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Magnetic results for 2004

Kakadu

Charters Towers

Learmonth

Alice Springs

Gnangara

Canberra

Macquarie Island

Casey

Mawson

– and –

Australian Repeat Station Network

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SUMMARY

During 2004 Geoscience Australia operated geomagnetic observatories 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.

The operations at Macquarie Island and Casey were the joint responsibility of the Australian Antarctic Division of the Commonwealth Department of the Environment and Heritage and GA. Operations at Mawson were the joint responsibility of the Australian Bureau of Meteorology of the Commonwealth Department of the Environment and Heritage and GA.

The absolute magnetometers in routine service at the Canberra Magnetic Observatory also served as the Australian Reference. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are referenced against those at Canberra

Magnetic mean value data at resolutions of 1-minute and 1-hour were provided to the World Data Centres for Geomagnetism at Boulder, USA (WDC-A) and at Copenhagen, Denmark (WDC-C1), as well as to the INTERMAGNET program. K indices, principal magnetic storms and rapid variations were scaled with computer assistance, for the Canberra and Gnangara observatories. The scaled data were provided regularly to the International Service of Geomagnetic Indices. K indices were digitally scaled for the Mawson observatory.

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

Seven repeat stations were re-occupied during a field survey within continental Australia in April and May 2004.

To assist the geomagnetism program in Indonesia, data were routinely received from the Tangerang and Tondano observatories for processing. These observatories were most recently upgraded by GA's Geomagnetism personnel in 2001 under an AusAID grant that also included the purchase of instrumentation and the training of staff from Indonesia's national meteorological and geophysical organisation, Badan Meteorologi & Geofisika (BMG).

This report describes instrumentation and activities, and presents monthly and annual mean magnetic values, plots of hourly mean magnetic values and K indices at the magnetic observatories and repeat stations operated by GA during calendar year 2004.

ACRONYMS and ABBREVIATIONS

AAD	Australian Antarctic Division
ACRES	Australian Centre for Remote Sensing
ACT	Australian Capital Territory
A/D	Analogue to Digital (data conversion)
ADAM	Data acquisition module produced by Advantech Co. Ltd.
AGR	Australian Geomagnetism Report
AGRF	Australian Geomagnetic Reference Field
AGSO	Australian Geological Survey Organisation (formerly BMR)
AMO	Automatic Magnetic Observatory
AMSL	Above Mean Sea Level
ANARE	Australian National Antarctic Research Expedition
ANARESAT	ANARE satellite (communication)
ASP	- Alice Springs (Magnetic Observatory) - Atmospheric & Space Physics (a program of the AAD)
AusAID	Australian Agency for International Development
BGS	British Geological Survey (Edinburgh)
BMR	Bureau of Mineral Resources, Geology, and Geophysics (Now Geoscience Australia)
BMG	Badan Meteorologi dan Geofisika (Indonesia)
BoM	(Australian) Bureau of Meteorology
CD-ROM	Compact Disk - Read Only Memory
CNB	Canberra (Magnetic Observatory)
CODATA	Committee on Data for Science and Technology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSY	Casey (Variation Station)
CTA	Charters Towers (Magnetic Observatory)
D	Magnetic Declination (variation)
DC	Direct Current
DEH	Department of the Environment and Heritage
DIM	Declination & Inclination Magnetometer (D,I-fluxgate magnetometer)
DMI	Danish Meteorological Institute
DOS	Disk operating system (for the PC)
DVS	Davis (Variation Station)
EDA	EDA Instruments Inc., Canada
e-mail	electronic mail
F	Total magnetic intensity
ftp	file transfer protocol
GA	Geoscience Australia
GIN	Geomagnetic Information Node
GNA	Gnangara (Magnetic Observatory)
GPS	Global Positioning System
GSM	GEM Systems magnetometer
H	Horizontal magnetic intensity
HDD	Hard disk drive (in a PC)
I	Magnetic Inclination (dip)
INTER-MAGNET	International Real-time Magnetic observatory Network
IAGA	International Association of Geomagnetism and Aeronomy
IBM	International Business Machines
IGRF	International Geomagnetic Reference Field
IGY	International Geophysical Year (1957-58)
IPGP	Institute de Physique du Globe de Paris
IPS	IPS Radio & Space Services (formerly the Ionospheric Prediction Service)
ISGI	International Service of Geomagnetic Indices
K	kennziffer (German: logarithmic index; code no.) Index of geomagnetic activity.
KDU	Kakadu, N.T. (Magnetic Observatory)
LRM	Learmonth, W.A. (Magnetic Obsv'ty)
LSO	Learmonth Solar Observatory
mA	milli-Amperes
MAW	Mawson (Magnetic Observatory)
MCQ	Macquarie Is. (Magnetic Observatory)
MGO	Mundaring Geophysical Observatory
MNS	Magnetometer Nuclear Survey (PPM)
nT	nanoTesla
N.T.	Northern Territory
OIC	Officer in Charge
PC	Personal Computer (IBM-compatible)
PGR	Proton Gyromagnetic Ratio
PPM	Proton Procession Magnetometer
PVC	poly-vinyl chloride (plastic)
PVM	Proton Vector Magnetometer
QHM	Quartz Horizontal Magnetometer
Qld.	Queensland
RCF	Ring-core fluxgate (magnetometer)
SC	Sudden (storm) commencement
sfe	Solar flare effect
ssc	Sudden storm commencement
Tas.	Tasmania
UPS	Uninterruptible Power Supply
UT/UTC	Universal Time Coordinated
W.A.	Western Australia
WDC	World Data Centre
WWW	World Wide Web (Internet)
X	North magnetic intensity
Y	East magnetic intensity
Z	Vertical magnetic intensity

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End of Part 2

The *Australian Geomagnetism Report* has been published in electronic format since Volume 47 for calendar year 1999.

These volumes are available on Geoscience Australia's web site: http://www.ga.gov.au/

The final volume that was produced in printed format was the *Australian Geomagnetism Report 1998,* Volume 46.

Part 1

ACTIVITIES and SERVICES

Geomagnetic Observatories

The Geomagnetism Project of Geoscience Australia (GA) operated nine permanent geomagnetic observatories in the Australian region during 2004. The observatories were, in order of latitude, located at:

- **Kakadu**, Northern Territory
- **Charters Towers**, Queensland
- **Learmonth**, Western Australia
- **Alice Springs**, Northern Territory
- **Gnangara** (near Perth) , Western Australia
- **Canberra**, Australian Capital Territory
- **Macquarie Island**, Tasmania (sub-Antarctic)
- **Casey**, Australian Antarctic Territory
- **Mawson**, Australian Antarctic Territory

Antarctic Operations

Geoscience Australia continued its contribution to the Australian National Antarctic Research Expedition (ANARE) in 2004 by the operation of a magnetic observatory at Macquarie Island (Tasmania) in the sub-Antarctic and observatories at Casey and Mawson in Antarctica. GA's operations at these three observatories were supervised and managed from GA headquarters in Canberra, where the observers were trained. Logistic support was provided by the Australian Antarctic Division, Department of the Environment and Heritage.

Magnetic repeat station network

GA maintains a network of magnetic repeat stations throughout continental Australia, its offshore islands, Papua New Guinea and some islands in the south-west Pacific Ocean. The repeat stations are occupied at intervals of between one and two years to determine the secular variation of the magnetic field.

During a field survey in April and May 2004 repeat stations at Maryborough, Mount Isa, Derby, Carnegie, Eucla, Parafield and Tibooburra, all within continental Australia, were re-occupied.

Calibration of compasses

During 2004 GA continued to provide a service for the calibration and testing of direction finding (and other) instrumentation at cost recovery rates. The service was used throughout the year by agencies requiring the calibration of compasses and compass theodolites as well as the determination of magnetic signatures of other equipment.

National Magnetometer Calibration Facility

In collaboration with the Australian Department of Defence a purpose-designed *National Magnetometer Calibration Facility* building was constructed in the south-east of the Canberra Magnetic Observatory compound in 1999. The construction, installation and initial calibration of a Finnish/Ukrainian designed large 3-axis coil system was completed in December of that year.

The facility is routinely used for the calibration of observatory variometers as well as for clients' instrumentation on a cost recovery basis.

Indonesian Observatories

As part of an AusAID funded project, in 2001 Geoscience Australia undertook work to assist in the upgrade of the Indonesian geomagnetic observatories at Tangerang (TNG) near Jakarta on Java and Tondano (TND) near Manado on Sulawesi. The AusAID grant also included the cost of instrumentation (that was purchased in 2000) and the training at GA of staff from Indonesia's BMG.

As a result of this project it is now possible to transmit absolute observation and variometer data to GA from these Indonesian observatories for routine processing. This continued in 2004, enabling assistance to be provided to the Indonesian geomagnetism program.

These data will also complement data gained during repeat station occupations to enhance AGRF models.

DATA DISTRIBUTION

During 2004 data from GA's observatory network were routinely provided in support of international programs.

Data were automatically transmitted to GA in Canberra from all observatories each day, where they were processed and made available on the GA web site. Data from INTERMAGNET observatories were also e-mailed to the Edinburgh GIN.

INTERMAGNET

Data from Australian magnetic observatories have been contributed to the INTERMAGNET project (see Trigg and Coles, 1994) since the first CDROM of definitive data was produced. The adjacent table summarises Australian data that have been distributed on INTERMAGNET CDROMs. This reflects the continuing incorporation of Australian observatories into the INTERMAGNET project. The commencement of regular transmission of near real-time preliminary 1-minute data to an INTERMAGNET GIN — all Australian data has been emailed to Edinburgh GIN to date — is also shown in the table.

Australian Magnetic Observatory	Data on CDROM	Regular Transmission
Kakadu (KDU)	from 2000	from Aug. 2001
Charters Towers (CTA)	from 2000	from Aug. 2001
Alice Springs (ASP)	from 1999	from Dec. 1999
Gnangara (GNA)	from 1994	from early 1995
Canberra (CNB)	from 1991	from Oct. 1994
Macquarie Island (MCQ)	from 2001	from Jun. 2002

Ørsted Satellite Support

Since October 1994, preliminary monthly mean values from Australian observatories have been provided to the Ørsted satellite project within about a fortnight after the end of each month. In support of the Ørsted satellite project, preliminary 2004 monthly mean values from all Australian observatories were provided by e-mail to IPGP, France.

Storms and Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 2004 were provided monthly to:

- National Oceanic and Atmospheric Administration, USA.
- WDC C2, Kyoto, Japan
- Ebro Observatory, Spain

Indices of Magnetic Disturbance

Canberra (with its predecessors at Toolangi and Melbourne) and Hartland (with its predecessors at Abinger and Greenwich) in Great Britain are the two observatories used to determine the 'antipodal' aa index.

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

During 2004, K indices for CNB were provided semi-monthly to the Adolf-Schmidt-Observatorium (Niemegk, Germany) for the derivation of global geomagnetic activity indicators such as the 'planetary' Kp index.

The weekly provision of CNB K indices to CLS, CNES, Toulouse, France and the Brussels observatory, Belgium, continued throughout 2004. CNB K indices were also provided weekly to the Geomagnetism Research Group of the British Geological Survey (BGS).

K indices for CNB and GNA were provided weekly to the International Service of Geomagnetic Indices (ISGI), France, for the compilation of the 'antipodal' aa index and the world-wide 'mondial' am index.

K indices from CNB and GNA were also sent weekly to the IPS Radio and Space Services, Sydney, from where they were further distributed to recipients of their bulletins and reports.

Throughout 2004 all routine K index information was sent by e-mail.

Until the end of November 2002 K indices for Canberra and Gnangara were derived by the hand scaling of H and D traces on magnetograms (with a scale of 3nT/mm and 20mm/hr.) produced from the digital data, using the method described by Mayaud (1967).

From 01 December 2002 the K indices for Canberra and Gnangara were derived using a computer assisted method developed at GA. 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 is then manipulated on a computer screen using a spline fitting technique that allows the observer to create what is considered a better estimate of the non-K variations. The estimate of the non-K variation curve for the day is automatically subtracted from the magnetic variations which are then scaled for K indices.

Distribution of mean magnetic values

Hourly mean values in all geomagnetic elements (X, Y, Z, F, H, D & I) and 1-minute mean values in X, Y, Z & F for the following observatories and years were provided to WDC-A, Boulder USA; WDC-C1, Copenhagen, and the Paris INTERMAGNET GIN during 2004 as indicated.

Observatory	WDC-A Boulder	WDC-C1 Cop'nhgn.	IM GIN Paris
Kakadu	2003		2003
Charters Towers	2003		2003
Learmonth	2003	2003	
Alice Springs	2003		2003
Gnangara	2003	2003	2003
Canberra	2003		2003
Macquarie Is.	2003		2003
Casey	2003		
Mawson	2003	2003	

Data were provided in response to numerous requests received from government, educational institutions, industry and individuals, relating to geomagnetism and the variations of the magnetic field at particular locations and over particular intervals.

Australian Geomagnetism Report series

Beginning publication 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***. With the same title the monthly series was replaced by the annual report in 1993 (Vol. 41). Details of other reports containing Australian geomagnetic data are in the *AGRs 1995* and *1996*.

The current annual series includes data from the magnetic observatories, variation stations and repeat stations operated by Geoscience Australia†, or in which the latter had significant involvement. Detailed information about the instrumentation and the observatories was included in the *AGRs 1993* and *1994*.

The last report that was produced and distributed in printed format was *AGR 1998*. Beginning with *AGR 1999*, the report has only been available on GA's web site, from where it may be viewed and downloaded.

World Wide Web

Australian Geomagnetic information is available via the Internet through Geoscience Australia's web site:

http://www.ga.gov.au

Regularly updated data and indices from Australian observatories and the current AGRF model, together with information about the Earth's magnetic field, are available on the Geomagnetism Project web pages.

† On 13 August 1992, the Bureau of Mineral Resources, Geology and Geophysics (BMR) was renamed the Australian Geological Survey Organisation (AGSO). References to BMR relate to the period before the name change, and references to AGSO relate to the period after the name change. On 7 August 2001 the Australian Geological Survey Organisation was renamed AGSO−Geoscience Australia, which, when amalgamated with the Australian Surveying and Land Information Group (AUSLIG) on 8 November 2001, became simply Geoscience Australia (GA).

During 2004 the basic system used at Australian observatories to monitor magnetic fluctuations comprised an (orthogonal) three component variometer, in combination with a Proton Precession Magnetometer (PPM) or Overhauser Magnetometer that measured the total field intensity.

The availability of Total Intensity data provided a redundant channel serving 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 variometer.

Data produced at observatories were recorded digitally on PC-based acquisition systems, with the capability of remote data recovery to GA, Canberra, by dial-up telephone lines or ftp via intermediate computer.

Intervals of Recording and Mean Values

The standard recording interval was 1-minute. In most cases this was a result of averaging all 1-second samples from the 3-component variometer, and all 10-second samples from the PPM, that fell within the 1-minute interval. The 1-second and 10-second samples were also recorded and were used in the computation of baselines and other variometer parameters.

The 1-minute means were centred on the UT minute, eg. the first value *within* an hour, labelled 01^m, was the mean over the interval from 00^m30^s to 01^m30^s, in accordance with IAGA resolution 12 adopted at the Canberra Assembly in December 1979. Hourly mean values were computed from minutes 00^m to 59^m, eg. the hourly mean value labelled 01^h, was the mean of the 1-minute means from 01^h00^m to 01^h59^m inclusive. Daily means were the average of hourly mean values 00^h to 23^h.when all hour means in the day existed.

Monthly means were 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 sub-sets that existed.

Annual means were 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 days means existed.

Magnetic Variometers

Details of the variometers that were employed at each of the magnetic observatories during the year are shown in the following table. Detailed descriptions of these instruments were given in the *Australian Geomagnetism Reports 1993* to *1996*. New variometers that have been introduced into the network since 1996 are briefly described below.

DMI 3-axis fluxgate magnetometers

These instruments have gradually been introduced into the Australian observatory network since 1998. Constructed by the Danish Meteorological Institute in Copenhagen, Denmark, they are available in a suspended or non-suspended configuration. Both types have been commissioned at Australian observatories. Sensors are built into the instrument to monitor the temperature of both the electronics and magnetic sensors. Although the instruments produce analogue outputs, they are digitised by built-in ADAM analogue to digital converters. Data are sampled at 1-second intervals from these instruments at Australian observatories.

GEM GSM90 Overhauser effect total field magnetometer

These instruments have been introduced into the Australian observatory network since 1998. They are constructed by GEM Systems Inc. in Ontario, Canada. At Australian observatories these are set to provide a digital reading every 10 seconds.

Since 1993, variometers installed at Australian observatories have been orientated so the three orthogonal sensor axes were not aligned with either the H, D and Z magnetic directions or with the cardinal directions North, East and Vertical. This 'non-aligned' configuration has enabled each of the measured components to be of a similar magnitude. This has optimized quality control and the recovery of data from an unserviceable channel when a total field instrument is also recording variations in F (Crosthwaite, 1992, 1994). The 'non-aligned' configuration was typically two orthogonal horizontal components each aligned at 45 degrees to the magnetic meridian (i.e. magnetic NW and NE) and a vertical component, although there was a variation† to this at Macquarie Island.
The F-check test (that calculates the difference between F observed and F derived from the three orthogonal components) gives better quality control when the magnitude of the components are similar.

† See the *Variometers* section, under *Macquarie Island* in this report.

Data Reduction

By the use of regular absolute observations, parameters were gained to 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:

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

where:
- A, B and C are the near-orthogonal, arbitrarily orientated variometer ordinates;
- matrix [S] combines scale-values and orientation parameters;
- vector [B] contains baseline values;
- vectors [Q] and [q] contain temperature-coefficients for sensors and electronics;
- T and t are the temperatures of the sensors and electronics, while 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] were determined using the calibration coils at the *National Magnetometer Calibration Facility* (see page 1 above) at the Canberra Observatory, while those in [B] and [D] that best fit the absolute observations were determined by multiple linear regressions. (If this technique failed, nominal values were adopted.)

By calculating the total field intensity, F, using the model parameters adopted above, and comparing the result with the recording PPM's readings, a continuous monitor of the validity of the model parameters is available. This is the so-called 'F-check' that is monitored continuously at all observatories with a redundant PPM channel.

Absolute magnetometers

The principal absolute magnetometer combination used to calibrate the variometers at the Australian magnetic observatories during 2004 was a D,I-fluxgate magnetometer (or Declination and Inclination Magnetometer – DIM) that measured the magnetic field direction, complemented by a PPM to measure the total field intensity. At some observatories, older classical QHMs were still available as backup should the primary instruments become unserviceable.

The DIM or D,I-fluxgate magnetometer comprises a single axis fluxgate sensor mounted on, and parallel with, the telescope of a non-magnetic theodolite. By setting the sensor perpendicular to the magnetic field vector, the direction of the latter could be determined: its Declination when the sensor was level; its Inclination when the sensor was in the magnetic meridian.

In 2004 Elsec 810, Bartington MAG-01H and DMI fluxgate Model G sensors and electronics were used together with Zeiss-Jena 020B and 010B non-magnetic theodolites.

A summary of the absolute magnetometers that were in use at each of the Australian observatories during the year is in the table on page 5 of this report.

Variometers in service at Australian Observatories in 2004

Observatory	Variometer/Serial no. (operational period)	Resolution (nT)	Acquisition interval (sec.)	Components recorded
KDU	DMI FGE fluxgate E0198/S0183	0.1	1, 60	NW, NE, Z†
	Geometrics 856 No.50707 (to 22 Nov. 2004)	0.1	10, 60	F
	GEM Systems GSM90 No. 4071413 / 42185 (from 26 Nov 2004)	0.01	10, 60	F
CTA	DMI FGE (ver.G) S0210/E0227	0.1	1, 60	NW, NE, Z†
	Elsec 820 PPMs no.157 (Start of year to 02 August 2004) no.139 (17 August 2004 to end of year)	0.1	10, 60	F
LRM	DMI s/n E0271/S0237	0.03	1,60	NW, NE, Z
	Geometrics 856 no. 50708	0.1	10, 60	F
ASP	Narod ring-core fluxgate/9004-3	0.025	1, 60	X, Y, Z‡
	GSM-90 Overhauser total field magnetometer s/n 708729, with sensor 3112370 (from 30 Mar 2004)	0.01	10, 60	F
GNA	DMI FGE (ver.D) S0160 with E0199 (to 23 Mar. 2004)	0.1	1, 60	NW, NE, Z†
	EDA FM105B sensor 2887, electr. 2877 (from 07 Apr. 2004)	0.2	1, 60	NW, NE, Z†
	Geometrics 856 No.50706	0.1	10, 60	F
CNB	Narod ring-core fluxgate/9004-2 [Secondary variometers: LEMI 3-axis fluxgate DMI FGE E0254 / S0227]	0.025	1, 60	NW, NE, Z†
	GEM Systems GSM-90 / 803810 / sensor 81225	0.01	1, 60	F
MCQ	Narod ring-core fluxgate 9305-1 (Primary instrument all 2004)	0.025	1, 60	A, B, C†
	DMI suspended fluxgate E290/S250 (Secondary instrument from 31 Aug. to 31 Dec. 2004)	0.3	1	NW, NE, Z
	Elsec 820M3 PPM 140	0.1	10, 60	F
CSY	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡
MAW	Narod ring-core fluxgate 9004-1	0.025	1, 60	NW, NE, Z†
	Elsec 820M3 PPM 158	0.1	10, 60	F

* The serial numbers of the EDA fluxgates are in the sequence: control electronics/sensor head.
** The EDAs at Casey (and Davis) were Australian Antarctic Division instruments.
‡ Installed before 1993.
† Recorded components A, B & C or (magnetic) NW, NE & Z indicate non-aligned orientation.

Reference Magnetometers

BMR/AGSO/GA has always maintained reference magnetometers for Declination and Total Magnetic Intensity. Since the late 1970s these absolute magnetometers have been held at the Canberra Magnetic Observatory where they were in routine use for the calibration of variometers there. During 1993 a Declination and Inclination magnetometer (DIM) replaced classical magnetometers as the primary Declination and Inclination reference for Australia. (Details of the magnetometers that served this purpose prior to 1993 are in *AGRs 1993-1997*.) The adoption of a DIM as the Inclination reference has eliminated the requirement for frequent QHM calibrations, at the Rude Skov magnetic observatory in Denmark, to maintain an accurate Horizontal Intensity, H, reference. This has enabled the more rapid adoption of final instrument corrections.

Proton precession magnetometer MNS2 no.3 served as the Total Intensity (F) reference from the late 1970s until 2000. In January 1995 its crystal oscillator frequency was found to be 13.4ppm below the (CODATA 1986) value recommended by IAGA for use from 1992. This resulted in F readings at Canberra that were theoretically 0.78nT too high.

Reference Magnetometers (cont.)

This correction was subsequently taken into account when referencing total field absolute instruments deployed at all Australian observatories. The instrument was described in *AGR*s 1993-2000.

In 2001 the MNS2 no. 3 PPM was replaced by the GEM Systems Inc. GSM90 Overhauser magnetometer with electronics no. 905926 and sensor no. 81241. Although a small theoretical difference between the old and new total field references was derived, viz.:

$$F(MNS2)_{old\ reference} = F(GSM90)_{new\ reference} + 0.4nT,$$

in view of the uncertainties, no difference between them has been adopted. The new GSM90 reference is applied without correction.

All absolute instruments in use within the Australian observatory network are periodically compared with the Canberra observatory reference magnetometers, although often through subsidiary travelling reference absolute instruments.

An *IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing* takes place at an observatory in the global network approximately every two years. Since the 1994 workshop a delegate from the GA Geomagnetism group has attended these workshops with a set of travelling absolute magnetometers. Magnetometer intercomparisons performed at the IAGA workshops enable the Australian Magnetic Reference magnetometers, and so all magnetometers used in the Australian observatory network, to be corrected to international standards.

Results identified as *final* in this report indicates that absolute magnetometers used to determine baselines have been corrected so as to be consistent with international standards via the Australian Magnetic Reference magnetometers held at Canberra observatory.

Absolute Magnetometers employed in 2004

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
KDU	DIM: Bartington MAG010H/B0622H; Zeiss 020B/359142*	D, I	0.1'
	PPM: Elsec 770/189	F	1 nT
	GEM Systems GSM90 No.4081421/42186	"	0.01 nT
CTA	DIM: Elsec 810/215; Zeiss 020B/313888* (to 22 June 2004)	D, I	0.1'
	DIM: DMI DI0036; Zeiss 020B/394050* (from 23 June 2004)		
	PPM: Geometrics 816/767 (to 22 June 2004)	F	1 nT
	PPM: GSM90 3091318; sensor 91472 (from 23 June 2004)		
LRM	DIM: Bartington 0702H; Zeiss 020B/312714	D, I	0.1'
	PPM: Geometrics 856 no. 50471; sensor 980801 (to June 2004)	F	0.1 nT
	PPM: GEM GSM90_3091316 sensor 761100 (from 25 June 2004)	"	0.01 nT
ASP	DIM: Elsec 810/221; Zeiss 020B/313887*	D, I	0.1'
	Overhauser total field magnetometer:		
	GSM-90 s/n 2101216, sensor 306403	F	0.01 nT
GNA	DIM: Bartington MAG010H/B0725H; Zeiss 020B/355937* (to 12 Feb '04)	D, I	0.1'
	DIM: DMI DI0037; Zeiss 020B/390444 (from 30 Apr 2004)	D, I	0.1'
	PPM: Geometrics 856 no. 50631/ sensor 28079922 (to 12 Feb 2004)	F	0.1 nT
	PPM: GEM GSM90 no. 3091317, sensor 91457 (from 30 Apr 2004)	F	0.01 nT
CNB	DIM: Elsec 810/200; Zeiss 020B/353756* (Australian Reference)	D, I	0.1'
	PPM: GSM-90 no.905926, sensor 21867 (Australian Reference)	F	0.1 nT
MCQ	DIM: Elsec 810/214; Zeiss 020B/311847*	D, I	0.1'
	PPM: Austral /525 (primary to 17 May 2004, secondary thereafter)	F	1 nT
	GSM90 no. 3091319, sensor 01504 (from 18 May 2004)	F	0.01 nT
	QHM Nos. 177‡, 178, 179 (secondary)	H, D	0.1 nT
CSY	DIM: Elsec 810/2591; Zeiss 020B/356514*†	D, I	0.1'
	PPM: Geometrics 816/766	F	1 nT
	QHM No. 493 (secondary)	H	0.1 nT
MAW	DIM: DMI D26035; Zeiss 020B/311542*	D,I	0.1'
	DMI DI0022; Zeiss 020B/353758*	"	"
	PPM: Elsec 770/210 (primary: Jan. – Mar.; secondary: Apr. – Dec., 2004)	F	1 nT
	GEM GSM90/3091315 (primary: Apr. – Dec., 2004)	"	0.01 nT
	Elsec 770/199 (secondary: Jan. – Mar., 2004)	"	1 nT
	QHM Nos. 300, 301, 302 (secondary: to Jan. 2004 only)	H	0.1 nT
	Declinometer: Askania 630332 (secondary: to Jan. 2004 only)	D	0.1'
	Askania circle 611665 (for mounting QHM and Declinometer)		

* DIM serial numbers are in the sequence DIM control module followed by Zeiss theodolite
† The DIM at Casey is an Antarctic Division instrument.
‡ QHM 177 was not sighted during a service visit to MCQ in March 2003.

Data Acquisition

During 2004 data acquisition at all the Australian observatories was computer-based. Throughout the year data were recorded every second and every minute at all observatories.

The timing of the data acquisition was controlled by the DOS clock in the acquisition PCs.

As it was possible that the drift rate of a PC's DOS clock could be up to a minute per day, acquisition software had the built-in capability to adjust the clock rate. The drift rate could thus be reduced to as low as a tenth of a second per day. The communication software also allowed the timing to be reset or adjusted by instructions from GA, Canberra, via modems over a telephone line. At most observatories the PC clocks were kept corrected by synchronizing them with 1-second GPS clock pulses.

Analogue to digital PC cards or external ADAM A/D converters were used to convert analogue data, produced by GA's DMI FGE variometers, to digital values for recording on data acquisition PCs.

The AAD's EDA FM105B variometers at Casey acquired data via their Analogue Data Acquisition System (ADAS).

The Narod ringcore fluxgate magnetometers provided digital data direct to the acquisition PCs.

> Digital data have been retrieved automatically from the observatories each day since March 1996. In 2004 the data from the observatories were either retrieved on demand by modems: via telephone lines within Australia; or ANARESAT satellite link from Antarctica, directly to GA headquarters in Canberra.

Ancillary Equipment

Uninterruptible Power Supplies (UPS) and lightning surge filters were installed at most observatories during 2004.

MAGNETIC OBSERVATORIES

The locations of the observatories are shown on the cover page of this *Australian Geomagnetism Report* and listed, together with the Observers in Charge, in the following table.

For a history of the observatories see also the *Australian Geomagnetism Reports* of *1993* to *1996*.

On the pages that follow there is an operational report and data summary for each magnetic observatory in the Australian network that operated in 2004.

Australian Magnetic Observatories: 2004

Observatory	IAGA code	Year begun	Geographic Coordinates Latitude S	Geographic Coordinates Longitude E	Geomagnetic† Lat.	Geomagnetic† Long.	Elev'n (m)	Observer in Charge
Kakadu	KDU	1995	12° 41' 11"	132° 28' 20"	-21.87°	205.52°	15	R. Lynch
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-27.86°	220.86°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.23°	186.38°	4	G.A. Steward
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-32.73°	208.08°	557	W. Serone
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-41.71°	188.75°	60	O. McConnel H. VanReeken
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.50°	226.79°	859	L. Wang
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-59.87°	244.01°	8	H. Banon Spencer Redfern
Casey	CSY	1999*	66° 17'	110° 32'	-76.33°	183.86°	40	M. Healy C. Clarke
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.08°	110.34°	12	R. Hegarty G. Roser

† Geomagnetic coordinates are based on the 2000.0 International Geomagnetic Reference Field (IGRF) model updated to 2004.5 with magnetic north pole position of 79.796°N, 288.282°E.

* From 1988 to 1999 absolute calibrations of the variometers at Casey were considered insufficient for observatory standard. From 1975 to 1987 no magnetic variometers operated at Casey: only monthly absolute observations were performed. (Further details in the Casey section of this report)

KAKADU OBSERVATORY

The Kakadu Magnetic Observatory is a part of the Kakadu Geophysical Observatory, located at the South Alligator Ranger Station of the Australian Nature Conservation Agency, Kakadu National Park, which is 210km east of Darwin and 40km west of Jabiru, on the Arnhem Highway in the Northern Territory. The observatory is situated on unconsolidated ferruginous and clayey sand. The Geophysical Observatory also houses a seismological observatory and a gravity station. Continuous magnetic recording began there in March 1995.

The observatory comprises:

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

Details of the establishment of the Kakadu observatory are in the *AGR 1994* and *AGR 1995*.

Key data for Kakadu Observatory:

- 3-character IAGA code: KDU
- Commenced operation: 05 March 1995
- Geographic‡ latitude: 12° 41' 10.9" S
- Geographic‡ longitude: 132° 28' 20.5" E
- Geomagnetic† : Lat. -21.87°; Long. 205.52°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier A
- Elevation of top of Pier A: 14.6 metres AMSL
- Azimuth of principal reference (Pillar AW from Pier A): 237° 52.8'
- Distance to Pillar AW: 99.6 metres
- Observer in Charge: Rory Lynch

‡ Geodetic Datum of Australia 1994 (GDA 94)
† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

Variations in the magnetic-NW, magnetic-NE and vertical components of the magnetic field were monitored at Kakadu in 2004 using a suspended 3-axis linear-fluxgate DMI FGE magnetometer (with sensor no. S0183 and electronics no. E0198).

The total magnetic field intensity, F, was monitored using a Geometrics model 856 proton precession magnetometer (no. 50707) until the 22-26 November 2004 maintenance visit during which it was replaced by a GEM Systems GSM90 Overhauser-effect magnetometer (no. 4071413, sensor no. 42185).

Analogue variometer outputs from the three fluxgate channels, together with the fluxgate sensor head and electronics temperature channels, were converted to digital data with an ADAM 4017 analogue-to-digital converter mounted inside the fluxgate electronics module. These digital data together with the digital PPM data were recorded on a PC. The computer was connected to a 1 pulse/sec. input from a GPS clock to keep the computer clock rate accurate; and a modem for communications.

The recording equipment and fluxgate-variometer electronics were located in the air-conditioned CONTROL HOUSE. The Geometrics variometer electronics was also located in the CONTROL HOUSE, but its replacement GSM90 variometer electronics was located in the covered vault with its sensor – both DC power and data cables ran between the GSM90 vault and the CONTROL HOUSE.

The sensor heads were located in the concrete underground vaults: the DMI fluxgate head in the northern vault (the one nearest the Absolute Shelter); and the PPM head in the southern vault. Both vaults were completely buried in soil to minimise head-temperature fluctuations. Both the fluxgate and PPM electronics consoles were placed in their own partially insulated plastic box, resting on the concrete base in the vault, 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 Geometrics 856 variometer cable was a double-screened marine armoured cable, with the outer shield (armour) earthed, and the inner shield attached to equipment earth. The data connections between the acquisition computer and both the ADAM A/D and the PPM variometer were via fibre-optic modems and several metres of fibre-optic cable to isolate any damage from lightning entering the system through any one piece of equipment.

The 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 pits, and a conducting loop around the CONTROL HUT. All of these lightning protection components were connected together. (See *AGR2000* for further details.)

The DMI FGE variometer sensitivity, alignment, and temperature sensitivity parameters were measured at the *National Magnetometer Calibration Facility* at Canberra Observatory before installation at Kakadu. The sensor assembly was aligned with the Z fluxgate sensor vertical, and the other two fluxgate sensors horizontal, each aligned at 45° to the declination at the time of installation. This was achieved by setting the X and Y offsets equal and rotating the instrument until the X and Y ordinates were equal. This method was found to be accurate by tests performed at the *National Magnetometer Calibration Facility* at Canberra Observatory. (See *AGR 2000* for details.)

Absolute Instruments and Corrections

The principal absolute magnetometers used at Kakadu in 2004 were a declination-inclination magnetometer, DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on a Zeiss 020B non-magnetic theodolite (no. 359142), and two total-field magnetometers: Elsec PPM model 770 (no. 189) through to November; then GEM Systems GSM90 (no. 4081421, with sensor no. 42186) in December. There was some overlap between the two total-field magnetometers in late November 2004.

As described in the *AGR1998*, the best way to use this DIM was to take all readings on the x10 scale, but 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 KDU throughout 2004.

DIM measurements were made using the *offset* method, where the theodolite was set to a whole number of minutes to give a small fluxgate reading and then a series of eight fluxgate vs. time measurements were recorded without moving the theodolite.

All DIM and PPM measurements were made on Pier A at the standard height.

Corrections were applied to the absolute magnetometers used at Kakadu to align them with the Australian reference instruments held in Canberra. The corrections that were applied in 2004 were determined through a series of instrument comparisons performed during regular maintenance and calibration visits in May 2003 and November 2004. The F corrections from 2002 to 2004 follow what might be described as regular aging: −2.3nT, −3.3nT and −4.0nT in 2002, 2003 and 2004 respectively.

The corrections adopted for the Kakadu absolute instruments for 2004 were: 0.0′, 0.0′ in D and I for the DIM (as for previous years) and −3.65nT in F for Elsec 770 no. 189, and 0nT for GSM90 no. 4081421. The adoption of these corrections effectively introduced a jump of −0.25nT in X and +0.25nT in Z in KDU data at 00:00UT on 01 January 2004 and again at 00:00UT on 01 December 2004.

At the mean magnetic field values at Kakadu these translate to corrections of:

$\Delta X = -2.75$nT $\Delta Y = -0.2$nT $\Delta Z = +2.35$nT
from January to November 2004

and

$\Delta X = 0$nT $\Delta Y = 0$nT $\Delta Z = 0$nT
in December 2004.

These instrument corrections have been applied to the 2004 data in this report.

Baselines

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

0.7nT in X; 0.9nT in Y; 0.7nT in Z

(In terms of the absolute observed components, they were:

0.7nT in F; 05" in D; 04" in I)

The drifts applied to any one of the X, Y, and Z baselines amounted to less than 1.5nT throughout 2004.

Throughout the year there was about a 1nT variation in the difference between F determined with the DMI fluxgate (final data model with drifts applied) and the variometer PPM. Typical daily variation of the difference was less than 0.5nT. (The difference was corrupted by spikes from lightning during the monsoons which are asymmetric in nature, and a better measure of system performance is the minimum value of the difference over an hour or a day. This minimum was used to derive these figures.)

From January to mid-August 2004, the difference between the KDU absolute Elsec 770 proton magnetometer and variometer Geometrics 856 proton magnetometer was consistent to within ±0.7nT. No seasonal variation was noticeable during that period. From mid-August to late-November 2004, the Geometrics 856 variometer was not sufficiently stable to reliably determine a value. There were too few GSM90 observations to determine a value for the December 2004 data.

Operations

The 2004 local observer (RL) 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 customary at geomagnetic observatories. However, the DMI FGE magnetometer baselines appeared to be exceptionally stable throughout 2004, and the fewer-than-normal observations did not affect the quality of the final data.

A service visit to KDU by GA staff (LJW & BS) was made between 22 and 26 November 2004 during which the Elsec and Geometrics total-field absolute and variometer magnetometers were replaced by GSM90 magnetometers, and the standard desktop acquisition computer (with a failing fan) was exchanged with a WAFER 5823 industrial computer.

1-second and 1-minute mean magnetic data were acquired at the Kakadu observatory throughout 2004.

The acquisition timing was controlled by the acquisition computer clock, the rate of which was kept accurate with the 1Hz pulse (not the actual data stream) from a GPS clock. On weekdays the time was checked, and corrected if necessary, via modem from GA. The GPS clock kept the acquisition computer clock within 0.1s of the nearest UTC second; i.e. an error of a whole number of seconds would not be corrected. The clock was accurate except during the maintenance visit, and between 22 and 24 November the data timing was on occasions in error by up to 2 seconds.

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 occasions the operation of the observatory was also checked by the observer. Completed absolute observation forms were sent to GA in Canberra by mail, where they were reduced and used to calibrate the variometer data.

Data were retrieved daily by standard telephone-line modem connection, usually at 9600 to 14400 baud.

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 electronics temperature was 27.0 ± 1.0 °C during 2004, except during October and November when the temperature rose as high as 31.0°C. The DMI fluxgate electronics temperatures varied with a typical daily variation of less than 0.25°C in January when temperature control was at its best, and 1.0°C in November when temperature control was at its worst.

The DMI sensor, although buried underground, varied between 26.0°C and 34.5°C during 2004. Some temperature changes were as rapid as 0.5°C/day persisting for several days, and there was a prolonged warming from mid-year at a rate of 0.07°C/day for 125 days.

Operations (cont.)

The DMI FGE fluxgate variometer maintained exceedingly stable baselines throughout 2004. After annual processing, it appeared that any drifts introduced to correct the fluxgate variometer data to the absolute observations made the data less consistent with the F variometer data. It is likely that the absolute instruments (the Elsec 770 PPM) were less stable than the variometer. (Nevertheless, the data were corrected to the absolute instruments.) Whether this is the case or not should become apparent in 2005 with the use of the GSM90 absolute magnetometer for measuring F.

Late in 2004 and into 2005, the DMI FGE variometer showed frequent shifts amounting to 1nT 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 GSM90 variometer and new computer were installed during the November 2004 maintenance visit. Although the pre-GSM90 data (Geometrics 856) was much noisier and such shifts not so obvious, no similar shifts were apparent before the visit. The source of this problem was not resolved in 2004.

The Geometrics 856 scalar variometer was frequently noisy whenever there were electrical storms in the region during the monsoon season. It performed very poorly from mid-August 2004. It was replaced by a GEM Systems GSM90 in late November 2004.

Kakadu Annual Mean Values

The table below gives 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 & F are on pages 15 & 16.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABC
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABC
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABC
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABC
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABC
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABC
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABC
2002.5	A	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	ABC
2003.5	A	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	ABC
2004.5	A	3	43.3	-40	15.7	35429	35354	2299	-30005	46428	ABC
1995.583	Q	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	ABC
1996.728	Q	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	ABC
1997.455	Q	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	ABC
1998.5	Q	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	ABC
1999.5	Q	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	ABC
2000.5	Q	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	ABC
2001.5	Q	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	ABC
2002.5	Q	3	44.5	-40	18.4	35454	35378	2313	-30074	46491	ABC
2003.5	Q	3	44.2	-40	17.4	35439	35363	2309	-30043	46459	ABC
2004.5	Q	3	43.3	-40	15.0	35441	35366	2301	-30003	46435	ABC
1995.583	D	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	ABC
1996.728	D	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	ABC
1997.455	D	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	ABC
1998.5	D	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	ABC
1999.5	D	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	ABC
2000.5	D	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	ABC
2001.5	D	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	ABC
2002.5	D	3	44.5	-40	20.4	35416	35341	2311	-30077	46464	ABC
2003.5	D	3	44.0	-40	19.8	35396	35321	2305	-30050	46431	ABC
2004.5	D	3	43.2	-40	16.9	35407	35332	2297	-30008	46412	ABC

* Elements ABC indicates non-aligned variometer orientation

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

KAKADU	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35350.4	2301.3	-30029.7	46440.6	35425.3	3° 43.5'	-40° 17.3'
	5xQ days	35357.3	2303.1	-30027.1	46444.3	35432.3	3° 43.6'	-40° 16.8'
	5xD days	35325.9	2297.9	-30031.8	46423.1	35400.5	3° 43.3'	-40° 18.6'
February	All days	35356.7	2303.4	-30024.3	46442.0	35431.6	3° 43.6'	-40° 16.7'
	5xQ days	35365.1	2305.4	-30022.7	46447.4	35440.1	3° 43.8'	-40° 16.2'
	5xD days	35339.2	2299.8	-30026.4	46429.9	35413.9	3° 43.4'	-40° 17.6'
March	All days	35357.4	2303.5	-30017.2	46438.0	35432.4	3° 43.7'	-40° 16.2'
	5xQ days	35377.4	2306.7	-30014.8	46451.8	35452.5	3° 43.8'	-40° 15.1'
	5xD days	35341.1	2302.1	-30021.5	46428.3	35416.0	3° 43.6'	-40° 17.2'
April	All days	35355.7	2304.3	-30012.4	46433.6	35430.7	3° 43.7'	-40° 16.0'
	5xQ days	35369.1	2306.5	-30009.6	46442.1	35444.2	3° 43.9'	-40° 15.2'
	5xD days	35344.3	2301.5	-30014.4	46426.0	35419.1	3° 43.5'	-40° 16.7'
May	All days	35362.3	2303.0	-30007.1	46435.1	35437.2	3° 43.6'	-40° 15.4'
	5xQ days	35370.6	2303.9	-30006.0	46440.8	35445.5	3° 43.6'	-40° 14.9'
	5xD days	35357.7	2302.9	-30007.1	46431.6	35432.6	3° 43.6'	-40° 15.6'
June	All days	35366.7	2302.8	-30002.8	46435.7	35441.6	3° 43.5'	-40° 15.0'
	5xQ days	35374.5	2302.4	-30000.3	46440.1	35449.4	3° 43.4'	-40° 14.4'
	5xD days	35360.5	2302.7	-30003.4	46431.4	35435.4	3° 43.6'	-40° 15.3'
July	All days	35347.1	2299.3	-30001.9	46420.1	35421.8	3° 43.3'	-40° 15.9'
	5xQ days	35372.4	2300.9	-29999.2	46437.6	35447.1	3° 43.3'	-40° 14.5'
	5xD days	35285.3	2292.6	-30008.9	46377.2	35359.8	3° 43.0'	-40° 19.2'
August	All days	35348.7	2298.4	-29997.9	46418.6	35423.3	3° 43.2'	-40° 15.6'
	5xQ days	35352.0	2297.7	-29998.8	46421.7	35426.6	3° 43.1'	-40° 15.5'
	5xD days	35329.3	2297.6	-29999.1	46404.6	35404.0	3° 43.3'	-40° 16.6'
September	All days	35357.9	2297.2	-29994.3	46423.2	35432.4	3° 43.0'	-40° 14.9'
	5xQ days	35364.2	2298.0	-29994.1	46427.9	35438.8	3° 43.1'	-40° 14.6'
	5xD days	35349.1	2298.0	-29995.6	46417.4	35423.8	3° 43.2'	-40° 15.4'
October	All days	35364.6	2295.8	-29989.7	46425.3	35439.0	3° 42.9'	-40° 14.3'
	5xQ days	35373.7	2296.1	-29988.3	46431.4	35448.2	3° 42.8'	-40° 13.8'
	5xD days	35345.7	2294.6	-29991.9	46412.3	35420.2	3° 42.9'	-40° 15.4'
November	All days	35329.3	2292.0	-29996.4	46402.6	35403.6	3° 42.7'	-40° 16.4'
	5xQ days	35358.1	2294.5	-29990.3	46420.7	35432.5	3° 42.8'	-40° 14.7'
	5xD days	35256.9	2286.3	-30006.4	46353.7	35331.0	3° 42.6'	-40° 20.5'
December	All days	35352.6	2291.8	-29989.6	46415.9	35426.8	3° 42.5'	-40° 14.9'
	5xQ days	35357.0	2293.7	-29990.2	46419.8	35431.4	3° 42.7'	-40° 14.7'
	5xD days	35349.0	2290.6	-29990.2	46413.5	35423.2	3° 42.5'	-40° 15.1'
Annual	All days	35354.1	2299.4	-30005.3	46427.6	35428.8	3° 43.3'	-40° 15.7'
Mean	5xQ days	35366.0	2300.7	-30003.4	46435.4	35440.7	3° 43.3'	-40° 15.0'
Values	5xD days	35332.0	2297.2	-30008.0	46412.4	35406.6	3° 43.2'	-40° 16.9'

(Calculated: 15:42 hrs.,Tue. 13 Dec. 2005)

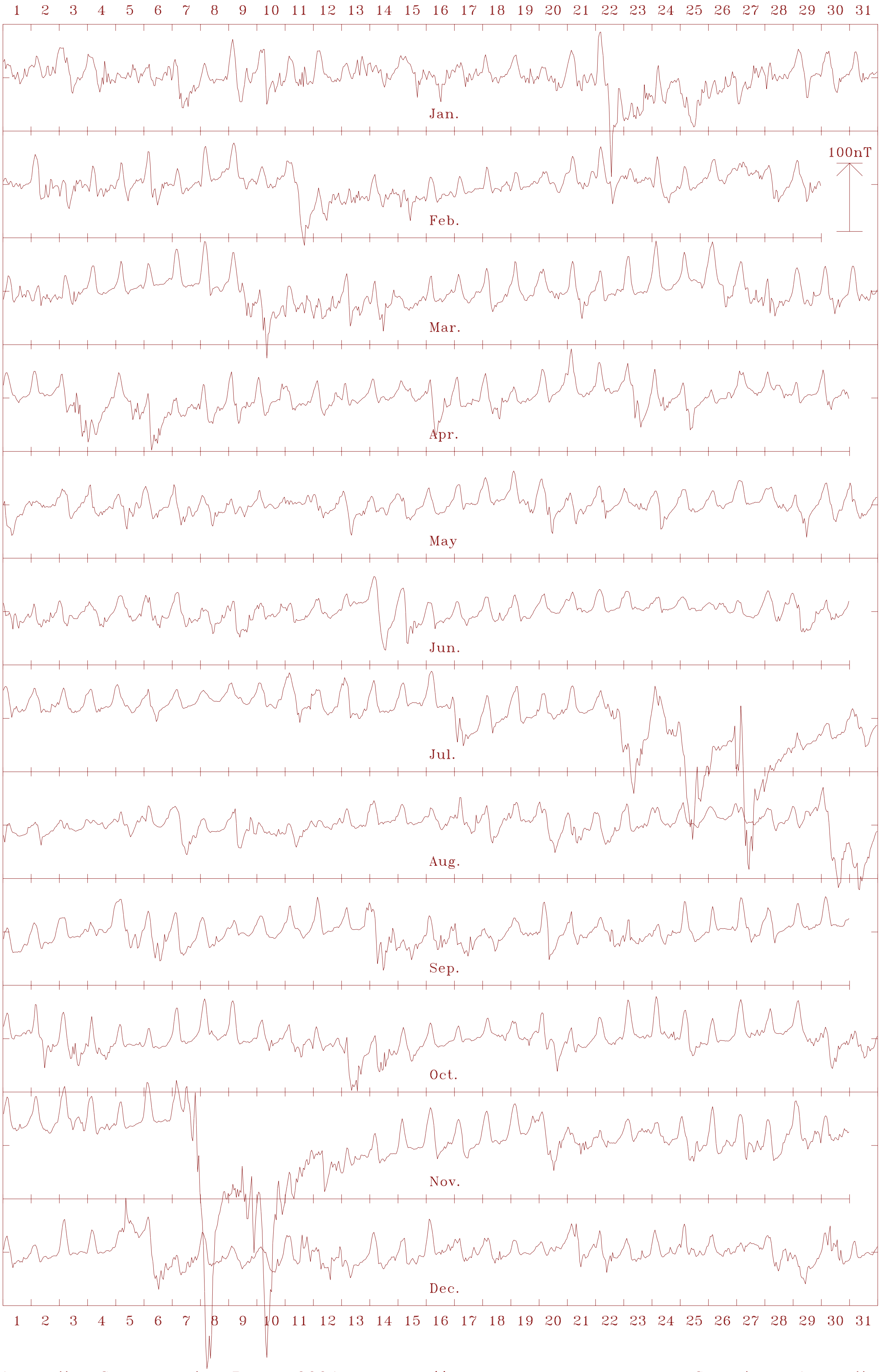
Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

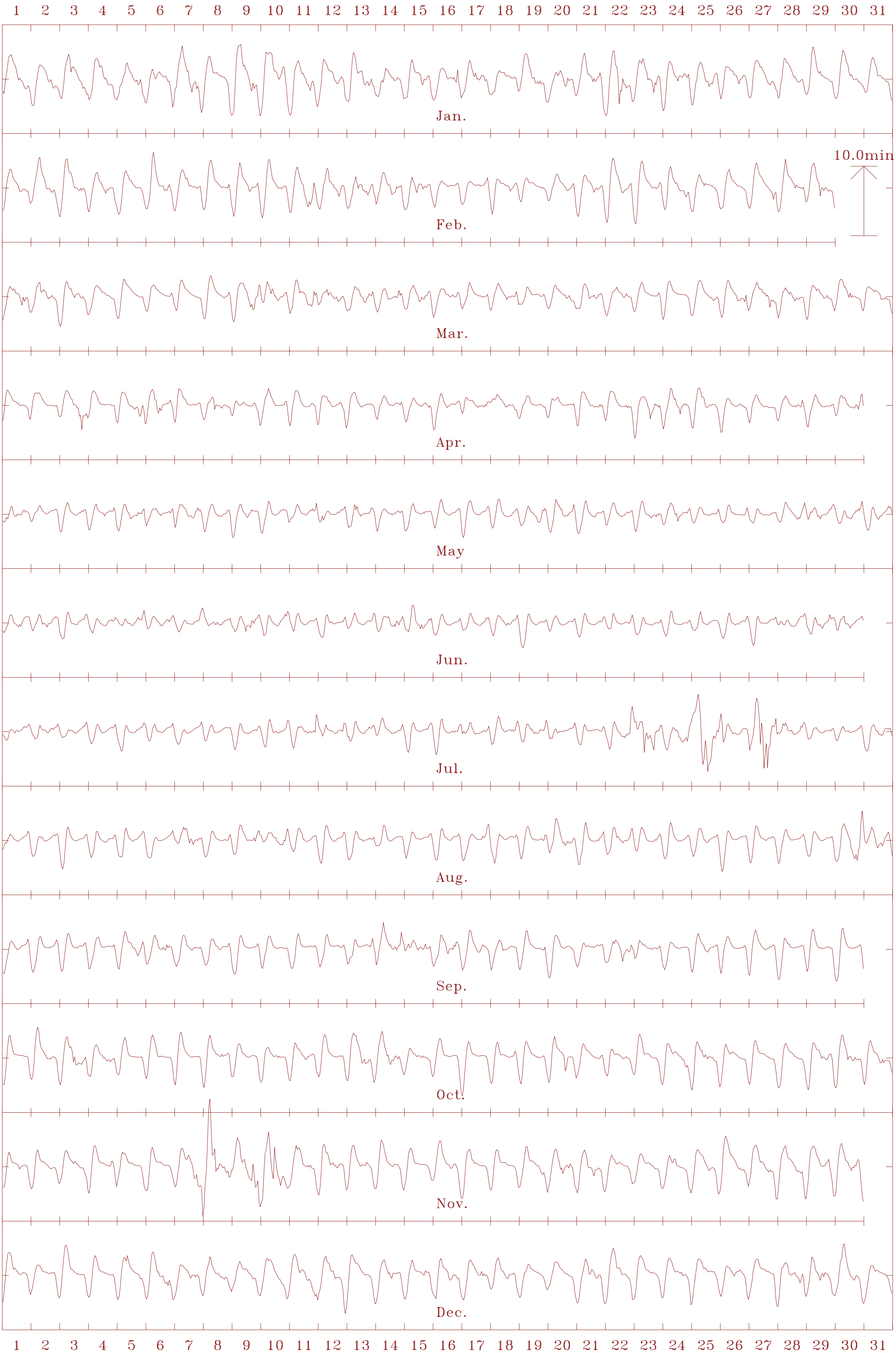
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

The mean value given at the top of each plot is the *all-days* annual mean value of the element.

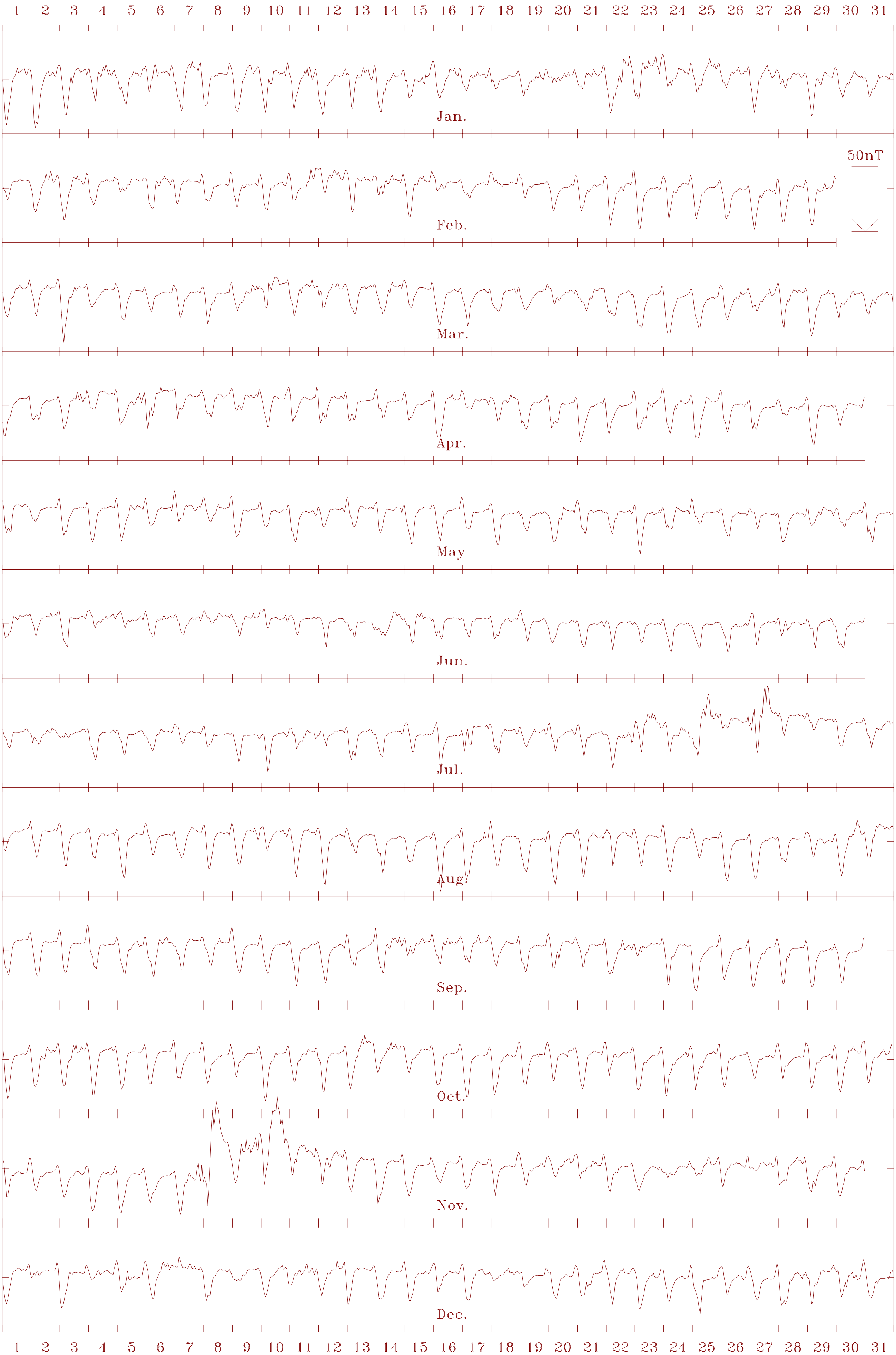
Kakadu, NT 2004 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 35429 nT



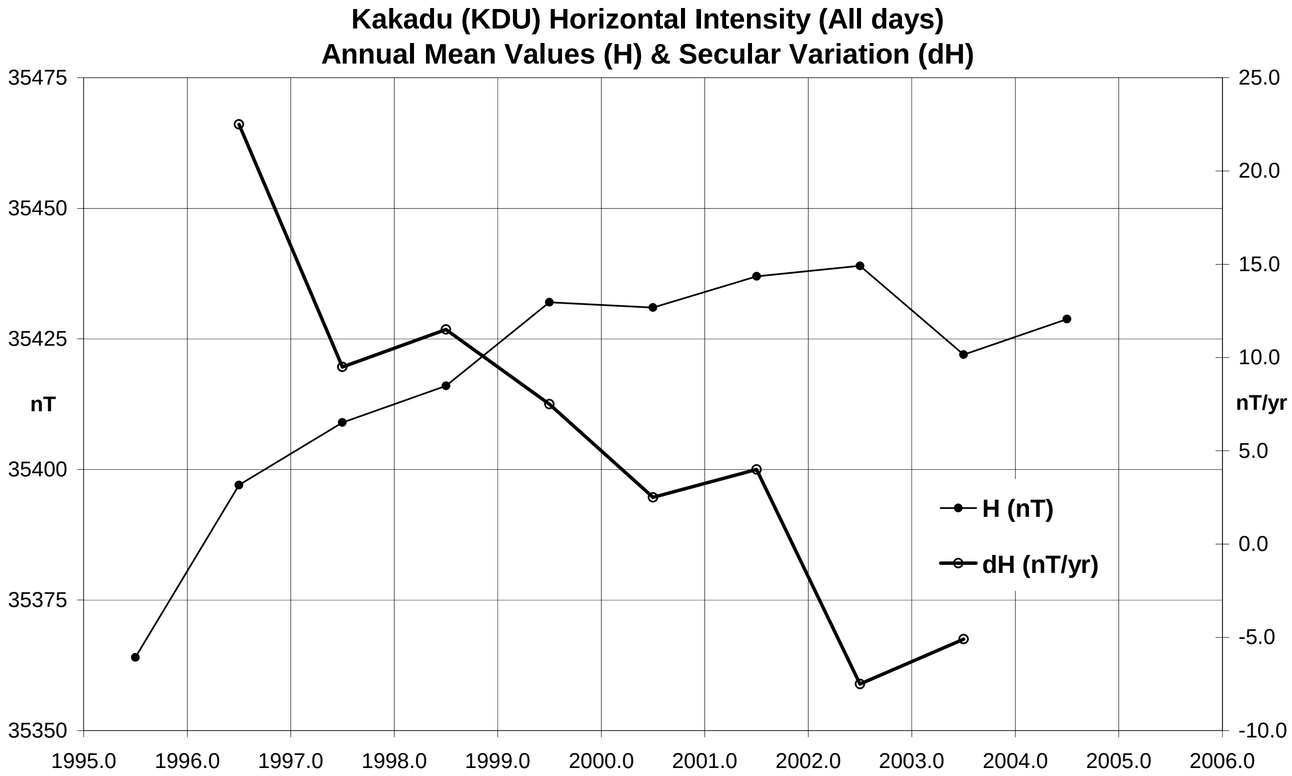
Kakadu, NT 2004 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.72 deg.

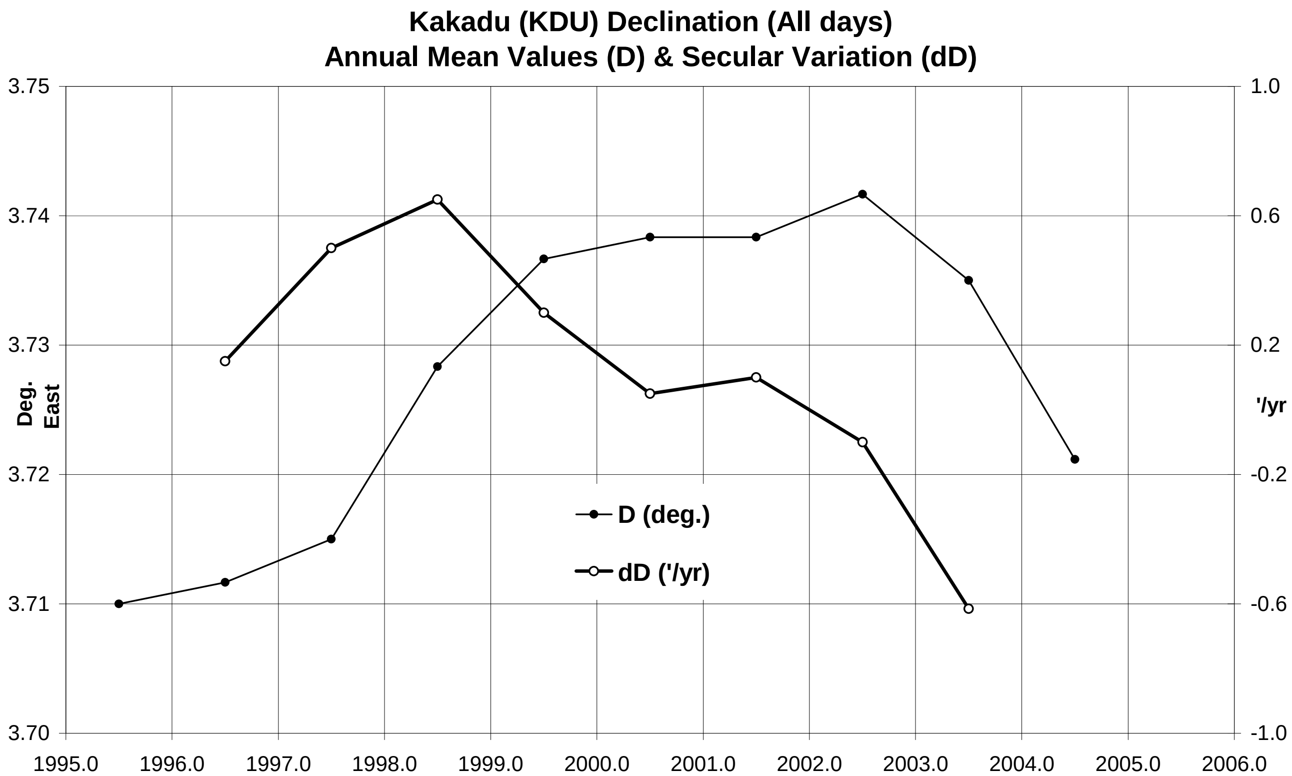


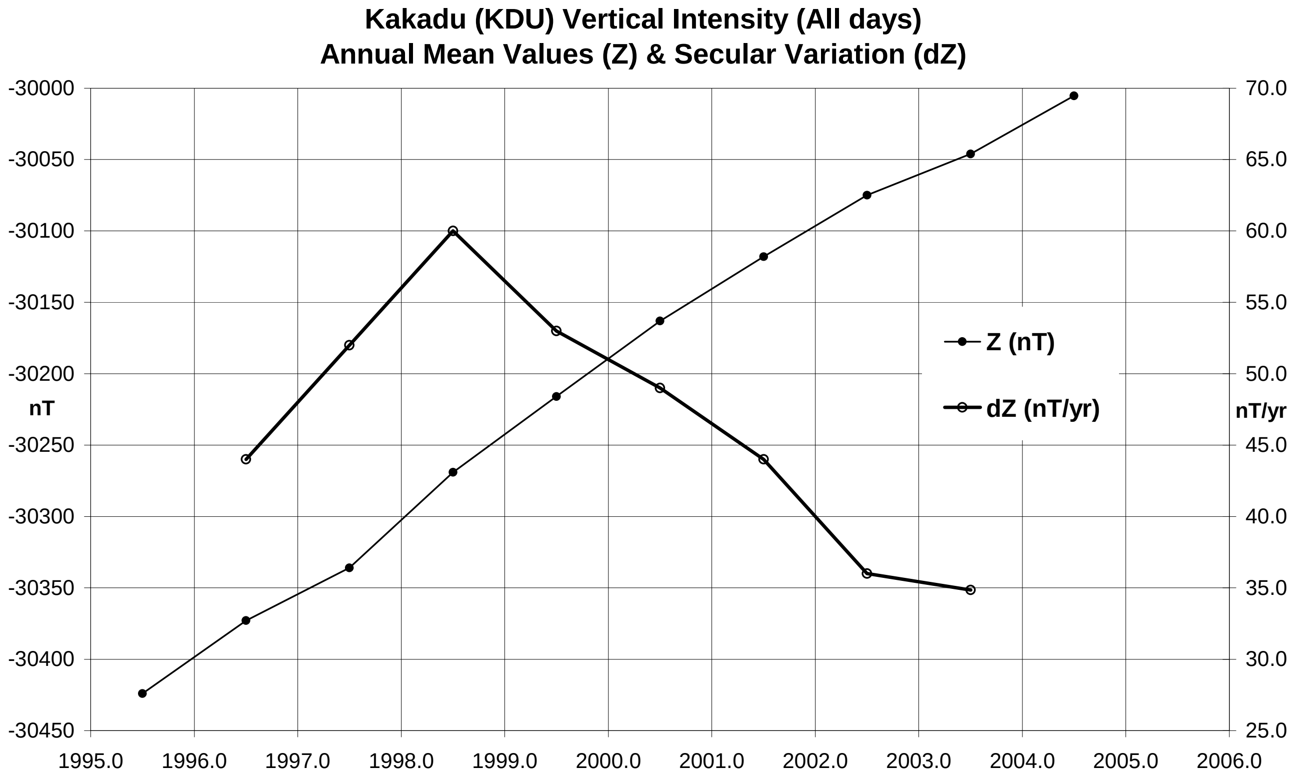
Kakadu, NT 2004 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −30005 nT

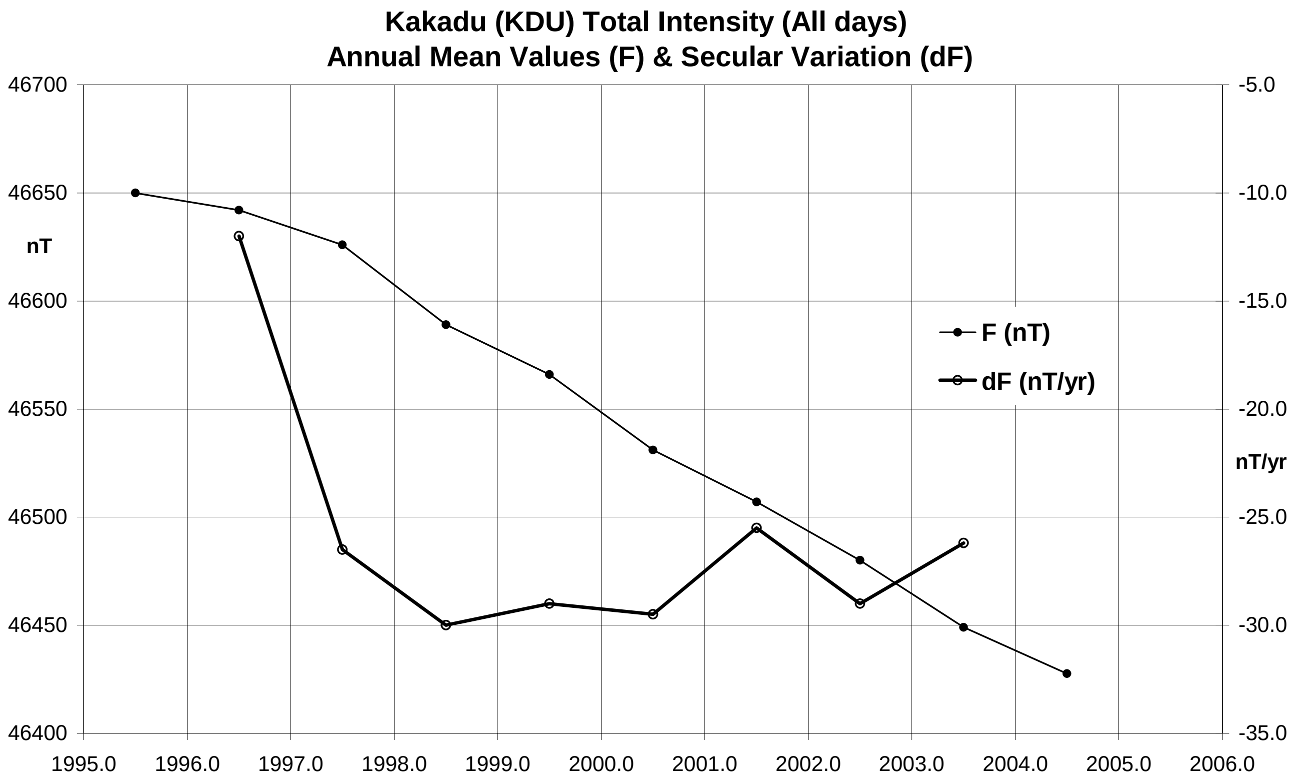


Kakadu, NT 2004 Total intensity (F). Scale: 7.5 nT/mm. Mean: 46428 nT


Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
35475
35450
35425
35400
35375
35350
nT
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
H (nT)
dH (nT/yr)


Kakadu (KDU) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
3.75
3.74
3.73
3.72
3.71
3.70
Deg. East
1.0
0.6
0.2
-0.2
-0.6
-1.0
'/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
D (deg.)
dD ('/yr)


Kakadu (KDU) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-30000
-30050
-30100
-30150
-30200
nT
-30250
-30300
-30350
-30400
-30450
70.0
65.0
60.0
55.0
50.0
nT/yr
45.0
40.0
35.0
30.0
25.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
Z (nT)
dZ (nT/yr)


Kakadu (KDU) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
46700
46650
nT
46600
46550
46500
46450
46400
-5.0
-10.0
-15.0
-20.0
nT/yr
-25.0
-30.0
-35.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
F (nT)
dF (nT/yr)

Significant Events in 2004 (Kakadu)

May 18 to 20. Seismic maintenance visit by GA staff.

Nov 18 Power failure at observatory: no loss of data.

Nov 22 to 26. Maintenance visit by GA staff. Absolute and variometer PPMs replaced by GSM90. Acquisition computer replaced.

Data losses in 2004

Jan 20 1102–1121 (20m) F channel: During electrical storm – no further reason apparent.

Nov 22 2333 (1m) Vector channels: Maintenance.
2144-23/0029 (2h 46m) F channel: Maintenance.

Nov 23 0000–0017, 0029, 0100–0101, 0112 (22m) Vector channels: Maintenance

0032–0033, 0044–0047, 0055–0112 (54m) F channel: Maintenance.

Nov 24 0820 (1m) All channels (1m): Maintenance.

Distribution of KDU data

Preliminary Monthly Means for Project Ørsted

- IPGP monthly (by e-mail)

1-minute and Hourly Mean Values to WDCs

- 2003 data: WDC-A, Boulder, USA (03 Mar. 2004)
- 2004 data: WDC-A, Boulder, USA (10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- 2003 data: to IM Paris GIN (03 Mar, 2004)
- 2004 data: to IM Paris GIN (04 & 29 Aug 2005)

CHARTERS TOWERS OBSERVATORY

The town of Charters Towers is approximately 120km inland to the south-west of the coastal city of Townsville in north Queensland.

Continuous recording at the Charters Towers Magnetic Observatory commenced in June 1983. A history of the observatory is in *AGR 1994*.

The variometers and recording equipment at Charters Towers were located within a disused gold mine tunnel approximately 100m into the northern side of Towers Hill formerly the site of the University of Queensland's Seismograph Station. The hilly area on the outskirts of the town where the observatory was located is approximately 1.7km SW of the town centre.

Although not controlled, the temperature within the tunnel where the variometers were located varied very little over the year: from about 26°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.

Absolute magnetic observations were performed on a pier located within a non-magnetic shelter on a hillside approximately 250m to the west of the variometers.

Key data for Charters Towers Observatory:

- 3-character IAGA code: CTA
- Commenced operation: June 1983
- Geographic latitude: 20° 05' 25" S
- Geographic longitude: 146° 15' 51" E
- Geomagnetic† : Lat. -27.86°; Long. 220.86°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier C
- Elevation of top of Pier C: 370 metres AMSL
- Azimuth of principal reference (PO spire from Pier C): 34° 40' 45"
- Distance to PO spire: 1.75 km
- Observer in Charge: J.M. Millican

† Based on the IGRF 2000.0 model updated to 2004.5

In 2002 the Towers Hill area was declared to be of Queensland heritage value, and handed over to the Charters Towers City Council. In 2004 the council and Geoscience Australia reached an agreement that the site of the observatory be leased to Geoscience Australia for operating the observatory. This has ensured Geoscience Australia can continue to operate the observatory without the threat of magnetic contamination to the site.

Variometers

From mid-1983 when the observatory was commissioned until 27 August 2000, EDA model FM-105B 3-component fluxgate magnetometers were employed as the principal variometers at the Charters Towers magnetic observatory.

From 28 August 2000 a DMI FGE suspended 3-component fluxgate magnetometer has been employed as the principal variometer at CTA observatory. DMI sensor unit S0210 with electronics E0227 operated throughout 2004. The sensor head of the instrument was located on the same concrete blocks in the mine tunnel previously used for the EDA FM-105B sensors. Two of its sensors were aligned horizontally at an approximately equal angle on either side of the magnetic meridian (magnetically NW and NE), and the third sensor was aligned vertically.

Prior to its installation at Charters Towers, the DMI FGE magnetometer’s scale-values, relative sensor alignments and temperature sensitivities were determined at the *National Magnetometer Calibration Facility* at Canberra Observatory. The results were summarised in the *AGR 2000*.

There was also a cycling proton precession magnetometer monitoring variations in the magnetic total intensity, F. The PPM sensor was suspended from the ceiling of the tunnel. During 2004 two Elsec model 820 PPM variometers were employed: E820_157 operating until 02 August 2004 and E820_139 from 17 August 2004. The continuously recording PPM served as both an F-check, and a backup, should any one of the channels of the 3-axis variometer become unserviceable.

Analogue outputs of A (X-coil), B (Y-coil), C (Z-coil) from the DMI FGE 3-channel fluxgate, as well as the fluxgate head and electronics temperature channels, were converted to digital data with an ADAM 4017 A/D converter mounted inside the electronics console. Throughout 2004 mean data values over 1-second and 1-minute intervals were recorded in the components A (NW), B (NE), C (Z), as well as the DMI variometer sensor and electronics temperatures. These digital data were recorded on a PC.

The digital readings from the Elsec 820 PPM variometer, that cycled every 10 seconds, were input directly to the PC on which they were recorded. Timing was derived from the PC clock. Its rate was corrected by software and the time was checked/adjusted on weekdays from GA in Canberra.

Absolute Instruments and Corrections

Throughout 2004 the variometers at CTA were calibrated by the performance of weekly absolute observations on Pier C in the absolute shelter. Until 22 June 2004 a Declination & Inclination Magnetometer (DIM) comprising an Elsec Type 810 (no. 215) fluxgate unit mounted on a Zeiss 020B theodolite (no. 313888) was used with a Geometrics 816 PPM (no. 767) to perform sets of absolute observations. On 22 June 2004 a DIM comprising DI0036 fluxgate sensor with Zeiss 020B theodolite, serial 394050, and PPM GSM90_3091318/91472 were introduced into the routine to replace the E810 DIM and G816 PPM.

Because both absolute PPM and DIM observations were performed on Pier C in 2004 there are no pier differences to be applied.

By regular inter-comparisons of 'travelling' reference absolute magnetometers at Canberra and at Charters Towers, corrections to the abovementioned absolute magnetometers used at CTA were determined to align them with the Australian Magnetic Reference. The corrections adopted for 2004, determined through a series of instrument comparisons made during a routine maintenance visit on 22-26 June 2004, were:

ΔF = GSM90_905926 = G816_767 − 1.7nT

ΔD = E810_200/313756 = E810_215/313888 + 0.30'

ΔI = E810_200/313756 = E810_215/313888 + 0.00'

The instrument corrections for GSM90_3091318/91472 and DIM DI0036/394050 to the Australian References were all zero.

Baselines

At the mean 2004 magnetic field values at Charters Towers of:

$X = 31511$nT, $Y = 4275$nT, $Z = -37710$nT,

the above instrument corrections translate to baseline corrections of:

$\Delta X = -1.46$nT, $\Delta Y = +2.60$nT, $\Delta Z = +1.3$nT.

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

The E0227/S0210 variometer performed well in 2004. The area around the variometer was not subjected to any magnetic contamination throughout the year. Baseline drift in X, Y, Z components was within an 8nT range.

The baseline drift of the E0227/S0210 variometer was also examined from an F-check plot. F-check is the difference between F calculated from the variometer components and F measured by variometer PPMs. F-check variation was within 2nT throughout 2004. These variations were mainly associated with temperature variations in the tunnel and the variometer baseline drift.

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

$\Delta X = -0.3 \pm 1.8$nT; $\Delta Y = -0.1 \pm 2.5$nT; $\Delta Z = -0.1 \pm 1.1$nT

Two sets of absolute instruments were used in 2004. The baselines from 01 January to 22 June were determined by E810_215 and G816_767 absolute instruments, while baselines from 23 June to 31 December 2004 were determined by DI0036/394050 and GSM90_3091318/91472 absolute instruments. The step in the baselines on 23 June (the differences between the corrections of the two absolute instrument sets) were:

$\Delta X = 1.5$nT; $\Delta Y = 2.6$nT; $\Delta Z = 1.3$nT.

On 27 September 2004 the system suffered a power failure at 0600 and was restarted at 0609. After restarting, it was apparent that steps had been introduced into the variometer channels of:

$\Delta X = 3$nT, $\Delta Y = 8$nT, $\Delta Z = 0.7$nT

Variometer F stepped by 0.8nT, and electronics temperature changed about 2°C. Absolute observations on 30 September 2004 did not indicate any baseline steps. To maintain a smooth change in X, Y and Z data over the period while not violating the absolute observations on 30 September, the following steps were included in the variometer model:

- Baseline step at 0601: $\Delta X = 2$nT, $\Delta Y = 7$nT, $\Delta Z = 0$nT;
- Drift from 0601 on 27 September to 0000 on 30 September so the baseline jump was offset by the drifts before absolute observations on 30 September 2004.

Operations

The officer in charge at CTA observatory performed most routine operations during 2004. Tasks included:

- weekly performance of a set of absolute observations;
- weekly temperature measurement in tunnel;
- mailing the observation-sheet and log-sheet to GA, Canberra, each week.

Throughout 2004 mean data values over 1-second and 1-minute intervals were recorded in the variables A, B, C and two temperature channels. Analogue outputs from the three DMI fluxgate channels, and the fluxgate head and electronics temperature channels, were converted to digital data with an ADAM 4017 analogue-to-digital-converter mounted inside the electronics console. These digital data together with the digital PPM data were recorded on a PC.

Time was taken from the PC system clock. The computer did not have an attached external GPS clock. On weekdays the PC clock was checked and set remotely from GA in Canberra. The maximum remote time correction made was less than 3 seconds (38 DOS ticks) on 27 September 2004 when the system was restarted. Generally time corrections were only a few tenths of a second. No time corrections were made to the data.

Data files were telemetered daily from CTA to GA in Canberra via modems and standard telephone lines.

The variometer and recording system was powered by 240VAC mains, backed up by a PowerTech UPS with sufficient capacity to power the system for up to four hours.

Significant Events in 2004

22–26 Jun.	Maintenance visit during which a new set of absolute instruments was introduced and absolute instrument comparisons were performed.
03 Aug.	Faulty PPM E820_157 sent to GA for repair.
16 Aug	PPM E820_139 installed, replacing E820_157.

Data losses in 2004

03 Aug.	1232 to 04/0442 (551m) PPM data lost intermittently during this interval.
04 Aug	0444 to 16/0352 (11d 23h 09m) PPM data lost.
23 Aug	0311–0425 (28m) Intermittent PPM data loss; 0429 to 26/0006 (2d 19h 38m) PPM data loss.
27 Sep.	0601–0608 (8 min.) All data channels lost: Power failure before reboot.
07 Dec.	0646 to 08/0354 (21h 09m) Fluxgate variometer channels lost. 0646 to 08/2342 (1d 16h 57m) PPM data lost.

Charters Towers Annual Mean Values

The table below gives 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 & F are on pages 25 & 26.

Zero instrument corrections have been applied to the baselines used in the calculation of the CTA annual mean values.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
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	ABC
2001.5	A	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	ABC
2002.5	A	7	44.5	-49	54.0	31815	31525	4285	-37781	49392	ABC
2003.5	A	7	44.1	-49	53.7	31796	31506	4279	-37751	49357	ABC
2004.5	A	7	43.6	-49	51.6	31800	31511	4275	-37710	49328	ABC
1983.729	Q	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	XYZ
1984.5	Q	7	41.9	-50	17.5	31788	31502	4258	-38278	49756	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	ABC
2001.5	Q	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	ABC
2002.5	Q	7	44.5	-49	53.2	31828	31538	4287	-37780	49400	ABC
2003.5	Q	7	44.2	-49	52.7	31811	31521	4282	-37749	49365	ABC
2004.5	Q	7	43.6	-49	50.9	31810	31522	4277	-37708	49334	ABC
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	ABC

continued on page 27 …

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Charters Towers	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31508.7	4273.9	-37732.1	49343.5	31797.3	7° 43.5'	-49° 52.7'
	5xQ days	31513.8	4275.5	-37731.0	49346.0	31802.5	7° 43.6'	-49° 52.4'
	5xD days	31487.0	4269.5	-37735.1	49331.6	31775.2	7° 43.3'	-49° 54.0'
February	All days	31514.3	4276.1	-37726.8	49343.1	31803.1	7° 43.6'	-49° 52.2'
	5xQ days	31521.4	4277.8	-37725.5	49346.8	31810.4	7° 43.7'	-49° 51.7'
	5xD days	31498.7	4271.2	-37728.8	49334.3	31786.9	7° 43.3'	-49° 53.1'
March	All days	31513.7	4277.2	-37720.1	49337.7	31802.7	7° 43.8'	-49° 51.9'
	5xQ days	31532.1	4280.5	-37717.2	49347.6	31821.3	7° 43.8'	-49° 50.8'
	5xD days	31499.0	4273.9	-37724.2	49331.2	31787.7	7° 43.6'	-49° 52.9'
April	All days	31511.9	4280.0	-37717.2	49334.6	31801.2	7° 44.1'	-49° 51.9'
	5xQ days	31524.0	4282.8	-37715.4	49341.2	31813.6	7° 44.2'	-49° 51.1'
	5xD days	31501.2	4275.6	-37718.2	49328.2	31790.1	7° 43.8'	-49° 52.5'
May	All days	31516.3	4282.1	-37712.0	49333.6	31805.8	7° 44.2'	-49° 51.4'
	5xQ days	31523.2	4283.3	-37710.4	49336.9	31812.8	7° 44.3'	-49° 50.9'
	5xD days	31512.5	4281.2	-37712.3	49331.4	31802.0	7° 44.2'	-49° 51.6'
June	All days	31519.8	4280.6	-37707.4	49332.2	31809.1	7° 44.0'	-49° 51.0'
	5xQ days	31526.7	4279.8	-37705.1	49334.8	31815.8	7° 43.8'	-49° 50.5'
	5xD days	31513.4	4279.7	-37708.1	49328.6	31802.7	7° 44.0'	-49° 51.4'
July	All days	31503.6	4273.8	-37706.1	49320.3	31792.2	7° 43.5'	-49° 51.8'
	5xQ days	31527.5	4277.1	-37703.0	49333.5	31816.3	7° 43.5'	-49° 50.4'
	5xD days	31447.4	4261.4	-37714.1	49289.5	31734.8	7° 43.0'	-49° 55.2'
August	All days	31506.2	4274.2	-37705.1	49321.2	31794.8	7° 43.5'	-49° 51.6'
	5xQ days	31508.5	4273.5	-37704.8	49322.5	31797.0	7° 43.4'	-49° 51.5'
	5xD days	31488.3	4272.0	-37707.0	49311.1	31776.8	7° 43.6'	-49° 52.7'
September	All days	31514.6	4274.5	-37700.3	49323.0	31803.2	7° 43.4'	-49° 51.0'
	5xQ days	31520.2	4274.6	-37699.7	49326.1	31808.7	7° 43.4'	-49° 50.7'
	5xD days	31506.9	4274.1	-37702.3	49319.5	31795.5	7° 43.5'	-49° 51.5'
October	All days	31522.3	4273.3	-37695.3	49324.0	31810.6	7° 43.2'	-49° 50.4'
	5xQ days	31529.6	4274.8	-37693.1	49327.0	31818.1	7° 43.3'	-49° 49.9'
	5xD days	31507.3	4270.6	-37698.0	49316.2	31795.4	7° 43.1'	-49° 51.3'
November	All days	31490.4	4267.2	-37702.2	49308.3	31778.2	7° 43.0'	-49° 52.4'
	5xQ days	31516.0	4271.6	-37694.9	49319.5	31804.1	7° 43.1'	-49° 50.7'
	5xD days	31424.0	4257.0	-37714.0	49274.2	31711.1	7° 42.9'	-49° 56.5'
December	All days	31513.0	4268.4	-37694.9	49317.3	31800.8	7° 42.8'	-49° 50.9'
	5xQ days	31516.5	4270.3	-37696.6	49321.0	31804.4	7° 43.0'	-49° 50.8'
	5xD days	31510.4	4266.6	-37694.6	49315.2	31798.0	7° 42.7'	-49° 51.0'
Annual	All days	31511.2	4275.1	-37709.9	49328.2	31799.9	7° 43.6'	-49° 51.6'
Mean	5xQ days	31521.6	4276.8	-37708.1	49333.6	31810.4	7° 43.6'	-49° 50.9'
Values	5xD days	31491.3	4271.1	-37713.1	49317.6	31779.7	7° 43.4'	-49° 52.8'

(Calculated: 13:29 hrs., Thu. 15 Dec. 2005)

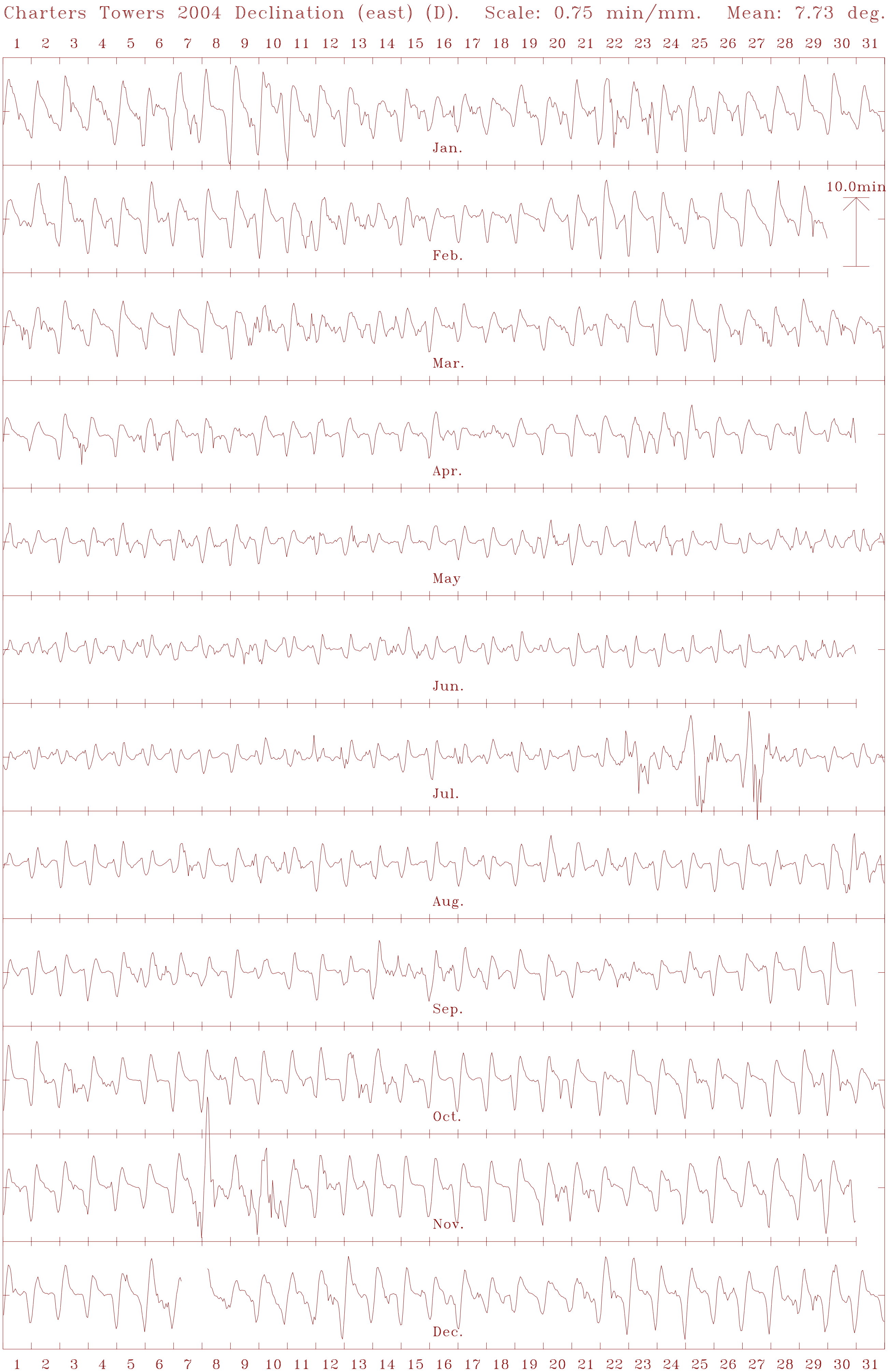
Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

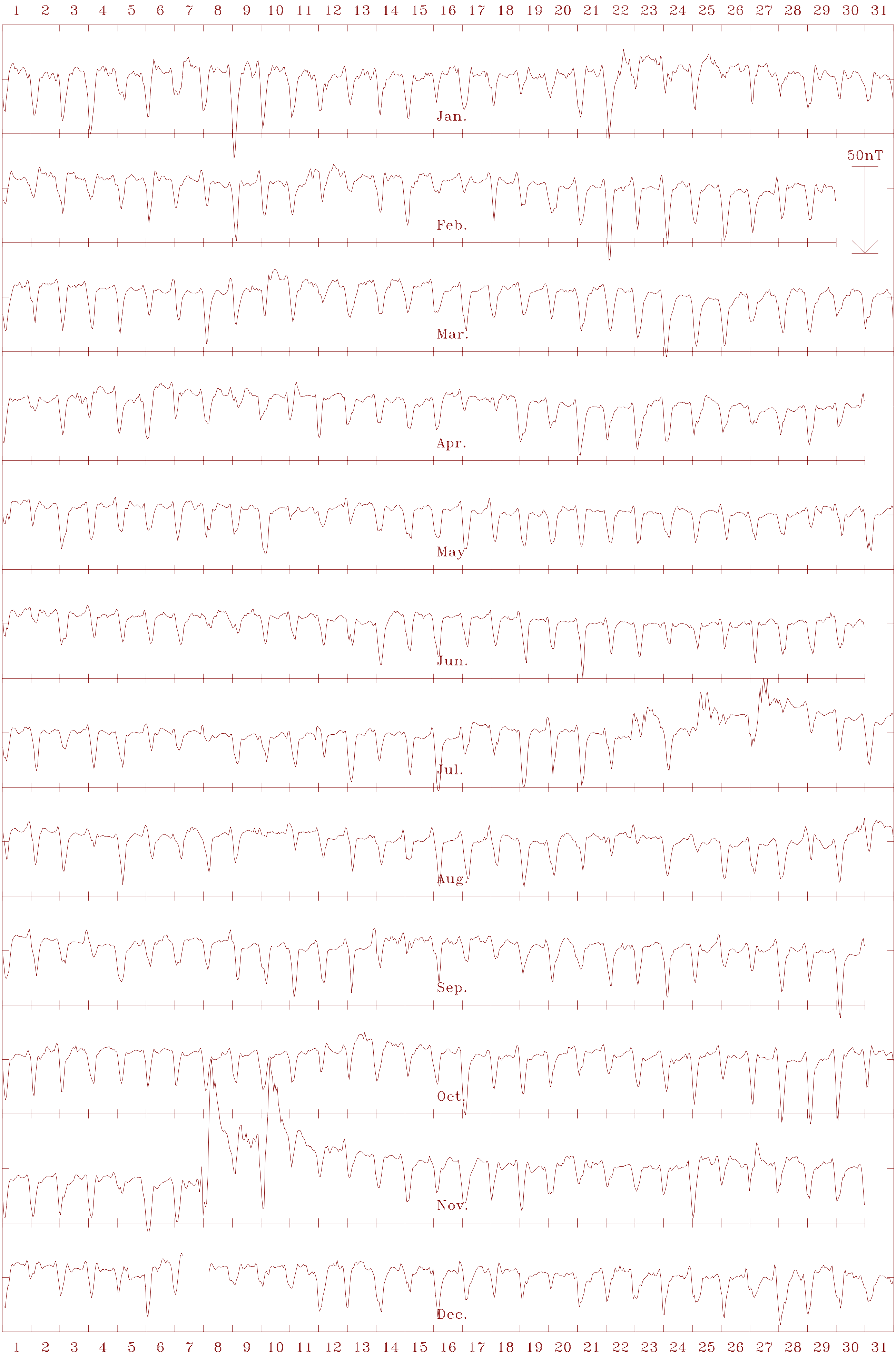
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Charters Towers 2004 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 31800 nT

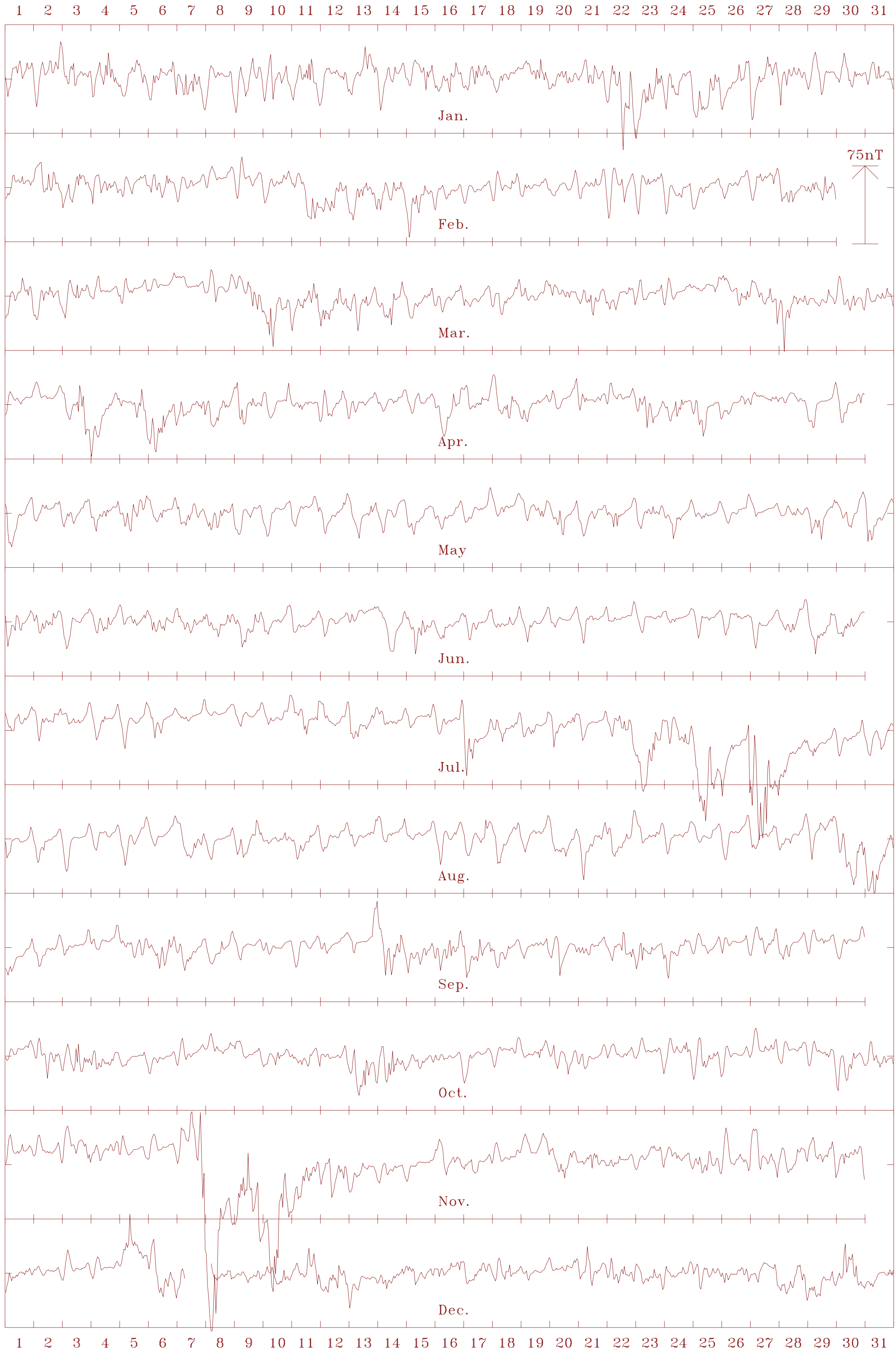


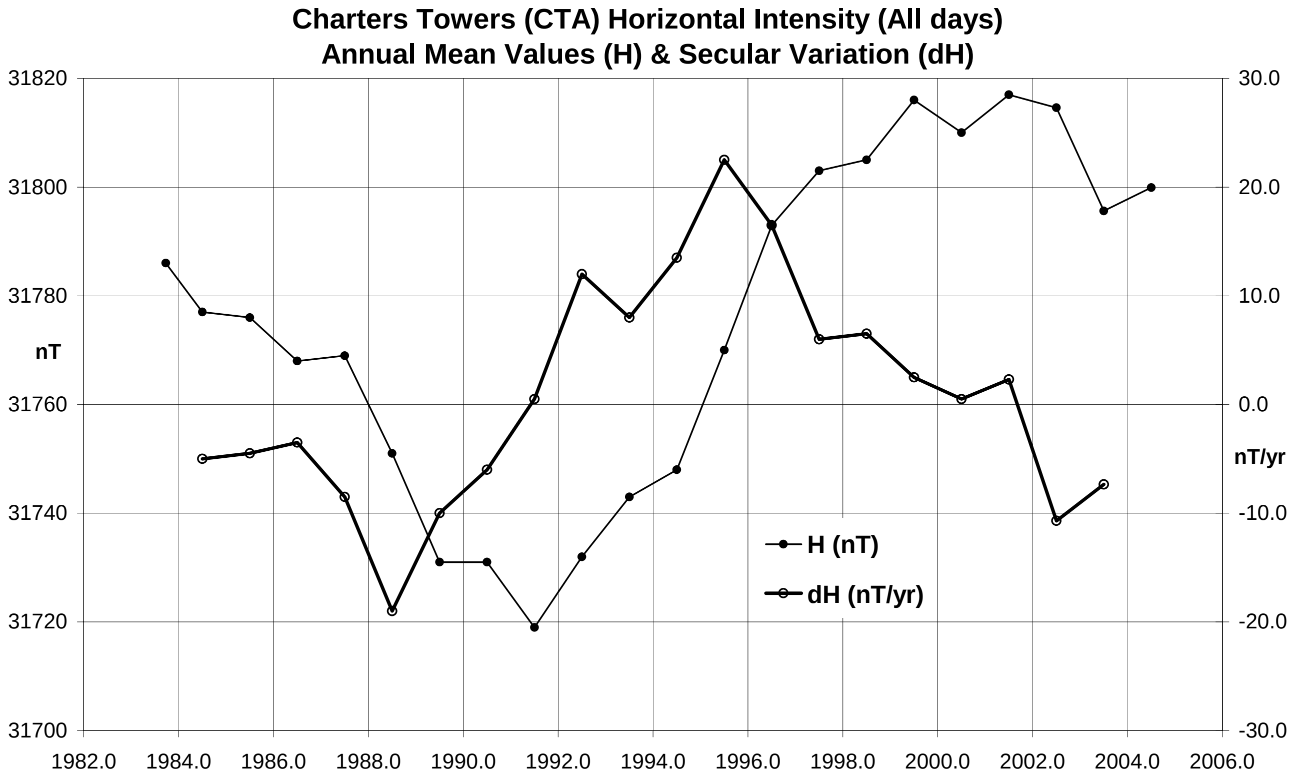
Charters Towers 2004 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.73 deg.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
10.0min
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

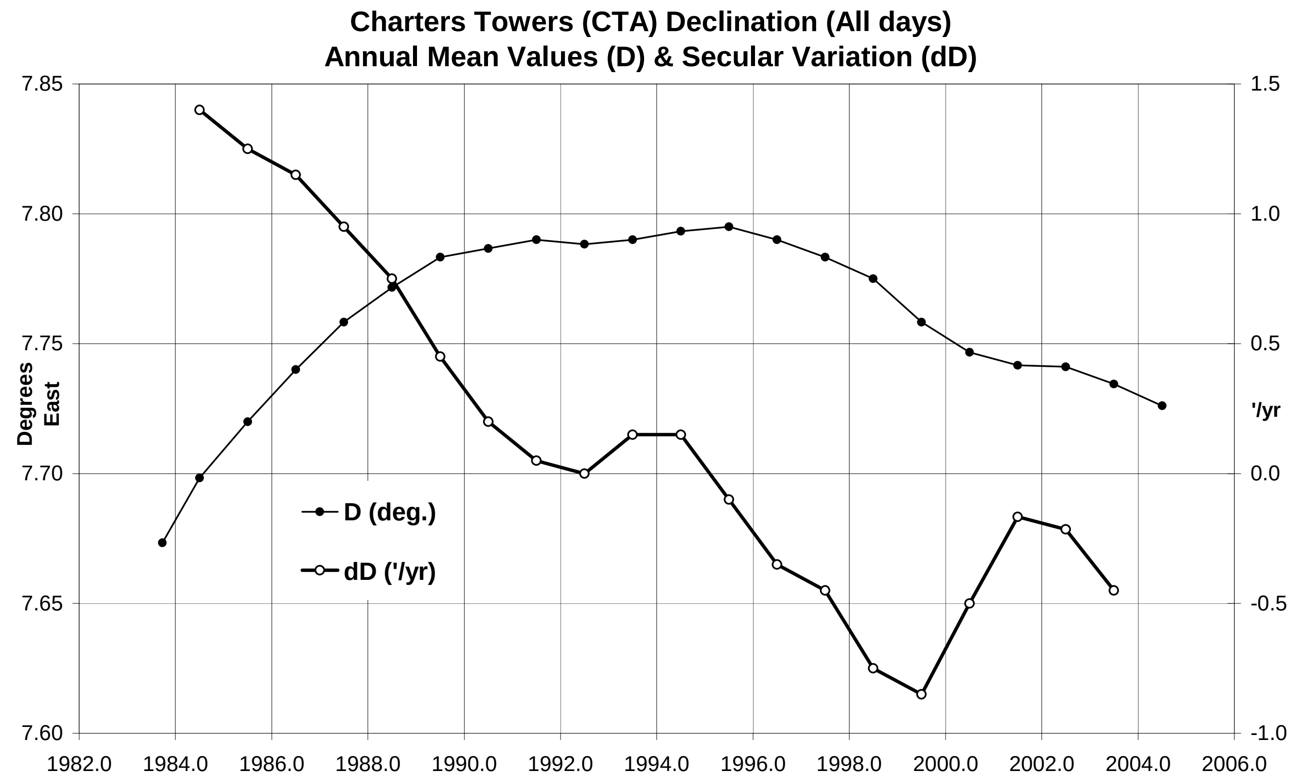
Charters Towers 2004 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −37710 nT

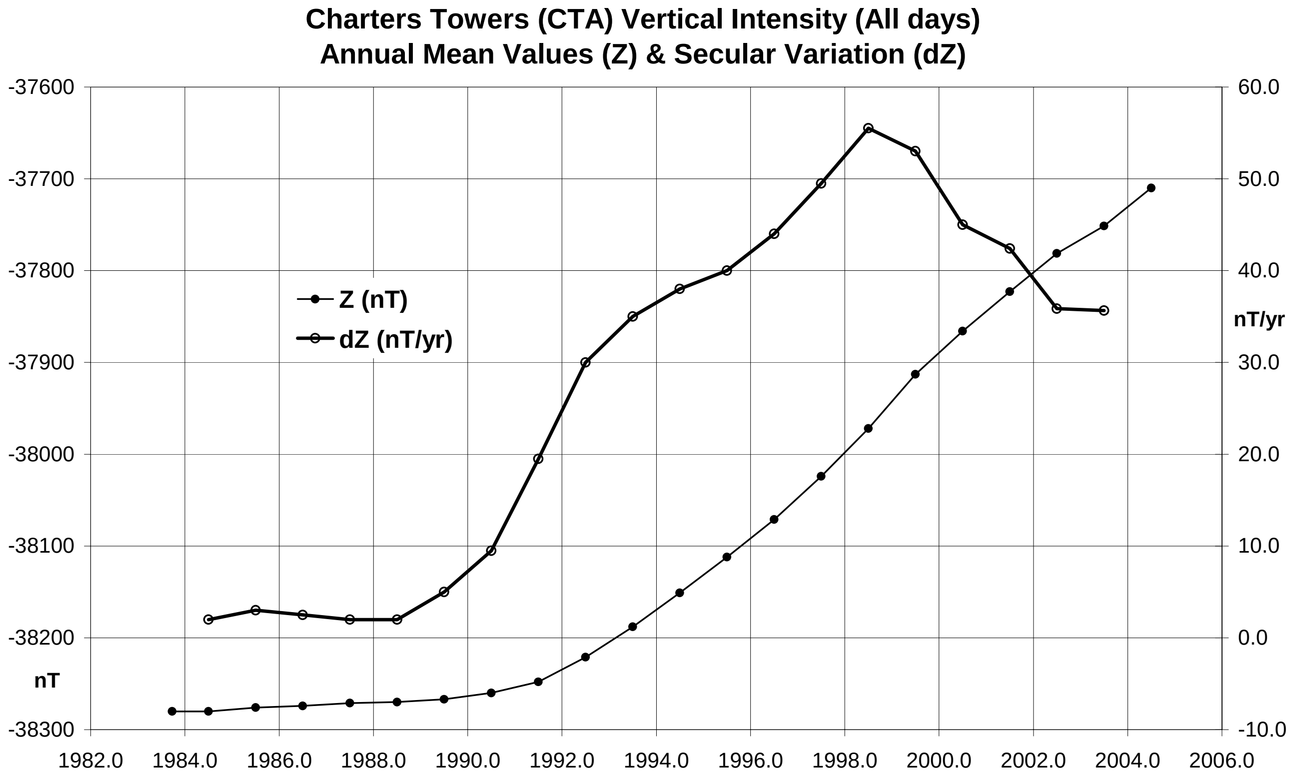


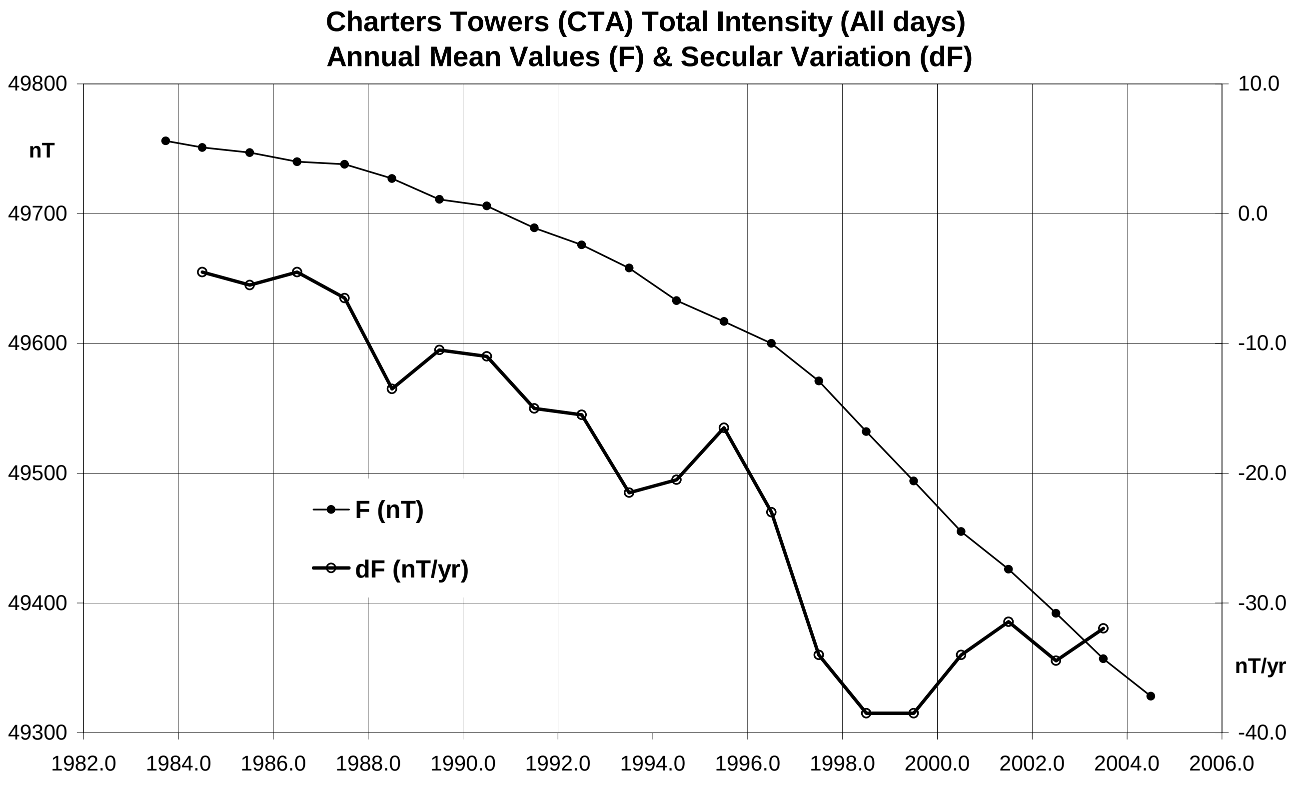
Charters Towers 2004 Total intensity (F). Scale: 5.0 nT/mm. Mean: 49328 nT




Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
31820
31800
31780
31760
31740
31720
31700
nT
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
nT/yr
H (nT)
dH (nT/yr)
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
7.85
7.80
7.75
7.70
7.65
7.60
Degrees East
1.5
1.0
0.5
0.0
-0.5
-1.0
'/yr
D (deg.)
dD ('/yr)
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-37600
-37700
-37800
-37900
-38000
-38100
-38200
-38300
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
49800
49700
49600
49500
49400
49300
10.0
0.0
-10.0
-20.0
-30.0
-40.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0

CTA – Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABC
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABC
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABC
2004.5	D	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	ABC

Distribution of CTA data

1-minute and Hourly Mean Values to WDCs

- 2003 data to WDC-A, Boulder USA on 12 Mar. 2004
- 2004 data to WDC-A, Boulder USA on 10 Jan. 2006

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2003

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- 2003 data sent to WDC-C1, Copenhagen (12 Mar 2004)

LEARMONTH OBSERVATORY

Learmonth, Western Australia, is situated on Australia's North West Cape overlooking the Exmouth Gulf to the east and Cape Range to the west. Learmonth is approximately 1100km north of the city of Perth. The nearest town is Exmouth, approximately 35km to the north. The Learmonth Geomagnetic Observatory is situated at the Learmonth Solar Observatory, jointly staffed by IPS Radio and Space Services, Department of Industry, Tourism and Resources and the U.S. Air Force. The magnetic observatory was established in late November 1986 from when it has operated continuously. More details of the observatory's history are in *AGR 1994*.

The observatory comprised:

- Three small underground vaults, two that housed the variometer sensors and one that housed the fluxgate electronics, all located within the perimeter of the solar observatory compound, at approximately 40m to the east of the solar observatory Radio Solar Telescope Network (RSTN) building.

  The principal (fluxgate sensor) vault was 0.6m x 0.6m of concrete construction with a 25mm plastic lid and was set into the ground by about two-thirds of its 1m depth. A smaller plastic subsidiary vault at a distance of approximately 3m from the principal vault housed the fluxgate electronics. A 50mm diameter PVC conduit carrying control and power cables ran underground from the subsidiary vault to the electronics console and data acquisition computer in the RSTN building.

  A second (plastic) PPM sensor vault was approximately 10m north of the principal vault. A PVC conduit carried the PPM sensor head signal cable to the electronics console in the RSTN building.

  Both vaults were lined with polystyrene foam and buried beneath local sand to minimize diurnal temperature fluctuations

- A concrete absolute observation pier within a roofed shelter with brick walls on two sides to the same height as the pier. This was about 200 metres south of the solar observatory, situated on Royal Australian Air Force property. There was a safety tie down bar on the absolute pier to ensure that the absolute instruments could not be accidentally dislodged from the pier during observations.
- The PPM control electronics, acquisition PC, GPS, modem and UPS back-up power were located within the central or Radio Solar Telescope Network building of the solar observatory.

Key data for Learmonth Observatory:

- 3-character IAGA code: LRM
- Commenced operation: November 1986
- Geographic latitude: 22 13' 19" S
- Geographic longitude: 114° 06' 03" E
- Geomagnetic† : Lat. -32.23°; Long. 186.38°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier A
- Elevation of top of Pier A: 4 metres AMSL
- Azimuth of principal reference (West windsock from Pier A): 283° 02' 18"
- Distance to West windsock: not recorded
- Observer in Charge: G.A. Steward (IPS Radio & Space Services)

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

Variations in the magnetic NW, NE and vertical components of the magnetic field were recorded at Learmonth in 2004 using a Danish Meteorological Institute FGE suspended three-axis fluxgate magnetometer.

The analogue data from the DMI instrument, including sensor and electronics temperatures were digitized with an ADAM 4017 8-channel 16-bit converter in +/-5V mode and recorded at 1-second intervals on the acquisition PC.

The data from the fluxgate instrument were also recorded independently by IPS for its use.

During 2004 a Geometrics model 856 (no. 50708) PPM measured variations in the total intensity of the magnetic field, F. This served both as a backup, should any one of the X, Y or Z variometer channels become unserviceable, and as an F-check of the variometer model. The digital data from the variometer PPM were recorded at 10-second intervals.

The data from both the DMI fluxgate and variometer PPM were recorded on a PC running MS-DOS-based data acquisition, control and display software. Timing was generated by the software (DOS) clock of the PC which was synchronized to 1-second pulses from a Trimble Accutime GPS clock.

The variometer and recording system was powered by 240VAC mains power. The equipment was protected from power outages and surges by an uninterruptible power supply.

Absolute Instruments and Corrections

The principal absolute instruments used to calibrate the magnetic variometer at the Learmonth observatory in 2004 were a declination and inclination fluxgate magnetometer (DIM) and a PPM. The DIM was a Bartington, model number MAG01H, serial number B0702H with a fluxgate element mounted on a Ziess 020B theodolite, serial number 312714. From 01 January until 24 June 2004 the absolute PPM used was Geometrics model 856, serial number 50471 with sensor 980801. From 25 June 2004 to the end of the year a GEM GSM90 (serial number 3091316, with sensor 761100) total field magnetometer was used.

Instrument comparisons between the LRM observatory absolute instruments (G856_50471/sensor 980801 PPM and B0702H / Zeiss 020B 312714 DIM) and the travelling reference instruments (GSM90_3091316/761100 total field magnetometer and B0610H / Zeiss 010B 160459 DIM) were performed at LRM on 25/26 June 2004.

The results of the comparisons were:

Travelling Reference		LRM instrument		Inst. difference
GSM90_3091316	–	G856_50471	=	–1.2nT (F)
B0610H/160459	–	B0702H/312714	=	0.0' (D)
B0610H/160459	–	B0702H/312714	=	–0.1' (I)

The adopted differences between the Australian Reference Instruments (E810_200/353756, GSM90_905926) and the abovementioned Travelling Reference Instruments were:

Australian Reference		Travelling Reference		Inst. Corr'n
GSM90_905926	–	GSM90_3091316	=	0.0nT (F)
E810_200/353756	–	B0610H/160459	=	0.0' (D)
E810_200/353756	–	B0610H/16045	=	+0.1' (I)

This resulted in the corrections to the LRM instruments of:

Australian Reference		LRM instrument		Inst. correction
GSM90_905926	–	G856_50471	=	–1.2nT (F)
E810_200/353756	–	B0702H/312714	=	0.0' (D)
E810_200/353756	–	B0702H/312714	=	+0.0' (I)

After 25 June 2004 zero corrections were adopted for the LRM observatory absolute instruments: DIM B0702H/312714 and total field magnetometer GSM90_3091316/761100.

Baselines

At the mean 2004 field values at LRM of X = 29759nT, Y = 228nT and Z = -44132nT, the instrument corrections adopted for the absolute magnetometers used at LRM during 2004 convert to the baseline corrections:

$$\Delta X = -0.7 \text{ nT} \qquad \Delta Y = 0.0 \text{ nT} \qquad \Delta Z = +1.0 \text{ nT}$$

between 01 January and 25 June 2004; and baseline corrections of zero for the rest of the year.

These two sets of corrections have been applied for the respective time periods to all LRM 2004 final data.

The standard deviations in the weekly absolute observations from the final adopted variometer model and data were 0.6nT in X, 1.1nT in Y, and 0.5nT in Z. (In terms of the absolute observed components, they were 0.4 nT in F, 07" in D, and 03" in I.) The drifts applied to the X, Y, and Z baselines amounted to less than 10nT in any of X, Y and Z components throughout the year, with each component having approximately the same amount of drift.

There was about 4nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM.

Operations

The local observer at LRM magnetic observatory was a staff member of IPS at the Learmonth Solar Observatory. During 2004 the observer performed routine tasks at the magnetic observatory that included:

- performing a set of absolute observations each week;
- mailing observation sheets to GA, Canberra each week;
- performing instrument checks, system resets etc. as required.

Throughout 2004 absolute observations were performed on the pier (A) in the absolute shelter. The DIM absolute observations were routinely performed using the *offset* method (see *Kakadu Observatory – Absolute Instruments and Corrections*, this report) throughout 2004.

1-second values and 1-minute mean value data were transferred daily through modems via telephone lines to GA in Canberra. The clocks on the acquisition PC were also checked each weekday and corrected if necessary via the telephone link to GA.

The DMI variometer had accurately determined temperature coefficients.

The absolute observations were processed at GA in Canberra, where final data calibration and adoptions were made.

Significant Events in 2004

05 Jan	No response from LRM modem. The UPS was faulty. There were atmospheric storms which may have caused telephone problems. Restart the system and by-pass UPS and plug system into mains power.
09 Jan	Send replacement UPS to LRM via road freight.
23 Jan	GAS back at work. UPS has been received and replaced this day. Variometer PPM now working again. Faulty Nikko UPS sent back to GA.
30 Jan	PC reboot - data loss
05 Feb	30m steel tape-measure 1.2m from absolute pier during observations.
25 Feb	System reboot - unknown reason.
26 Feb	Absolute observation missed
08 Mar	PC reboot
01 May	PC reboot
14 May	DIM batteries went flat during observation - one observation only
17 May	System down at ~22:30 caused by power problems
18 May	System back up at 01:26. PPM memory filled at 17:40
19 May	Request GAS to fix PPM problems
03 Jun	Speak to OIC LSO (JK) about TCP/IP network connection at LRM
16 Jun	Data loss and reboot
23 Jun	Maintenance visit by GA officer (AML) commenced
25 Jun	GSM90_3091316 replaced G856_50471 as absolute PPM
29 Jun	Maintenance visit ended
01 Jul	Power off, PPM failure
08 Jul	Reboot, PPM stalled,
09 Jul	Send Critec Dataguard UPS to LRM request JK to re-set PPM: reset about 00:45
12 Jul	OIC at LSO confirmed the PPM was running. No one from IPS will be at the station from 14th until local observer returns.
20 Jul	0645: system rebooted; UPS replaced with Critec DataGuard. PPM O.K. System timing reset.

Significant Events in 2004 (LRM) (cont.)

10 Sep	Several system reboots; variometer PPM stopped.
14 Sep	PPM restarted
28 Sep	GA officer (BS) inspected observatory and communicated with JK about GSM90 and interference.
30 Sep	Local observer (GAS) on leave for two weeks.
04 Nov	System rebooted twice. PPM failed to re-start.
05 Nov	PPM restarted 02:05 System reboot. PPM failed to re-start.
09 Nov	PC rebooted
12 Nov	0549–0601: Local observer tested for GSM90 RF interference to IPS data at the PPM vault
08 Dec	~2330: Crane commenced about a week of maintenance work on 28ft LSO dish.
14 Dec	Crane removed from observatory.
20 Dec	Mains power problems, 2 reboots, UPS failed, PPM failed to restart. Last reboot 0600UT
22 Dec	PPM restarted by GAS
24 Dec	M8.0 Macquarie Island earthquake at 15:05 shakes suspended fluxgate system
26 Dec	M9.0 Sumatran earthquake at 01:05 shakes suspended fluxgate system

Distribution of LRM data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2004.

1-minute and Hourly Mean Values to WDCs

- 2003: WDC-C1, Copenhagen, Denmark (via IM GIN, Paris) (sent 15 Apr. 2004 & amended 23 May 2006)
- 2003: WDC-A, Boulder, USA (15 Apr. 2004 & amended 23 May 2006)
- 2004: WDC-A, Boulder, USA (10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- 2004 data sent to IM GIN, Paris (04 & 16 Aug 2005)

Note. The distributed LRM 2003 data contained an error in the instrument corrections applied. These data were corrected and redistributed on 23-May-2006. The LRM 2003 data reported in AGR volume 51 was based upon the application of the correct instrument corrections.

Data losses in 2004

04 Jan	0839 to 05/0224 (17h 46m) X,Y,Z channels: Power outage; 0839 to 23/0603 (18d 21h 25m) F-channel.
05 Jan	0226 (1min) X,Y,Z channels.
06 Jan	0851–0852 (2min) X,Y,Z channels.
23 Jan	0559 (1min); 0601–0602 (2min) X,Y,Z channels.
30 Jan	0030–0032 (3min) All channels.
08 Feb	0126–0128 (3min) All channels.
01 May	0029–0031 (3min) All channels.
17 May	2330 to 18/0126 (1h 57m) X,Y,Z channels; 2330 to 18/0139 (2h 10m) F-channel
18 May	1740 to 19/0453 (11h 14m) F-channel: internal memory full.
16 Jun	0028–0030 (3min) All channels.
28 Jun	0132–0134 (3min) X,Y,Z channels; 0132–0135 (4min), 0138 (1min): F-channel.
01 Jul	0958–0959 (2min), 1013–1014 (2 min): XYZ channels; 0958 to 02/0122 (15h 25m) F-channel.
08 Jul	0949–0951 (3min), 1004–1005 (2 min) X,Y,Z channels; 0949–2359 (14h 11m) F-channel.
19 Jul	0647–0648 (2min) X,Y,Z channels; 0647–0653 (7min) F-channel.
10 Sep	1600–1601 (2min), 2107 (1min) X,Y,Z channels; 1600 to 14/0159 (3d 10h 00m) F-channel.
14 Sep	0201 (1min) F-channel.
04 Nov	0129–0130 (2min), 0330 (1min) X,Y,Z channels; 0129 to 05/0204 (1d 00h 36m) F-channel.
05 Nov	0601–0602 (2min), 0752 (1min) X,Y,Z channels; 0601 to 07/0429 (1d 22h 29m) F-channel.
09 Nov	0815–0817 (2min) all channels; 0820–0821 (2min) X,Y,Z channels; 0820–0822 (3min) F-channel.
10 Nov	0024 (1min), 0027–0028 (2min) F-channel.
08 Dec	0500 to 12/2200 (4d 17h 01m) all channels: data contaminated.
20 Dec	0530–0531 (2min), 0600 (1min): X,Y,Z channels; 0530 to 21/0150 (20h 21m) F-channel.

Notes and Errata (cumulative since *AGR'93*)

The adjustment applied to the absolute PPM used at Learmonth in 1994 was given as -1nT on in the *AGR1994* (p. 44). This correction was in addition to a -1nT correction to the reference PPM (MNS2 no.3) and so should have been shown as -2nT. This results in baseline adjustments in X, Y and Z of -1.1nT, 0.0nT and +1.7nT respectively. No changes in the data presented are required as the correct adjustments were applied in their calculation.

Learmonth Annual Mean Values

The table below gives 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 & F are on pages 36 & 37.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ (1)
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 (2)
2000.5	A	0	13.5	-56	7.9	29707	29706	116	-44260	53305	ABZ
2001.5	A	0	17.7	-56	5.7	29724	29724	153	-44227	53287	ABZ
2002.5	A	0	20.8	-56	4.2	29734	29733	180	-44197	53268	ABZ
2003.5	A	0	23.8	-56	3.1	29737	29736	206	-44174	53250	ABZ
2004.5	A	0	26.3	-56	0.4	29759	29758	228	-44132	53229	ABZ
1987.5	Q	-0	34.8	-56	26.3	29486	29484	-299	-44445	53336	DHZ (1)
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 (2)
2000.5	Q	0	13.5	-56	7.1	29719	29719	117	-44258	53311	ABZ
2001.5	Q	0	17.8	-56	5.0	29736	29736	154	-44225	53293	ABZ
2002.5	Q	0	20.8	-56	3.3	29748	29747	180	-44195	53274	ABZ
2003.5	Q	0	23.8	-56	2.2	29752	29751	206	-44171	53256	ABZ
2004.5	Q	0	26.3	-55	59.8	29770	29769	228	-44130	53233	ABZ
1987.5	D	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	DHZ (1)
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 (2)
2000.5	D	0	13.4	-56	9.5	29679	29679	116	-44264	53294	ABZ
2001.5	D	0	17.6	-56	7.2	29699	29699	152	-44230	53276	ABZ
2002.5	D	0	20.8	-56	5.4	29712	29712	179	-44200	53259	ABZ
2003.5	D	0	23.8	-56	4.5	29713	29713	206	-44177	53240	ABZ
2004.5	D	0	26.3	-56	1.6	29739	29738	227	-44135	53219	ABZ

Note (1): At the near zero magnetic declination at LRM the DHZ sensor orientation closely approximated an XYZ orientation.

Note (2): ABZ indicates sensor alignments in the magnetic NW, NE and vertical directions.

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Learmonth	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29749.3	216.2	-44158.3	53245.0	29750.1	+0° 25.0'	-56° 01.9'
	5xQ days	29755.1	217.0	-44156.2	53246.5	29755.9	+0° 25.1'	-56° 01.5'
	5xD days	29727.4	213.4	-44161.5	53235.4	29728.1	+0° 24.7'	-56° 03.2'
February	All days	29753.9	220.1	-44152.0	53242.3	29754.7	+0° 25.4'	-56° 01.4'
	5xQ days	29760.5	219.9	-44149.9	53244.2	29761.3	+0° 25.4'	-56° 01.0'
	5xD days	29737.1	218.3	-44154.0	53234.6	29737.9	+0° 25.2'	-56° 02.4'
March	All days	29755.4	221.2	-44145.0	53237.3	29756.2	+0° 25.6'	-56° 01.1'
	5xQ days	29772.1	222.2	-44141.4	53243.7	29773.0	+0° 25.7'	-56° 00.0'
	5xD days	29741.2	219.8	-44148.2	53232.1	29742.1	+0° 25.4'	-56° 01.9'
April	All days	29754.9	224.7	-44140.2	53233.1	29755.7	+0° 26.0'	-56° 00.9'
	5xQ days	29767.2	225.7	-44137.7	53237.9	29768.1	+0° 26.1'	-56° 00.2'
	5xD days	29741.8	221.9	-44142.4	53227.6	29742.6	+0° 25.6'	-56° 01.7'
May	All days	29762.8	225.4	-44134.6	53232.8	29763.6	+0° 26.0'	-56° 00.3'
	5xQ days	29770.0	225.3	-44132.8	53235.4	29770.9	+0° 26.0'	-55° 59.8'
	5xD days	29758.7	225.9	-44134.4	53230.4	29759.5	+0° 26.1'	-56° 00.5'
June	All days	29767.0	228.6	-44129.8	53231.3	29767.9	+0° 26.4'	-55° 59.9'
	5xQ days	29773.8	228.8	-44127.5	53233.2	29774.7	+0° 26.4'	-55° 59.5'
	5xD days	29761.0	229.9	-44130.3	53228.3	29761.9	+0° 26.6'	-56° 00.2'
July	All days	29749.7	230.3	-44128.7	53220.7	29750.6	+0° 26.6'	-56° 00.8'
	5xQ days	29774.8	229.8	-44125.3	53231.9	29775.7	+0° 26.5'	-55° 59.3'
	5xD days	29689.0	230.3	-44137.6	53194.3	29690.0	+0° 26.7'	-56° 04.4'
August	All days	29755.0	230.0	-44127.2	53222.4	29755.9	+0° 26.6'	-56° 00.4'
	5xQ days	29758.1	229.1	-44128.3	53225.0	29759.0	+0° 26.5'	-56° 00.3'
	5xD days	29736.3	229.0	-44127.6	53212.3	29737.2	+0° 26.5'	-56° 01.5'
September	All days	29765.2	233.0	-44121.3	53223.2	29766.1	+0° 26.9'	-55° 59.7'
	5xQ days	29769.1	232.8	-44121.4	53225.4	29770.0	+0° 26.9'	-55° 59.5'
	5xD days	29758.1	234.3	-44122.1	53219.9	29759.0	+0° 27.1'	-56° 00.1'
October	All days	29774.0	231.6	-44115.1	53222.9	29774.9	+0° 26.7'	-55° 59.0'
	5xQ days	29782.9	231.7	-44113.3	53226.5	29783.8	+0° 26.7'	-55° 58.4'
	5xD days	29757.4	231.4	-44118.5	53216.5	29758.3	+0° 26.7'	-55° 60.0'
November	All days	29744.1	234.4	-44121.7	53211.8	29745.0	+0° 27.1'	-56° 00.8'
	5xQ days	29768.2	233.5	-44115.8	53220.3	29769.1	+0° 27.0'	-55° 59.3'
	5xD days	29679.5	234.7	-44132.8	53185.0	29680.4	+0° 27.2'	-56° 04.7'
December	All days	29770.4	236.1	-44113.1	53219.3	29771.3	+0° 27.3'	-55° 59.1'
	5xQ days	29772.9	237.0	-44112.9	53220.6	29773.9	+0° 27.4'	-55° 59.0'
	5xD days	29767.2	237.3	-44112.7	53217.2	29768.2	+0° 27.4'	-55° 59.3'
Annual	All days	29758.5	227.6	-44132.2	53228.5	29759.3	+0° 26.3'	-56° 00.4'
Mean	5xQ days	29768.7	227.7	-44130.2	53232.5	29769.6	+0° 26.3'	-55° 59.8'
Values	5xD days	29737.9	227.2	-44135.2	53219.5	29738.8	+0° 26.3'	-56° 01.6'

(Calculated: 14:54 hrs., Mon., 19 Dec., 2005)

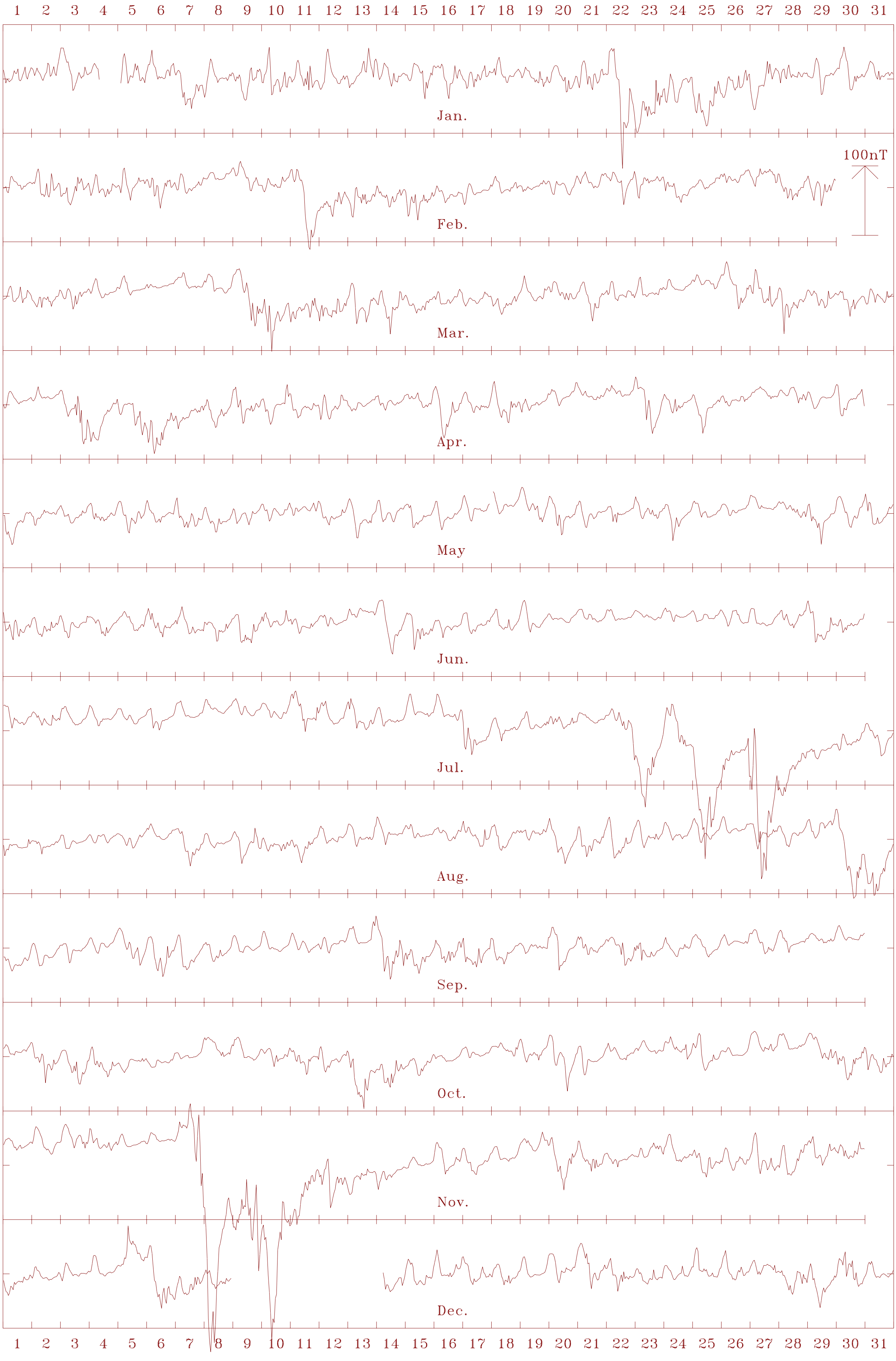
Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

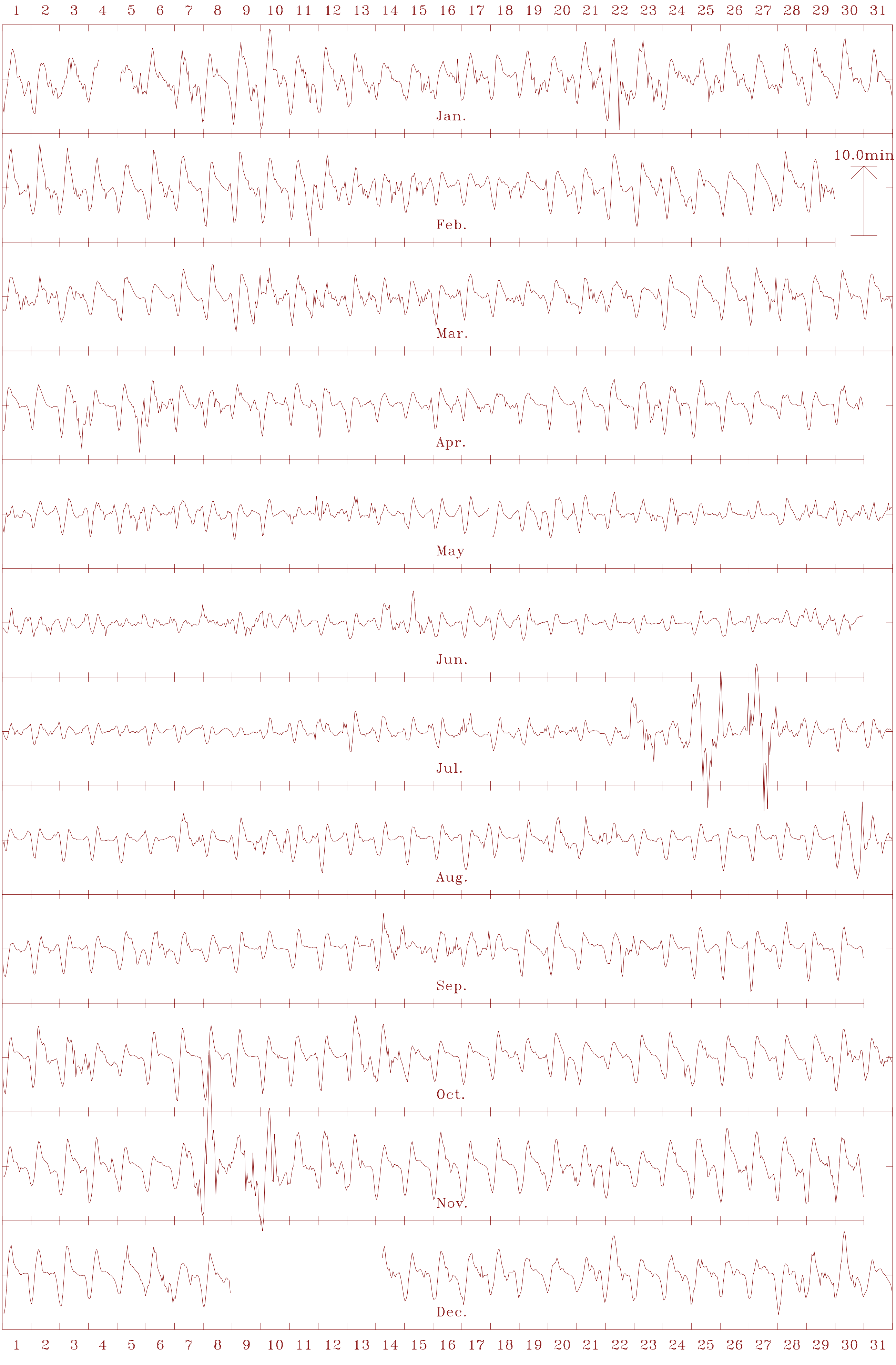
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

The mean value given at the top of each plot is the *all-days* annual mean value of the element.

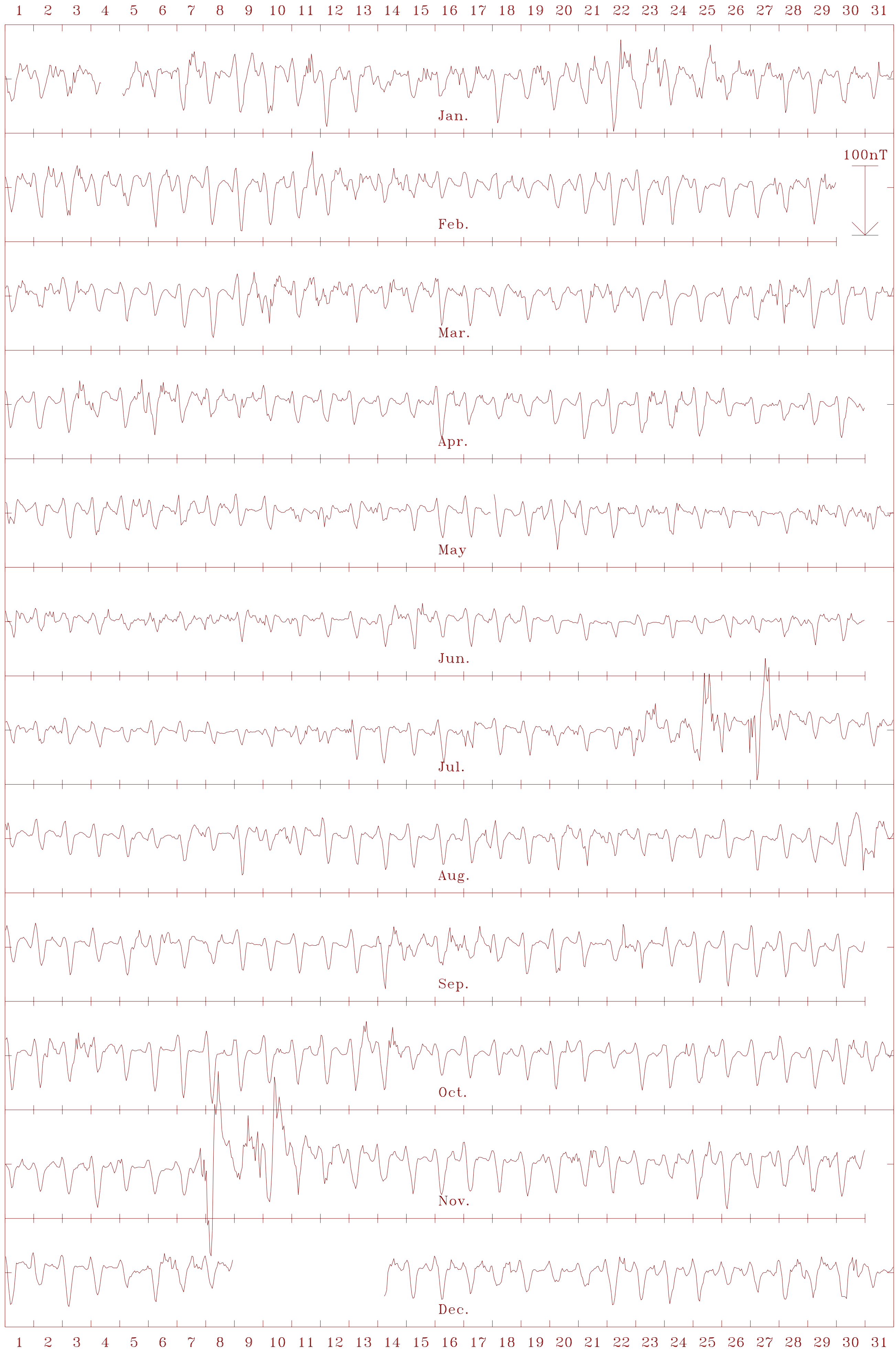
Learmonth 2004 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29759 nT



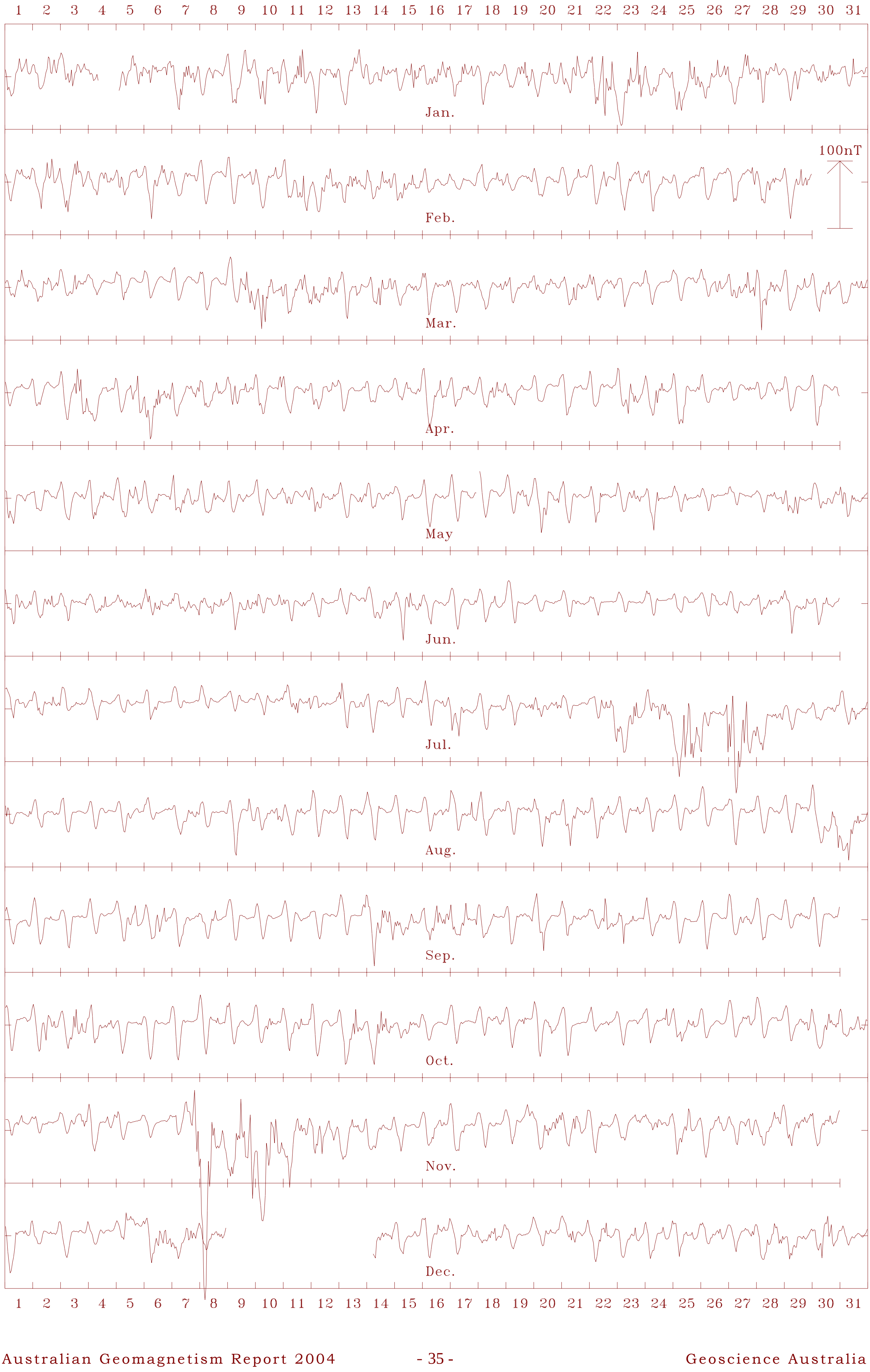
Learmonth 2004 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.44 deg.

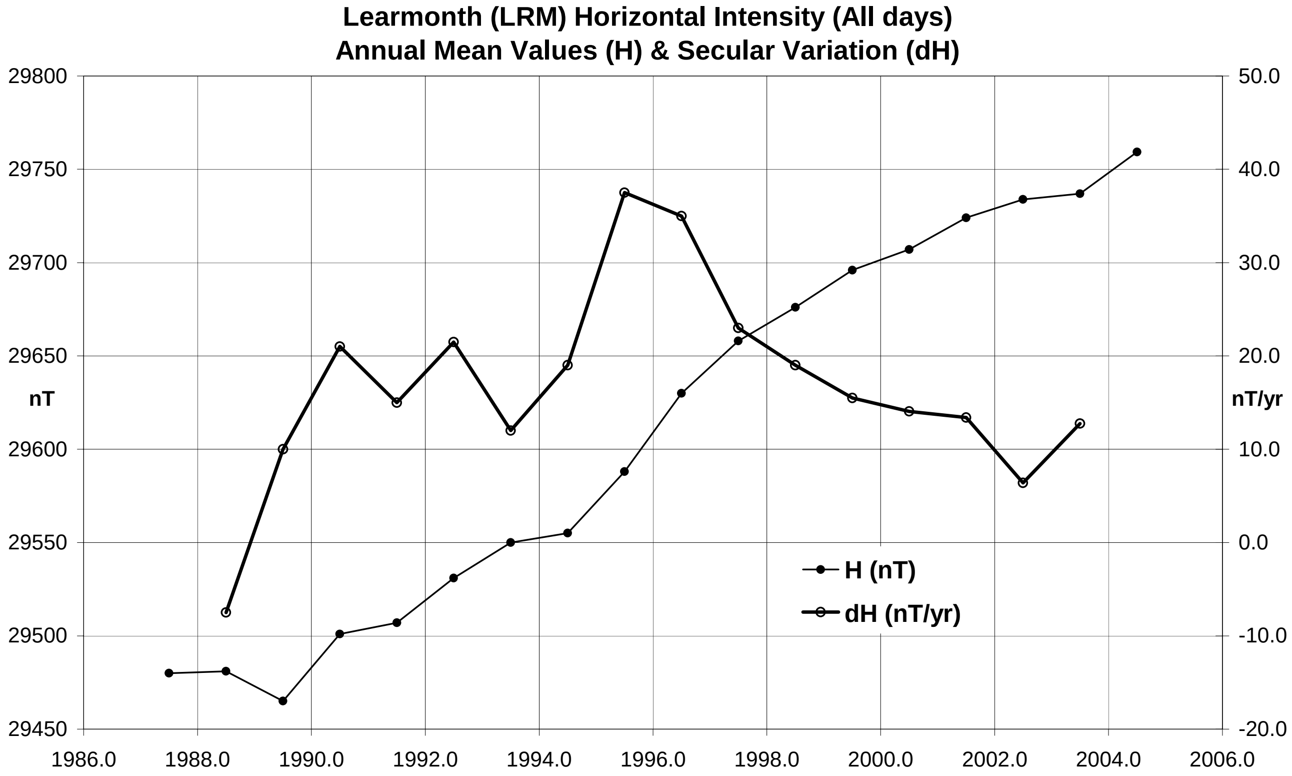


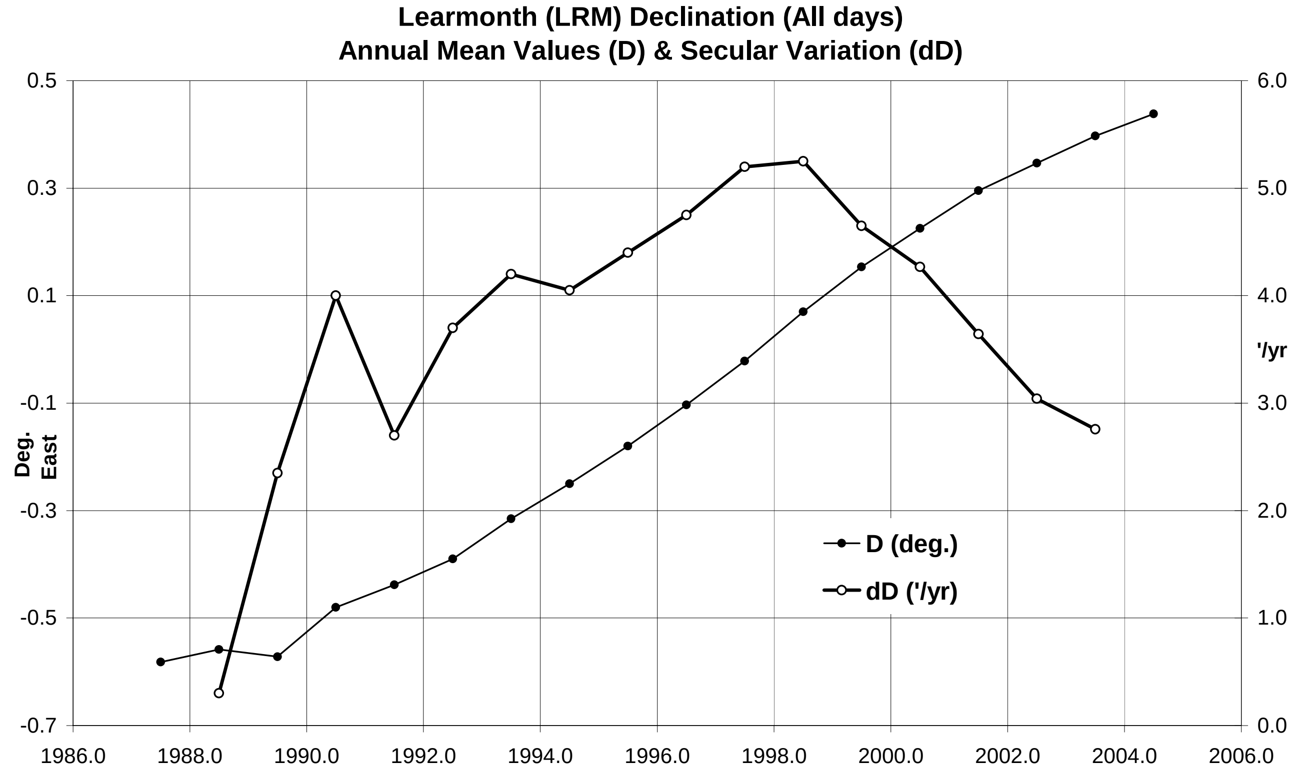
Learmonth 2004 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −44132 nT

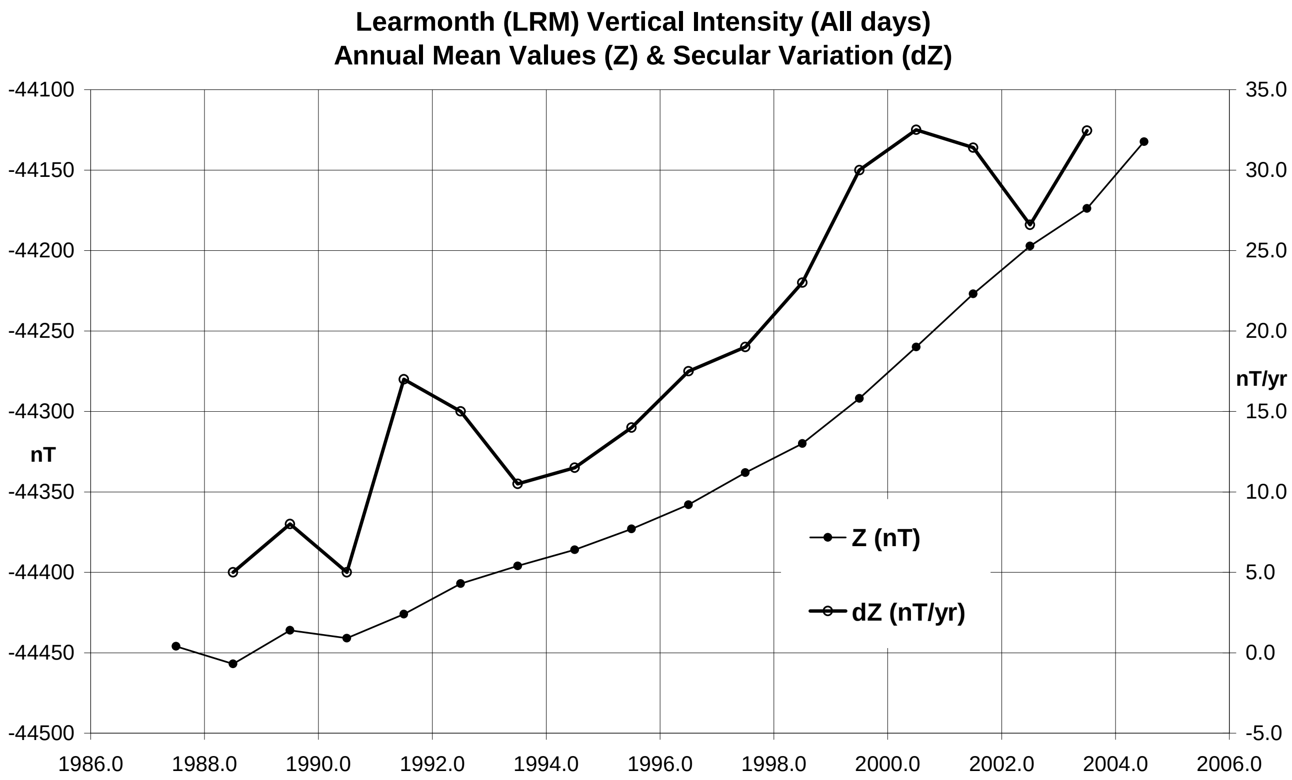


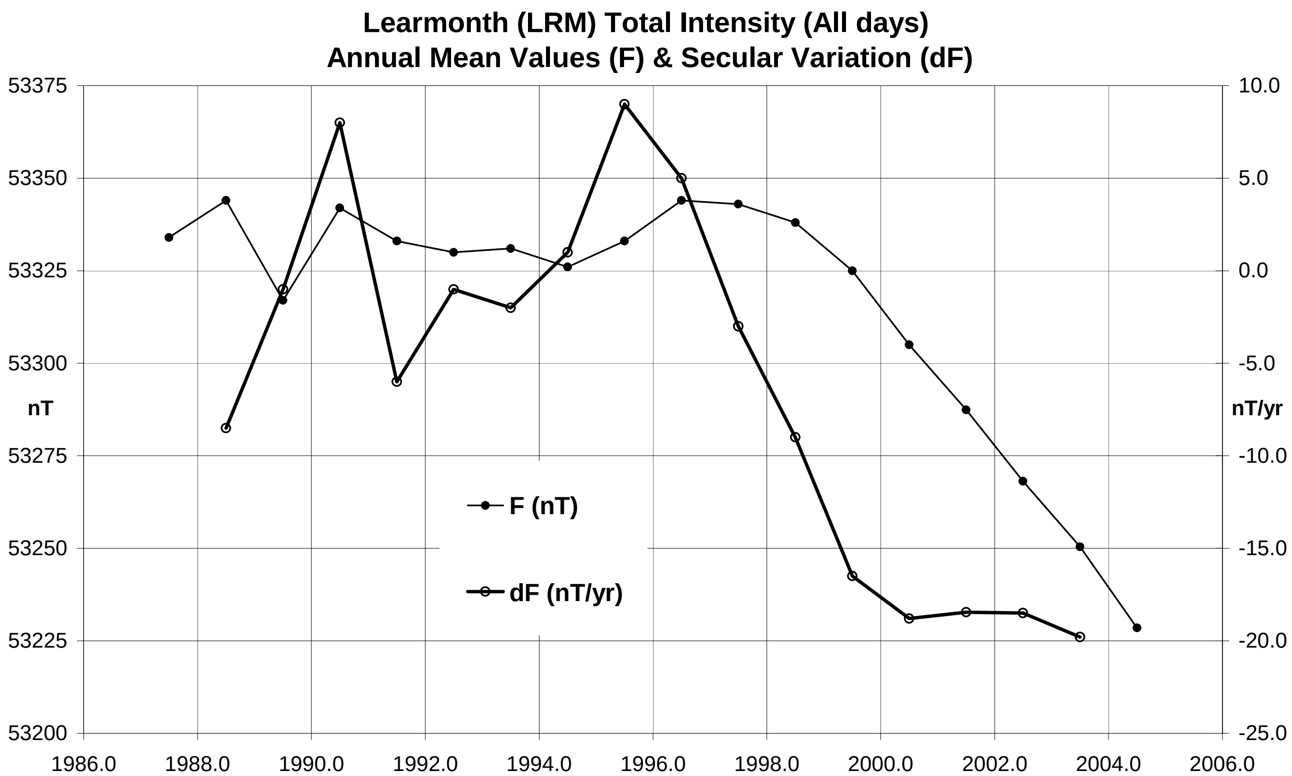
Learmonth 2004 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53229 nT




Learmonth (LRM) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
29800
29750
29700
29650
29600
29550
29500
29450
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Learmonth (LRM) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Deg. East
'/yr
D (deg.)
dD ('/yr)
0.5
0.3
0.1
-0.1
-0.3
-0.5
-0.7
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Learmonth (LRM) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
nT
nT/yr
Z (nT)
dZ (nT/yr)
-44100
-44150
-44200
-44250
-44300
-44350
-44400
-44450
-44500
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Learmonth (LRM) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
nT
nT/yr
F (nT)
dF (nT/yr)
53375
53350
53325
53300
53275
53250
53225
53200
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0

The Alice Springs Magnetic Observatory is located approximately 10km to the south of the city of Alice Springs in the Northern Territory, on the research station of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Sustainable Ecosystems Centre for Arid Zone Research. The observatory is situated on an alluvial plain over tertiary sediments, overlying late Proterozoic carbonates and quarzites.

Continuous recording of magnetic data commenced at the Alice Springs Magnetic Observatory on 01 June 1992. A detailed history of the observatory was given in the *AGR* 1994.

The observatory comprised: a 3m x 3m air-conditioned concrete-brick CONTROL HOUSE where all recording instrumentation and control equipment was housed; a 3m x 3m roofed absolute shelter, 80m SE of the CONTROL HOUSE, which enclosed a concrete observation pier (Pier G), the top of which was 1277mm above the concrete floor; two 300mm diameter azimuth pillars that were about 85m from the absolute shelter at approximate true bearings of 130° and 255°; and two small (1m cube) underground vaults located approximately 50m north and 50m east of the CONTROL HOUSE in which the variometer sensors were housed.

The absolute pier was identified as pier G because there has been a sequence of repeat stations in the Alice Springs area. Repeat stations from A to F were used in the period since 1912.

Key data for Alice Springs Observatory:

- 3-character IAGA code: ASP
- Commenced operation: June 1992
- Geographic latitude: 23° 45' 39.6" S
- Geographic longitude: 133° 53' 00.0" E
- Geomagnetic†: Lat. -32.73°; Long. 208.08°
- Lower limit for K index of 9: 350 nT
- Principal pier identification: Pier G
- Elevation of top of Pier G: 557 metres AMSL
- Azimuth of principal reference (Pillar B from Pier G): 255° 00' 50"
- Distance to Pillar B: 85 metres
- Observer in Charge: W. Serone (ACRES)

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

Variations in the X, Y and Z components of the magnetic field were recorded at Alice Springs in 2004 using a three-component Narod ring-core fluxgate (RCF) magnetometer and in the total magnetic field intensity (F) using a GEM Systems GSM-90 Overhauser-effect proton precession magnetometer. (PPM).

The six channels of variometer data (three RCF channels, RCF head and electronics temperatures, and the PPM data) were recorded on a PC. The electronic equipment for variometer control and data recording was housed in the temperature-controlled, thermally insulated CONTROL HOUSE.

The variometer sensor heads were housed in the underground concrete vaults: the RCF head in the eastern vault; the PPM head in the northern vault. The RCF sensor head was aligned so that the (nominally orthogonal) sensor elements were as close as possible to geographic north, geographic east and vertical. The RCF sensor vault was insulated with foam beads and both vaults were completely concealed beneath local soil to minimise temperature fluctuations. The cables from each of the sensor vaults to the CONTROL HOUSE passed through underground conduits.

The equipment was protected from power outages, surges and lightening strikes by an uninterruptible power supply, a surge absorber, lightening filter and isolation transformer.

Absolute Instruments and Corrections

The principal absolute instruments employed at Alice Springs during 2004 were a D,I fluxgate magnetometer (DIM) and an Overhauser effect proton precession magnetometer (PPM). The DIM used was Elsec Type 810, no. 221 with fluxgate sensor mounted on Zeiss 020B non-magnetic theodolite, no. 313887, and the PPM used was a GEM model GSM90, no 2101216 with sensor 306403. A Psion Organiser II handheld computer was used to communicate via the serial data port of the GSM90 PPM until 17 August 2004. The Psion was replaced with a Hewlett Packard H4300 Personal Data Assistant on 18 August 2004.

Comparisons between the ASP absolute instruments: DIM E810_221/318887 and GSM90_2101216/306403 that were in use at the observatory at the time, and the travelling reference absolute instruments B0610H/160459 and GSM90_003985/11690, were performed in March 2004 at Alice Springs and DIM E810_221/313887 was compared to the Australian Reference DIM E810_200/353756 at Canberra Observatory in December 2004.

DIM: $Ds - Dasp = 0.0'$ and $Is - Iasp = -0.1'$

PPM: $Fs - Fasp = 0.6$nT

where Ds, Is and Fs are the declination, inclination and total intensity by the Australian Reference instruments (DIM E810_200/353756 and PPM GSM90_905926/21867 at the Canberra Observatory) and Dasp, Iasp and Fasp are the absolute instruments in use at the ASP observatory in 2004.

These instrument differences convert to baseline corrections of:

$\Delta X = -0.94$nT, $\Delta Y = -0.08$nT, $\Delta Z = -1.37$nT

at the average magnetic field values at Alice Springs of

$X = 29954$nT, $Y = 2680$nT, $Z = -44134$nT

These corrections have been applied to all final ASP 2004 data.

Baselines

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

2.02nT in X; 1.81nT in Y; 1.51nT in Z

(In terms of the absolute observed components, they were:

0.89nT in F; 12" in D; 09" in I)

The drifts applied to the X, Y, and Z baselines amounted to less than 20nT in any of X, Y and Z components throughout the year.

There was about 7nT 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.

Operations

Absolute observations were performed weekly (often on a Wednesday afternoon) by the local Observer in Charge, who was an officer at the nearby Australian Centre for Remote Sensing (ACRES) installation. DIM and PPM observations were routinely performed on absolute pier G, using pillar B as azimuth reference. The operation of the observatory was checked twice weekly (usually on Mondays and Fridays) by the observer. The absolute observation data were sent weekly by post to GA in Canberra, where they were processed and used to calibrate the variometer data.

Operations (ASP) (cont.)

Daily files of both 1-minute and 1-second resolution data were automatically retrieved from Alice Springs to GA in Canberra by modems via a telephone line connection. After preliminary processing the data were then automatically e-mailed to the INTERMAGNET Geomagnetic Information Node at Edinburgh as well as being made available on the GA website. System timing checks and PC hard-disk housekeeping tasks were also performed semi-automatically via the telemetry line. Accurate timing on the data acquisition computer was maintained with a one-second pulse from a Trimble Accutime GPS clock mounted outside the CONTROL HUT.

GA staff (AML, BS) made a maintenance visit to the Alice Springs observatory during the period 29 March to 02 April, 2004. During the visit the GEM GSM90 variometer PPM no. 708729 was re-installed replacing sensor 21889 with 3112370, with both the sensor and electronics inside the PPM vault. Instrument checks and comparisons were also performed, pier gradients measured, azimuth mark angles checked and pier differences to the remote reference stations at the airport (E and F) were determined.

Data losses in 2004

01 Jan.	0000 to 0555/29 Mar. (88d 05h 56m) No PPM data for most of first 3 months of 2004: F-channel only.
29 Mar	0700–0702 (3min), 0707–0709 (3min), 2351 to 0018/30 Mar. (28m): F-channel only
03 May	0420 to 0000/04 May (19h 41m) F channel only.
28 Aug	1911–1913 (3min) F channel only.
19 Oct	0117 (1 min.), 0122 (1 min.), 0128 (1 min.) F channel only.
30 Oct	2325 to 0022/31 Oct. (58 min) System failure on all channels. Unknown reason.

Significant Events in 2004

22 Jan.	Absolute PPM stand lost a leg. A replacement stand S/N 20031203 was sent from GA.
29 Jan.	0500–800: Data noisy.
29 Mar. to 02 Apr.	Maintenance visit to observatory by GA staff (AML & BS): re-installed variometer PPM with electronics in the vault. Instrument comparisons, remote station observations etc. (See report GN 2004-10.)
26 May	Prepare and send PDA (s/n TWC3480CN7) for use with GSM90 used for absolutes. PDA lost in transit. Replacement unit sent in July, after which trouble was encountered in running JOBS software. A new version of this software was sent on SD card.
03 Aug.	0920: A step in F-check identified.
18 Aug.	First observation using HP PDA to run GSM90.
25 Aug.	1900–1910: PPM data noisy.
01 Nov.	Small step (up and down) in F-check occurred.
02 Nov.	System timing out since reboot on 31 October. Corrected by 4 seconds (+75 ticks) at 0355UT.
3 & 4 Nov.	Officer from GA Minerals Division (RT) scheduled to visit ASP CONTROL HUT for gravity observations.
Nov.	Re-commenced negotiations with ACRES to establish a network connection to ASP through their facilities.
10 Dec.	Local observer (WFS) on extended leave resulting in no absolute observations until late January 2005. DIM arrived at GA for comparison and to have the Elsec sensor replaced with a DMI sensor.

Alice Springs Annual Mean Values

The table below gives 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 & F are on pages 45 & 46.

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

continued on page 47 …

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Alice Springs	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29947.4	2680.7	-44156.2	53421.1	30067.2	5° 06.9'	-55° 44.9'
	5xQ days	29952.3	2683.3	-44154.7	53422.6	30072.2	5° 07.1'	-55° 44.6'
	5xD days	29925.1	2676.1	-44160.0	53411.5	30044.6	5° 06.6'	-55° 46.2'
February	All days	29954.6	2682.3	-44151.5	53421.2	30074.5	5° 07.0'	-55° 44.3'
	5xQ days	29961.4	2684.3	-44149.9	53423.8	30081.5	5° 07.2'	-55° 43.9'
	5xD days	29939.6	2678.0	-44154.7	53415.3	30059.1	5° 06.7'	-55° 45.3'
March	All days	29953.4	2683.0	-44144.5	53414.8	30073.3	5° 07.1'	-55° 44.1'
	5xQ days	29970.6	2686.5	-44140.3	53421.2	30090.8	5° 07.3'	-55° 43.0'
	5xD days	29940.0	2681.2	-44148.3	53410.3	30059.9	5° 07.0'	-55° 45.0'
April	All days	29952.4	2683.1	-44141.0	53411.3	30072.4	5° 07.1'	-55° 44.1'
	5xQ days	29963.7	2685.5	-44138.6	53415.8	30083.8	5° 07.3'	-55° 43.4'
	5xD days	29940.6	2679.6	-44143.4	53406.6	30060.3	5° 06.9'	-55° 44.8'
May	All days	29959.0	2682.7	-44135.1	53410.2	30078.9	5° 07.0'	-55° 43.5'
	5xQ days	29966.6	2684.5	-44132.8	53412.6	30086.6	5° 07.1'	-55° 43.0'
	5xD days	29955.6	2682.0	-44135.3	53408.4	30075.4	5° 07.0'	-55° 43.7'
June	All days	29965.4	2682.6	-44130.8	53410.2	30085.2	5° 06.9'	-55° 43.0'
	5xQ days	29974.4	2680.9	-44128.4	53413.2	30094.0	5° 06.7'	-55° 42.4'
	5xD days	29959.2	2682.7	-44131.3	53407.2	30079.1	5° 07.0'	-55° 43.3'
July	All days	29945.7	2679.9	-44130.2	53398.5	30065.4	5° 06.8'	-55° 44.0'
	5xQ days	29970.2	2681.9	-44126.7	53409.5	30089.9	5° 06.8'	-55° 42.6'
	5xD days	29886.3	2670.0	-44139.1	53372.1	30005.3	5° 06.3'	-55° 47.6'
August	All days	29948.0	2679.5	-44130.4	53400.0	30067.6	5° 06.8'	-55° 43.9'
	5xQ days	29950.7	2679.6	-44130.6	53401.6	30070.3	5° 06.7'	-55° 43.8'
	5xD days	29931.9	2677.7	-44131.0	53391.4	30051.5	5° 06.7'	-55° 44.8'
September	All days	29958.9	2678.6	-44122.7	53399.6	30078.4	5° 06.6'	-55° 43.1'
	5xQ days	29965.0	2678.6	-44121.8	53402.3	30084.5	5° 06.5'	-55° 42.7'
	5xD days	29951.9	2678.4	-44124.7	53397.4	30071.4	5° 06.6'	-55° 43.5'
October	All days	29966.0	2679.4	-44116.9	53398.9	30085.6	5° 06.6'	-55° 42.5'
	5xQ days	29973.7	2680.8	-44114.8	53401.6	30093.4	5° 06.6'	-55° 42.0'
	5xD days	29950.3	2676.3	-44119.9	53392.4	30069.7	5° 06.4'	-55° 43.4'
November	All days	29935.4	2674.4	-44125.2	53388.4	30054.6	5° 06.3'	-55° 44.4'
	5xQ days	29958.6	2676.7	-44117.1	53394.8	30078.0	5° 06.3'	-55° 42.9'
	5xD days	29871.7	2666.5	-44137.0	53362.1	29990.5	5° 06.1'	-55° 48.3'
December	All days	29959.3	2676.5	-44119.8	53397.4	30078.7	5° 06.3'	-55° 42.9'
	5xQ days	29963.3	2679.3	-44120.2	53400.1	30082.8	5° 06.6'	-55° 42.7'
	5xD days	29957.0	2674.7	-44120.7	53396.8	30076.2	5° 06.1'	-55° 43.1'
Annual	All days	29953.8	2680.2	-44133.7	53406.0	30073.5	5° 06.8'	-55° 43.7'
Mean	5xQ days	29964.2	2681.8	-44131.3	53409.9	30084.0	5° 06.9'	-55° 43.1'
Values	5xD days	29934.1	2676.9	-44137.1	53397.6	30053.6	5° 06.6'	-55° 44.9'

(Calculated: 12:32 hrs., Thu., 31 Mar. 2005)

Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

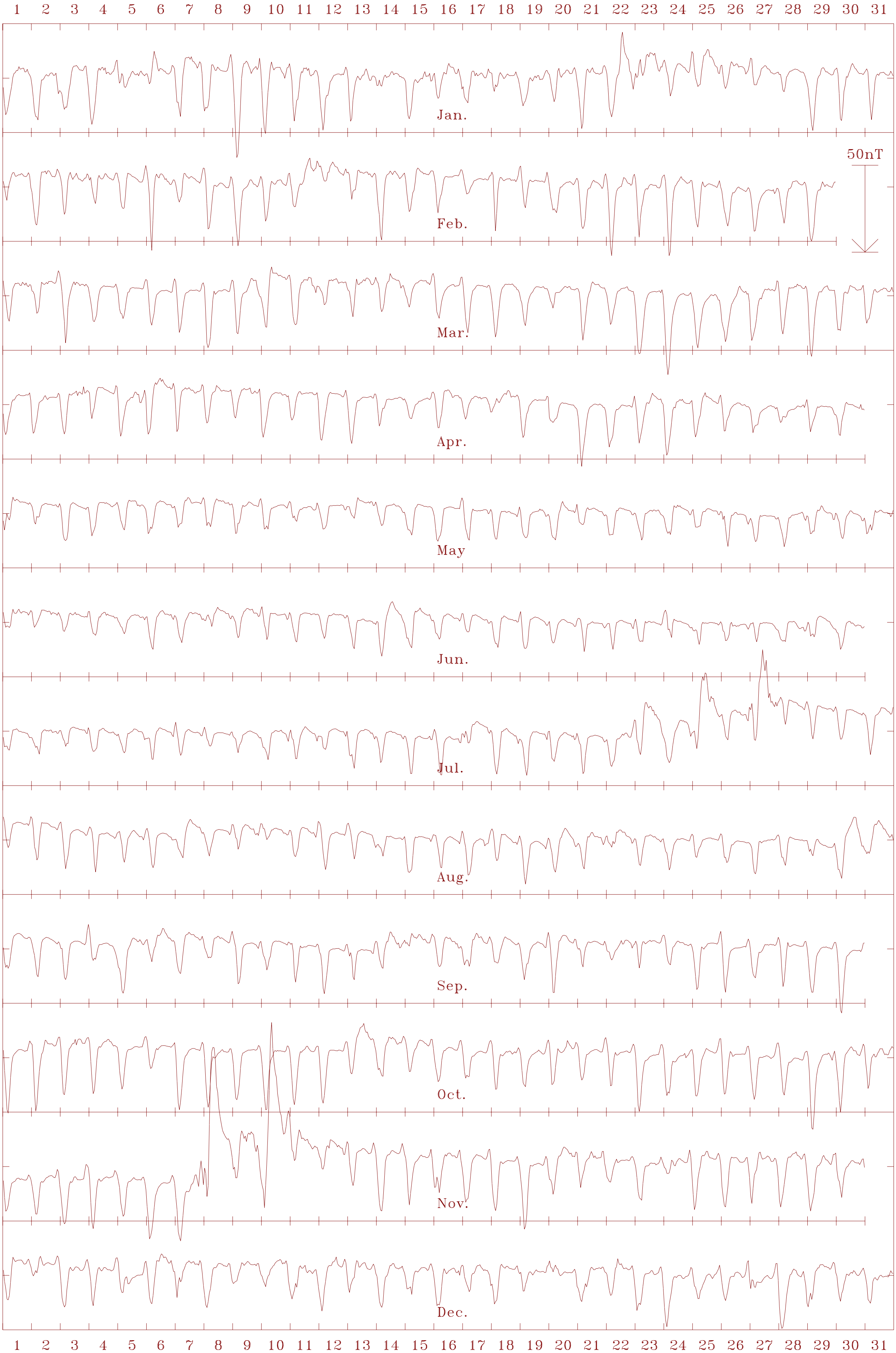
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

The mean value given at the top of each plot is the *all-days* annual mean value of the element.

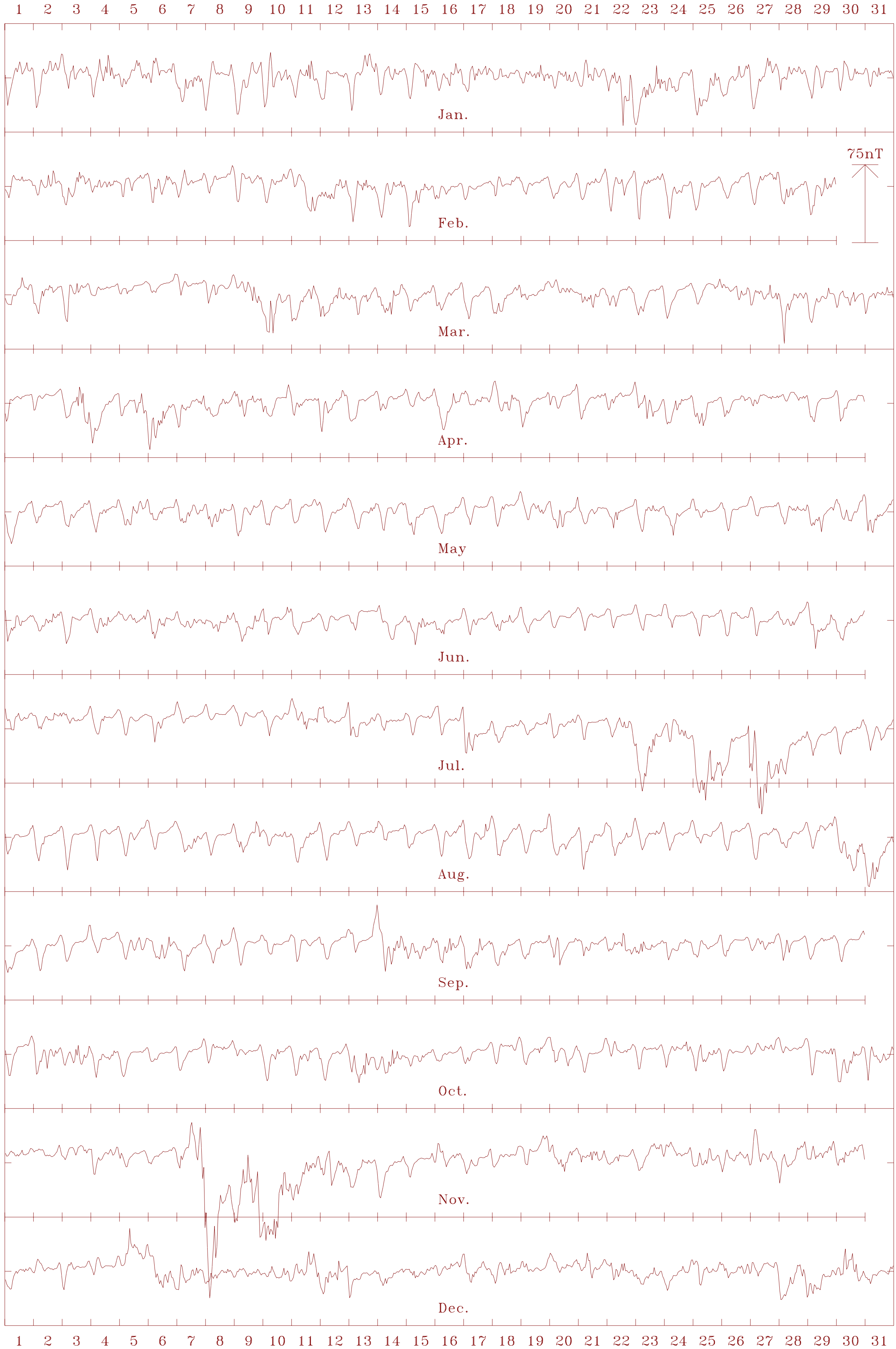
Alice Springs 2004 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 30074 nT

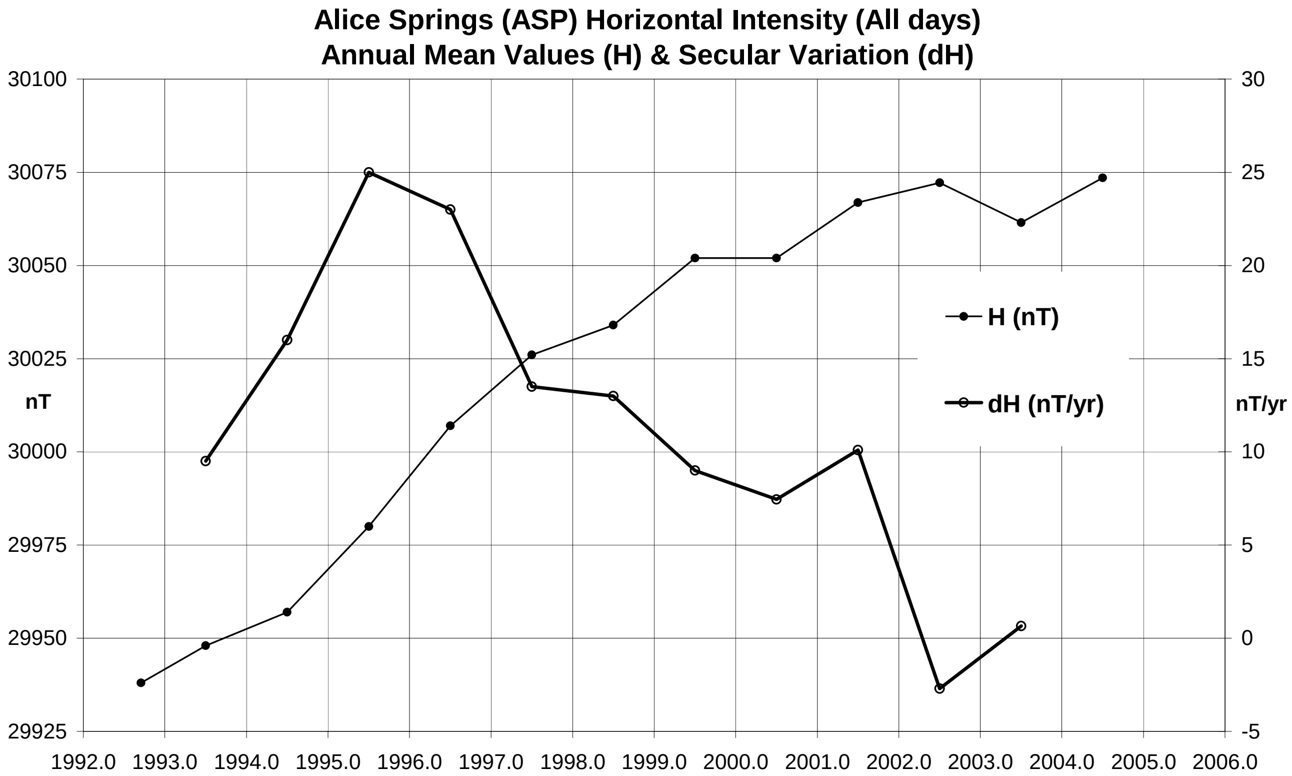
Alice Springs 2004 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.11 deg.

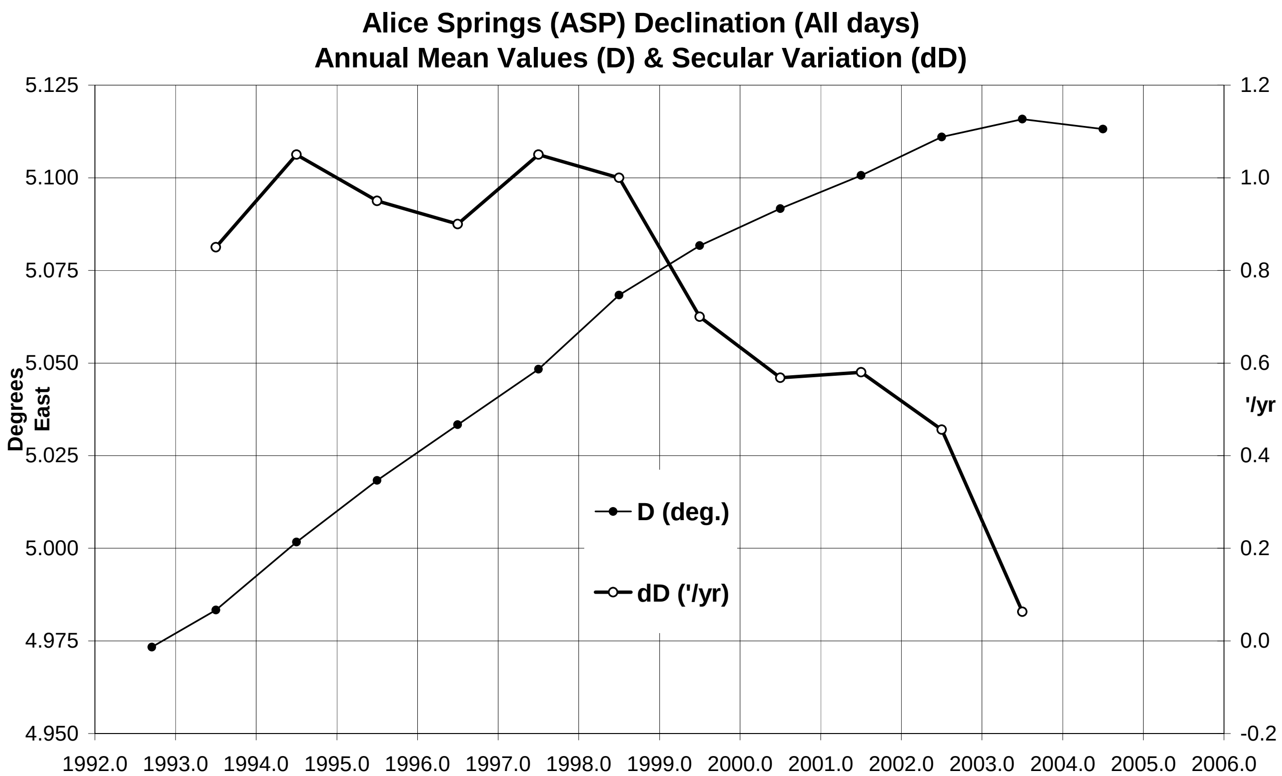
Alice Springs 2004 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44134 nT

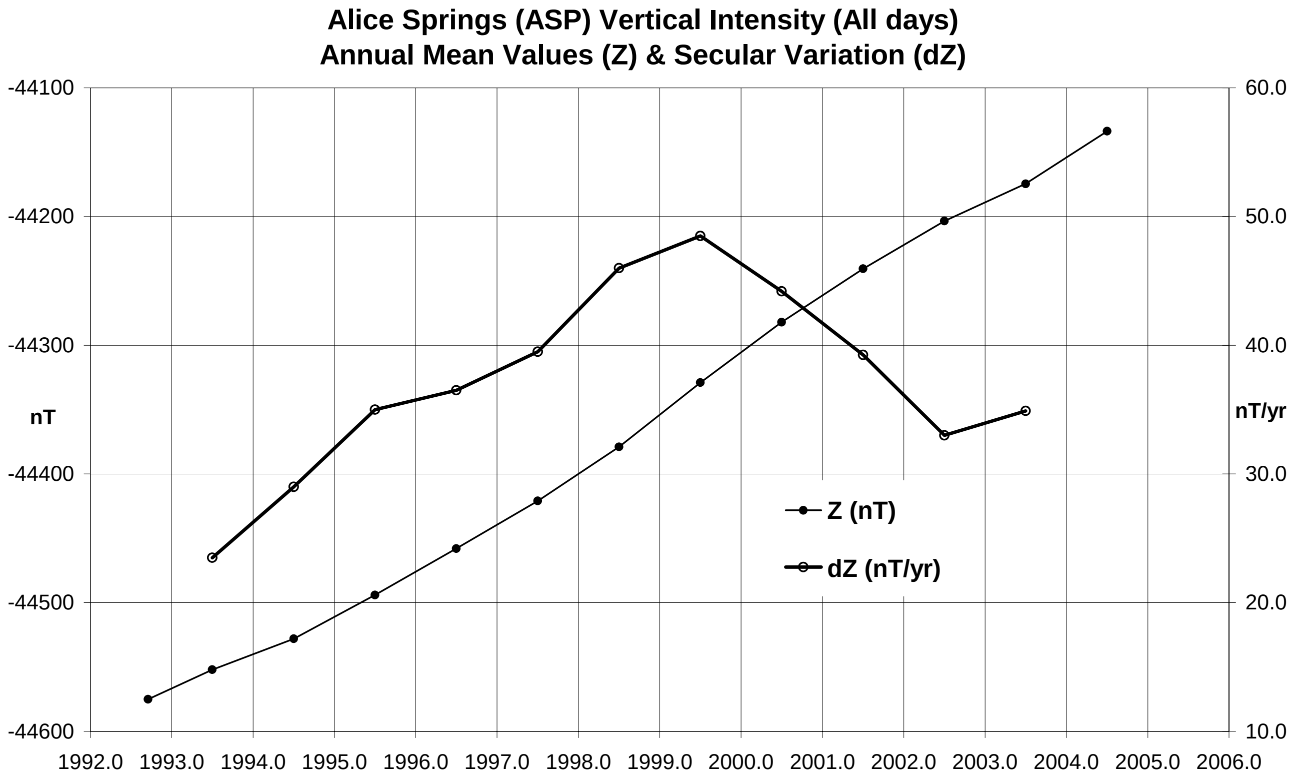


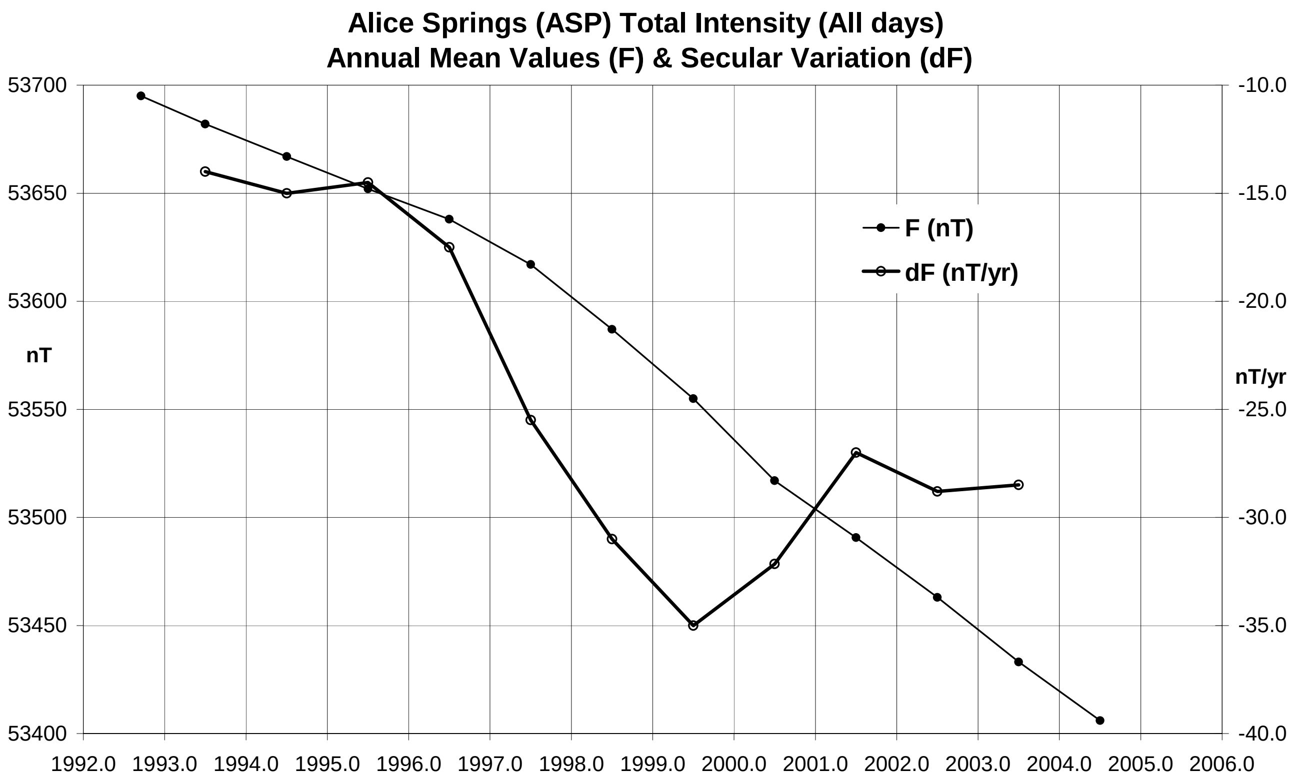
Alice Springs 2004 Total intensity (F). Scale: 5.0 nT/mm. Mean: 53406 nT




Alice Springs (ASP) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
30100
30075
30050
30025
30000
29975
29950
29925
30
25
20
15
10
5
0
-5
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0


Alice Springs (ASP) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
5.125
5.100
5.075
5.050
5.025
5.000
4.975
4.950
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0


Alice Springs (ASP) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-44100
-44200
-44300
-44400
-44500
-44600
nT
60.0
50.0
40.0
30.0
20.0
10.0
nT/yr
Z (nT)
dZ (nT/yr)
1992.0 1993.0 1994.0 1995.0 1996.0 1997.0 1998.0 1999.0 2000.0 2001.0 2002.0 2003.0 2004.0 2005.0 2006.0


Alice Springs (ASP) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53700
53650
53600
53550
53500
53450
53400
nT
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
nT/yr
F (nT)
dF (nT/yr)
1992.0 1993.0 1994.0 1995.0 1996.0 1997.0 1998.0 1999.0 2000.0 2001.0 2002.0 2003.0 2004.0 2005.0 2006.0

Alice Springs Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
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

Distribution of ASP data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2004

1-minute and Hourly Mean Values to WDCs

- 2003: WDC-A, Boulder, USA (22 Mar. 2004)
- 2004: WDC-A, Boulder, USA (10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive data for the INTERMAGNET CD-ROM series:
  2003 data: to INTERMAGNET Paris GIN (22 Mar. 2004)
  2004 data: to INTERMAGNET Paris GIN (16 Aug. 2005)

GNANGARA OBSERVATORY

The Gnangara Magnetic Observatory is located within the Gnangara pine plantation approximately 27km to the north-east of the city of Perth in Western Australia. This places it just a few kilometres from recent urban development. It succeeds the observatory at Watheroo (1919-1959) located 180km north of Perth. Magnetic recording began at Gnangara in 1957. A brief history of the observatory was given in the *AGR 1994*.

The observatory was built on the north-eastern part of an approximately 260m x 140m (3.6 hectare) site. In 2004 the observatory comprised a VARIOMETER/RECORDER VAULT and an ABSOLUTE HOUSE approximately 70m north-east of the former. The site is on well drained sand with low natural magnetic gradients of less than 1nT/m, although numerous artificial features have introduced higher gradients.

The VARIOMETER VAULT is partially underground, and partially buried beneath sand. It is approximately 10m x 5m and provided a secure, temperature-stable and physically stable environment. This vault housed the recording equipment, fluxgate variometer sensor and electronics, total field variometer electronics, GPS clock, backup power supply, telephone, and alarm system.

A small vault, connected by an underground conduit and approximately 20m north-west of the VARIOMETER VAULT, housed the total field variometer sensor. As the sensor vaults were below the ground, the diurnal temperature changes of the variometers were kept to a minimum.

There were also four azimuth reference marks on the site.

Key data for Gnangara Observatory:

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic‡ latitude: 31° 46' 48" S
- Geographic‡ longitude: 115° 56' 48" E
- Geomagnetic† : Lat. -41.71°; Long. 188.75°
- Lower limit for K index of 9: 450 nT
- Principal pier identification: Pier B
- Elevation of top of Pier B: 60 metres AMSL

Key data (cont.)

- Azimuth of principal reference (Pillar N from Pier B): 315° 21' 42"
- Distance to Pillar N: 70 metres
- Observers in Charge: O. McConnel (GA) and G. van Reeken

‡ In June 1998 these were measured using GPS as 31° 46' 48.49"S 115° 56' 57.61"E (WGS84) 63.5m above geoid height (OSU91A) at instrument height.

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

From the beginning of the year until 23 March 2004 at 0530UT magnetic field variations were monitored with a Danish Meteorological Institute suspended 3-component FGE model 89 version D (sensor no. S0160; electronics module no. E0199 with internal A to D converter) fluxgate variometer. For security reasons, on the 07 April 2004 the variometer was replaced with an EDA model FM105B 3-component fluxgate magnetometer (electronics no. 2877 and sensor no. 2887). In turn, each of the instruments was located in the VARIOMETER VAULT and each was aligned with two of their sensors horizontal and both aligned at 45° to the magnetic meridian to monitor the magnetic NW and NE components. The other sensor was vertical. The sensors were located at the eastern end of the vault, while the electronic equipment and acquisition PC were confined to the western end. The FGE variometer had in-built sensors for both sensor and electronics temperatures. The analogue outputs of the FGE were digitised with the internal ADAM A to D converter. The EDA also used an internally installed ADAM A to D converter for magnetic data and temperature.

Variations in the total intensity were monitored with a Geometrics 856 PPM (serial 50706).

The standard temperature for the observatory was 20°C. The temperatures of both the fluxgate sensors and electronics (within the VARIOMETER VAULT) range annually from around 15°C in winter to 28°C in summer and have a maximum rate of

Variometers - GNA (cont.)

change of < 0.1°C/day. The F variometer PPM sensor would have experienced temperature changes greater than this as the vault in which it was located was not as well insulated as the VARIOMETER VAULT.

Throughout 2004, the fluxgate magnetic channels and sensor and electronics temperatures were sampled and recorded on a PC every 1-second, and the PPM every 10-seconds. 1-minute means of the magnetic components and temperatures were also recorded.

The acquisition computer was accessible via a modem for remote control and data retrieval. The telephone and equipment were protected from lightning and powered through a UPS.

Timing was derived from a GPS receiver with antenna at the west of the VARIOMETER VAULT. The acquisition computer clock was synchronised to the 1-second pulse from the GPS clock, but the time code from the GPS was not used. Timing errors were normally less than 0.1s.

Absolute Instruments and Corrections

On the 18 March 2004 the ABSOLUTE HOUSE was broken into and the absolute instruments were stolen. On account of this two sets of absolute instruments were employed during 2004. The Declination and Inclination Magnetometer (DIM) Bartington Mag-010H/0725H with Zeiss020B/355937 was employed regularly until 18 March 2004. For the rest of the year, beginning on 07 April 2004 a new DIM with a Danish Meteorological Institute model G (no.DI0037) sensor on Zeiss020B/390444 was used. Both DIMs were used on Pier B in the ABSOLUTE HOUSE. (The Bartington Mag-01H was kept on the x1 scale throughout all observations.)

Geometrics 856/50631 PPM with sensor 28079922 was employed to perform absolute observations in total intensity, F, from the beginning of the year until 18 March 2004. The sensor for the G-856 was located on the auxiliary pier (a wall bracket - Pier C) in the same building as Pier B. Before 18 March 2004 both the DIM theodolite and the PPM sensor normally remained in place between weekly observations

From 07 April 2004, GEM model GSM90 PPM no. 3091317 was used to perform absolute observations in total intensity. A Personal Data Assistant (PDA) was used to control the GSM90. The GSM90 sensor was located on Pier B.

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

Corrections of 0.0′ in D, and 0.0′ in I, have been applied to the Bartington Mag-010H/0725H with Zeiss020B/355937 DIM used on Pier B at GNA during 2004 until 18 March. These corrections were re-determined at GNA on 17 May 2005.

A composite correction has been applied to the absolute PPM used at GNA on the auxiliary pier during 2004. The components of the correction are:

- Corrections to the G-856 relative to the Canberra Total Field Reference (GEM Systems GSM90 No. 905926 with sensor no 81241) of:

  -1.4 nT determined at GNA on 06 May 2003;

  0.0 nT determined 07 April 2004
- -3.8 nT auxiliary pier adjustment to Pier B.

These corrections, together with the zero corrections to the DIM, result in a vector pier difference in (X,Y,Z) of (-2.0, +0.1, +4.7) nT up to 06 April 2004 and (0.0, 0.0, 0.0) nT thereafter, and have been applied to Gnangara data in this report.

During a maintenance visit to GNA in May 2005 it was discovered that the magnetic, metal, DIM instrument case was being placed at a distance of about 2 metres from the absolute pier during some of the routine absolute observations that had been performed between April 2004 and May 2005. To determine the magnetic effect of the DIM case at pier B, observations were performed both with the case near pier B and with the case removed (by 10m from pier B), with the following results at Pier B:

F (without DIM box) - F (with DIM box) = -8.0nT

D (without DIM box) - F (with DIM box) = +1.6'

I (without DIM box) - I (with DIM box) = -0.3'

i.e.

the difference (without DIM box) - Pier B (with DIM box) is

3.18nT in X, -0.11nT in Y and -7.34nT in Z

However it was also discovered that the location of the DIM case was not consistent at each observation. Its placement differed by up to 1m between observations. This affected the total field intensity at the pier between -4nT and -8nT. During some observations the DIM case was over 6m from the pier and so had little effect. A method was devised to correct for the contamination at the pier that was based on the difference between the absolute PPM and the variometer PPM (FP). If the difference between the two PPMs was between -4 nT and -8 nT for observations between 30 April and 31 December 2004, the following pier corrections were applied:

FP	D correction	I correction	Pier name
-4 nT	1.2'	-0.2'	B4
-5 nT	1.3'	-0.2'	B5
-6 nT	1.4'	-0.2'	B6
-7 nT	1.5'	-0.3'	B7
-8 nT	1.6'	-0.3'	B8

If the difference was between -2nT and -3nT or greater than -8 nT the observation was not included in the final baseline calculations.

The corrections to the 2004 observations were as follows:

2004	Obs'n	Pier	2004	Obs'n	Pier
30 Apr.	1	B6	02 Sep	2	B7
15 Jun.	1	B7	14 Sep.	1	B5
15 Jun.	2	B8	14 Sep.	2	B6
29 Jun.	1	B5	28 Sep.	1	not used
15 Jul.	1,2	B4	28 Sep.	2	B4
28 Jul.	1	B5	14 Oct.	1	B7
28 Jul.	2	B6	14 Oct.	2	not used
10 Aug.	1,2	B4	07 Dec.	1,2	not used
02 Sep.	1	B5			

After the application of the above corrections the results showed a significant improvement in consistency and a more uniform difference between total field values calculated from the corrected fluxgate variometer data and the PPM variometer data.

Baselines

The scale values and orientations of the variometer sensors were determined from a sequence of absolute observations performed in June 1999. No temperature corrections were applied to 2004 data: any temperature effects being accounted for through the regular absolute observations. Variometer temperature changes between absolute observations averaged less than 0.5°C, and the expected effect on baselines was less than 0.1nT.

The mean values and standard deviations of the differences between the absolute measurements in 2004 and the derived values from the variometer data and model were:

$+0.17 \pm 1.32$ nT in X

-0.33 ± 1.76 nT in Y

$+0.12 \pm 0.59$ nT in Z

Baselines – GNA (cont.)

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM varied from −4.5nT to −9.2nT in 2004.

All reported magnetic values in this report refer to the standard Pier B.

Operations

The Gnangara magnetic observatory was maintained by an out-posted GA staff member. Absolute observations were performed by a contract observer.

1-second and 1-minute mean variometer data in the magnetic NE, NW, vertical and total intensity magnetic components, with sensor and electronics temperatures, were acquired on a PC at the observatory. These raw data were retrieved by modem directly from the observatory to GA, Canberra, shortly after 00hrs UT each day.

The routine processing of absolute observations; the scaling of principal magnetic storms, rapid variations and K indices; and the distribution of data, was performed by staff at GA in Canberra.

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

The area close to Gnangara observatory is being developed for residential use. Although this currently poses no threat to the observatory in a technical sense, there has been an increasing problem with security breaches at the site. As well as vandalism, break-ins and theft from the observatory, considerable data were lost in 2004 due to power outages and data contamination caused by these events. Since late in 2000, the observers have no longer felt safe at the site, and a security firm was engaged to attend during routine absolute observations to ensure their safety. This continued throughout 2004. The search for an alternative observatory site also continued in 2004.

Significant Events in 2004

Jan 29	0300: Variometer PPM re-started after power failure, however failed again at 1900 due to full memory.
Feb 02	0250: Variometer PPM started.
Feb 26	Absolute PPM failed. Local observer determined that the electronics were not working. GSM90_3091317 with sensor 91457 ands iPaq 4350 PDA was sent to replace them.
Mar 07	The VARIOMETER HOUSE was broken into as well as unsuccessful attempt to enter the ABSOLUTE HOUSE. The UPS was stolen. There was a baseline jump and a 93 minute data loss.
Mar 08-11	Repair to VARIOMETER HOUSE resulting in data loss due to contamination.
Mar 18	~0100: ABSOLUTE HOUSE broken into and items stolen. Police alerted on 22 March. Stolen items include: D/I magnetometer (Zeiss 020B/355937 with Mag01H/B0725H sensor and electronics), DIM charger, Trimble tripod. The offender may have cut the power that resulted in the 67 minutes of data that was lost due to power failure.
Mar 23	0530: DMI variometer switched off due and removed from the site due to security concerns.
Apr 06	EDA 3-axis fluxgate variometer (no. 2877 with sensor 2887) was installed. Replacement absolute instruments DIM DI0037 with Zeiss 390444 and GSM90_3091317 were also introduced, enabling the first absolute observations since the 12 February 2004 to take place.

Significant Events (cont.)

May 16	The front gate to the observatory compound was pulled out of the ground and the security grill on the VARIOMETER VAULT pulled out by intruders. Nothing was stolen and the observatory continued operating.
May 19	0630: Grill on VARIOMETER VAULT repaired and replaced resulting in 30 minutes of corrupted data.
May 28	Absolute observations indicated a change in the local environment since the previous observations. F-check on daily plot was normal. Although repairs to the ABSOLUTE HOUSE that took place the previous week may have contaminated the hut, investigation revealed a steel star picket leaning against the ABSOLUTE HOUSE, probably placed there during the repairs. This absolute observation was not be used.
Aug 24	Observer unable to access VARIOMETER VAULT due to seized lock: no absolute observations performed.
Oct 21	0144 to 23/0304: A seismic sensor was installed (by (local GA officer (OM)) to record air-blasts of a seismic vessel for a day. No baseline jumps or contamination apparent for the period and only about 30mins of data contaminated by installation.
Oct 28	Absolute observations could not be performed due to bee hive in lock of ABSOLUTE HOUSE. (There have still been no permanent repairs to hut.) Bees removed by pest controller on 29 October 2004.

Data losses in 2004

Jan 25	0313–0618 (3h 06m) XYZ channels: Power loss
	0313 to 29/0257 (3d 23h 45m) F channel: Power loss after which PPM failed to start on reboot.
Jan 29	1857 to Feb 02/0248 (3d 07h 52m) F channel: Memory full
Feb 02	0251–0252 (2 min) F channels: Memory full.
Mar 07	0820–0952 (1h 33m) All channels: Observatory broken into and UPS stolen.
Mar 08	0125–0131 (7 min) F channels: System tests.
Mar 08	0142–0226 (45 min) All channels: Contamination due to repairs
Mar 09	0250–0645 (3h 56m) All channels: Contamination due to repairs.
Mar 10	0300–0312 (13 min) All channels: Contamination due to repairs
Mar 10	0340–0416 (37 min) All channels: Contamination due to repairs.
Mar 11	0052–0058 (7 m) All channels: Contamination due to repairs
Mar 18	0140–0246 (1h 07m) All channel: Power loss associated with observatory being broken into.
Mar 18	0247 to 23/0530 (5d 02h 44m) F channel: PPM failed to restart after power loss.
Mar 23	0532 to Apr 06/0650 (14d 01h 19m) XYZ channels: Variometer switched off.
Mar 23	0539–0548 (10 min) F channel: System modifications.
Apr 06	0000-0650 (6h 51m) XYZ channels: EDA switched on at 0650.
Apr 06	0633–0650 (18 min) F channel: Data contamination.
Apr 07	0110–0113 (4 min) All channel: Data contamination.
May 16	0731–0734 (4 min) F channel: Data contamination.
May 19	0608–0617 (10 min) F channel: Data contamination.

Data losses in 2004 – GNA (cont.)

Sep 05 0038 (1 min) All channels: PC rebooted

Oct 06 0249–0304 (16 m) All channels: Data contamination.

Oct 21 0145–0252 (1h 08m) All channels: Data contamination.

K indices

K indices from the Gnangara Magnetic Observatory contribute to the global am-index, and its derivatives.

The table on the next page shows K indices for Gnangara for 2004.

Throughout 2004 K indices for Gnangara were derived using a computer assisted method developed at GA. The method, based on the IAGA accepted LRNS algorithm, is described in the *Data Distribution* section near the beginning of this report.

Notes and Errata (cumulative since *AGR'93*)

The *AGR1999* (p.40) and *AGR2000* (p.42) both show the same incorrect value in the table entitled *Gnangara Annual Mean Values*. The H component value given for the International Quiet Day mean for 1999.5 incorrectly shown as 23224 (in nT) should read **23234** (nT).

Distribution of GNA data

K indices (weekly):

- Regional Warning Centre (IPS) Sydney
- ISGI, Paris, France

Principal Magnetic Storms, Rapid Variations and K indices (monthly)

- World Data Center-A, Boulder, USA
- WDC-C2, Kyoto, Japan
- Ebro Observatory, Roquetas, Spain
- Regional Warning Centre, (IPS) Sydney

1-minute and Hourly Mean Values to WDCs

- 2003: WDC-A, Boulder, USA (8 Jun. 2004)
- 2003: WDC-C1, Copenhagen, Denmark (9 Jul. 2004)
- 2004: WDC-A, Boulder, USA (10 Jan. 2006)

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2004

1-minute values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- 2003 data: to Paris INTERMAGNET GIN (09 Jun 2004)
- 2004 data: to Paris INTERMAGNET GIN (04 Aug 2005)

Principal Magnetic Storms: Gnangara, 2004

Commencement			SC amplitudes			Maximum 3 hr. K index		Ranges			U.T. End	
Mth. Day	Hr.Min.	Type	D(')	H(nT)	Z(nT)	Day (3 hr. periods)	K	D(')	H(nT)	Z(nT)	Day	Hr.
Jan. 15	12 ··	···	··	··	··	15(6), 16(6,7)	5	19	64	106	18	12
22	01 36	ssc	7.7	14	29	22(5)	7	41	182	233	24	09
Feb. 11	09 ··	···	··	··	··	11(6)	6	30	110	122	16	03
Mar. 09	09 ··	···	··	··	··	09(6,7,8), 10(3), 11(6,7)	5	18	138	122	12	21
Jul. 22	10 36	ssc	2.1	12	11	25(5)	8	58	224	250	26	06
26	22 48	ssc*	12.9*	30*	53*	27(5)	8	59	241	323	28	06
Aug. 29	10 05	ssc	0.9	11	3	30(8)	6	26	143	177	31	23
Oct. 20	11 ··	···	··	··	··	20(5,6)	5	14	57	89	21	09
Nov. 07	10 52	ssc	4.4	37	15	8(1)	8	48	471	310	08	15
09	06 ··	···	··	··	··	10(4)	9	77	286	482	10	21

There were no Principle Magnetic Storms reported for GNA in Apr., May, Jun., Sep. and Dec., 2005

Rapid Variation Phenomena

Sudden Storm Commencements (ssc) - GNA 2004

Month & date	U.T.	Type &	Quality	Chief movement (nT) H	D	Z
Jan. 22	0136	ssc	B	–14	–52	–29
Apr. 10	2009	ssc	B	+24	+32	+27
Jul. 22	1036	ssc	A	+12	+14	+11
26	2248	ssc*	A	+30 *	+88 *	+53 *
Aug. 29	1005	ssc	B	+11	+6	+3
Sep. 13	2001	ssc	A	+36	+60	+41
Nov. 07	1052	ssc	A	+37	+30	+15
07	1825	ssc	A	+63	+74	+59
Dec. 05	0747	ssc*	A	+73 *	+26	+37

No *ssc* reported at GNA in Feb., Mar., May, Jun., and Oct., 2004

Solar Flare Effects (sfe) - GNA 2004

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Feb. 26	0154	0206	0231	+4	–13	–4	solar
26	2213	2235	2253	+3	–8	–3	solar
Jul. 15	0135	0149	0206	+7	+0.5	+3	solar
16	0204	0208	0212	+8	+0.8	+4	solar
Sep. 12	0136	0140	0143	–2	–0.3	–2	solar
Nov. 03	0124	0134	0144	+5	–1	–4	solar

No ***sfe*** reported at GNA in Jan., Mar.– Jun., Aug., Oct. and Dec., 2004.

K indices and Daily K sums at Gnangara (K=9 limit: 450 nT) for 2004

Date	January	February	March	April	May	June	Date
01	4233 4343 26	3221 4222 18	3232 3442 23	Q ---- ---- --	3212 1232 16	D 3232 3332 21	01
02	3222 3343 22	2133 3433 22	D 3232 3333 22	Q ---- ---- --	1102 1121 09	2221 3332 18	02
03	3344 3443 28	3333 4432 25	2213 4332 20	D ---- ---- --	1112 1232 13	1221 1113 12	03
04	3233 5433 26	3232 3323 21	2122 1221 13	---- ---- --	2131 3123 16	2211 3221 14	04
05	3233 4544 28	2223 2323 19	1112 0111 08	D ---- ---- --	D 2123 3533 22	2111 2233 15	05
06	3332 2334 23	2233 3342 22	Q 1101 0001 04	D ---4 4242 --	1121 2032 12	1223 3132 17	06
07	D 3245 4342 27	2123 3121 15	Q 1001 0122 07	1121 2233 15	D 2242 3332 21	1112 3222 14	07
08	Q 2112 2122 13	Q 1110 1112 08	Q 1121 0111 08	2224 3322 20	2103 3331 16	2213 2241 17	08
09	3243 4443 27	2110 3222 13	D 1223 3555 26	D 3332 2332 21	2201 2201 10	D 2224 3432 22	09
10	2343 4452 27	Q 2211 3312 15	D 3453 4243 28	2121 2144 17	1110 1132 10	2220 2142 15	10
11	2233 4441 23	D 3213 4653 27	D 4234 4554 31	3211 1231 14	3120 1244 17	1121 0210 08	11
12	Q 2211 3332 17	D 3444 4544 32	D 3332 3432 23	2121 1231 13	2420 1121 13	0110 1100 04	12
13	3222 5444 26	D 3333 5433 27	3223 4342 23	2113 3131 15	0232 2243 18	0011 0101 04	13
14	Q 4122 3232 19	3313 5432 24	3124 4242 22	1110 2211 09	1110 2111 08	1123 3331 17	14
15	2222 4544 25	D 3334 2433 25	2212 4442 21	1112 2223 14	2112 1212 12	D 3332 4332 23	15
16	D 3323 3553 27	3101 1121 10	3102 2332 16	1233 2333 20	Q 1011 1222 10	2222 2111 13	16
17	3224 3343 24	Q 1001 0212 07	2101 1232 12	2101 3321 13	Q 0000 1012 04	1112 1131 11	17
18	3323 2223 20	1100 1343 13	-321 3333 --	1231 3332 18	Q 1011 1000 04	1212 3211 13	18
19	3224 4433 25	3211 0233 15	3101 1232 13	2112 2121 12	1011 2432 14	1112 1100 07	19
20	3322 4533 25	Q 1101 1221 09	2211 3432 18	Q 1010 0022 06	D 2234 1123 18	Q 1110 0221 08	20
21	2233 5343 25	1101 4223 14	2224 4332 22	1220 1231 12	2221 1321 14	1010 1000 03	21
22	D 5446 7454 39	2111 4232 16	3222 2432 20	Q 1111 1121 09	1232 1211 13	Q 1000 0000 01	22
23	D 2244 4654 31	2111 3222 14	21-- ---- --	D 2234 5433 26	2112 3232 16	Q 0000 0011 02	23
24	3332 3333 23	3113 3332 19	Q ---- ---- --	1123 4221 16	2222 4111 15	0120 1000 04	24
25	D 4-33 5445 --	2003 1122 11	Q ---- ---- --	1233 2221 16	1112 1210 09	Q 0000 1020 03	25
26	3222 3443 23	Q 2000 2102 07	---- ---- --	1101 0221 08	Q 0001 1001 03	0111 2221 10	26
27	4232 4433 25	1213 2143 17	---- ---- --	1210 0221 09	Q 1221 0111 09	Q 1100 1112 07	27
28	4222 4332 22	2333 3333 23	---- ---- --	1021 1243 14	1111 2332 14	D 1212 1233 15	28
29	Q 2112 3112 13	D 3325 4333 26	---- ---- --	Q 1211 0011 07	D 1123 3333 19	D 3332 3343 24	29
30	2234 3433 24		---- ---- --	1121 1254 17	2213 2233 18	2233 3121 17	30
31	Q 2124 3112 16		---- ---- --		D 2223 3132 18		31
Mean K-sum	**24.0**	**17.7**	**18.1**	**14.2**	**13.3**	**12.0**	

Date	July	August	September	October	November	December	Date
01	2233 2322 19	3110 0033 11	2121 1222 13	0000 0111 03	2111 3101 10	3222 2322 18	01
02	1211 2322 14	0121 0122 09	1111 0211 08	1233 4321 19	Q 1001 1222 09	Q 2100 1221 09	02
03	1122 3121 13	Q 1100 0000 02	Q 1000 0110 03	0124 4334 21	2112 2333 17	Q 2110 1111 08	03
04	1112 0111 08	Q 0000 2100 03	Q 1001 1001 04	D 3222 2231 17	3321 1333 19	Q 1000 0000 01	04
05	2101 1122 10	0001 1212 07	1012 2332 14	1110 0121 07	Q 2110 0011 06	0253 2223 19	05
06	Q 1112 0000 05	1100 0011 04	D 1123 3422 18	0001 0001 02	Q 2011 0000 04	D 3222 4333 22	06
07	Q 0000 1021 04	2243 3232 21	3223 2221 17	Q 0000 1000 01	D 2214 3557 29	3222 3332 20	07
08	Q 0000 0000 00	Q 1110 0110 05	2121 2101 10	0021 2313 12	D 8776 4233 40	2213 3222 17	08
09	Q 1110 0010 04	1222 1342 17	0100 1011 04	3211 0111 10	D 4346 6676 42	1012 2332 14	09
10	0111 1221 09	D 3211 4332 19	Q 0100 0000 01	2202 2122 13	D 7579 6542 45	2221 2333 18	10
11	1012 3135 16	2213 2332 18	Q 0000 1111 04	2111 3223 15	3333 3333 24	2121 4343 20	11
12	3330 2124 18	2211 2212 13	Q 1100 0100 03	2121 1103 11	D 4444 3443 30	D 3233 3444 26	12
13	3331 2232 19	2111 2123 13	0000 0044 08	D 3333 5433 27	1023 2312 14	3232 1201 14	13
14	1211 2221 12	2222 1011 11	D 3334 4454 30	D 2234 4332 23	3111 2121 12	1222 4222 17	14
15	1100 0132 08	0100 0010 02	4212 3422 20	2112 3222 15	Q 1111 1001 06	2230 1413 16	15
16	1121 1223 13	0101 2221 09	D 3224 4342 24	1111 1002 07	1222 4423 20	1220 3334 18	16
17	4332 2022 18	2011 2432 15	D 3222 3324 21	Q 0000 0000 00	3122 1111 12	D 4333 3433 26	17
18	2121 0121 10	2121 1112 11	2212 2000 09	1000 1231 08	Q 1100 0111 05	3213 4221 18	18
19	0112 2223 13	1100 0121 06	1010 1123 09	1001 2212 09	1111 0222 10	Q 2110 0122 09	19
20	1211 2232 14	D 2132 2332 18	3132 2212 16	2221 5513 21	3223 4433 24	2111 2111 10	20
21	Q 1110 0200 05	D 2332 3233 21	2121 1112 11	3221 0012 11	3224 4422 23	2134 2333 21	21
22	1003 3356 21	3224 2322 20	D 1133 5432 22	2101 2311 11	2122 1122 13	D 3343 4332 25	22
23	D 4354 5521 29	2111 0221 10	2311 2221 14	Q 1000 1112 06	2001 2222 11	2111 2312 13	23
24	D 2243 5445 29	Q 2110 2120 09	2102 1221 11	2201 1342 15	2112 2212 13	Q 2010 1312 10	24
25	D 5457 8555 44	Q 0111 1210 07	1002 2211 09	3333 4322 23	3223 4332 22	3343 2322 22	25
26	D 6312 1136 23	1100 1111 06	1000 0022 05	Q 2000 0000 02	2122 2213 15	3222 2322 18	26
27	D 5567 8745 47	2110 1231 11	1001 2221 09	0010 2322 10	3123 2522 20	2221 1232 15	27
28	3322 4442 24	1222 0221 12	1221 0012 09	Q 2000 0111 05	2121 2323 16	3122 2352 20	28
29	2222 1111 12	1002 2111 08	2011 2222 12	1002 3342 15	3323 2444 25	3323 3313 21	29
30	1111 2223 13	D 2134 4546 29	2000 0020 04	D 3223 3422 21	3323 3343 24	D 3353 4422 26	30
31	2112 3321 15	D 3343 2432 24		D 2112 3421 16		1112 2212 12	31
Mean K-sum	**15.8**	**12.0**	**11.4**	**12.1**	**18.7**	**16.9**	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	0	14	67	87	61	15	2	1	0	0	1
February	17	53	59	76	21	5	1	0	0	0	0
March	12	37	55	44	23	6	0	0	0	0	71
April	14	72	63	35	11	2	0	0	0	0	43
May	28	90	79	42	8	1	0	0	0	0	0
June	47	80	66	41	6	0	0	0	0	0	0
July	38	75	67	32	12	15	4	3	2	0	0
August	51	81	73	31	10	1	1	0	0	0	0
September	62	70	70	22	14	2	0	0	0	0	0
October	64	65	64	40	12	3	0	0	0	0	0
November	20	59	68	51	23	5	6	6	1	1	0
December	19	49	90	69	18	3	0	0	0	0	0
ANNUAL TOTAL	**372**	**745**	**821**	**570**	**219**	**58**	**14**	**10**	**3**	**1**	**115**

Gnangara Annual Mean Values

The table below gives 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 & F are on the pages 58 & 59. See also *Notes and Errata* section for this observatory.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	ABC
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	ABC
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	ABC
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	ABC
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	ABC
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	ABC
2000.5	A	-2	13.6	-66	36	23230	23212	-903	-53682	58493	ABC
2001.5	A	-2	9.0	-66	34.7	23241	23225	-872	-53651	58468	ABC
2002.5	A	-2	4.7	-66	33.8	23245	23230	-843	-53622	58444	ABC
2003.5	A	-2	1.1	-66	33.4	23243	23229	-819	-53601	58424	ABC
2004.5	A	-1	57.3	-66	31.6	23260	23247	-794	-53562	58395	
1959.5	Q	-2	54.1	-65	52.4	23954	23923	-1213	-53482	58603	DHZ
1960.5	Q	-2	53.5	-65	52.1	23959	23928	-1209	-53480	58599	DHZ
1961.5	Q	-2	53.3	-65	52.7	23952	23922	-1207	-53491	58606	DHZ
1962.5	Q	-2	52.8	-65	53.0	23945	23915	-1203	-53490	58599	DHZ
1963.5	Q	-2	52.3	-65	54.0	23931	23901	-1199	-53497	58600	DHZ
1964.5	Q	-2	51.7	-65	54.9	23916	23886	-1194	-53501	58599	DHZ
1965.5	Q	-2	51.7	-65	55.3	23906	23876	-1194	-53497	58589	DHZ
1966.5	Q	-2	52.4	-65	56.3	23889	23859	-1198	-53499	58582	DHZ
1967.5	Q	-2	54.1	-65	57.4	23868	23837	-1208	-53499	58572	DHZ
1968.5	Q	-2	55.7	-65	58.6	23843	23812	-1218	-53494	58558	DHZ
1969.5	Q	-2	57.5	-65	59.7	23820	23788	-1229	-53488	58538	DHZ
1970.5	Q	-2	59.7	-66	1.2	23786	23754	-1243	-53475	58516	DHZ
1971.5	Q	-3	2.3	-66	2.2	23761	23728	-1259	-53461	58490	DHZ
1972.5	Q	-3	5.2	-66	3.9	23727	23693	-1278	-53454	58467	DHZ
1973.5	Q	-3	7.8	-66	6.2	23686	23651	-1293	-53460	58454	DHZ
1974.5	Q	-3	9.9	-66	9.0	23642	23606	-1305	-53477	58456	DHZ
1975.5	Q	-3	11.5	-66	11.3	23608	23571	-1314	-53496	58457	DHZ
1976.5	Q	-3	12.3	-66	14.2	23567	23530	-1318	-53528	58471	DHZ
1977.5	Q	-3	13.6	-66	17.0	23528	23491	-1324	-53557	58478	DHZ
1978.5	Q	-3	15.1	-66	20.5	23481	23443	-1332	-53596	58499	DHZ
1979.5	Q	-3	16.5	-66	23.1	23444	23406	-1339	-53624	58525	DHZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1346	-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	17.9	-66	36.5	23258	23219	-1338	-53772	58587	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	8.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	6.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	2.0	-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	23165	-1173	-53757	58547	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	ABC
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	ABC
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	ABC
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	ABC
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	ABC
1999.5	Q	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	ABC
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	ABC
2001.5	Q	-2	08.8	-66	34.1	23252	23235	-871	-53648	58470	ABC
2002.5	Q	-2	04.5	-66	33.1	23257	23242	-842	-53619	58446	ABC
2003.5	Q	-2	01.1	-66	32.7	23255	23241	-819	-53599	58426	ABC
2004.5	Q	-1	57.2	-66	31.0	23269	23256	-793	-53559	58396	ABC

* J = Jump due to change of observation site: jump value = old site value - new site value

continued on page 60 …

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Gnangara	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23241.3	-809.0	-53584.1	58412.9	23255.4	-1° 59.6'	-66° 32.4'
	5xQ days	23245.6	-807.8	-53581.9	58412.6	23259.6	-1° 59.4'	-66° 32.1'
	5xD days	23221.4	-811.9	-53589.8	58410.3	23235.7	-2° 00.1'	-66° 33.6'
February	All days	23243.7	-804.5	-53579.2	58409.3	23257.6	-1° 58.9'	-66° 32.1'
	5xQ days	23248.3	-804.4	-53577.3	58409.4	23262.2	-1° 58.9'	-66° 31.8'
	5xD days	23229.5	-807.6	-53582.4	58406.6	23243.5	-1° 59.5'	-66° 33.0'
March	All days	23240.3	-800.4	-53573.7	58402.9	23254.1	-1° 58.4'	-66° 32.2'
	5xQ days	23256.5	-799.1	-53569.9	58405.8	23270.3	-1° 58.1'	-66° 31.2'
	5xD days	23227.3	-800.4	-53575.2	58399.0	23241.1	-1° 58.4'	-66° 32.9'
April	All days	23244.7	-796.2	-53568.5	58399.8	23258.3	-1° 57.7'	-66° 31.8'
	5xQ days	23254.1	-794.0	-53564.9	58400.2	23267.6	-1° 57.3'	-66° 31.2'
	5xD days	23236.9	-799.8	-53572.4	58400.3	23250.7	-1° 58.3'	-66° 32.3'
May	All days	23248.3	-793.3	-53564.2	58397.2	23261.8	-1° 57.3'	-66° 31.5'
	5xQ days	23255.1	-792.1	-53563.0	58398.8	23268.6	-1° 57.1'	-66° 31.1'
	5xD days	23243.6	-792.6	-53564.2	58395.4	23257.1	-1° 57.2'	-66° 31.8'
June	All days	23254.4	-790.0	-53560.3	58396.1	23267.8	-1° 56.7'	-66° 31.1'
	5xQ days	23261.3	-790.5	-53557.5	58396.2	23274.7	-1° 56.8'	-66° 30.7'
	5xD days	23248.6	-789.0	-53562.0	58395.2	23262.0	-1° 56.6'	-66° 31.5'
July	All days	23236.9	-790.9	-53559.8	58388.7	23250.4	-1° 57.0'	-66° 32.1'
	5xQ days	23260.5	-791.5	-53554.9	58393.5	23273.9	-1° 56.9'	-66° 30.7'
	5xD days	23178.1	-792.2	-53571.1	58375.7	23191.6	-1° 57.5'	-66° 35.5'
August	All days	23241.6	-786.8	-53558.7	58389.4	23254.9	-1° 56.3'	-66° 31.8'
	5xQ days	23244.5	-787.6	-53558.4	58390.3	23257.8	-1° 56.4'	-66° 31.6'
	5xD days	23224.3	-789.1	-53560.1	58383.9	23237.7	-1° 56.8'	-66° 32.7'
September	All days	23251.4	-788.2	-53552.4	58387.5	23264.8	-1° 56.5'	-66° 31.1'
	5xQ days	23254.3	-788.1	-53554.1	58390.2	23267.6	-1° 56.5'	-66° 31.0'
	5xD days	23244.9	-787.2	-53553.0	58385.6	23258.2	-1° 56.4'	-66° 31.5'
October	All days	23262.1	-789.2	-53544.9	58385.0	23275.4	-1° 56.6'	-66° 30.4'
	5xQ days	23270.0	-788.3	-53541.4	58384.9	23283.3	-1° 56.4'	-66° 29.8'
	5xD days	23248.0	-790.4	-53549.3	58383.4	23261.5	-1° 56.8'	-66° 31.2'
November	All days	23237.1	-789.2	-53553.3	58382.8	23250.5	-1° 56.7'	-66° 31.9'
	5xQ days	23257.4	-789.2	-53545.6	58383.7	23270.8	-1° 56.6'	-66° 30.6'
	5xD days	23179.8	-791.1	-53568.7	58374.2	23193.4	-1° 57.3'	-66° 35.3'
December	All days	23257.9	-786.7	-53544.9	58383.3	23271.2	-1° 56.2'	-66° 30.6'
	5xQ days	23260.1	-784.8	-53543.3	58382.7	23273.4	-1° 56.0'	-66° 30.4'
	5xD days	23255.3	-786.9	-53546.6	58383.8	23268.6	-1° 56.3'	-66° 30.8'
Annual	All days	23246.6	-793.7	-53562.0	58394.6	23260.2	-1° 57.3'	-66° 31.6'
Mean	5xQ days	23255.6	-793.1	-53559.3	58395.7	23269.2	-1° 57.2'	-66° 31.0'
Values	5xD days	23228.1	-794.8	-53566.2	58391.1	23241.8	-1° 57.6'	-66° 32.7'

(Calculated: 14:52 hrs., Thu., 09 Feb. 2006)

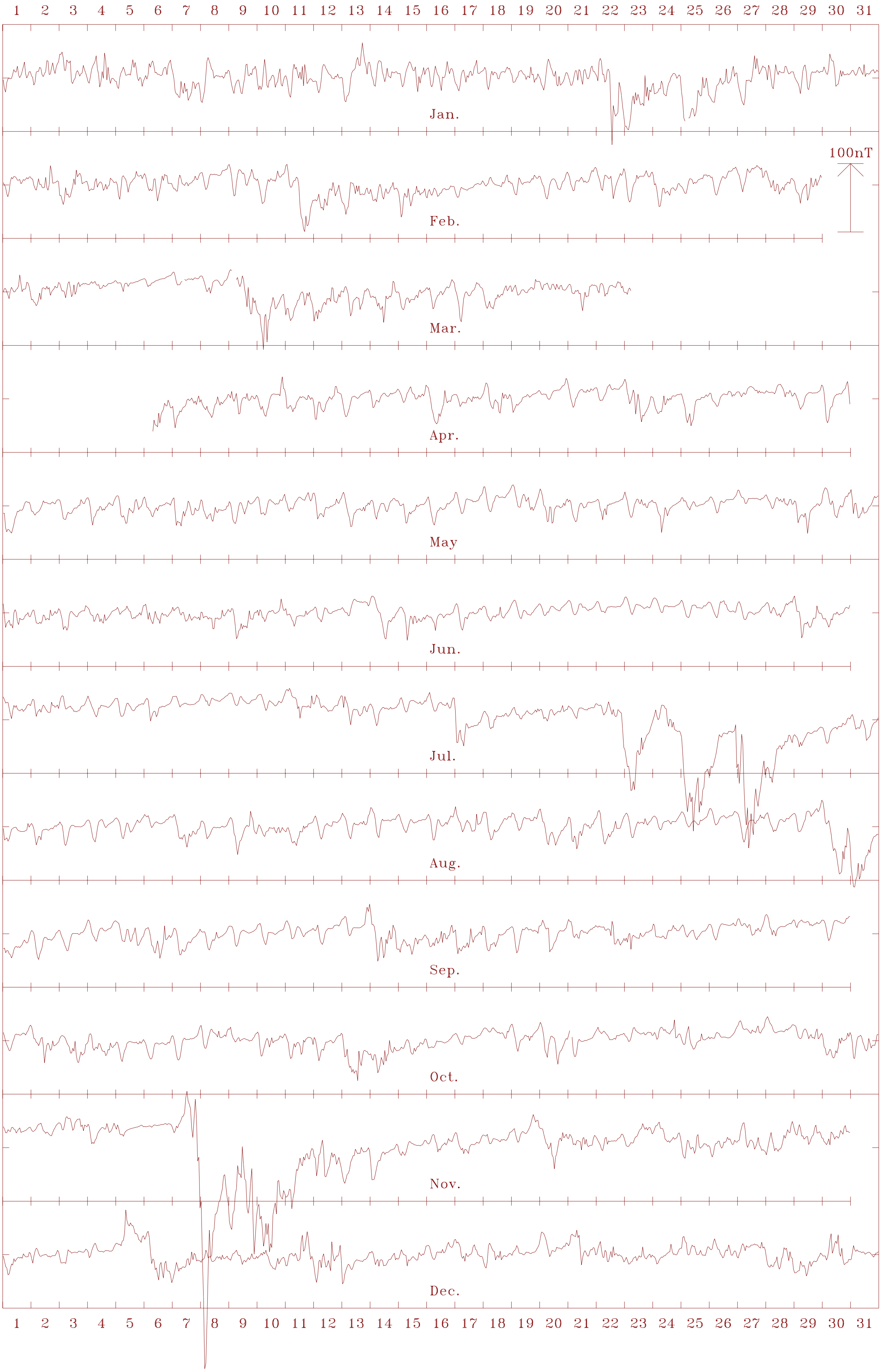
Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Gnangara 2004 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23260 nT

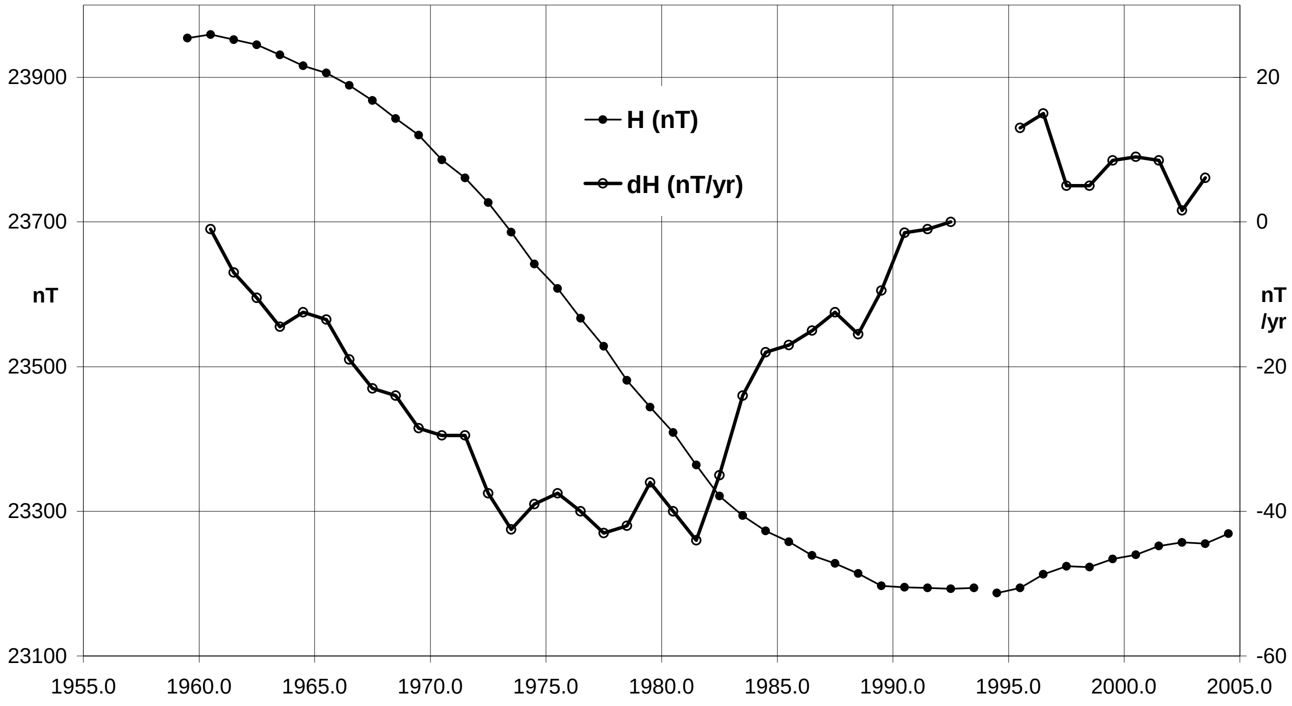


Gnangara 2004 Declination (east) (D). Scale: 1.00 min/mm. Mean: −1.96 deg.

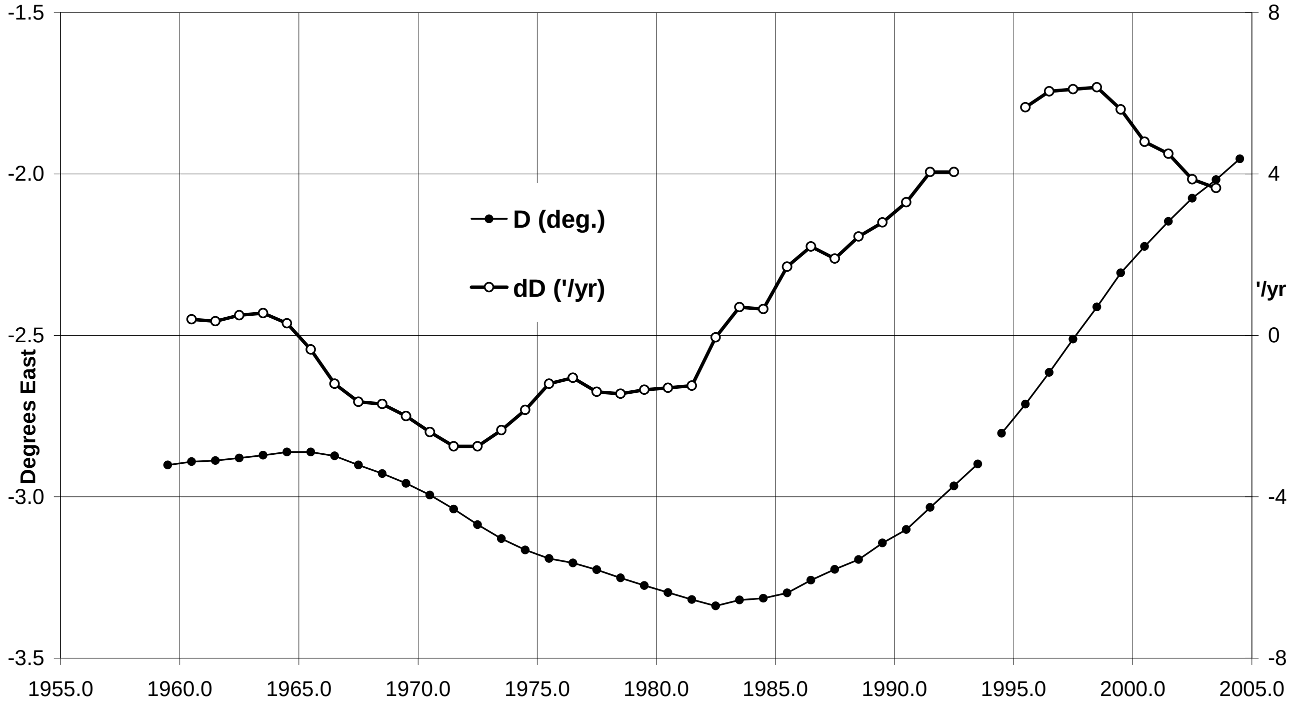
Gnangara 2004 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53562 nT

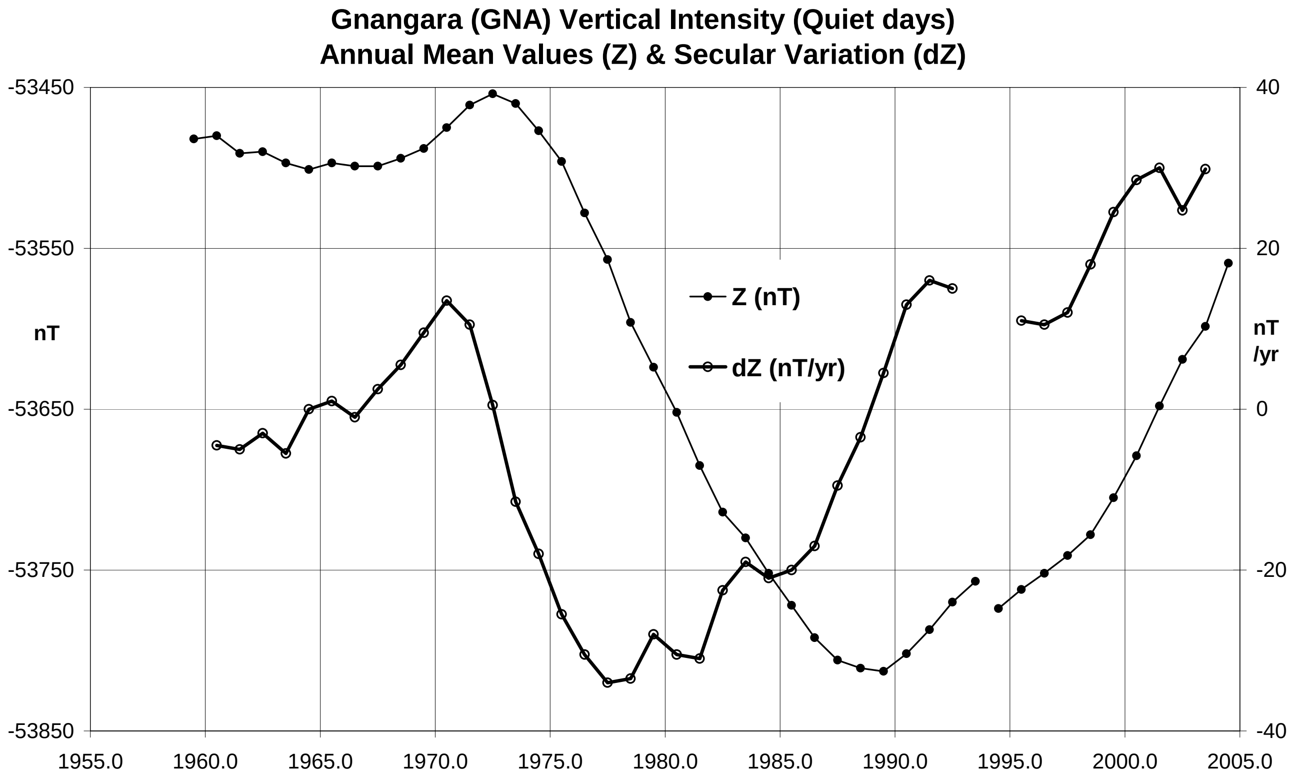
Gnangara 2004 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58395 nT

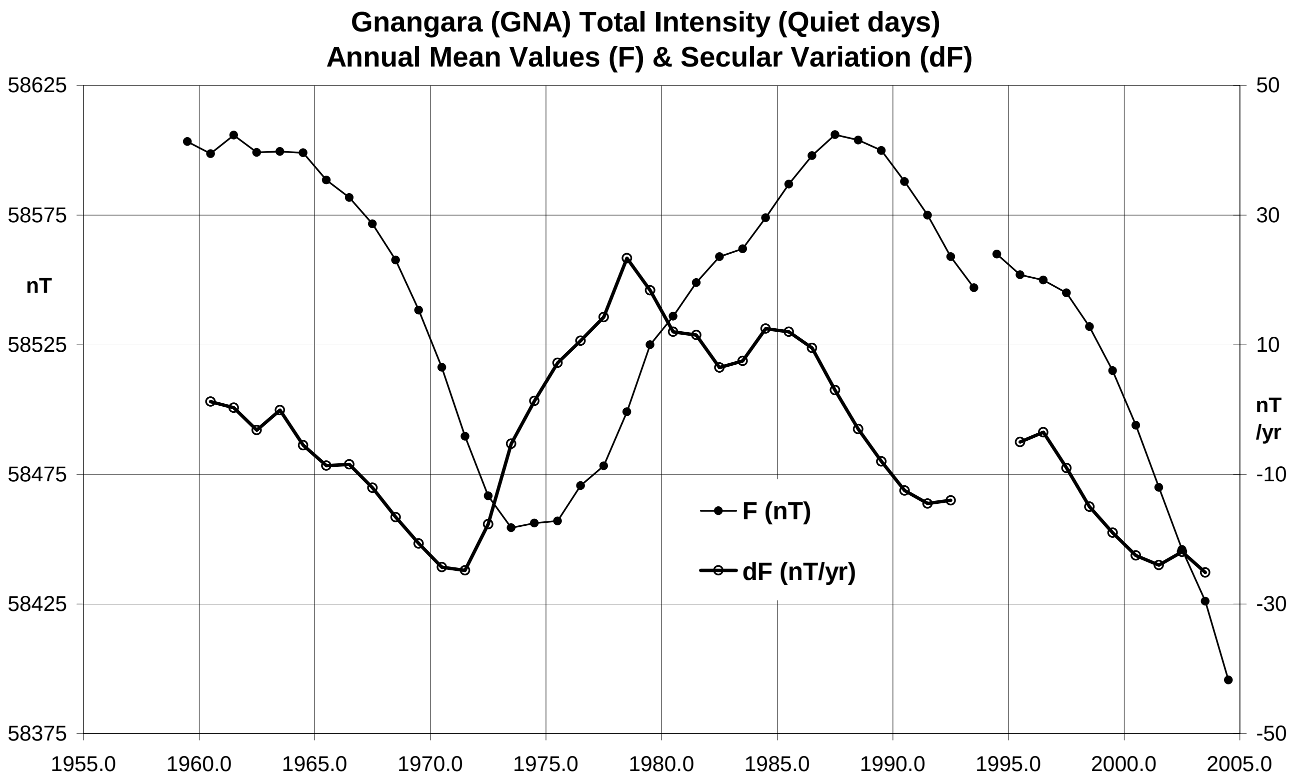
Gnangara (GNA) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)



Gnangara (GNA) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)




Gnangara (GNA) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-53450
-53550
-53650
-53750
-53850
nT
40
20
0
-20
-40
nT
/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
Z (nT)
dZ (nT/yr)


Gnangara (GNA) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)
58625
58575
58525
58475
58425
58375
nT
50
30
10
-10
-30
-50
nT
/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
F (nT)
dF (nT/yr)

Annual Mean Values – GNA (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	ABC
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	ABC
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	ABC
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	ABC
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	ABC
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	ABC
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	ABC
2001.5	D	-2	09.6	-66	36.0	23219	23203	-875	-53656	58465	ABC
2002.5	D	-2	04.9	-66	34.9	23227	23211	-844	-53627	58441	ABC
2003.5	D	-2	01.3	-66	34.5	23225	23210	-819	-53605	58420	ABC
2004.5	D	-1	57.6	-66	32.7	23242	23228	-795	-53566	58391	ABC

* J = Jump due to change of observation site: jump value = old site value - new site value

End of Part 1

Australian Government

Geoscience Australia

AUSTRALIAN GEOMAGNETISM REPORT 2004

MAGNETIC OBSERVATORIES

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Parliamentary Secretary: The Hon. Bob Baldwin MP
Department Secretary: Mark Paterson

Geoscience Australia

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Magnetic results for 2004

Kakadu

Charters Towers

Learmonth

Alice Springs

Gnangara

Canberra

Macquarie Island

Casey

Mawson

– and –

Australian Repeat Station Network

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During 2004 Geoscience Australia operated geomagnetic observatories 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.

The operations at Macquarie Island and Casey were the joint responsibility of the Australian Antarctic Division of the Commonwealth Department of the Environment and Heritage and GA. Operations at Mawson were the joint responsibility of the Australian Bureau of Meteorology of the Commonwealth Department of the Environment and Heritage and GA.

The absolute magnetometers in routine service at the Canberra Magnetic Observatory also served as the Australian Reference. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are referenced against those at Canberra

Magnetic mean value data at resolutions of 1-minute and 1-hour were provided to the World Data Centres for Geomagnetism at Boulder, USA (WDC-A) and at Copenhagen, Denmark (WDC-C1), as well as to the INTERMAGNET program. K indices, principal magnetic storms and rapid variations were scaled with computer assistance, for the Canberra and Gnangara observatories. The scaled data were provided regularly to the International Service of Geomagnetic Indices. K indices were digitally scaled for the Mawson observatory.

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

Seven repeat stations were re-occupied during a field survey within continental Australia in April and May 2004.

To assist the geomagnetism program in Indonesia, data were routinely received from the Tangerang and Tondano observatories for processing. These observatories were most recently upgraded by GA’s Geomagnetism personnel in 2001 under an AusAID grant that also included the purchase of instrumentation and the training of staff from Indonesia’s national meteorological and geophysical organisation, Badan Meteorologi & Geofisika (BMG).

This report describes instrumentation and activities, and presents monthly and annual mean magnetic values, plots of hourly mean magnetic values and K indices at the magnetic observatories and repeat stations operated by GA during calendar year 2004.

ACRONYMS and ABBREVIATIONS

AAD	Australian Antarctic Division
ACRES	Australian Centre for Remote Sensing
ACT	Australian Capital Territory
A/D	Analogue to Digital (data conversion)
ADAM	Data acquisition module produced by Advantech Co. Ltd.
AGR	Australian Geomagnetism Report
AGRF	Australian Geomagnetic Reference Field
AGSO	Australian Geological Survey Organisation (formerly BMR)
AMO	Automatic Magnetic Observatory
AMSL	Above Mean Sea Level
ANARE	Australian National Antarctic Research Expedition
ANARESAT	ANARE satellite (communication)
ASP	- Alice Springs (Magnetic Observatory) - Atmospheric & Space Physics (a program of the AAD)
AusAID	Australian Agency for International Development
BGS	British Geological Survey (Edinburgh)
BMR	Bureau of Mineral Resources, Geology, and Geophysics (Now Geoscience Australia)
BMG	Badan Meteorologi dan Geofisika (Indonesia)
BoM	(Australian) Bureau of Meteorology
CD-ROM	Compact Disk - Read Only Memory
CNB	Canberra (Magnetic Observatory)
CODATA	Committee on Data for Science and Technology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSY	Casey (Variation Station)
CTA	Charters Towers (Magnetic Observatory)
D	Magnetic Declination (variation)
DC	Direct Current
DEH	Department of the Environment and Heritage
DIM	Declination & Inclination Magnetometer (D,I-fluxgate magnetometer)
DMI	Danish Meteorological Institute
DOS	Disk operating system (for the PC)
DVS	Davis (Variation Station)
EDA	EDA Instruments Inc., Canada
e-mail	electronic mail
F	Total magnetic intensity
ftp	file transfer protocol
GA	Geoscience Australia
GIN	Geomagnetic Information Node
GNA	Gnangara (Magnetic Observatory)
GPS	Global Positioning System
GSM	GEM Systems magnetometer
H	Horizontal magnetic intensity
HDD	Hard disk drive (in a PC)
I	Magnetic Inclination (dip)
INTER-MAGNET	International Real-time Magnetic observatory Network
IAGA	International Association of Geomagnetism and Aeronomy
IBM	International Business Machines
IGRF	International Geomagnetic Reference Field
IGY	International Geophysical Year (1957-58)
IPGP	Institute de Physique du Globe de Paris
IPS	IPS Radio & Space Services (formerly the Ionospheric Prediction Service)
ISGI	International Service of Geomagnetic Indices
K	kennziffer (German: logarithmic index; code no.) Index of geomagnetic activity.
KDU	Kakadu, N.T. (Magnetic Observatory)
LRM	Learmonth, W.A. (Magnetic Obsv'ty)
LSO	Learmonth Solar Observatory
mA	milli-Amperes
MAW	Mawson (Magnetic Observatory)
MCQ	Macquarie Is. (Magnetic Observatory)
MGO	Mundaring Geophysical Observatory
MNS	Magnetometer Nuclear Survey (PPM)
nT	nanoTesla
N.T.	Northern Territory
OIC	Officer in Charge
PC	Personal Computer (IBM-compatible)
PGR	Proton Gyromagnetic Ratio
PPM	Proton Procession Magnetometer
PVC	poly-vinyl chloride (plastic)
PVM	Proton Vector Magnetometer
QHM	Quartz Horizontal Magnetometer
Qld.	Queensland
RCF	Ring-core fluxgate (magnetometer)
SC	Sudden (storm) commencement
sfe	Solar flare effect
ssc	Sudden storm commencement
Tas.	Tasmania
UPS	Uninterruptible Power Supply
UT/UTC	Universal Time Coordinated
W.A.	Western Australia
WDC	World Data Centre
WWW	World Wide Web (Internet)
X	North magnetic intensity
Y	East magnetic intensity
Z	Vertical magnetic intensity

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The *Australian Geomagnetism Report* has been published in electronic format since Volume 47 for calendar year 1999.

These volumes are available on Geoscience Australia's web site: http://www.ga.gov.au/

The final volume that was produced in printed format was the *Australian Geomagnetism Report 1998,* Volume 46.

Part 2

CANBERRA OBSERVATORY

The Canberra Magnetic Observatory is located in the Australian Capital Territory, approximately 30km east of the city of Canberra. The Canberra observatory is the successor to the Rossbank (1840-1854), Melbourne (1858-1919), Toolangi (1919-1979) observatory sequence of sites in south eastern Australia (McGregor, 1979; Hopgood, 1993).

Recording at the Canberra Magnetic Observatory commenced in 1978 after which it replaced Toolangi as the principal magnetic observatory in the region. A detailed history of the observatory is in *AGR 1994*.

Situated on an approximately 8 hectare site, the observatory comprises a complex of buildings and structures: a RECORDER HOUSE 60m north of the entry gate; a SECONDARY VARIOMETER HOUSE (formerly known as the (AMO or PPM) SENSOR HOUSE) 75m to its west; an ABSOLUTE HOUSE 60m NE of the RECORDER HOUSE; a COMPARISON HOUSE 10m west of the ABSOLUTE HOUSE; a VARIOMETER HOUSE 80m NW of the RECORDER HOUSE; a TEST HOUSE 220m north of the RECORDER HOUSE; and the NATIONAL MAGNETOMETER CALIBRATION FACILITY 100m SE of the RECORDER HOUSE.

Other structures on the site include a sheltered external observation site, four azimuth pillars and a seismic vault. The latter houses seismometers operated by GA's Geophysical Networks and Nuclear Monitoring groups.

Key data for Canberra Observatory:

- 3-character IAGA code: CNB
- Commenced operation: 1978
- Geographic latitude: 35° 18' 52.6" S
- Geographic longitude: 149° 21' 45.4" E
- Geomagnetic† : Lat. -42.50°; Long. 226.79°
- Lower limit for K index of 9: 450 nT
- Principal pier identification: Pier AW
- Elevation of top of Pier AW: 859 metres AMSL
- Azimuth of principal reference (NW pillar from Pier AW): 328° 37' 03"
- Distance to NW pillar: 137.3 metres
- Observers in Charge: L. Wang (GA)

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

During 2004 (since November 1995) a Narod ring-core fluxgate (RCF) variometer operated as the principal variometer at the observatory. It was located on the pier in the eastern room of the VARIOMETER HOUSE. It monitored variations in three orthogonal components of the magnetic field, and was aligned to measure the (magnetic) north-west; north-east and vertical field components, denoted A, B and Z respectively.

A GEM Systems GSM-90 Overhauser effect magnetometer (electronics no. 803810, sensor no. 81225) monitored variations in Total Intensity. Since 17 Nov 2003 this instrument has operated in the western room of the VARIOMETER HOUSE with its sensor mounted on a standard PPM tripod.

Both a LEMI and DMI (no. E0254/S0227) 3-component fluxgate variometers served as secondary instruments during 2004 should the principal variometer become unserviceable.

Damage caused to the observatory by vandals in 2004 necessitated the relocation of variometers several times during the year. The LEMI operated in the SECONDARY VARIOMETER HOUSE from the beginning of 2004 until 19 Feb. and from 17 Sep. to the end of the year. The DMI E0254 S227 operated in the NATIONAL MAGNETOMETER CALIBRATION FACILITY between 07 Apr. and 22 Sep. 2004.

The two intrusions by vandals caused damage to observatory buildings. Subsequent substantial security upgrades and building repairs that were carried out in June and July 2004 resulted in the contamination of Narod variometer data. No apparent baseline jumps occurred after these events or repair work.

The contaminated data were recovered from the backup variometers in the following UT time periods in 2004:

With DMI E0254 S0227:

June	11:	00:00 – 03:00;
	14:	22:00 – 23:30;
	17:	22:00 – 23:59;
	18:	00:18 – 01:00;
	21:	00:00 – 02:59
	28:	02:00 – 02:59
	29:	01:00 to 30 / 14:59
July	04:	00:00 – 00:59
	06:	23:00 to 09 / 05:59
	12:	04:30 – 05:29
	14:	00:00 – 05:59
	20:	00:00 – 00:59
Aug	09:	01:20 – 01:40
	25:	23:00 – 23:59

With the LEMI:

Oct	21:	01:00 – 01:59

Absolute Instruments and Corrections

Throughout 2004 absolute observations were regularly performed at Canberra with a Declination & Inclination Magnetometer (DIM) and a total field magnetometer.

The principal DIM used was an Elsec 810 (no. 200) electronics and sensor, with a Zeiss 020B (no. 353756) non-magnetic theodolite. This instrument was routinely used on ABSOLUTE HOUSE pier AW. In consideration of numerous intercomparisons between DIMs (and other magnetometers), zero corrections have been applied to absolute observations performed with the DIM Elsec 810/200; Zeiss 020B/353756.

The principal total field instrument used in 2004 was GSM90 Overhauser magnetometer with electronics no. 905926 and sensor no. 21867. (This sensor replaced no. 81241 in September 2002.) During 2004 this GSM90 magnetometer was used during regular absolute observations on pier AW in the ABSOLUTE HOUSE. Observations with this, the GSM90 reference, are used without correction.

The principal absolute magnetometers at the Canberra Magnetic Observatory also serve as the reference instruments for the Australian observatory network. Their standardizations are traceable to international standards that are regularly maintained. (See the *Reference Magnetometers* section near the beginning of this report.)

Absolute Instruments and Corrections – CNB (cont.)

During 2004 several pier difference comparisons were performed between pier AW and external GPS Station GS. The comparison results showed no evidence of magnetic contamination around the piers.

The total field intensity difference measured on 06 and 20 July 2004 using GSM90_905926 with sensor 21867 on both pier AW and Station GS, and calculated using the RCF as a base-station was:

F(AW) = F(GS) − 3.6 nT

The Declination and Inclination differences between these sites, measured using DIM E810_200/353756 on pier AW and DIM B0610h/160459 on a tripod 1.6 meter above station GS pad surface, and calculated using the RCF as a base-station, were:

D(AW) = D(GS) − 1.97' ± 0.01' (06 Jul. 2004)

D(AW) = D(GS) − 1.92' ± 0.03' (20 Jul. 2004)

I(AW) = I(GS) + 0.25' ± 0.01' (06 Jul. 2004)

I(AW) = I(GS) + 0.24' ± 0.02' (20 Jul. 2004)

Instrument corrections were not taken into account.

Baselines

The variometers remained reasonably stable throughout 2004. Over the year baselines drifted by approximately:

8 nT in X; 12 nT in Y; 3 nT in Z.

The drift patterns of three channels were very similar to those in 2002 and 2003, i.e. the Narod variometer baseline drifts appear to be seasonally dependent.

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

0.0 ± 0.7 in X; 0.1 ± 0.7 in Y; 0.0 ± 0.5 in Z.

There was less than 2.0 nT variation throughout the year in the F check calculated as the difference between F measured with the fluxgate (the final variometer model with drifts applied) and the variometer PPM.

Operations

Absolute observations were performed weekly (routinely on Tuesdays) by staff of the Geomagnetism Section on a roster. The rostered duties also included the computer-assisted hand-scaling and distribution of the previous week's K indices, and overseeing the transmission of 1-minute data from CNB (and other observatories) to INTERMAGNET.

The Narod RCF variometer was situated on pier (VE) in the east room of the VARIOMETER HOUSE that, for baseline stability, was maintained at a temperature of 26.5 ± 0.5°C throughout 2004. The temperature variation of the principal variometer sensors was 25.0 ± 0.5°C. Data from the RCF were transmitted via optical fibre to the RECORDER HOUSE where they were recorded on an acquisition PC.

The GSM90 Total Intensity variometer, serving as an F-check on the vector variometer model, was located in the west room of the VARIOMETER HOUSE. It was controlled from the RECORDER HOUSE, to where its data were transmitted via optical fibre and recorded on the acquisition computer.

See the CNB *Variometers* section of this report for a description of the deployment of a LEMI and a DMI fluxgate variometer that served as secondary vector instruments.

Since the beginning of 2001, digital data were retrieved automatically every 10 minutes from the CNB observatory to GA via a real-time data link using modems and the telephone line that was established on 20 July 2000. From 23 April 2001 data telemetry was via a radio modem link.

Operations (cont.)

Once the raw data were received at GA, processing was automatically scheduled, after which processed 1-minute resolution data were provided by e-mail to ISGI, France every 10 minutes (to enable the production of a real-time aa-index) and daily to the Edinburgh INTERMAGNET GIN.

System power was backed up with a UPS with an approximately 4-hour capacity.

Significant Events in 2004

05 Feb	Termite monitoring stations deployed by Sentricon. (Report received 03 Jun., 2004)
19 Feb	Intrusion by vandals caused damage to the SECONDARY VARIOMETER HOUSE. The LEMI variometer was removed from there for security reasons.
7 Apr	DMI E0254/S0227 variometer was installed in the NATIONAL MAGNETOMETER CALIBRATION FACILITY to serve as a backup variometer.
08 Jun	Commencement of security updates and repairs to the damaged SECONDARY VARIOMETER HOUSE.
21 Jun	CPC pest control inspected the SECONDARY VARIOMETER HOUSE for termites. No further action recommended.
30 Jun	Security updates and repairs to the SECONDARY VARIOMETER HOUSE completed. Break-in by vandals occurred again at 20:30 local time.
07 Jul	Repairs to buildings damaged again by vandals commenced.
16 Jul	Repairs to damaged buildings completed.
20 Jul	GPS survey, round of angles, station differences to pier AW were carried out about station GS.
25 Aug	Two non-magnetic internal door latches were installed in the PRIMARY VARIOMETER HOUSE.
17 Sep	LEMI variometer re-installed in the SECONDARY VARIOMETER HOUSE to replace DMI E0254/S0277.
13 Oct	Windows of the COMPARISON HOUSE were discovered to have been broken by vandalism.
19 Oct	Security signage installed on doors of all buildings, front gate, around fence. Broken window of the COMPARISON HOUSE was replaced.
16 Nov	Electronics of (Australian Reference) DIM E810_200 failed. No absolute observations performed this week.
23 Nov	DIM electronics E810_215 replaced E810_200 in the routine absolute observations.
14 Dec	Installation of fibre IP hub in CONTROL HUT rack and router in green radio box. Bottom lock repaired in door and intruder alarm installed in TOP HOUSE.

Data losses in 2004

05 Mar	1040 to 06/0153 (15h 14m) All channels: Power failure
07 Apr	0140–0153 (14m) Narod channels; 0147–0153 (7m) PPM channel: Instrument installation
20 Apr	0140–0153 (14m) Narod channels;
30 Jun	0135–0141 (6m) both Narod and backup variometer data contaminated.
21 Oct.	0133–0142 (10m) PPM channel.

Variometer PPM data were contaminated during the following periods (so excluded from INTERMAGNET data files):

Data losses in 2004 – CNB (cont.)

17 Jun	2210 to 18/0130
21 Jun	0000–0100
28 Jun	0200–0300
07 Jul	0200–0300
08 Jul	0000–0530
08 Jul	2200 to 09/0100
09 Jul	0400–0430
12 Jul	0440–0520
09 Aug	0100–0200
25 Aug	2300–2359

Distribution of CNB data

K indices - weekly by e-mail

- IPS Radio & Space Services, Sydney
- British Geological Survey, Edinburgh
- International Service of Geomagnetic Indices, Paris
- Royal Observatory of Belgium, Brussels
- CLS, CNES (French Space Agency), Toulouse

Distribution of CNB data (cont.)

K indices - semi-monthly by e-mail

- Adolph-Schmidt-Observatory Niemegk, Germany

K indices with Principal Magnetic Storms and Rapid Variations - monthly by email.

- World Data Center-A, Boulder, USA
- WDC-C2, Kyoto, Japan
- Ebro Observatory, Roquetas, Spain

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP.

Preliminary 1-minute values

- Sent every 10 minutes to ISGI, France throughout 2004

1-minute and Hourly Mean Values to WDCs

- 2003: WDC-A, Boulder, USA (19 January 2004)
- 2004: WDC-A, Boulder, USA (01 August 2005; and 10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail
- 2003 data sent to Paris GIN: 19 March 2004
- 2004 data sent to Paris GIN: 04 August 2005

Principal Magnetic Storms: Canberra, 2004

Commencement			SC amplitudes			Maximum 3 hr. K index		Ranges			U.T. End	
Mth. Day	Hr.Min.	Type	D(')	H(nT)	Z(nT)	Day (3 hr. periods)	K	D(')	H(nT)	Z(nT)	Day	Hr.
Jan. 22	01 36	ssc	-5.8	11	17	22(5)	7	26.2	219	78	24	03
Mar. 11	03 ..	...	..	..	..	11(6,7)	5	14.6	116	40	12	18
Apr. 05	12 ..	...	..	..	..	05(6,7)	5	15.9	135	63	06	18
Jul. 22	10 36	ssc	0.5	19	4	25(3)	7	39.8	203	144	26	09
26	22 48	ssc*	-6.1*	-58*	8*	27(3,4,5)	7	44.4	231	151	28	06
Aug. 29	10 05	ssc	0.6	14	4	30(6,7,8)	5	24.5	139	51	31	23
Nov. 07	10 52	ssc	2.0	53	13	07(7,8), 08(1,2,3)	7	44.5	387	340	08	18
09	03 ..	...	..	..	..	10(4)	8	55.2	301	220	10	21
Dec. 05	07 46	ssc*	2.2	114*	15*	05(3)	6	12.8	142	22	06	03
30	04 ..	...	..	..	..	30(3)	6	12.4	153	22	30	21

No Principal Magnetic Storms reported for Canberra in: Feb., May, Jun., Sep. or Oct., 2004

Rapid Variation Phenomena

Sudden Storm Commencements (ssc) - CNB 2004

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Jan. 22	0136	ssc	B	+11	–40	+17
Jul. 22	1036	ssc	A	+19	+4	+4
26	2248	ssc*	A	–58 *	–42 *	+8 *
Aug. 29	1005	ssc	B	+14	+4	+4
Sep. 13	2001	ssc	A	+32	+29	+4
22	0634	ssc	B	+30	+7	+2
Nov. 07	1052	ssc	A	+53	+14	+13
07	1827	ssc	A	+34	+64	+8
Dec. 05	0746	ssc*	A	+114 *	+15	+15

No ***ssc*** reported: Feb., Mar. – Jun. and Oct., 2004.

Solar Flare Effects (sfe) - CNB 2004

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Feb. 26	0154	0202	0232	–12	–2	+2	solar
26	2213	2240	2255	+1	–7	+1	solar
Jul. 15	0132	0140	0154	+4	–1	+4	solar
16	0159	0211	0234	+4	–1	+2	solar
22	0027	0034	0045	+2	–1	–1	solar
Sep. 12	0136	0140	0143	–2	–1	+1	solar

No ***sfe*** reported: Jan., Mar. – Jun., Aug., Sep., Oct. – Dec. in 2004.

K indices

K indices from the Canberra Magnetic Observatory contribute to the global Kp and aa indices, the southern hemisphere Ks index, and all their derivatives.

The table on the next page shows K indices for Canberra for 2004.

From 01 December 2002 K indices for Canberra were derived using a computer assisted method developed at GA. The method, based on the IAGA accepted LRNS algorithm, is described the *Data Distribution* section near the beginning of this report. (Before this K indices were derived by the hand scaling of H and D traces on magnetograms produced from the digital data, using the method described by Mayaud (1967).)

Canberra Annual Mean Values

The table below gives 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 & F are on pages 71 & 72.

Year	Days	D		I		H	X	Y	Z	F	Elts*
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
1979.5	A	12	05.6	-66	05.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	08.6	-66	06.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	09.1	23770	23234	5018	-53771	58791	DFI
1982.5	A	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	DFI
1983.5	A	12	16.6	-66	11.3	23723	23180	5044	-53756	58758	DFI
1984.5	A	12	18.4	-66	11.7	23709	23164	5054	-53741	58739	DFI
1985.5	A	12	20.7	-66	11.6	23703	23155	5067	-53726	58723	DFI
1986.5	A	12	23.2	-66	12.1	23689	23137	5081	-53716	58707	DFI
1987.5	A	12	25.5	-66	12.0	23684	23129	5096	-53699	58690	DFI
1988.5	A	12	27.6	-66	12.8	23665	23107	5106	-53690	58674	DFI
1989.5	A	12	29.0	-66	13.8	23644	23085	5111	-53683	58659	DFI
1990.5	A	12	30.7	-66	13.6	23641	23079	5121	-53667	58643	DFI
1991.5	A	12	31.8	-66	13.9	23628	23066	5126	-53652	58624	DFI
1992.5	A	12	32.4	-66	12.8	23637	23073	5132	-53625	58603	DFI
1993.5	A	12	33.0	-66	11.6	23646	23081	5138	-53597	58581	DFI
1994.5	A	12	33.5	-66	10.8	23649	23083	5142	-53571	58559	DFI
1995.5	A	12	33.8	-66	09.2	23665	23098	5148	-53540	58537	DFI
1996.5	A	12	34.2	-66	07.4	23684	23108	5154	-53507	58514	ABC
1997.5	A	12	34.2	-66	06.1	23695	23127	5157	-53476	58491	ABC
1998.5	A	12	34.2	-66	05.2	23698	23130	5157	-53444	58463	ABC
1999.5	A	12	34.1	-66	03.7	23709	23140	5159	-53403	58429	ABC
2000.5	A	12	34.2	-66	02.9	23706	23139	5160	-53367	58396	ABC
2001.5	A	12	34.7	-66	01.5	23716	23146	5164	-53327	58362	ABC
2002.5	A	12	35.1	-66	00.5	23718	23148	5168	-53291	58331	ABC
2003.5	A	12	35.5	-66	00.3	23710	23139	5169	-53264	58303	ABC
2004.5	A	12	35.5	-65	58.8	23719	23149	5171	-53225	58271	ABC
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	23108	5155	-53506	58515	ABC
1997.5	Q	12	34.2	-66	05.6	23703	23135	5159	-53474	58492	ABC
1998.5	Q	12	34.3	-66	04.8	23706	23137	5159	-53443	58464	ABC
1999.5	Q	12	34.1	-66	03.2	23716	23148	5161	-53400	58430	ABC
2000.5	Q	12	34.3	-66	02.2	23718	23149	5162	-53365	58398	ABC
2001.5	Q	12	34.7	-66	00.9	23726	23156	5167	-53324	58364	ABC
2002.5	Q	12	35.1	-65	59.8	23730	23159	5171	-53289	58334	ABC
2003.5	Q	12	35.5	-65	59.5	23723	23152	5172	-53261	58306	ABC
2004.5	Q	12	35.5	-65	58.3	23728	23157	5173	-53223	58273	ABC
1979.5	D	12	5.6	-66	6.9	23816	23287	4990	-53782	58819	DFI
1980.5	D	12	8.4	-66	7.8	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

continued on page 73 …

K indices and Daily K sums at Canberra (K=9 limit: 450 nT) for 2004

Date	January	February	March	April	May	June	Date
01	3343 5343 28	2321 3212 16	2223 3432 21	Q 0111 2001 06	3133 2211 16	D 2243 4311 20	01
02	3322 3342 22	2233 4322 21	D 2243 3322 21	Q 0111 0000 03	1012 1111 08	2222 2332 18	02
03	3344 3233 25	3444 3332 26	1214 4312 18	D 0123 5454 24	0222 1231 13	2221 1103 12	03
04	3243 4432 25	2233 3312 19	1232 1111 12	4202 2112 14	2232 3122 17	2213 3311 16	04
05	3333 4333 25	2333 1222 18	211- ---- --	D 0111 4552 19	D 1224 2432 20	1212 2221 13	05
06	3342 2234 23	1334 3332 22	Q -111 0000 --	D 3444 4232 26	1222 2122 14	2223 2121 15	06
07	D 2354 4433 28	1123 3111 13	Q 0101 0111 05	2232 2223 18	D 2343 3321 21	2113 3221 15	07
08	Q 1112 2122 12	Q 0111 1112 08	Q 1232 0100 09	2234 3321 20	2223 3211 16	1113 1231 13	08
09	2343 3432 24	1022 3312 14	D 2323 4444 26	D 3443 2321 22	0102 3200 08	D 2134 2421 19	09
10	2443 4341 25	Q 1111 3212 12	D 2454 3223 25	1232 1123 15	1101 1111 07	2210 2031 11	10
11	2233 3421 20	D 2123 4542 23	D 2334 4553 29	2122 2211 13	2201 1133 13	2122 0210 10	11
12	Q 1211 3232 15	D 3444 3433 28	D 3433 3411 22	2232 1221 15	1331 2121 14	0210 1000 04	12
13	2222 5433 23	D 3333 4332 24	2233 4321 20	2212 2111 12	0243 2231 17	0011 0100 03	13
14	Q 3222 3232 19	2313 4422 21	2234 4331 22	2100 2101 07	1110 2100 06	1034 3221 16	14
15	1122 4434 21	D 3334 2423 24	3212 3332 19	1112 2222 13	1102 1201 08	D 2343 4321 22	15
16	D 2323 4443 25	2112 2111 11	1103 2321 13	1343 2322 20	Q 0011 1111 06	2132 2100 11	16
17	2323 3333 22	Q 0001 0202 05	1201 1021 08	1222 3221 15	Q 0001 1011 04	1112 1122 11	17
18	2331 3233 20	1111 1322 12	1322 3321 17	1232 4321 18	Q 1002 1000 04	1112 3220 12	18
19	2233 4423 23	3211 0122 12	2202 1122 12	1112 1100 07	1001 2331 11	1122 1100 08	19
20	2332 4422 22	Q 1000 1211 06	1211 2312 13	Q 1011 0001 04	D 1134 2222 17	Q 0010 0010 02	20
21	2342 4333 24	1102 3212 12	2324 4322 22	0211 1221 10	2211 2210 11	0010 1010 03	21
22	D 4456 7353 37	2112 4312 16	2232 2322 18	Q 0110 1011 05	0232 1211 12	Q 0101 0000 02	22
23	D 3345 4554 33	2112 2212 13	1121 0121 09	D 2344 4322 24	2212 3221 15	Q 0000 0000 00	23
24	2232 3322 19	2223 3333 21	Q 1200 0000 03	1124 3311 16	1133 4110 14	0120 1000 04	24
25	D 3434 4343 28	1103 1011 08	Q 0000 1222 07	2344 3211 20	1012 1100 06	Q 0000 1010 02	25
26	2323 4333 23	Q 2100 1001 05	1112 3333 17	1010 0220 06	Q 0101 1000 03	0001 2211 07	26
27	3133 3322 20	2323 2132 18	2223 3435 24	1211 0110 07	Q 1011 0000 03	Q 0000 1110 03	27
28	4322 3322 21	1343 3333 23	3433 3322 23	0010 1222 08	0011 2332 12	D 1113 2122 13	28
29	Q 2123 3113 16	D 1325 4323 23	1222 3311 15	Q 0101 0001 03	D 1124 3222 17	D 3233 3231 20	29
30	2344 3322 23		1234 4311 19	2121 1144 16	1124 2232 17	2233 3110 15	30
31	Q 1124 2111 13		1122 3232 16		D 3223 3121 17		31
Mean K-sum	22.7	16.3	16.7	13.5	11.8	10.7	

Date	July	August	September	October	November	December	Date
01	1133 2211 14	3110 0012 08	1112 2211 11	0001 0111 04	1112 3200 10	2332 1211 15	01
02	1111 2321 12	0122 1001 07	1111 0200 06	2234 4311 20	Q 0012 1112 08	Q 1110 1111 07	02
03	1122 3120 12	Q 0100 0000 01	Q 1100 0100 03	1124 4322 19	1113 2233 16	Q 1111 1111 08	03
04	1113 0000 06	Q 0000 1100 02	Q 0011 1000 03	D 2322 2222 17	2321 1212 14	Q 0000 1000 01	04
05	1101 1111 07	0012 2111 08	0013 2331 13	0120 0001 04	Q 1110 0000 03	1263 2232 21	05
06	Q 1113 1000 07	2110 0011 06	D 1134 3322 19	0012 0000 03	Q 1011 1010 05	D 2333 4433 25	06
07	Q 0010 1000 02	1244 4211 19	1223 2211 14	Q 0001 2000 03	D 1214 4477 30	3222 3333 21	07
08	Q 0000 0000 00	Q 0110 0000 02	1121 3100 09	0021 2312 11	D 7776 4233 39	2222 2212 15	08
09	Q 1110 0010 04	2222 1232 16	0101 1000 03	2111 1001 07	D 3455 6576 41	1112 2122 12	09
10	0112 1210 08	D 2111 3332 16	Q 0102 0000 03	1213 2011 11	D 6678 6542 44	1232 3323 19	10
11	2113 3124 17	1123 2221 14	Q 0000 1201 04	2221 3212 15	2333 3224 22	1122 5333 20	11
12	3220 2123 15	2111 2101 09	Q 2200 1100 06	1122 1102 10	D 3454 3433 29	D 2334 3533 26	12
13	3231 2232 18	1100 2122 09	0000 0034 07	D 2433 5422 25	1123 2212 14	4332 1111 16	13
14	0121 2110 08	1222 1111 11	D 3344 4443 29	D 2334 5321 23	2121 2121 12	1233 3222 18	14
15	1001 0112 06	0100 1000 02	2213 3322 18	2113 2111 12	Q 1110 0000 03	1230 1312 13	15
16	1011 1113 09	0101 1111 06	D 2234 4322 22	1211 1001 07	1233 4422 21	1321 3334 20	16
17	4333 3111 19	1001 2441 13	D 3323 4212 20	Q 0000 0000 00	1222 1000 08	D 3432 2323 22	17
18	1121 0121 09	1232 1001 10	3213 3000 12	0000 1221 06	Q 1000 1101 04	2323 3221 18	18
19	0213 2212 13	1100 1111 06	1011 1112 08	0101 2311 09	1220 1222 12	Q 1121 1011 08	19
20	1212 2221 13	D 2224 3321 19	2143 2201 15	2331 4412 20	3334 4433 27	1111 2001 07	20
21	Q 1110 0100 04	D 2343 2222 20	1233 1111 13	2321 0011 10	3234 4322 23	2144 2323 21	21
22	1013 3345 20	2234 2311 18	D 1132 5322 19	1211 2211 11	2222 1122 14	D 2444 4222 24	22
23	D 3355 4521 28	0111 1210 07	2311 3111 13	Q 0001 1111 05	2102 1212 11	1112 2212 12	23
24	D 3333 4324 25	Q 1001 2100 05	1012 2211 10	1211 1342 15	2123 2112 14	Q 2111 1312 12	24
25	D 4576 6644 42	Q 0001 1200 04	0003 2000 05	2233 3211 17	3333 4221 21	2443 2212 20	25
26	D 5323 1127 24	0000 1101 03	0000 0011 02	Q 1100 1000 03	1121 2212 12	2332 2322 19	26
27	D 6677 7635 47	1000 1121 06	0003 2221 10	0021 2221 10	2122 3322 17	1332 1122 15	27
28	3322 3232 20	2332 0110 12	2221 0012 10	Q 1100 0111 05	1232 2322 17	2133 2343 21	28
29	1222 1100 09	0102 1122 09	1011 3212 11	0003 3332 14	3333 3333 24	2334 3312 21	29
30	1111 2112 10	D 3234 4555 31	1000 1000 02	D 3334 3312 22	3433 3333 25	D 2364 5432 29	30
31	1212 3221 14	D 3444 3332 26		D 2213 3322 18		1111 2211 10	31
Mean K-sum	14.3	10.5	10.7	11.5	18.0	16.6	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	0	21	69	100	48	8	1	1	0	0	0
February	18	63	65	65	19	2	0	0	0	0	0
March	25	58	74	58	23	4	0	0	0	0	6
April	38	78	73	26	21	4	0	0	0	0	0
May	45	89	72	34	8	0	0	0	0	0	0
June	66	73	63	31	7	0	0	0	0	0	0
July	45	89	50	37	9	7	6	5	0	0	0
August	70	87	54	21	13	3	0	0	0	0	0
September	73	72	50	33	11	1	0	0	0	0	0
October	61	79	62	33	11	2	0	0	0	0	0
November	26	57	68	51	19	5	6	7	1	0	0
December	12	72	78	63	18	3	2	0	0	0	0
ANNUAL TOTAL	479	838	778	552	207	39	15	13	1	0	6

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

CANBERRA	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23147.3	5168.4	-53244.1	58287.6	23717.4	12° 35.2'	-65° 59.4'
	5xQ days	23151.4	5169.5	-53244.7	58289.9	23721.6	12° 35.2'	-65° 59.2'
	5xD days	23129.9	5162.6	-53246.9	58282.8	23699.1	12° 34.9'	-66° 00.4'
February	All days	23149.3	5169.4	-53240.4	58285.1	23719.4	12° 35.3'	-65° 59.2'
	5xQ days	23155.0	5171.5	-53237.7	58285.1	23725.5	12° 35.4'	-65° 58.8'
	5xD days	23137.2	5163.1	-53242.2	58281.4	23706.3	12° 34.8'	-65° 59.9'
March	All days	23146.7	5171.1	-53233.6	58278.0	23717.3	12° 35.6'	-65° 59.1'
	5xQ days	23160.7	5175.2	-53230.1	58280.7	23731.8	12° 35.7'	-65° 58.3'
	5xD days	23134.7	5167.8	-53236.5	58275.6	23704.9	12° 35.5'	-65° 59.9'
April	All days	23146.3	5172.8	-53230.4	58275.1	23717.3	12° 35.9'	-65° 59.1'
	5xQ days	23156.9	5175.4	-53227.8	58277.2	23728.2	12° 35.9'	-65° 58.4'
	5xD days	23137.4	5169.3	-53230.8	58271.6	23707.9	12° 35.6'	-65° 59.6'
May	All days	23152.5	5172.9	-53226.5	58274.0	23723.4	12° 35.7'	-65° 58.6'
	5xQ days	23159.1	5174.9	-53225.0	58275.4	23730.2	12° 35.8'	-65° 58.2'
	5xD days	23148.3	5171.0	-53226.4	58272.1	23718.9	12° 35.5'	-65° 58.9'
June	All days	23156.1	5173.3	-53222.4	58271.7	23726.9	12° 35.6'	-65° 58.3'
	5xQ days	23163.3	5173.3	-53220.3	58272.6	23734.0	12° 35.4'	-65° 57.9'
	5xD days	23150.2	5172.4	-53223.7	58270.5	23721.0	12° 35.7'	-65° 58.7'
July	All days	23141.2	5168.0	-53222.0	58265.0	23711.3	12° 35.3'	-65° 59.2'
	5xQ days	23162.7	5172.1	-53216.8	58269.1	23733.1	12° 35.2'	-65° 57.9'
	5xD days	23090.8	5150.6	-53230.2	58251.0	23658.3	12° 34.5'	-66° 02.2'
August	All days	23144.3	5172.2	-53223.8	58268.2	23715.2	12° 35.8'	-65° 59.0'
	5xQ days	23146.4	5172.5	-53224.1	58269.3	23717.3	12° 35.8'	-65° 58.9'
	5xD days	23128.9	5169.0	-53225.6	58263.4	23699.5	12° 35.9'	-65° 59.9'
September	All days	23150.4	5172.8	-53217.9	58265.3	23721.3	12° 35.7'	-65° 58.5'
	5xQ days	23154.2	5172.6	-53217.9	58266.7	23724.9	12° 35.6'	-65° 58.3'
	5xD days	23143.5	5172.9	-53220.0	58264.4	23714.5	12° 36.0'	-65° 59.0'
October	All days	23158.4	5172.5	-53210.6	58261.8	23729.1	12° 35.4'	-65° 57.9'
	5xQ days	23164.9	5174.8	-53208.7	58262.9	23735.9	12° 35.6'	-65° 57.5'
	5xD days	23145.7	5169.4	-53212.7	58258.4	23715.9	12° 35.4'	-65° 58.7'
November	All days	23135.5	5166.8	-53219.8	58260.6	23705.4	12° 35.3'	-65° 59.4'
	5xQ days	23153.4	5171.6	-53211.0	58260.1	23724.0	12° 35.5'	-65° 58.2'
	5xD days	23083.4	5155.1	-53236.4	58254.1	23652.1	12° 35.3'	-66° 02.7'
December	All days	23155.1	5169.7	-53210.5	58260.1	23725.2	12° 35.1'	-65° 58.1'
	5xQ days	23157.8	5172.3	-53211.0	58261.9	23728.4	12° 35.4'	-65° 58.0'
	5xD days	23153.3	5167.5	-53210.9	58259.6	23723.0	12° 34.9'	-65° 58.3'
Annual	All days	23148.6	5170.8	-53225.2	58271.0	23719.1	12° 35.5'	-65° 58.8'
Mean	5xQ days	23157.1	5173.0	-53222.9	58272.6	23727.9	12° 35.5'	-65° 58.3'
Values	5xD days	23132.0	5165.9	-53228.5	58267.1	23701.8	12° 35.3'	-65° 59.8'

(Calculated: 14:49 hrs., Wed., 11 Jan. 2006)

Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

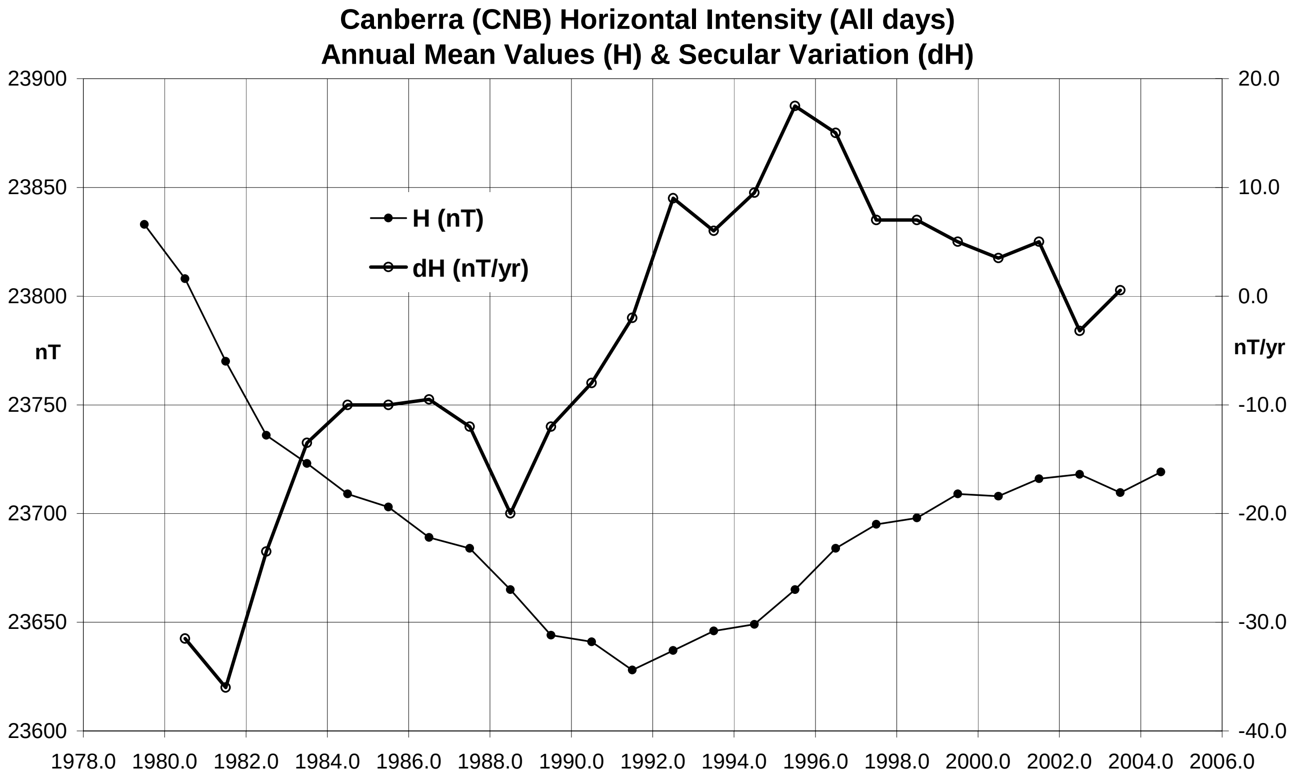
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

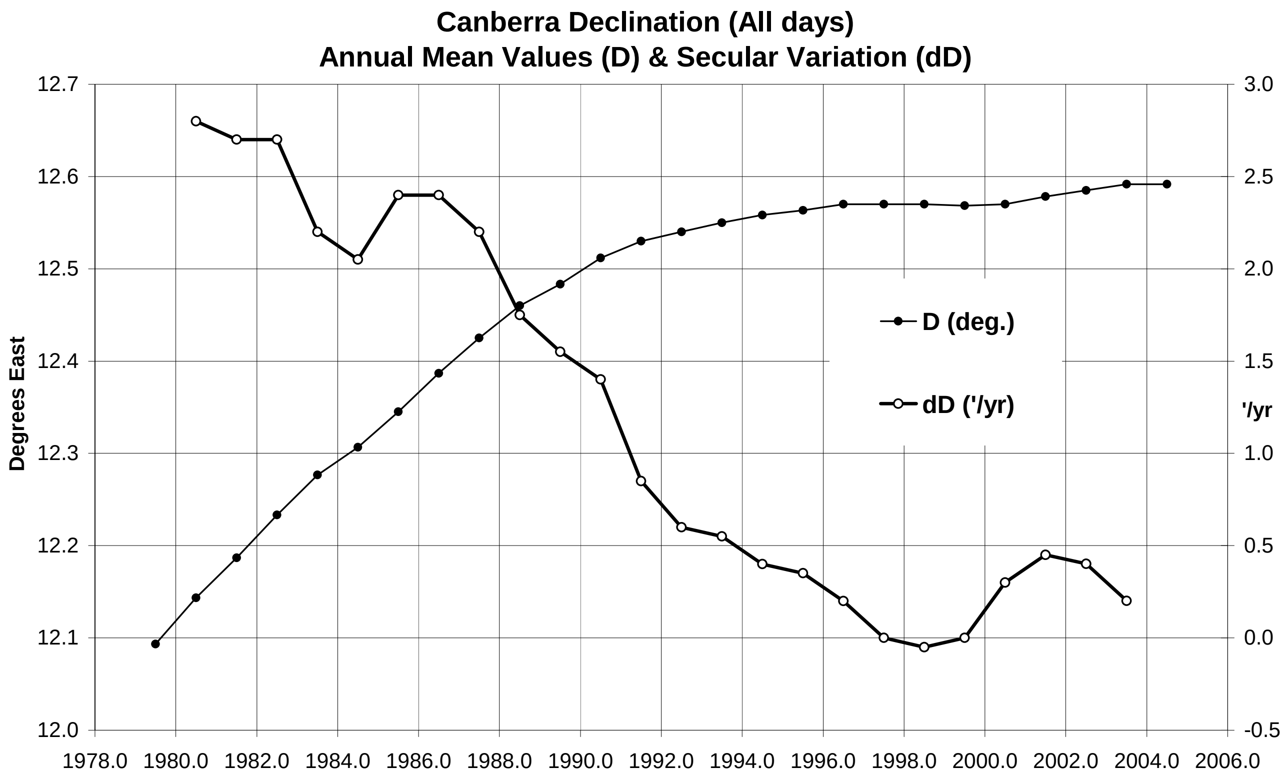
Canberra 2004 Horizontal intensity (H). Scale: 8.0 nT/mm. Mean: 23719 nT

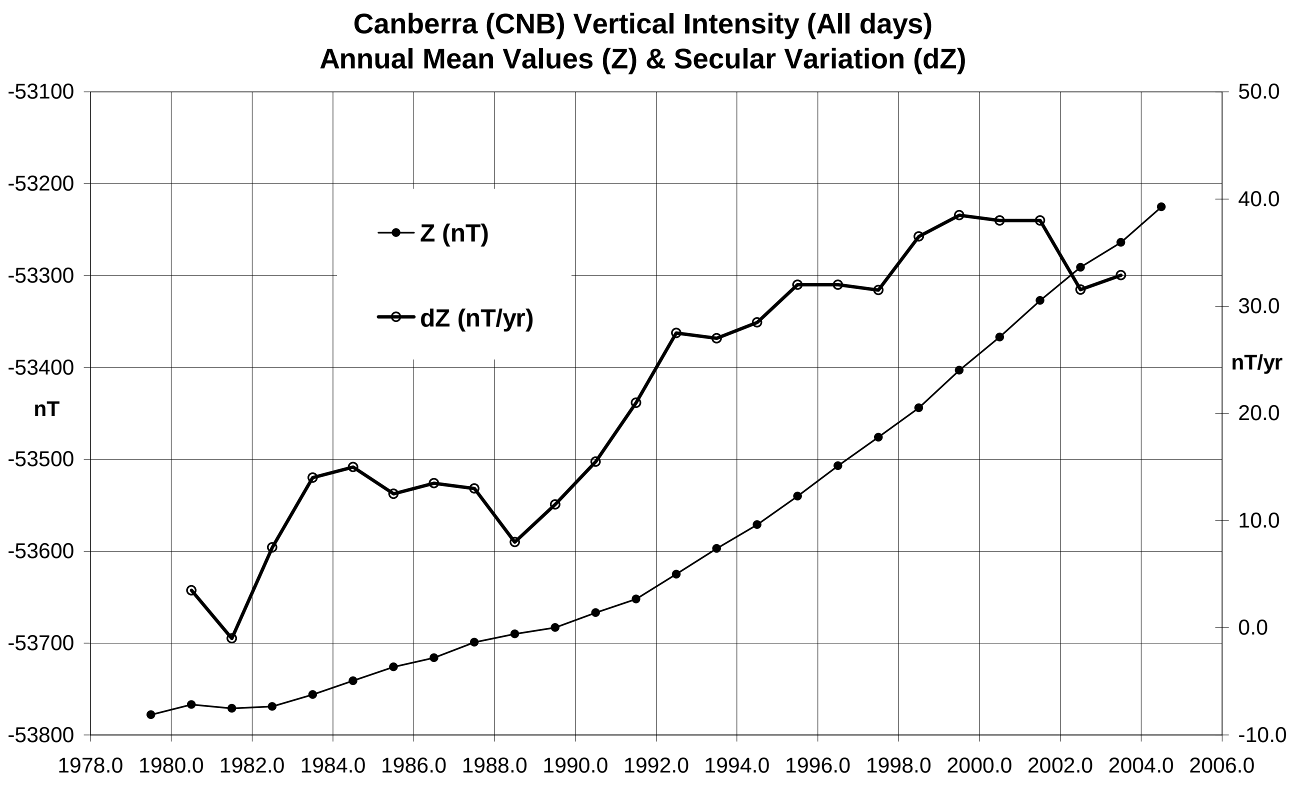
Canberra 2004 Declination (east) (D). Scale: 1.00 min/mm. Mean: 12.59 deg.

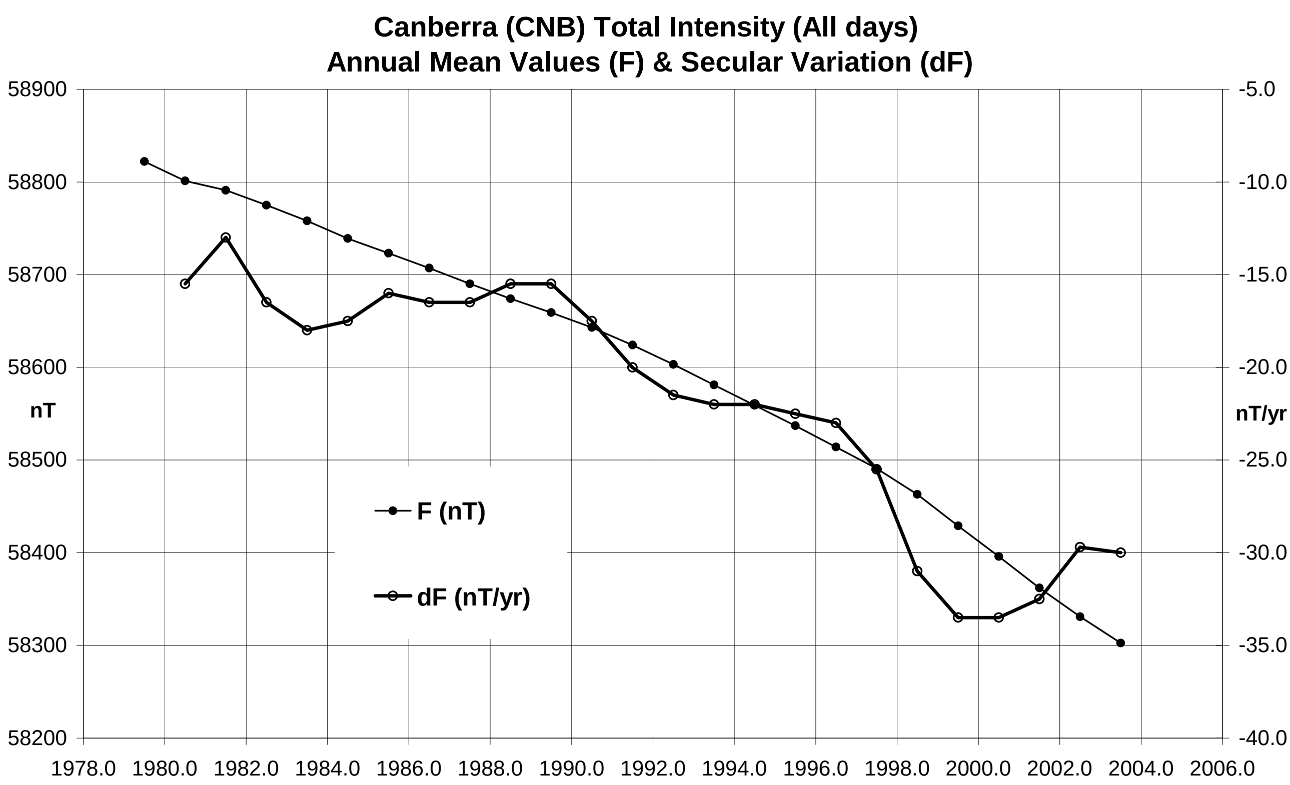
Canberra 2004 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −53225 nT

Canberra 2004 Total intensity (F). Scale: 5.0 nT/mm. Mean: 58271 nT


Canberra (CNB) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT/yr
23900
23850
23800
23750
23700
23650
23600
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
1978.0
1980.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Canberra Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
D (deg.)
dD ('/yr)
Degrees East
'/yr
12.7
12.6
12.5
12.4
12.3
12.2
12.1
12.0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1978.0
1980.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Canberra (CNB) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-53100
-53200
-53300
-53400
-53500
-53600
-53700
-53800
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
1978.0 1980.0 1982.0 1984.0 1986.0 1988.0 1990.0 1992.0 1994.0 1996.0 1998.0 2000.0 2002.0 2004.0 2006.0


Canberra (CNB) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
58900
58800
58700
58600
58500
58400
58300
58200
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
1978.0 1980.0 1982.0 1984.0 1986.0 1988.0 1990.0 1992.0 1994.0 1996.0 1998.0 2000.0 2002.0 2004.0 2006.0

Canberra Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
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	7.9	23676	23108	5152	-53508	58512	ABC
1997.5	D	12	34.1	-66	6.9	23683	23115	5154	-53479	58488	ABC
1998.5	D	12	34.2	-66	6.4	23678	23110	5153	-53450	58459	ABC
1999.5	D	12	34.1	-66	4.6	23692	23124	5156	-53407	58427	ABC
2000.5	D	12	34.2	-66	4.2	23685	23117	5155	-53372	58392	ABC
2001.5	D	12	34.6	-66	2.7	23695	23126	5159	-53331	58358	ABC
2002.5	D	12	35.2	-66	1.6	23700	23130	5165	-53296	58328	ABC
2003.5	D	12	35.4	-66	1.5	23688	23118	5163	-53266	58295	ABC
2004.5	D	12	35.3	-65	59.8	23702	23132	5166	-53229	58267	ABC

* Elements ABC indicates non-aligned variometer orientation

MACQUARIE ISLAND

Macquarie Island (Tasmania) is approximately 1,350 km. SSE of Hobart, about half way between Tasmania and the coast of the continent of Antarctica.

In December 1911 a magnetic station was first established at Caroline Cove at the southern end of Macquarie Island by Eric Webb. Another magnetic station, referred to as station A, was also established in 1911, on the Macquarie Island isthmus at the northern end of the island. Station A was re-occupied in 1930 by the British Australian New Zealand Antarctic Expedition (BANZARE) and again in 1948 by the first Australian National Antarctic Research Expedition (ANARE).

The Macquarie Island magnetic observatory was built at the ANARE station on the isthmus and magnetic recording has been continuous since 1952. The observatory was upgraded to produce digital data in October 1984. Data recording was upgraded to one second sampling rates in 1993. The Macquarie Island Magnetic Observatory was accepted as an INTERMAGNET Magnetic Observatory in March 2002.

The observatory consists of a VARIOMETER HOUSE some 100 metres south of the office in the station's Science building; an ABSOLUTE HOUSE about 30 metres further south; and a PPM VARIOMETER HOUSE between the VARIOMETER and ABSOLUTE HOUSES. During summer, the area around the huts is used by elephant seals for breeding, so all cables and power to the huts are routed underground.

Key data for Macquarie Island Observatory:

- 3-character IAGA code: MCQ
- Commenced operation: 1952
- Geographic latitude: 54° 30' S
- Geographic longitude: 158°57' E
- Geomagnetic†: Lat. -59.87°; Long. 244.01°
- Lower limit for K index of 9: 1500 nT
- Principal pier identification: Pier AE
- Elevation of top of Pier AE: 8 metres AMSL

Key data (cont.)

- Azimuth of principal reference (Pillar NMI from Pier AE): 353° 44' 13"
- Distance to Pillar NMI: ~200 metres
- Observers in Charge: H. Banon (2003/04), S. Redfern (2004/05)

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

The equipment employed to monitor magnetic variations at MCQ in 2004 included an Elsec 820M3 PPM for measuring the magnetic total intensity and a Narod 3-axis ringcore fluxgate (RCF) magnetometer. The RCF sensors, mounted on a marble '*tombstone'* base, were not aligned with either the standard field elements or cardinal points, but were oriented in such a way that the three mutually orthogonal components recorded were of approximately equal magnitudes. At Macquarie Island the magnetic field vector is approximately 11 degrees off-vertical and each ring-core sensor made an angle of approximately 55 degrees with the magnetic vector. Details of the *'tombstone'* RCF sensor base and the orientation of the sensors were given in the section on *Variometer Alignment* in *AGRs 1993-1996.*

The RCF sensors were located in the VARIOMETER HOUSE and the associated electronics were in the ante-room of that building. The VARIOMETER HOUSE temperature was controlled with a heating system. The variometer PPM sensor and electronics were situated in the PPM HOUSE, which had no temperature control. The data acquisition system and backup power were situated in the office, within the Science building.

On 19 August 2004 installation of a new DMI three axis fluxgate magnetometer commenced on the NE pillar of the VARIOMETER HOUSE. The new DMI magnetometer was in addition to the existing Narod RCF variometer on the SE pillar of the VARIOMETER HOUSE. The DMI electronics were housed in an insulated box on the floor of the VARIOMETER HOUSE.

Variometers – MCQ (cont.)

A wireless TCP/IP network link was installed to connect the VARIOMETER HOUSE to the Macquarie Island Local Area Network. An industrial PC running the QNX operating system was installed in the ante-room of the VARIOMETER HOUSE to acquire and log data from both the DMI variometer and also the Narod RCF variometer. The QNX PC was connected to the local network. A GPS clock was installed on the VARIOMETER HOUSE to provide accurate timing for the QNX data logging system.

The installation was completed on 30 August 2004. The original data logging system remained unaltered and data recorded from the Narod RCF and PPM magnetometers on the old acquisition system remained as the primary source of data throughout 2004.

Absolute Instruments and Corrections

Magnetic absolute measurements were performed in the ABSOLUTE HOUSE: on the principal pier AE with an Elsec 810 DIM (serial 214) and a Zeiss020B theodolite (serial 311847) and on pier AW with an Austral PPM (serial 525) until 17 May 2004. From 18 May a GSM90 proton magnetometer (serial 3091319 with sensor no. 01504) became the primary absolute total field magnetometer. An HP palmtop computer was used to communicate with the GSM90 magnetometer. The Austral PPM remained on-site as a back-up instrument.

The classical QHMs (serial 178, 179 on Askania circle 640616) were available as backup for use on pier AE.

A pier difference of:

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

was applied to adjust observations performed on pier AW to be equivalent to observations on the principal Pier AE. This was adopted from pier difference absolute observations performed in 1991 and 1993 (confirmed by 2003 observations).

Instrument comparisons between the Macquarie Island absolute instruments (E810_214/311847 DIM and Austral 525) and travelling reference instruments (B0806H/100856 DIM and GSM90_003985/11690) were performed at Macquarie Island on 24 and 26 Mar 2003. GSM90_3091319 was compared to the Australian Reference at Canberra Observatory on 02 Dec 2003

The results of the instrument comparisons were:

Travelling Reference		MCQ instrument		Inst. difference
GSM90_003985	–	Austral 525 PPM	=	+0.38nT (F)
B0806H/100856	–	E810_214/311847	=	+0.19' (D)
B0806H/100856	–	E810_214/311847	=	+0.04' (I)

Comparisons between the travelling reference instruments and the Australian Reference instruments were performed on 03-04 March 2003 at CNB observatory. These comparisons resulted in the adoption of instrument differences of:

0nT, 0.0' and 0.0' in F, D, and I respectively.

Corrections to the MCQ instruments are therefore:

Australian Reference		MCQ instrument		Inst. correction
GSM90_905926*	–	Austral 525	=	+0.38nT (F)
E810_200/353756	–	E810_214/311847	=	+0.19' (D)
E810_200/353756	–	E810_214/311847	=	+0.04' (I)
GSM90_905926*	–	GSM90_3091319**	=	0.0nT (F)

* with sensor 21867 ** with sensor 01504

At the mean 2004 field values at MCQ of 10823nT, 6456nT and -63134nT in X, Y and Z respectively, the instrument corrections adopted for the absolute magnetometers used at MCQ during that year convert to the baseline corrections:

01 Jan to 18 May 2004:

$\Delta X = +0.34$ nT $\Delta Y = +1.01$ nT $\Delta Z = -0.23$ nT.

18 May to 31 Dec. 2004:

$\Delta X = +0.28$ nT $\Delta Y = +0.97$ nT $\Delta Z = +0.15$ nT.

Absolute Instruments and Corrections (cont.)

These corrections have been applied to all MCQ 2004 final data including in this report.

Baselines

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

$\sigma_X = 1.5$ nT $\sigma_Y = 1.7$ nT $\sigma_Z = 1.2$ nT.

(In terms of the absolute observed components, they were:

$\sigma_F = 1.2$ nT $\sigma_D = 28"$ $\sigma_I = 5"$.)

The drifts applied to the X, Y, and Z baselines amounted to less than 20nT in any of these components throughout the 2004, with the Y component showing the most drift and the Z component the least drift. There were several sudden jumps in the baseline throughout 2004, the largest being 10nT in the X-component on 24 December 2004.

Throughout the year there was about 5nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM.

Operations

The magnetic observers-in-charge at Macquarie Island in 2004 were supported jointly by the Australian Antarctic Division (AAD) in the Department of The Environment and Heritage and GA. They were members of the Australian National Antarctic Research Expedition (ANARE).

The duties of the magnetic observer included maintaining the equipment, performing absolute observations to calibrate the variometers, and maintaining the integrity of the observatory and reporting any changes to GA in Canberra.

During 2004, weekly absolute calibrations were performed on the observation piers in the ABSOLUTE HOUSE by the ANARE communications technical officers: the 2003/04 officer (HB) (from 27 March 2003) until 07 March 2004; and the 2004/05 officer (SR) from 08 March 2004 (until 27 March 2005).

The RCF variometer produced 8 samples per second that were averaged and output as 1-second data. The PPM variometer produced 10-second samples. The 1-second RCF data and 10-second PPM data as well as 1-minute means of both were recorded on an acquisition PC. All data were automatically transmitted daily, via a network connection routed through the Australian Antarctic Division in Hobart Tasmania, to GA where they were processed and distributed. Timing control at the observatory was provided by the Antarctic Division's GPS clock (which was also used with Atmospheric and Space Physics experiments).

During August 2004 a wireless network connection was installed to connect the VARIOMETER HOUSE to the Macquarie Island Local Area Network; a second 3-axis fluxgate variometer, a DMI suspended FGE system digitised using an ADAM4017 A/D unit, was installed in the VARIOMETER HOUSE; a computer acquisition system running the QNX6.1 operating system was also installed in the VARIOMETER HOUSE, as was a GPS clock to provide timing for the new system.

The new computer acquisition system logged data from both the new DMI variometer and the existing Narod variometer. Data from this new dual system was automatically retrieved once per day via the network connection.

The existing DOS acquisition system continued unaltered, to log the Narod RCF data and E820 PPM data as the primary system. The installation of the new system caused contamination of the data from this primary system over the period 19−30 August 2004.

Distribution of MCQ data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP

1-minute and Hourly Mean Values to WDCs

- 2003 data: WDC-A, Boulder, USA (sent 03 Mar. 2004)
- 2004 data: WDC-A, Boulder, USA (sent 10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- 2003 data to the Paris GIN on 03 Mar. 2004
- 2004 data to the Paris GIN on 19 Aug. 2005

Significant Events in 2004

26 Jan.	2300 to 27/0100. Communications outage.
24 Feb.	No response from DOS acquisition PC. QNX4 is operating. Acquisition PC had failed.
25 Feb	03:52:54 (according to system clock but the timing was about 40 seconds slow) Replacement PC (old MACQ V0314 PC) was installed. Clock set remotely (from GA) at 22:18:00 although it may still be a few seconds out due to communications delays.
26 Feb	Local OIC set timing exactly and confirmed that one minute time marks were received. All communications to Antarctic stations were down due to fibre-optic problems in Sydney.
08 Mar	First observation by 2004/05 observer (SR).
18 May	First routine observations with GSM90_3091319 and 01504 using PDA for data communications. Instrument and pier comparisons performed with Austral525 and GSM90_3091319 PPMs.
21 May	New QNX6 computer networked in Science Building. Test being undertaken.
23 Jun	0220 (approx): Local observer (SR) entered the VARIOMETER HUT.
07 Jul	0116–0134 and 0148–0213: Local observer (SR) in VARIOMETER HUT to prepare for new equipment installations.
08 Jul	0430–0500: Local observer (SR) in VARIOMETER HUT.
11 Jul	2316–2326: Encroachment in magnetic quiet zone.
12 Jul	0000–0010: Encroachment in magnetic quiet zone A number of sudden jumps in XYZ throughout the day.
05 Aug	0342: Clock of QNX4 OS was set.
20 Aug	Installation of network link from Variometer to Communications Building
24 Aug	Problems with wireless network link WaveRider radios.
25 Aug	Radio link between VARIOMETER HUT and Science Building configured and working.
26 Aug	Steel bolts in radio link antenna mount on VARIOMETER HOUSE replaced with non-magnetic bolts. Power point installed in the roof space for the WaveRider radio link. Observations performed after all work completed.
27 Aug	Another new power point installed in VARIOMETER HUT by electrician who unknowingly tripped circuit breaker in Science Building causing the UPS to cut in. New variometer equipment installed, but sensor not yet aligned due to minor problems.
28 Aug	0003: Primary system restarted after UPS exhaused.
29 Aug	22:55:10 Primary system timing reset. Has been 5 seconds slow since restart on 28 August.

Significant Events (cont.)

31 Aug	- Numerous visits into VARIOMETER HUT to get new DMI system operational.
01 Sep	First absolute observation after DMI system installed.
03 Sep	0056: Gdap clock stopped and restarted as GPS clock not operating on Gdap.
11 Sep	2240 (approx.): Gdap system stopped data recording. PC is still running satisfactorily.
13 Sep	23:45 (approx.): Narod variometer connected to Gdap system. New installation photographed.
14 Sep	Gdap system rebooted to restart DMI logging and start Narod logging.
21 Sep	Fence at back of ABSOLUTE HUT found to have been damaged by seals.
Sep.	Seals knocked open the door to the PPM HUT. The exact date is not known.
01 Oct	Time on QNX4 acquisition system set. Approximately 500 1-second samples lost on primary Narod data between 1310 and 1338 (no whole minute of data was lost.)
20 Oct	0030–0545: Data (mostly F and Z) contaminated during repairs to ABSOLUTE HUT seal-fence.
21 Oct	0100–0255, 0430–0435: Repairs to ABSOLUTE HUT seal fence continued. Work on radio link in Science building. Gdap system rebooted.
25 Oct	Experiment with absolute GSM90 PPM tuning – left it on 64μT.
08 Nov	0133: Set QNX4 OS and RT clock at (OS clock was ~7 minutes fast)
23 Nov	0600: Network outage during maintenance at AAD in Hobart.
02 Dec	~0500: Timing set by local observer after it was noted that that the DOS system was about 5 seconds slow.
24 Dec	Could not communicate to QNX6 by telnet. System rebooted by local observer.

Data losses in 2004

22 Feb.	0000 to 25 / 0352 (3d 03h 53m) All data channels: Data acquisition PC failure.
07 Mar.	2201 (1 min.) F-channel only.
13 Jun	2048–2220 (1h 33m)
27 Aug.	0848 to 28 / 0003 (15h 16m) X,Y,Z channels;
	0848 to 28 / 0006 (15h 19m) F channel;
28 Aug.	0008 (1 min.) F-channel.

The data (all channels) acquired over the following intervals were contaminated and so omitted from processing:

13 Jun.	2045–2245 (2h 01m) RCF failure with X,Y,Z channels all a constant non-zero value.
09 Jul.	0434–1120 (6h 47m)
	2235–2245 (11 mins)
11 Jul.	1829–1850 (22 mins)
19 Aug.	2300 to 30 / 0300 (10d 04h 01m)
20 Oct.	0025–0515 (4h 51m)
21 Oct.	0145–0340 (1h 56m)
24 Dec.	0156–0157 (2 mins) RCF baseline jump.

Macquarie Island Annual Mean Values

The table below gives 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 & F are on pages 82 & 83.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
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
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

continued on page 84 …

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Macquarie Island	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	10805.2	6438.8	-63147.8	64388.5	12578.2	30° 47.5'	-78° 44.1'
	5xQ days	10828.2	6448.3	-63142.9	64388.3	12602.8	30° 46.4'	-78° 42.8'
	5xD days	10765.5	6421.1	-63182.5	64414.5	12535.3	30° 49.0'	-78° 46.7'
February	All days	10819.5	6444.0	-63146.0	64389.6	12593.1	30° 46.7'	-78° 43.3'
	5xQ days	10837.5	6453.7	-63142.5	64390.0	12613.6	30° 46.4'	-78° 42.2'
	5xD days	10780.2	6423.5	-63160.0	64394.8	12549.0	30° 47.4'	-78° 45.8'
March	All days	10812.3	6445.5	-63135.2	64377.9	12587.7	30° 48.0'	-78° 43.5'
	5xQ days	10840.9	6459.4	-63139.9	64388.6	12619.4	30° 47.3'	-78° 41.9'
	5xD days	10778.5	6428.5	-63128.4	64364.0	12550.0	30° 48.8'	-78° 45.4'
April	All days	10821.3	6454.4	-63144.1	64389.0	12600.0	30° 48.9'	-78° 42.9'
	5xQ days	10837.3	6462.0	-63144.8	64393.1	12617.7	30° 48.4'	-78° 42.0'
	5xD days	10771.0	6431.2	-63136.5	64371.0	12545.0	30° 50.5'	-78° 45.7'
May	All days	10834.0	6460.9	-63135.4	64383.3	12614.3	30° 48.6'	-78° 42.1'
	5xQ days	10839.5	6464.6	-63136.5	64385.6	12620.9	30° 48.7'	-78° 41.7'
	5xD days	10826.8	6456.2	-63125.7	64372.1	12605.7	30° 48.5'	-78° 42.4'
June	All days	10840.3	6463.8	-63131.0	64380.3	12621.2	30° 48.4'	-78° 41.7'
	5xQ days	10843.6	6465.6	-63128.7	64378.7	12624.9	30° 48.3'	-78° 41.4'
	5xD days	10837.5	6461.2	-63125.2	64373.8	12617.5	30° 48.2'	-78° 41.8'
July	All days	10815.4	6451.5	-63135.9	64379.8	12593.5	30° 49.0'	-78° 43.2'
	5xQ days	10845.2	6464.4	-63132.0	64382.1	12625.6	30° 47.8'	-78° 41.4'
	5xD days	10697.0	6390.5	-63150.5	64369.3	12461.1	30° 51.4'	-78° 50.3'
August	All days	10822.6	6462.6	-63133.6	64379.7	12605.4	30° 50.6'	-78° 42.5'
	5xQ days	10832.1	6464.9	-63138.3	64386.1	12614.7	30° 49.8'	-78° 42.1'
	5xD days	10757.5	6437.5	-63124.6	64357.7	12536.7	30° 53.9'	-78° 46.0'
September	All days	10830.7	6464.0	-63133.7	64381.3	12613.0	30° 49.8'	-78° 42.1'
	5xQ days	10834.1	6463.9	-63135.2	64383.3	12615.9	30° 49.3'	-78° 42.0'
	5xD days	10811.1	6458.7	-63129.4	64373.4	12593.5	30° 51.3'	-78° 43.1'
October	All days	10831.6	6465.0	-63120.2	64368.4	12614.3	30° 49.9'	-78° 41.9'
	5xQ days	10842.4	6470.7	-63120.6	64371.1	12626.5	30° 49.7'	-78° 41.3'
	5xD days	10816.5	6456.7	-63124.4	64369.2	12597.1	30° 50.1'	-78° 42.9'
November	All days	10814.7	6457.3	-63127.8	64372.3	12596.1	30° 50.5'	-78° 43.0'
	5xQ days	10834.2	6468.3	-63123.2	64372.1	12618.2	30° 50.3'	-78° 41.7'
	5xD days	10747.9	6426.8	-63121.4	64352.4	12524.0	30° 52.9'	-78° 46.7'
December	All days	10828.0	6462.8	-63119.0	64366.4	12610.0	30° 49.9'	-78° 42.1'
	5xQ days	10839.0	6468.0	-63122.2	64371.8	12622.1	30° 49.6'	-78° 41.5'
	5xD days	10810.1	6453.7	-63127.9	64371.3	12590.1	30° 50.3'	-78° 43.3'
Annual	All days	10823.0	6455.9	-63134.2	64379.7	12602.2	30° 49.0'	-78° 42.7'
Mean	5xQ days	10837.8	6462.8	-63133.9	64382.6	12618.5	30° 48.5'	-78° 41.8'
Values	5xD days	10783.3	6437.1	-63136.4	64373.6	12558.8	30° 50.2'	-78° 45.0'

(Calculated: 15:33 hrs., Fri., 15 Apr. 2005)

Hourly Mean Values

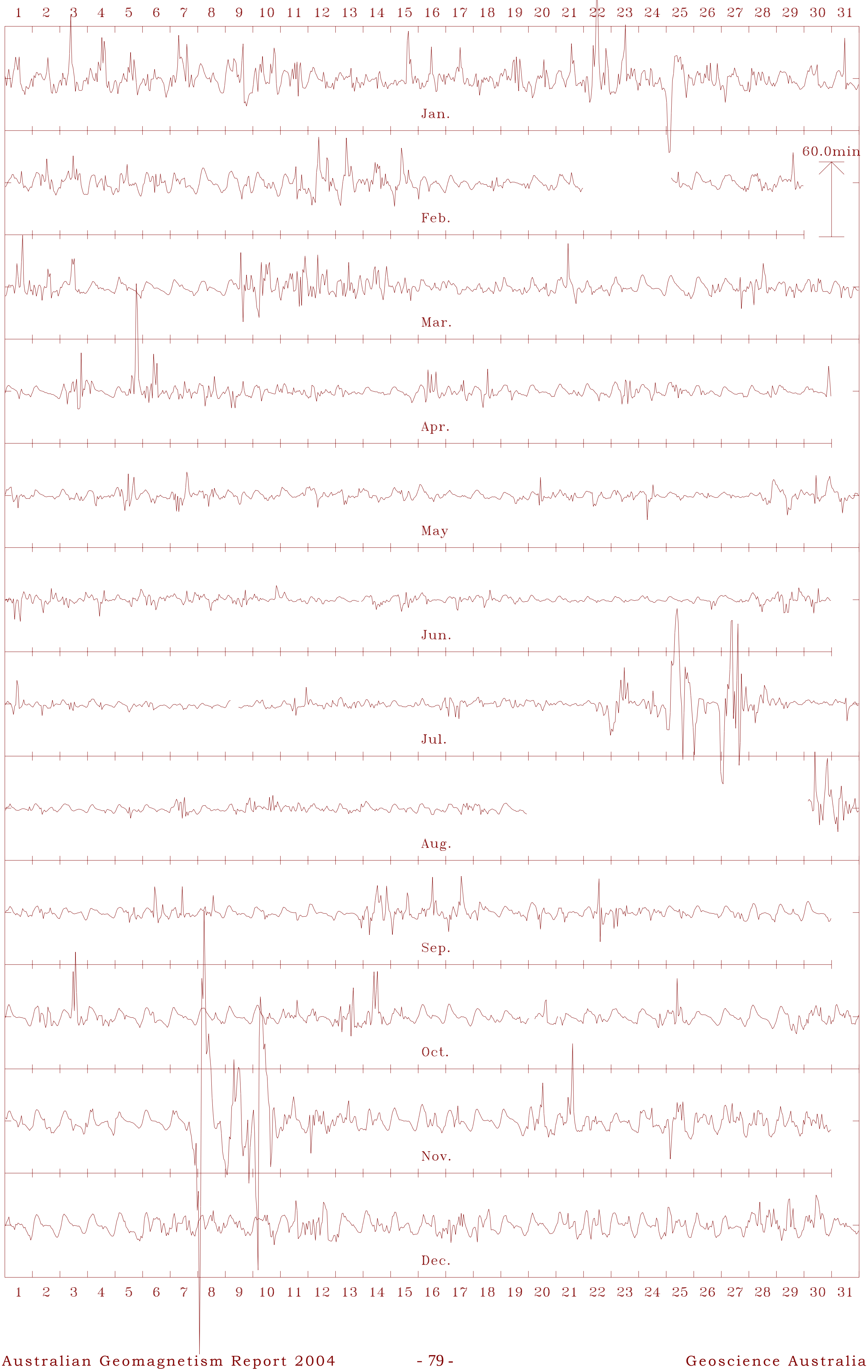
The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

The mean value given at the top of each plot is the *all-days* annual mean value of the element.

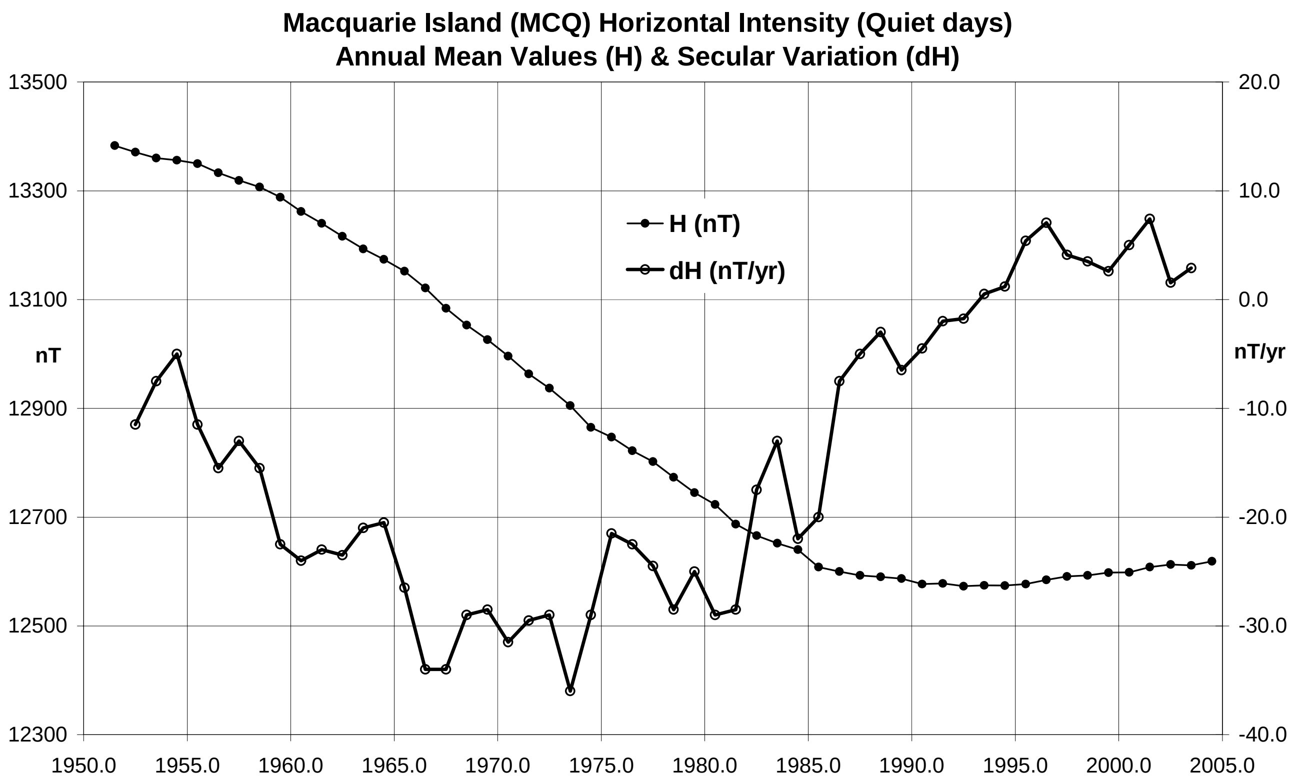
Macquarie Is. 2004 Horizontal intensity (H). Scale: 40.0 nT/mm. Mean: 12603 nT

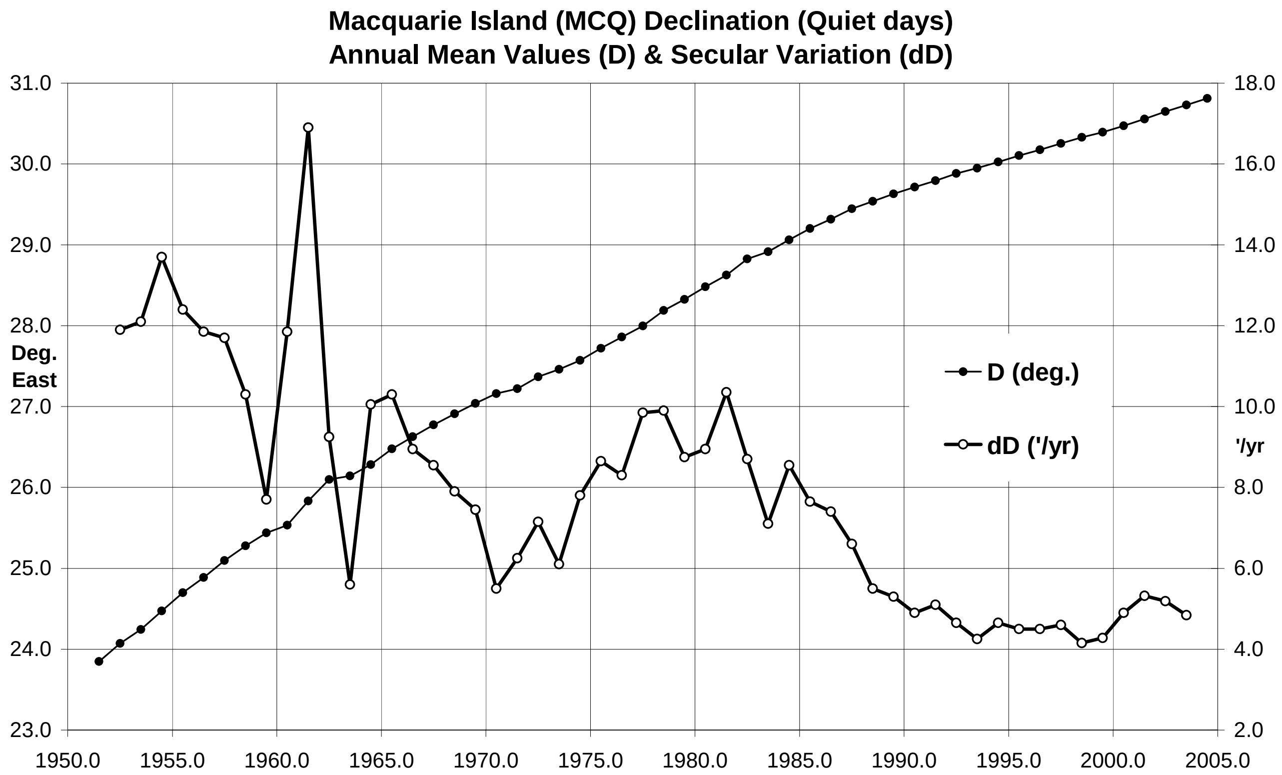
Macquarie Is. 2004 Declination (east) (D). Scale: 4.00 min/mm. Mean: 30.82 deg.

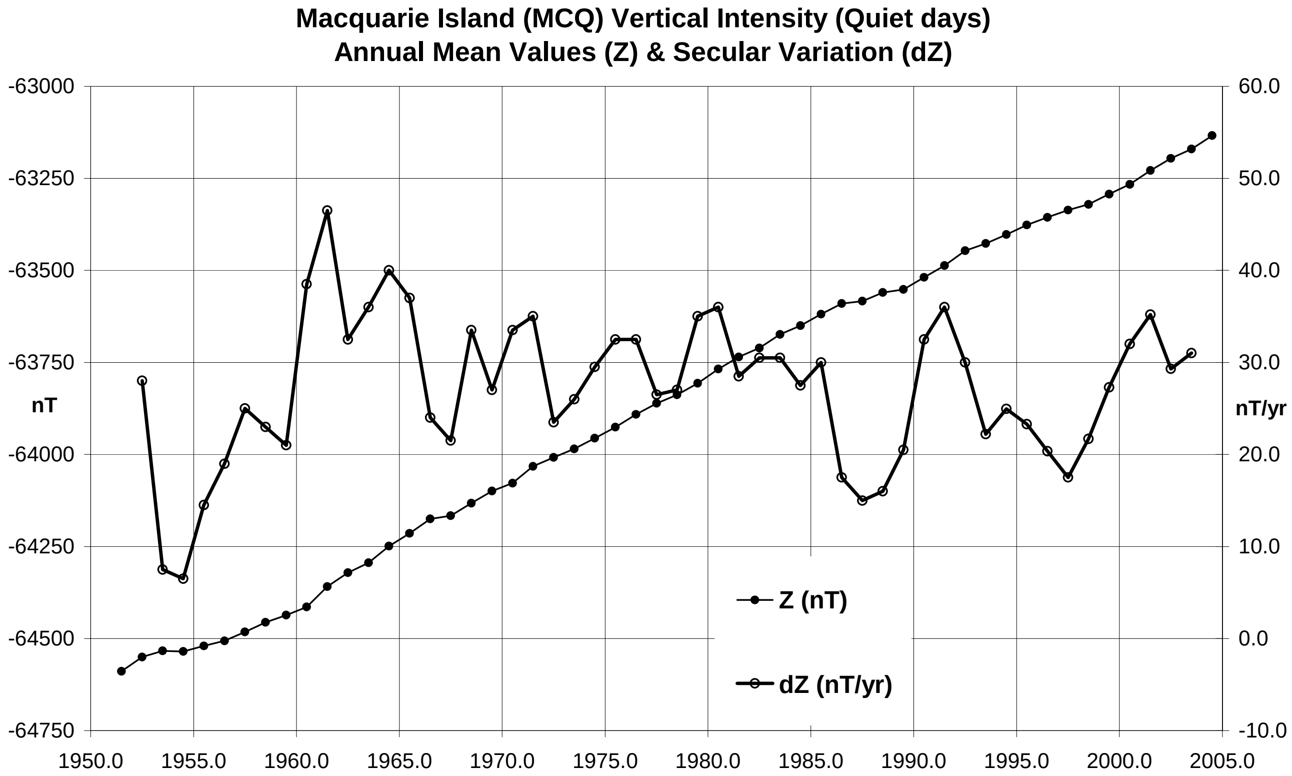


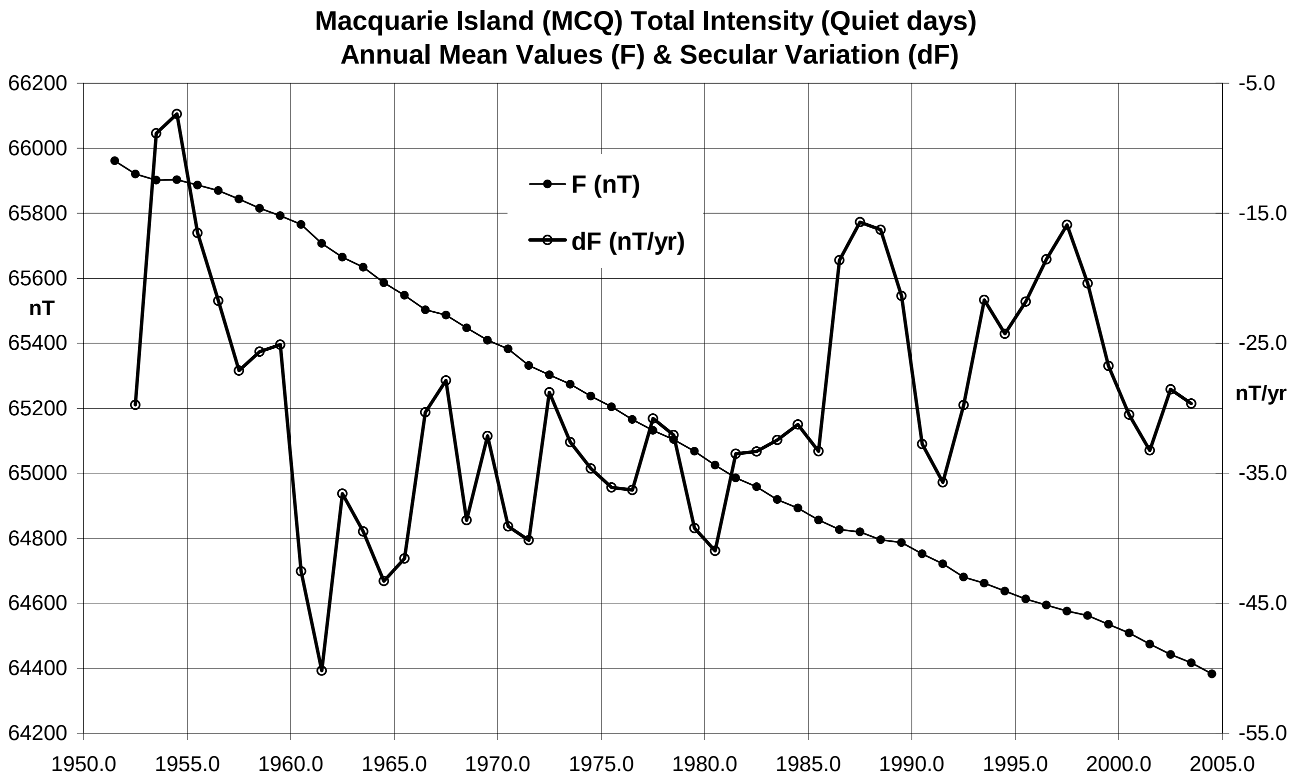
Macquarie Is. 2004 Vertical intensity (Z). Scale: 25.0 nT/mm. Mean: −63134 nT

Macquarie Is. 2004 Total intensity (F). Scale: 25.0 nT/mm. Mean: 64380 nT


Macquarie Island (MCQ) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT/yr
13500
13300
13100
12900
12700
12500
12300
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0


Macquarie Island (MCQ) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
D (deg.)
dD ('/yr)
Deg.
East
'/yr
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0


Macquarie Island (MCQ) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
nT
nT/yr
-63000
-63250
-63500
-63750
-64000
-64250
-64500
-64750
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
Z (nT)
dZ (nT/yr)


Macquarie Island (MCQ) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)
nT
nT/yr
66200
66000
65800
65600
65400
65200
65000
64800
64600
64400
64200
-5.0
-15.0
-25.0
-35.0
-45.0
-55.0
1950.0
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
F (nT)
dF (nT/yr)

MCQ Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
2004.5	Q	30	48.5	-78	41.8	12619	10838	6463	-63134	64383	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

* Elements ABC indicates non-aligned variometer orientation

CASEY OBSERVATORY

Casey is the Australian Antarctic station nearest to Australia, situated 3880km south of Perth. The magnetic ABSOLUTE HUT is about 120 metres 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 1km to the north-east of the present Casey.

The crystalline rocks of Casey have unusually high concentrations of magnetic minerals producing high magnetic gradients in and around the magnetic 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 was achieved in 1999. A more detailed history of the Casey (and Wilkes) observatory was given in the *AGR*s 1999-2002.

Key data for Casey Station (AAT) Observatory:

- 3-character IAGA code: CSY
- Commenced operation: see above
- Geographic latitude: 66° 17' S
- Geographic longitude: 110°32' E
- Geomagnetic† : Lat. -76.33°; Long. 183.86°
- Lower limit for K index of 9: n.a.
- Principal pier identification: Pier A
- Elevation of top of Pier A: 40 metres AMSL
- Azimuth of principal reference (Pillar G11 from Pier A): 307° 41' 02"
- Distance to Pillar G11: not recorded
- Observers in Charge: M. Paterson (AAD)

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

An Antarctic Division EDA FM105B fluxgate variometer, with its data acquired by PC, operated at Casey throughout 2004. The fluxgate sensors were housed on the hill about 300m west of the Casey Science building. The sensors were aligned close to true north, true east and vertical. The temperatures were maintained at 20°C. Further description is in Crosthwaite (1999). No total field variometer operated at Casey during 2004.

Absolute Instruments and Corrections

Magnetometers used to calibrate the recording variometers at Casey were Elsec 810 DIM no. 2591 with Zeiss020B theodolite no. 356514 (owned by the Australian Antarctic Division), and Geometrics 816 no. 766 PPM, (owned by GA). A QHM and QHM circles were available as a backup in the event that one of the primary instruments became unserviceable.

For consistency with the Australian Magnetic Reference magnetometers held at Canberra, a correction of +0.7nT has been applied to the absolute PPM readings. Corrections of zero were applied to the DIM readings. These resulted in baseline corrections of:

$\Delta X = -0.01$ nT $\Delta Y = -0.10$ nT $\Delta Z = -0.69$ nT.

Because of the extreme magnetic gradients at Casey, it has been necessary to apply a correction to magnetic data from the station acquired since early 1993. QHMs were used at Casey until 1993, and DIMs since that time. The 70mm difference in sensor heights between the two instruments required the following corrections to DIM/PPM readings to produce equivalent QHM/PPM readings (with the PPM height similarly adjusted):

$\Delta D = +15.1'$ $\Delta I = +0.2'$ $\Delta F = +45$ nT

($\Delta X = +42$ nT $\Delta Y = -11.5$ nT $\Delta Z = -44$ nT)

It is desirable that a new absolute observation house and pier be located on a more suitable site. A site with gradients of about 10nT per metre was chosen during a maintenance visit by a GA officer in the 1998/99 summer (Crosthwaite 1999).

Casey Annual Mean Values

The table below gives annual mean values for Casey station. 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 & F are on the pages 91 & 92.

Year	Days	D		I		H	X	Y	Z	F	Elts
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
1977.96	AB	-88	29.6	-81	38.7	9495	250	-9492	-64650	65344	DHZ
1978.5	AB	-89	4.3	-81	36.2	9518	154	-9516	-64488	65187	DHZ
1979.5	AB	-89	21.6	-81	35.7	9525	106	-9524	-64469	65169	DHZ
1980.5	AB	-89	31.5	-81	33.9	9568	79	-9568	-64528	65233	DHZ
1981.5	AB	-88	2.1	-81	32.0	9540	327	-9534	-64083	64789	DHZ
1982.5	AB	-90	10.0	-81	28.4	9650	-28	-9650	-64400	65120	DHZ
1983.5	AB	-90	32.0	-81	31.5	9585	-89	-9585	-64326	65037	DHZ
1984.5	AB	-90	50.0			9640	-140	-9639			DHZ
1985.5	AB	-90	50.0	-81	25.9	9650	-140	-9649	-64067	64790	DHZ
1986.5	AB	-90	52.9	-81	27.2	9634	-148	-9633	-64101	64821	DHZ
1987.5	AB	-91	18.6	-81	29.1	9596	-219	-9593	-64097	64811	DHZ
1988.5	AB	-91	28.4	-81	27.2	9630	-248	-9627	-64086	64805	DHZ
1989.5	AB	-90	45.5	-81	23.5	9672	-128	-9671	-63887	64615	DHZ
1990.5	AB	-91	55.0	-81	27.4	9601	-321	-9596	-63920	64637	DHZ
1991.5	QM	-92	1.2	-81	25.0	9642	-340	-9636	-63881	64605	XYZ
1992.5	QM	-92	10.0	-81	25.0	9637	-364	-9630	-63848	64571	XYZ
1993.5	QM	-92	7.3	-81	25.0	9638	-357	-9631	-63852	64576	XYZ
1994.5	QM	-92	17.1	-81	25.3	9629	-384	-9621	-63824	64547	XYZ
1995.5	QM	-92	27.5	-81	25.6	9620	-413	-9611	-63807	64528	XYZ
1996.5	QM	-92	35.4	-81	25.3	9625	-435	-9615	-63804	64526	XYZ
1997.5	QM	-92	42.1	-81	25.2	9623	-454	-9612	-63774	64496	XYZ
1998.5	Q	-92	55.4	-81	25.7	9614	-490	-9601	-63777	64497	XYZ
1999.5	Q	-93	4.9	-81	26.5	9595	-516	-9581	-63762	64480	XYZ
2000.5	Q	-93	12.9	-81	27.0	9584	-537	-9568	-63749	64465	XYZ
2001.5	Q	-93	21.6	-81	27.9	9564	-561	-9548	-63729	64443	XYZ
2002.5	Q	-93	26.1	-81	28.3	9553	-572	-9536	-63708	64421	XYZ
2003.5	Q	-93	37.5	-81	29.4	9534	-603	-9514	-63713	64422	XYZ
2004.5	Q	-93	46.5	-81	30.5	9510	-626	-9489	-63691	64397	XYZ
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
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

Operations

The magnetic observer-in-charge at Casey in 2004 was an officer of the Australian Antarctic Division, of the Commonwealth Department of the Environment and Heritage. He was a member of the Australian National Antarctic Research Expedition (ANARE). GA partially funded the position to enable the operation of the magnetic observatory to continue.

The magnetic observer performed approximately weekly absolute observations on the observation piers in the ABSOLUTE HOUSE to calibrate the variometers and provided regular reports to GA in Canberra.

The EDA variometer produced 1-second samples that were recorded on an AAD computer via their Analogue Data Acquisition System (ADAS). These were sent daily by ftp to GA where they were reformatted and used to produce calibrated minute, monthly and annual mean magnetic values.

There was no PPM variometer operating at Casey in 2004.

Throughout 2004 AAD performed system tests on its ADAS acquisition system daily at UT 0001, 1200−1201 and 1630−1631. This contaminated the variometer data at these times, so they have been removed from processing.

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Casey Station	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	-608.0	-9497.8	-63713.1	64420.3	9518.4	-93° 39.8'	-81° 30.2'
	5xQ days	-601.9	-9489.9	-63700.2	64406.2	9509.8	-93° 37.9'	-81° 30.5'
	5xD days	-588.0	-9516.5	-63698.0	64408.2	9536.5	-93° 32.3'	-81° 29.1'
February	All days	-609.9	-9502.4	-63696.5	64404.4	9522.5	-93° 40.4'	-81° 29.8'
	5xQ days	-596.4	-9506.1	-63682.5	64390.9	9525.1	-93° 35.5'	-81° 29.6'
	5xD days	-587.7	-9508.0	-63690.5	64399.2	9526.8	-93° 32.3'	-81° 29.6'
March	All days	-621.7	-9492.9	-63702.1	64408.6	9513.5	-93° 44.8'	-81° 30.4'
	5xQ days	-638.7	-9484.3	-63686.8	64392.3	9505.9	-93° 51.2'	-81° 30.6'
	5xD days	-586.9	-9487.9	-63691.8	64397.4	9506.5	-93° 32.4'	-81° 30.7'
April	All days	-627.7	-9494.4	-63701.5	64408.2	9515.2	-93° 47.0'	-81° 30.3'
	5xQ days	-648.4	-9497.6	-63708.4	64415.8	9519.8	-93° 54.3'	-81° 30.1'
	5xD days	-616.4	-9494.1	-63712.5	64419.1	9514.3	-93° 42.9'	-81° 30.4'
May	All days	-631.6	-9488.7	-63698.6	64404.6	9509.7	-93° 48.5'	-81° 30.5'
	5xQ days	-630.1	-9488.2	-63690.4	64396.3	9509.1	-93° 48.0'	-81° 30.5'
	5xD days	-636.3	-9485.1	-63703.0	64408.4	9506.5	-93° 50.3'	-81° 30.7'
June	All days	-636.0	-9484.8	-63697.4	64402.9	9506.1	-93° 50.2'	-81° 30.7'
	5xQ days	-630.1	-9482.5	-63688.1	64393.3	9503.5	-93° 48.1'	-81° 30.8'
	5xD days	-644.4	-9482.0	-63705.7	64410.8	9504.0	-93° 53.3'	-81° 30.9'
July	All days	-645.5	-9490.9	-63720.1	64426.3	9513.0	-93° 53.5'	-81° 30.5'
	5xQ days	-632.7	-9488.9	-63682.4	64388.6	9510.0	-93° 48.9'	-81° 30.4'
	5xD days	-682.0	-9481.4	-63809.0	64513.4	9506.6	-94° 07.0'	-81° 31.6'
August	All days	-640.9	-9486.8	-63708.7	64414.3	9508.5	-93° 51.9'	-81° 30.7'
	5xQ days	-642.0	-9483.9	-63704.9	64410.2	9505.6	-93° 52.4'	-81° 30.8'
	5xD days	-653.5	-9484.8	-63734.7	64440.0	9507.5	-93° 56.5'	-81° 30.9'
September	All days	-634.4	-9487.5	-63705.2	64410.9	9508.9	-93° 49.5'	-81° 30.6'
	5xQ days	-633.4	-9488.1	-63699.9	64405.8	9509.3	-93° 49.2'	-81° 30.6'
	5xD days	-650.6	-9486.6	-63741.9	64447.4	9509.3	-93° 55.4'	-81° 30.9'
October	All days	-632.4	-9489.6	-63692.1	64398.3	9510.9	-93° 48.8'	-81° 30.4'
	5xQ days	-632.6	-9490.3	-63682.3	64388.7	9511.5	-93° 48.9'	-81° 30.3'
	5xD days	-634.1	-9488.1	-63714.0	64419.9	9509.8	-93° 49.5'	-81° 30.7'
November	All days	-624.4	-9493.4	-63697.9	64404.7	9514.7	-93° 45.8'	-81° 30.3'
	5xQ days	-609.2	-9487.5	-63685.7	64391.5	9507.2	-93° 40.5'	-81° 30.6'
	5xD days	-642.7	-9497.7	-63746.8	64454.4	9521.5	-93° 52.4'	-81° 30.3'
December	All days	-618.5	-9484.4	-63683.4	64388.9	9505.1	-93° 44.0'	-81° 30.7'
	5xQ days	-618.2	-9482.4	-63679.2	64384.4	9502.7	-93° 43.9'	-81° 30.7'
	5xD days	-633.3	-9479.1	-63680.6	64385.5	9501.0	-93° 49.4'	-81° 30.9'
Annual	All days	-627.6	-9491.1	-63701.4	64407.7	9512.2	-93° 47.0'	-81° 30.4'
Mean	5xQ days	-626.2	-9489.1	-63690.9	64397.0	9510.0	-93° 46.5'	-81° 30.5'
Values	5xD days	-629.7	-9490.9	-63719.0	64425.3	9512.5	-93° 47.8'	-81° 30.5'

(Calculated: 13:55 hrs., Mon., 20 Feb., 2006)

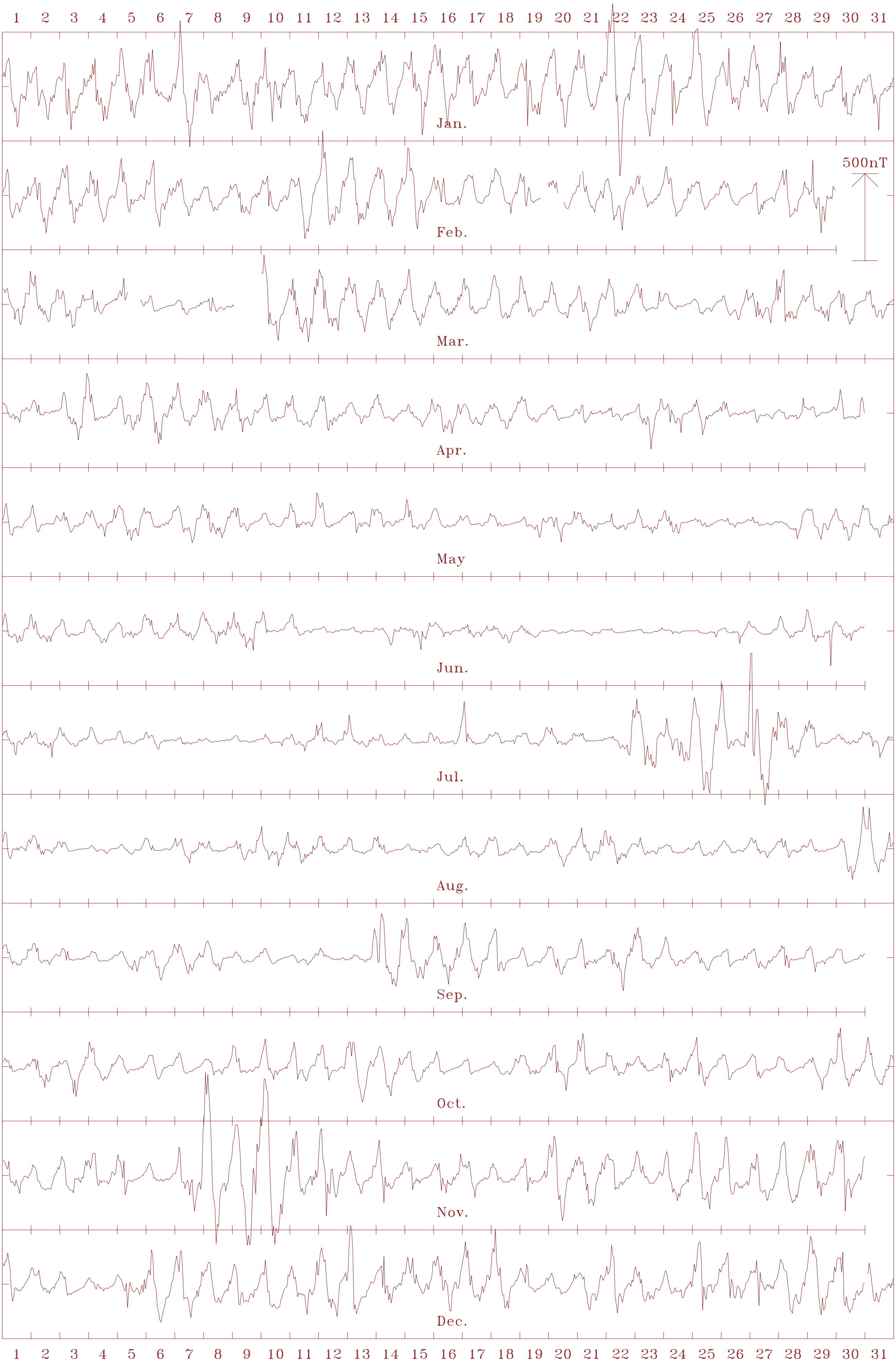
Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

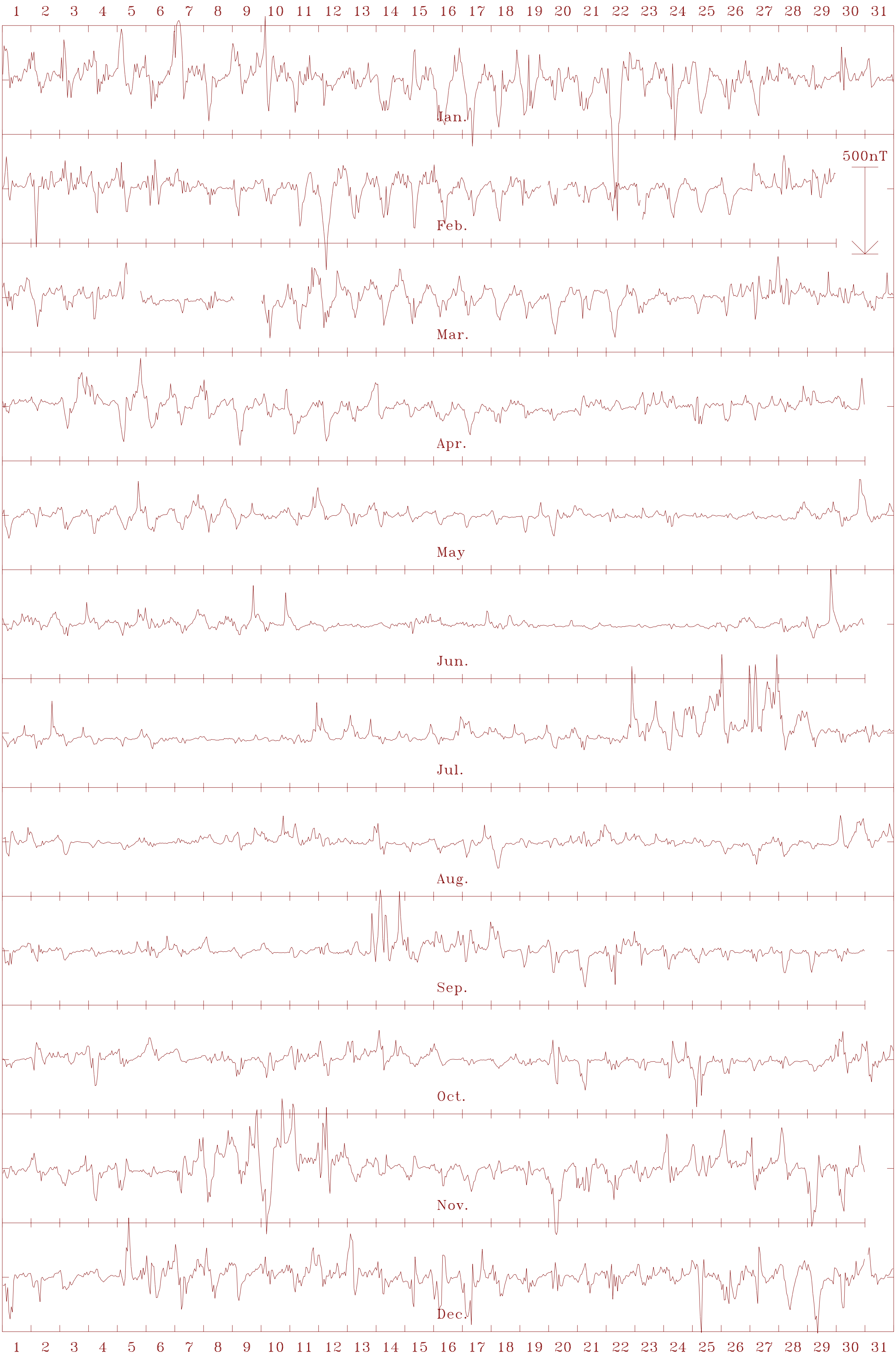
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Casey Stn. 2004 Horizontal intensity (H). Scale: 30.0 nT/mm. Mean: 9512 nT

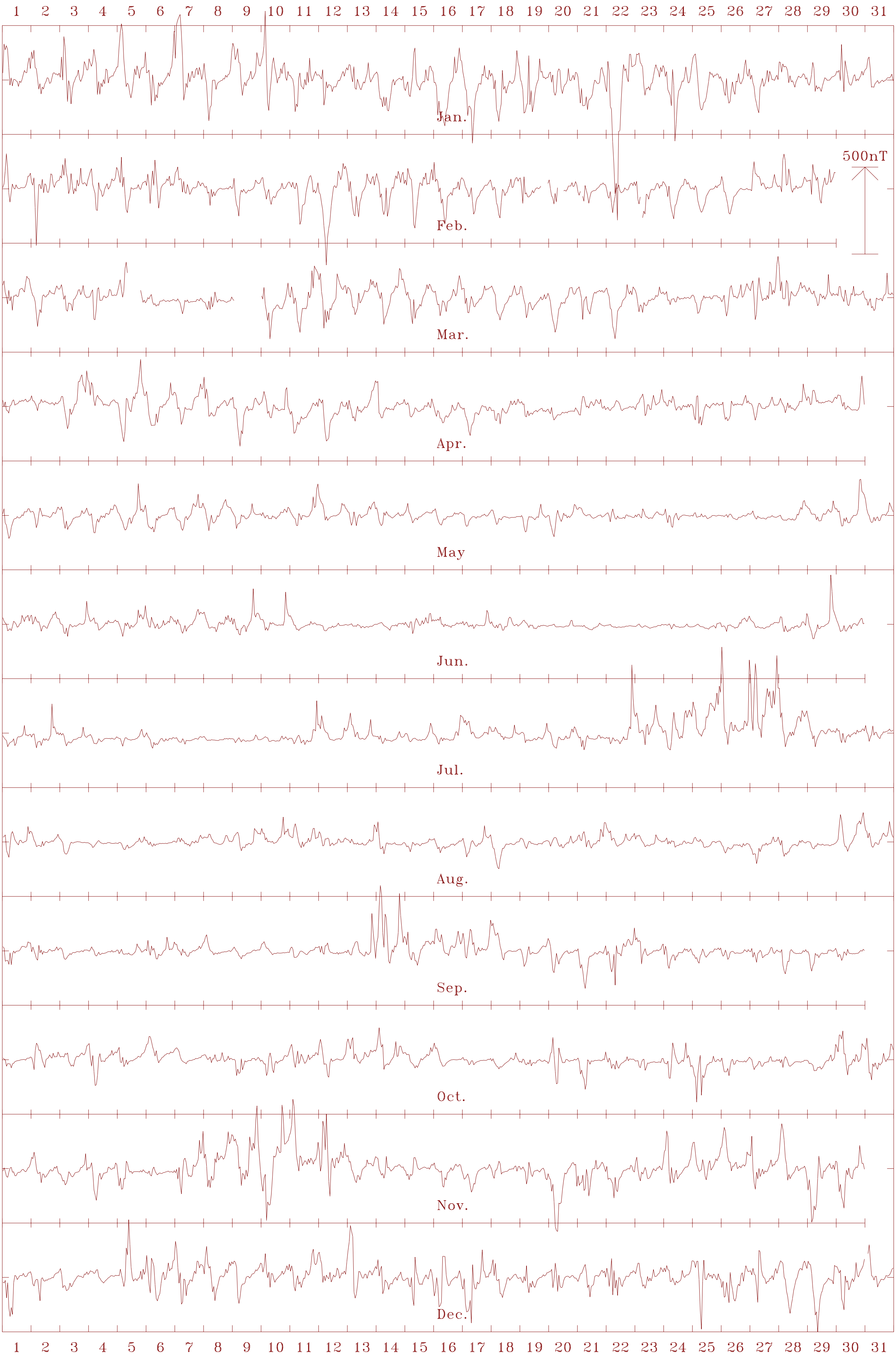


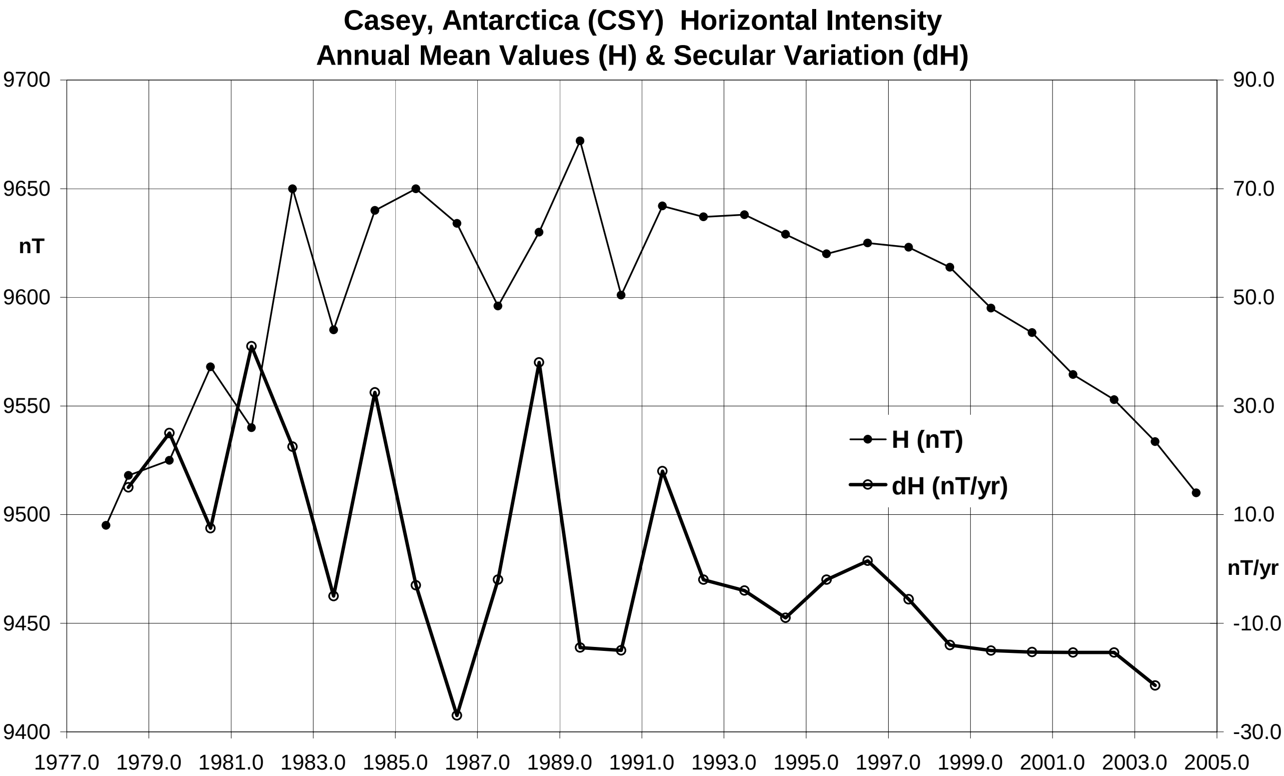
Casey Stn. 2004 Declination (east) (D). Scale: 12.0 min/mm. Mean: −93.78 deg.

Casey Stn. 2004 Vertical intensity (Z). Scale: 30.0 nT/mm. Mean: -63701 nT

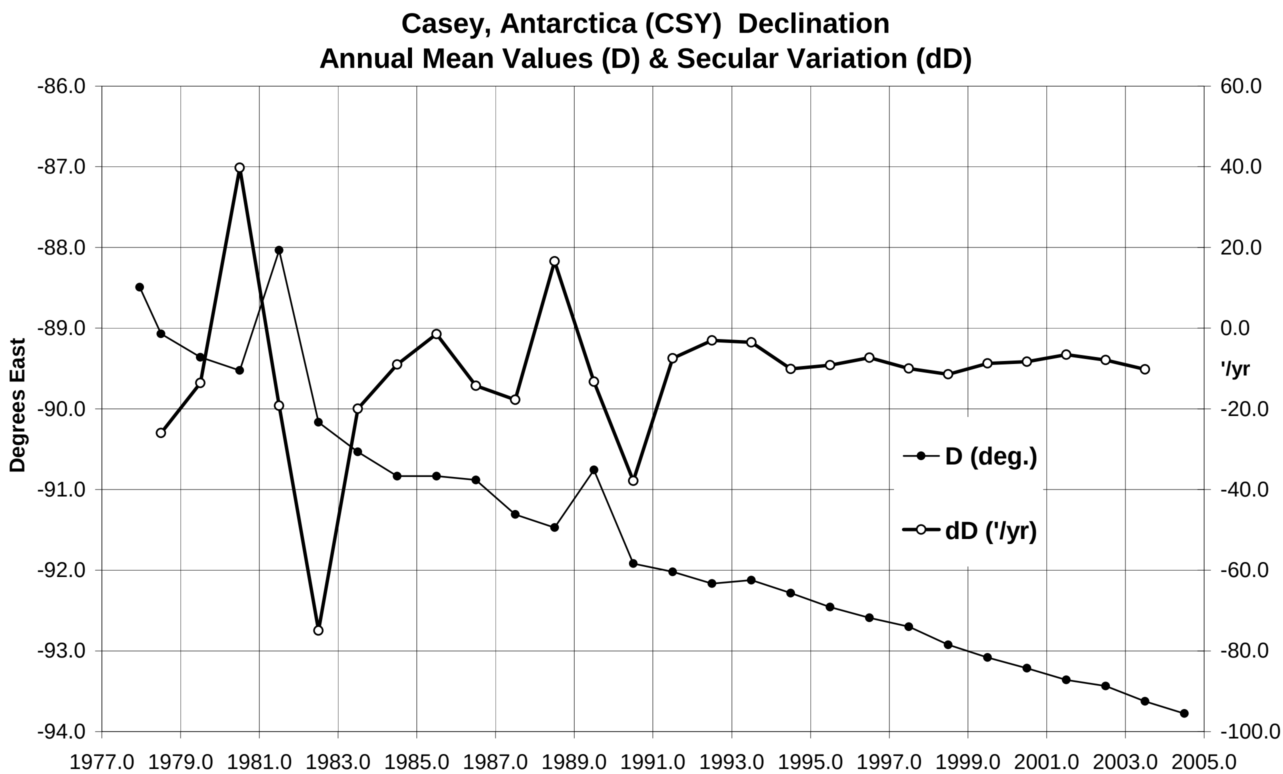


Casey Stn. 2004 Total intensity (F). Scale: 30.0 nT/mm. Mean: 64408 nT

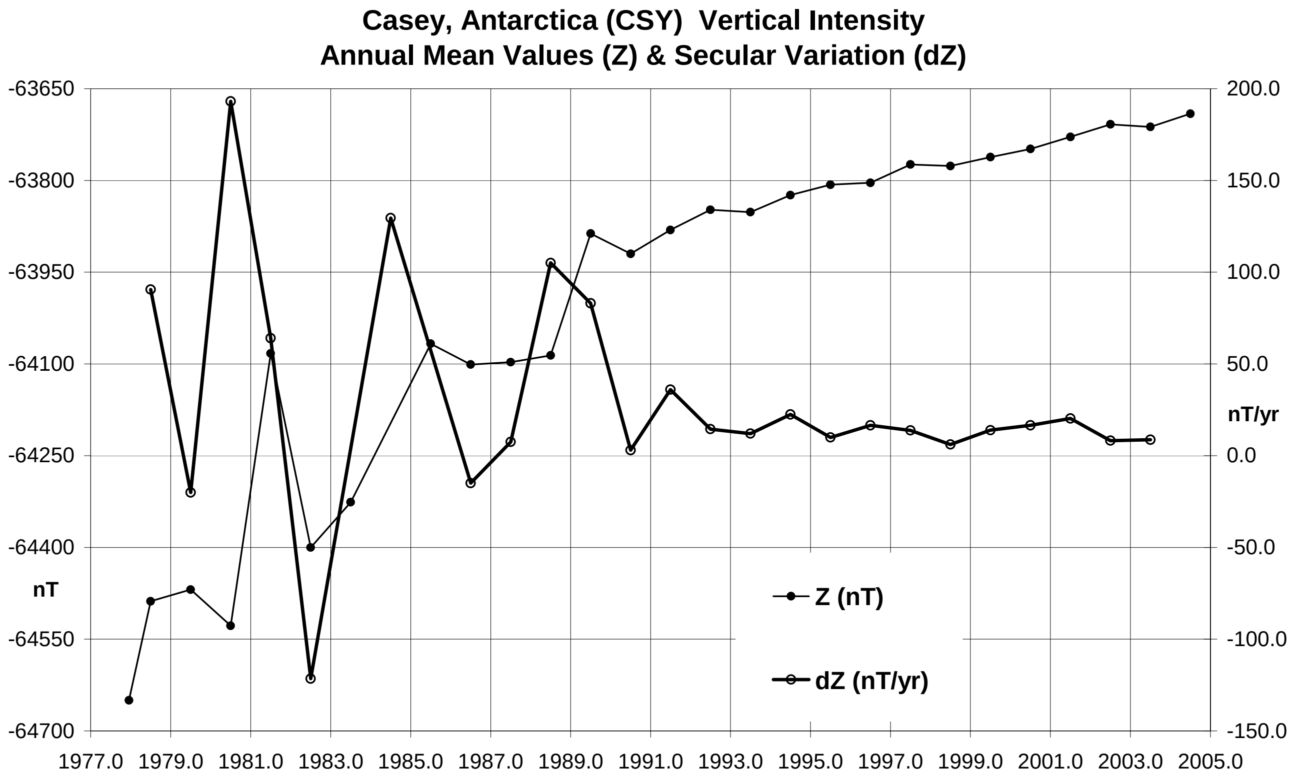


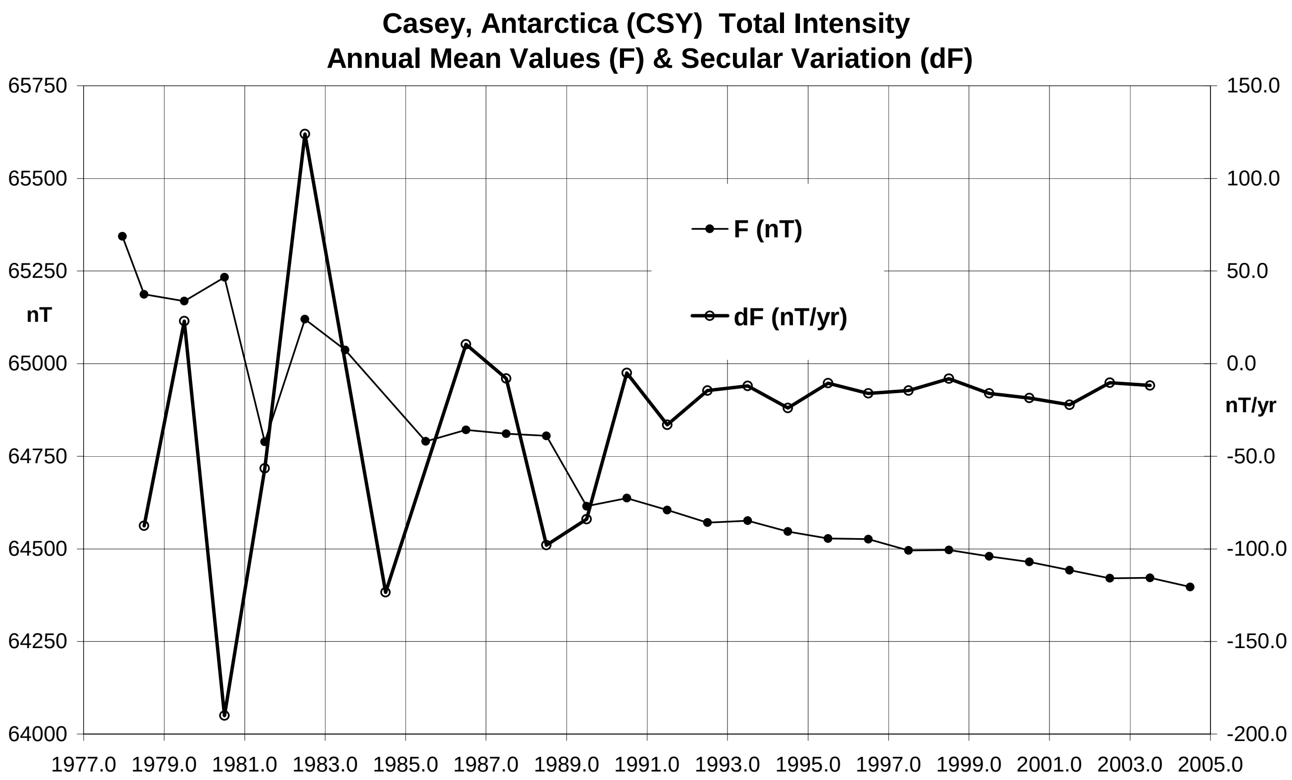


Casey, Antarctica (CSY) Horizontal Intensity
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
9700
9650
9600
9550
9500
9450
9400
90.0
70.0
50.0
30.0
10.0
-10.0
-30.0
1977.0 1979.0 1981.0 1983.0 1985.0 1987.0 1989.0 1991.0 1993.0 1995.0 1997.0 1999.0 2001.0 2003.0 2005.0



Casey, Antarctica (CSY) Declination
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
-86.0
-87.0
-88.0
-89.0
-90.0
-91.0
-92.0
-93.0
-94.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
1977.0 1979.0 1981.0 1983.0 1985.0 1987.0 1989.0 1991.0 1993.0 1995.0 1997.0 1999.0 2001.0 2003.0 2005.0


Casey, Antarctica (CSY) Vertical Intensity
Annual Mean Values (Z) & Secular Variation (dZ)
-63650
-63800
-63950
-64100
-64250
-64400
-64550
-64700
nT
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
nT/yr
Z (nT)
dZ (nT/yr)
1977.0 1979.0 1981.0 1983.0 1985.0 1987.0 1989.0 1991.0 1993.0 1995.0 1997.0 1999.0 2001.0 2003.0 2005.0


Casey, Antarctica (CSY) Total Intensity
Annual Mean Values (F) & Secular Variation (dF)
65750
65500
65250
65000
64750
64500
64250
64000
nT
150.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
nT/yr
F (nT)
dF (nT/yr)
1977.0 1979.0 1981.0 1983.0 1985.0 1987.0 1989.0 1991.0 1993.0 1995.0 1997.0 1999.0 2001.0 2003.0 2005.0

Significant Events in 2004 (CSY)

11 Feb — The acquisition computer required maintenance due to the detection of a computer virus. Some data loss from 11th to 24th (system calibrations). Several reboots and data loss.

05 Mar — 0800–2000: Contamination to data with a period of about 25 minutes. The station manager advised that the heating in the building that houses the variometer electronics was turned down at 0610UT. A large drift was recorded in the variometer during this period. These data were not included in final processing.

09 Mar — 0100–2340: Contamination to data with a period of about 25 minutes. These data were not included in final processing.

04 May — 0022: The station manager advised that the temperature in the building that houses the variometer electronics was increased to its normal value of approximately 20°C.

06 May — Steep drift in variometer data appears to have ceased.

10 May — ~0830: The station manager advised that the temperature in the building that houses the variometer electronics was again reduced, this time for the remainder of the winter.

31 Dec — Data missing due to a problem with AAD's GPS system.

Data losses in 2004

Short intervals of data were contaminated by daily calibration pulses automatically scheduled by AAD to occur at 0001, 1200−1201 and 1630−1631 on all days in 2004. These 5 minutes of data each day were removed from the GA data set.

There was no PPM recording variations in total intensity at Casey during 2004. The periods of data loss that follow refer to EDA fluxgate variometer data.

Jan 22 — 0431–0440 (10 min) All channels: System upgrades.

Feb 11 — 0935–1026 (52 min) All channels.

Feb 12 — 0640–0656 (17 min) All channels: System upgrades.

Feb 13 — 0155–0242 (48m); 0436–0438 (3m); 0440–0443 (4m): All channels: System upgrades.

Feb 18 — 0049–0053 (5 min) All channels: System upgrades.

Feb 19 — 0021–0023 (3m); 0031–0034 (4m); 0122–0125 (4m); 1016–1020 (5m); 1751–2315 (5h 25m) All channels: System upgrades.

Feb 20 — 0620–0625 (6m); 0749–0754 (6m); 0801–1153 (3h 53m) All channels: System upgrades.

Data losses (cont.)

Feb 21 — 0257–0304 (8m); 0308–0308 (1m); 0313–0409 (57m); 0737–0800 (24m) All channels: system upgrades.

Feb 23 — 0258–0347 (50m); 0457–0611 (1h 15m); 0657–0705 (9m); 0724–0730 (7m); 0758–0758 (1m) All channels: System upgrades.

Feb 24 — 0401–0435 (35m); 0514–0516 (3m); 0519–0521 (3m); 0524–0536 (13m); 0651–0657 (7m); 0701 (1m); 0718–0731 (14m); 2249–2250 (2m) All channels: System upgrades.

Mar 05 — 0821–1917 (10h 56m) All channels: Data contamination.

Mar 09 — 0124–2359 (22h 36m) All channels: Data contamination.

Apr 13 — 0039–0041 (3 min) All channels: System failure.

Apr 15 — 0244–0247 (4 min) All channels: System failure.

Jul 16 — 0022–0023 (2m); 0728–0729 (2m) All channels: System reboot.

Aug. 16 — 0728–0729 (2 min) All channels.

Oct 14 — 0504–0506 (3m); 0749–0750 (2m); 2256–2259 (4m) All channels: System reboot.

Oct 15 — 0014–0015 (2 min) All channels: System reboot.

Dec 31 — 0002–0209 (2h 08m) All channels: System reboot.

Distribution of CSY data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2004.

1-minute and Hourly Mean Values to WDCs

- 2003: WDC-A, Boulder, USA (sent 02 Sep. 2004)
- 2004: WDC-C1, Copenhagen, Denmark (sent 2 Jan 2006)
- 2004: WDC-A, Boulder, USA (sent 10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- 2004: to Paris GIN (sent 22 Dec. 2005)

Enquiries for variation data from Casey for 1997 or earlier should be directed to the Atmospheric and Space Physics Section of the Australian Antarctic Division, Channel Highway, Kingston, Tasmania.

Notes and Errata (including Davis Station) (cumulative since *AGR'93*)

There was an inconsistency in the Davis magnetic H component monthly means in the *AGR1996*. Corrected values were given in the *AGR1997*.

The magnetic observatory is part of Mawson scientific research station, built on the edge of Horseshoe Harbour, MacRobertson Land , in Antarctica. It is built on bare charnockite basement rock: there is no ice or soil cover.

The magnetic observatory buildings, comprising the VARIOMETER HOUSE and the ABSOLUTE HOUSE, are situated on the south-east and inland side of the Mawson base, at the end of East Bay. They are in a magnetic quiet zone at an extremity of the Mason base.

In 1955 the Mawson observatory commenced recording magnetic variations with a three-component analogue magnetograph. The observatory has continuously recorded the geomagnetic field (and seismic activity) at Mawson since that time. In December 1985 the magnetic observatory was converted to digital recording. It is operated by Geoscience Australia as part of the Australian National Antarctic Research Expeditions (ANARE).

Further details of the observatory's history are in the *AGR 1994*.

Key data for Mawson Observatory:

- 3-character IAGA code: MAW
- Commenced operation: 1955
- Geographic latitude: 67° 36' 14" S
- Geographic longitude: 62° 52' 45" E
- Geomagnetic† : Lat. -73.08°; Long. 110.34°
- Lower limit for K index of 9: 1500 nT
- Principal pier identification: Pier A
- Elevation of top of Pier A: 12 metres AMSL
- Azimuth of principal reference (Mark BMR89/1 from Pier A): 350° 36.9'
- Distance to Mark BMR89/1: 112 metres
- Observers in Charge: R. Hegarty (2004, GA/BoM)
G. Roser (2005, GA/AAD)
- Observers in Charge:

† Based on the IGRF 2000.0 model updated to 2004.5

Variometers

A 3-axis Narod ringcore fluxgate (RCF) magnetometer and an Elsec 820M3 PPM continuously monitored variations in the Earth's magnetic field at Mawson throughout 2004. The RCF sensor was located within the sensor room of the MAW VARIOMETER HOUSE and the PPM sensor was in the recording room of the same building. This building also housed a global positioning system (GPS) clock, a data acquisition PC, a network PC, an Aironet ethernet radio link and a standby power supply.

Two of the orthogonal RCF magnetometer sensors were horizontal and oriented so that they were each at an angle of 45 degrees to the direction of the horizontal component of the magnetic field (ie 45° to the magnetic declination, D). The third sensor was aligned vertically, ie. parallel with the geomagnetic element Z.

The RCF produced 8 samples per second that were averaged and output as 1-second data. The PPM variometer produced 10-second samples.

The temperatures of the sensors and the electronics of the RCF system were monitored by its in-built dual temperature system. Temperature within the sensor room was kept close to 10°C by a fast-cycle heater and displayed by a Doric Trendicator digital thermometer with its sensor on a disused (PEM/Y) pier. The recorded variometer head and electronics temperatures were about 6.5±1.0°C (with a total range from 4.5°C to 10°C) throughout the year.

An old EDA 3-component fluxgate magnetometer and its associated data acquisition PC were available as a standby variometer to replace the principal system should it have become unserviceable. This system, also in the VARIOMETER HOUSE, was tested during a service visit by a Geomagnetism project officer (PGC) in January 2003, but was left powered off during 2004.

The F variometer performed very poorly throughout 2004. From late July it also began to auto-trigger rather than trigger on command from the acquisition computer, causing data sequence errors. This appeared as duplicate minute-records containing a single F value and did not harm the recorded or processed 1-minute vector data, but it was a hindrance to the detection of missing data.

Absolute Instruments and Corrections

The principal absolute magnetometers used to calibrate the recording variometers at Mawson in 2004 were Danish fluxgate magnetometer no. D26035 mounted on a Zeiss 020B theodolite no. 311542 and Elsec model 770 PPM no. 210 until the end of March, then GEM model GSM90 no. 3091315 from April 2004 onwards.

Danish fluxgate magnetometer no. DI0022 mounted on a Zeiss 020B theodolite no. 353758 was used monthly as a secondary instrument from February 2004 onwards.

Elsec model 770 PPM no. 199 was used as a secondary instrument until the end of March 2004, and Elsec model 770 PPM no. 210 was used as a secondary instrument from April onwards.

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

Instrument comparisons performed at Mawson throughout 2004 indicated relative corrections to the absolute magnetometers in use at there were:

$$F\,(E770\_210) = F\,(E770\_199) + 1.7 \pm 0.5\text{nT}$$
$$F\,(GSM90\_3091315) = F\,(E770\_210) - 0.4 \pm 0.4\text{nT}$$
$$D\,(D26035/311542) = D\,(DI0022/353758) + 0.04' \pm 0.17'$$
$$I\,(D26035/311542) = I\,(DI0022/353758) + 0.07' \pm 0.04'$$

Instrument comparisons performed at Canberra Observatory on 01-02 December 2003 indicated that the corrections to the Mawson instruments, required to align them to Australian Magnetic Reference held at the Canberra Observatory, were:

$$F\,(GSM90\_3091315) = F\,(CNB) + 0.0\text{ nT}$$
$$D\,(DI0022/353758) = D\,(CNB) - 0.07'$$
$$I\,(DI0022/353758) = I\,(CNB) - 0.07'$$

The adopted instrument corrections for PPM GSM90_3091315 and to DIM D26035/311542 are respectively:

$$\Delta F = 0.0\text{ nT} \qquad \Delta D = 0.0' \qquad \Delta I = 0.0'$$

Mawson data in this report have been adjusted to the absolute instruments GSM90_3091315 and D26035/311542 using these "zero" adopted corrections, and as a consequence no corrections have been applied to the Mawson data in this report.

According to these measurements, after the adoption of E770_210 as the standard total intensity instrument, 2003 data should have been corrected by:

$$\Delta X = -0.1\text{ nT} \qquad \Delta Y = +0.1\text{ nT} \qquad \Delta Z = +0.4\text{ nT},$$

although **no** corrections were applied to those data as the above small values exceeded the standard deviations of their estimates. This resulted in a small step in the data across the 2003/2004 boundary.

Until the end of January 2004 classical magnetometers were routinely used to maintain calibration in case of failure of the primary instruments. They included an Askania declinometer (serial 630332), three horizontal magnetometers (QHM serial 300, 301, and 302) and Askania circle 611665. With the availability of DIM and PPM backup instruments, the classical instruments were placed out of service at the end of January 2004. No data analysis of those instruments for their brief service in 2004 is included in this report.

Baselines

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

σ_X = 0.8nT σ_Y = 1.2nT σ_Z = 0.8nT.

(In terms of the absolute observed components, they were:

σ_F = 0.6nT σ_D = 10" σ_I =6")

Operations

The personnel who operated the Mawson observatory in 2004 were: the 2004 observer (RH) employed jointly by Geoscience Australia (GA) and the Bureau of Meteorology (BoM) who performed absolute observations from 19 November 2003; and the 2005 observer (GR) whose position with the Australian Antarctic Division (AAD) was partially funded by GA who performed absolute observations from 7 December 2004. They were members of the Australian National Antarctic Research Expedition (ANARE). The Mawson Station personnel changeover each summer, with varying amounts of overlap.

The observers were responsible for the continuous operation of the observatory and performed equipment maintenance as required. In 2004 the observers performed absolute observations once each week and forwarded them by e-mail to GA where all data processing was performed. During the observations the variometer system was also checked.

The 1-second RCF data and the 10-second PPM data as well as 1-minute means of both were recorded on an acquisition PC in the recorder room. The computer was connected to a pulse-per-second input from a GPS clock to keep the clock rate accurate. A PC running QNX, also in the VARIOMETER HOUSE, that was connected to the station's radio network-hub, automatically copied files from the acquisition PC each day.

The files on this PC were subsequently automatically retrieved at GA, Canberra, from a secure network by ftp via the ANARE satellite communications system. To ensure correct operation and to check system timing, the data acquisition system was routinely interrogated using a PC in the Science Building.

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 seems to have improved the situation, but there are still unacceptable data losses during blizzards which also delay attention from the local observer for a few days. Blizzard was the major cause of data loss during 2004, either corrupting data or the computer clock, or halting the computer outright, and accounting for almost all of the 1.2% data loss for the year.

Operations (cont.)

The daily data were processed at GA then distributed, usually within a few hours after UT0. Daily data plots were examined at GA for possible problems, which were usually quickly rectified by the local observer. The final data for the year were reduced and analysed by GA staff.

On 1 November 2004, external mark LEE (1,561m from Pier A) was occupied for magnetic observations for the first time. The magnetic parts of the mark were temporarily removed during the observations. The observations were at 1.6m agl (above ground level – not above mark level). Two observations were made at LEE and compared to baselines on Pier A at a different time of the same day. There were inconsistencies between the declination results at LEE, but the second of the two observations seemed to be more internally consistent – both results summarised below:

1st set:	D at Pier A	=	D at LEE – 1.1'
	I at Pier A	=	I at LEE + 1.6'
	F at Pier A	=	F at LEE – 1.4 nT
2nd set	D at Pier A	=	D at LEE + 4.7'
	I at Pier A	=	I at LEE + 1.6'
	F at Pier A	=	F at LEE – 1.4 nT

The external mark BMR89/2 could not be occupied during the latter stages of the 2004 observer's (RH's) term as it remained buried under snow until he departed Mawson.

On 8 March 2004, a round of angles using BMR89/1 (Ref. azimuth 350º 36.9' at Pier A) and marks A, BMR89/2, BMR85/2, and SOH gave unexpected results for A and BMR85/2. The round of angles was repeated on 26 April 2004, including the same marks and also LEE. These results were within 0.1' of the expected results, with the exception of BMR85/2 which was 0.2' lower than expected.

The conclusion was that the marks and Pier A were stable.

Data losses in 2004

Mar 08 0745−0748 (4 min) All channels: Unknown cause.

May 04 2244-to 06 / 0504 (1d 6h 21m) All channels: Blizzard.

Jun 09 1600−2047 (4h 48m) All channels: Most likely caused by blizzard.

Jul 24 2333 to 26 / 0747 (1d 08h 15m) All channels: Blizzard.

Aug 25 1338−1339 (2 min) All channels: Most likely caused by blizzard.

Aug 25 1410 to 27 / 0214 (1d 12h 05m) All channels: Blizzard.

The F variometer data from about half of all days during the year was not usable and so withheld from processing.

Mawson Annual Mean Values

The table below gives 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 as indicated. Plots of these data with secular variation in H, D, Z & F are on pages 104 & 105.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1955.5		-58	38.1	-69	33.3	18272	9854	-15387	-49012	52307	DHZ
1956.5		-58	53.2	-69	32.5	18282	9927	-15352	-49006	52305	DHZ
1957.5		-59	08.7	-69	31.1	18292	9461	-15655	-48974	52279	DHZ
1958.5		-59	25.6	-69	30.3	18293	9538	-15610	-48940	52247	DHZ
1959.5		-59	42.6	-69	28.5	18293	9615	-15562	-48860	52172	DHZ
1960.5		-59	59.6	-69	25.2	18323	9708	-15540	-48800	52127	DHZ
1961.5		-60	14.6	-69	23.1	18322	9228	-15828	-48707	52039	DHZ
1962.5		-60	30.1	-69	21.1	18333	9305	-15796	-48650	51990	DHZ
1963.5		-60	45.2	-69	17.6	18356	9386	-15775	-48562	51915	DHZ
1964.5		-60	59.2	-69	15.4	18353	9449	-15734	-48460	51819	DHZ

continued next page …

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1965.5		-61	12.6	-69	13.1	18356	8958	-16022	-48368	51734	DHZ
1966.5		-61	24.0	-69	09.6	18362	9014	-15997	-48235	51612	DHZ
1967.5		-61	34.4	-69	07.2	18374	9068	-15980	-48168	51553	DHZ
1968.5		-61	43.8	-69	05.2	18365	9107	-15948	-48060	51449	DHZ
1969.5		-61	53.0	-69	03.4	18353	9144	-15913	-47954	51346	DHZ
1970.5		-62	00.5	-69	00.4	18358	8621	-16208	-47840	51241	DHZ
1971.5		-62	05.3	-68	56.4	18375	8652	-16211	-47719	51135	DHZ
1972.5		-62	11.4	-68	53.1	18381	8683	-16201	-47600	51026	DHZ
1973.5		-62	17.6	-68	49.7	18391	8717	-16194	-47486	50923	DHZ
1974.5		-62	24.8	-68	47.2	18390	8750	-16175	-47380	50824	DHZ
1975.5		-62	31.4	-68	44.0	18397	8785	-16164	-47269	50723	DHZ
1976.5		-62	37.3	-68	40.0	18418	8823	-16167	-47157	50626	DHZ
1977.5		-62	43.9	-68	36.9	18425	8857	-16157	-47051	50530	DHZ
1978.5		-62	51.9	-68	35.5	18421	8893	-16132	-46986	50468	DHZ
1979.5		-62	57.9	-68	32.9	18425	8923	-16120	-46890	50380	DHZ
1980.5		-63	05.8	-68	29.8	18432	8396	-16409	-46784	50284	DHZ
1981.5		-63	14.6	-68	27.1	18443	8443	-16397	-46705	50215	DHZ
1982.5		-63	21.2	-68	25.5	18433	8470	-16372	-46616	50128	DHZ
1983.5		-63	26.6	-68	22.3	18439	8498	-16364	-46503	50025	DHZ
1984.5		-63	33.1	-68	19.3	18446	8532	-16354	-46404	49936	DHZ
1985.5		-63	40.2	-68	17.0	18457	8571	-16346	-46342	49882	DHZ
1986.5		-63	48.7	-68	15.1	18460	8613	-16328	-46276	49822	XYZ
1987.5		-63	56.6	-68	12.5	18470	8655	-16317	-46198	49753	XYZ
1988.5		-64	04.4	-68	10.7	18475	8120	-16595	-46142	49703	XYZ
1989.5		-64	12.8	-68	09.7	18474	8160	-16574	-46099	49663	XYZ
1990.5		-64	21.1	-68	06.4	18492	8208	-16570	-46015	49592	XYZ
1991.5		-64	28.8	-68	04.2	18502	8250	-16561	-45957	49542	XYZ
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	ABC
1994.5	Q	-64	51.8	-67	57.4	18537	7874	-16781	-45779	49389	ABC
1995.5	Q	-65	00.4	-67	55.3	18550	7838	-16813	-45731	49350	ABC
1996.5	Q	-65	09.2	-67	53.5	18561	7799	-16843	-45692	49318	ABC
1997.5	Q	-65	18.9	-67	52.0	18572	7757	-16875	-45663	49295	ABC
1998.5	Q	-65	28.6	-67	51.3	18575	7710	-16900	-45642	49277	ABC
1999.5	Q	-65	38.5	-67	50.2	18579	7663	-16925	-45611	49250	ABC
2000.5	Q	-65	48.0	-67	49.6	18579	7616	-16946	-45585	49225	ABC
2001.5	Q	-65	56.3	-67	48.9	18577	7574	-16963	-45555	49198	ABC
2002.5	Q	-66	05.2	-67	48.2	18581	7532	-16986	-45540	49185	ABC
2003.5	Q	-66	14.7	-67	48.7	18570	7481	-16997	-45532	49174	ABC
2004.5	Q	-66	23.5	-67	48.1	18568	7436	-17014	-45503	49146	ABC
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	ABC
1994.5	A	-64	52.9	-67	59.4	18511	7858	-16760	-45794	49394	ABC
1995.5	A	-65	00.9	-67	56.7	18532	7828	-16798	-45741	49352	ABC
1996.5	A	-65	09.8	-67	54.5	18548	7791	-16833	-45698	49319	ABC
1997.5	A	-65	19.4	-67	53.0	18560	7749	-16865	-45670	49297	ABC
1998.5	A	-65	29.1	-67	52.4	18561	7702	-16887	-45648	49278	ABC
1999.5	A	-65	39.0	-67	51.5	18561	7653	-16910	-45618	49250	ABC
2000.5	A	-65	48.2	-67	50.6	18566	7610	-16935	-45594	49230	ABC
2001.5	A	-65	56.2	-67	49.8	18567	7571	-16953	-45565	49203	ABC
2002.5	A	-66	05.8	-67	49.3	18568	7524	-16975	-45546	49185	ABC
2003.5	A	-66	15.6	-67	50.7	18546	7466	-16976	-45546	49177	ABC
2004.5	A	-66	24.1	-67	49.6	18549	7426	-16998	-45514	49149	ABC
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	ABC
1994.5	D	-64	55.3	-68	01.9	18476	7831	-16734	-45804	49390	ABC
1995.5	D	-65	01.7	-67	58.8	18504	7812	-16774	-45752	49353	ABC
1996.5	D	-65	11.1	-67	56.2	18525	7775	-16814	-45707	49318	ABC
1997.5	D	-65	20.4	-67	55.0	18534	7733	-16844	-45682	49299	ABC
1998.5	D	-65	30.9	-67	54.8	18530	7680	-16864	-45665	49282	ABC
1999.5	D	-65	41.0	-67	53.9	18528	7630	-16884	-45626	49245	ABC
2000.5	D	-65	49.7	-67	52.6	18543	7593	-16917	-45614	49239	ABC
2001.5	D	-65	56.4	-67	51.6	18547	7561	-16935	-45583	49212	ABC
2002.5	D	-66	07.6	-67	51.2	18540	7504	-16953	-45552	49180	ABC
2003.5	D	-66	17.4	-67	53.3	18510	7443	-16947	-45556	49173	ABC
2004.5	D	-66	26.0	-67	52.1	18517	7404	-16972	-45530	49152	ABC

* Elements ABC indicates non-aligned variometer orientation

Distribution of MAW data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by e-mail to IPGP

1-minute and Hourly Mean Values to WDCs

- 2003 data: WDC-A, Boulder, USA (sent 19 Apr. 2004)
- 2004 data: WDC-A, Boulder, USA (sent 10 Jan. 2006)

1-minute Values for Project INTERMAGNET

- 2003 data: WDC-C1, Copenhagen, Den. (sent 19 Apr. 2004)

Significant Events in 2004

Nov 19 2003	The 2003 observer (KS) handed over responsibility for absolute observations and the observatory to the 2004 observer (RH).
Jan 26	to Jan 31: Mawson station resupply going on.
Feb 02	PPM variometer sensor no.28079910 installed, which performed poorly.
Feb 10	Installed *spare* PPM sensor in variometer (may have been E820_158 incorrectly recorded as E820_159)
Feb 11	New GSM90 installed in the ABSOLUTE HOUSE.
Feb 19	Heater removed from ABSOLUTE HOUSE for repair.
Feb 25	New DIM installed in ABSOLUTE HOUSE.
Feb 27	Repaired heater re-installed in ABSOLUTE HOUSE.
March	PDA software for running GSM90 installed and GSM90 phased in as primary absolute F reference.
Mar 08	Round of angles from Pier A measured.
Apr 05	Floppy-disc drive removed from VARIOMETER HOUSE.
Apr 26	Another round of angles from Pier A measured.
May 11	Blown light bulb removed from VARIOMETER HOUSE.
May 18	New light bulb installed in VARIOMETER HOUSE.
May 31	0530–0550: Maintenance carpenter inspected VARIOMETER HOUSE.

Significant Events (cont.)

Jun 11	Acquisition time adjusted by −1s following reboot.
Jul 26	Acquisition time adjusted by −1s following reboot. Variometer PPM began to self-trigger.
Aug 20	Connection re-seated after the acquisition PC keyboard had locked-up.
Aug 23	0808: Acquisition time adjusted by +1s.
Aug 27	Acquisition PC rebooted and time adjusted by −1s. Narod RCF magnetometer reset.
Nov 01	LEE (Lee Island marker) absolute observations made for external remote reference.
Dec 07	The 2004 observer (RH) handed over responsibility for absolute observations and the observatory to the 2005 observer (GR).

K indices

The table on the next page shows Mawson K indices for 2004. Using the digital data, these have been derived by a computer algorithm that calculates a simple range in the X and Y magnetic components over each 3-hour UT period. The K indices were calculated from the maximum of the X and Y ranges in the usual manner. This was suitable for Mawson as the diurnal variation is small.

Notes and Errata (cumulative since *AGR'93)*

In *AGR1998* through to *AGR2001* the principle azimuth mark at Mawson (MAW) was reported as being BMR89/2 at an azimuth of 19° 14.0' and distance of 105m from principle

observation Pier A. This mark ceased to be used after May 1998, from when mark BMR89/1 was principally used.

K indices and Daily K sums at Mawson Antarctica (K=9 limit: 1500 nT) for 2004

Date	January	February	March	April	May	June	Date
01	5554 5456 39	4553 4355 34	5444 4776 41	Q 3221 2142 17	6544 3244 32	D 6644 3346 36	01
02	6534 4456 37	4454 4546 36	D 5454 3376 37	Q 3221 0110 10	4321 0054 19	6544 2355 34	02
03	4655 4464 38	5565 4545 39	3534 4351 28	D 3553 4656 37	2334 3255 27	4443 2226 27	03
04	5554 6564 40	6344 4346 34	2333 2333 22	5423 2312 22	3542 1166 28	5433 4244 29	04
05	6644 4776 44	5544 3333 30	5543 2204 25	D 2121 3675 27	D ---- ---- --	4431 2446 28	05
06	5563 3346 35	4664 3663 38	Q 3323 2113 18	D 5555 4266 38	--44 3256 --	4553 4265 34	06
07	D 5776 6564 46	4443 3233 26	Q 2212 2245 20	6543 2275 34	D 3554 3476 37	5432 3246 29	07
08	Q 3333 4235 26	Q 3223 2125 20	Q 2232 2212 16	5544 3366 36	4534 3355 32	5433 4252 28	08
09	4654 4564 38	2322 4355 26	D 2433 4556 32	D 3554 2365 33	4431 1214 20	D 6454 3--5 --	09
10	5454 4773 39	Q 4333 3324 25	D 6665 4267 42	3452 3276 32	3421 1155 22	6431 2065 27	10
11	3445 5645 36	D 3334 5674 35	D 5554 5676 43	5443 2465 33	6532 1157 30	6433 3112 23	11
12	Q 3322 4475 30	D 6666 4575 45	D 6555 3676 43	5553 3252 30	4732 1264 29	1222 1003 11	12
13	4443 5545 34	D 5654 4765 42	5453 4465 36	5332 2254 26	3554 2365 33	3121 1105 14	13
14	Q 5533 4444 32	5455 4675 41	5554 3475 38	4421 1125 20	3531 2114 20	3345 3343 28	14
15	5542 4765 38	D 6666 3556 43	5543 4565 37	3312 3346 25	7342 2135 27	D 2464 4366 35	15
16	D 5666 5566 45	5433 2253 27	5432 3366 32	3663 3365 35	Q 4332 1125 21	5443 2114 24	16
17	5555 3566 40	Q 4442 2244 26	4542 2245 28	4533 2244 27	Q 3311 1135 18	4443 3254 29	17
18	3463 4376 36	5532 2455 31	5452 3465 34	3552 3346 31	Q 4212 2112 15	3344 4332 26	18
19	3544 4756 38	4432 1256 27	6432 2133 24	5542 2435 30	2321 3533 22	4333 2221 20	19
20	5654 5646 41	Q 4431 2353 25	6442 2655 34	Q 4422 1125 21	D 3344 2235 26	Q 2221 2121 13	20
21	4653 4465 37	5422 4345 29	6443 3464 34	2522 1152 20	5543 2223 26	2222 2134 18	21
22	D 7777 6675 52	5433 3345 30	5443 3645 34	Q 2221 1232 15	3543 3212 23	Q 1220 0012 08	22
23	D 6655 6675 46	3433 3246 28	4442 2275 30	D 3335 4447 33	5433 2363 29	Q 2111 1114 12	23
24	6454 3356 36	5553 2555 35	Q 3311 1004 13	3343 3225 25	5455 4113 28	0121 1000 05	24
25	D 6665 5655 44	4442 2234 25	Q 3121 2231 15	3544 3255 31	4333 3222 22	Q 1101 0013 07	25
26	4544 4475 37	Q 4431 2111 17	3332 3566 31	4321 1254 22	Q 2332 2114 18	3101 1345 18	26
27	5543 4335 32	2633 2244 26	4344 4536 33	3211 0236 18	Q 3321 2223 18	Q 3221 0134 16	27
28	7664 3365 40	3674 3356 37	4754 3463 36	5121 1276 25	3222 2365 25	D 5534 2136 29	28
29	Q 3533 4235 28	D 4654 4346 36	3544 3435 31	Q 3322 1136 21	D 4643 3366 35	D 4655 3365 37	29
30	5545 4445 36		3444 5234 29	4552 2367 34	5333 3265 30	4543 3244 29	30
31	Q 3435 3223 25		3332 3462 26		D 6554 3364 36		31
Mean K-sum	37.6	31.5	30.4	26.9	25.8	23.2	

Date	July	August	September	October	November	December	Date
01	5443 3266 33	7431 1056 27	4432 2266 29	2222 1244 19	3323 3214 21	4664 3245 34	01
02	4532 2436 29	3433 1145 24	5333 1144 24	4443 3335 29	Q 4323 3332 23	Q 4331 3333 23	02
03	4332 2252 23	Q 3321 0000 09	Q 2311 1112 12	3434 4456 33	4323 2345 26	Q 3222 2234 20	03
04	5532 2225 26	Q 0131 1111 09	Q 2111 1013 10	D 6542 3455 34	3552 2355 30	Q 3121 1022 12	04
05	5422 2235 25	1222 2346 22	3222 2442 21	4332 1234 22	Q 6221 0112 15	3343 2233 23	05
06	Q 5542 2114 24	4320 1014 15	D 4344 4545 33	3333 2234 23	Q 2321 2022 14	D 4665 6465 42	06
07	Q 1321 1033 14	6654 3356 38	4453 4365 34	Q 3321 1111 13	D 4523 3566 34	5554 4456 38	07
08	Q 2200 0011 06	Q 3421 1234 20	5563 2234 30	2332 3325 23	D 9676 6366 49	4564 3435 34	08
09	Q 4420 1122 16	3453 3375 33	2211 2235 18	5321 1224 20	D 6756 5787 51	4433 3334 27	09
10	3432 1334 23	D 4322 3757 33	Q 3221 1100 10	6522 3135 27	D 7776 6766 52	4434 4434 30	10
11	3313 2247 25	2444 3266 31	Q 0010 1244 12	4542 2256 30	5666 2335 36	3442 4455 31	11
12	6543 1136 29	5432 3234 26	Q 4210 0102 10	5543 2115 26	D 6645 4665 42	D 5653 4533 34	12
13	6454 2365 35	4532 1336 27	2100 0055 13	D 5564 4465 39	4443 3233 26	6643 3322 29	13
14	2443 1125 22	4333 1104 19	D 5664 5566 43	D 5554 4565 39	5543 2223 26	3344 4333 27	14
15	4222 1265 24	2100 0023 08	6532 4545 34	3533 2355 29	Q 3331 2011 14	4442 3454 30	15
16	2222 2246 22	2211 4236 21	D 5454 4566 39	4422 1003 16	2334 4444 28	3652 4345 32	16
17	7562 2246 34	4311 2655 27	D 4554 3337 34	Q 2221 0102 10	3443 2124 23	D 4654 4556 39	17
18	4343 1244 25	4553 1015 24	6633 3102 24	2021 2254 18	Q 3221 2211 14	6554 4255 36	18
19	3333 2336 26	4211 0234 17	2121 1237 19	3322 3215 21	2422 2234 21	Q 4332 1222 19	19
20	4542 2155 28	D 5443 3446 33	4344 4314 27	3442 4425 28	4664 4354 36	4422 3245 32	20
21	Q 3320 0114 14	D 4653 2376 36	5543 2234 28	6653 2244 32	4554 4565 38	4434 3464 32	21
22	2112 4377 27	5553 3366 36	D 3443 4767 38	4422 2343 24	4553 2224 27	D 4674 4325 35	22
23	D 6775 3644 42	5542 2233 26	5553 2235 30	Q 2322 1115 17	5422 2235 25	4443 3344 29	23
24	D 4564 4536 37	Q 3221 1221 14	4523 1234 24	5332 2553 28	4433 3334 27	Q 3332 3233 22	24
25	D ---- ---- --	Q 1442 1--- --	2222 3244 21	3654 3324 30	5654 4564 39	5663 2344 33	25
26	D --34 3369 --	---- ---- --	2221 1135 17	Q 3321 2101 13	4553 3346 33	4543 3454 32	26
27	D 8787 6679 58	-231 2135 --	4221 2432 20	2121 2224 16	4453 4654 35	4552 2354 30	27
28	5553 4576 40	4333 2254 26	3532 2125 23	Q 3321 1124 17	5564 4345 36	4544 4576 39	28
29	5443 3143 27	3412 2123 18	3122 1134 17	3223 3442 23	5555 3456 38	5565 4445 38	29
30	3323 2245 24	D 4455 3767 41	4120 1043 15	D 6544 3436 35	5763 3374 38	D 4665 5545 40	30
31	3322 3334 23	D 6664 3474 40		D 3433 3476 33		5433 2334 27	31
Mean K-sum	26.9	25.0	23.6	24.7	30.6	30.4	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	0	0	7	37	65	72	49	18	0	0	0
February	0	7	30	53	61	48	28	5	0	0	0
March	3	12	38	55	57	46	28	9	0	0	0
April	3	27	56	50	33	45	20	6	0	0	0
May	2	32	46	64	38	36	16	4	0	0	10
June	16	38	43	47	52	24	18	0	0	0	2
July	8	23	54	50	41	28	20	10	2	2	10
August	15	37	39	53	40	25	19	8	0	0	12
September	16	38	52	40	45	31	14	4	0	0	0
October	6	28	62	57	46	35	13	1	0	0	0
November	3	12	42	52	48	40	31	10	1	1	0
December	1	5	31	63	80	43	23	2	0	0	0
ANNUAL TOTAL	**73**	**259**	**500**	**621**	**606**	**473**	**279**	**77**	**3**	**3**	**34**

Monthly and Annual Mean Values

The following table gives final monthly and annual mean values of each of the magnetic elements for the year.

A value is given for means computed from all days in each month (All days), the five least disturbed of the International Quiet days (5xQ days) in each month and the five International Disturbed days (5xD days) in each month.

Mawson Antarctica	2004	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	7463.3	-16994.3	-45516.3	49155.4	18561.1	-66° 17.5'	-67° 48.9'
	5xQ days	7477.6	-17016.5	-45514.1	49163.2	18587.0	-66° 16.7'	-67° 47.2'
	5xD days	7432.8	-16959.9	-45540.9	49162.0	18517.6	-66° 20.1'	-67° 52.3'
February	All days	7448.4	-16992.0	-45525.2	49160.6	18552.9	-66° 19.8'	-67° 49.7'
	5xQ days	7453.3	-17003.5	-45524.5	49164.6	18565.3	-66° 19.8'	-67° 48.8'
	5xD days	7442.0	-16976.7	-45529.7	49158.6	18536.4	-66° 19.8'	-67° 50.8'
March	All days	7432.2	-16986.6	-45528.6	49159.4	18541.4	-66° 22.2'	-67° 50.5'
	5xQ days	7446.4	-17009.9	-45505.5	49148.1	18568.4	-66° 21.5'	-67° 48.1'
	5xD days	7420.2	-16960.8	-45560.9	49178.8	18513.1	-66° 22.3'	-67° 53.2'
April	All days	7426.1	-16988.7	-45520.5	49151.6	18540.8	-66° 23.4'	-67° 50.3'
	5xQ days	7439.1	-17007.8	-45505.8	49146.6	18563.5	-66° 22.6'	-67° 48.5'
	5xD days	7426.8	-16975.7	-45525.5	49152.0	18529.3	-66° 22.3'	-67° 51.2'
May	All days	7424.8	-16992.9	-45509.5	49142.8	18544.2	-66° 23.9'	-67° 49.8'
	5xQ days	7433.4	-17006.2	-45499.1	49139.0	18559.8	-66° 23.4'	-67° 48.5'
	5xD days	7416.1	-16985.4	-45512.6	49141.8	18534.0	-66° 24.8'	-67° 50.5'
June	All days	7426.1	-17001.9	-45497.0	49134.4	18553.0	-66° 24.3'	-67° 48.9'
	5xQ days	7437.0	-17014.5	-45489.2	49133.2	18568.9	-66° 23.4'	-67° 47.7'
	5xD days	7406.9	-16985.6	-45495.7	49124.8	18530.4	-66° 26.4'	-67° 50.3'
July	All days	7409.4	-16990.0	-45509.1	49139.1	18535.5	-66° 26.3'	-67° 50.4'
	5xQ days	7431.1	-17012.5	-45489.8	49132.2	18564.6	-66° 24.3'	-67° 48.0'
	5xD days	7332.5	-16908.2	-45573.7	49159.8	18430.1	-66° 33.4'	-67° 58.9'
August	All days	7412.6	-16995.7	-45510.6	49142.8	18541.9	-66° 26.2'	-67° 50.0'
	5xQ days	7426.3	-17016.4	-45505.4	49147.2	18566.3	-66° 25.4'	-67° 48.3'
	5xD days	7391.8	-16962.8	-45513.2	49130.9	18503.5	-66° 27.3'	-67° 52.5'
September	All days	7412.2	-17001.4	-45514.2	49148.1	18547.0	-66° 26.7'	-67° 49.7'
	5xQ days	7424.0	-17015.7	-45502.6	49144.1	18564.8	-66° 25.7'	-67° 48.3'
	5xD days	7390.5	-16977.2	-45513.3	49135.9	18516.2	-66° 28.6'	-67° 51.7'
October	All days	7415.2	-17004.4	-45505.5	49141.5	18550.9	-66° 26.4'	-67° 49.3'
	5xQ days	7422.9	-17017.2	-45498.0	49140.1	18565.7	-66° 26.0'	-67° 48.1'
	5xD days	7393.5	-16978.7	-45514.7	49138.1	18518.8	-66° 28.2'	-67° 51.6'
November	All days	7412.3	-17007.8	-45529.2	49164.3	18553.0	-66° 27.1'	-67° 49.8'
	5xQ days	7421.4	-17019.3	-45503.4	49145.7	18567.1	-66° 26.4'	-67° 48.2'
	5xD days	7370.7	-16973.8	-45586.9	49200.3	18505.8	-66° 31.7'	-67° 54.3'
December	All days	7423.6	-17017.6	-45506.9	49148.8	18566.4	-66° 25.9'	-67° 48.3'
	5xQ days	7420.6	-17024.5	-45503.5	49147.4	18571.5	-66° 26.9'	-67° 47.9'
	5xD days	7418.1	-17016.2	-45494.4	49135.9	18563.1	-66° 26.8'	-67° 48.2'
Annual	All days	7425.5	-16997.8	-45514.4	49149.1	18549.0	-66° 24.1'	-67° 49.6'
Mean	5xQ days	7436.1	-17013.7	-45503.4	49145.9	18567.7	-66° 23.5'	-67° 48.1'
Values	5xD days	7403.5	-16971.8	-45530.1	49151.6	18516.5	-66° 26.0'	-67° 52.1'

(Calculated: 15:51 hrs., Tue., 24 Jan., 2006)

Hourly Mean Values

The charts on the following pages are plots of hourly mean values.

The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

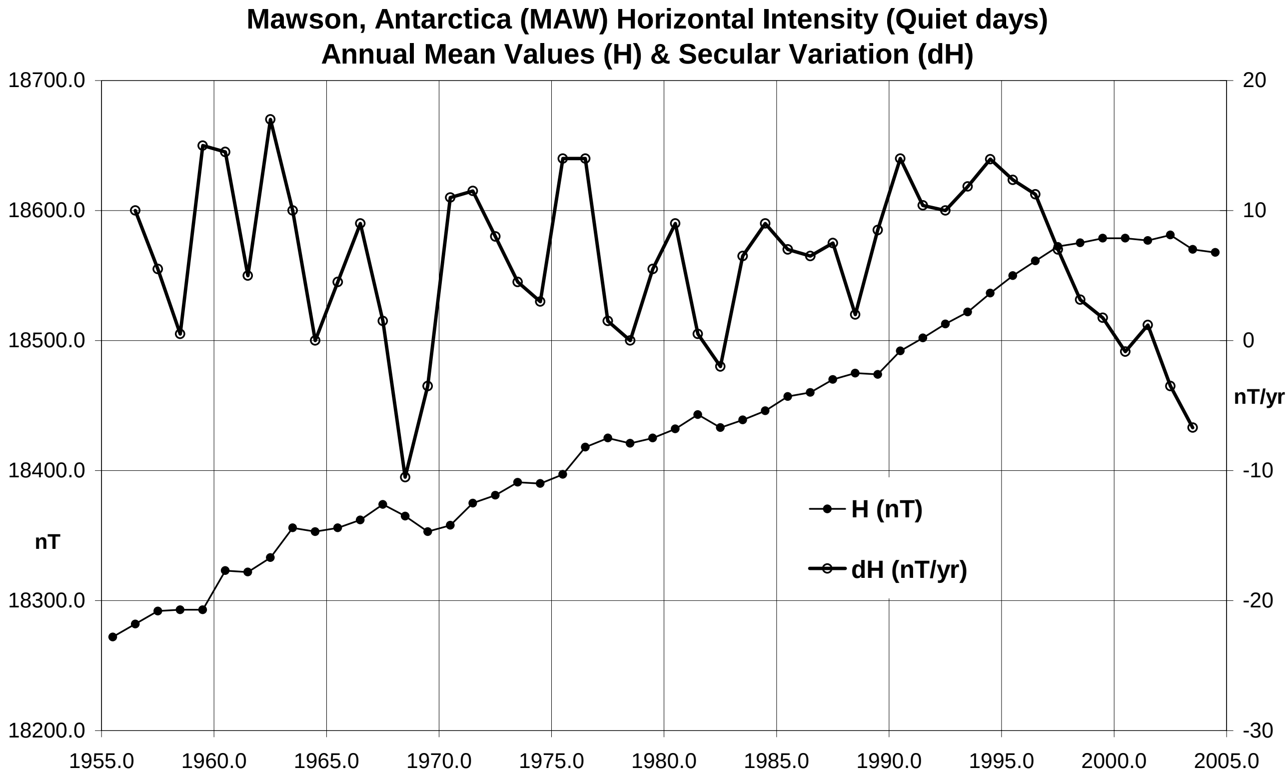
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

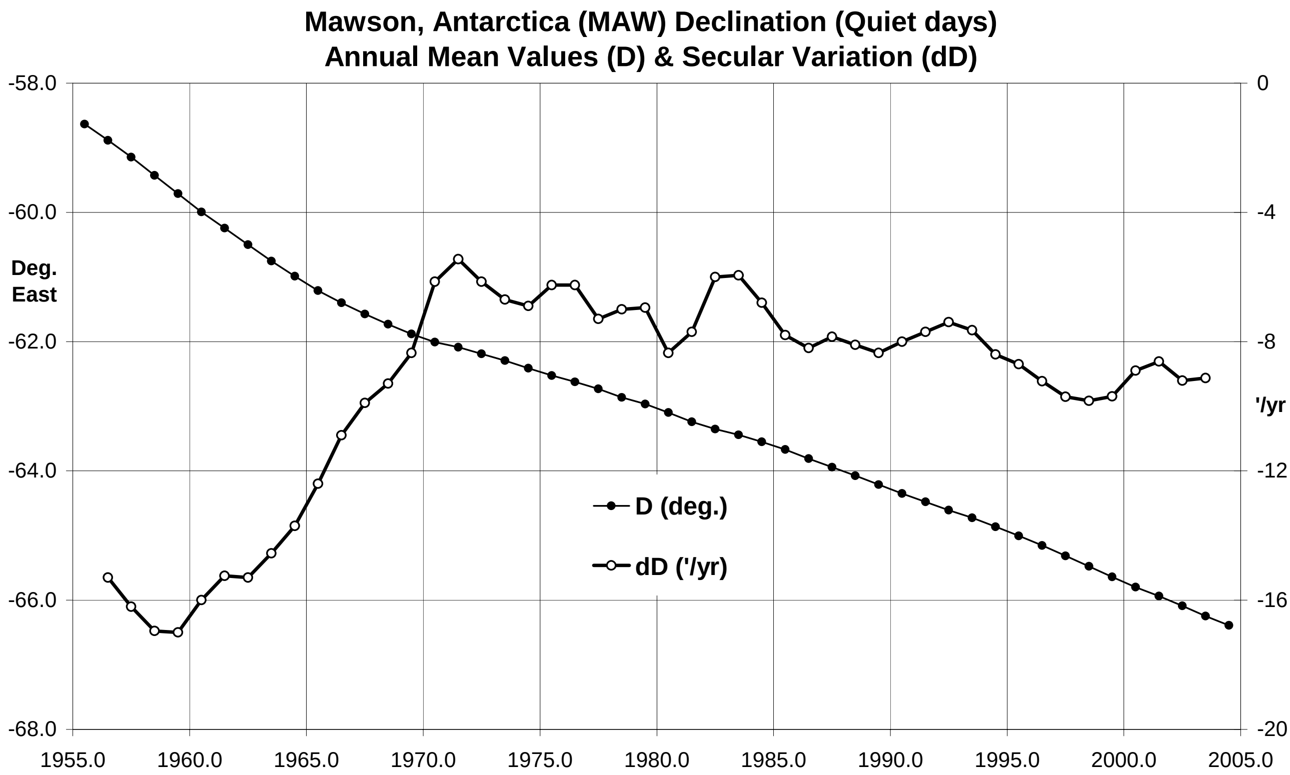
Mawson Stn. 2004 Horizontal intensity (H). Scale: 40.0 nT/mm. Mean: 18549 nT

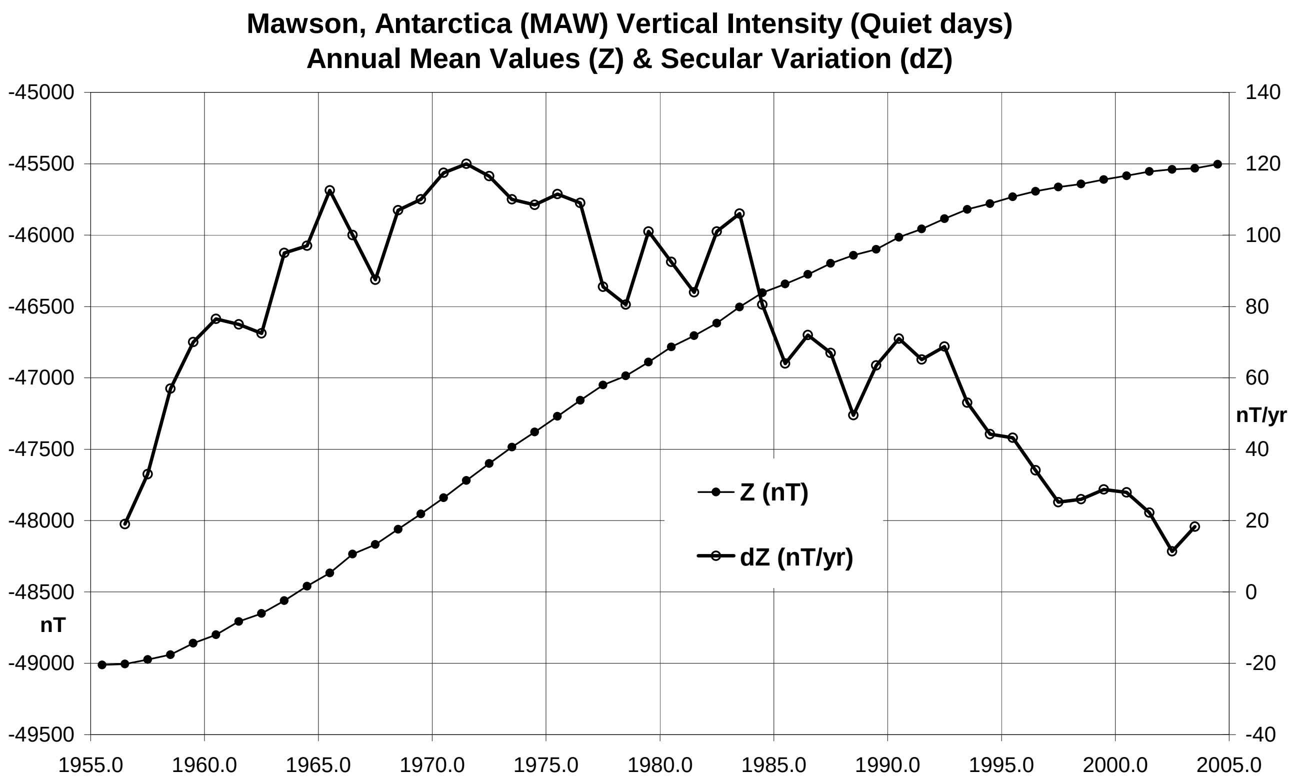
Mawson Stn. 2004 Declination (east) (D). Scale: 5.00 min/mm. Mean: −66.40 deg.

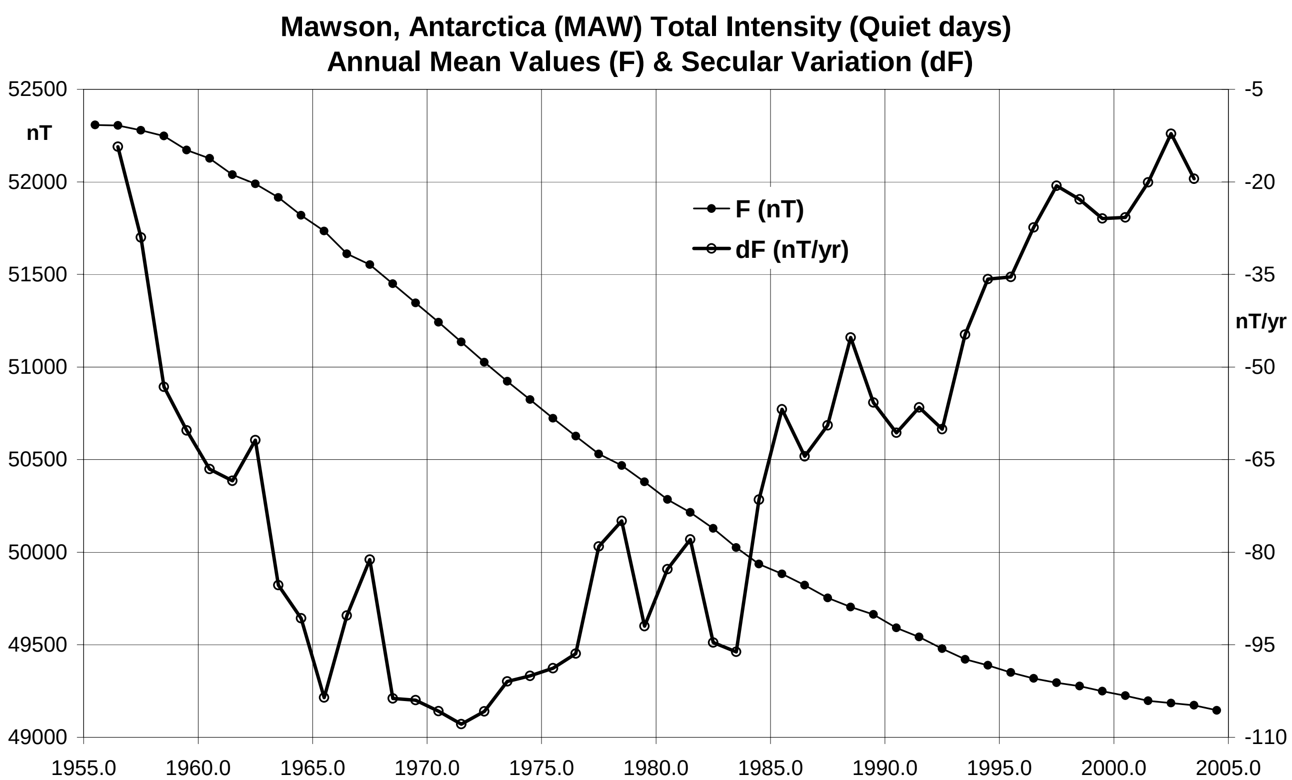
Mawson Stn. 2004 Vertical intensity (Z). Scale: 40.0 nT/mm. Mean: −45514 nT

Mawson Stn. 2004 Total intensity (F). Scale: 40.0 nT/mm. Mean: 49149 nT


Mawson, Antarctica (MAW) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
18700.0
18600.0
18500.0
18400.0
18300.0
18200.0
nT
20
10
0
-10
-20
-30
nT/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
H (nT)
dH (nT/yr)


Mawson, Antarctica (MAW) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
-58.0
-60.0
-62.0
-64.0
-66.0
-68.0
Deg.
East
0
-4
-8
-12
-16
-20
'/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
D (deg.)
dD ('/yr)


Mawson, Antarctica (MAW) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-45000
-45500
-46000
-46500
-47000
-47500
-48000
-48500
-49000
-49500
nT
140
120
100
80
60
40
20
0
-20
-40
nT/yr
Z (nT)
dZ (nT/yr)
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0


Mawson, Antarctica (MAW) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)
52500
52000
51500
51000
50500
50000
49500
49000
nT
-5
-20
-35
-50
-65
-80
-95
-110
nT/yr
F (nT)
dF (nT/yr)
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0

Summary of data loss from the Australian observatories

The table below summarizes the 2004 monthly digital data acquisition losses, in minutes per month, at the Australian observatories. The first figure refers to the principal 3-component variometers and the second figure (in parentheses) to the recording total intensity instruments. A single figure indicates the same data loss in a month for both instruments. Annual totals and percentage losses are also shown.

For details of events that resulted in loss of data, including the contamination of data subsequently excluded from processing, see the sections entitled *Significant Events* and *Data Loss* contained in the respective observatory descriptions in this report.

2004	KDU	CTA	LRM	ASP	GNA	CNB	MCQ	CSY	MAW
Jan	0 (20)	0	1,077 (27,208)	0 (44,640)	186 (8,928)	0	0	166	0 (25 days)
Feb	0	0	0	0 (41,760)	0 (,1611)	0	4,553	1,170	0 (23 days)
Mar	0	0	3	1 (40,710)	12,788 (7,541)	914	0	155	4 (23 days)
Apr	0	0	0	0	7,598 (0)	14 (8)	0	157	0 (20 days)
May	0	0	180 (867)	0 (1,181)	0	0	0	155	1,821 (27 days)
Jun	0	0	6 (8)	0	0	0	121	150	288 (17 days)
Jul	0	0	11 (1,819)	0	0	0	440	157	1,935 (16 days)
Aug	0	0 (21,866)	0	0 (3)	0	0	14,641	157	2,167 (16 days)
Sep	0	8	3 (4,921)	0	1	0	0	150	0 (3 days)
Oct	0	0	0	58 (63)	2 (37)	0 (10)	407	166	0 (5 days)
Nov	24 (191)	0	11 (4,274)	0	0	0	0	150	0 (10 days)
Dec	0	1,269 (2,457)	3 (1,221)	0	0	0	2	283	0 (12 days)
3-axis variom.	24 (0.005%)	1,277 (0.24%)	1,294 (0.25%)	58 (0.011%)	20,575 (3.90%)	928 (0.18%)	20,164 (3.83%)	3,016 (0.57%)	6,215 (1.18%)
Total field	211 (0.04%)	24,331 (4.62%)	40,321 (7.65%)	128,357 (24.3%)	18,118 (3.44%)	932 (0.18%)	20,164 (3.83%)	no PPM	197 days (53.83%)

International Quiet and Disturbed Days

2004	Quietest days 1 - 5					Quietest days 6 - 10					Most Disturbed days 1 - 5				
January	8A	29A	12A	31A	14A	21A	2A	15A	27A	11A	22	23	25	16	7
February	26	17	8	20	10	25	16A	21A	9A	7A	12	29	13	15	11
March	24	7	6	8	25	5	4	17K	19A	23A	10	11	12	9	2
April	2	1	22	20	29	27	14	26	19	13	3	6	5	9*	23*
May	26	18	17	27	16	25	9	14	10	2K	7*	29*	5*	20*	31*
June	22	23	27	20	25	12	21	13	24	19	29*	15*	1*	28*	9*
July	8	7	9	21	6	29	4	10	18	3	27	25	23	26	24
August	4	8	24	3	25	19	15	23	26	16	30	31	21*	10*	20*
September	11	10	4	12	3	30	26	25	9	27	14	17	16*	22*	6*
October	17	26	7	28	23	1	6	27	19	18	13	14	30*	31*	4*
November	6	15	18	2	5K	19	1K	17K	23	13A	10	8	9	7	12
December	4	3	19	2	24	20	23	15	14A	31A	12	6	22	30*	17*

Notes: If any of the selected quietest days were not truly quiet, they have been identified: with an A if the daily Ap index is > 6; or with a K if either one Kp index ≥ 3_o or two Kp indices ≥ 3_- occurred during the day.

If any of the 5 most disturbed days have an index Ap < 20 they are identified with an *.

International Quiet and Disturbed Day information was supplied by the International Service of Geomagnetic Indices (ISGI), International Union of Geodesy and Geophysics (IUGG), Association of Geomagnetism and Aeronomy (IAGA), edited by Institut für Geophysik, Göttingen, Germany.

REPEAT STATION NETWORK

GA maintains a network of fifteen repeat stations throughout mainland Australia, its offshore islands, and the south-west Pacific region. The repeat stations are usually occupied at intervals of approximately two years to determine the secular variation of the magnetic field. During each three to four day repeat station occupation, four components of the magnetic field are monitored continuously with a portable on-site 3-axis fluxgate variometer and a total field magnetometer.

During 2004 a Narod three-axis ring-core fluxgate magnetometer was used to monitor variations in three orthogonal components of the magnetic field. The digital output from this magnetometer was recorded as 1-second and 1-minute means with a portable industrial computer running an MS-DOS data acquisition system. A GEM Systems GSM90 Overhauser-effect total field magnetometer was used to monitor the total magnetic intensity. The digital output from the total field magnetometer was recorded at a sampling interval of 10 seconds.

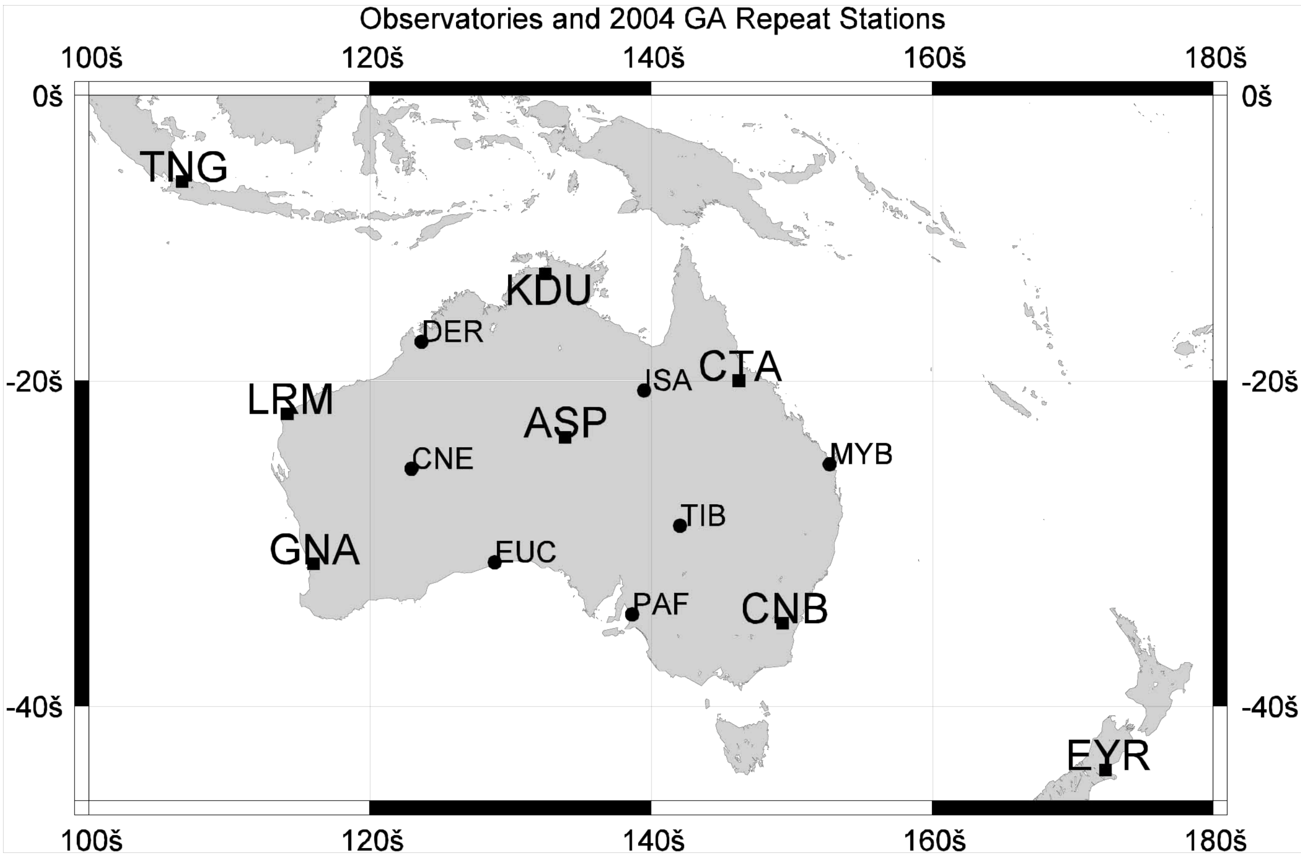
The magnetometers, acquisition and recording system were all powered by either two 12V DC batteries and solar panels or 240V AC mains power, depending on the location. Preliminary data processing and analysis was carried out on-site on a lap-top computer.

The variometer recordings were calibrated to observatory standard with a campaign of absolute magnetic observations made during each station occupation. Usually from 24 to 30 sets of absolute observations were performed on each primary repeat station. Vector field differences between the primary and secondary station 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 absolute instruments used on the repeat station surveys during 2004 were Elsec 810 DIM, no. 220 with Zeiss 020B theodolite, no. 308887, and GEM Systems GSM90 no. 810881 with sensor no. 31960. The GSM90 was also used for total field surveys around each station.

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 magnetic 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.



The distribution of permanent magnetic observatories and repeat stations occupied in 2004

Station Occupations

Seven repeat stations were re-occupied in April/May 2004: Maryborough (MYB), Mount Isa (ISA), Derby (DER), Carnegie (CNE), Eucla (EUC), Parafield (PAF) and Tibooburra (TIB). The map above shows the location of these repeat stations and the permanent magnetic observatories in the region.

The adopted normal field values at the time of the 2004 occupations and the average secular variation over the interval between the two most recent occupations for each station are shown in the tables below. All available data from the repeat stations are plotted in the figures that follow.

Adopted Main Field Values at Time of Station Occupations

Station (site)	Occupation	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D	I
Maryborough (D)	2004 04 22	29237	5499	-43157	52417	29750	10º 39.1’	-55º 25.2’
Mount Isa (A)	2004 04 27	31784	3409	-39547	50851	31966	06º 07.3’	-51º 03.0’
Derby (E)	2004 05 04	33366	1563	-37287	50060	33403	02º 40.9’	-48º 08.7’
Carnegie (A)	2004 05 13	28109	1186	-47494	55202	28134	02º 24.9 ’	-59º 21.5’
Eucla (D)	2004 05 17	23714	1926	-53274	58345	23792	04º 38.5 ’	-65º 56.1’
Parafield (C)	2004 05 22	22831	3389	-54703	59373	23082	08º 26.6’	-67º 07.4’
Tibooburra (A)	2004 05 26	26675	4011	-49213	56121	26974	08º 33.0’	-61º 16.3’

Average Secular Variation between two most recent Occupations

Station (site)	Previous occupation	ΔX (nT/yr)	ΔY (nT/yr)	ΔZ (nT/yr)	ΔF (nT/yr)	ΔH (nT/yr)	ΔD (′/yr)	ΔI (′/yr)
Maryborough (D)	2002 05 17	-6	-2	41	-37	-6	-0.1	1.2
Mount Isa (A)	2002 05 11	4	-5	41	-30	3	-0.6	1.9
Derby (E)	2002 05 04	12	-2	38	-20	12	-0.2	2.3
Carnegie (A)	2002 05 10	13	10	41	-28	14	1.1	2.0
Eucla (D)	2002 04 21	13	11	38	-30	13	1.4	1.7
Parafield (C)	2002 04 16	6	6	32	-27	7	0.7	1.1
Tibooburra (A)	2002 04 11	1	-2	38	-33	1	-0.2	1.2

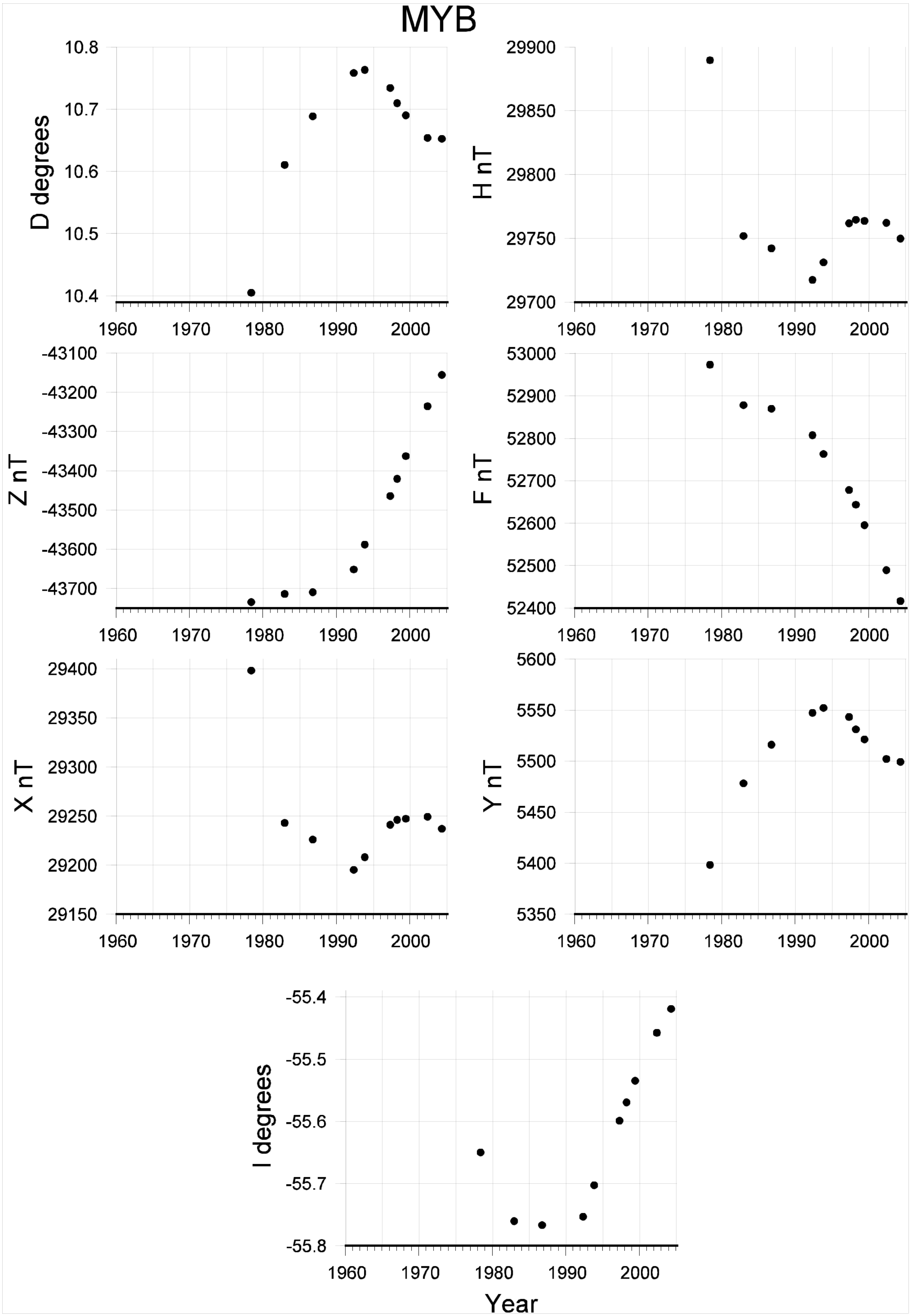
Distribution of Repeat Station data

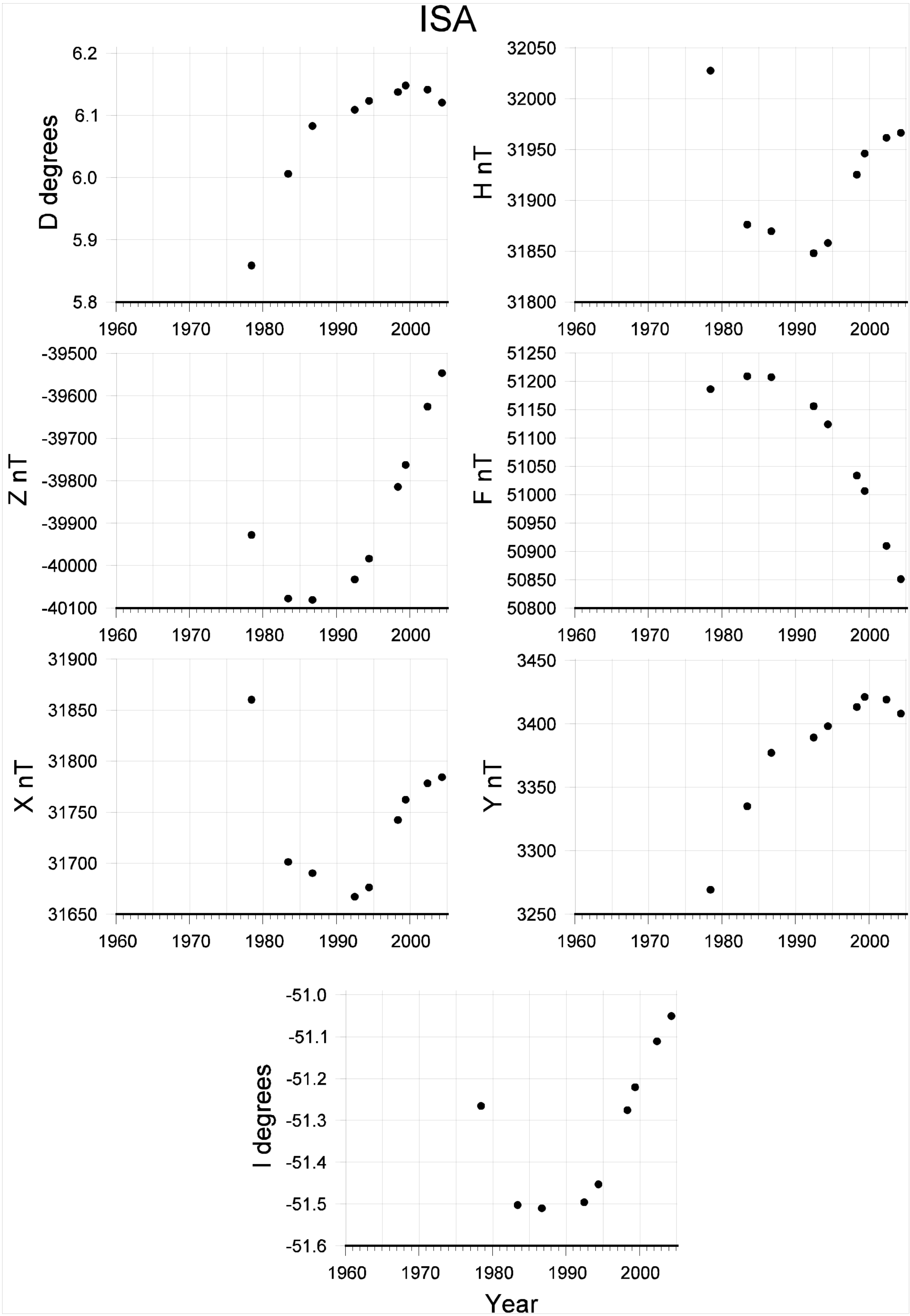
Australian Repeat Station data acquired over the 2001-2004 period were distributed to WDC-A, Boulder, USA and BGS, Edinburgh, UK on 10 Sep. 2004

Australian Geomagnetic Reference Field

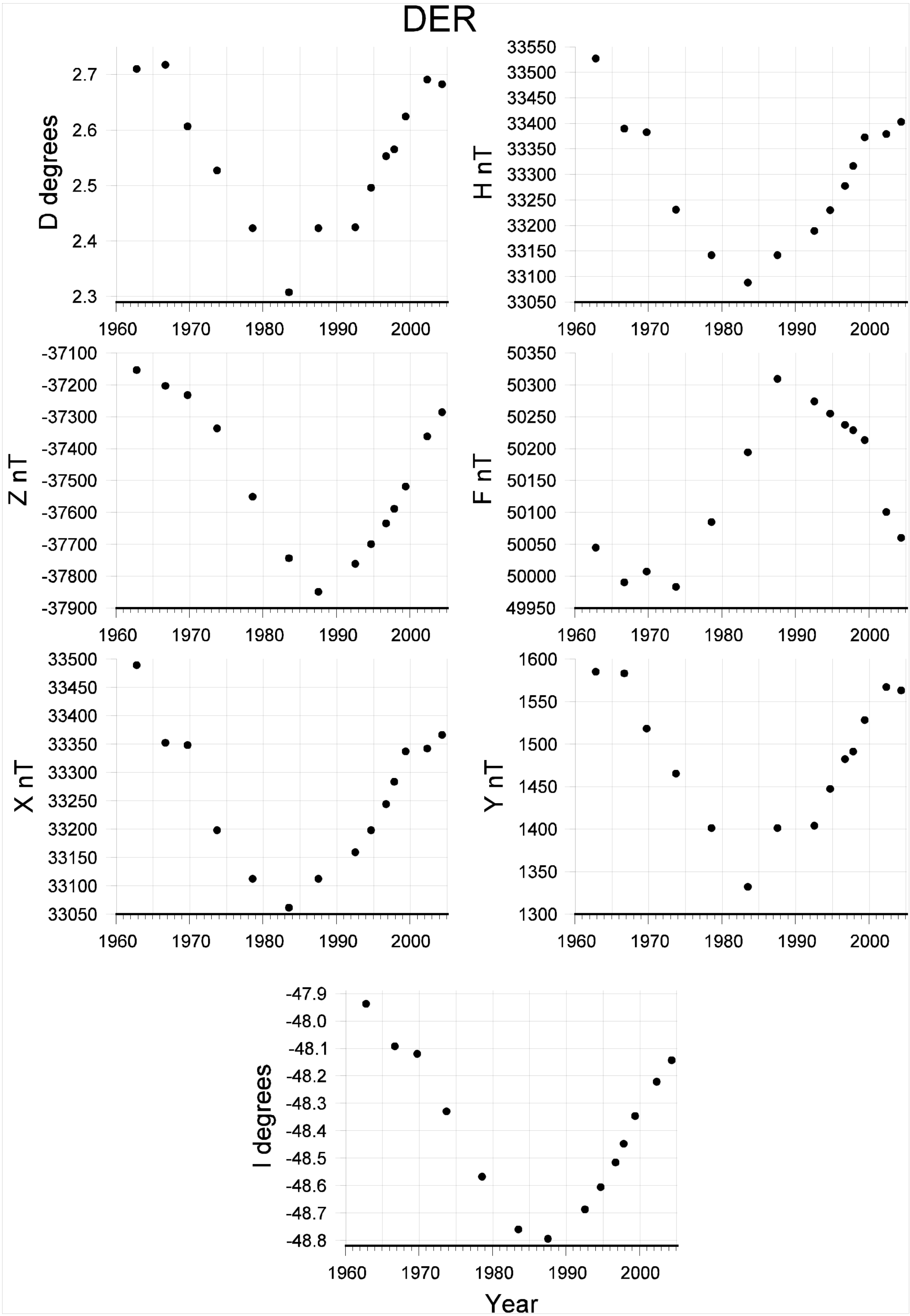
The latest revision of the Australian Geomagnetic Reference Field was for epoch 2000.0 (AGRF00) that was released in 2000 (Lewis, 2000). It is considered the best available geomagnetic field model for direction-finding applications in the Australian region. Charts in each of the magnetic elements X, Y, Z, F, H, D and I from the AGRF00 model are in the *AGR 2000*. The next AGRF model to be developed will be for 2005.0.

Epoch charts over the region have been produced on a regular basis since 1944. An Australian Geomagnetic Reference Field model (AGRF) has been produced every five years since 1980. These were listed in the *Charts and Models* table that appeared in *AGRs 1993-1997*.

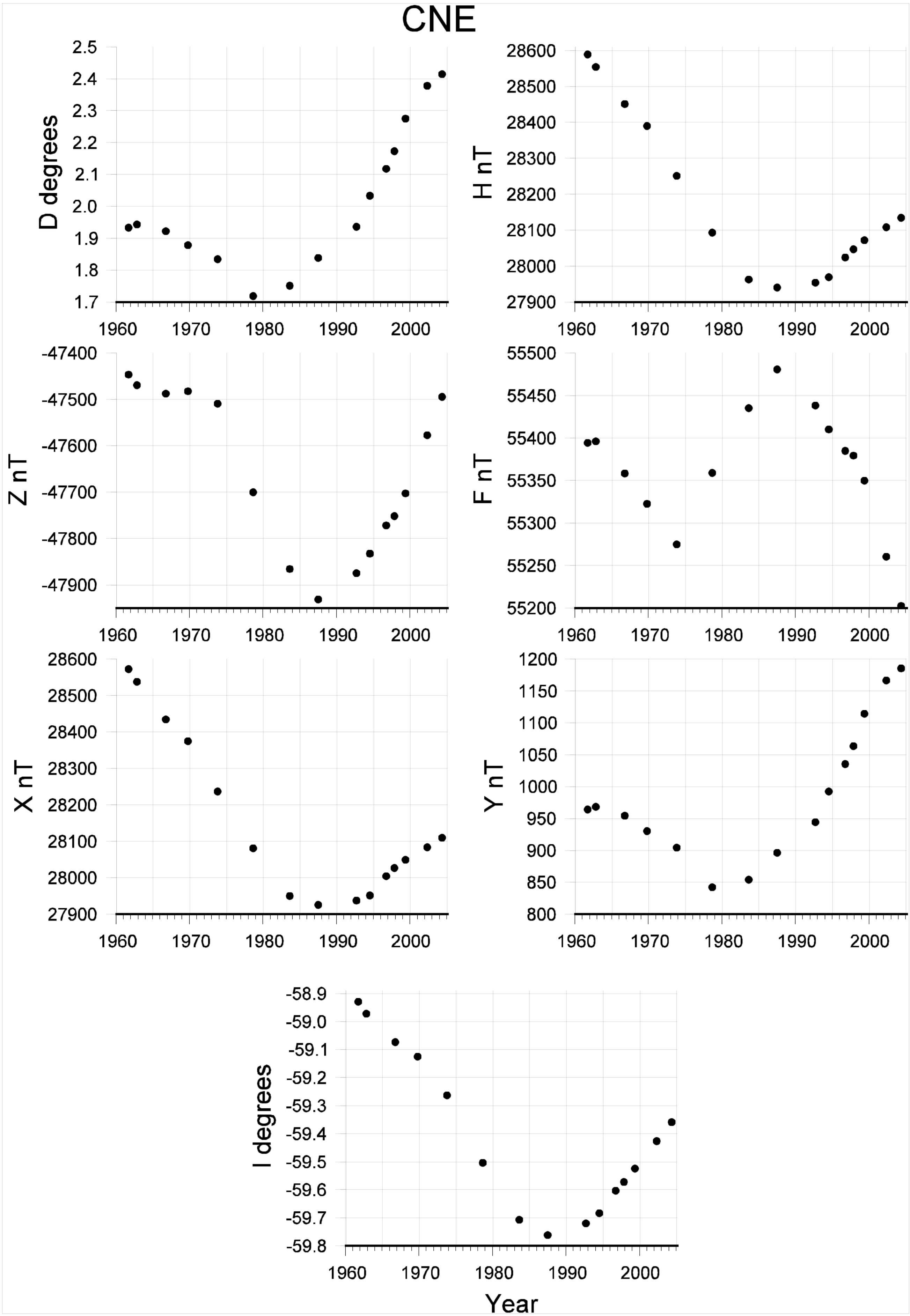

MYB
D degrees
10.8
10.7
10.6
10.5
10.4
H nT
29900
29850
29800
29750
29700
Z nT
-43100
-43200
-43300
-43400
-43500
-43600
-43700
F nT
53000
52900
52800
52700
52600
52500
52400
X nT
29400
29350
29300
29250
29200
29150
Y nT
5600
5550
5500
5450
5400
5350
I degrees
-55.4
-55.5
-55.6
-55.7
-55.8
1960
1970
1980
1990
2000
Year

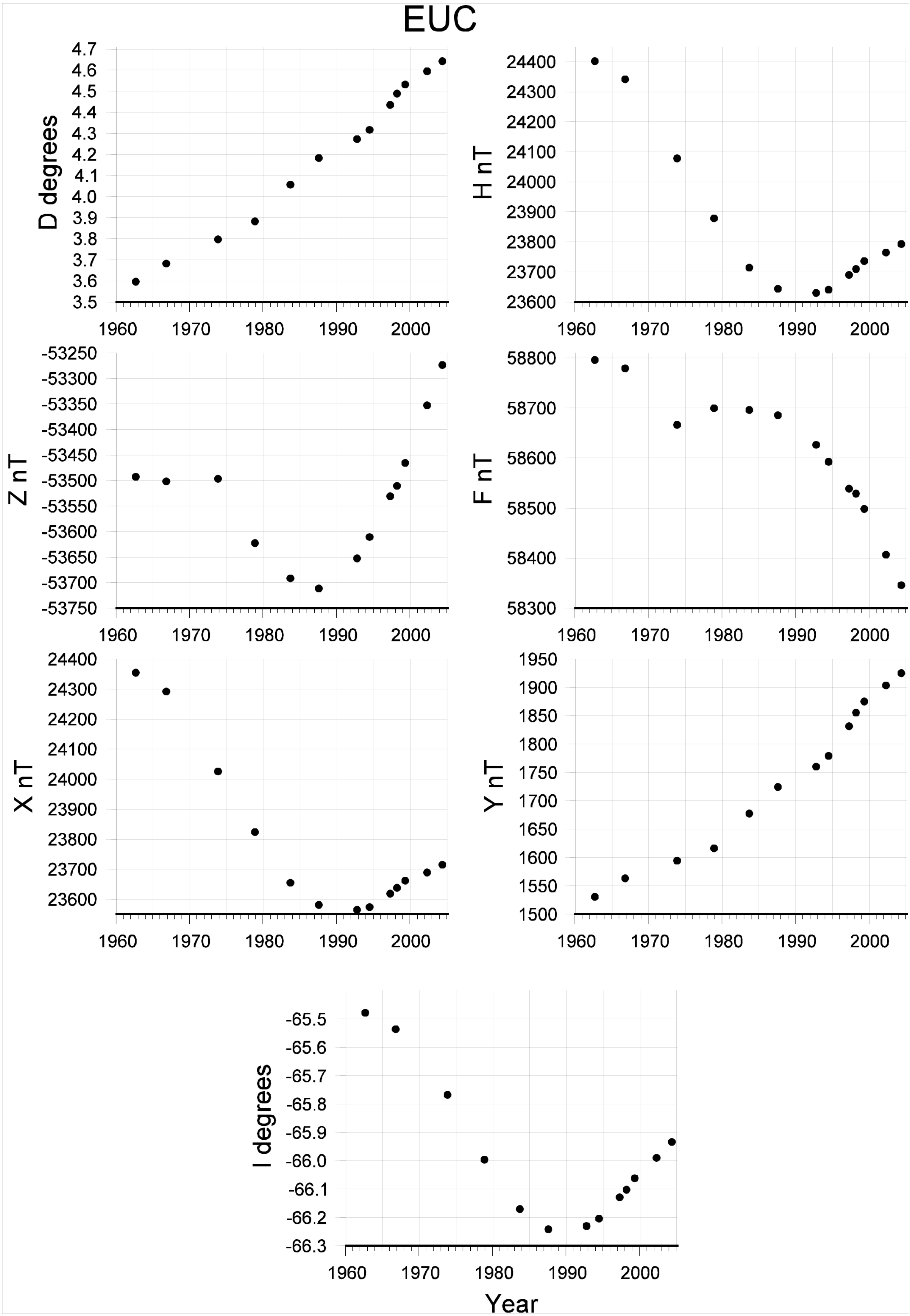

ISA
D degrees
6.2
6.1
6.0
5.9
5.8
1960
1970
1980
1990
2000
H nT
32050
32000
31950
31900
31850
31800
Z nT
-39500
-39600
-39700
-39800
-39900
-40000
-40100
F nT
51250
51200
51150
51100
51050
51000
50950
50900
50850
50800
X nT
31900
31850
31800
31750
31700
31650
Y nT
3450
3400
3350
3300
3250
I degrees
-51.0
-51.1
-51.2
-51.3
-51.4
-51.5
-51.6
Year

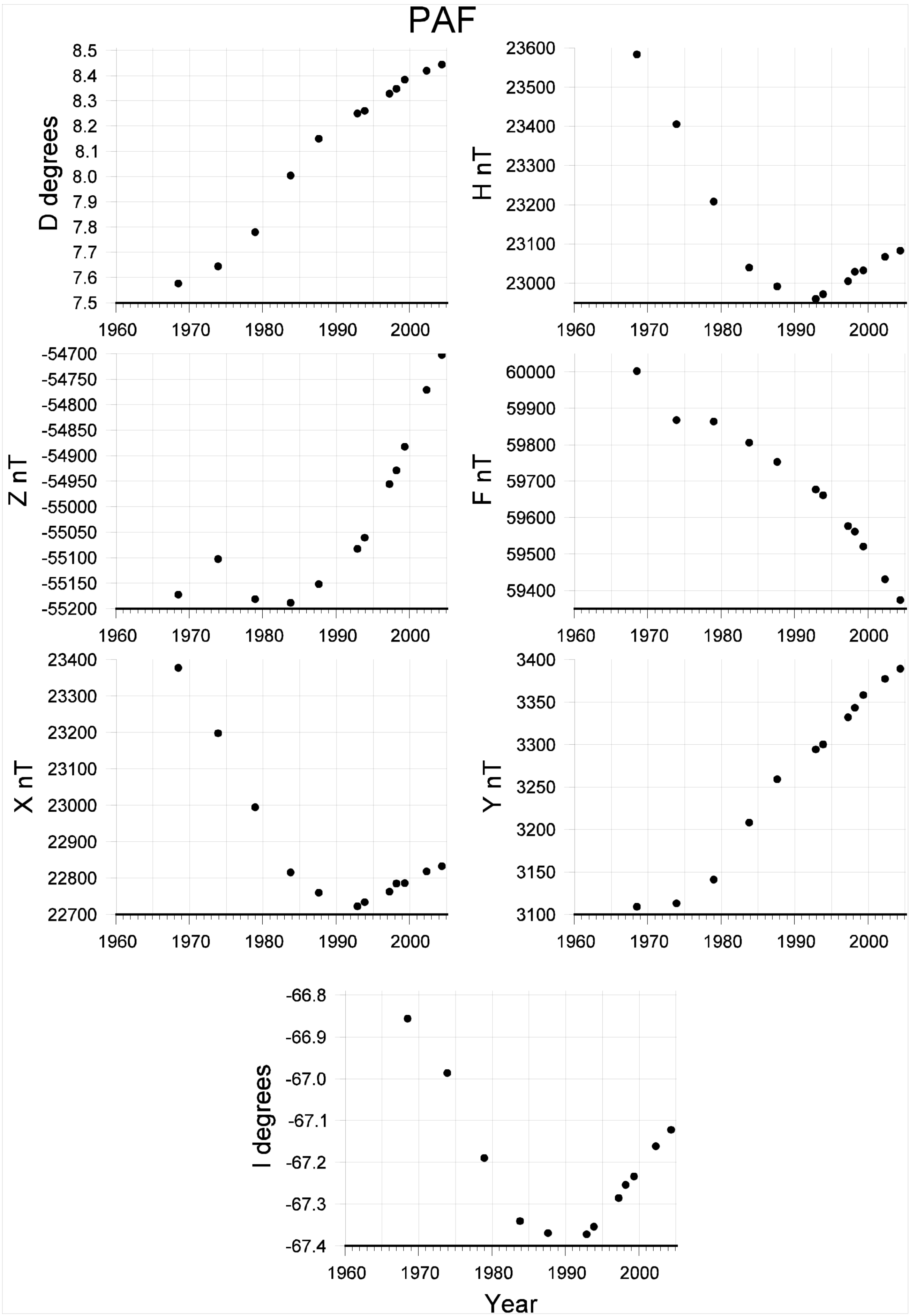
DER

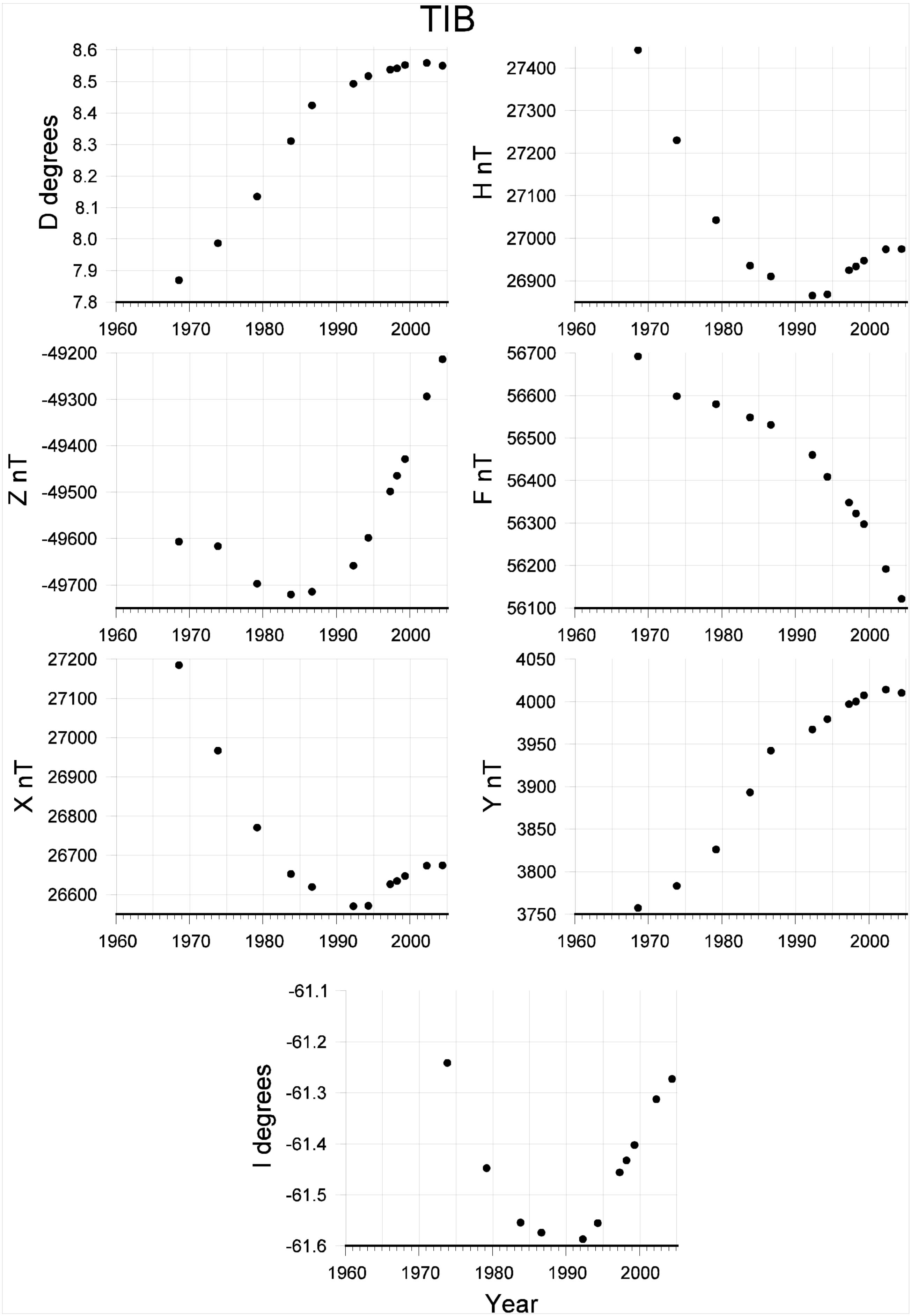


DER
D degrees
2.7
2.6
2.5
2.4
2.3
H nT
33550
33500
33450
33400
33350
33300
33250
33200
33150
33100
33050
Z nT
-37100
-37200
-37300
-37400
-37500
-37600
-37700
-37800
-37900
F nT
50350
50300
50250
50200
50150
50100
50050
50000
49950
X nT
33500
33450
33400
33350
33300
33250
33200
33150
33100
33050
Y nT
1600
1550
1500
1450
1400
1350
1300
I degrees
-47.9
-48.0
-48.1
-48.2
-48.3
-48.4
-48.5
-48.6
-48.7
-48.8
1960
1970
1980
1990
2000
Year


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


EUC
D degrees
H nT
Z nT
F nT
X nT
Y nT
I degrees
Year
1960
1970
1980
1990
2000


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



TIB
D degrees
8.6
8.5
8.4
8.3
8.2
8.1
8.0
7.9
7.8
H nT
27400
27300
27200
27100
27000
26900
Z nT
-49200
-49300
-49400
-49500
-49600
-49700
F nT
56700
56600
56500
56400
56300
56200
56100
X nT
27200
27100
27000
26900
26800
26700
26600
Y nT
4050
4000
3950
3900
3850
3800
3750
I degrees
-61.1
-61.2
-61.3
-61.4
-61.5
-61.6
1960
1970
1980
1990
2000
Year

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Geomagnetism Staff List 2004

Name	Classification	Responsibility
Peter A. Hopgood	GA Level 6	Project Manager
Peter G. Crosthwaite	GA Level 5	Digital acquisition, system and software development and maintenance; Kakadu and Gnangara observatories
Andrew M. Lewis	GA Level 5	Repeat Station Survey; Alice Springs and Learmonth observatories
Liejun Wang	GA Level 4	Data-base development; Canberra and Charters Towers observatories
Nick Bartzis	GA Level 2	Observatories
Bruce Sibson	GA Level 3	Technical support
Owen D. McConnel	GA Level 3	Technical support, Western Australia*

* The Mundaring Geophysical Observatory was closed at the end of April 2000. Only one member of staff (ODM) remained with Geoscience Australia after that time. This officer provided technical support for the Gnangara and Learmonth magnetic observatories as well as the seismograph network in Western Australia.

Non-GA Observers/OICs

Warren Serone	ACRES (contracted by GA)	Alice Springs
Jack M. Millican	Contracted by GA	Charters Towers
Graham Steward	Learmonth Solar Observatory, IPS	Learmonth
Rory Lynch	Contracted by GA	Kakadu
Gerard (Hans) Van Reeken	Contracted by GA	Gnangara
Ray Hegarty	Technical Officer 2 (BOM & GA)	Mawson, 2004 observer
Glenn Roser	Technical Officer 2 (AAD & GA)	Mawson, 2005 observer
Henry Banon	Technical Officer 2 (AAD & GA)	Macquarie Island, 2003/04 observer
Spencer Redfern	Technical Officer 2 (AAD & GA)	Macquarie Island, 2004/05 observer
Mark Healy	Technical Officer 2 (AAD & GA)	Casey, 2004 observer
Chris Clarke	Technical Officer 2 (AAD & GA)	Casey, 2005 observer

End of Part 2