UT)

2006-09-01 Terry Smith entered secondary variometer hut at about 02:39

2006-09-06 Installed new Fibre/Copper switches in Control, MagCal, Top, Seismic. Replaced Fibre/copper 10M converters in Primary and Secondary variometers with ADAM (1xF,4xTP) 10/100M converters. Disconnected all serial/fibre converters and associated stuff. Changed UPS power supply and outlets. Could not confirm that the MagCal was working with new TCP/IP servers on ga-cnb-mag2 and ga-cnb-magcald, but a test client program worked OK. All seems to work OK, and Control Hut somewhat tidier than before, although cabling could still be better labelled. Trimble GPS attached to ga-cnb-magcald.

2006-09-07 disk drive failed on NGL computer, no data after 19:20 until 2006-09-08 02:27. AML/PGC investigated, installed Wafer5823 destined for exactly that location, although it had not been completely configured or tested. But it worked ok, Need to reconfigure it for MagCal operations. Wafer 5823 in enclosure EBC-1000/ACE-890V Ver 0.06 s/n WA05C00347

Tried MagCal - GdapCALs is not producing the correct format for MagCal, but used cable 8 for analogue data and seemed ok. Could replace Switch with ADAM as for variometer huts.

Later - configured ga-cnb-mag2 for MagCal operations (services, inetd.conf, .blv, .con). Still need to fix GdapCALs format.

2006-09-08 Commenced FTP delivery of CNB Real-time data and daily data to ftp-isgi.cetp.ipsl.fr/minute_data/Canberra at 06:00 UT. E-mail R-T delivery to ISGI continues, but e-mail delivery may cease at a later date.

2006-09-15 AML tested new networking at MagCal. Noticed MagCal attempted break-in and Seismic vault damage. The break-in happened probably at 2-3pm, 2006-09-10 Sunday local time, as evidenced from seismic signal. No apparent damage elsewhere noticed so far. Steve Read to attend Friday afternoon. LEMI ADAM network (TP,F) had fallen off the wall. Drill two cable access holes in MAGCAL instrument bench.

2006-09-26 ~02:30 Replaced all broken light globes in primary variometer hut. ~02:45 Moved heater and controller from secondary var hut to comparison hut and installed replacement heater and controller in secondary var hut - heater has two IR globes and two "lizard" warmers. Set Controller to "SUMMER" = 25 degs. IR globes on controller, lizard warmers on mains power.

2006-10-26 Contractor Steve Elliot and Excavator Tony Brucic to be working this weekend on ATWS installation.

	Switched one lizard warmer to "controller" on secondary variometer heater.
2006-10-28	(Saturday) Digging equipment working on excavation for tsunami equipment
2006-10-31	Replaced 10 m absolute PPM sensor cable with a 5m sensor cable for absolute observation - Today's Obs used the 5 m cable.
2006-12-05	Switched all elements on heater in secondary hut (LEMI) to "controlled"
2006-12-21	Skilled Maintenance Team at Observatory - Repair to tiles on variometer hut and MagCal

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	2007
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 2006 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 2006 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 2006 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.

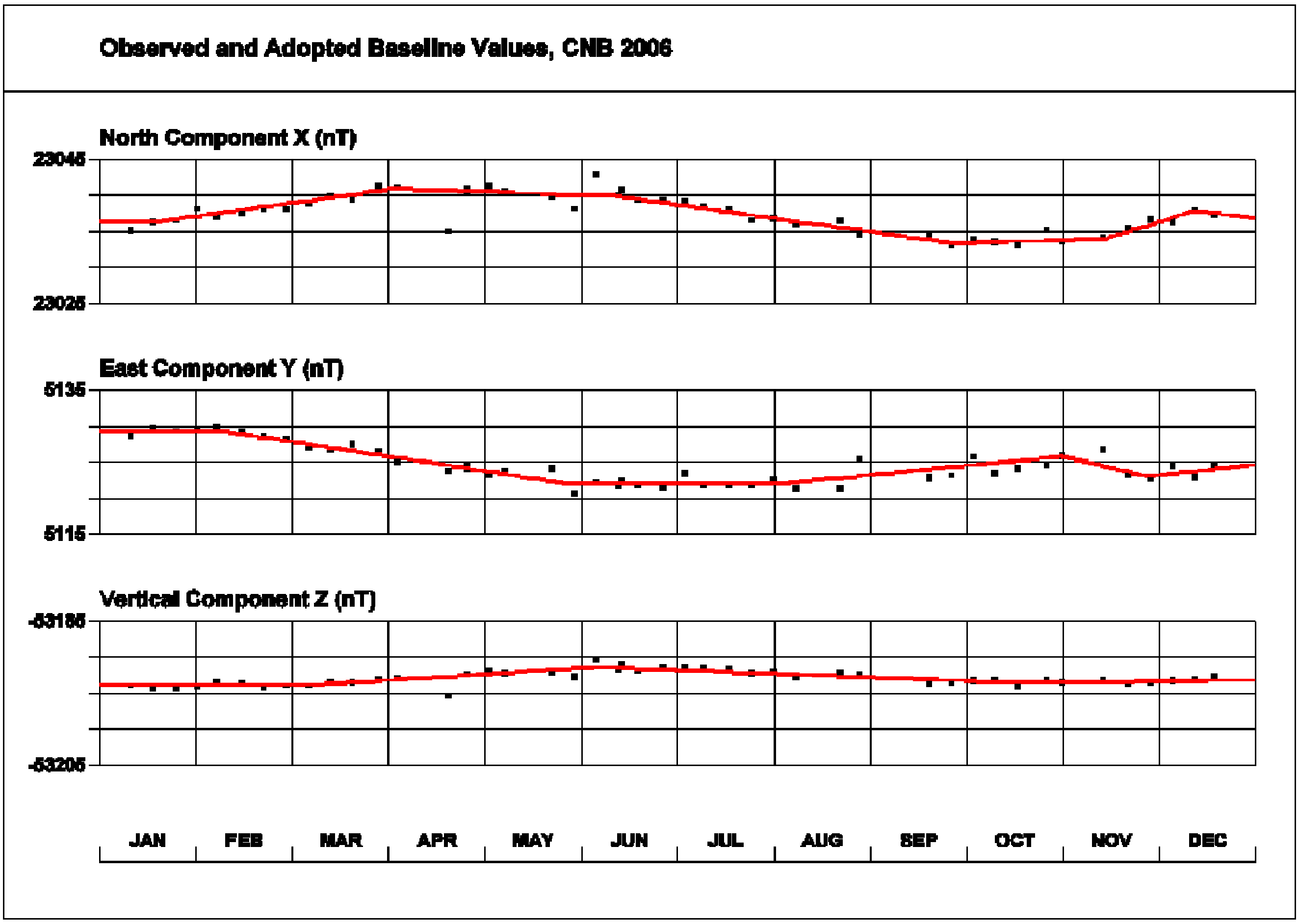


Figure 6.1. Canberra baseline plots.

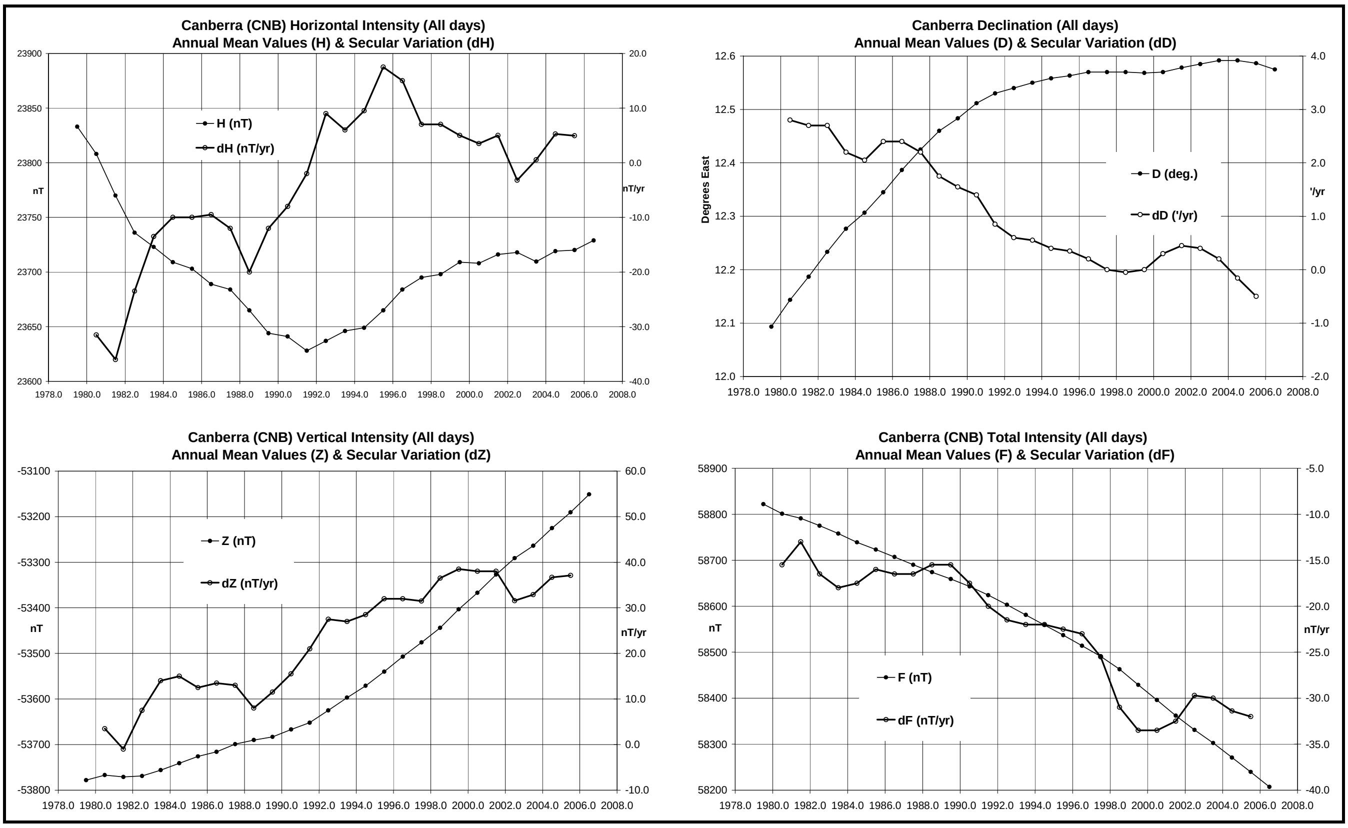


Figure 6.2. Annual mean values and secular variation for H, D, Z and F measured at Canberra.

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

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	1122	3221	14	0221	2121	11	1122	4201	13	0000	1100	2	0011	0000	2	0224	2221	15
02	2332	1222	17	1112	1122	11	1111	1001	6	0000	0000	0	1010	1100	4	2212	0220	11
03	1011	2200	7	3112	2122	14	0101	1111	6	0000	0001	1	1010	0011	4	1110	1100	5
04	1110	1000	4	1221	2200	10	1111	0100	5	1222	2223	16	0034	5321	18	0000	0000	0
05	1111	2100	7	0211	0112	8	0010	0000	1	2235	5441	26	2222	3200	13	0000	0010	1
06	0122	3221	13	1232	3323	19	0122	3333	17	1143	3111	15	1222	5533	23	1134	3442	22
07	1221	2310	12	1211	1111	9	2323	2101	14	0001	2101	5	2344	3221	21	2334	3323	23
08	0112	2201	9	1011	1000	4	1001	2111	7	0012	2101	7	2222	1000	9	3353	3333	26
09	1110	0000	3	0011	2011	6	0100	0111	4	3454	4433	30	1002	0201	6	2223	2221	16
10	0110	1201	6	1011	1012	7	2323	3212	18	2343	2321	20	0000	0012	3	2122	3211	14
11	0002	2210	7	1221	2310	12	2234	2222	19	2111	1102	9	2334	3122	20	1112	2201	10
12	1220	0011	7	2221	2100	10	0211	2010	7	0100	0000	1	3332	3212	19	1001	2200	6
13	1110	1201	7	0110	2201	7	0000	0001	1	1323	4312	19	3323	2221	18	0000	0000	0
14	1111	1121	9	0110	1002	5	0001	2002	5	3567	5644	40	2312	1111	12	1021	1213	11
15	1110	0222	9	1223	2323	18	2222	2220	14	2345	4432	27	0112	1100	6	2244	5322	24
16	1333	3442	23	2233	2111	15	1223	1311	14	2323	3211	17	1000	1000	2	2222	2222	16
17	2233	3212	18	1121	2111	10	0102	1011	6	1111	0102	7	1101	1101	6	1133	2210	13
18	1224	1312	16	0211	2001	7	1234	3433	23	2210	0100	6	1133	2331	17	0134	1000	9
19	2112	3112	13	2321	2211	14	5445	5333	32	0001	0000	1	2221	1111	11	1000	0000	1
20	1112	3212	13	1233	4532	23	3344	3332	25	0112	3100	8	1123	0110	9	0000	1000	1
21	2101	2000	6	2144	4332	23	2322	4322	20	0101	2311	9	1012	0121	8	0000	0100	1
22	0012	3312	12	2124	4411	19	2221	1221	13	3334	3201	19	1011	2122	10	0112	1110	7
23	1333	3222	19	1111	1011	7	1101	1000	4	1131	0101	8	2110	1100	6	0000	0000	0
24	2221	1102	11	1103	2200	9	1001	1011	5	1012	1000	5	0011	1100	4	0000	1010	2
25	2222	1122	14	1111	0000	4	0112	3210	10	1100	2100	5	0101	0011	4	1002	0000	3
26	3323	4434	26	1311	2311	13	1202	2231	13	0001	0000	1	0000	2010	3	0000	0000	0
27	2223	3212	17	1000	2001	4	2200	1302	10	1110	1111	7	1000	0000	1	0001	2111	6
28	1122	2111	11	0113	3111	11	1321	1110	10	2243	2001	14	1112	2100	8	2233	4132	20
29	2100	0001	4				1101	0101	5	0000	0000	0	0000	0010	1	1212	3321	15
30	1101	1100	5				1001	1101	5	1000	0000	1	0002	3220	9	1121	4210	12
31	1000	1101	4				1012	3120	10				1011	1110	6			

Day	July			August			September			October			November			December		
01	0111	2010	6	1234	4311	19	2133	3333	21	2344	4211	21	0101	3211	9	1002	1111	7
02	0000	0000	0	1132	2212	14	1111	2221	11	1122	3121	13	1112	2321	13	0110	2000	4
03	0001	0000	1	1101	1011	6	1111	2101	8	1112	2201	10	1213	4210	14	1110	0211	7
04	0011	3233	13	0000	0000	0	3433	2331	22	1100	1200	5	1322	1212	14	0000	0000	0
05	3342	2222	20	1100	0000	2	1123	2310	13	0110	1020	5	0123	3201	12	0002	1312	9
06	2233	1220	15	0011	2100	5	1113	3310	13	0122	1011	8	0011	0011	4	3234	4333	25
07	0112	3310	11	2446	4321	26	1121	3310	12	1100	2322	11	0000	0000	0	3343	4312	23
08	0011	0000	2	1233	2210	14	0111	1000	4	2123	2111	13	0000	0000	0	2444	3223	24
09	0000	0112	4	1214	2211	14	1100	0000	2	1210	0011	6	0000	2333	11	1310	1223	13
10	2111	3421	15	1000	1012	5	1001	1211	7	1100	0011	4	3545	4322	28	2322	3423	21
11	0111	2221	10	1112	2210	10	1333	3110	15	1112	2101	9	3243	3322	22	2332	2123	18
12	1224	4110	15	1211	2321	13	1122	1010	8	1002	2202	9	1122	2111	11	2343	4432	25
13	0111	2000	5	0001	0000	1	2322	2010	12	1355	3233	25	0100	0001	2	4211	1112	13
14	1112	4431	17	0000	1000	1	0113	1000	6	2334	3433	25	0111	2111	8	1213	5647	29
15	0111	2000	5	0000	1100	2	1000	0000	1	1223	1221	14	1222	1112	12	6555	5322	33
16	0000	0000	0	0000	1000	1	1000	1110	4	1122	2211	12	1220	1011	8	2322	1233	18
17	0001	1100	3	0021	1111	7	1124	4232	19	0101	1000	3	1201	3200	9	2221	1111	11
18	0000	0100	1	2232	3212	17	4334	3232	24	0002	0000	2	0011	1001	4	0212	2323	15
19	0000	0000	0	1213	5555	27	3343	3211	20	0102	1000	4	1212	1001	8	2224	3222	19
20	0100	0000	1	4431	1312	19	0010	0000	1	2233	4433	24	0110	2000	4	2223	4323	21
21	0000	0000	0	1222	3323	18	1001	2000	4	2233	3422	21	1000	1000	2	3333	3322	22
22	0111	0001	4	2244	4430	23	0001	0000	1	1321	3222	16	0022	2112	10	2334	3322	22
23	1001	1000	3	1331	0101	10	1101	1133	11	0002	1111	6	1244	4333	24	2233	3332	21
24	1011	2310	9	1100	1310	7	3435	4212	24	2121	2111	11	2433	4221	21	2222	3322	18
25	1110	2110	7	0001	0000	1	1213	3102	13	1221	0100	7	1222	3432	19	2232	2202	15
26	1101	1000	4	0000	0000	0	1211	2211	11	1012	2100	7	1232	3122	16	2111	2211	11
27	0000	2222	8	0134	3333	20	2112	0210	9	1101	2012	8	2223	1221	15	1110	1000	4
28	5534	3201	23	3332	2332	21	1102	1000	5	1123	4423	20	2212	2112	13	0000	0001	1
29	1001	0010	3	1123	2220	13	0010	1110	4	2232	2222	17	1322	1112	13	0101	0011	4
30	1101	0100	4	1122	1211	11	1434	2222	20	2224	2211	16	1355	5411	25	1112	2110	9
31	1232	4311	17	1132	2322	16				0001	2112	7				1110	0001	4

Table 6.6. K indices and daily K sums measured at Canberra in 2006.

Commencement				SSC-amplitudes			Maximum 3hr K indices		Storm Ranges			End		
Mth	**Day**	**Hr**	**Mn**	**D(')**	**H(nT)**	**Z(nT)**	**Day (3hr Periods)**	**K**	**D(')**	**H(nT)**	**Z(nT)**	**Mth**	**Day**	**Hr**
Mar	18	02	00	...			19(1,4,5)	5	15.9	120.7	46.6	Mar	20	21
Apr	05	06	00	...			5(4,5)	5	17.1	86.4	32.2	Apr	05	21
	14	03	00	...			14(4)	7	34.6	211.5	82.7		16	18
May	06	12	00	...			6(5,6)	5	12.3	114.8	35.4	May	08	14
Jul	27	13	53	0.42	12.84	2.73	28(1,2)	5	10.1	123.4	43.1	Jul	28	16
Aug	07	02	00	...			7(4)	6	23.2	87.9	57.8	Aug	07	18
	19	11	00	...			19(5,6,7,8)	5	9.2	73.7	26.6		20	10
Oct	13	02	00	...			13(3,4)	5	3.6	12.6	6.1	Oct	14	02
Nov	30	03	23	...			30(3,4,5)	5	17.7	93.6	52.6	Nov	30	21
Dec	14	14	14	1.32	70.63	13.23	14(8)	7	23.6	279.4	96.6	Dec	15	17

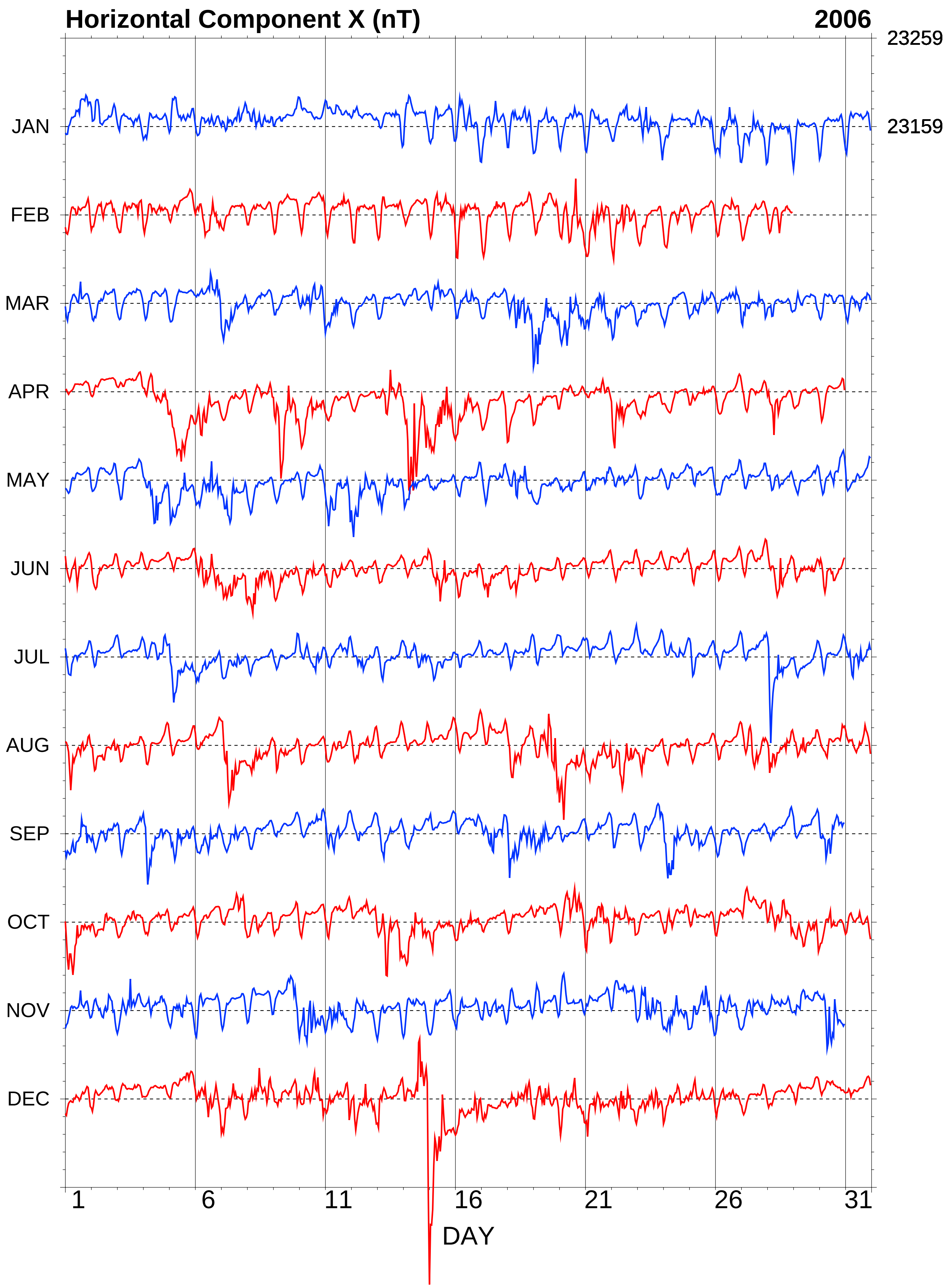
Table 6.7. Principal magnetic storms observed at Canberra in 2006.

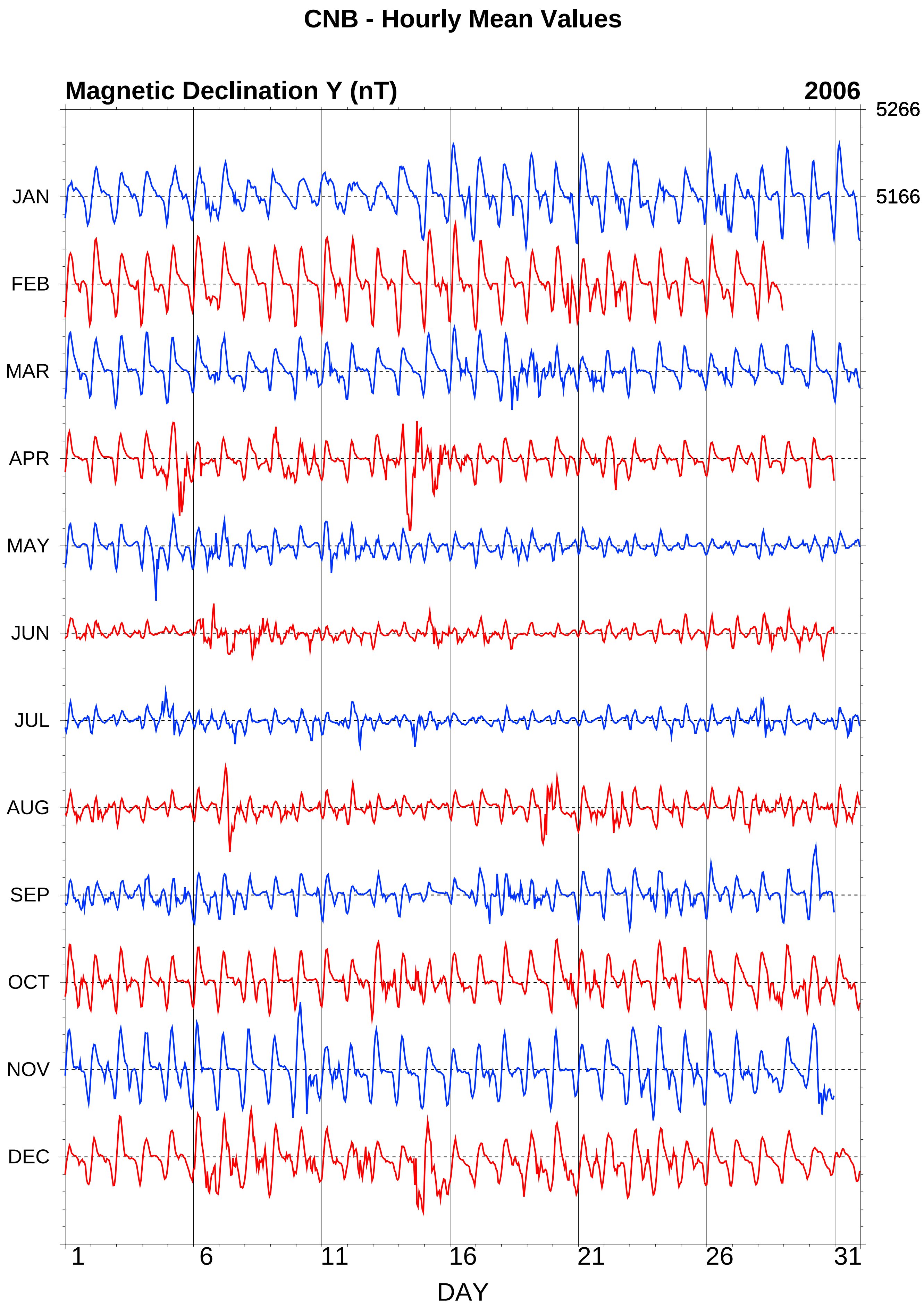
UT Date				Type & Quality		Chief movement (nT)		
Mth	**Day**	**Hr**	**Mn**	**ssc/ssc***	**A,B,C**	**H(x)**	**D(y)**	**Z**
Jul	09	21	35	ssc*	a	5.38*	-8.35*	2.33
	27	13	53	ssc	a	12.84	2.99	2.73
Aug	17	07	21	ssc	a	13.49	7.89	2.16
Dec	14	14	14	ssc	a	70.63	9.33	13.23

Mth	Day	UT of movement			Amplitude (nT)			Confirmation
		Start	**Max**	**End**	**H(x)**	**D(y)**	**Z**	
May	02	06:25	06:35	06:55	3.6	0.1	0.0	solar

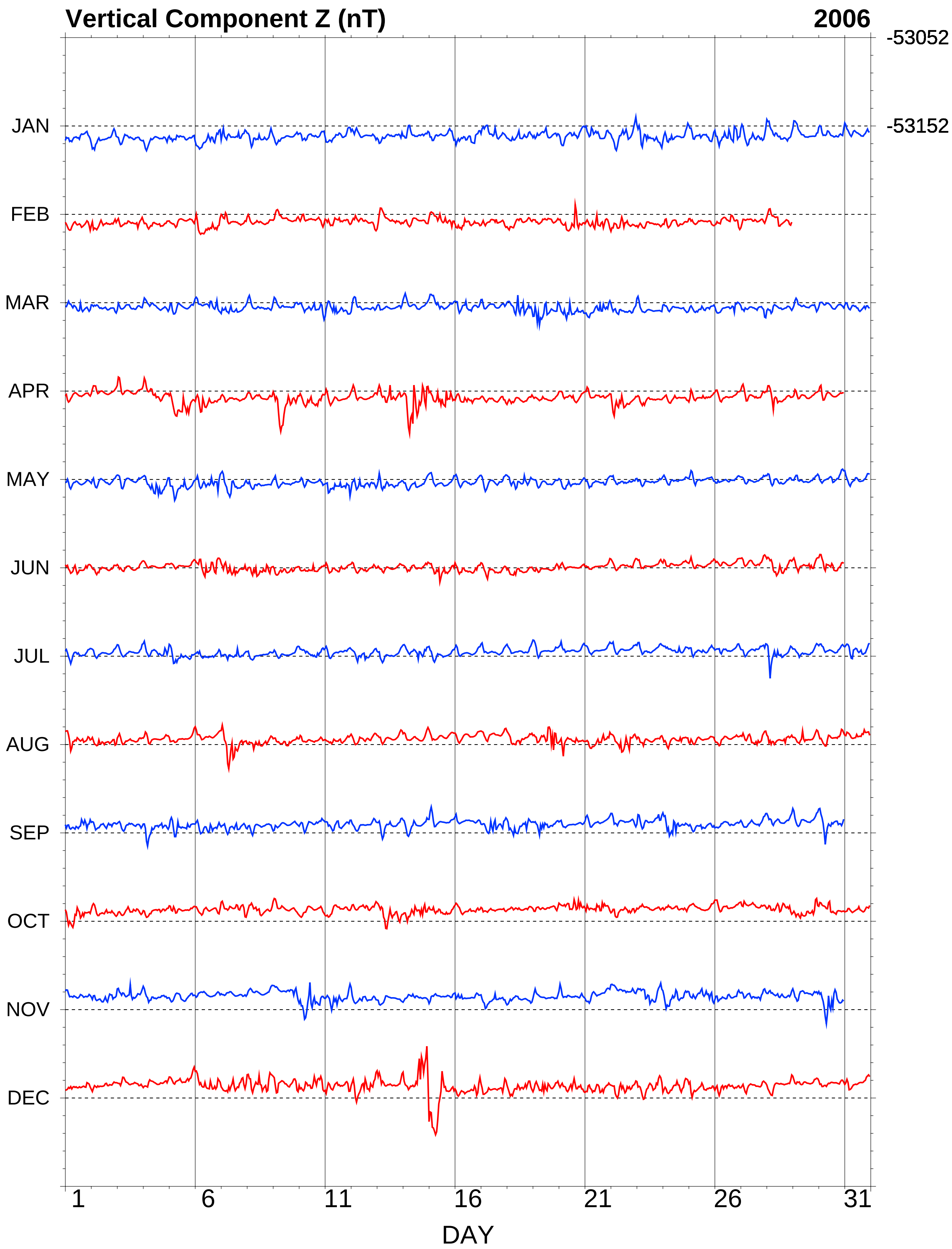
Table 6.8. Sudden storm commencements and solar flare effects observed at Canberra in 2006.

CNB - Hourly Mean Values




CNB - Hourly Mean Values
Magnetic Declination Y (nT)
2006
5266
5166
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1
6
11
16
21
26
31
DAY

CNB - Hourly Mean Values



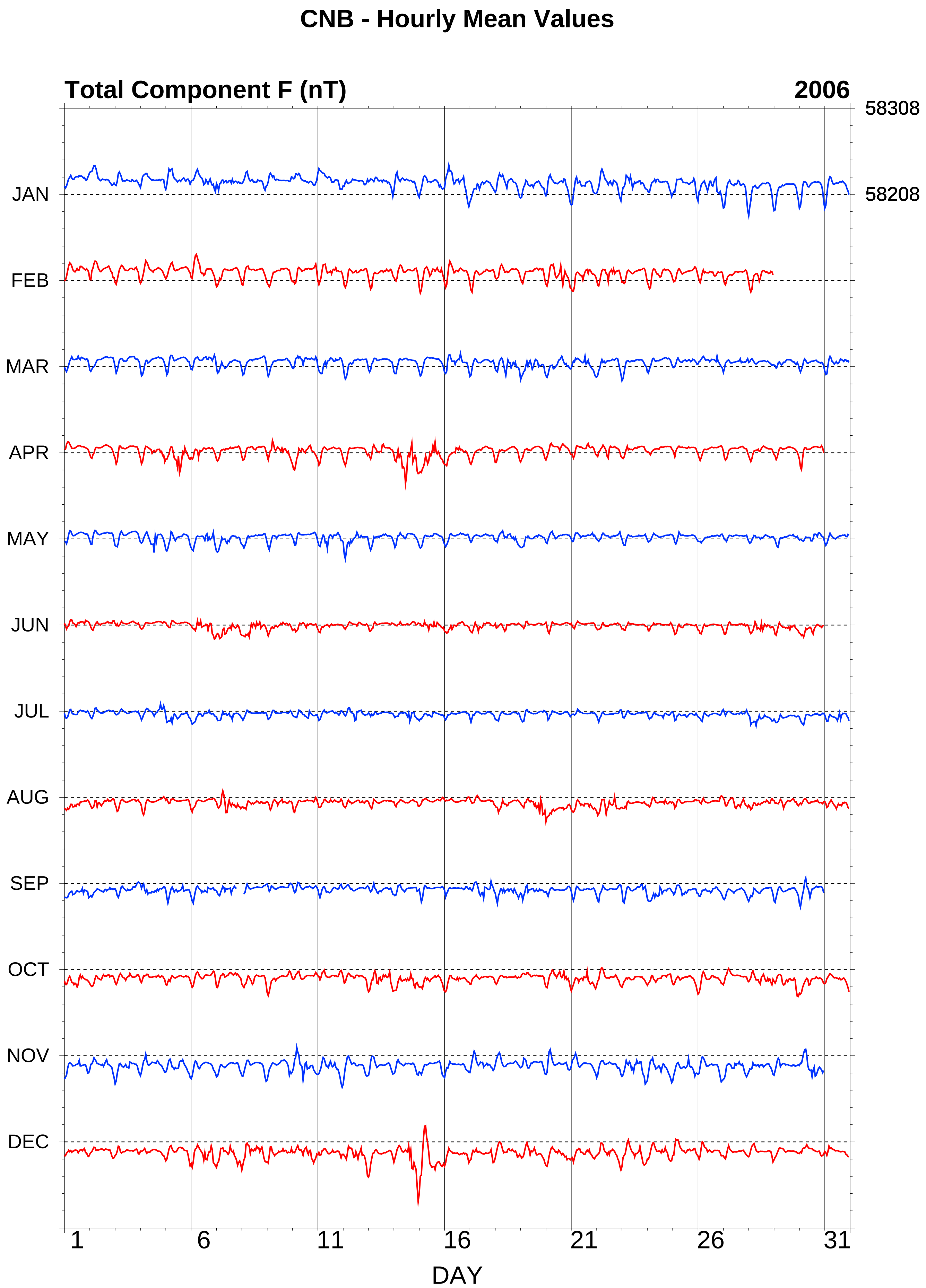


Figure 6.3. Hourly mean values in X, Y, Z and F measured at Canberra.

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 Macquarie Island.

The observatory consists of:

- 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:	-59.85°
Geomagnetic longitude:	244.13°
K 9 index lower limit:	1500 nT
Principal pier:	Pier AE
Pier elevation (top):	8 m AMSL
Principal reference mark:	NMI
Reference mark azimuth:	353° 44' 13"
Reference mark distance:	~200 m
Observers:	B. Copley (until 5 April) J. Wruck (from 6 April)

Table 7.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 are described in Table 7.2.

The primary 3-component 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. The electronic console of the primary variometer was situated in the ante-room of the Variometer House. The primary total-field 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 for most of the year, however the heating system was not operational from early March until 12 July.

A secondary 3-component variometer was housed in the instrument room of the Variometer House and a secondary total-field variometer was located in the PPM House.

The data acquisition system was situated in the ante-room of the Variometer House and the source of backup power was situated in the office until 03 Apr after which backup power was split between the office (for the Narod RCF and Elsec PPM) and the variometer house ante-room (for the acquisition PC, DMI variometer, and GSM-90 PPM).

3-component variometer:	Narod (Primary)
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 (Secondary)
Serial number:	E0290/S0250
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:	until 5 April
3-component variometer:	DMI FGE (Secondary)
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 (Primary)
Serial number:	4081418/42176
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Total-field variometer:	Elsec 820 M3 (Secondary)
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 clock
Communications:	real time telemetry

Table 7.2. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at Macquarie Island and their adopted corrections for 2006 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. An HP H4300 personal digital assistant 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 (Aust525) were available as back-up absolute instruments and were used occasionally throughout the year, in addition to the primary instruments.

DI fluxgate:	Elsec 810
Serial number:	214
Theodolite:	Zeiss 020B
Serial number:	311847
Resolution:	0.1’
D correction:	0.1’
I correction:	-0.1’
Period of use:	until 23 February
DI fluxgate:	DMI
Serial number:	DI0045
Theodolite:	Zeiss 020B
Serial number:	393911
Resolution:	0.1’
D correction:	0.15’
I correction:	-0.10’
Period of use:	from 24 February
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091319/01504
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period of use:	until 3 April
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	5091720/52453
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period of use:	from 4 April
Total-field magnetometer:	Austral (backup)
Serial number:	525
Type:	Proton precession
Resolution:	1 nT

Table 7.3. Absolute magnetometers and their adopted corrections for 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Instrument comparisons between the Macquarie Island absolute instruments (E810_214/311847 DIM) and travelling reference instruments (B0806H/100856 DIM) were performed at Macquarie Island on 24 and 26 March 2003. The MCQ absolute total field instrument GSM90_3091319/01504 was compared to the Australian reference at Canberra observatory on 02 December 2003, and to GSM90_5091720/52453 at Macquarie Island on 04 April 2006. DI0045/393911 was compared to the Australian reference at Canberra observatory on 13 and 27 Dec 2005.

These series of instrument comparisons yield the instrument differences listed in Table 7.3. They have been applied to all absolute observations used to calibrate the MCQ 2006 final data.

At the 2006 mean magnetic field values at Macquarie Island these D, I, and F corrections translate to corrections of:

$\Delta X = -1.8$ nT $\Delta Y = -0.6$ nT $\Delta Z = -0.4$ nT

These corrections have been applied to all Macquarie Island 2006 final data.

Baselines

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

	σ		σ
X	1.2 nT	D	18"
Y	1.1 nT	I	4"
Z	0.8 nT	F	0.6 nT

The drifts applied to the X, Y, and Z baselines amounted to less than 15 nT throughout 2006, with the X and Y baselines showing most drift. There were two sudden jumps in the baseline throughout 2006, the largest being 9 nT in the Y baseline. Throughout the year there was about 3 nT of variation in the difference between F measured with the vector variometer and the variometer PPM.

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

Operations

The magnetic observers at Macquarie Island in 2006 were members of the Australian National Antarctic Research Expedition and were supported jointly by the Australian 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 2006, weekly absolute calibrations were performed on the observation piers in the absolute house by the ANARE communications technical officers: Barry Copley, from March 2005 until 5 April 2006, and Jodi Wruck, from 6 April 2006 until April 2007.

The Narod variometer produced 8 samples per second which were averaged and output as 1-second data. The PPM variometer produced 10-second samples. The 1-second Narod data and 10-second PPM data were recorded on an acquisition PC. Data were transmitted every 10 minutes to Geoscience Australia. Acquisition timing control was provided by a dedicated Garmin GPS clock mounted on the variometer building.

Data losses at Macquarie Island in 2006 are identified in Table A.7.

Significant events

2006-01-16	~22:39 baseline shift and increased noise on Narod. Noise continued throughout 17 Jan. Unknown cause.
2006-01-30	Power failure approx 1100-1115 UT
2006-02-07	installed new CheckTimeCorrections cron job - accidentally removed /tmp directory at MCQ about 05UT. Recreated it but with loss of log files etc.
2006-02-14	Commence real-time one-minute data delivery to IPS Radio and Space Services for MCQ,CNB,MAW,KDU,CTA
2006-02-23	Noise on all channels 13:15, 14:45, 16:30,
2006-02-24	Barry was in the mag-zone from approx 0250-0300UTC
2006-03-04	Variometer heater probably failed sometime in second half of the day
2006-03-18	System reboot
2006-04-03	Andrew Lewis arrived at MCQ, connected E820 at 9600 baud to QNX, Disconnect DOS/QNX4.

2006-04-04	Start using GSM90_5091720 #52453 as primary absolute PPM
2006-04-05	Install DMI suspended system (E0307/S0262), Assist Hiroko Kohta to install Japanese (SERC) MagDas system in variometer hut Install UPS battery box into variometer hut
2006-04-06	Jodi Wruck commenced as Observer-in-charge. Data contamination 00:00 - 02:30, 23:30-23:59
2006-04-13	First magnetic absolute obs from Jodi
2006-05-05	In Mag zone 01 - 01:30 UT to measure for non-magnetic steps for observations.
2006-05-16	Data contamination 22:50 - 23:30
2006-05-17	06:00 commence INTERMAGNET filtering of 1 minute real-time data delivery
2006-05-18	First observation with new non-magnetic steps installed in absolute hut
2006-07-05	00:00 commence delivery of 1-second RT data to IPS Radio and Space Services (switch off 1 minute delivery to IPS)
2006-07-12	00:10 heater re-installed into variometer hut after repair. Some data contamination
2006-07-13	to 07-21 Jodi away from station
2006-09-09	Jodi will be off station for next 9 days,no obs
2006-11-25	Jodi will be off station for radio repairs,no obs
2006-12-15	Observation made during large magnetic storm.
2006-12-20	Power circuit breaker tripped to UPS in Science Building. Narod and E820 PPM stopped 10:32UT Jodi resets and NAROD re-starts ~22:39 E820 does not reset.
2006-12-21	Jodi resets E820 and restarts GdapE820 ~01:00

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	2007
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 7.4. Distribution of 2006 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 2006 data are shown in Figure 7.3.

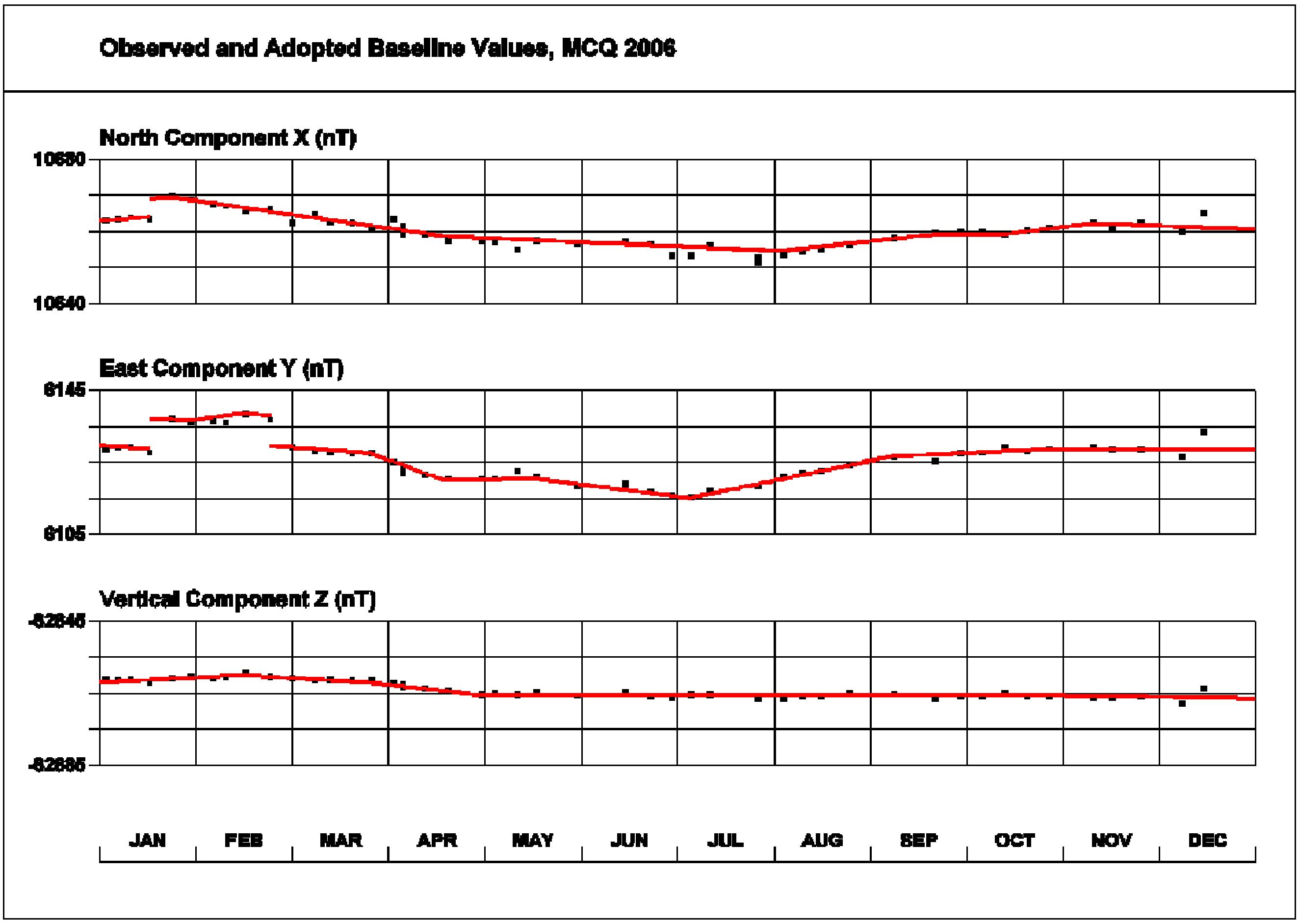


Figure 7.1. Macquarie Island baseline plots.

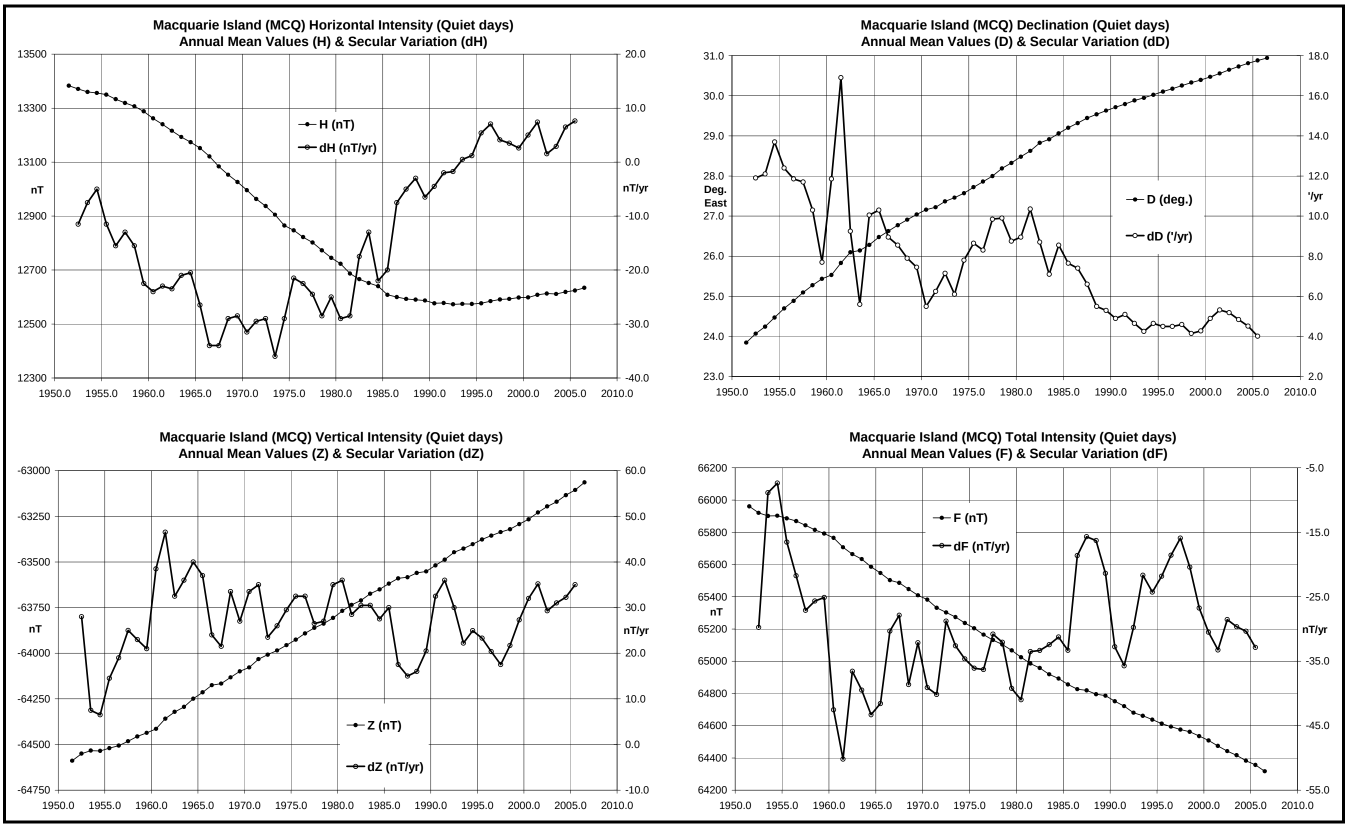


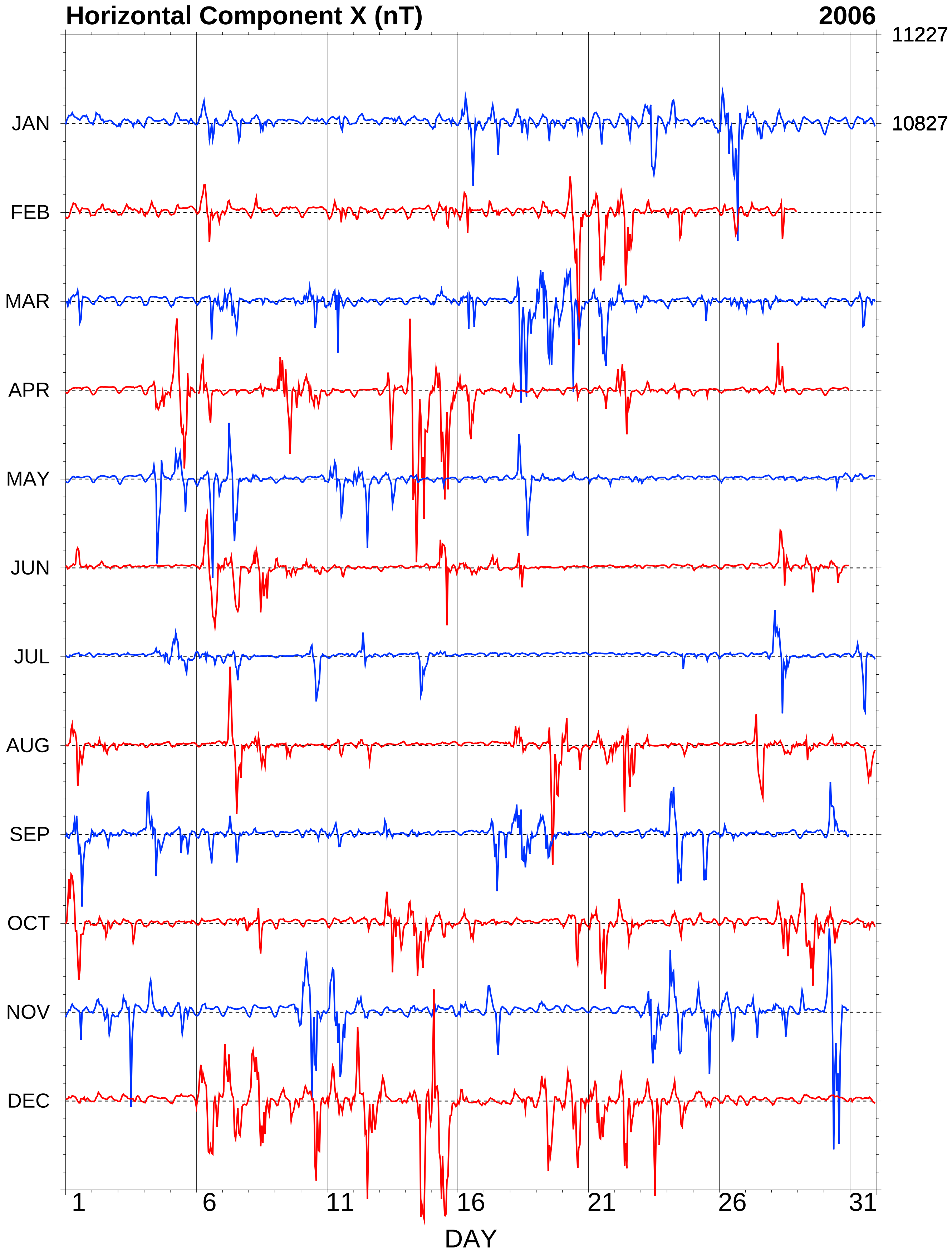
Figure 7.2. Annual mean values and secular variation for H, D, Z and F measured at Macquarie Island.

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
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

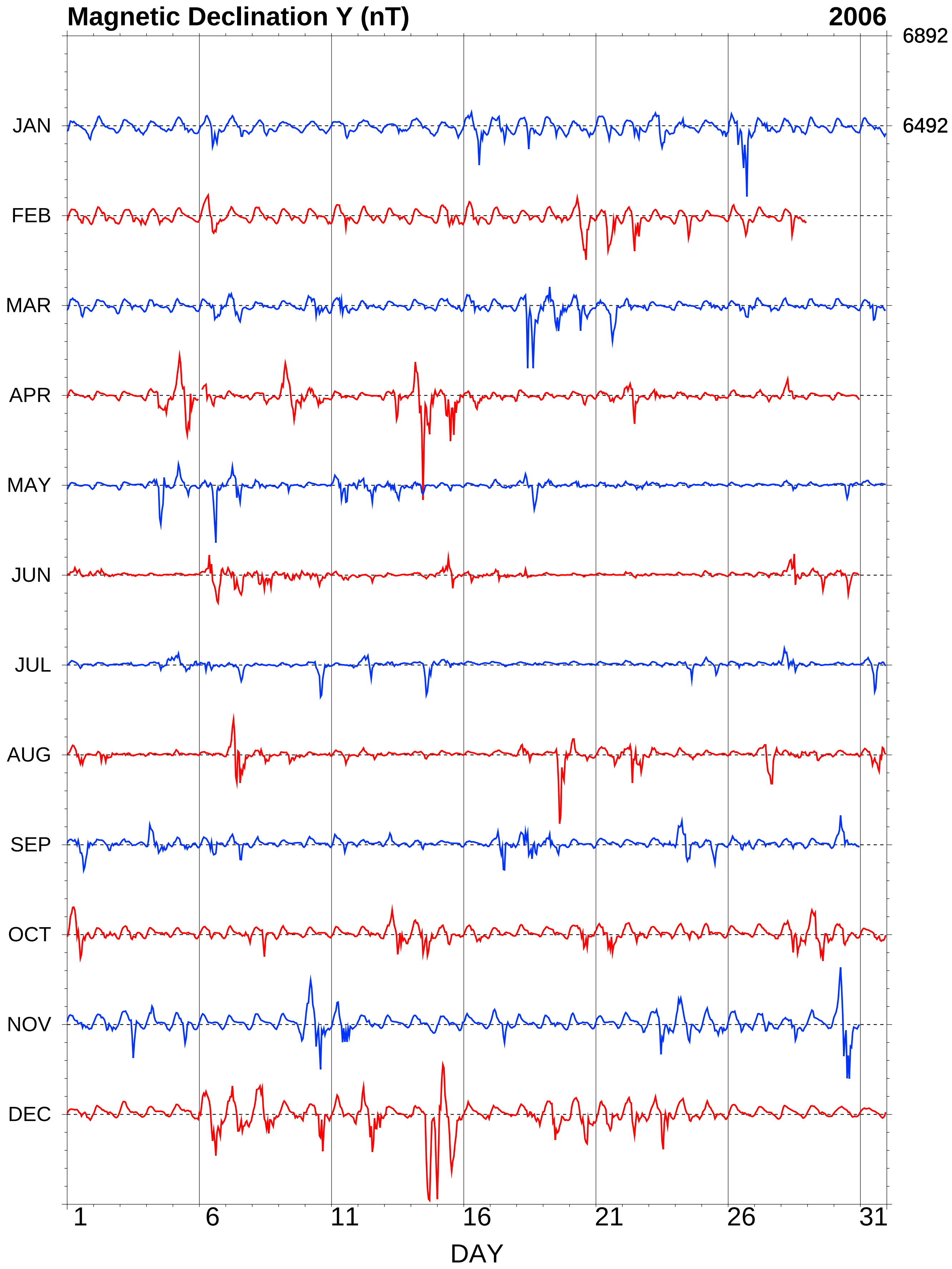
2001.5	Q	30	33.3	-78	43.4	12608	10857	6409	-63229	64474	ABC
2002.5	Q	30	38.9	-78	42.8	12613	10851	6429	-63196	64442	ABC
2003.5	Q	30	43.7	-78	42.6	12611	10841	6444	-63170	64417	ABC
2004.5	Q	30	48.5	-78	41.8	12619	10838	6463	-63134	64383	ABC
2005.5	Q	30	52.7	-78	41.3	12624	10835	6479	-63106	64356	ABC
2006.5	Q	30	56.6	-78	40.3	12634	10836	6496	-63064	64317	ABC
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

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.

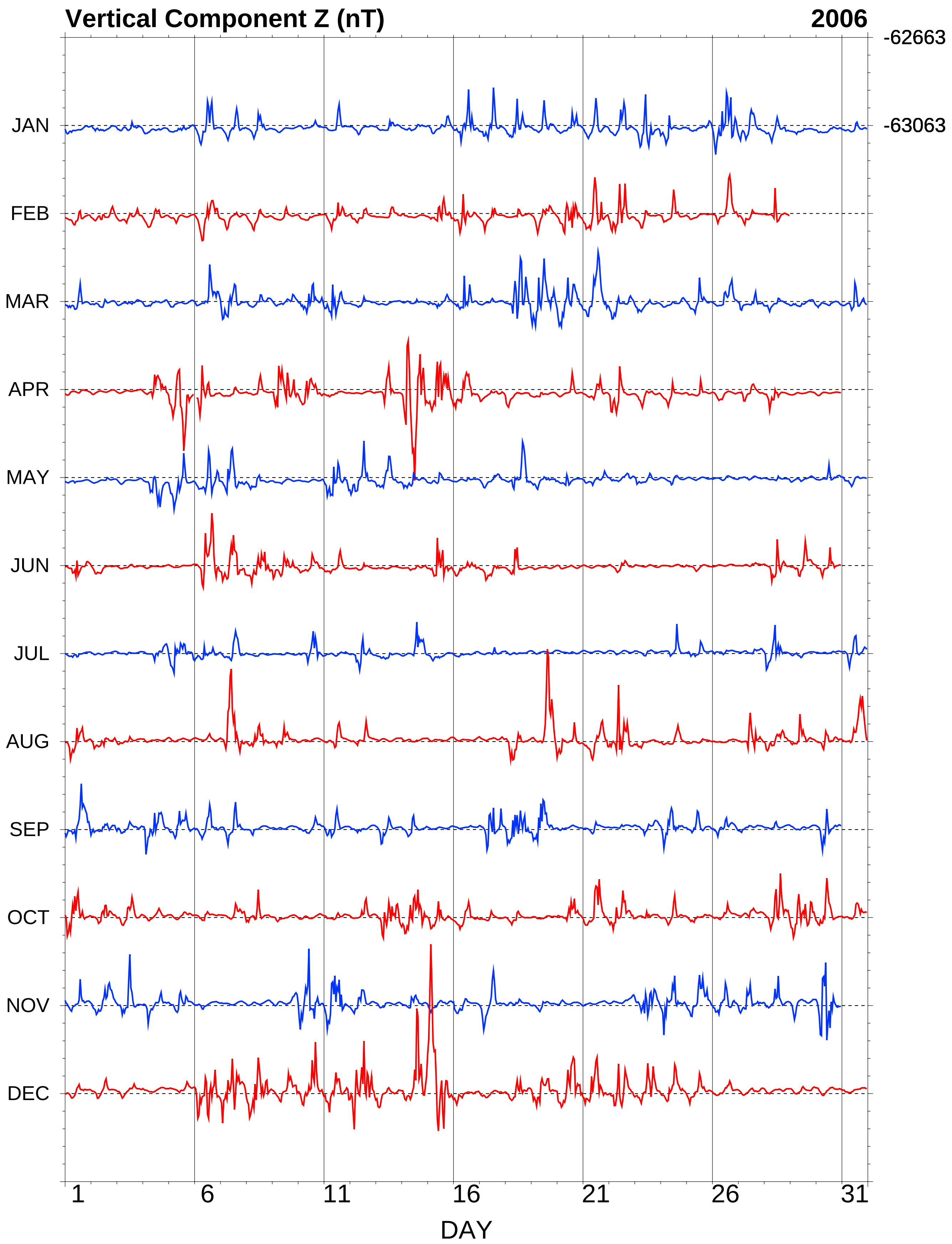
MCQ - Hourly Mean Values



MCQ - Hourly Mean Values



MCQ - Hourly Mean Values



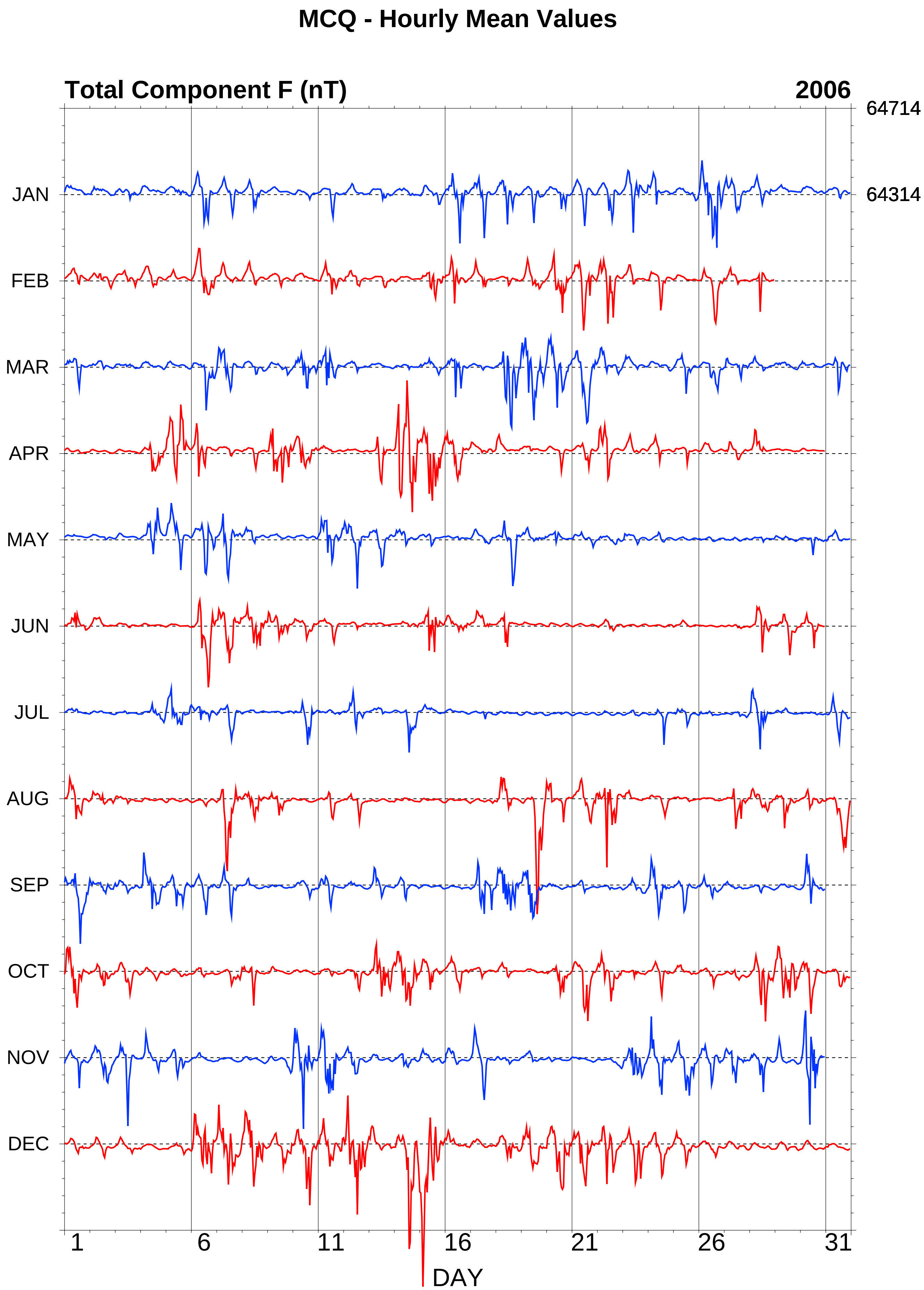


Figure 7.3. Hourly mean values in X, Y, Z and F measured at Macquarie Island.

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 have been made at Casey since 1975. A variation station operated from 1988 and 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).

IAGA code:	CSY
Commenced operation:	1999
Geographic latitude:	66° 17' S
Geographic longitude:	110° 32' E
Geomagnetic latitude:	-76.32°
Geomagnetic longitude:	184.06°
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
Observer:	T. Taylor

Table 8.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 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.

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
Communications:	ANARESAT

Table 8.2. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at Casey in 2006 are described in Table 8.3.

DI fluxgate:	Elsec 810
Serial number:	2591
Theodolite:	Zeiss 020B
Serial number:	356514
Resolution:	0.1’
Period of use:	until 13 January
DI fluxgate:	DMI
Serial number:	DI0051
Theodolite:	Zeiss 020B
Serial number:	313888
Resolution:	0.1’
Period of use:	from 14 January
Total-field magnetometer:	Geometrics G816
Serial number:	766
Type:	Proton precession
Resolution:	0.01 nT
Period of use:	until 13 January
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081416/42172
Type:	Overhauser effect
Resolution:	0.01 nT
Period of use:	from 14 January

Table 8.3. Absolute magnetometers.

Baselines

No usable baselines were derived for Casey data in 2006.

Operations

Absolute observations were made periodically throughout the year however baselines were not meaningful due to the periodic signal of unknown origin in the variometer data.

Significant events

2006-01-15 Absolute hut was stripped of paint and sealed and painted to repair leaking roof

2006-02-16 Absolute Hut Fire: something to do with the heating caught fire and covered everything in the hut with soot, including the magnetometers. Observations deferred until investigation.

2006-03-26 AML completed difficult 24hr at CSY - far too little time to complete necessary work. It was made difficult by bad weather and it was impossible to get shore-leave for any decent length of time, in fact lucky to get any at all.

Data losses

There is complete data loss for Casey in 2006.

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.

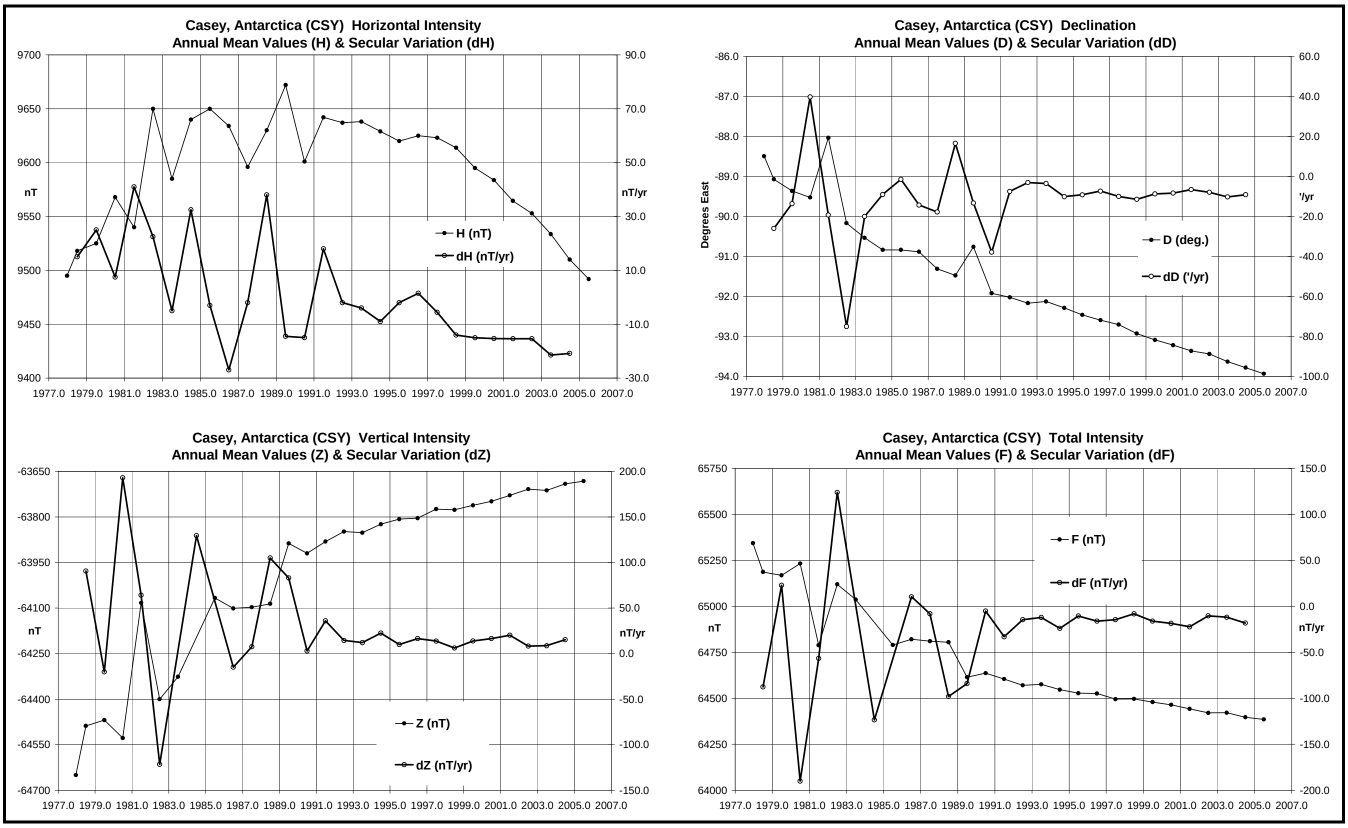


Figure 8.1. Annual mean values and secular variation for H, D, Z and F measured at Casey.

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

Table 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.

IAGA code:	MAW
Commenced operation:	1955
Geographic latitude:	67° 36' 14" S
Geographic longitude:	62° 52' 45" E
Geomagnetic latitude:	-73.10°
Geomagnetic longitude:	110.52°
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:	D. Taylor (2006) I. McLean (2007)

Table 9.1. Key observatory data. Geographic coordinates are derived using the Geodetic Datum of Australia 1994 (GDA 94); geomagnetic coordinates are based on the IGRF 2005.0 model updated to 2006.5.

Variometers

The variometers used during 2006 are described in Table 9.2.

The Narod and total-field sensors were located within the sensor (western) 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 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.

A 3-axis DMI suspended linear fluxgate magnetometer continuously monitored the variations from 20 May without the levelling mechanism released and from 9 June with the levelling mechanism released. The DMI sensor was located in the recording (eastern) 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 temperatures of the sensors and the electronics of both fluxgate magnetometers were monitored by in-built dual temperature systems.

Temperature within the sensor room was maintained close to 10°C by a fast-cycle heater and monitored by a Doric Trendicator digital thermometer with its sensor on a disused pier. The recorded variometer head and electronics temperatures were about 7.2±0.7°C throughout the year (7.6±0.6°C in summer and 6.8±0.6°C in winter, with a total range from 5.4°C to 8.5°C). The heater capacity was not sufficient to maintain 10°C in winter. During the months April to September inclusive, 5°C would have been a preferable standard temperature. There was greater short-period (period of about 1 week) temperature variation during winter.

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

3-component variometer:	Narod (Primary)
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 (Secondary)
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)
Period of use:	from 20 May
Total-field variometer:	GEM Systems GSM-90 (Primary)
Serial number:	4081417/42175
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	until 1 December
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS16 clock
Communications:	ANARESAT

Table 9.2. Magnetic variometers.

The Narod variometer parameters changed when the DMI variometer was installed on 20 May. There was a change in the baselines indicated by absolute calibrations at the end of October and beginning of December. There were no absolute calibrations during November – this was a changeover period between observers and station re-supply. The F variometer was removed in mid-November to replace a damaged absolute F instrument. (The absolute sensor had apparently been dropped at some stage, possibly causing it to leak fluid slowly and, consequently, become increasingly erratic.) The concurrence of events made it difficult to identify the cause of the change in baselines. However it is likely that some temperature effect changed the baselines of both the Narod and DMI variometers during the first week of November. See below. The baselines were accordingly assigned a drift during this period.

The DMI variometer parameters, judged by FCheck results, changed over a short period between 13-14 September. There was a change of about 1 nT in FCheck. Before that time FCheck had a 1 to 2-week periodic nature about 2 nT peak-to-peak. After that time it had an aperiodic nature of about 0.5 nT peak-to-peak. There was also a slow change in FCheck during the first week in November. The changes may have been caused by weather (external temperature) and the inability of the heating system to compensate for changing temperatures. The temperature gradients in the DMI installation may have changed as the sensor and electronics temperatures did not change in harmony.

Absolute instruments

The principal absolute magnetometers used at Mawson and their adopted corrections for 2006 are described in Table 9.3.

DI fluxgate:	DMI
Serial number:	D26035
Theodolite:	Zeiss 020B
Serial number:	311542
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Period of use:	until 21 July and from 1 December
DI fluxgate:	DMI
Serial number:	DI0022
Theodolite:	Zeiss 020B
Serial number:	353758
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Period of use:	from 28 July to 13 November
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091315/91378
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period of use:	until 13 November
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081417/42175
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Period of use:	from 1 December
Total-field magnetometer:	Elsec 770 (backup)
Serial number:	210
Type:	Proton precession
Resolution:	1 nT
Correction:	undetermined
Period of use:	until 2 June

Table 9.3. Absolute magnetometers and their adopted corrections for 2006. Instrument corrections are applied in the sense Standard = Instrument + correction.

Theodolite 311542 became unserviceable after 21 July and was not used again until 1 December. The focus mechanism became jammed apparently due to operator error and was corrected by the new operator.

GSM-90 3091315 became unserviceable after 13 November, apparently due to a faulty sensor. The variometer GSM-90 4081417 with sensor 42175 was used as an absolute instrument from 1 December.

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 2006. At the 2006 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

These corrections have been applied to all Mawson 2006 final data.

Baselines

There were many problems with baselines during 2006. Noting that there have been fewer problems in 2007, it seems that the cause may have been insufficient operator training. Many absolute observations were rejected.

Of the remainder of the observations, the standard deviations between the adopted variometer model and data, and the absolute observations, were:

	σ		σ
X	2.7 nT	D	32"
Y	1.9 nT	I	6"
Z	0.8 nT	F	0.8 nT

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

Operations

The 2006 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 2006 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 2006 data were recorded on a QNX6 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 QNX6 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 occasionally to ensure it was working. If not, it was reset remotely or, if necessary, the computer was re-booted.

During 2006, adjustments to the acquisition timing exceeded 10 ms on the following occasions:

2006-02-20	05:44:04	+197ms	GPS program failed
2006-06-30	01:31:31	+585ms	System restart

2006-07-03	03:28:41	+386ms	System restart
2006-08-14	23:26:24	+115ms	GPS program failed
2006-10-09	01:11:12	-17ms	GPS program failed

The recorder room also housed an uninterruptible power supply for power back-up.

In earlier years (particularly 2000) considerable effort was made to isolate the variometer system from static electricity sparks originating from the very dry blown snow during the severe blizzards that are common at Mawson. The sparks occasionally halted the acquisition computer. This effort seems to have improved the situation, but there were still data losses during blizzards in following years. However, there were no losses attributed to blizzards in 2006.

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.

An application for MAW to be accepted as an INTERMAGNET observatory was lodged in August 2005. Real-time transmission of MAW data to INTERMAGNET began on 24 November 2005. An INTERMAGNET certificate was received on 18 January 2006. The INTERMAGNET-filter was applied to real-time data from 17 May 2006. FINAL INTERMAGNET 1-minute data for 2006 has the INTERMAGNET-filter applied to 1-second data.

Data losses at Mawson in 2006 are identified in Table A.9.

Some vector data were recovered from filtered 1 s backup variometer data in June (404 minutes), July (1644 minutes) and September (13 minutes).

Some data were included that did not fully meet the INTERMAGNET filtering requirements in April (15th 46 minutes, 17th 2 minutes, 19th 6 minutes), June (30th 2 minutes), July (3rd 3 minutes, 8th 108 minutes, 9th 3 minutes), September (13th 16 minutes) and November (26th 2 minutes).

Significant events

2006-01-18	Received INTERMAGNET CERTIFICATE for MAW
2006-01-31	20:00 GPS clock failed
2006-02-03	03:07 Restart GPS clock, 8 ms correction
2006-02-17	20:00 GPS clock failed
2006-02-20	05:44 Restart GPS clock, +197 ms correction
2006-03-11	NGL variometer stalled, GSM90 variometer data still being recorded;
2006-03-13	00:02 Reset NGL variometer (qtalk ^C)
2006-03-22	NGL variometer stalled ~12:30. Modified NGL driver to lengthen timeout. Restart new driver ~22:40. Then OK. NGL may have been disconnected when DOS computer was removed triggering an infinite reset loop caused by faulty software timeout parameter.
2006-04-20	03:00 GPS clock failed
2006-04-21	01:39 Restart GPS clock, +3 ms correction
2006-05-17	Connected the DMI fluxgate variometer. Initially not set up properly. Commence INTERMAGNET filtering of 1 m real-time INTERMAGNET data.
2006-05-18	~23:00 DMI recording recommenced.
2006-05-19	~08:00 Apparent adjustments to DMI offsets. Noted change in FCheck.
2006-05-24	Photos being taken in variometer building.
2006-06-09	Raised the self-levelling mechanism of the DMI sensor before absolute observations (after realising from photos that the screws had been turned the wrong way and removed rather than raising the self-levelling mechanism during initial installation.)
2006-06-29	NGL not operating correctly. Sparse data only.
2006-06-30	Restart the NGL driver at 01:14. QNX Shutdown at 01:27. NGL did not recover.
2006-07-03	Restart NGL driver and reset NGL ~01:40. NGL did not recover.~03:30 Power off/on NGL. NGL then OK.
2006-07-05	Commence delivery of 1-second real-time data to IPS. Also switch off 1-minute data delivery to IPS.
2006-07-08	~16:17 No data received from DMI variometer.
2006-07-09	~23:30 Stop ADAM A/D driver (to DMI variometer) and check using qtalk that ADAM was ok. Restart ADAM driver at 23:37. OK now.
2006-07-21	Decided theodolite 311542 (used with DIM D26035) was unserviceable, and began using 353758(still with D26035).
2006-07-28	Began using DI0022 with theodolite 353758.
2006-09-05	Terry Smith sending 11 batteries to MAW (9-11 for UPS, any spares for absolute battery box). Two variometer battery boxes should be ok for another year.
2006-09-13	ADAM data (from DMI variometer) failed. Restart ADAM driver. Then OK.Also some NGL data gaps, strange GPS clockbehaviour? no known reason.
2006-09-14	ADAM stopped again. Restart driver then OK.
2006-09-26	GPS clock failed. Restart ~16:35.
2006-10-07	20:50 GPS clock failed.
2006-10-09	Restart GPS clock program ~01:10, -17ms correction.
2006-11	Mid-Nov The 2006 observer (DT) handed over responsibility for absolute observations and the observatory to the 2007 observer (IM). REVERT TO ORIGINAL DIM.
2006-12-01	Confirm Absolute GSM90 failed. Disconnected variometer GSM90 to use as Absolute instrument. Found that the focusing adjustment of the main telescope of 311542 had been jammed. Resumed using D26035/311542 as primary absolute instrument.
2006-12-19	~00:20 GPS clock failed.
2006-12-20	Restart GPS clock program ~02:10. -4 ms correction.

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	2007
Monthly mean values		
Ørsted Satellite Project	preliminary	monthly

Table 9.4. Distribution of 2006 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 2006 data are shown in Figure 9.3.

K indices

Table 9.6 shows Mawson K indices for 2006. They have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm.

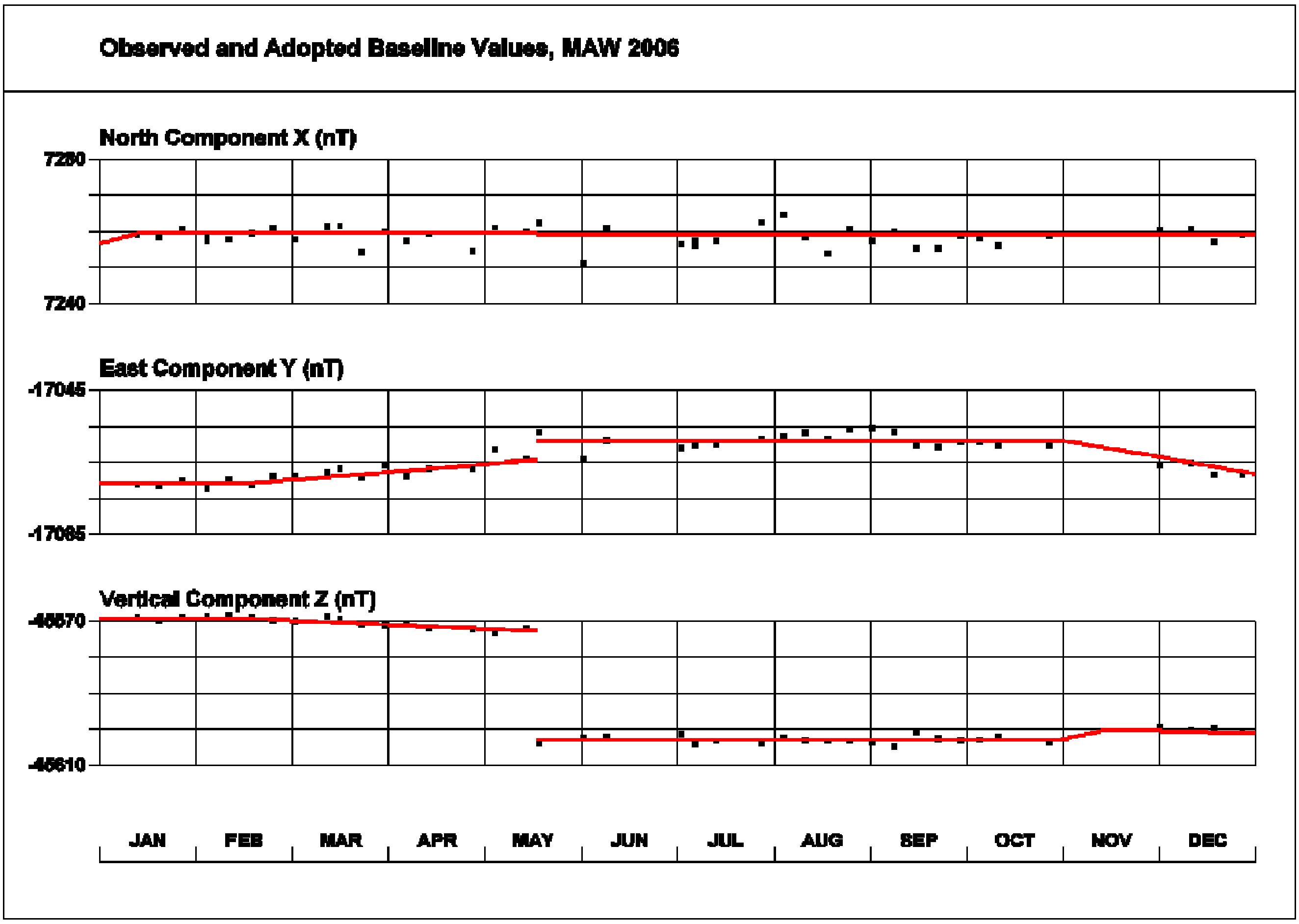


Figure 9.1. Mawson baseline plots.

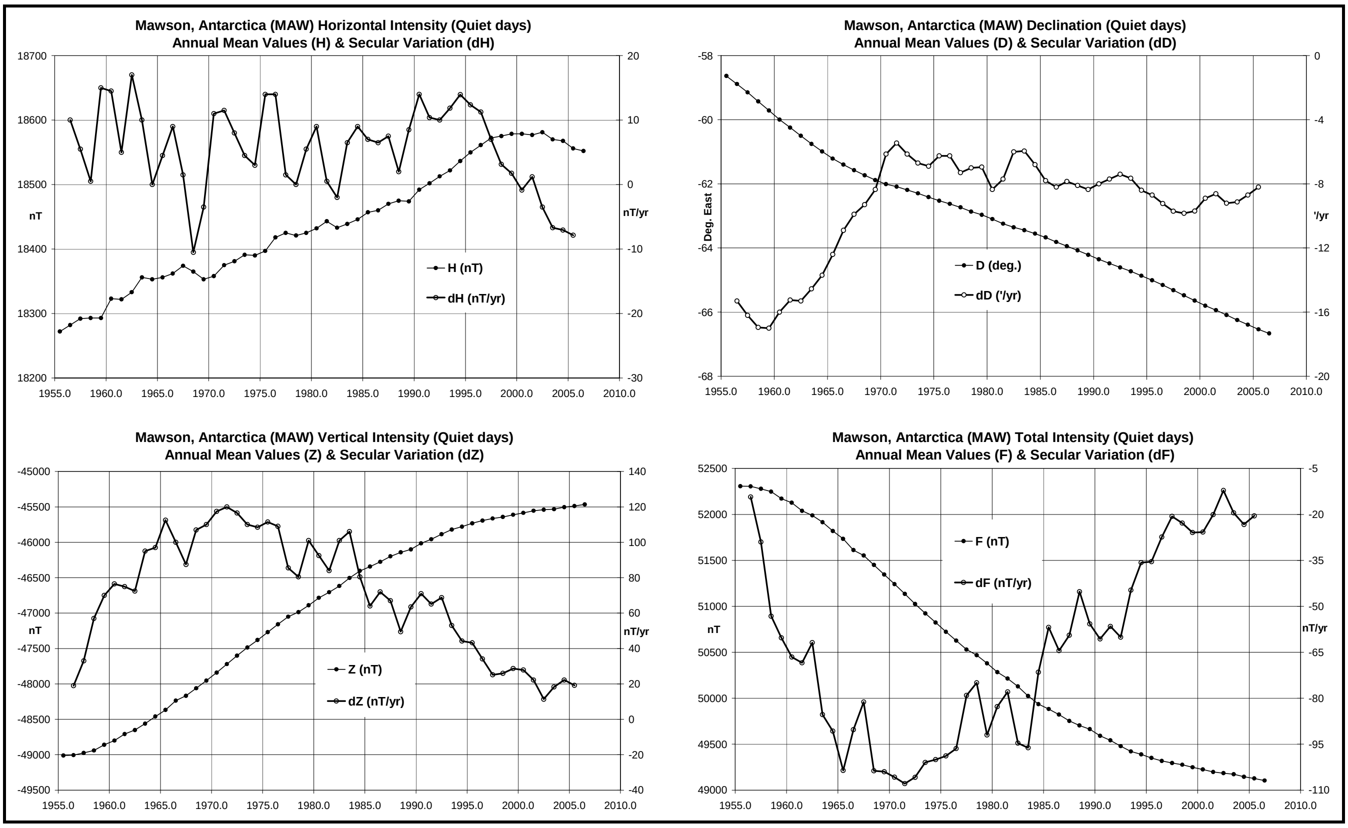


Figure 9.2. Annual mean values and secular variation for H, D, Z and F measured at Mawson.

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

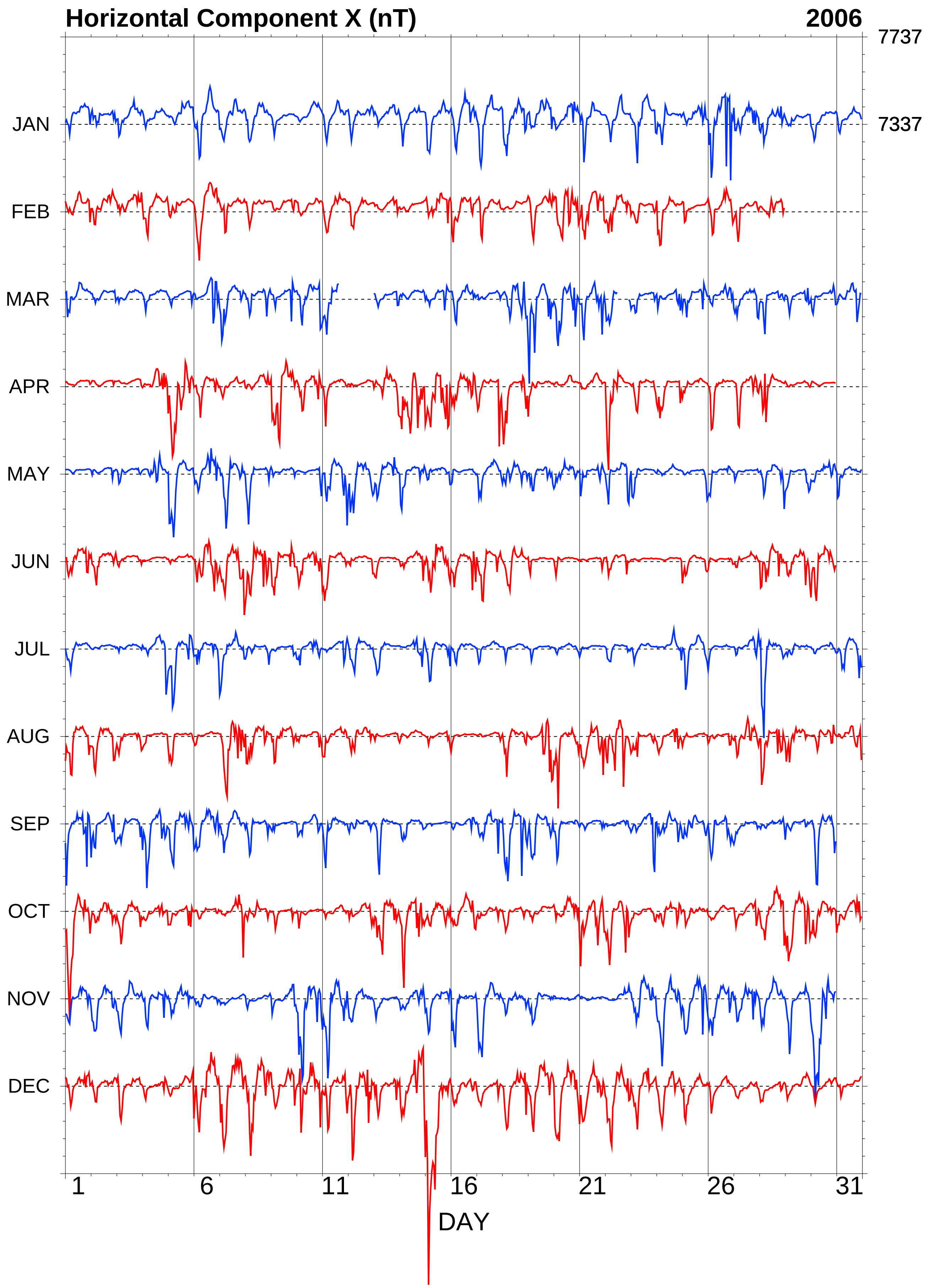
Table 9.5. Annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z and F are shown in Figure 9.2.

Day	January			February			March			April			May			June		
01	5322	3324	24	2322	3015	18	5323	3212	21	1010	0003	5	0211	1000	5	4334	4355	31
02	4433	2325	26	3322	2341	20	2321	1104	14	1010	2004	8	3020	0052	12	3443	3223	24
03	4411	2323	20	2322	2263	22	3211	1212	13	0000	0004	4	3210	0023	11	3232	3223	20
04	2211	1120	10	4432	2212	20	2312	0114	14	2123	3546	26	1144	4514	24	2100	0000	3
05	0012	3233	14	4222	2111	15	2200	1104	10	5654	4442	34	7553	3202	27	2110	0232	11
06	4442	4323	26	4544	4344	32	2201	3465	23	3453	2354	29	4323	4636	31	5445	4576	40
07	4323	3323	23	4431	1133	20	5533	2255	30	2211	0211	10	3555	3365	35	4455	4356	36
08	3323	2212	18	2222	1123	15	2322	2255	23	3111	2244	18	5543	3124	27	6555	4677	45
09	3311	1002	11	1132	2145	19	2300	1162	15	6665	4446	41	3232	1114	17	5553	3366	36
10	0111	2132	11	2100	0044	11	2433	3326	26	3444	3576	36	1100	0036	11	4443	4546	34
11	3311	3323	19	3332	3321	20	5433	3---	-	4532	3215	25	4545	3266	35	5422	2234	24
12	4421	0034	18	2432	3210	17	----	----	-	2121	0010	7	6554	3345	35	3223	2115	19
13	3211	2334	19	0110	2334	14	2222	1124	16	3234	4345	28	5433	4353	30	4210	0024	13
14	3412	2231	18	2220	1101	9	2101	1012	8	6545	5876	46	5552	3234	29	4221	2227	22
15	5421	1322	20	2333	3266	28	4232	2352	23	6555	3777	45	3321	2134	19	4555	4466	39
16	3434	4554	32	5443	2345	30	3322	2324	21	4554	3355	34	4100	0113	10	5443	2366	33
17	3534	4312	25	2522	2114	19	2110	1024	11	5342	2226	26	4411	2334	22	4454	4354	33
18	5433	2356	31	3201	2111	11	2355	4667	38	6422	1135	24	3335	3434	28	2444	3232	24
19	3233	3335	25	3432	2264	26	7664	3377	43	5311	1221	16	4442	2235	26	5221	1001	12
20	2212	3443	21	3445	6566	39	5654	2576	40	2112	2312	14	5333	3243	26	4312	1103	15
21	3523	4111	20	5544	4656	39	3643	3556	35	2212	2323	17	5222	1265	25	1000	0034	8
22	1333	3311	18	5544	4444	34	5443	----	-	7755	3211	31	4522	2246	27	2321	1153	18
23	3454	4336	32	3333	2124	21	4422	1014	18	2443	2115	22	5342	1112	19	1010	0000	2
24	4443	3012	21	5522	2100	17	4211	2245	21	4542	2105	23	2233	2202	16	0000	0003	3
25	2323	2365	26	4321	0000	10	3422	2263	24	5221	1213	17	2311	1025	15	4222	1135	20
26	5743	4878	46	2421	3535	25	2211	2455	22	5422	2211	19	4312	1133	18	3000	0013	7
27	6333	4455	33	3431	2015	19	4420	2236	23	1531	1245	22	4110	0013	10	2210	1134	14
28	4332	3365	29	2223	3224	20	2531	1234	21	3563	3111	23	2432	2145	23	5354	4354	33
29	2221	1003	11				2301	1244	17	2221	0013	11	3110	1145	16	4433	4355	31
30	3311	1022	13				4210	0055	17	2000	0001	3	3311	3353	22	6553	3334	32
31	3211	2213	15				3112	3464	24				5232	2112	18			

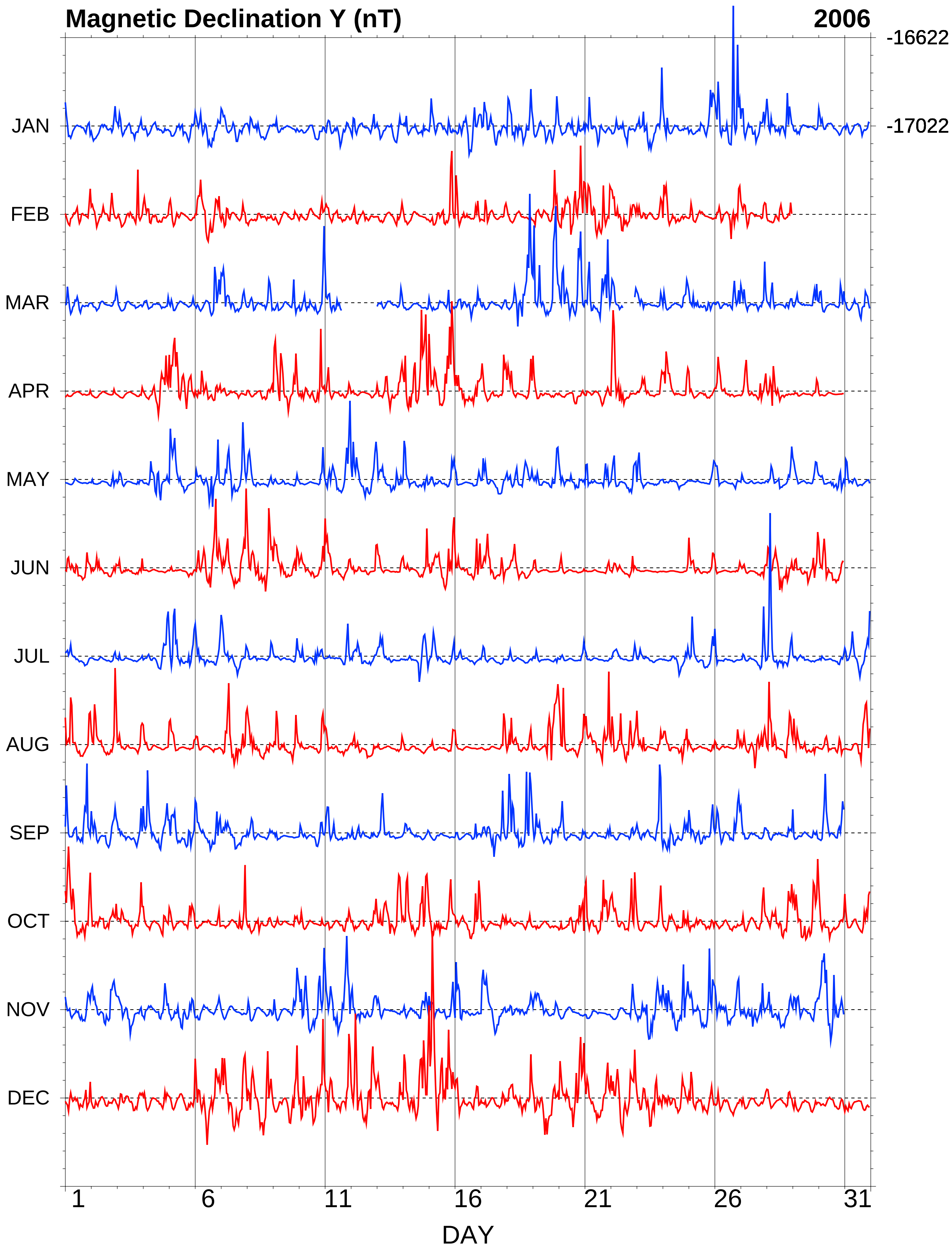
Day	July			August			September			October			November			December		
01	3422	3222	20	5763	3315	33	6224	2475	32	7753	3545	39	4322	2345	25	2433	3245	26
02	1011	0223	10	4543	3236	30	4422	3255	27	5223	3344	26	5322	3465	30	3321	2232	18
03	2101	1103	9	4332	1135	22	4322	3335	25	3333	3236	26	4423	3123	22	3321	1234	19
04	2221	3357	25	4200	0011	8	5754	2456	38	3221	0353	19	3432	3265	28	2210	0143	13
05	5753	3256	36	5420	0013	15	5444	3354	32	3211	1345	20	2233	3243	22	1102	1323	13
06	5443	2346	31	3221	1101	11	4333	4365	31	1111	1204	11	2211	1134	15	6545	6465	41
07	5333	3314	25	2575	5566	41	3433	3332	24	1110	2456	20	2210	0001	6	6554	4455	38
08	3232	1025	18	5443	4444	32	2421	2235	21	3223	3334	23	4100	0002	7	5655	4464	39
09	2110	0134	12	3633	2236	28	2310	0001	7	2322	1053	18	4010	1336	18	3331	2447	27
10	4312	3564	28	2210	2126	16	4230	1355	23	3310	0003	10	6664	5366	42	4633	4557	37
11	0101	2265	17	4332	2233	22	5533	2213	24	1210	0243	13	5663	3466	39	5654	3247	36
12	3444	4323	27	4432	2324	24	3133	1134	19	3221	1225	18	4333	3234	25	4754	4676	43
13	4444	2100	19	3000	0014	8	2553	1110	18	4454	3366	35	3221	0102	11	5433	2225	26
14	1212	4545	24	3001	1121	9	3332	3213	20	3633	3577	37	2322	2555	26	5534	7778	46
15	3433	2225	24	2200	0115	11	1020	0000	3	3443	2465	31	4422	2235	24	9976	6675	55
16	3321	1111	13	4100	0000	5	2101	1143	13	3232	3365	27	6532	2221	23	4433	2355	29
17	3321	1111	13	1121	0125	13	3335	4263	29	3211	1043	15	6543	3334	31	3221	2353	21
18	2300	0111	8	4544	1224	26	6554	3476	40	3211	1153	17	2311	2233	17	4433	3436	30
19	2300	0023	10	2212	5667	31	4444	2234	27	1201	1100	6	4433	1123	21	4445	4344	32
20	2210	1005	11	5732	3346	33	5531	1023	20	3223	4355	27	1110	1101	6	6443	5666	40
21	3100	0001	5	5334	2547	33	2111	1024	12	6453	3665	38	2000	2000	4	6545	3555	38
22	3221	0004	12	5445	5655	39	1101	0244	13	4543	3476	36	0012	3155	17	5555	3356	37
23	2212	1000	8	5441	1134	23	3211	1248	22	3213	1135	19	3445	4354	32	4354	4543	32
24	1111	3325	17	4221	2455	25	4454	4254	32	2232	2144	20	5654	4364	37	4443	4554	33
25	4541	2235	26	4110	1012	10	5334	4235	29	3322	2223	19	4433	3475	33	5532	4344	30
26	6211	2300	15	3000	2045	14	4532	2355	29	2212	1221	13	5434	3366	34	3432	3222	21
27	3221	2256	23	3312	4435	25	4322	1213	18	3201	0155	17	3434	3463	30	2211	1123	13
28	7765	2225	36	7653	3555	39	3211	2035	17	3333	4456	31	4423	3324	25	2100	1234	13
29	3223	2111	15	5434	2232	25	5010	1243	16	5544	4466	38	4532	1144	24	3221	0232	15
30	1231	1123	14	2244	2253	24	2673	3335	32	5443	3333	28	5665	6544	41	2311	2234	18
31	4443	4355	32	2131	3556	26				4111	1355	21	2311	0123	13			

Table 9.6. K indices and daily K sums measured at Mawson in 2006.

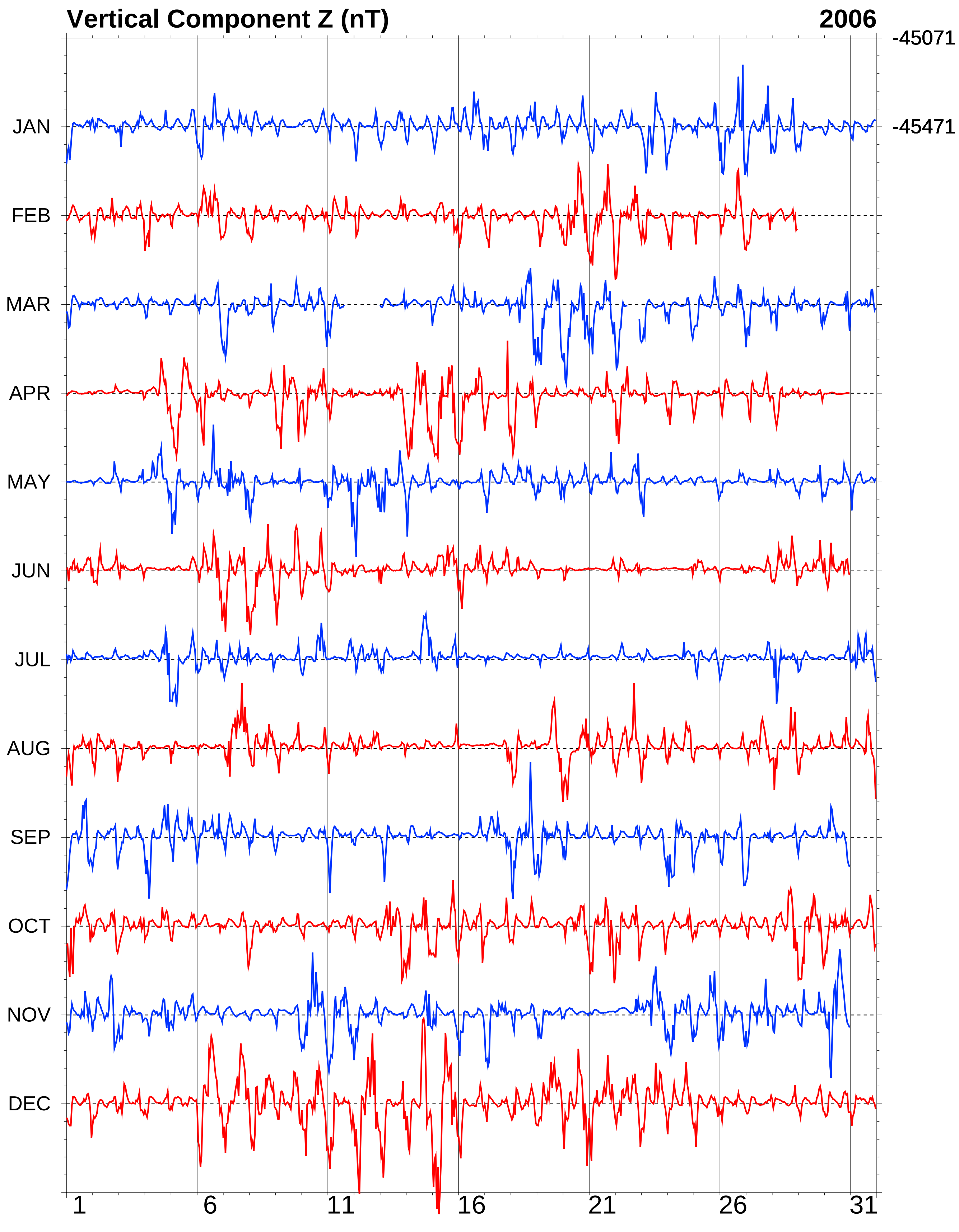
MAW - Hourly Mean Values



MAW - Hourly Mean Values



MAW - Hourly Mean Values



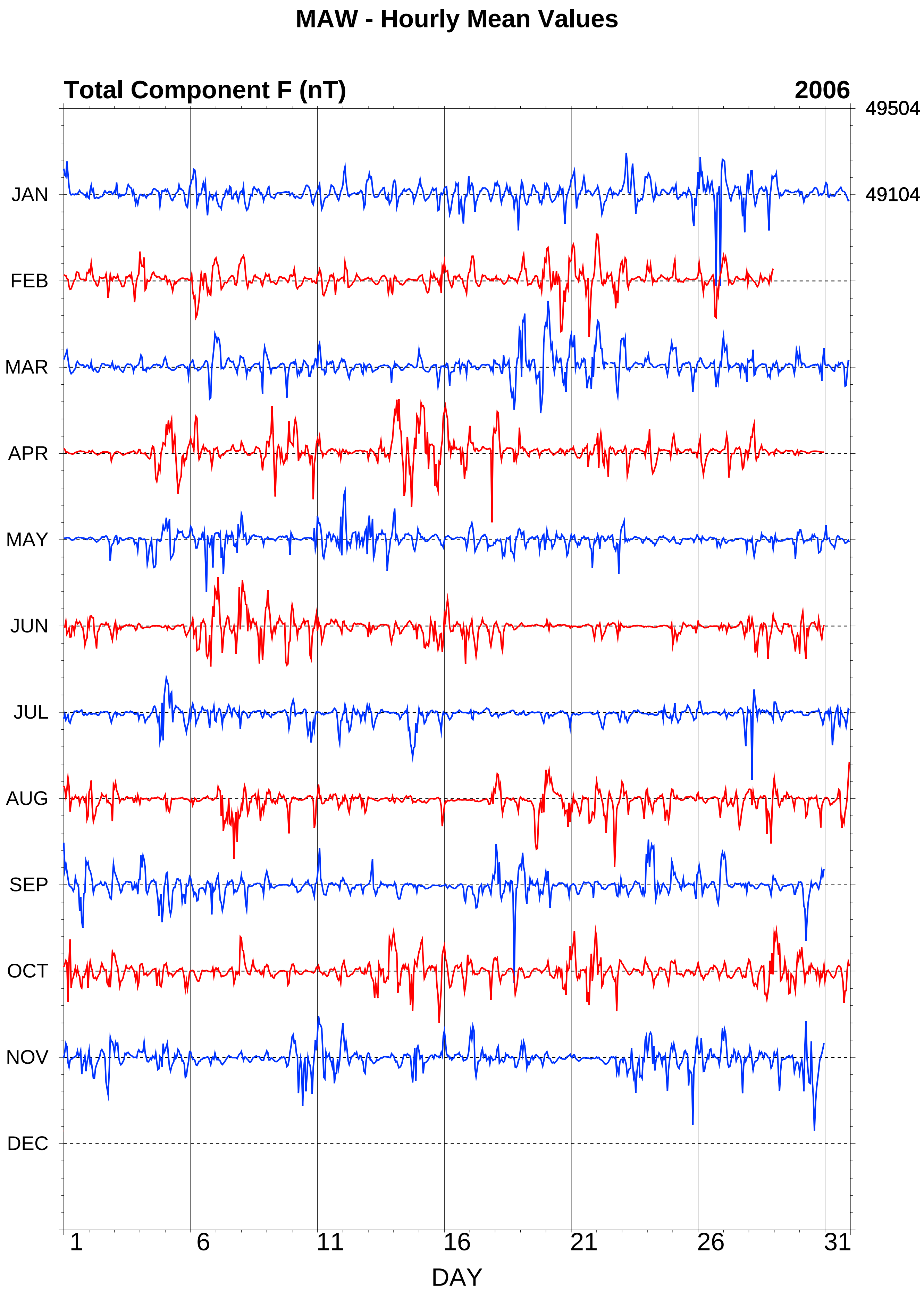


Figure 9.3. Hourly mean values in X, Y, Z and F measured at Mawson.

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 repeat station occupation the magnetic field is monitored continuously with portable on-site three-component and total-field magnetic variometers.

Variometers

The variometers used during 2006 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:	801882/81315
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS clock

Table 10.1. Magnetic variometers.

Absolute instruments

The principal absolute magnetometers used at repeat stations and their adopted corrections for 2006 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:	810881/31960
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Table 10.2. Absolute magnetometers and their adopted corrections for 2006.

Operations

The variometer recordings were calibrated to observatory standard with 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 a three month period of 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 value from the previous occupation of the station.

Station occupations

The repeat station at Hobart (HOB) was re-occupied in January 2006. Figure 10.1 shows the location of the repeat station and the Australian permanent magnetic observatories.

The adopted normal field values at the time of the 2006 occupation and the average secular variation over the interval between the two most recent occupations for the station are shown in Tables 10.3 and 10.4. All available data from Hobart are plotted in Figure 10.2.

Figure 10.1. Repeat stations occupied in 2006 (black dot) and the Australian magnetic observatory network (red dots).

Station (site)	Date	D (°	')	I (°	')	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)
Hobart (H)	2006-01-17	14	48.0	-72	42.3	18426	17815	4707	-59179	61981

Table 10.3. Adopted main field values at the time of 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)
Hobart (H)	2002-11-05	-0.1	+0.5	+0.5	+0.7	-0.5	+30.6	-29.0

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

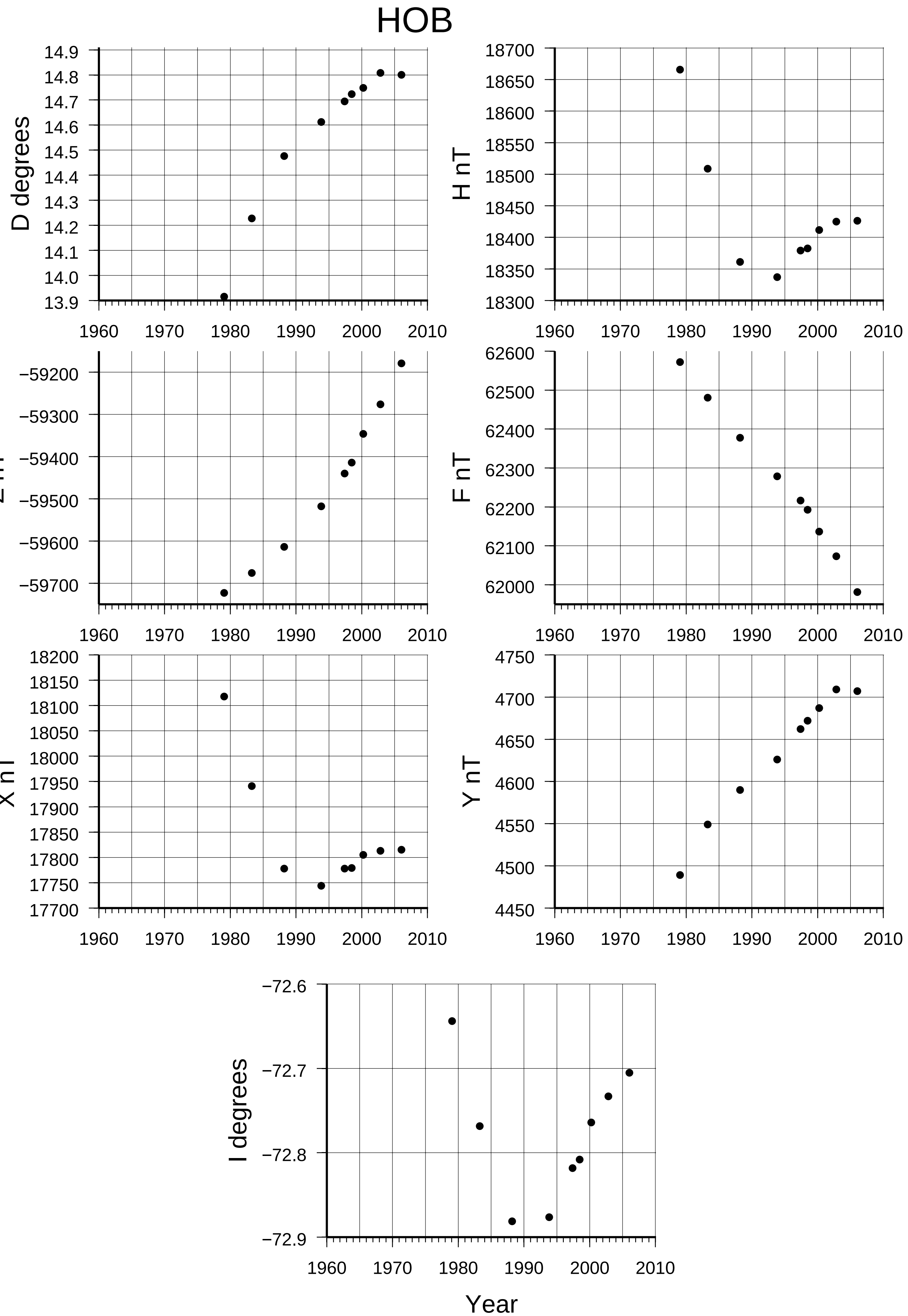


Figure 10.2. Adopted main-field values at time of station occupations.

Appendix A. Data losses

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-01-06	XYZ	22:32 - 23:50	79
	F	22:33 - 23:50	78

Table A.1. Kakadu data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-01-09	XYZ	00:03 - 23:36	1414
	F	00:04 - 23:36	1413
2006-01-11	XYZ	05:13 - 05:15	3
	F	05:14 - 05:15	2
2006-01-12	XYZ	01:01 - 01:03	3
	F	01:02 - 01:03	2
2006-01-24	F	04:05 - 04:10	6
2006-04-04	XYZ	03:09 - 23:59	1251
	F	03:10 - 23:59	1250
2006-04-05	XYZF	00:00 - 23:59	1440
2006-04-06	XYZF	00:00 - 23:59	1440
2006-04-07	XYZ	00:00 - 04:20	261
	F	00:00 - 04:19	260
2006-05-03	XYZ	06:58 - 07:08	11
	F	06:59 - 07:08	10
	XYZ	21:47 - 21:51	5

Table A.2. Charters Towers data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-01-11	F	08:14 - 08:14	1
2006-02-06	XYZ	22:55 - 23:59	65
2006-02-07	XYZ	00:00 - 06:35	396
2006-03-04	F	15:43 - 15:56	14
2006-03-16	F	19:57 - 19:57	1
2006-03-27	F	01:43 - 04:37	175
	F	04:41 - 23:59	1159
2006-03-28	F	00:00 - 23:59	1440
2006-03-29	XYZ	06:51 - 06:53	3
	XYZ	06:56 - 06:58	3
	F	00:00 - 23:59	1440
2006-03-30	F	00:00 - 23:59	1440
2006-03-31	F	00:00 - 23:59	1440
	XYZ	00:44 - 00:46	3
2006-04-01	F	00:00 - 23:59	1440
2006-04-02	F	00:00 - 23:59	1440
2006-04-03	F	00:00 - 23:59	1440
2006-04-04	F	00:00 - 23:59	1440
2006-04-05	F	00:00 - 23:59	1440
2006-04-06	F	00:00 - 23:59	1440
2006-04-07	F	00:00 - 23:59	1440
2006-04-08	F	00:00 - 23:59	1440
2006-04-09	F	00:00 - 23:59	1440
2006-04-10	F	00:00 - 04:54	295
	F	20:53 - 23:59	187
2006-04-11	F	00:00 - 03:22	203
	F	03:25 - 03:26	2
	F	19:24 - 23:59	276
2006-04-12	F	00:00 - 04:29	270
2006-05-18	F	02:47 - 03:40	54
	XYZ	02:40 - 03:40	61
2006-07-14	XYZ	01:46 - 01:50	5
	XYZ	05:03 - 05:05	3
	F	01:47 - 01:47	1
	F	01:49 - 01:50	2
	F	05:04 - 05:05	2
2006-07-26	F	00:09 - 02:04	116
	XYZ	00:00 - 02:05	126
2006-08-03	F	08:32 - 08:32	1
2006-10-09	F	02:27 - 02:27	1
2006-11-06	F	01:14 - 01:41	28
	XYZ	01:10 - 01:45	36
2006-11-14	F	08:31 - 08:31	1
2006-11-22	F	06:05 - 06:14	10
2006-11-23	F	01:01 - 23:23	1343
	XYZ	01:00 - 23:59	1380
	F	23:29 - 23:59	31
2006-11-24	F	00:00 - 09:00	541
	XYZ	00:00 - 09:00	541
2006-12-30	F	05:44 - 05:45	2
	XYZ	05:43 - 05:46	4

Table A.3. Learmonth data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-01-04	F	10:59 - 10:59	1
2006-01-13	F	07:39 - 07:39	1
2006-01-18	F	18:03 - 18:03	1
2006-01-23	F	17:09 - 17:09	1
2006-01-24	F	06:00 - 06:00	1
2006-01-25	F	15:47 - 15:47	1
	F	17:27 - 17:27	1
	F	21:02 - 21:02	1
2006-01-26	F	18:31 - 18:31	1
2006-01-27	F	23:12 - 23:12	1
2006-01-29	F	11:04 - 11:04	1
	F	12:07 - 12:07	1
	F	12:40 - 12:40	1
2006-01-31	F	12:39 - 12:39	1
2006-02-17	F	05:18 - 05:18	1
	F	06:32 - 06:32	1
2006-02-18	F	06:09 - 06:09	1
2006-03-10	F	20:43 - 20:43	1
	F	23:20 - 23:20	1
2006-03-11	F	04:10 - 04:10	1
2006-03-25	F	14:59 - 16:00	62
2006-04-02	F	05:06 - 05:47	42
2006-04-20	F	05:24 - 05:24	1
	XYZ	05:25 - 05:36	12
	F	05:35 - 05:48	14
	XYZ	05:53 - 05:57	5
	F	05:54 - 05:54	1
2006-07-20	XYZ	01:31 - 01:33	3
	F	01:32 - 01:32	1
2006-10-09	F	04:36 - 04:36	1

Table A.4. Alice Springs data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-01-03	F	18:30 - 18:30	1
2006-01-05	F	02:31 - 02:31	1
2006-01-17	F	22:05 - 22:05	1
2006-01-26	XYZ	02:11 - 02:21	11
	F	02:12 - 02:15	4
	F	02:17 - 02:20	4
	XYZ	07:34 - 07:39	6
	F	07:35 - 07:38	4
	XYZ	08:26 - 23:59	934

	F	08:27 - 23:59	933
2006-01-27	XYZ	00:00 - 04:41	282
	F	00:00 - 04:33	274
2006-02-02	XYZ	02:19 - 02:53	35
	F	02:25 - 02:42	18
	F	14:02 - 14:02	1
2006-02-06	F	01:18 - 01:20	3
	F	06:16 - 06:16	1
	F	07:07 - 07:07	1
	F	17:37 - 17:37	1
2006-02-08	F	09:28 - 09:28	1
2006-02-11	F	07:57 - 09:28	1
2006-02-13	F	23:48 - 23:48	1
2006-02-14	F	13:10 - 13:10	1
2006-02-19	F	01:44 - 01:44	1
2006-02-20	F	06:55 - 06:55	1
2006-02-21	F	06:28 - 06:28	1
	F	06:57 - 06:57	1
	F	09:19 - 09:19	1
2006-02-25	F	03:08 - 03:08	1
2006-02-27	F	19:32 - 19:32	1
2006-03-03	F	15:22 - 15:22	1
	XYZ	19:00 - 19:05	6
	F	19:01 - 19:05	5
	XYZ	21:39 - 21:44	6
	F	21:40 - 21:43	4
	XYZ	23:17 - 23:59	43
	F	23:18 - 23:59	42
2006-03-04	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-03-05	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-03-06	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-03-07	F	00:00 - 06:54	415
	F	07:04 - 07:04	1
2006-03-08	F	07:58 - 07:58	1
2006-03-09	F	18:07 - 18:07	1
2006-03-11	F	17:25 - 17:25	1
2006-03-12	F	06:40 - 06:40	1
2006-03-13	F	19:17 - 19:17	1
2006-03-18	F	03:53 - 03:53	1
	F	09:55 - 09:55	1
2006-03-19	F	10:34 - 10:34	1
2006-03-28	F	01:22 - 01:22	1
2006-03-31	F	03:54 - 03:54	1
2006-04-02	XYZ	15:55 - 23:59	485
	F	15:56 - 23:59	484
2006-04-03	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-04-04	XYZ	00:00 - 00:22	23
	F	00:00 - 00:21	22
2006-04-10	F	14:44 - 14:44	1
2006-04-13	F	00:44 - 00:44	1
	F	11:27 - 11:27	1
2006-04-18	F	03:59 - 03:59	1
2006-04-27	F	19:51 - 19:51	1
2006-05-16	F	01:05 - 01:05	1
2006-05-18	F	13:12 - 13:12	1
2006-05-22	F	18:26 - 18:26	1
	F	18:29 - 18:29	1
	F	19:09 - 19:10	2
2006-05-23	F	00:08 - 00:08	1
	F	02:41 - 02:41	1
2006-06-12	F	05:49 - 05:49	1
2006-06-19	XYZ	19:32 - 23:59	268
	F	19:33 - 23:59	267
2006-06-20	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-06-21	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-06-22	XYZ	00:00 - 05:10	311
	F	00:00 - 05:09	310
2006-06-28	F	02:53 - 02:53	1
2006-07-11	F	04:00 - 04:00	1
2006-07-30	F	08:18 - 08:18	1
2006-08-01	F	22:13 - 22:13	1
2006-08-06	F	05:01 - 05:01	1
2006-08-07	F	20:43 - 20:43	1
2006-08-12	XYZ	03:16 - 03:21	6
	F	03:17 - 03:20	4
2006-08-13	XYZ	05:58 - 06:03	6
	F	05:59 - 06:02	4
	XYZ	20:35 - 23:59	205
	F	20:36 - 23:59	204
2006-08-14	XYZ	00:00 - 23:59	1440
	F	00:00 - 23:59	1440
2006-08-15	XYZ	00:00 - 06:18	379
	F	00:00 - 06:17	378
2006-08-18	F	07:34 - 07:34	1
2006-08-21	XYZ	03:45 - 03:46	2
2006-08-23	F	01:29 - 01:29	1
2006-08-25	F	16:16 - 16:16	1
2006-09-05	XYZ	02:41 - 02:42	2
	F	02:42 - 02:42	1
2006-09-25	F	03:44 - 03:44	1
2006-09-30	F	08:16 - 08:16	1
2006-10-03	F	11:33 - 11:33	1
2006-10-16	F	18:38 - 18:38	1
2006-10-17	F	16:24 - 16:24	1
2006-10-18	F	03:27 - 03:27	1
2006-10-23	F	22:41 - 22:41	1
2006-10-24	F	04:46 - 04:46	1
2006-10-28	F	05:34 - 05:34	1
	F	05:49 - 05:49	1
	F	07:00 - 07:00	1
2006-11-03	F	03:15 - 03:15	1
2006-11-04	F	09:48 - 09:48	1
2006-11-17	F	01:19 - 01:19	1
2006-11-20	XYZ	05:26 - 05:28	3
	F	05:27 - 05:27	1
2006-11-29	F	02:50 - 02:50	1
	F	10:17 - 10:17	1
2006-12-05	F	08:11 - 08:11	1
	F	10:44 - 10:44	1
2006-12-15	F	09:01 - 09:01	1
	F	19:32 - 19:32	1
2006-12-17	F	10:52 - 10:52	1
2006-12-25	F	14:01 - 14:01	1
2006-12-27	F	06:37 - 06:37	1
	F	14:48 - 14:48	1

Table A.5. Gnangara data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-03-26	XYZ	03:20 - 03:21	2
2006-03-27	XYZ	18:50 - 18:51	2
2006-06-06	XYZ	02:46 - 03:13	28
2006-09-06	F	02:58 - 03:08	11
	F	03:16 - 03:17	2
	F	03:20 - 03:20	1
2006-09-07	F	19:21 - 23:59	279
2006-09-08	F	00:00 - 02:28	149
	F	02:38 - 02:38	1
2006-11-29	F	03:26 - 03:26	1

Table A.6. Canberra data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-02-24	XYZ	02:50-03:05	16
2006-03-18	XYZ	20:11-20:13	3
	F	20:12-20:12	1
	F	22:23-22:23	1
	XYZ	22:22-22:25	4
2006-04-02	XYZ	23:53-23:59	7
	F	23:54-23:59	6
2006-04-03	XYZ	01:30-01:32	3
	F	01:29-01:32	4
	F	02:44-02:52	9
	XYZ	03:18-03:21	4
2006-04-05	XYZ	03:23-03:32	10
	F	03:24-03:32	9
2006-04-06	XYZ	00:00-02:30	151
	XYZ	23:30-23:59	30
2006-05-16	XYZF	22:50-23:30	41
2006-07-12	XYZ	00:10-00:15	6

Table A.7. Macquarie Island data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
Complete			

Table A.8. Casey data losses.

Date	Channel	Interval (hh:mm)	Data loss (minutes)
2006-03-11	XYZ	15:54-23:59	486
2006-03-11	F	20:08-20:08	1
2006-03-11	F	20:51-20:51	1
2006-03-11	F	21:10-21:10	1
2006-03-11	F	21:32-21:32	1
2006-03-12	XYZ	00:00-23:59	1440
2006-03-13	XYZ	00:00-00:05	6
2006-03-22	XYZ	11:14-22:43	690
2006-03-22	F	11:14-12:51	98
2006-06-29	F	14:33-14:33	1
2006-06-29	F	14:38-14:38	1
2006-06-29	F	14:41-14:41	1
2006-06-29	F	14:44-14:44	1
2006-06-29	F	15:15-15:15	1
2006-06-29	F	15:17-15:17	1
2006-06-29	F	15:25-15:25	1
2006-06-29	F	15:29-15:30	2
2006-06-29	F	15:34-15:35	2
2006-06-29	F	15:37-15:37	1
2006-06-29	F	15:40-15:40	1
2006-06-29	F	15:43-15:43	1
2006-06-29	F	21:22-21:22	1
2006-06-29	F	23:23-23:23	1
2006-06-29	F	23:27-23:27	1
2006-06-29	F	23:32-23:32	1
2006-06-29	F	23:35-23:36	2
2006-06-29	F	23:40-23:44	5
2006-06-29	F	23:46-23:46	1
2006-06-29	F	23:55-23:57	3
2006-06-30	F	00:01-00:02	2
2006-06-30	F	00:04-00:04	1
2006-06-30	F	00:16-00:17	2
2006-06-30	F	00:22-00:22	1
2006-06-30	F	00:25-00:25	1
2006-06-30	F	00:28-00:28	1
2006-06-30	F	00:31-00:31	1
2006-06-30	F	00:33-00:33	1
2006-06-30	F	00:37-00:38	2
2006-06-30	F	00:45-00:45	1
2006-06-30	F	00:55-00:56	2
2006-06-30	F	00:58-00:58	1
2006-06-30	F	01:02-01:02	1
2006-06-30	F	01:11-01:12	2
2006-06-30	F	01:17-01:17	1
2006-06-30	F	01:25-01:25	1
2006-06-30	F	01:27-01:28	2
2006-06-30	F	01:33-01:33	1
2006-06-30	F	01:39-01:39	1
2006-06-30	F	01:42-01:42	1
2006-06-30	F	01:58-01:58	1
2006-06-30	F	02:00-02:01	2
2006-06-30	F	02:05-02:05	1
2006-06-30	F	02:11-02:11	1
2006-06-30	F	02:13-02:13	1
2006-06-30	F	02:16-02:17	2
2006-06-30	F	02:20-02:20	1
2006-06-30	F	02:23-02:23	1
2006-06-30	F	02:32-02:33	2
2006-06-30	F	02:36-02:37	2
2006-06-30	F	03:10-03:10	1
2006-07-02	F	07:08-07:08	1
2006-07-02	F	07:21-07:21	1
2006-07-02	F	08:01-08:01	1
2006-07-02	F	08:06-08:06	1
2006-07-02	F	11:25-11:25	1
2006-07-03	F	03:27-03:27	1
2006-07-08	F	15:26-15:26	1
2006-07-08	F	15:39-15:39	1
2006-07-08	F	15:42-15:42	1
2006-07-08	F	15:45-15:51	7
2006-07-08	F	15:53-15:53	1
2006-07-08	F	15:55-15:55	1
2006-07-08	F	15:58-15:58	1
2006-07-08	F	16:00-16:01	2
2006-07-08	F	16:03-16:03	1
2006-07-08	F	16:06-16:06	1
2006-07-08	F	16:14-16:14	1
2006-07-08	F	16:16-16:18	3
2006-07-08	F	16:20-16:20	1
2006-07-08	F	16:22-16:22	1
2006-07-08	F	16:25-16:25	1
2006-07-08	F	16:28-16:28	1
2006-07-08	F	16:35-16:35	1
2006-07-08	F	16:49-16:49	1
2006-07-08	F	16:51-16:52	2
2006-07-08	F	16:56-16:56	1
2006-07-08	F	17:21-17:21	1
2006-07-08	F	17:28-17:28	1
2006-07-08	F	17:35-17:35	1
2006-07-08	F	17:55-17:55	1
2006-07-08	F	17:57-17:57	1
2006-07-08	F	18:05-18:05	1
2006-07-08	F	18:16-18:18	3
2006-07-08	F	18:25-18:25	1
2006-07-08	F	18:47-18:47	1
2006-07-08	F	19:17-19:17	1
2006-07-08	F	20:13-20:13	1
2006-07-08	F	20:16-20:16	1
2006-07-08	F	20:18-20:18	1
2006-07-08	F	20:20-20:20	1
2006-07-08	F	20:33-20:33	1
2006-07-08	F	20:51-20:51	1
2006-07-08	F	20:59-20:59	1
2006-07-08	F	21:06-21:06	1
2006-07-08	F	21:26-21:26	1
2006-07-09	F	10:39-10:39	1

2006-09-13	F	15:01-15:01	1
2006-09-13	F	16:14-16:14	1
2006-09-13	F	18:09-18:09	1
2006-09-13	F	18:19-18:19	1
2006-09-13	F	19:11-19:11	1
2006-11-10	F	05:36-05:36	1
2006-12-01	F	00:27-23:59	1413
2006-12-02	F	00:00-23:59	1440
2006-12-03	F	00:00-23:59	1440
2006-12-04	F	00:00-23:59	1440
2006-12-05	F	00:00-23:59	1440
2006-12-06	F	00:00-23:59	1440
2006-12-07	F	00:00-23:59	1440
2006-12-08	F	00:00-23:59	1440
2006-12-09	F	00:00-23:59	1440
2006-12-10	F	00:00-23:59	1440
2006-12-11	F	00:00-23:59	1440
2006-12-12	F	00:00-23:59	1440
2006-12-13	F	00:00-23:59	1440
2006-12-14	F	00:00-23:59	1440
2006-12-15	F	00:00-23:59	1440
2006-12-16	F	00:00-23:59	1440
2006-12-17	F	00:00-23:59	1440
2006-12-18	F	00:00-23:59	1440
2006-12-19	F	00:00-23:59	1440
2006-12-20	F	00:00-23:59	1440
2006-12-21	F	00:00-23:59	1440
2006-12-22	F	00:00-23:59	1440
2006-12-23	F	00:00-23:59	1440
2006-12-24	F	00:00-23:59	1440
2006-12-25	F	00:00-23:59	1440
2006-12-26	F	00:00-23:59	1440
2006-12-27	F	00:00-23:59	1440
2006-12-28	F	00:00-23:59	1440
2006-12-29	F	00:00-23:59	1440
2006-12-30	F	00:00-23:59	1440
2006-12-31	F	00:00-23:59	1440

Table A.9. Mawson data losses.

Observatory	**XYZ**		**F**	
	(minutes)	**(%)**	**(minutes)**	**(%)**
Kakadu	79	0.01	78	0.01
Charters Towers	5828	1.11	5821	1.11
Learmonth	2811	0.53	3514	0.67
Alice Springs	20	0.00	142	0.03
Gnangara	13526	2.57	13530	2.57
Canberra	32	0.01	444	0.08
Macquarie Island	275	0.05	71	0.01
Mawson	2622	0.50	44849	8.53
Total	**25193**	**0.60**	**594049**	**1.63**

Table A.10. Summary of annual data losses. (The complete data loss for Casey for 2006 has been excluded from these statistics.)

Appendix B. Backup data

Date	Interval (hh:mm)	Data in filled (minutes)
2006-01-02	13:51 - 13:52	2
2006-01-04	02:11 - 02:12	2
2006-01-05	15:21 - 15:22	2
2006-01-07	10:41 - 10:42	2
2006-01-09	05:21 - 05:22	2
2006-01-11	09:31 - 09:32	2
2006-01-13	02:51 - 02:52	2
2006-01-14	18:11 - 18:12	2
2006-01-16	02:41 - 02:42	2
2006-01-17	20:51 - 20:53	3
2006-01-19	11:50 - 11:51	2
2006-01-20	20:31 - 20:32	2
2006-01-22	12:20 - 12:21	2
2006-01-24	05:04 - 05:05	2
2006-01-25	22:00 - 22:01	2
2006-01-27	12:41 - 12:42	2
2006-02-01	19:30 - 19:31	2
2006-02-03	01:10 - 01:11	2
2006-02-04	08:11 - 08:12	2
2006-02-05	05:51 - 05:53	3
2006-02-06	21:41 - 21:43	3
2006-02-08	05:01 - 05:02	2
2006-02-08	05:09 - 05:12	4
2006-02-09	22:10 - 22:11	2
2006-02-11	04:11 - 04:12	2
2006-02-12	22:10 - 22:11	2
2006-02-14	09:30 - 09:31	2
2006-02-15	20:31 - 20:32	2
2006-02-17	07:01 - 07:02	2
2006-02-18	16:04 - 16:05	2
2006-02-19	22:41 - 22:42	2
2006-02-21	14:04 - 14:05	2
2006-02-23	08:21 - 08:22	2
2006-02-24	20:01 - 20:02	2
2006-02-24	20:08 - 20:11	4
2006-02-26	14:21 - 14:22	2
2006-02-27	23:51 - 23:52	2
2006-03-02	00:51 - 00:52	2
2006-03-03	08:41 - 08:42	2
2006-03-05	02:41 - 02:42	2
2006-03-06	19:21 - 19:22	2
2006-03-08	04:01 - 04:02	2
2006-03-09	16:51 - 16:52	2
2006-03-10	20:04 - 20:05	2
2006-03-12	09:30 - 09:31	2
2006-03-13	17:04 - 17:05	2
2006-03-15	03:41 - 03:42	2
2006-03-17	05:41 - 05:42	2
2006-03-18	17:40 - 17:41	2
2006-03-20	01:30 - 01:31	2
2006-03-21	19:11 - 19:12	2
2006-03-22	20:20 - 20:21	2
2006-03-24	16:20 - 16:21	2
2006-03-29	05:01 - 05:02	2
2006-03-30	19:50 - 19:51	2
2006-04-01	00:41 - 00:42	2
2006-04-02	19:04 - 19:05	2
2006-04-04	18:20 - 18:21	2
2006-04-06	12:20 - 12:21	2
2006-04-08	05:51 - 05:52	2
2006-04-09	18:01 - 18:02	2
2006-04-11	07:04 - 07:05	2
2006-04-13	08:11 - 08:12	2
2006-04-14	21:30 - 21:31	2
2006-04-16	11:20 - 11:21	2
2006-04-18	07:10 - 07:11	2
2006-04-19	21:30 - 21:31	2
2006-04-21	05:41 - 05:42	2
2006-04-22	17:04 - 17:05	2
2006-04-24	06:41 - 06:42	2
2006-04-25	17:21 - 17:22	2
2006-04-07	03:11 - 03:12	2
2006-04-28	11:04 - 11:05	2
2006-04-30	03:41 - 03:42	2
2006-05-01	05:10 - 05:11	2
2006-05-02	16:21 - 16:22	2
2006-05-04	14:50 - 14:51	2
2006-05-06	06:51 - 06:52	2
2006-05-07	15:21 - 15:22	2
2006-05-09	03:31 - 03:32	2
2006-05-10	12:41 - 12:42	2
2006-05-11	20:21 - 20:22	2
2006-05-13	01:11 - 01:12	2
2006-05-14	13:01 - 13:02	2
2006-05-15	22:10 - 22:11	2
2006-05-17	06:41 - 06:42	2
2006-05-18	21:41 - 21:42	2
2006-05-20	07:51 - 07:52	2
2006-05-21	16:41 - 16:42	2
2006-05-23	03:41 - 03:42	2
2006-05-24	13:40 - 13:41	2
2006-05-25	23:41 - 23:42	2
2006-05-27	09:01 - 09:02	2
2006-05-29	01:41 - 01:42	2
2006-05-30	03:21 - 03:22	2
2006-05-31	14:21 - 14:22	2
2006-06-02	01:10 - 01:11	2
2006-06-03	10:11 - 10:12	2
2006-06-04	16:21 - 16:22	2
2006-06-06	01:10 - 01:11	2
2006-06-07	00:11 - 00:12	2
2006-06-08	23:41 - 23:42	2
2006-06-10	13:31 - 13:32	2
2006-06-11	22:41 - 22:42	2
2006-06-13	12:10 - 12:12	3
2006-06-15	05:50 - 05:52	3
2006-06-16	19:51 - 19:52	2
2006-06-18	03:10 - 03:12	3
2006-06-19	17:11 - 17:12	2
2006-06-21	01:50 - 01:52	3
2006-06-22	10:31 - 10:32	2
2006-06-23	16:31 - 16:32	2
2006-06-25	04:10 - 04:12	3
2006-06-26	22:31 - 22:32	2
2006-06-28	08:01 - 08:02	2
2006-06-30	01:01 - 01:02	2
2006-07-01	10:04 - 10:05	2
2006-07-02	17:10 - 17:12	3
2006-07-04	04:01 - 04:02	2
2006-07-05	18:01 - 18:02	2
2006-07-07	05:41 - 05:42	2
2006-07-08	16:51 - 16:52	2
2006-07-10	00:21 - 00:22	2
2006-07-11	12:21 - 12:22	2
2006-07-13	00:21 - 00:22	2
2006-07-14	14:31 - 14:32	2
2006-07-16	07:31 - 07:32	2
2006-07-17	09:04 - 09:05	2
2006-07-19	06:01 - 06:02	2
2006-07-20	18:01 - 18:02	2
2006-07-22	05:01 - 05:02	2

2006-07-23	23:41 - 23:42	2
2006-07-25	11:31 - 11:32	2
2006-07-26	22:51 - 22:52	2
2006-07-28	14:51 - 14:52	2
2006-07-30	10:04 - 10:05	2
2006-08-01	01:04 - 01:05	2
2006-08-02	17:21 - 17:22	2
2006-08-04	07:01 - 07:02	2
2006-08-06	05:30 - 05:32	3
2006-08-07	13:41 - 13:42	2
2006-08-09	02:31 - 02:32	2
2006-08-10	17:01 - 17:02	2
2006-08-12	05:21 - 05:22	2
2006-08-13	05:41 - 05:42	2
2006-08-15	01:31 - 01:32	2
2006-08-16	16:01 - 16:02	2
2006-08-17	18:41 - 18:42	2
2006-08-19	13:51 - 13:52	2
2006-08-21	02:31 - 02:32	2
2006-08-22	14:31 - 14:32	2
2006-08-23	23:51 - 23:52	2
2006-08-25	10:51 - 10:52	2
2006-08-26	12:21 - 12:22	2
2006-08-27	22:11 - 22:12	2
2006-08-29	19:01 - 19:02	2
2006-08-01	08:31 - 08:32	2
2006-09-02	09:31 - 09:32	2
2006-09-04	03:51 - 03:52	2
2006-09-05	16:21 - 16:22	2
2006-09-06	03:15 - 03:17	3
2006-09-06	03:19 - 03:21	3
2006-09-07	19:20 - 23:59	280
2006-09-08	00:00 - 02:24	145
2006-09-08	02:27 - 02:28	2
2006-11-27	13:05 - 13:06	2
2006-12-01	15:25 - 15:27	3
2006-12-04	16:33 - 16:34	2
2006-12-08	07:35 - 07:36	2
2006-12-11	10:04 - 10:05	2
2006-12-15	07:15 - 07:16	2
2006-12-17	16:10 - 16:12	3
2006-12-20	02:15 - 02:17	3
2006-12-22	02:25 - 02:26	2
2006-12-23	22:42 - 22:43	2
2006-12-26	22:40 - 22:42	3
2006-12-28	23:57 - 23:58	2
2006-12-30	19:00 - 19:02	3

Table B.1. Canberra secondary variometer data used for in fill of primary variometer during 2006.

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Staff

Name	Classification	Responsibility
Peter Crosthwaite	GA Level 5	Digital acquisition, system and software development and maintenance; Kakadu and Mawson observatories
Andrew Lewis	GA Level 5	Project Leader (until June); repeat station survey; Learmonth and Macquarie Island observatories; Australian Geomagnetic Reference Field Model
Adrian Hitchman	GA Level 5	Project Leader (from July)
Peter Hopgood	GA Level 6	Gnangara and Alice Springs observatories
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
Alan Brockman	IPS	Learmonth (from 3 July)
Barry Copley	AAD and GA	Macquarie Island (until 5 April)
Shaun Evans	ACRES, GA	Alice Springs
Rory Lynch	Northern Land Council	Kakadu (until 19 February)
Owen McConnel	GA	Gnangara, technical support
Ian McLean	AAD and GA	Mawson (from mid-November)
Jack Millican		Charters Towers
Stephen Pryde	IPS	Learmonth (until 30 June)
Andy Ralph	Kakadu Culture Camp	Kakadu (from 15 September)
Warren Serone	ACRES, GA	Alice Springs
Dominic Taylor	AAD and GA	Mawson (until mid-November)
Tracey Taylor	AAD and GA	Casey
Gerard van Reeken		Gnangara
Jodi Wruck	AAD and GA	Macquarie Island (from 6 April)

Table 3. Observatory-based staff.