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MAGNETIC OBSERVATORIES

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Australian Government
Geoscience Australia

Magnetic results for 2003

Kakadu

Charters Towers

Learmonth

Alice Springs

Gnangara

Canberra

Macquarie Island

Casey

Mawson

– & –

Australian Repeat Station Network

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SUMMARY

During 2003 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 standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised 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 and principal magnetic storms were scaled with computer assistance, and rapid variations were hand-scaled, 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.

Three repeat stations were re-occupied during a field survey in Papua New Guinea and the south-western Pacific in October 2003.

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 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 2003.

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
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

Contents continued …

Part 2

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 & SERVICES

Geomagnetic Observatories

The Geomagnetism Section of Geoscience Australia (formerly the Australian Geological Survey Organisation) operated nine permanent geomagnetic observatories in the Australian region during 2003. 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 2003 by the operation of a magnetic observatory at Macquarie Island (Tasmania) in the sub-Antarctic and observatories at Mawson and Casey 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 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 October 2003 repeat stations at Kavieng and Vanimo in Papua New Guinea; and at Noumea in New Caledonia in the south-west Pacific Ocean were re-occupied.

Calibrations of compasses

GA continued to provide a compass calibration facility at cost recovery rates during 2003. This service was used throughout the year by agencies requiring the calibration of compasses and compass theodolites.

Magnetic Calibration Facility

In collaboration with the Australian Department of Defence a purpose-designed *Australian Magnetic 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 1999. The facility was officially opened on 18 February 2000.

The facility is routinely used for the calibration of observatory variometers as well as for clients' instrumentation at cost recovery rates.

Indonesian Observatories

As part of an AusAID funded project, in 2001 Geoscience Australia undertook work to assist in the upgrade of the two 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 of staff from Indonesia's BMG at Geoscience Australia.

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 2003, enabling assistance to be provided to the Indonesian geomagnetism program.

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

DATA DISTRIBUTION

During 2003 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, 2003 preliminary monthly mean values from all Australian observatories were provided by e-mail to IPGP, France.

Storms & Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 2003 were provided monthly to:

- World Data Centre (WDC) A, Boulder, U.S.A.
- WDC C2, Kyoto, Japan
- Observatorio del Ebro, Spain
- IPS, Sydney.

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. Both Gnangara and Canberra are two of the twenty observatories in the sub-auroral zones used in the derivation of the 'mondial' am index.

During 2003, 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 2003. 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 2003 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 is 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 2003 as indicated.

Observatory	WDC-A Boulder	WDC-C1 Cop'nhgn.	IM GIN Paris
Kakadu	2002	2002	2002
Charters Towers	2002	2002	
Learmonth	2002	2002	
Alice Springs	2002	2002	2002
Gnangara	2002		2002
Canberra	2002		2002
Macquarie Is.	2002	2002	
Casey	2002		2002
Mawson	2002	2002	

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 magnetic 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 & Land Information Group (AUSLIG) became simply Geoscience Australia (GA) on 8 November 2001.

During 2003 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*.

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 from a four component system where F constitutes the fourth component (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* on page 72 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 *Magnetic Calibration Facility* at the Canberra Observatory (see page 1 above), 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 2003 was a D,I-fluxgate magnetometer (or Declination and Inclination Magnetometer – DIM) that measured the magnetic field direction, complimented by a PPM to measure the total field intensity. At some observatories, older classical QHMs were still available for use 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 on 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 2003 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 2003

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	0.1	10, 60	F
CTA	DMI FGE (ver.G) S0210/E0227	0.1	1, 60	NW, NE, Z†
	Elsec 820 PPM no.157 (Start year to 26 Jun 2003 & 15 Jul - 07 Aug 2003)	0.1	10, 60	F
	Elsec 820 PPM no.141 (22 Aug 2003 to end of year)			
	(No PPM 27/06/03 -14/07/03 & 08/08/03 - 21/08/03			
LRM	DMI s/n E0254/S0277 (to 01 May 2003) DMI s/n E0271/S0227 (01 May to 02 Jun 2003 DMI s/n E0271/S0237 (from 02 Jun 2003)	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 magnetometers: s/n 708729, sensor 3112370 (to 19 May 2003) s/n 708729, sensor 21889 (after 23 May 2003)	0.01	10, 60	F
GNA	DMI FGE (ver.D) S0160 with E0167 (until 16 Apr. 2004) electronics E0199 (from 16 Apr. 2004)	0.1	1, 60	NW, NE, Z†
	Geometrics 856 No.50706	0.1	10, 60	F
CNB	Narod ring-core fluxgate/9004-2	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	0.025	1, 60	A, B, C†
	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.

Magnetic Standards

BMR/AGSO/GA has always maintained its own standards for Declination and Total Intensity. Since the late 1970s the Australian magnetic standard absolute magnetometers have been held at the Canberra Magnetic Observatory where they are in routine use for the calibration of that observatory. During 1993, a Declination and Inclination magnetometer (DIM) replaced classical magnetometers as the primary Declination and Inclination standard for Australia. (Details of the magnetometers that served as standards prior to 1993 can be found in *AGR*s *1993-1997*.) The adoption of the DIM as the Inclination standard eliminated the need for International calibrations to maintain a Horizontal Intensity, H, standard. This enabled the more rapid adoption of final instrument corrections.

Proton precession magnetometer MNS2 no.3 served as the Total Intensity (F) standard 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. This correction was subsequently taken into account when standardizing total field absolute instruments deployed at all Australian observatories. The instrument was described in *AGR*s 1993-2000.

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

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

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

All absolute instruments were standardised against Canberra DIM Elsec 810 no.200 with Zeiss020B theodolite no. 353756 and GSM90 with electronics no. 905926 and sensor no. 81241, although often through subsidiary travelling 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 the Australian Magnetic Standard held at Canberra.

Ancillary equipment

Uninterruptible Power Supplies (UPS) and lightning surge filters were installed at most observatories during 2003.

Data Acquisition

During 2003 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.

Data Acquisition (cont.)

As 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 2003 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.

Absolute Magnetometers employed in 2003

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
KDU	DIM: Bartington MAG010H/B0622H; Zeiss 020B/359142* PPM: Elsec 770/189	D, I F	0.1' 1 nT
CTA	DIM: Elsec 810/215; Zeiss 020B/313888* PPM: Geometrics 816/767	D, I F	0.1' 1 nT
LRM	DIM: Bartington 0702H; Zeiss 020B/312714 PPM: Geometrics 856 no. 50471	D, I F	0.1' 0.1 nT
ASP	DIM: Elsec 810/221; Zeiss 020B/313887* Total field magnetometers: GSM-19 s/n 11435, sensor 306403 (until 21 May 2003) GSM-90 s/n 2101216, sensor 306403 (from 21 May 2003)	D, I F	0.1' 0.01 nT
GNA	DIM: Bartington MAG010H/B0725H; Zeiss 020B/355937* PPM: Geometrics 856 no. 50631 (sensor 28079922)	D, I F	0.1' 0.1 nT
CNB	DIM: Elsec 810/200; Zeiss 020B/353756* (Australian Standard) PPM: GSM-90 no.905926, sensor 21867 (Australian Standard)	D, I F	0.1' 0.1 nT
MCQ	DIM: Elsec 810/214; Zeiss 020B/311847* PPM: Austral /525 (primary); /524 (secondary) QHM Nos. 177‡, 178, 179 (secondary)	D, I F H, D	0.1' 1 nT 0.1 nT
CSY	DIM: Elsec 810/2591; Zeiss 020B/356514*† PPM: Geometrics 816/1024 QHM No. 493 (secondary)	D, I F H	0.1' 1 nT 0.1 nT
MAW	DIM: DMI D26035; Zeiss 020B/311542* PPM: Elsec 770/199 (to end of March 2003) Elsec 770/210 (from April 2003) Elsec 770/206 (secondary: not used in 2003) QHM Nos. 300, 301, 302 (secondary) Declinometer: Askania 630332 (secondary) Askania circle 611665 (for mounting QHM and Declinometer)	D,I F F H D	0.1' 1 nT 1 nT 0.1 nT 0.1'

* 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.

MAGNETIC OBSERVATORIES

The locations of the observatories are shown on the front cover 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 2002.

Australian Magnetic Observatories, 2003

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"	-21.91°	205.50°	15	K. Stellmacher A. Hudd
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-27.90°	220.84°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.28°	186.34°	4	G.A. Steward
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-32.77°	208.05°	557	W. Serone
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-41.75°	188.72°	60	O. McConnel H. VanReeken
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.53°	226.79°	859	Liejun Wang
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-59.90°	244.04°	8	P. Pokorny H. Banon
Casey	CSY	1999*	66° 17'	110° 32'	-76.37°	183.81°	40	B.Harper
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.09°	110.17°	12	K. Steinberner R. Hegarty

† Geomagnetic coordinates are based on the 2000.0 International Geomagnetic Reference Field (IGRF) model updated to 2003.5 with magnetic north pole position of 79.754°N, 288.315°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 the SSW and one to the WSW. Cables between the sensor vaults and the control house are routed via underground conduits.
- a concrete slab, with tripod foot placements and 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 the principal observation pier (Pier A) of the observatory are:

- 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. -21.91°; Long. 205.50°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of pier): 14.6 metres
- Lower limit for K index of 9: 300 nT.
- Azimuth of principal reference pillar (AW) from Pier A: 237° 52.8'
- Distance to Pillar AW: 99.6 metres
- Observers in Charge: Kim Stellmacher, Anita Hudd

‡ Geodetic Datum of Australia 1994 (GDA 94)

Variometers

Variations in the magnetic-NW, magnetic-NE and vertical components of the magnetic field were monitored at Kakadu in 2003 using a suspended 3-axis linear-fluxgate DMI FGE magnetometer (with sensor no. S0183 and electronics no. E0198). An analogue-to-digital converter was integrated with the electronics module.

The total magnetic field intensity, F, was monitored using a Geometrics model 856 proton precession magnetometer (no. 50707).

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 clock rate accurate, and a modem for communications.

The recording and variometer-control equipment was located in the air-conditioned control house.

The variometer 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 variometer PPM 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 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 *Magnetic 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 *Magnetic Calibration Facility*. (See *AGR 2000* for details.)

Absolute Instruments & Corrections

The principal absolute magnetometers used at Kakadu in 2003 were a declination-inclination magnetometer, DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on a Zeiss 020B non-magnetic theodolite (no. 359142), and a proton precession magnetometer, PPM: Elsec model 770 (no. 189).

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 2003.

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.

Instrument corrections that were applied to the absolute magnetometers used at Kakadu in 2003 were determined through a series of instrument comparisons performed during a regular maintenance and calibration visit in May 2003. These corrections differ slightly from previous years.

KDU data in this report have been aligned with the Australian Total Intensity Standard: Gem Systems GSM90 No. 905926 with Sensor No. 81241.

The corrections adopted for the Kakadu absolute instruments for 2003 were 0.0′, 0.0′ in D and I for the DIM, and −3.3 nT in F for the PPM. (Corrections adopted in previous years were 0.0′, 0.0′ and −2.3 nT respectively.) At the mean magnetic field values at Kakadu these translate to corrections of:

$\Delta X = -2.5nT \qquad \Delta Y = -0.2nT \qquad \Delta Z = +2.1nT.$

These instrument corrections have been applied to the 2003 data in this report.

Baselines

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

0.6nT in X; 0.9nT in Y; 0.6nT in Z

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

0.5nT in F; 06" in D; 03" in I)

The drifts applied to any one of the X, Y, and Z baselines amounted to less than 3nT throughout the year. Most of the fluxgate baseline drift appeared to be about 4nT in the B (NE) channel. There appeared to be about 1.5nT drift in the A (NW) and C (vertical) channels.

Throughout the period January to mid-August 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. The variometer PPM failed in mid-August. When the variometer PPM was again in service in December, there was a jump of 1.7nT in this difference. 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.

During 2003, the difference between the KDU absolute Elsec 770 proton magnetometer and variometer Geometrics 856 proton magnetometer was consistent to within ±0.5nT during the period January to August while the Geometrics was working. No seasonal variation was noticeable during this period. There was a change in December, but there were few observations thereafter to extract any trend with certainty.

Operations

The local observer continuing from 2002 (KS) operated the observatory until July 2003, after which she recruited her replacement (AH) who operated it from August to November 2003, and found her successor (RL) who was not available until January 2004. There was no local observer during December 2003.

1-second and 1-minute mean magnetic data were acquired at the Kakadu observatory throughout 2003.

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. The time was checked/corrected via modem on weekdays. 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. However, the computer clock was 2 seconds fast following a power failure on 15 August, and this persisted until 2239 on 19 August. (It was also 2 seconds fast after equipment failure on 02 December, but there were no data collected during this period.) There were no other significant timing errors during 2003.

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 in charge. 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 DMI fluxgate electronics and sensor temperatures varied with a typical daily variation of less than 0.5°C. The DMI electronics temperature was 27.5 ± 1.0 °C during 2003.

The DMI sensor, although buried underground, varied between 27.5°C and 34.5°C during 2003. Some temperature changes were as rapid as 0.5°C/day persisting for a week, and there was a prolonged warming for 130 days from mid-year of 0.05°C/day.

The DMI fluxgate variometer failed on a few occasions. On 15 August, a prolonged power failure beyond the limits of the UPS caused a 154 minute data loss. On 02 December, an event (most likely caused by an electrical storm) put the ADAM A/D converter on the DMI variometer out of service. Unfortunately at this time there was no local observer available. Data acquisition resumed when the ADAM was powered off and on again on 09 December by visiting GA staff, by which time over 7 days data were lost.

The Geometrics 856 scalar variometer was frequently noisy whenever there were electrical storms in the region during the monsoon season. It failed after a power failure on 15 August. Neither it nor any replacements could be made to work until GA staff visited in December 2003 and re-configured it. It worked well again after 11 December. The problem was that it could not be configured unless disconnected from the nearest fibre-optic modem (installed for lightning protection purposes).

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 14-15.

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

* Elements ABC indicates non-aligned variometer orientation

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35368.5	2311.3	-30059.7	46474.3	35443.9	3° 44.3'	-40° 18.1'
	5xQ days	35379.8	2314.5	-30057.0	46481.3	35455.4	3° 44.6'	-40° 17.4'
	5xD days	35356.6	2310.9	-30058.9	46464.7	35432.0	3° 44.4'	-40° 18.6'
February	All days	35358.1	2309.8	-30057.9	46465.2	35433.5	3° 44.3'	-40° 18.5'
	5xQ days	35368.1	2311.2	-30054.6	46470.7	35443.5	3° 44.3'	-40° 17.8'
	5xD days	35337.1	2304.8	-30063.9	46452.8	35412.2	3° 43.9'	-40° 19.8'
March	All days	35350.1	2310.1	-30055.3	46457.4	35425.5	3° 44.3'	-40° 18.7'
	5xQ days	35367.7	2312.4	-30051.3	46468.3	35443.2	3° 44.4'	-40° 17.6'
	5xD days	35325.7	2305.4	-30058.8	46440.8	35400.8	3° 44.0'	-40° 20.1'
April	All days	35343.1	2310.6	-30049.9	46448.6	35418.5	3° 44.4'	-40° 18.7'
	5xQ days	35356.9	2310.8	-30048.6	46458.2	35432.3	3° 44.4'	-40° 18.0'
	5xD days	35333.1	2309.6	-30051.3	46441.8	35408.5	3° 44.4'	-40° 19.3'
May	All days	35337.4	2309.7	-30049.6	46444.0	35412.8	3° 44.4'	-40° 19.0'
	5xQ days	35353.5	2308.8	-30049.0	46455.8	35428.8	3° 44.2'	-40° 18.2'
	5xD days	35319.1	2309.0	-30051.4	46431.3	35394.5	3° 44.4'	-40° 20.0'
June	All days	35337.8	2310.2	-30048.6	46443.7	35413.2	3° 44.4'	-40° 18.9'
	5xQ days	35351.8	2310.7	-30046.3	46452.9	35427.2	3° 44.4'	-40° 18.1'
	5xD days	35311.1	2309.0	-30051.5	46425.2	35386.5	3° 44.5'	-40° 20.3'
July	All days	35344.0	2309.7	-30044.8	46445.9	35419.4	3° 44.3'	-40° 18.4'
	5xQ days	35358.6	2311.5	-30044.3	46456.8	35434.1	3° 44.4'	-40° 17.7'
	5xD days	35316.0	2308.4	-30045.5	46425.0	35391.3	3° 44.4'	-40° 19.8'
August	All days	35341.4	2308.4	-30041.3	46441.6	35416.7	3° 44.2'	-40° 18.3'
	5xQ days	35359.4	2308.9	-30037.4	46452.8	35434.7	3° 44.2'	-40° 17.2'
	5xD days	35310.8	2306.2	-30045.7	46421.1	35386.0	3° 44.2'	-40° 20.0'
September	All days	35350.4	2306.7	-30035.1	46444.4	35425.5	3° 44.0'	-40° 17.6'
	5xQ days	35365.1	2306.1	-30032.4	46453.8	35440.2	3° 43.9'	-40° 16.7'
	5xD days	35325.6	2304.8	-30039.1	46428.0	35400.7	3° 44.0'	-40° 19.0'
October	All days	35337.3	2303.6	-30038.1	46436.2	35412.3	3° 43.8'	-40° 18.4'
	5xQ days	35365.4	2308.6	-30032.1	46453.9	35440.7	3° 44.1'	-40° 16.7'
	5xD days	35271.0	2294.9	-30047.8	46391.7	35345.6	3° 43.4'	-40° 22.1'
November	All days	35336.4	2301.9	-30038.9	46436.0	35411.3	3° 43.6'	-40° 18.5'
	5xQ days	35362.6	2305.2	-30034.7	46453.3	35437.6	3° 43.8'	-40° 16.9'
	5xD days	35307.9	2296.3	-30042.4	46416.3	35382.5	3° 43.3'	-40° 20.0'
December	All days	35357.7	2302.7	-30032.8	46448.2	35432.6	3° 43.6'	-40° 17.1'
	5xQ days	35368.9	2304.0	-30030.2	46455.1	35443.8	3° 43.6'	-40° 16.4'
	5xD days	35336.2	2301.6	-30038.6	46435.6	35411.1	3° 43.6'	-40° 18.4'
Annual	All days	35346.8	2307.9	-30046.0	46448.8	35422.1	3° 44.1'	-40° 18.3'
Mean	5xQ days	35363.1	2309.4	-30043.2	46459.4	35438.5	3° 44.2'	-40° 17.4'
Values	5xD days	35320.8	2305.1	-30049.6	46431.2	35396.0	3° 44.0'	-40° 19.8'

(Calculated: 12:35 hrs., Wed. 10 Nov. 2004)

Hourly Mean Values

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

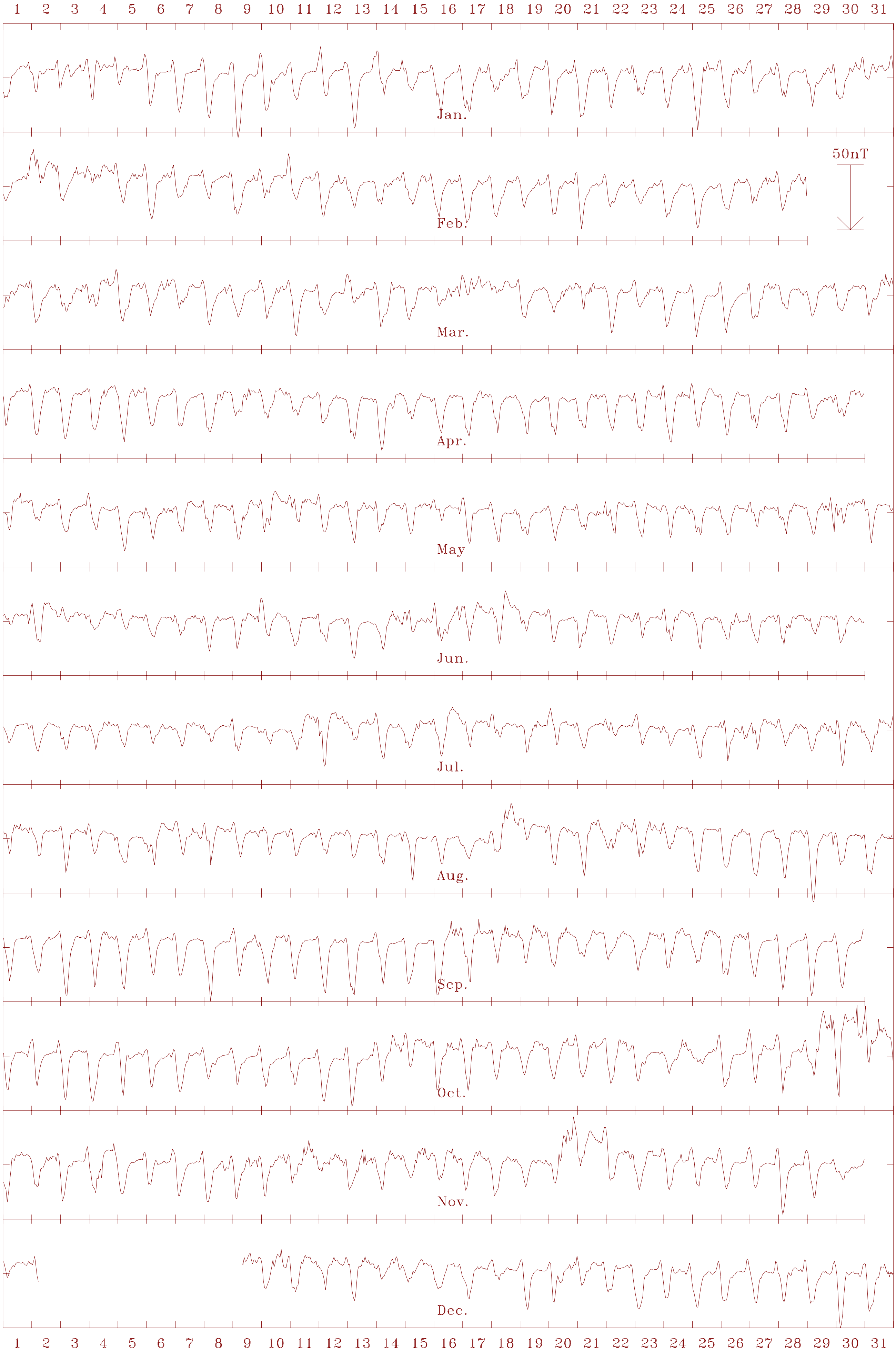
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

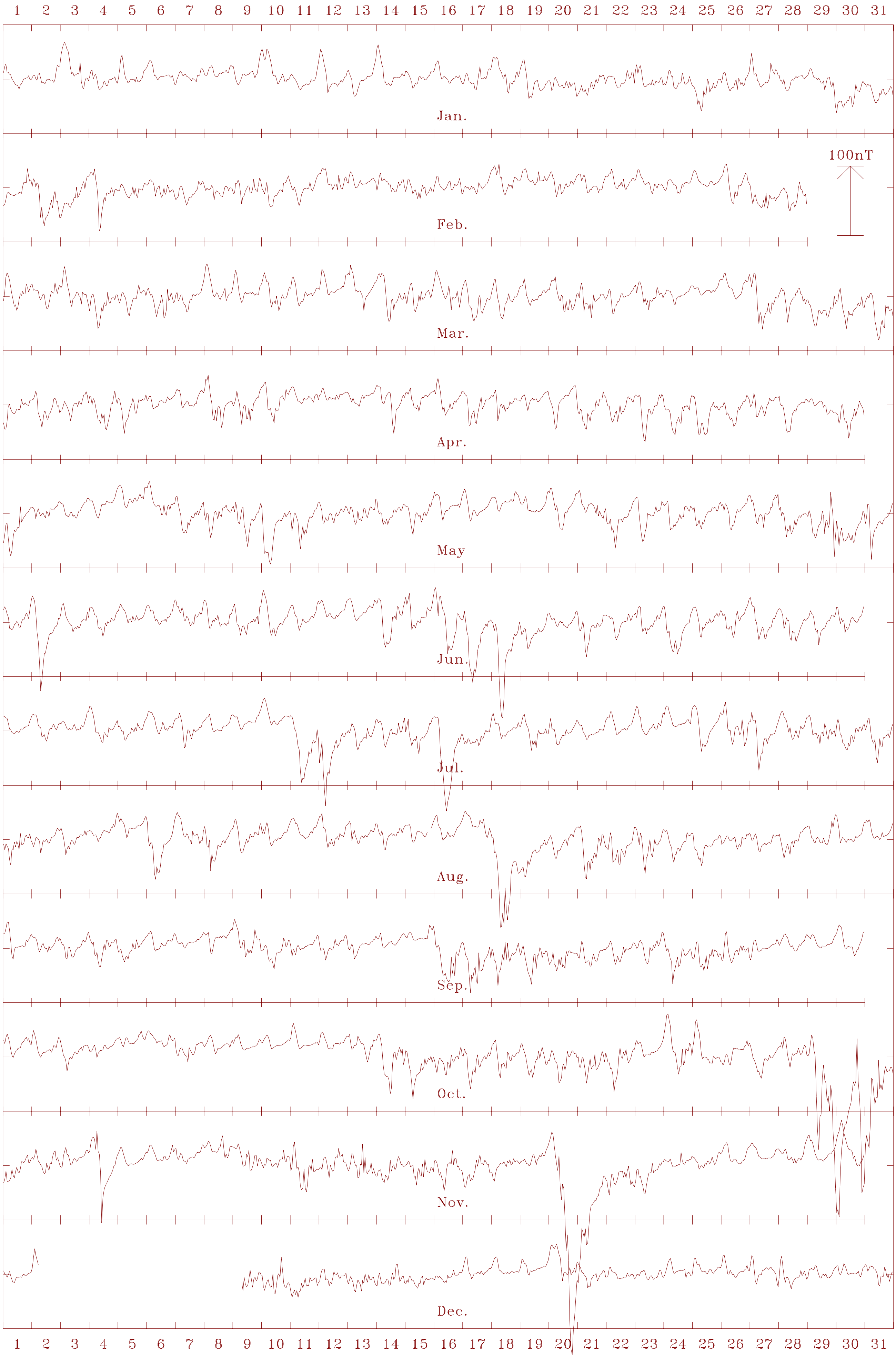
Kakadu, NT 2003 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 35422 nT

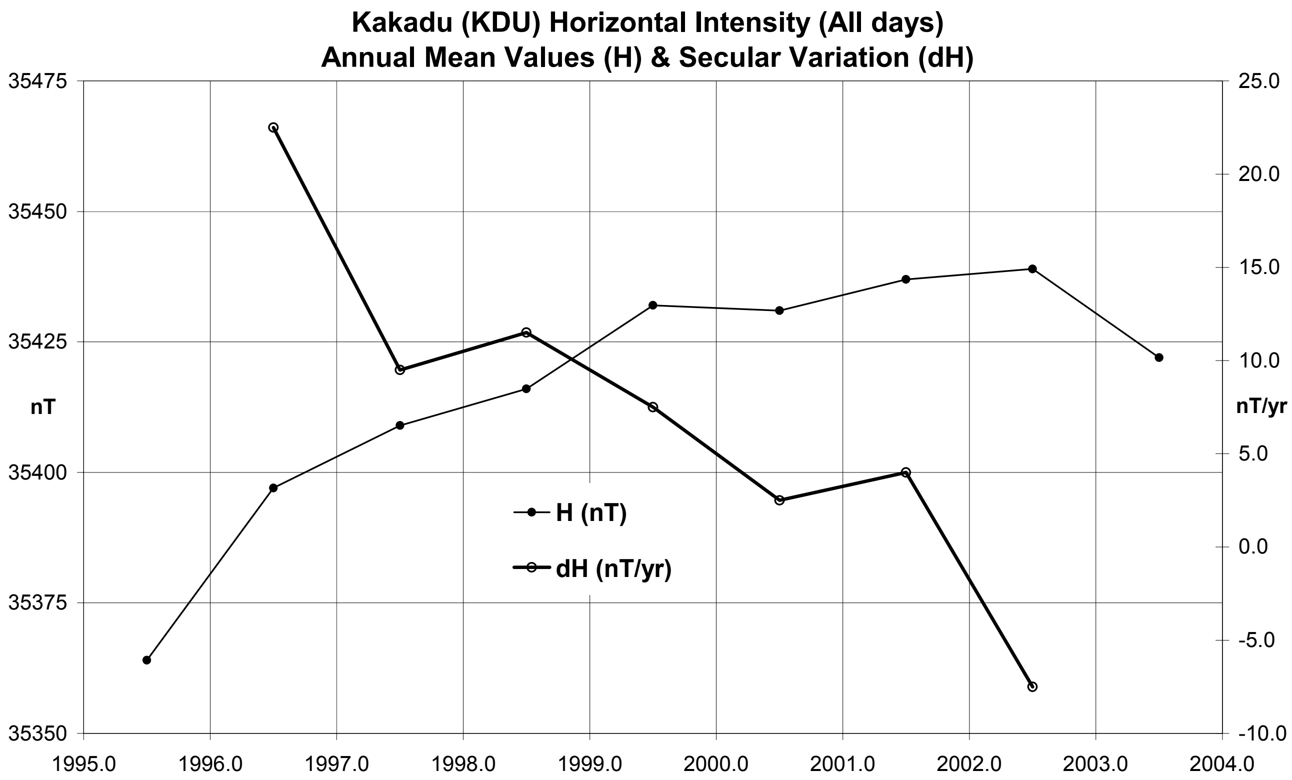
Kakadu, NT 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.74 deg.

Kakadu, NT 2003 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: -30046 nT

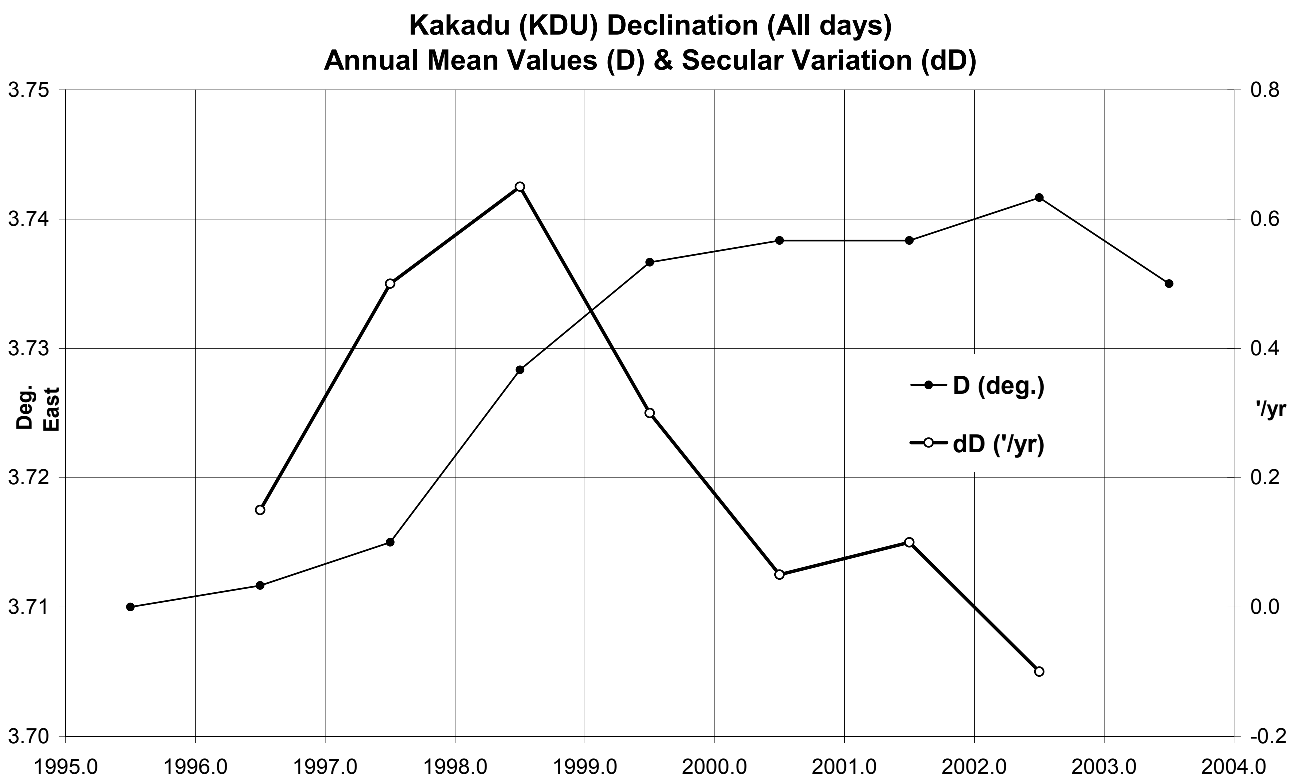


Kakadu, NT 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 46449 nT

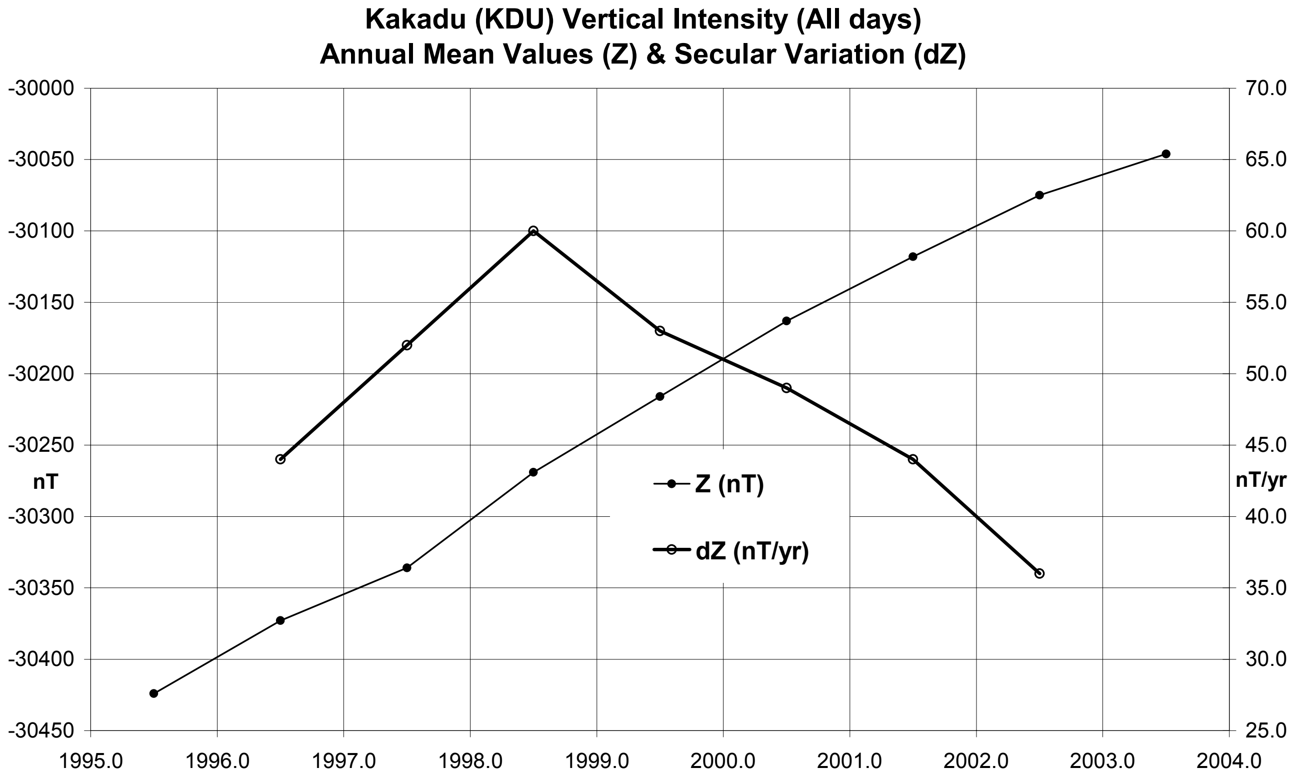


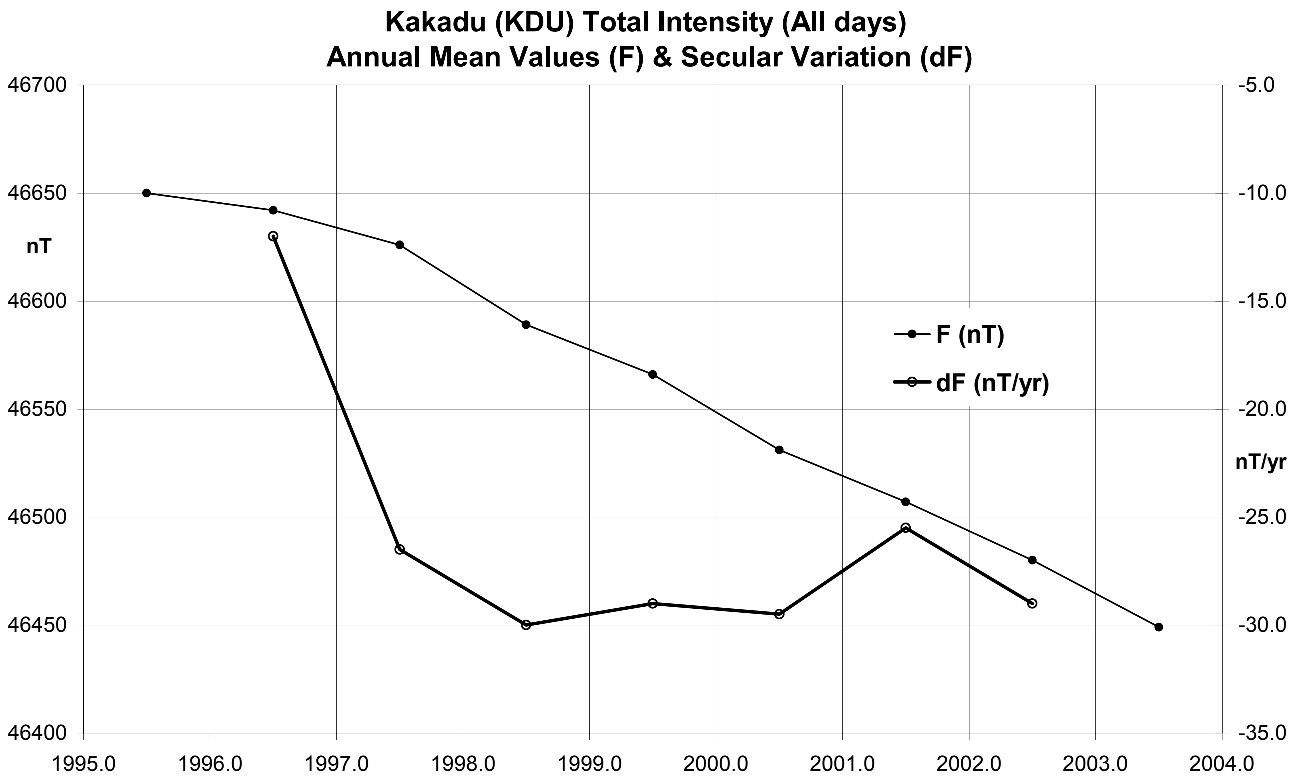


Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
35475
35450
35425
35400
35375
35350
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0



Kakadu (KDU) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Deg. East
'/yr
D (deg.)
dD ('/yr)
3.75
3.74
3.73
3.72
3.71
3.70
0.8
0.6
0.4
0.2
0.0
-0.2
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0


Kakadu (KDU) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
nT
nT/yr
Z (nT)
dZ (nT/yr)
-30000
-30050
-30100
-30150
-30200
-30250
-30300
-30350
-30400
-30450
70.0
65.0
60.0
55.0
50.0
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


Kakadu (KDU) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
nT
nT/yr
F (nT)
dF (nT/yr)
46700
46650
46600
46550
46500
46450
46400
-5.0
-10.0
-15.0
-20.0
-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

Significant Events 2003 - Kakadu

May 19 to 24th Routine maintenance/calibration visit by GA staff.

Jul 30 Change of local observer (KS to AH)

Aug 15 Variometer PPM failed after power failure.

Nov 30 No local observer until January 2004 (AH to RL).

Dec 02 A/D failure, probably caused by lightning.

Dec 10 Service visit by GA staff to repair variometer.

Data losses in 2003:

Aug 15 1855−2128 (2h 34m) All channels: Power failure.

Aug 15 1855 to Dec 11 / 0447, except for some scattered periods of data on Aug 16, 30; Oct 02, 26; Nov 13 and Dec 09, 10 (totalling 112d 22h 12m) Total field channel only: Initially a power failure.

Dec 02 0527 to 09 / 0716 (7d 01h 50m). A/D failure

Data losses in 2003 (cont.):

Dec 10 0007−0008 (2 min) All channels: Maintenance

Dec 10 0026−0044 (19 min) All channels: Data processing inhibited for period of maintenance.

Distribution of KDU data during 2003

Preliminary Monthly Means for Project Ørsted

- IPGP monthly (by e-mail)

1-minute & Hourly Mean Values

- 2002 data: WDC-A, Boulder, USA (31 Mar. 2003)
- 2003 data: WDC-A, Boulder, USA (03 Mar. 2004)

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- Definitive data for the INTERMAGNET CD-ROMs:
  2002 data: to INTERMAGNET Paris GIN (27 Mar 2003)
  2003 data: to INTERMAGNET Paris GIN (03 Mar, 2004)
  (These data also sent to WDC-C1, Copenhagen, Denmark)

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 on 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 the principal observation pier (Pier C) of the observatory are:

- 3-character IAGA code: CTA
- Commenced operation: June 1983
- Geographic latitude: 20° 05' 25" S
- Geographic longitude: 146° 15' 51" E
- Geomagnetic† : Lat. -27.90°; Long. 220.84°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of pier): 370 metres
- Lower limit for K index of 9: 300 nT.
- Azimuth of principal reference PO spire from pier C: 34° 40' 45"
- Distance to PO Spire: 1.75km.
- Observer in Charge: J.M. Millican

In 2002 The Towers Hill area was declared as being of Queensland heritage value, and handed over to the Charters Towers City Council. The council and Geoscience Australia have been working together on a lease arrangement to ensure 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 unit with electronics E0227 and sensor S0210 operated throughout 2003. The sensor head of the instrument was located on the same concrete blocks in the mine tunnel that the EDA FM-105B sensors were previously. Its sensors were aligned with two of them horizontal, aligned at an approximately equal angle on either side of the magnetic meridian (magnetically NW and NE), and the third sensor vertical.

Prior to its installation at Charters Towers, the DMI FGE magnetometer's scale-values, relative sensor alignments and temperature sensitivities were determined at the *Magnetic 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 2003 a number of PPM variometers were employed – all of them Elsec model 820. These are summarized in the table of variometers in use on page 4 of this report.

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, along with 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 2003 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 & 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 adjusted daily from GA in Canberra.

Absolute Instruments and Corrections

Throughout 2003 the variometers at CTA were calibrated by the performance of weekly absolute observations on Pier C in the absolute shelter. 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 with a Geometrics 816 PPM (no. 767) to perform sets of absolute observations.

Because both absolute PPM and DIM observations were performed on Pier C in 2003 there are no pier differences to be applied.

By regular intercomparisons of 'travelling' standard 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 Standard. The corrections adopted in 2003, determined through a series of instrument comparisons made during a routine maintenance visit on 14-18 July 2003, were:

ΔF = GSM90_905926 = G816_767 − 0.8nT

ΔD = E810_200/313756 = E810_215/313888 + 0.35'

ΔI = E810_200/313756 = E810_215/313888 − 0.02'

Baselines

At the mean 2003 magnetic field values at Charters Towers of:

X = 31506nT, Y = 4279nT, Z = −37751nT,

The above instrument corrections translate to baseline corrections of

ΔX = −1.2nT, ΔY = +3.1nT, ΔZ = +0.4nT

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

Three small baseline steps, indicated from F-check data, were incorporated in the variometer model:

2003	UT	ΔX(nT)	ΔY(nT)	ΔZ(nT)
14 Feb	04:06	+2.3	+0.8	+0.6 (04:14UT)
17 Feb	04:13	−3.5	−1.0	−0.4
22 Feb	03:38	+0.7	−1.4	+0.5

The variometer was stable throughout the remainder of 2003.

The X-baseline drift was within a 6nT range, gradually drifting up about 4 nT from the beginning of 2003 to mid-August, remaining unchanged until November, then drifting down by about 1nT to the end of the 2003.

The Y-baseline drifted quite significantly at the beginning of the 2003, changing by about 7.6nT in the first two months. From March to the end of the year it was relatively stable with only about a 1nT change.

The Z baseline drift was within 5 nT and varied smoothly through 2003.

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:

X: −0.16 ± 1.3 nT; Y: −0.05 ± 1.4 nT; Z: −0.07 ± 1.2 nT

F-check (the difference between F derived from the vector variometer and the F-variometer (Elsec 820/157 PPM) varied by up to 2nT during 2003.

Operations

The officer in charge at CTA observatory performed most routine operations during 2003. Tasks included:

- weekly performance of a set of absolute observations;
- weekly temperature measurement in tunne;l
- mailing the observations & log-sheet to GA, Canberra, each week.

Operations (cont.)

Throughout 2003 mean data values over 1-second and 1-minute intervals were recorded in the variables A, B, C & 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 week days the PC clock was checked and set remotely from GA in Canberra. The maximum remote time correction made was about 3.3 seconds (60 ticks) on 12 December 2003 when system restarted after a 22 hour power failure. 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 2003

April	The custodianship of the Towers Hill area reverted back to the City Council. Negotiations with the council ensued to ensure the magnetic observatory operations could continue well into the future. This included fencing-off the absolute shelter area and tunnel area.
26 Jun	E820_157 variometer PPM developed problems. No data during 26 Jun - 15 Jul. and 07-21 Aug.
04 Jul	to 03:00UT / 08 Jul: Z-channel of DMI variometer became noisy after which it returned to normal.
14-18 July	Annual maintenance visit during which absolute instrument comparisons were performed.
22 Aug	Variometer E820_157 PPM replaced with E820_141.
09 Dec	IAGA2002 data exchange format adopted for daily minute data distribution to INTERMAGNET.
11 Dec	data lost from 6:00am 11 Dec - 5:20 am 12 Dec due to power failure. 60 ticks clock correction.

CTA 2003 – Data losses

14 Feb.	0406 (1 min.), 0414 (1 min.): Processing inhibited due to baseline adjustment in DMI variometer model.
17 Feb.	0413 (1 min.): Processing inhibited due to baseline adjustment in DMI variometer model
22 Feb.	0338 (1 min.): Processing inhibited due to baseline adjustment in DMI variometer model
25 Jun.	1343-2359 (86 min. lost intermittently) F data only.
26 Jun.	0004-0056 (16 min); 0059-0158 (60 min. lost intermittently) F data only; 0200 to 15 July / 0009 (18d 22h 10m) F channel only.
26 Jul.	0147-2359 (870 min. lost intermittently) F data only.
27 Jul.	0000 to 28 / 0425 (1d 04h 26m) F channel only.
08 Aug.	0650-2357 (595 min. lost intermittently) F data only.
09 Aug.	0000-0347 (172 min. lost intermittently) F data only; 0349 to 18 / 0048 (8d 21h 00m) F channel only.
18 Aug.	0050-0103 (11 min. lost intermittently) F data only; 0106 to 22 / 0018 (3d 23h 13m) F channel only
11 Dec	0631 to 0520 / 12th Dec. (22h 50m) All channels: Power failure.
12 Dec.	0521-0522 (2 min) F channel only

Distribution of CTA data

1-minute & Hourly Mean Values (in WDC format)

- 2002 data to WDC-A, Boulder USA on 27 Jun. 2003
- 2003 data to WDC-A, Boulder USA on 12 Mar. 2004

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2003

1-minute Values (in INTERMAGNET format)

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive data for the INTERMAGNET CD-ROMs:
  - 2002 data sent to WDC-C1, Copenhagen (27 Jun 2003)
  - 2003 data sent to WDC-C1, Copenhagen (12 Mar 2004)

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 24-25.

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

Year	Days	D		I		H	X	Y	Z	F	Elts
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
1983.729	A	7	40.4	-50	17.7	31786	31501	4244	-38280	49756	XYZ
1984.5	A	7	41.9	-50	18.2	31777	31491	4256	-38280	49751	XYZ
1985.5	A	7	43.2	-50	18.0	31776	31488	4268	-38276	49747	XYZ
1986.5	A	7	44.4	-50	18.4	31768	31479	4278	-38274	49740	XYZ
1987.5	A	7	45.5	-50	18.2	31769	31478	4288	-38271	49738	XYZ
1988.5	A	7	46.3	-50	19.2	31751	31459	4294	-38270	49727	XYZ
1989.5	A	7	47.0	-50	20.1	31731	31439	4297	-38267	49711	XYZ
1990.5	A	7	47.2	-50	19.8	31731	31438	4299	-38260	49706	XYZ
1991.5	A	7	47.4	-50	19.8	31719	31427	4299	-38248	49689	XYZ
1992.5	A	7	47.3	-50	18.0	31732	31439	4300	-38221	49676	XYZ
1993.5	A	7	47.4	-50	15.9	31743	31450	4303	-38188	49658	XYZ
1994.5	A	7	47.6	-50	14.1	31748	31455	4305	-38151	49633	XYZ
1995.5	A	7	47.7	-50	11.1	31770	31476	4309	-38112	49617	XYZ
1996.5	A	7	47.4	-50	8.1	31793	31500	4309	-38071	49600	XYZ
1997.5	A	7	47.0	-50	5.5	31803	31510	4307	-38024	49571	XYZ
1998.5	A	7	46.5	-50	3.0	31805	31513	4302	-37972	49532	XYZ
1999.5	A	7	45.5	-49	59.8	31816	31525	4295	-37913	49494	XYZ
2000.5	A	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	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
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
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

continued on page 26 …

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31530.5	4279.1	-37762.7	49381.2	31819.6	7° 43.7'	-49° 52.9'
	5xQ days	31541.9	4282.7	-37761.1	49387.6	31831.3	7° 43.9'	-49° 52.2'
	5xD days	31520.3	4278.7	-37762.3	49374.4	31809.3	7° 43.8'	-49° 53.4'
February	All days	31517.9	4279.6	-37761.0	49371.9	31807.2	7° 44.0'	-49° 53.5'
	5xQ days	31526.0	4283.5	-37758.6	49375.6	31815.7	7° 44.2'	-49° 52.9'
	5xD days	31500.7	4272.1	-37766.4	49364.4	31789.1	7° 43.4'	-49° 54.7'
March	All days	31508.5	4280.5	-37758.9	49364.4	31797.9	7° 44.2'	-49° 53.9'
	5xQ days	31524.2	4284.6	-37756.1	49372.6	31814.0	7° 44.4'	-49° 52.9'
	5xD days	31486.8	4274.7	-37762.0	49352.4	31775.6	7° 43.9'	-49° 55.2'
April	All days	31502.3	4282.6	-37756.7	49359.0	31792.1	7° 44.5'	-49° 54.1'
	5xQ days	31515.0	4283.7	-37755.1	49365.9	31804.8	7° 44.4'	-49° 53.4'
	5xD days	31493.0	4280.3	-37758.3	49354.0	31782.5	7° 44.4'	-49° 54.7'
May	All days	31497.1	4281.4	-37756.0	49355.0	31786.8	7° 44.5'	-49° 54.4'
	5xQ days	31512.1	4282.5	-37753.6	49362.8	31801.8	7° 44.3'	-49° 53.5'
	5xD days	31480.5	4280.3	-37757.8	49345.6	31770.1	7° 44.6'	-49° 55.3'
June	All days	31497.5	4280.3	-37754.9	49354.3	31787.0	7° 44.3'	-49° 54.3'
	5xQ days	31511.3	4282.9	-37752.8	49361.7	31801.1	7° 44.4'	-49° 53.5'
	5xD days	31471.1	4275.4	-37758.2	49339.6	31760.2	7° 44.2'	-49° 55.9'
July	All days	31502.6	4280.6	-37751.5	49355.0	31792.1	7° 44.3'	-49° 53.9'
	5xQ days	31515.8	4282.2	-37750.0	49362.4	31805.4	7° 44.3'	-49° 53.1'
	5xD days	31475.1	4278.9	-37754.0	49339.2	31764.6	7° 44.5'	-49° 55.5'
August	All days	31500.0	4279.8	-37748.3	49350.7	31789.4	7° 44.2'	-49° 53.9'
	5xQ days	31516.7	4282.5	-37744.7	49358.9	31806.3	7° 44.3'	-49° 52.8'
	5xD days	31473.1	4275.6	-37752.9	49336.8	31762.2	7° 44.2'	-49° 55.5'
September	All days	31507.6	4279.8	-37742.7	49351.4	31796.9	7° 44.1'	-49° 53.2'
	5xQ days	31520.3	4281.8	-37738.6	49356.5	31809.8	7° 44.1'	-49° 52.4'
	5xD days	31485.3	4273.7	-37747.0	49339.9	31774.1	7° 43.8'	-49° 54.6'
October	All days	31498.4	4275.4	-37742.5	49345.0	31787.2	7° 43.8'	-49° 53.7'
	5xQ days	31524.1	4281.8	-37738.2	49358.6	31813.6	7° 44.1'	-49° 52.1'
	5xD days	31437.2	4264.8	-37751.3	49311.8	31725.2	7° 43.5'	-49° 57.4'
November	All days	31497.9	4274.4	-37743.6	49345.4	31786.6	7° 43.7'	-49° 53.8'
	5xQ days	31521.8	4280.5	-37739.9	49358.4	31811.1	7° 44.0'	-49° 52.3'
	5xD days	31474.0	4264.2	-37746.4	49331.5	31761.6	7° 42.9'	-49° 55.3'
December	All days	31515.7	4276.5	-37737.5	49352.3	31804.6	7° 43.6'	-49° 52.6'
	5xQ days	31526.9	4278.2	-37734.8	49357.5	31815.8	7° 43.7'	-49° 51.9'
	5xD days	31499.1	4277.2	-37742.1	49345.3	31788.2	7° 44.0'	-49° 53.7'
Annual	All days	31506.3	4279.2	-37751.3	49357.1	31795.6	7° 44.1'	-49° 53.7'
Mean	5xQ days	31521.3	4282.2	-37748.6	49364.9	31810.9	7° 44.2'	-49° 52.7'
Values	5xD days	31483.0	4274.6	-37754.9	49344.6	31771.9	7° 43.9'	-49° 55.1'

(Calculated: 15:07 hrs., Wed. 03 Nov. 2004)

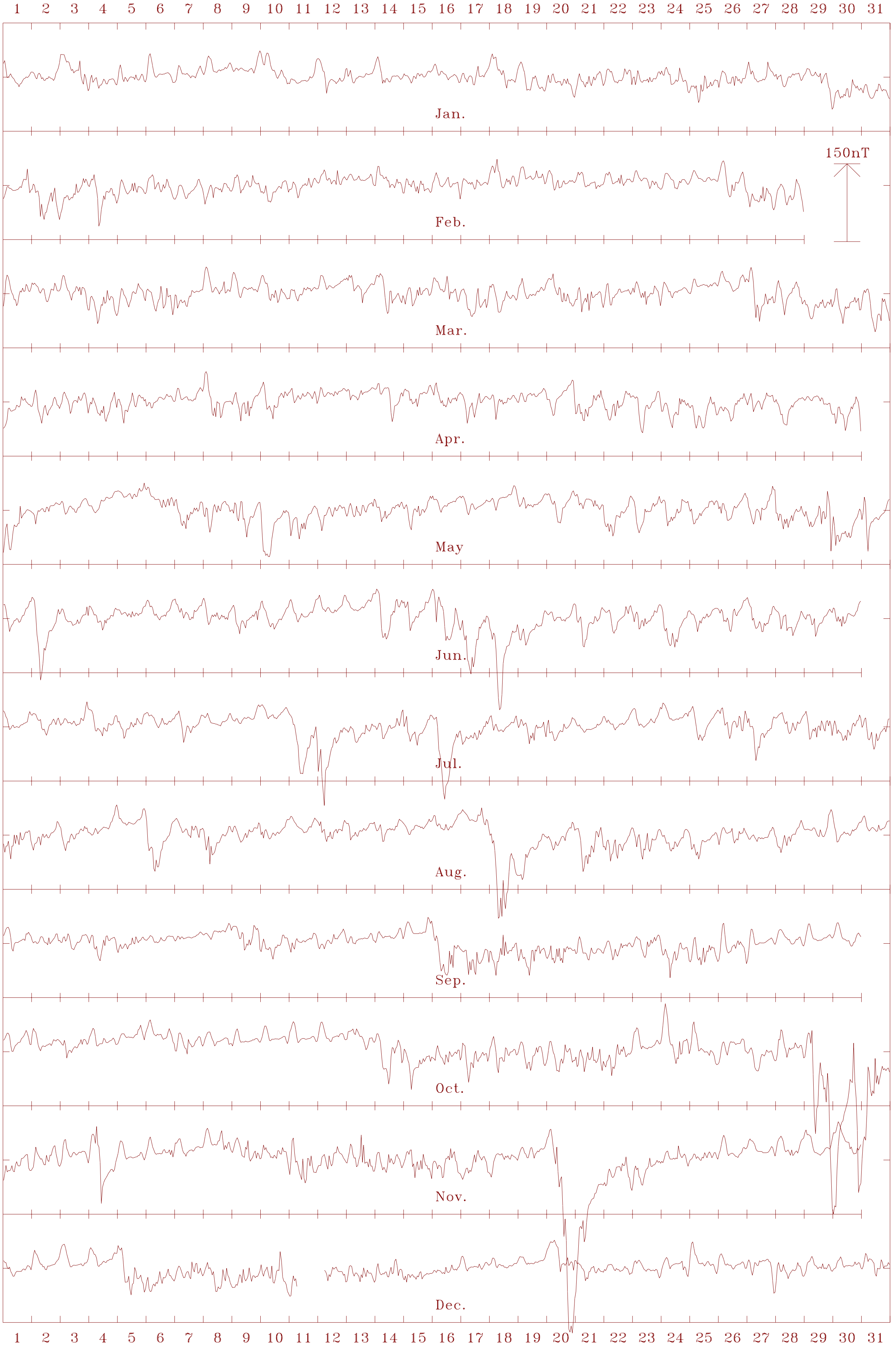
Hourly Mean Values

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.

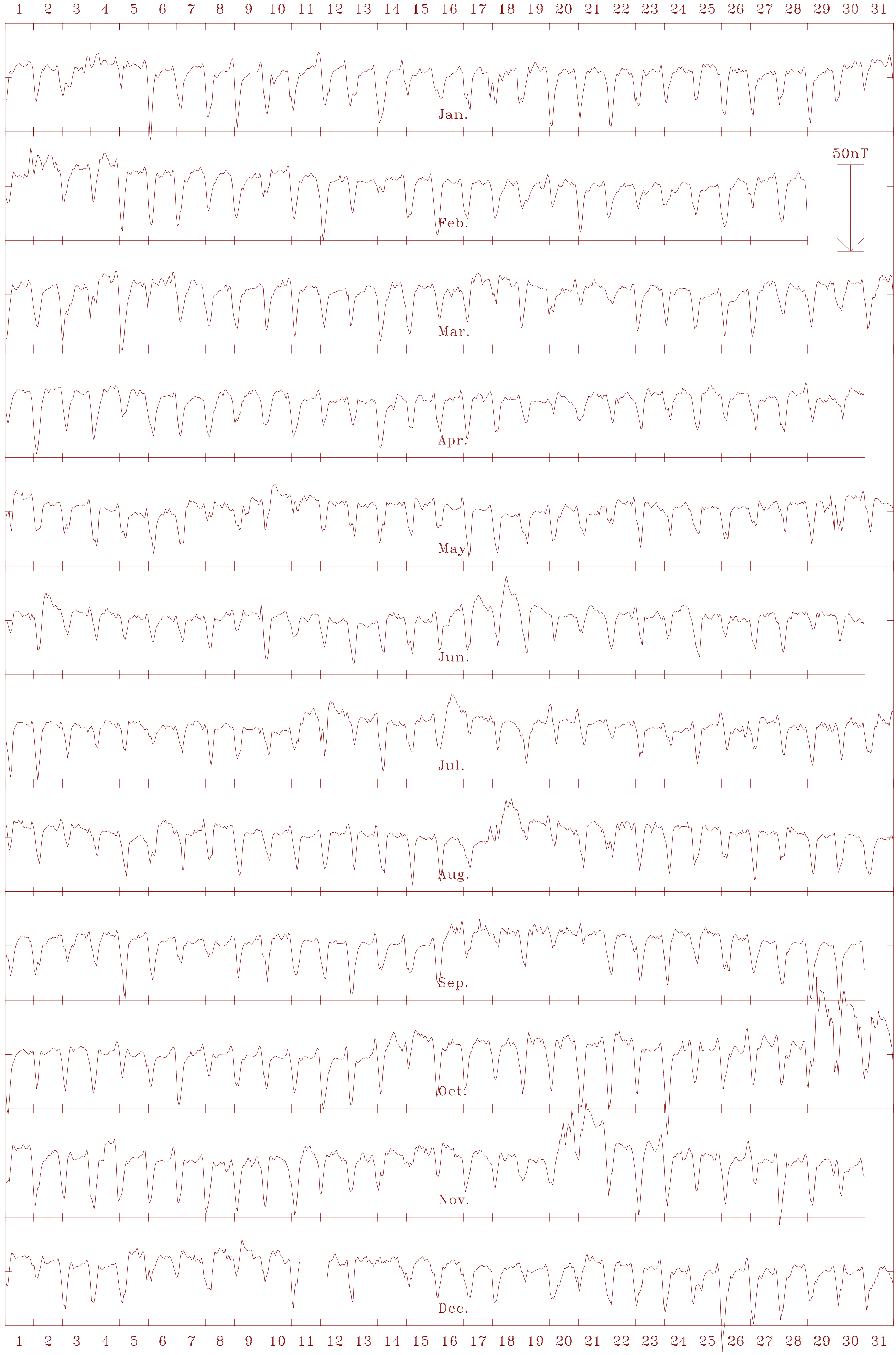
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Charters Towers 2003 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 31796 nT

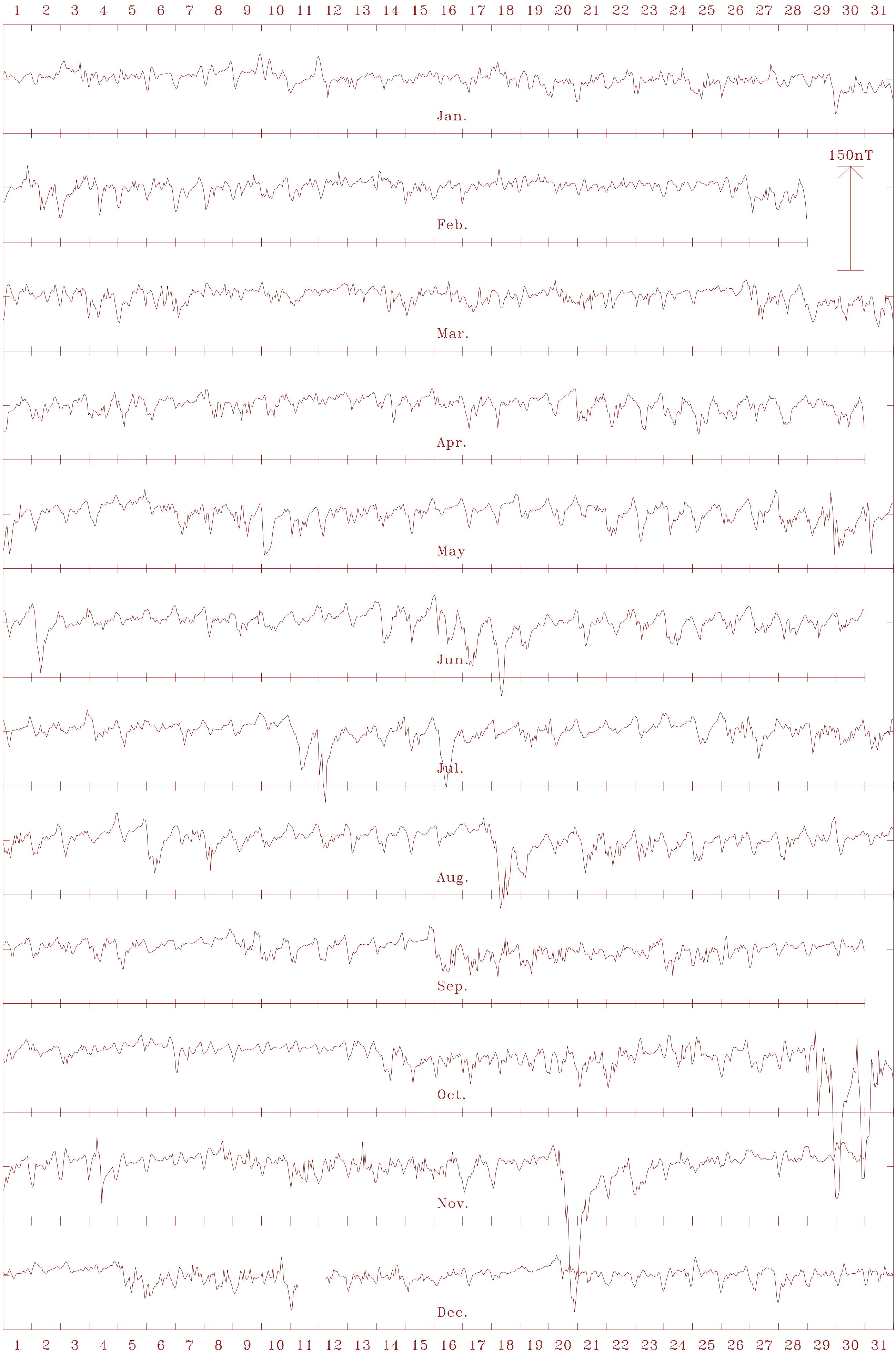


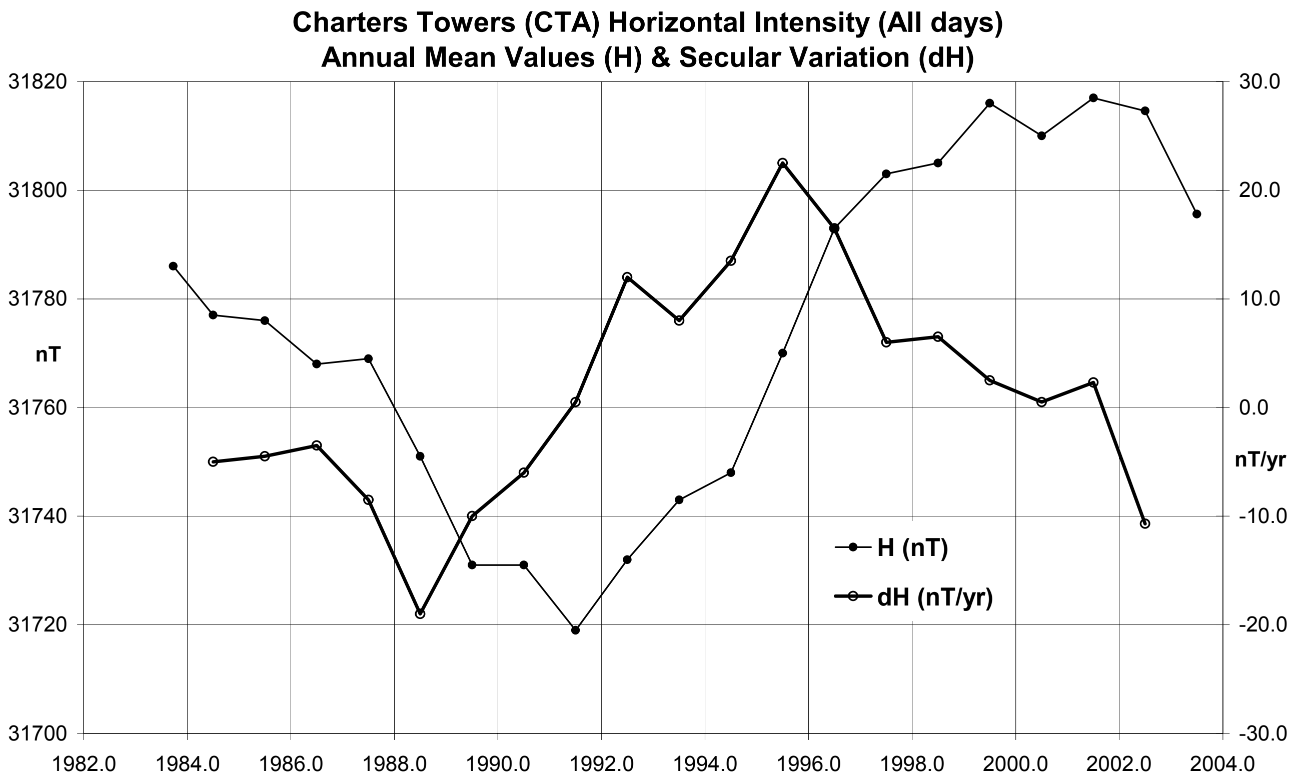
Charters Towers 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.73 deg.

Charters Towers 2003 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −37751 nT

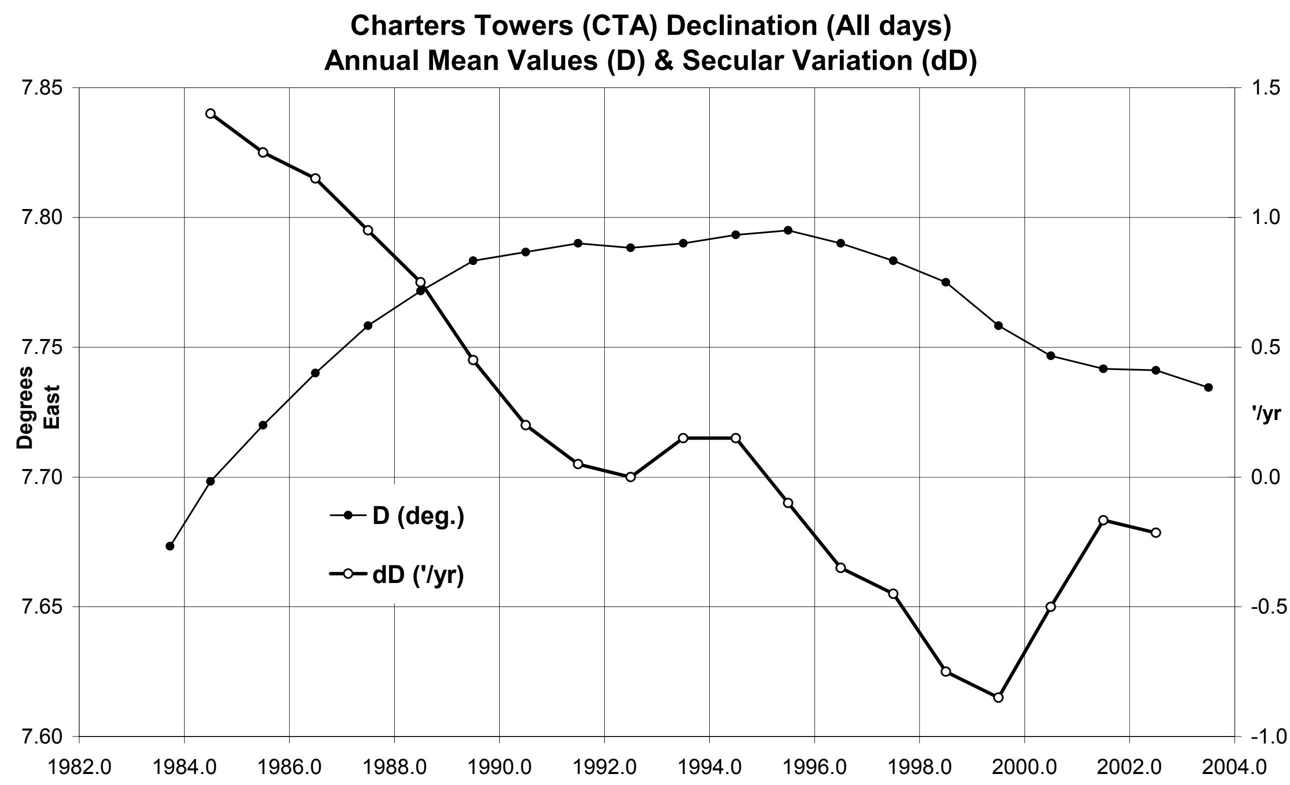


Charters Towers 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 49357 nT



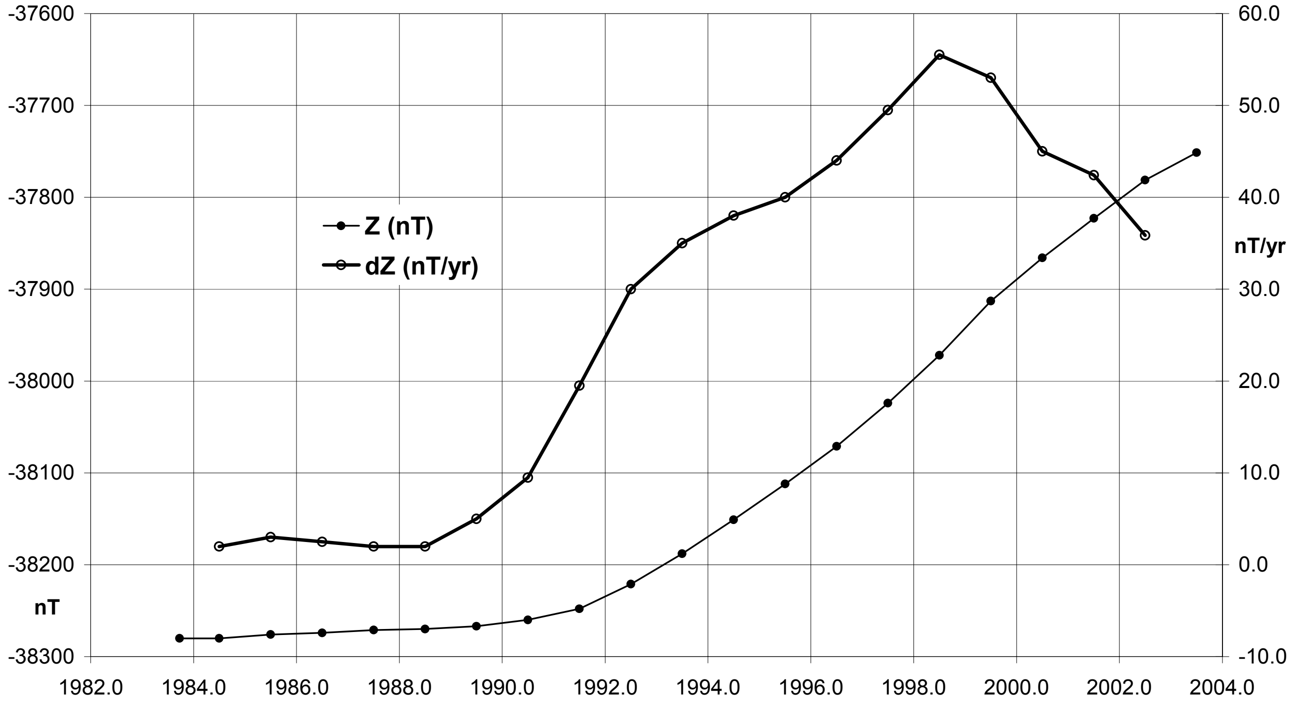


Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
31820
31800
31780
31760
31740
31720
31700
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0

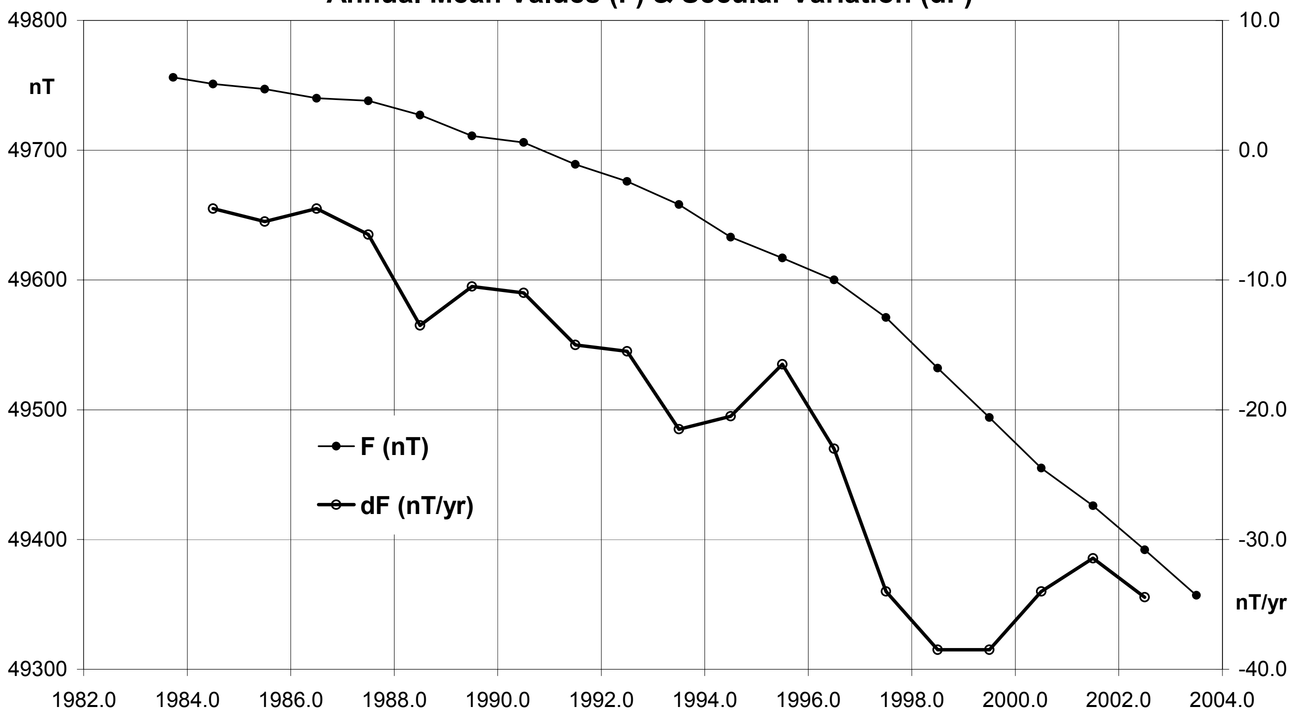


Charters Towers (CTA) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
7.85
7.80
7.75
7.70
7.65
7.60
1.5
1.0
0.5
0.0
-0.5
-1.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0

Charters Towers (CTA) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)



Charters Towers (CTA) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)



CTA – Annual Mean Values (cont.)

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

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 & 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 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 solar observatory Radio Solar Telescope Network (RSTN) building.

  A second (wooden) 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 that the absolute instruments could not be knocked 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 the observation pier of the observatory are:

- 3-character IAGA code: LRM
- Commenced operation: November 1986
- Geographic latitude: 22 13' 19" S
- Geographic longitude: 114° 06' 03" E

Key data for the observatory (cont.)

- Geomagnetic† : Lat. -32.28°; Long. 186.34°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of Pier A): 4 metres
- Lower limit for K index of 9: 300 nT.
- Azimuth of principal reference (west windsock) from Pier A: 283° 02' 18"
- Observer in Charge: G.A. Steward (IPS Radio & Space Services)

Variometers

Variations in the magnetic NW, NE and vertical components of the magnetic field were recorded at Learmonth in 2003 using one of several Danish Meteorological Institute FGE suspended three-axis fluxgate magnetometers.
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 their use.

During 2003 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.

The vertical (Z) channel of the fluxgate data commenced a rapid drift on about 12 Feb 2003. These data were discarded and replaced with values computed from the two horizontal channels and the total field PPM samples from 11 Feb until the problem was fixed on 02 June 2003. The first attempt to fix the problem saw the fluxgate electronics replaced on 02 May 2003, the existing unit (E0254) was replaced with E0271 on 01 May 2003. This was not successful and a further attempt was made by replacing the existing sensor (S0227) with S0237 on 02 June 2003. This successfully fixed the problem. As the variometer PPM sampled at a rate of once every 10s there are no one-second data available for the period when the Z channel was recovered.

Absolute Instruments & Corrections

Throughout 2003 the local observer performed regular (approximately weekly) sets of absolute observations, on the pier (A) in the absolute shelter, using the DIM comprising Bartington 010H no. 0702H fluxgate unit with Zeiss 020B theodolite no. 312714 together with Geometrics 856 no. 50471 PPM.

The DIM absolute observations were routinely performed using the *offset* method (see *Kakadu Observatory – Absolute Instruments & Corrections*, this report) throughout 2003.

Instrument comparisons between the LRM observatory absolute instruments (G856_50471/sensor 980801 PPM and B0702H / Zeiss 020B 312714 DIM) and the travelling standard instruments (GSM90_003985/11690 PPM, B0610H / Zeiss 010B 160459 DIM) were performed at LRM on 02−03 May 2003.

The results of the comparisons were:

Travelling Stndrd		LRM instrument		Inst. difference
GSM90_003985	–	G856_50471	=	−1.4nT (F)
B0610H/160459	–	B0702H/312714	=	0.0' (Decl'n)
B0610H/160459	–	B0702H/312714	=	+0.1' (Incl'n)

The adopted differences between the Australian Standards (E810_200/353756, GSM90_905926) and the above-mentioned Travelling Standards were:

Australian Stndrd		Travelling Stndrd		Inst. correction
GSM90_905926	–	GSM90_003985	=	0.0nT (F)
E810_200/353756	–	B0610H/160459	=	0.0' (Decl'n)
E810_200/353756	–	B0610H/16045	=	+0.1' (Incl'n)

This resulted in the corrections to the LRM instruments of:

Australian Stndrd		LRM instrument		Inst. correction
GSM90_905926	–	G856_50471	=	−1.4nT (F)
E810_200/353756	–	B0702H/312714	=	0.0' (Decl'n)
E810_200/353756	–	B0702H/312714	=	+0.2' (Incl'n)

Baselines

The instrument corrections adopted for the absolute magnetometers used at LRM during 2003 convert to the baseline corrections:

$$\Delta X = +1.8 \text{ nT} \qquad \Delta Y = 0.0 \text{ nT} \qquad \Delta Z = +2.9 \text{ nT}.$$

at the mean 2003 field values at LRM of 29720nT, 198nT and -44252nT in X, Y and Z respectively. These corrections have been applied to all LRM final data in this report.

The standard deviations in the weekly absolute observations from the final adopted variometer model and data were 0.96nT in X, 1.25nT in Y, and 0.69nT in Z. (In terms of the absolute observed components, they were 0.6 nT in F, 09" in D, and 04" 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, with the drift largest for the Y component.

There was about 3nT 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 and not being used to recover the Z channel of the fluxgate.

Operations

The local observer at LRM magnetic observatory was a staff member of IPS at the Learmonth Solar Observatory. During 2003 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;
- instrument checks, system re-sets etc. as required.

Operations (cont.)

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.

LRM –Significant Events 2003

10 Jan	Theodolite bumped and sensor shifted.
12 Jan	14:23:12 Sudden and unexplained (751 count) jump in B-channel.
11 Feb	Commenced recovery of C-channel from 10s PPM data.
14 Jan	Rapid drift of C channel commenced.
26 Feb	Multiple reboots for reasons unknown; PPM did not restart.
02 Mar	System reboot
04 Mar	~0300: Local observer reset the variometer PPM; Crane working in Solar Observatory caused baseline jumps.
10 Mar	1945−1948: System reboot causing PPM to stop again. UPS is probably failing.
11 Mar	0503: PPM re-started.
12 Mar	UPS confirmed faulty; system rebooted. Cycle time of G856 PPM fixed; Telephone line problems.
14 Mar	Modem reset to fix telephone line problems.
Mar	Nikko ULT1500 s/n 20515457 UPS + Battery Box SMK-3K s/n 20522609 sent to replaceme faulty UPS.
21 Mar	System rebooted
22 Mar	System rebooted
26 Mar	System rebooted
29 Apr	0430−0615: PPM spikes (while F is being used to recover faulty C-channel (Z))
01 May	DMI electronics E0254 replaced with E0271.
02 Jun	DMI sensor S0271 replaced with S0273. System rebooted.
04 Jul	Local observer away until August, so no absolute observations until then. F-check problems.
05 Aug	Local observer returned from absence.
05 Aug	Steps in F-check.
06 Aug	to 8th: Heavy equipment working at Solar Observatory
11 Aug	& 12th: Steps in F-check
mid Sep	Two absolute observations missed due to absence of local observer.
28 Nov	Absolute observation missed
01 Dec	2330 to 02 / 0700; 03 / 0430−0530 (suspected); 04 / 2230 to 05 / 0700 (during absolute observation) : Work on 28 ft solar observatory radio dish, causing contamination on magnetic variometer data.
11 Dec	Local observer absent until 22 Jan 2004.

LRM 2003 Data Loss – See page 36.

Distribution of LRM data during 2003

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2003

1-minute & Hourly Mean Values

- 2002: WDC-C1, Copenhagen, Denmark (16 Apr. 2003)
- 2002: WDC-A, Boulder, USA (16 Apr. 2003)
- 2003: WDC-C1, Copenhagen, Denmark (15 Apr. 2004)
- 2003: WDC-A, Boulder, USA (15 Apr. 2004)

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

The adjustment applied to the absolute PPM used at Learmonth in 1994 was given as -1nT on page 44 in the *AGR1994*. This correction was in addition to a -1nT correction to the standard 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 34-35.

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
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
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

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 & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29750.8	193.7	-44182.7	53266.0	29751.5	+0° 22.4'	-56° 02.7'
	5xQ days	29759.6	194.3	-44182.2	53270.4	29760.2	+0° 22.4'	-56° 02.2'
	5xD days	29738.8	193.6	-44181.6	53258.3	29739.5	+0° 22.4'	-56° 03.3'
February	All days	29742.8	197.0	-44182.6	53261.4	29743.5	+0° 22.8'	-56° 03.1'
	5xQ days	29751.1	198.4	-44181.4	53265.0	29751.7	+0° 22.9'	-56° 02.6'
	5xD days	29726.0	194.3	-44188.2	53256.6	29726.6	+0° 22.5'	-56° 04.2'
March	All days	29733.3	200.8	-44178.3	53252.6	29734.0	+0° 23.2'	-56° 03.5'
	5xQ days	29752.7	201.7	-44174.0	53259.8	29753.4	+0° 23.3'	-56° 02.3'
	5xD days	29712.9	202.6	-44182.5	53244.7	29713.6	+0° 23.4'	-56° 04.7'
April	All days	29728.3	203.0	-44178.9	53250.2	29729.0	+0° 23.5'	-56° 03.7'
	5xQ days	29740.8	202.9	-44177.3	53255.9	29741.5	+0° 23.5'	-56° 03.0'
	5xD days	29719.5	203.4	-44181.2	53247.3	29720.2	+0° 23.5'	-56° 04.3'
May	All days	29726.3	205.2	-44177.9	53248.3	29727.0	+0° 23.7'	-56° 03.8'
	5xQ days	29741.6	204.1	-44176.6	53255.7	29742.3	+0° 23.6'	-56° 03.0'
	5xD days	29709.3	203.6	-44179.8	53240.3	29710.0	+0° 23.6'	-56° 04.8'
June	All days	29727.2	207.6	-44177.6	53248.5	29727.9	+0° 24.0'	-56° 03.8'
	5xQ days	29740.0	205.7	-44175.5	53254.0	29740.7	+0° 23.8'	-56° 03.0'
	5xD days	29702.2	209.3	-44181.5	53237.9	29703.0	+0° 24.2'	-56° 05.2'
July	All days	29733.3	208.4	-44173.6	53248.7	29734.1	+0° 24.1'	-56° 03.3'
	5xQ days	29746.3	207.8	-44171.0	53253.8	29747.1	+0° 24.0'	-56° 02.5'
	5xD days	29708.0	211.4	-44176.0	53236.5	29708.8	+0° 24.5'	-56° 04.7'
August	All days	29731.6	209.2	-44170.3	53245.0	29732.3	+0° 24.2'	-56° 03.3'
	5xQ days	29747.1	208.6	-44167.5	53251.3	29747.8	+0° 24.1'	-56° 02.3'
	5xD days	29704.0	208.7	-44174.3	53232.9	29704.7	+0° 24.2'	-56° 04.9'
September	All days	29741.5	209.4	-44166.1	53247.1	29742.3	+0° 24.2'	-56° 02.6'
	5xQ days	29755.3	208.8	-44162.7	53251.9	29756.1	+0° 24.1'	-56° 01.7'
	5xD days	29718.5	209.2	-44169.1	53236.7	29719.3	+0° 24.2'	-56° 03.9'
October	All days	29732.7	211.4	-44166.5	53242.5	29733.5	+0° 24.4'	-56° 03.1'
	5xQ days	29757.0	211.4	-44160.1	53250.7	29757.7	+0° 24.4'	-56° 01.5'
	5xD days	29672.7	208.2	-44175.6	53216.5	29673.4	+0° 24.1'	-56° 06.6'
November	All days	29733.1	211.9	-44168.5	53244.3	29733.8	+0° 24.5'	-56° 03.1'
	5xQ days	29756.7	213.1	-44164.9	53254.5	29757.5	+0° 24.6'	-56° 01.7'
	5xD days	29706.9	208.6	-44170.6	53231.4	29707.6	+0° 24.1'	-56° 04.6'
December	All days	29752.6	215.3	-44162.2	53250.0	29753.4	+0° 24.9'	-56° 01.8'
	5xQ days	29764.5	217.1	-44157.8	53253.0	29765.3	+0° 25.1'	-56° 01.0'
	5xD days	29733.8	214.2	-44167.4	53243.8	29734.5	+0° 24.8'	-56° 03.0'
Annual	All days	29736.1	206.1	-44173.8	53250.4	29736.9	+0° 23.8'	-56° 03.1'
Mean	5xQ days	29751.1	206.2	-44170.9	53256.4	29751.8	+0° 23.8'	-56° 02.2'
Values	5xD days	29712.7	205.6	-44177.3	53240.3	29713.4	+0° 23.8'	-56° 04.5'

(Calculated: 13:38 hrs., Fri., 01 Apr., 2005)

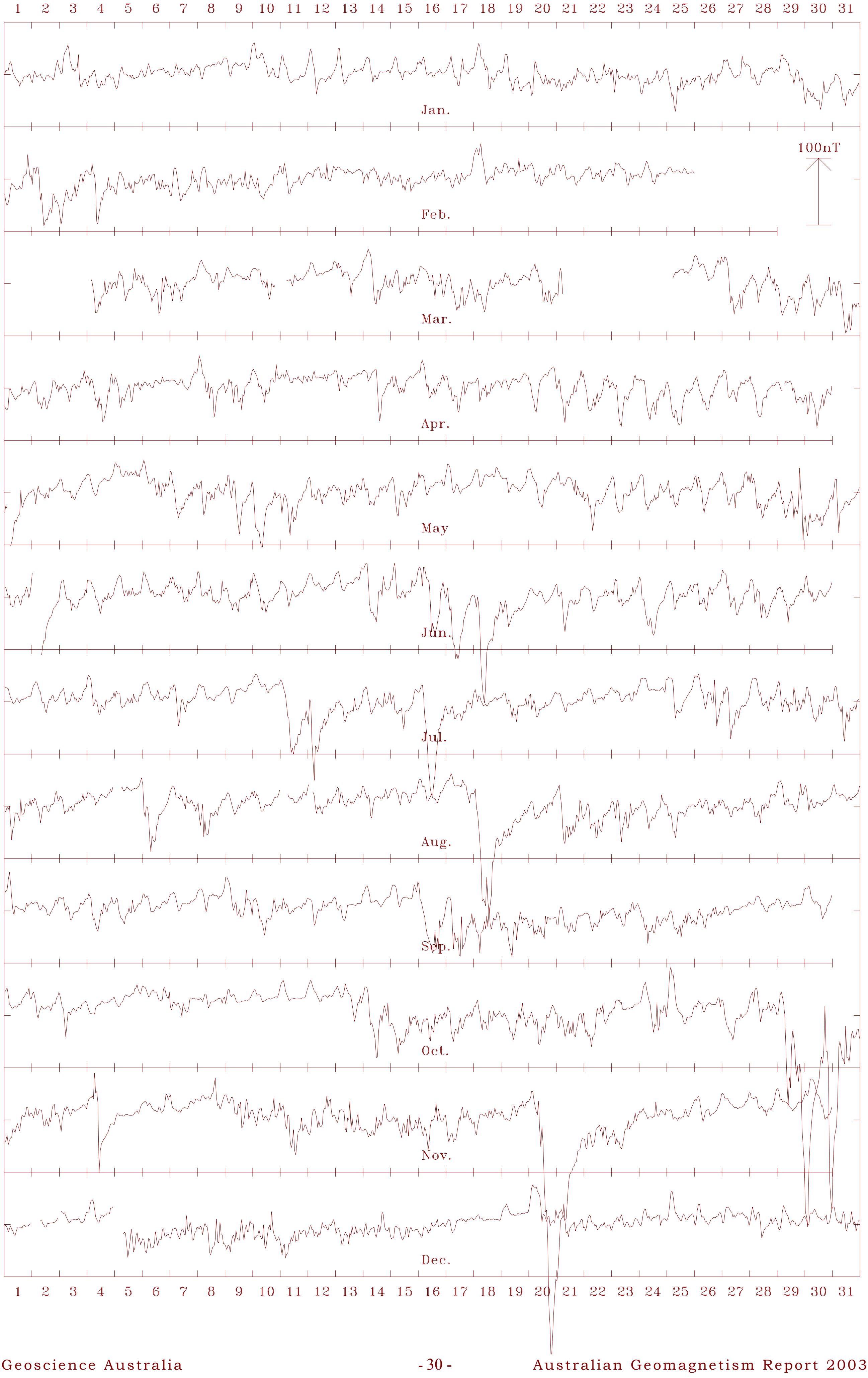
Hourly Mean Values

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

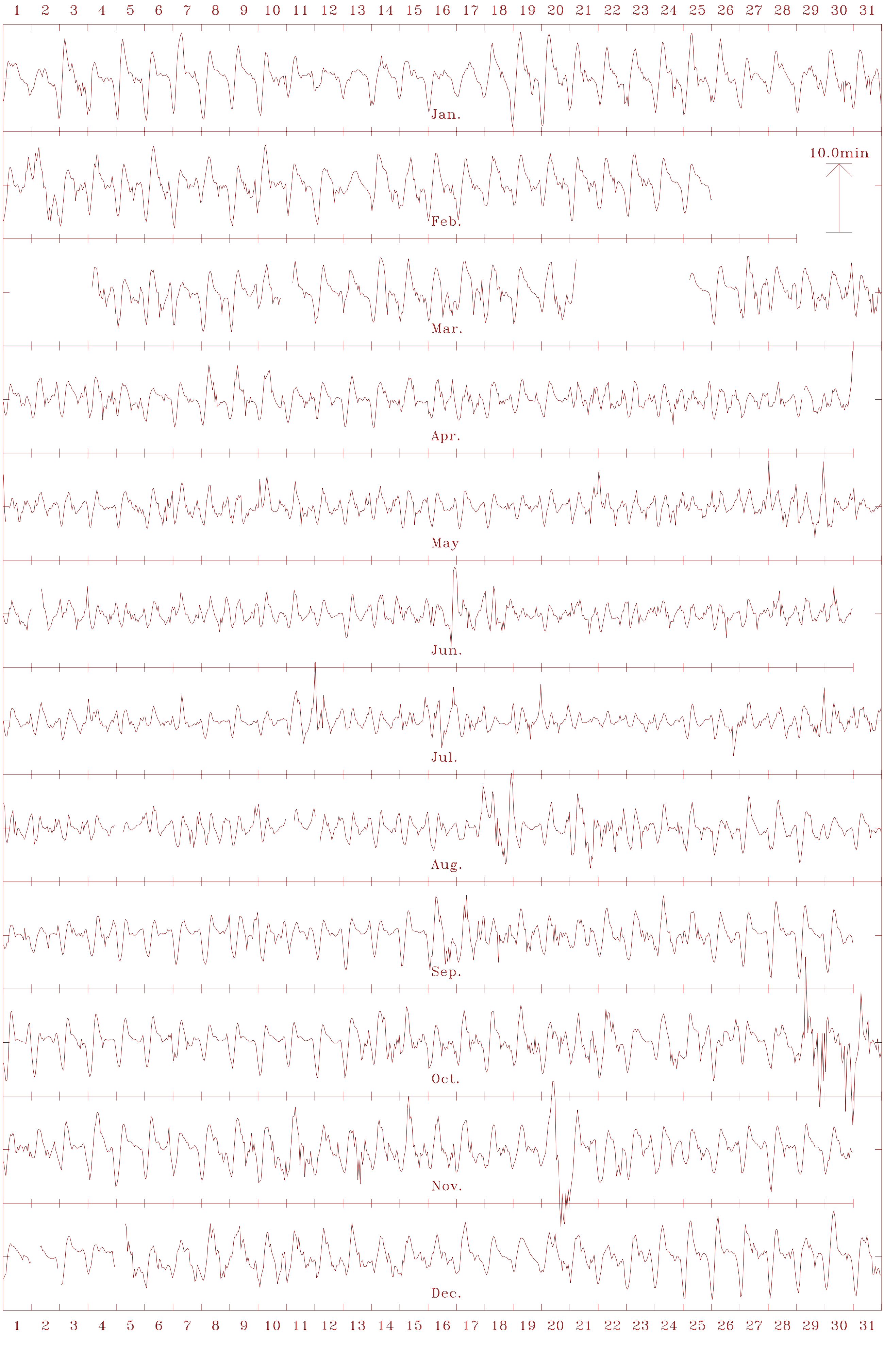
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

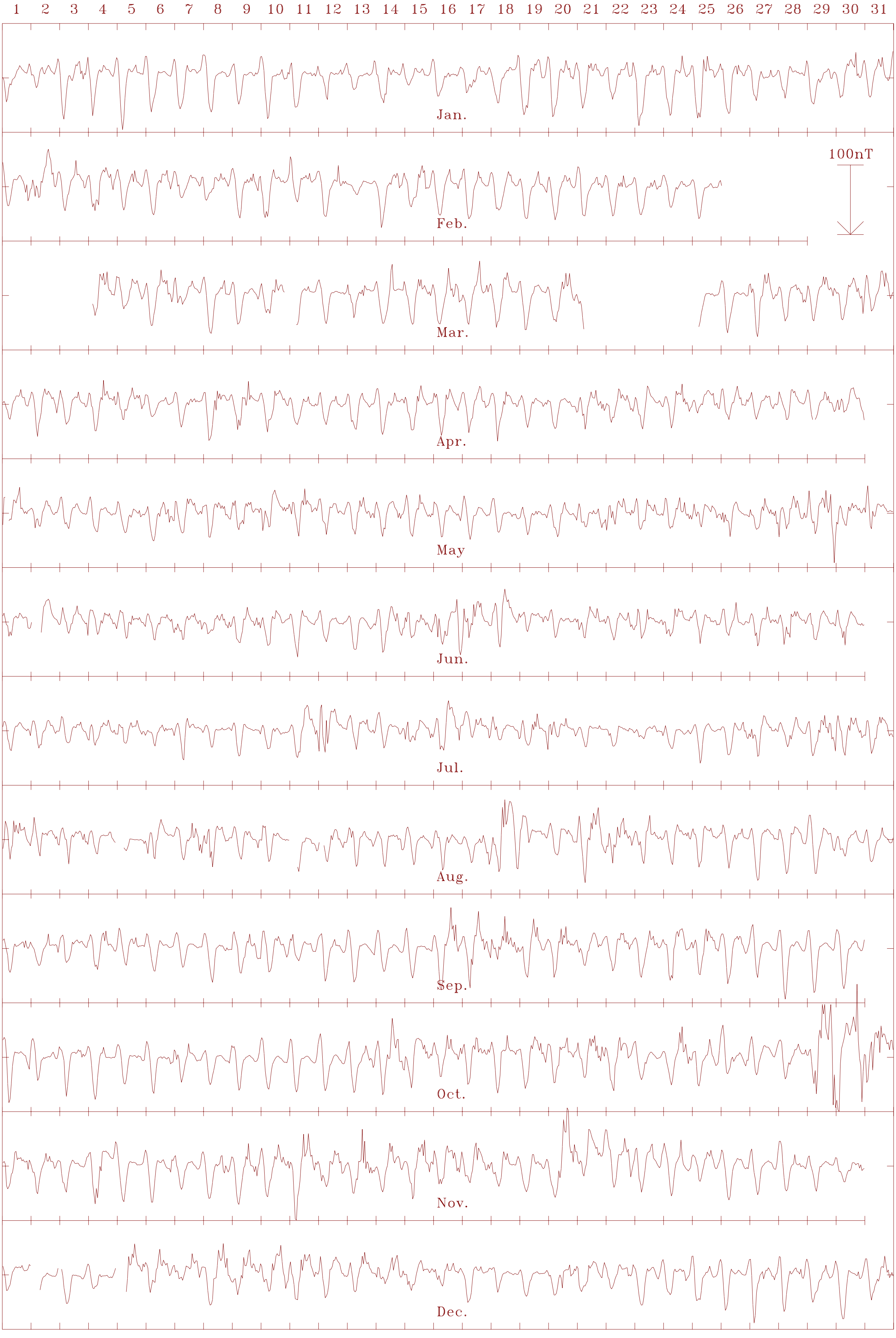
Learmonth 2003 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29737 nT



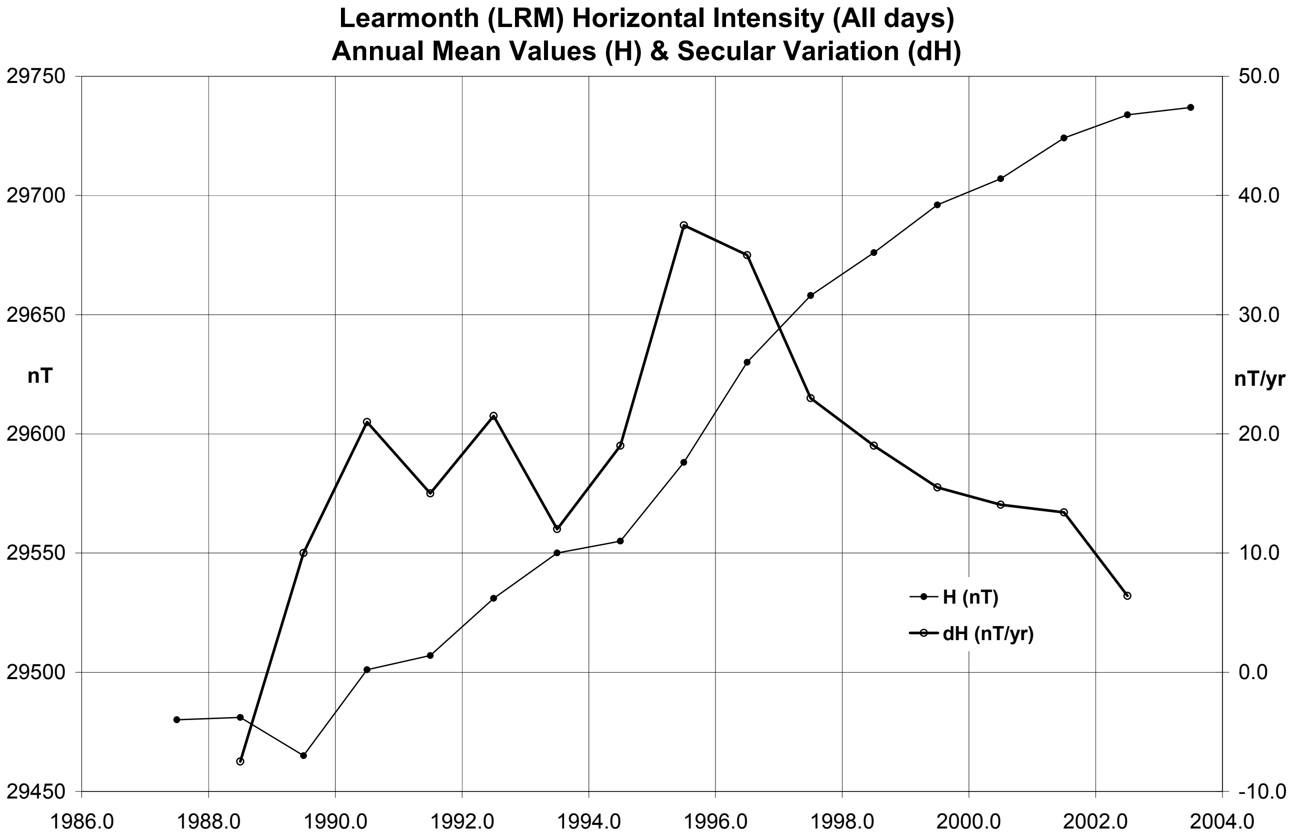
Learmonth 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.40 deg.



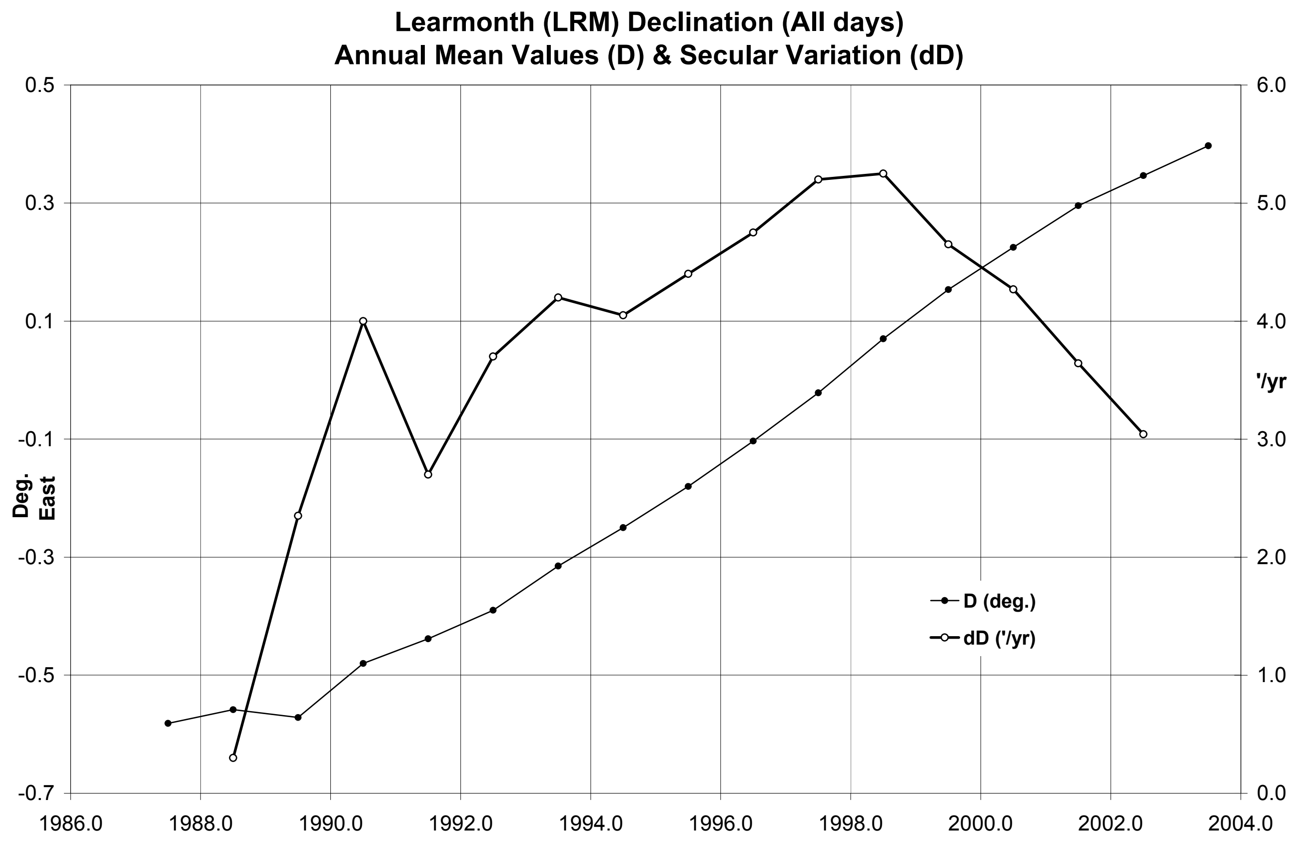
Learmonth 2003 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −44174 nT



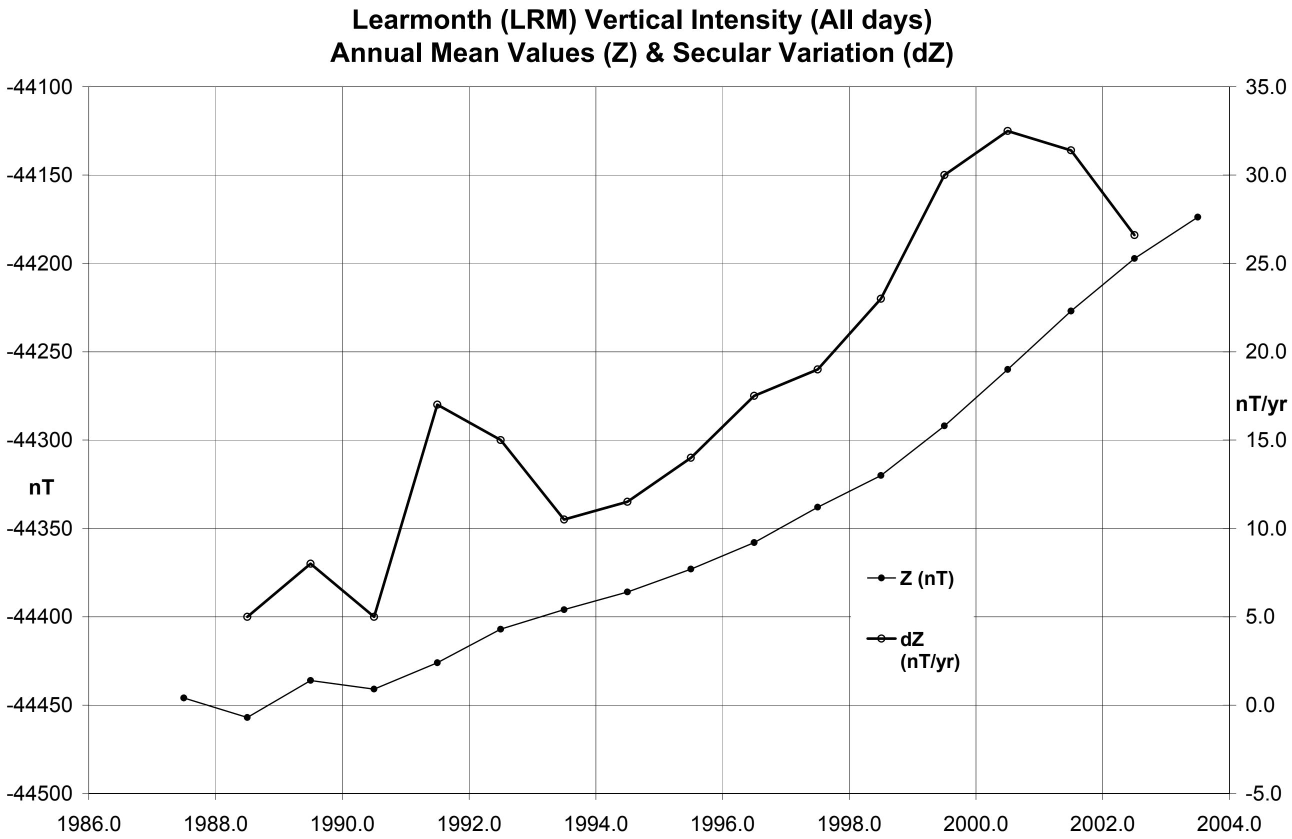
Learmonth 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53250 nT



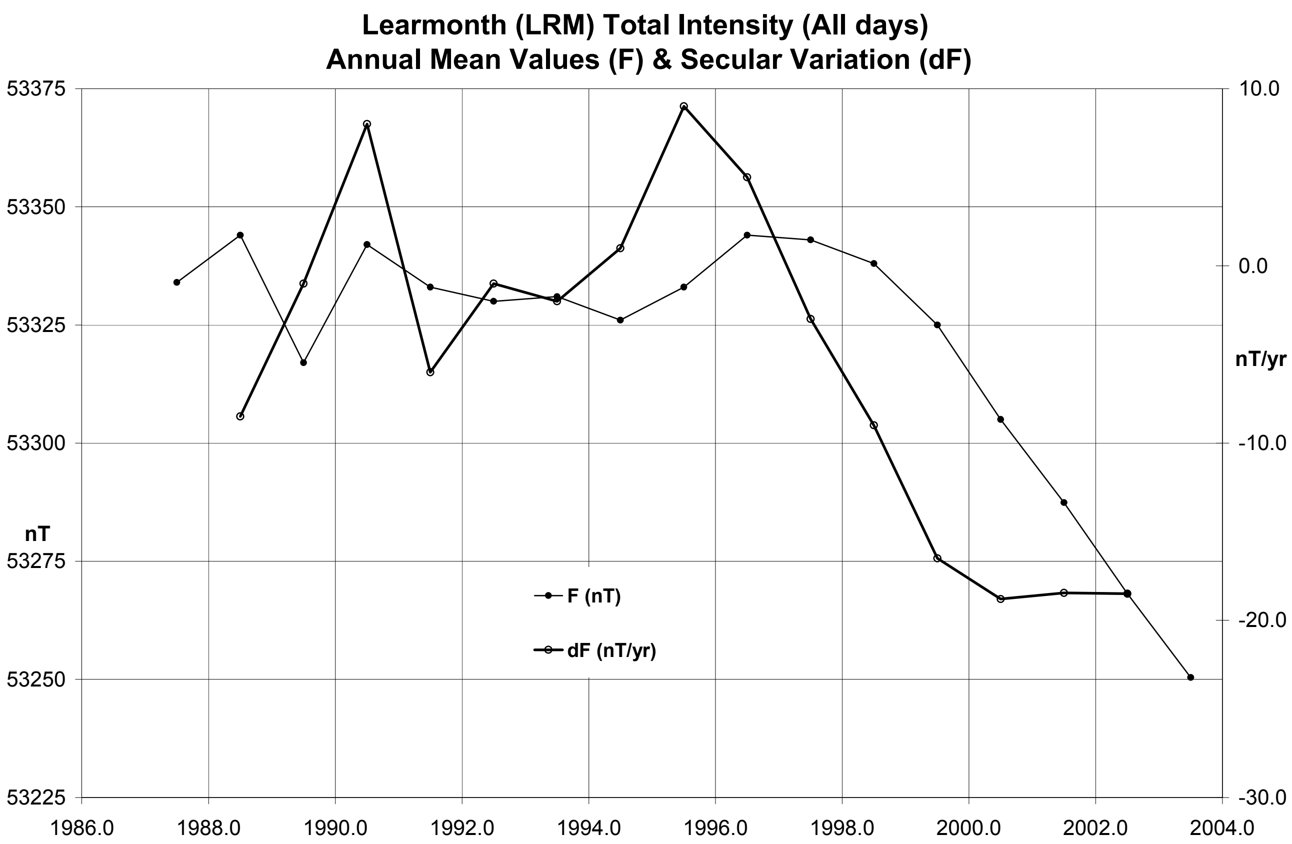
Learmonth (LRM) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
29750
29700
29650
29600
29550
29500
29450
nT
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
nT/yr
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
H (nT)
dH (nT/yr)



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



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



Learmonth (LRM) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53375
53350
53325
53300
nT
53275
53250
53225
10.0
0.0
nT/yr
-10.0
-20.0
-30.0
F (nT)
dF (nT/yr)
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0

LRM – Data loss in 2003

Note: In the period 11 Feb to 02 June F data loss implies total data loss as the PPM data was used to derive the vertical channel of the fluxgate variometer.

12 Jan 1423 (1 min) All channels: Processing inhibited when spike occurred.

26 Feb 0110 to 04 Mar / 0254 (6d 01h 45m) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

26 Feb. / 0110–0111 (2m), 0212–0215 (4m), 0731 (1m) XYZ channels;

26 Feb 0110 to 04 Mar 0245 (6d 01h 36m) F channel;

Mar 02 / 0212–0215 (4m) XYZ channels: reboot;

Mar 04 / 0249–0251 (3m) F channel.

10 Mar. 1947 to 11 / 0504 (09h 18m) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

10 / 1947–1948 (2m); 2353 (1m) XYZ channels: PC Rebooted.

10 / 1947 to 11 / 0502 (9h 16m) F channel.

12 Mar. 0501–0509 (9m) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

0502–0503 (2m) XYZ channels;

0502–0505 (4m), 0508 (1m) F channel.

21 Mar. 0557 to 25 / 0538 (3d 23h 42m)) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

21 / 0558–0559 (2m) XYZ channels: reboot,

21 / 0657 (1m) XYZ channels: reboot;

21 / 0558 to 25 / 0537 (3d 23h 40m) F channel.

22 / 2101–2102 (2m) XYZ channels: reboot

22 / 2138 (1m) XYZ channels: reboot.

26 Mar. 0528–0559 (32m) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

0528–0531 (4m) XYZ channels: reboot,

0534–0538 (5m) XYZ channels;

0528–0555 (28m) F channel.

29 Apr 0435–0614 (1h 40m) All channels: Data processing inhibited due to data contamination.

01 May 0230–0539 (3h 10m) All channels: Processing inhibited during maintenance to variometer, during which period data acquisition did not take place in the interval: 0445–0502 (18m) XYZ channels

02 Jun. 0045–0759 (7h 15m) All channels: Processing inhibited during maintenance to variometer, during which period data acquisition did not take place in the intervals:

0133–0356 (2h 24m) XYZ channels,

0545 (1m) F channel only.

Due to contamination, processing of data (all channels) was inhibited over the following periods:

04 Aug 2250 to 05 / 0514 (6h 25m)

10 Aug 2350 to 11 / 0554 (6h 05m)

12 Aug 0015–0424 (4h 10m)

01 Dec 2335 to 02 / 0704 (7h 30m)

02 Dec 2230 to 03 / 0129 (3h 00m)

03 Dec 0445–0519 (35m)

04 Dec 2225 to 05 / 0649 (8h 25m)

ALICE SPRINGS OBSERVATORY

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), Division of Wildlife and Range Lands 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 have been used in the period since 1912.

Key data for the principal observation site (Pier G) of the observatory are:

- 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. -32.77°; Long. 208.05°

† Based on the IGRF 2000.0 model updated to 2003.5

- Elevation above mean sea level (top of pier): 557 metres
- Lower limit for K index of 9: 350 nT.
- Azimuth of principal reference pillar (B) from Pier G: 255° 00' 50"
- Distance to Pillar B: 85 metres
- Observer in Charge: W. Serone (ACRES)

ASP – Variometers

Variations in the X, Y and Z components of the magnetic field were recorded at Alice Springs in 2003 using a three-component Narod ring-core fluxgate (RCF) magnetometer and in the total magnetic field intensity (F) using GEM system GSM-90 Overhauser-effect proton precession magnetometers (PPM). The GSM90s suffered from noise problems which caused significant data losses throughout the year.

The six channels of variometer data, (three RCF channels, RCF head and electronics temperatures, and the PPM data), were recorded on a PC.

The recording, and variometer, electronic control equipment 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, 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. The Critec DataGuard UPS had a partial failure during testing in May and later a complete failure in June. The unit was replaced with a Leibert UPS station GX on 07 July 2003.

The air-conditioning system for the control hut was serviced on 01 September 2003.

Absolute Instruments and Corrections

The principal absolute instruments employed at Alice Springs during 2003 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. GEM model GSM-19 no 11435 Overhauser effect PPM was used as the absolute PPM from 01 January 2003 until 20 May 2003. This was replaced by a GEM model GSM90, no 2101216 with sensor 306403, on 21 May 2003. Prior to 21 May the Elsec 810 was powered by 12 D cell batteries, after which it was powered from a re-chargeable external 18V battery box.

The Alice Springs DIM failed on 18 November 2003. The instrument was sent to GA for servicing and returned to Alice Springs after a broken electrical connection in the plug was repaired.

Comparisons between the ASP absolute instruments: DIM E810_221/318887 and GSM19_11435/306403 that were in use at the observatory at the beginning of the year to 21 May 2003, and the travelling standard absolute instruments B0610H/160459 and GSM90_003985/11690, were performed in May 2003. The instrument differences determined were:

DIM: $Ds - Dasp1 = 0.0'$ and $Is - Iasp1 = 0.1'$

PPM: $Fs - Fasp1 = 0.7nT$

where Ds, Is and Fs are the declination, inclination and total intensity by the Australian Standard instruments (DIM E810_200/353756 and PPM GSM90_905926/21867 at the Canberra Observatory) and Dasp1, Iasp1 and Fasp1 are the absolute instruments in use at the ASP observatory at the beginning of the year to 21 May 2003.

Absolute Instruments and Corrections (cont.)

These instrument differences convert to baseline corrections of:

$\Delta X = 1.7nT$, $\Delta Y = 0.2nT$, $\Delta Z = 0.3nT$

at the average magnetic field values at Alice Springs of

$X = 29955nT$, $Y = 2680nT$, $Z = -44200nT$

These corrections have been applied to the data from 01 Jan 2003 to 02:46:00UT on 21 May 2003.

After 21 May the standard absolute instruments used at ASP were E810_221/318887 and GSM90_2101216/306403. Instrument differences for this set of instruments were determined as:

DIM: $Ds - Dasp2 = 0.0'$ and $Is - Iasp2 = 0.1'$

PPM: $Fs - Fasp2 = 0.2nT$

where Dasp2, Iasp2 and Fasp2 are the absolute instruments used at ASP from 21 May to the end of 2003. These instrument differences convert to baseline corrections of:

$\Delta X = 1.4nT$, $\Delta Y = 0.1nT$, $\Delta Z = 0.7nT$

which have been applied to the data from 02:46:01UT on 21 May 2003 to then end of 2003.

Baselines

At approximately 0700 on most weekdays in the first half of 2003 there was a small jump of approximately 0.5nT in the difference between the variometer PPM and the total field calculated from the fluxgate data, then an equal but opposite jump at approximately 2230. These jumps were probably caused by a vehicle parking too close to the variometer and causing 0.5nT contamination during working hours.

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

1.53nT in X; 1.61nT in Y; 1.45nT in Z

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

1.1nT in F; 11" in D; 7" 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 5nT 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 (usually 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 azimuth pillar B. 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.

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 and 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.

Operations – ASP (cont.)

A maintenance visit was made to the Alice Springs observatory 19–23 May 2003. During the visit the variometer PPM sensor was replaced, the absolute total field instrument (GSM19_11435) was replaced with GSM90_2101216 and the power for Elsec 810_221 fluxgate electronics was changed over from internal D cells to an external re-chargeable battery box.

The absolute instruments were also tested and compared to travelling standard instruments. Pier gradients and mark azimuths were also measured.

Significant Events 2003 - ASP

09 Jan	Request that OIC switch DIM to µT for moving sensor and nT for reading to minimise hysteresis effects. All future observations should follow this schedule.
29 Jan	Variometer PPM started short periods of intense spiking.
05 Feb	Absolute PPM produced bad reading and displayed "Hi Grad" during last set of observations.
19 Feb	Periods of noise on variometer PPM.
26 Feb	~02:20UT: OIC reset GSM90. Still gave bad readings.
11 Mar	to 17 Mar: No absolute observations as OIC away from observatory.
17 Mar	Variometer GSM90 removed and sent to GA.
28 Mar	GSM90 electronics reinstalled after no problem found at GA.
30 Mar	Contamination due to CSIRO tractor near fluxgate. System reboot to tune GSM90.
01 Apr	Contamination, mostly on fluxgate, caused by CSIRO tractor ploughing in preparation for hazard reduction burns when weather cools.
15 May	ASP DIM electronics E810_221 arrived at GA. Battery box connector installed.
May 19 to 24th	Maintenance visit: variometer PPM sensor 3112370 replaced with 21889; absolute PPM GSM90_11435/306403 replaced with GSM90_2101216/306403; Commenced using battery box with E810_221. Also instrument comparisons, rounds, sunshots, gradients, observations etc.
21 May	GSM90_2101216/306403 used as absolute PPM from 21 May to replace GSM19_11435/306403. Also started using battery box for DIM power.
12 Jun	OIC checked the control hut air conditioner setting and changed it from cool cycle to warm, to test if cool temperatures might be causing the PPM problems in recent days. Also the UPS was "alarming" continuously and probably should be replaced.
25 Jun	Arranged replacement UPS (Leibert UPSstation GX Model RT1500-50, Part Number UGX1500RT050, I/P 240V 6A, O/P 230V 1500VA, IEC mains input lead, 4 IEC output plugs, Inside are 6x12V 7AH CSB GP 1270 batteries). There was no AGSO bar code, no manual, no photographs were taken.
24 Jun	Psion RS-232 comms to GSM90 failed: no PPM observations made during absolutes.
02 Jul	Problem with Psion - maybe in cabling to GSM90.
07 Jul	0350: UPS installed losing about 3 minutes of data. System operated O.K. with new UPS.
10 Jul	Variometer PPM went bad again. Large drilling-rig about 200m from hut (not sure which hut).

Significant Events 2003 – ASP (cont.)

18 Jul	0436: Remote system reboot to tune GSM90 PPM.
21 Jul	0226: Clock time 1 second fast from reboot on 18 Jul until now.
14 Aug	22:15:15 Variometer PPM stepped.
16 Aug	1505 and 22:21:40 Variometer PPM steps.
01 Sep	Control hut air-conditioner serviced by Airtemp.
12 Sep	0315: Variometer PPM GSM90_708729 disconnected and returned to GA (15th) for testing
16 Sep	Telstra repaired faulty modem telephone line
03 Oct	GSM90 reinstalled. System rebooted (off: 07:23:24; on: 07:24:24) after PPM data appeared incorrect.
23 Oct	GSM90 Variometer PPM electronics removed and sent to GA.
15 Nov	DIM failed: cannot perform absolute observations; output reading drifts. DIM sent to GA, where broken wires in the plug were fixed.
09 Dec	IAGA2002 data exchange format adopted for INTERMAGNET minute data distribution.

See also description of regular contamination event in ***Baselines*** section for ASP observatory.

ASP – Data losses in 2003

26 Feb	0217-0221 (5min) F channel only
17 Mar	0608 to 28th Mar (11d 13h 25m) F channel only
29 Mar	30th (1d 23h 12m) F channel only
30 Mar	0145-2359 (22h 15m) XYZ channels: Contamination by heavy machinery
31 Mar	0145-2359 (22h 15m) XYZ & F channels: Contamination by heavy machinery.
01 Apr	0000-0235 (2h 36m) XYZ & F channels: Contamination by heavy machinery.
10 May	0347 (1 min) F channel only.
19 May	0516-0524 (9 min) XYZ & F channels: Contamination of fluxgate vault
20 May	0634-0657 (24 min) XYZ & F channels: Contamination of fluxgate vault
20 May	0726-0243 (18 min) XYZ channels; Intermittent loss (234 mins) F channel
22 May	0305 (1 min), 0321-0404 (44 min) XYZ channels; Intermittent loss (112 mins) F channel
07 Jul	0350-0353 (4 min) XYZ & F channels
18 Jul	0435 (1 min) XYZ channels; 0435-0436 (2 min) F channel.
12 Sep	0320 to 02 Oct / 2359 (20d 20h 40m) F channel
03 Oct	0723 (1 min) XYZ channel
October	On the following days in October data were lost intermittently from the F channel only:

03 (730 mins);	04 (707 mins);	05 (762 mins);
06 (675 mins);	07 (441 mins);	08 (355 mins);
09 (278 mins);	10 (235 mins);	11 (253 mins);
12 (304 mins);	13 (299 mins);	14 (398 mins);
15 (335 mins);	16 (381 mins);	17 (292 mins);
18 (209 mins);	19 (165 mins);	20 (240 mins);
21 (215 mins);	22 (335 mins);	

23 Oct	0000 to 31 Dec 2003 / 2359 (70 days) F channel.

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29959.9	2678.2	-44187.3	53453.6	30079.4	5° 06.5'	-55° 45.4'
	5xQ days	29970.0	2680.7	-44185.6	53458.0	30089.6	5° 06.7'	-55° 44.7'
	5xD days	29947.6	2677.0	-44187.5	53446.8	30067.0	5° 06.5'	-55° 46.0'
February	All days	29950.9	2678.3	-44185.3	53446.9	30070.4	5° 06.6'	-55° 45.8'
	5xQ days	29958.5	2680.8	-44182.0	53448.5	30078.2	5° 06.8'	-55° 45.2'
	5xD days	29934.6	2673.1	-44190.8	53442.0	30053.7	5° 06.2'	-55° 46.8'
March	All days	29942.5	2681.6	-44181.5	53439.2	30062.3	5° 07.1'	-55° 46.1'
	5xQ days	29956.3	2683.8	-44178.5	53444.5	30076.3	5° 07.2'	-55° 45.2'
	5xD days	29922.8	2678.4	-44184.1	53430.2	30042.4	5° 06.9'	-55° 47.2'
April	All days	29935.8	2680.0	-44180.9	53434.9	30055.5	5° 06.9'	-55° 46.4'
	5xQ days	29947.1	2680.6	-44179.3	53439.9	30066.9	5° 06.9'	-55° 45.7'
	5xD days	29926.6	2678.9	-44182.9	53431.3	30046.2	5° 06.9'	-55° 47.0'
May	All days	29932.4	2681.1	-44179.6	53432.0	30052.3	5° 07.1'	-55° 46.5'
	5xQ days	29947.2	2680.6	-44178.6	53439.4	30066.9	5° 06.9'	-55° 45.7'
	5xD days	29916.7	2679.3	-44180.3	53423.7	30036.4	5° 07.1'	-55° 47.4'
June	All days	29932.9	2681.4	-44178.9	53431.7	30052.8	5° 07.1'	-55° 46.5'
	5xQ days	29945.9	2681.9	-44176.1	53436.7	30065.7	5° 07.1'	-55° 45.7'
	5xD days	29906.8	2679.4	-44183.9	53421.1	30026.6	5° 07.2'	-55° 48.0'
July	All days	29939.1	2681.6	-44174.7	53431.6	30058.9	5° 07.1'	-55° 46.0'
	5xQ days	29952.4	2682.8	-44173.1	53437.9	30072.3	5° 07.1'	-55° 45.2'
	5xD days	29911.9	2680.5	-44177.3	53418.5	30031.8	5° 07.2'	-55° 47.5'
August	All days	29936.9	2682.8	-44171.4	53427.8	30056.9	5° 07.3'	-55° 46.0'
	5xQ days	29953.0	2682.9	-44168.5	53434.4	30072.9	5° 07.1'	-55° 45.0'
	5xD days	29909.9	2679.2	-44175.3	53415.7	30029.6	5° 07.1'	-55° 47.6'
September	All days	29943.8	2681.0	-44165.1	53426.3	30063.5	5° 07.0'	-55° 45.4'
	5xQ days	29955.0	2682.0	-44161.1	53429.4	30074.9	5° 07.0'	-55° 44.6'
	5xD days	29922.8	2679.0	-44169.2	53417.9	30042.5	5° 07.0'	-55° 46.7'
October	All days	29936.5	2679.2	-44164.3	53421.6	30056.2	5° 06.9'	-55° 45.8'
	5xQ days	29959.6	2684.1	-44156.9	53428.6	30079.6	5° 07.2'	-55° 44.2'
	5xD days	29877.7	2670.9	-44173.5	53395.8	29996.8	5° 06.5'	-55° 49.3'
November	All days	29936.3	2679.3	-44165.9	53422.7	30056.0	5° 06.9'	-55° 45.8'
	5xQ days	29959.9	2683.3	-44160.4	53431.6	30079.9	5° 07.1'	-55° 44.4'
	5xD days	29911.7	2671.1	-44170.1	53412.1	30030.8	5° 06.2'	-55° 47.3'
December	All days	29954.2	2682.0	-44160.6	53428.5	30074.0	5° 07.0'	-55° 44.7'
	5xQ days	29965.8	2684.3	-44157.5	53432.5	30085.8	5° 07.1'	-55° 43.9'
	5xD days	29938.1	2681.6	-44165.8	53423.8	30057.9	5° 07.1'	-55° 45.7'
Annual	All days	29941.8	2680.5	-44174.6	53433.1	30061.5	5° 06.9'	-55° 45.8'
Mean	5xQ days	29955.9	2682.3	-44171.5	53438.5	30075.7	5° 07.0'	-55° 45.0'
Values	5xD days	29918.9	2677.4	-44178.4	53423.2	30038.5	5° 06.8'	-55° 47.2'

(Calculated: 11:46 hrs. Thu. 26 Feb. 2004)

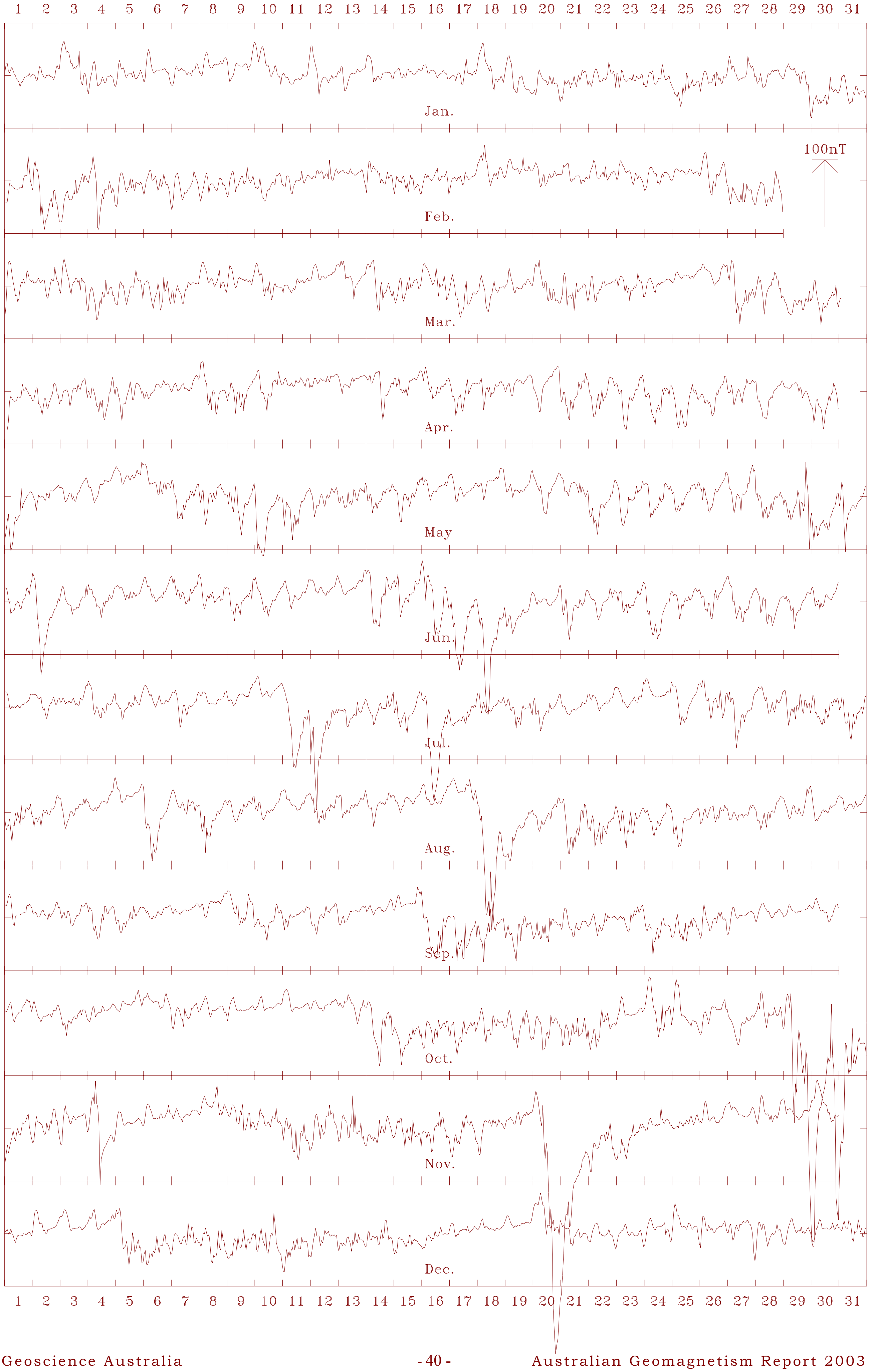
Hourly Mean Values

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.

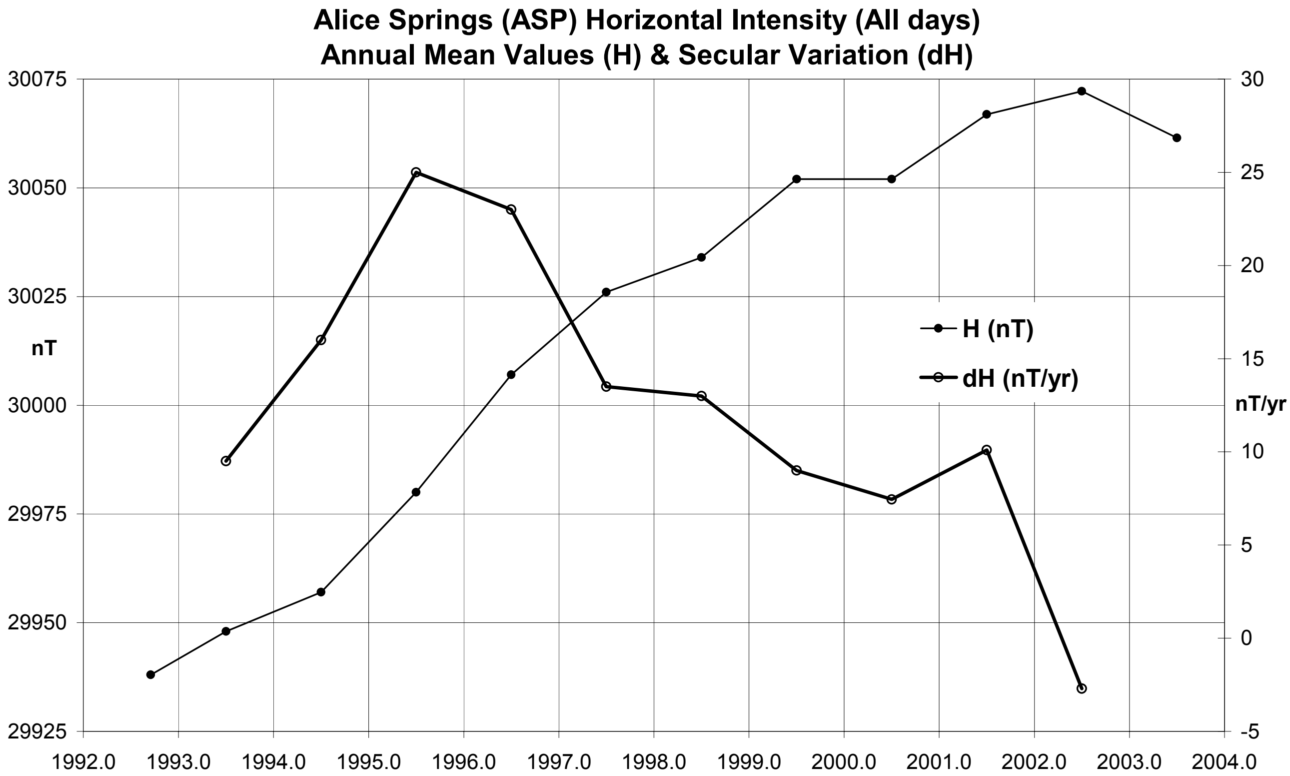
Alice Springs 2003 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 30062 nT



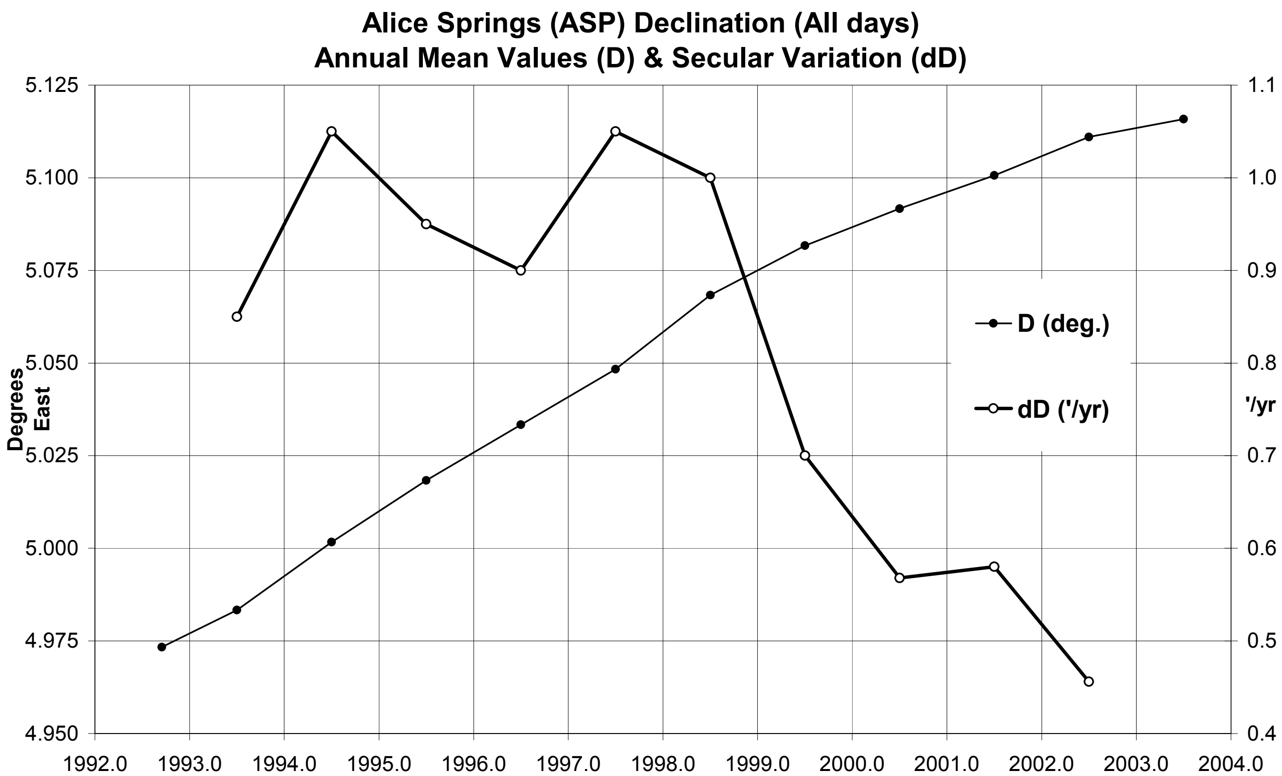
Alice Springs 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.12 deg.

Alice Springs 2003 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44175 nT

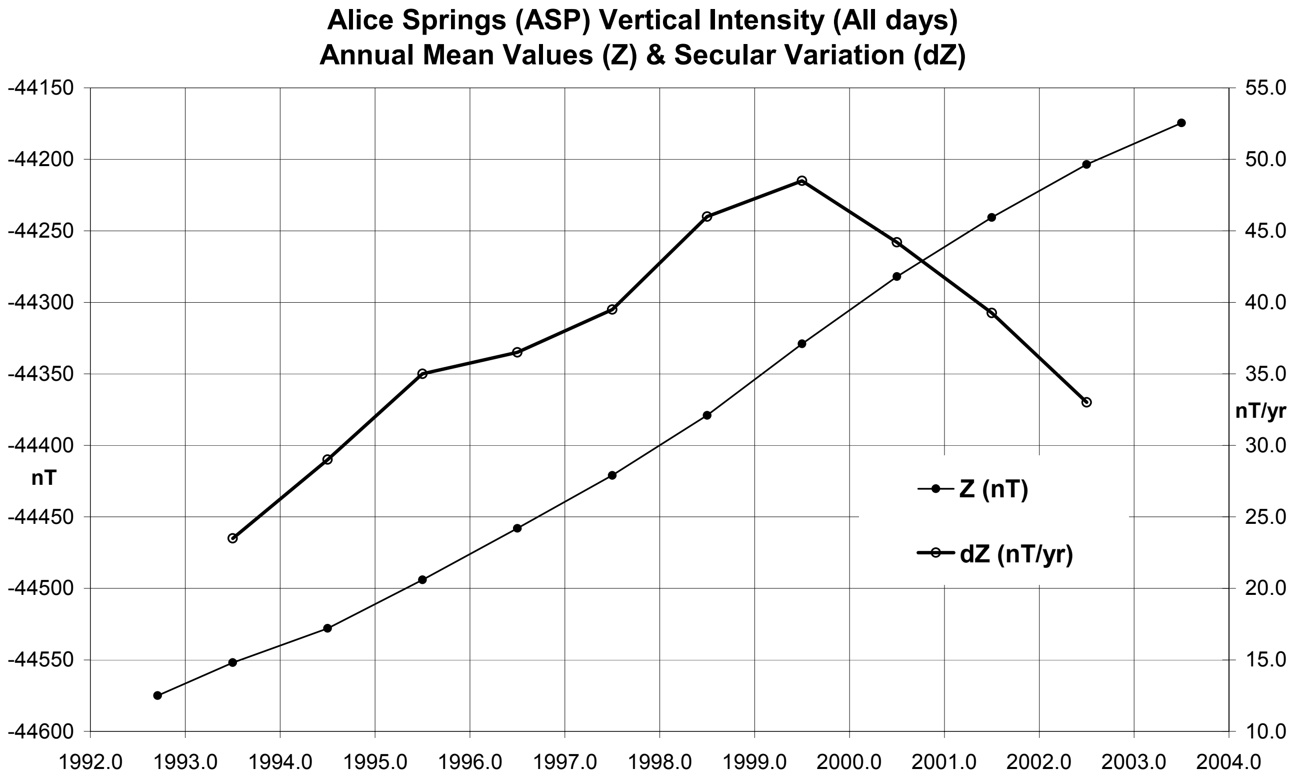
Alice Springs 2003 Total intensity (F). Scale: 5.0 nT/mm. Mean: 53433 nT



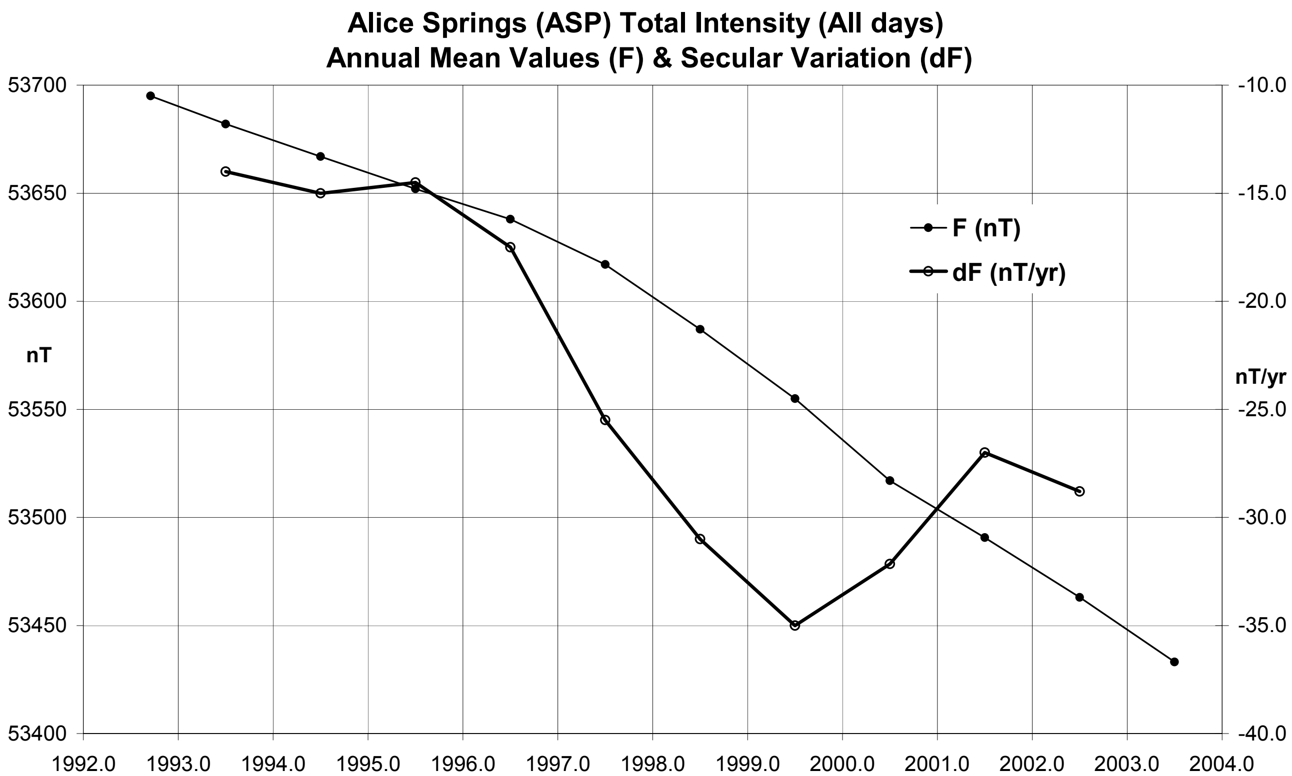
Alice Springs (ASP) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
30075
30050
30025
30000
29975
29950
29925
30
25
20
15
10
5
0
-5
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0



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
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
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



Alice Springs (ASP) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-44150
-44200
-44250
-44300
-44350
-44400
nT
-44450
-44500
-44550
-44600
55.0
50.0
45.0
40.0
35.0
nT/yr
30.0
25.0
20.0
15.0
10.0
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
Z (nT)
dZ (nT/yr)



Alice Springs (ASP) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53700
53650
53600
nT
53550
53500
53450
53400
-10.0
-15.0
-20.0
nT/yr
-25.0
-30.0
-35.0
-40.0
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
F (nT)
dF (nT/yr)

Distribution of ASP data during 2003

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2003

1-minute & Hourly Mean Values

- 2002: WDC-A, Boulder, USA (30 Jun. 2003)
- 2003: WDC-A, Boulder, USA (22 Mar. 2004)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive data for the INTERMAGNET CD-ROMs:
  2002 data: to INTERMAGNET Paris GIN (30 Jun. 2003)
  2003 data: to INTERMAGNET Paris GIN (22 Mar. 2004)
  (These data also sent to WDC-C1, Copenhagen, Denmark)

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 44-45.

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

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 is in *AGR 1994*.

The observatory was built on the north-eastern part of an approximately 260m x 140m (3.6 hectare) site. In 2003 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 pit, connected by 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 the principal observation pier (B) of the Gnangara observatory are:

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic‡ latitude: 31° 46' 48" S
- Geographic‡ longitude: 115° 56' 48" E
- Geomagnetic† : Lat. -41.75°; Long. 188.72°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of pier): 60 metres
- Lower limit for K index of 9: 450 nT.
- 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.

Variometers

Throughout 2003 magnetic field variations were monitored with a Danish Meteorological Institute suspended 3-component FGE model 89 version D (sensor no. S0160) fluxgate variometer, that was located in the Variometer Vault. FGE electronics module no. E0167 was used until 16 April 2003, when it was replaced with electronics no. E0199, that had an internal A to D converter. Two of the fluxgate variometer's sensors were 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 using a DT2085-5716A 16-bit PC ISA digitising board until the new electronics (no. E0199) was installed which employed an internal ADAM A to D converter.

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 sensor 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 change of < 0.1°C/day. The F variometer PPM sensor would have had temperature changes greater than this as the pit in which it was located was not as well insulated as the Variometer Vault.

Throughout 2003, 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

Declination and Inclination Magnetometer (DIM) Bartington Mag-010H/0725H with Zeiss020B/355937 was employed regularly throughout 2003. It was used on Pier B in the Absolute House. The Bartington Mag-01H was kept on the x 1 scale throughout all observations

PPM Geometrics 856/50631 with sensor 28079922 was employed throughout 2003 to perform absolute observations in total intensity, F. The PPM sensor was located on the auxiliary pier (a wall bracket - Pier C) in the same building as Pier B.

Both the DIM theodolite and the PPM sensor normally remained in place between weekly observations.

The absolute instruments were periodically compared with instruments from the Canberra magnetic observatory that served as the reference standard 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 absolute DIM used on Pier B at GNA during 2003. This was re-determined at GNA on 06 May 2003.

A composite correction has been applied to the absolute PPM used at GNA on the auxiliary pier during 2003. The components of the correction are:

- -1.4nT correction relative to the new Australian Total Field Standard (GEM Systems GSM90 No. 905926 with sensor no 81241) determined at GNA on 06 May 2003;
- -6.0nT auxiliary pier adjustment to Pier B to 06 May 2003 (determined at GNA on 06 May 2003) and -3.8nT thereafter.

These corrections, together with the zero corrections to the DIM, have been applied as a vector pier difference in (X,Y,Z) of (-2.9, +0.1, +6.8) nT up to 06 May 2003 and (-2.0, +0.1, +4.7) nT thereafter to Gnangara data in this report. This change in the auxiliary pier adjustment occurred during a routine visit for an unknown reason (see also *Significant Events*).

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 2003 data: any temperature effects being accounted for through the weekly 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 2003 and the derived values from the variometer data and model were:

−0.13 ± 1.84 nT in X

−0.04 ± 1.12 nT in Y

−0.02 ± 0.80 nT in Z

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM in 2003 varied from −2.0 nT to +1.5 nT, with a standard deviation of 1.0 nT.

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

Operations

The Gnangara magnetic observatory was operated by an out-posted GA staff member. Absolute observations were performed on a roster by the OIC and a contract observer, mostly by the latter.

1-second and 1-minute mean variation data in the magnetic NE, NW, vertical & total intensity magnetic components, with sensor and electronics temperatures, were acquired on a PC at

GNA – Operations (cont.)

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. 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 2003. The search for an alternative site also continued in 2003.

Significant Events 2003

25 Feb. One set of absolute observations discarded due to inconsistent results.

01 Apr. Computer rebooted after it stopped on 29 Mar during a severe electrical storm and failed to reboot due to a keyboard error. Some problems with G856 also detected. Data was lost.

Apr. 09 An electrical storm caused damage to the acquisition computer resulting in data loss. (The security company was called as a break-in was suspected!)

Apr. 16 A new PC104 industrial acquisition computer was installed and DMI electronics E0167 replaced with E0199 (with inbuilt ADAM A to D as a replacement to the DT2805 A to D).

Apr. 28 Routine service visit by GA staff during which instrument comparisons were performed. PC re-boot resulted in some data loss.

May 06 After the service visit, a step in the absolute PPM data was discovered. This was not measured, it occurred in association with moving the G856 PPM sensor from the main pier (B) to the absolute PPM pier (C). This was determined by a distinct change between the absolute PPM and variometer PPM of −2.245nT. A change to the instrument corrections to reduce the absolute pier to the variometer pier have been adopted.

Sep. 20 0014 to 22 / 0800: Noise with a period of about 22 sec and amplitude of about 2nT apparent on the Z-channel of the DMI fluxgate variometer.

Oct. 26 Lighting struck the observatory and the surrounding area causing damage to the telephone line, a main power transformer, the main power switch at the observatory and the alarm system. Data was lost after the UPS became exhausted.

Nov. 01 Repairs to the mains power and alarm system caused contamination to data.

Nov. 07 New alarm panel installed causing a baseline step. Data lost due to contamination.

Dec. 07 UPS replaced causing a baseline step.

GNA 2003 – Data loss

Mar. 29 1547 to April 01 / 0542 (2d 13h 56m) All channels: Acquisition computer failed during an electrical storm.

Apr. 01 0546−0547 (2 min); 0614 (1 min) F channel only: Computer reboots.

GNA 2003 – Data loss (cont.)

Apr. 09 0000 to 17 / 0159 (8d 02h 00m) All channels: Processing inhibited, during which period data acquisition did not take place in the intervals:

09 / 0000 to 16 / 0102 (7d 01h 03m) All channels: Acquisition computer destroyed during an electrical storm;

16 / 0103 (1 min); 16 / 0106 (1 min) F-channel only.

Apr. 28 0456−0457 (2 min) All channels: Computer rebooted.

Oct. 26 1955 to 31 / 0212 (4d 06h 18m) XYZ channels: Electrical storm destroyed main power, telephone lines and alarm system.

Oct. 26 1955 to Nov 05 / 0028 (9d 04h 34m) F channel: Electrical storm (see above) and PPM problems.

Oct. 31 0221 (1 min) XYZ channels: Computer rebooted.

Nov. 01 0304−0306 (3 min) All channels: Data processing inhibited due to data contamination while equipment was inspected.

Nov. 05 0037−0042 (6 min) F channel only: PPM restarted.

Nov. 07 0100−0439 (3h 40m) All channels: Data processing inhibited due to data contamination when the alarm panel was changed.

Dec. 07 0030−0229 (2h 00m) All channels: Data processing inhibited during which period (and beyond) data acquisition did not take place in the intervals:

07 / 0046−0200 (1h 15m) XYZ channels: the UPS was replaced;

07 / 0046 to 08 / 0711 (1d 06h 26m) F-channel: PPM failed to automatically re-start when the UPS was replaced

Dec. 08 0655−0724 (30 min) All channels: Data processing inhibited due to PPM being re-started.

Dec. 08 0701−0710 (10 min) All channels: UPS fixed.

Dec. 08 0713 (1 min) F channel: Computer rebooted.

Distribution of GNA data during 2003

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 & Hourly Mean Values

- 2002: WDC-A, Boulder, USA (16 Jul. 2003)
- 2003: WDC-A, Boulder, USA (8 Jun. 2004)
- 2003: WDC-C1, Copenhagen, Denmark (9 Jul. 2004)

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2003

1-minute values in Project INTERMAGNET format

- Preliminary data to the Edinburgh GIN daily by e-mail.
- Definitive data for the INTERMAGNET CD-ROM:
  2002 data: to Paris INTERMAGNET GIN (16 Jul 2003)
  2003 data: to Paris INTERMAGNET GIN (09 Jun 2004)

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 2003.

Throughout 2003 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* and *AGR2000* both show the same incorrect value in the table entitled Gnangara Annual Mean Values that appears on page 40 and page 42 in the respective volumes. The H component value given for the International Quiet Day mean for 1999.5 incorrectly shown as 23224 (in nT) should read **23234** (nT).

Gnangara, 2003 – Principal Magnetic Storms

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.	02	12 ··	···	··	··	··	03(6), 04(1)	5	16.8	115	119	04	21
Feb.	01	13 ··	···	··	··	··	02(6)	6	24	120	164	05	21
	26	06 ··	···	··	··	··	27(5)	6	27	84	133	28	01
Mar.	03	06 ··	···	··	··	··	03(6)	6	18	69	105	05	06
	20	04 44	ssc	1.0	15	7	20(4,5,6)	5	21	63	126	21	15
Apr.	03	12 ··	···	··	··	··	04(6), 05(6,7)	5	19	88	125	06	12
	29	14 ··	···	··	··	··	30(8)	6	27	112	132	**02**	21
May	05	12 ··	···	··	··	··	06(5,6,7), 07(3,4,5) 08(4,6,7), 09(5), 10(1,3), 11(4,5)	5	19	142	121	12	03
	27	10 ··	···	··	··	··	06(6,7,8)	6	39	186	215	31	09
Jun.	01	18 ··	···	··	··	··	02(4,5,6)	5	19	126	90	02	21
	13	15 ··	···	··	··	··	14(4,5)	5	14	100	117	15	09
	16	09 ··	···	··	··	··	18(4)	6	34	196	252	19	21
	23	15 ··	···	··	··	··	24(5)	6	20	113	130	26	18
	28	00 ··	···	··	··	··	28(4)	6	16	107	123	30	21
Jul.	11	03 ··	···	··	··	··	12(1)	6	26	185	125	12	15
	15	06 ··	···	··	··	··	16(4)	6	29	185	201	17	06
	29	03 ··	···	··	··	··	29(5,6,7,8), 30(4)	5	23	125	133	31	21
Aug.	01	00 ··	···	··	··	··	01(1,4,5)	5	18	108	93	03	00
	17	14 22	ssc*	2.7	28 *	-16	18(4)	7	42	217	268	19	18
	20	15 ··	···	··	··	··	21(7)	6	24	114	160	23	21
Sep.	15	23 ··	···	··	··	··	17(5)	8	45	175	241	20	21
	24	03 ··	···	··	··	··	25(4,5)	5	18	88	100	26	02
Oct.	14	06 ··	···	··	··	··	14(7), 15(4)	6	24	114	165	18	01
	19	06 ··	···	··	··	··	21(5,6), 22(6)	6	21	98	129	22	21
	24	12 ··	···	··	··	··	24(6)	6	22	116	137	26	01
Nov.	09	09 ··	···	··	··	··	11(6), 13(5), 16(6)	6	32	132	168	17	21
	20	08 02	ssc	12.3	100	65	20(6,7)	8	69	598	381	23	09
Dec.	05	02 ··	···	··	··	··	05(4,5)	5	17	84	125	06	03
	07	12 ··	···	··	··	··	08(5), 10(6)	6	56	210	168	15	03
	20	09 ··	···	··	··	··	20(8), 21(1), 22(6)	5	15	80	85	22	21

See page 51 for GNA 2003 Storms & Rapid Variations

K indices & Daily K sums at Gnangara (K=9 limit: 450 nT) for 2003

Date	January	February	March	April	May	June	Date
01	1221 2122 13	1111 3343 17	3222 4343 23	--22 2332 --	D 4445 5432 31	2332 4234 23	01
02	2112 2222 14	D 5554 5664 40	2212 3353 21	2334 3334 25	3424 3322 23	D 3445 5523 31	02
03	3223 3544 26	D 3223 5343 25	3122 3654 26	3112 3344 21	Q 2323 3222 19	4324 4334 27	03
04	5422 3221 21	D 3443 3242 25	D 5334 4443 30	D 3224 4544 28	Q 2112 2112 12	3334 3432 25	04
05	1111 3432 16	2214 4423 22	3223 4444 26	D 3322 4552 26	1232 3343 21	Q 2233 3432 22	05
06	Q 1210 0112 08	2233 3343 23	3223 4434 25	Q 2111 0421 12	4223 5554 30	1223 2333 19	06
07	Q 1111 1232 12	3222 3242 20	3222 3133 19	Q 1001 3311 10	D 3355 5443 32	3334 3334 26	07
08	Q 2111 0111 08	3232 4333 23	Q 2112 3442 19	4234 4323 25	D 4335 4553 32	3343 4544 30	08
09	Q 1111 1122 10	4232 3434 25	2221 2224 17	---- ---- --	3444 5323 28	3333 4335 27	09
10	3222 3334 22	3333 2244 24	2222 4443 23	---- ---- --	5453 2342 28	4333 3332 24	10
11	4211 2222 16	Q 3222 3312 18	3232 3322 20	---- ---- --	4245 5333 29	2232 2232 18	11
12	2242 1222 17	2213 2433 20	Q 3221 1123 15	Q ---- ---- --	3343 4344 28	Q 2111 2211 11	12
13	2112 1223 14	Q 2112 2002 10	4332 3112 19	Q ---- ---- --	2335 4344 28	Q 1111 1223 12	13
14	3332 2212 18	4223 4434 26	3233 5344 27	---- ---- --	3343 4543 29	2235 5443 28	14
15	2112 2212 13	D 3324 4422 24	4334 4444 30	---- ---- --	2323 5333 24	3432 3443 26	15
16	Q 1112 3112 12	3223 3344 24	2224 4544 27	D -335 4455 --	Q 3221 2133 17	D 3424 3455 30	16
17	3113 3212 16	3223 3323 21	D 3343 5445 31	2334 4432 25	Q 2231 2110 12	D 4435 4423 29	17
18	3223 4333 23	2543 4322 25	4334 5333 28	2223 4433 23	Q 1111 1243 14	D 4446 4454 35	18
19	3233 4433 25	3212 3423 20	3231 2222 17	Q 2221 2132 15	2222 3234 20	3223 2241 19	19
20	3322 3334 23	2233 3342 22	2335 5544 31	2221 2232 16	2222 3232 18	Q 2232 3422 20	20
21	4324 3333 25	2232 1432 19	4335 4233 27	3344 3453 29	2211 3544 22	3343 1445 27	21
22	D 3222 3325 22	2112 4423 19	3323 3123 20	3234 4344 27	5332 4342 26	Q 2223 1342 19	22
23	D 4322 3324 23	Q 3211 3322 17	3235 3342 25	2233 3342 22	2234 3522 23	4434 2333 26	23
24	4233 3444 27	Q 1002 3211 10	Q 3123 1221 15	3233 4543 27	3333 4453 28	3344 6323 28	24
25	D 4344 4323 27	Q 2111 1212 11	Q 1010 0221 07	D 3234 3435 27	3323 1333 21	2333 3442 24	25
26	D 4224 3223 22	1134 3224 20	Q 1222 2232 16	2233 3443 24	4232 2033 19	2234 4312 21	26
27	4211 1324 18	D 5334 6454 34	4233 4532 26	3232 3433 23	3223 3354 25	3343 4332 25	27
28	4222 2222 18	3123 3534 24	3332 2444 25	3334 3112 20	5335 4543 32	D 3436 4433 30	28
29	2112 4434 21		D 3322 4--- --	2221 4444 23	D 3334 5666 36	4344 3433 28	29
30	D 4324 4532 27		D ---- ---- --	D 3434 3446 31	D 5433 3444 30	3353 3332 25	30
31	3224 4332 23		D ---- ---- --		5531 2221 21		31
Mean K-sum	18.7	21.7	22.7	22.8	24.5	24.5	

Date	July	August	September	October	November	December	Date
01	2221 2222 15	D 5435 5333 31	1332 2242 19	2112 1134 15	4334 4343 28	2221 1213 14	01
02	2212 2232 16	3333 3443 26	3211 4223 18	2120 1244 16	3433 3453 28	2222 2002 12	02
03	2222 3434 22	2332 3232 20	3224 3353 25	3312 2332 19	3322 2332 20	Q 1111 1311 10	03
04	4334 3422 25	Q 2233 0232 17	3334 4344 28	Q 2121 3001 10	3256 2232 25	1001 1123 09	04
05	3333 3333 24	Q 2110 0012 07	3233 3312 20	1100 0223 09	Q 2010 0232 10	D 3445 5443 32	05
06	2122 3322 17	4443 3112 22	2123 2332 18	2111 2234 16	3111 3243 18	3234 3333 24	06
07	2233 3231 19	2122 4454 24	Q 2100 0220 07	4124 3432 23	3-11 2222 --	2222 4443 23	07
08	Q 0001 1100 03	3533 3443 28	0001 1123 08	2112 1023 12	Q 1113 4433 20	D 3335 6543 32	08
09	Q 0111 1121 08	2243 3234 23	2233 4454 27	3111 1111 10	3123 5453 26	D 3344 4434 29	09
10	Q 1112 3122 13	3122 3221 16	4234 4333 26	Q 1000 0012 04	4334 4545 32	D 4334 4645 33	10
11	D 3345 4445 32	1221 2323 16	4312 2332 20	Q 1000 0001 02	D 4445 5654 37	D 3344 4433 28	11
12	D 6553 3243 31	3334 4432 26	3222 2122 16	Q 1001 1112 07	3334 4453 29	3333 4334 26	12
13	3332 2322 20	2221 3233 18	3232 0023 15	2122 3444 22	D 3235 6554 33	3234 4333 25	13
14	1122 2332 16	2232 1242 18	Q 1120 2221 11	D 3244 4565 33	3335 5343 29	3233 4544 28	14
15	4325 3145 27	1121 1333 15	1000 0122 06	3346 5543 33	D 3455 5534 34	4334 4433 28	15
16	D 3346 5434 32	Q 3113 3321 17	D 4234 5442 28	3224 4433 25	D 3333 5654 32	3123 1322 17	16
17	3324 3343 25	0010 3445 17	D 3355 8554 38	2345 4333 27	3335 5534 31	2101 2321 12	17
18	2211 1233 15	D 4357 5665 41	D 3436 5554 35	2233 4333 23	4334 5442 29	Q 1101 1100 05	18
19	3223 4335 25	3232 2212 17	D 4345 4453 32	2234 5453 28	3223 3332 21	Q 0010 1100 03	19
20	4333 3223 23	0222 2333 17	3435 5532 30	3234 3544 28	D 2256 6887 44	2224 3435 25	20
21	Q 3210 1021 10	D 4353 4464 33	3233 4432 24	D 4233 6655 34	5454 2433 30	5433 3443 29	21
22	Q 2111 1230 11	D 4345 5454 34	2223 3342 21	3244 4632 28	4322 3564 29	3334 3533 27	22
23	2122 1332 16	D 3354 5432 29	2223 3433 22	Q 3132 1101 12	3332 4243 24	2222 2332 18	23
24	2100 1123 10	2234 3342 23	D 3343 4443 28	1112 5645 25	2222 4433 22	1221 2322 15	24
25	1132 1001 09	3332 2422 21	3235 5433 28	4332 5433 27	3332 3422 22	Q 3112 3211 14	25
26	2333 3454 27	4113 3433 22	2232 3332 20	2233 223- --	2222 3223 18	3222 2223 18	26
27	4434 4322 26	Q 2123 2233 18	3100 0111 07	---- ---- --	Q 2211 1122 12	2213 2333 19	27
28	2223 4433 23	3233 2323 21	Q 1001 2220 08	---- ---- --	Q 2212 4212 16	3322 2343 22	28
29	D 2334 5555 32	1123 4352 21	Q 1001 1111 06	D ---- ---- --	Q 2221 1112 12	Q 2222 1411 15	29
30	3335 4343 28	3222 2321 17	Q 1121 3312 14	D ---- ---- --	3322 3333 22	1111 1233 13	30
31	D 3335 4443 29	Q 2111 3121 12		D -766 6544 --		2224 3443 24	31
Mean K-sum	20.3	21.5	20.2	19.5	25.3	20.3	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	3	54	91	60	36	4	0	0	0	0	0
February	4	26	68	73	41	9	3	0	0	0	0
March	3	20	69	73	49	14	1	0	0	0	19
April	3	16	45	63	44	9	1	0	0	0	59
May	2	20	59	85	48	31	3	0	0	0	0
June	0	15	51	97	61	13	3	0	0	0	0
July	13	39	67	79	33	15	2	0	0	0	0
August	8	32	70	82	36	16	3	1	0	0	0
September	22	32	62	70	35	17	1	0	1	0	0
October	21	43	44	47	35	14	9	1	0	0	34
November	3	20	57	78	42	29	7	1	2	0	1
December	13	42	60	78	44	9	2	0	0	0	0
ANNUAL TOTAL	**95**	**359**	**743**	**885**	**504**	**180**	**35**	**3**	**3**	**0**	**113**

GNA 2003 – Rapid Variation Phenomena

Sudden Storm Commencements (ssc) - GNA 2003

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Mar. 20	0444	ssc	C	+15	+7	+7
Apr. 08	0110	ssc	B	+20	+44	+19
Aug. 17	1422	ssc*	B	+28 *	+18	-16
Nov. 04	0625	ssc	A	+69	+42	+44
20	0802	ssc	A	+100	+83	+65

No ***ssc*** reported: Jan, Feb, May - Jul, Sep, Oct, Dec., 2003

Solar Flare Effects (sfe) - GNA 2003

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Jan. 07	2329	2334	2359	+8	+15	+11	solar

No ***sfe*** reported: Feb. – Dec., 2003

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 57-58. See also *Notes & 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
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

continued on page 59 …

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23242.5	-830.1	-53608.1	58435.7	23257.3	-2° 02.7'	-66° 32.8'
	5xQ days	23251.4	-829.4	-53607.4	58438.6	23266.2	-2° 02.6'	-66° 32.3'
	5xD days	23229.8	-831.3	-53608.4	58430.9	23244.7	-2° 03.0'	-66° 33.5'
February	All days	23235.4	-828.4	-53607.3	58432.2	23250.2	-2° 02.5'	-66° 33.2'
	5xQ days	23244.9	-826.7	-53604.8	58433.5	23259.6	-2° 02.2'	-66° 32.6'
	5xD days	23221.0	-831.7	-53612.1	58430.8	23235.9	-2° 03.1'	-66° 34.1'
March	All days	23226.8	-825.2	-53603.5	58425.2	23241.4	-2° 02.1'	-66° 33.6'
	5xQ days	23239.1	-825.0	-53600.8	58427.6	23253.7	-2° 02.0'	-66° 32.8'
	5xD days	23207.9	-822.8	-53607.5	58421.3	23222.5	-2° 01.8'	-66° 34.7'
April	All days	23219.1	-821.0	-53605.8	58424.2	23233.6	-2° 01.5'	-66° 34.0'
	5xQ days	23229.9	-822.1	-53604.2	58427.0	23244.4	-2° 01.6'	-66° 33.4'
	5xD days	23209.0	-821.2	-53606.0	58420.4	23223.6	-2° 01.6'	-66° 34.6'
May	All days	23217.0	-819.1	-53607.0	58424.4	23231.5	-2° 01.2'	-66° 34.2'
	5xQ days	23231.2	-821.1	-53604.8	58428.0	23245.7	-2° 01.5'	-66° 33.4'
	5xD days	23201.1	-820.9	-53607.1	58418.2	23215.6	-2° 01.6'	-66° 35.0'
June	All days	23218.7	-817.0	-53606.7	58424.8	23233.0	-2° 00.9'	-66° 34.1'
	5xQ days	23229.9	-818.3	-53603.6	58426.4	23244.3	-2° 01.1'	-66° 33.4'
	5xD days	23196.6	-814.5	-53612.9	58421.7	23210.9	-2° 00.7'	-66° 35.4'
July	All days	23223.7	-816.1	-53602.8	58423.1	23238.0	-2° 00.7'	-66° 33.7'
	5xQ days	23235.4	-816.8	-53599.3	58424.6	23249.7	-2° 00.8'	-66° 33.0'
	5xD days	23199.5	-812.9	-53608.2	58418.5	23213.7	-2° 00.4'	-66° 35.2'
August	All days	23223.7	-815.3	-53600.6	58421.2	23238.0	-2° 00.6'	-66° 33.7'
	5xQ days	23238.1	-815.7	-53597.3	58423.9	23252.4	-2° 00.6'	-66° 32.8'
	5xD days	23196.9	-817.1	-53606.2	58415.7	23211.4	-2° 01.0'	-66° 35.3'
September	All days	23231.5	-815.6	-53595.3	58419.4	23245.8	-2° 00.6'	-66° 33.1'
	5xQ days	23241.8	-815.2	-53591.8	58420.3	23256.1	-2° 00.5'	-66° 32.5'
	5xD days	23210.7	-817.2	-53599.1	58414.6	23225.1	-2° 01.0'	-66° 34.3'
October	All days	23232.1	-812.8	-53592.6	58417.1	23246.3	-2° 00.2'	-66° 33.0'
	5xQ days	23244.4	-813.5	-53587.7	58417.5	23258.7	-2° 00.3'	-66° 32.3'
	5xD days	23205.6	-813.2	-53596.6	58410.2	23219.8	-2° 00.4'	-66° 34.6'
November	All days	23230.6	-814.1	-53595.0	58418.7	23244.9	-2° 00.4'	-66° 33.2'
	5xQ days	23249.1	-812.7	-53593.4	58424.6	23263.3	-2° 00.1'	-66° 32.1'
	5xD days	23209.6	-818.6	-53596.4	58411.8	23224.1	-2° 01.2'	-66° 34.3'
December	All days	23245.4	-809.8	-53591.1	58420.9	23259.5	-1° 59.7'	-66° 32.3'
	5xQ days	23253.9	-808.3	-53587.8	58421.3	23267.9	-1° 59.5'	-66° 31.8'
	5xD days	23232.2	-810.6	-53595.8	58420.0	23246.4	-1° 59.9'	-66° 33.1'
Annual	All days	23228.9	-818.7	-53601.3	58423.9	23243.3	-2° 01.1'	-66° 33.4'
Mean	5xQ days	23240.7	-818.7	-53598.6	58426.1	23255.2	-2° 01.1'	-66° 32.7'
Values	5xD days	23210.0	-819.3	-53604.7	58419.5	23224.5	-2° 01.3'	-66° 34.5'

(Calculated: 15:01 hrs., Mon. 08 Nov. 2004)

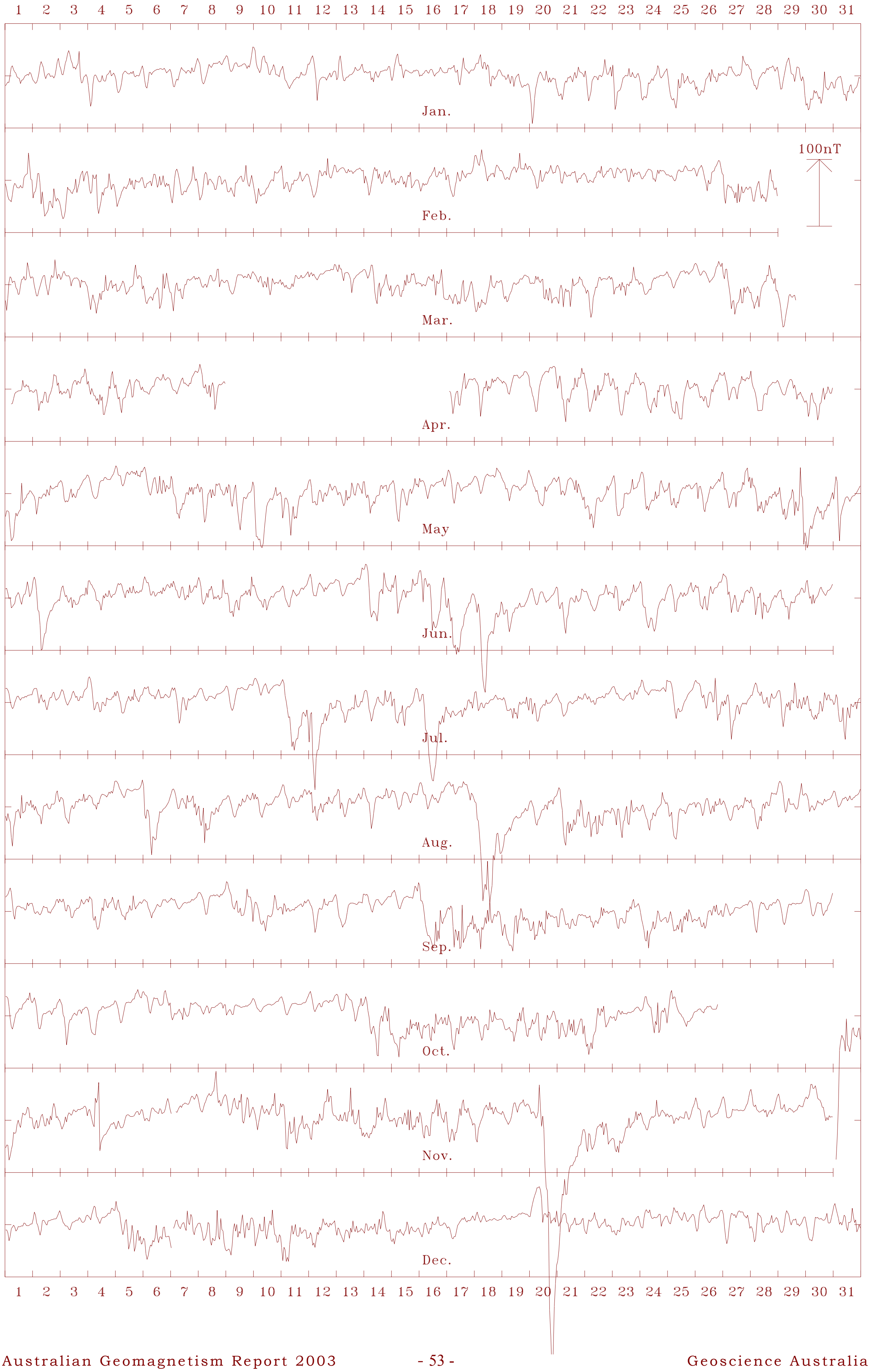
Hourly Mean Values

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

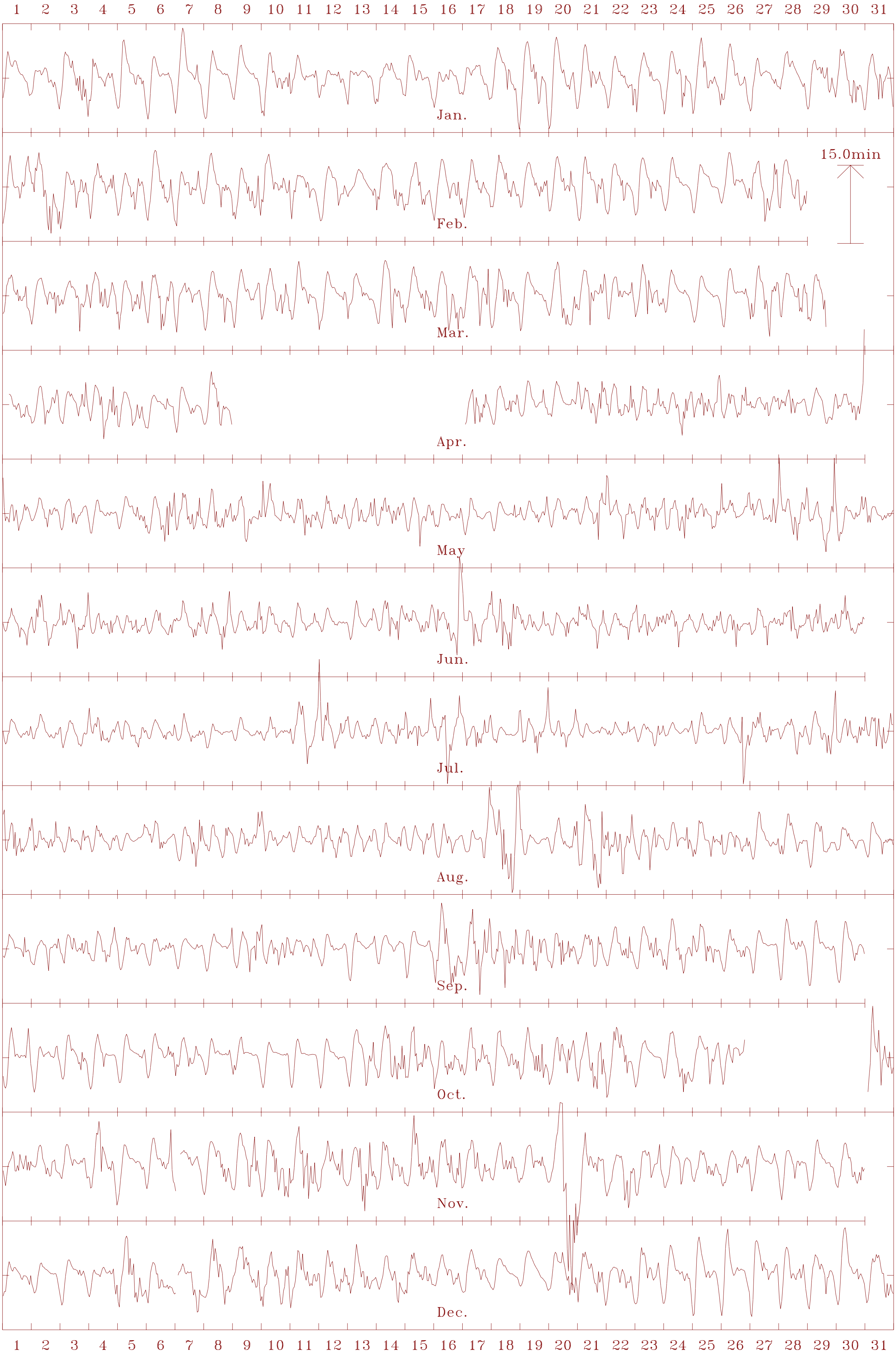
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

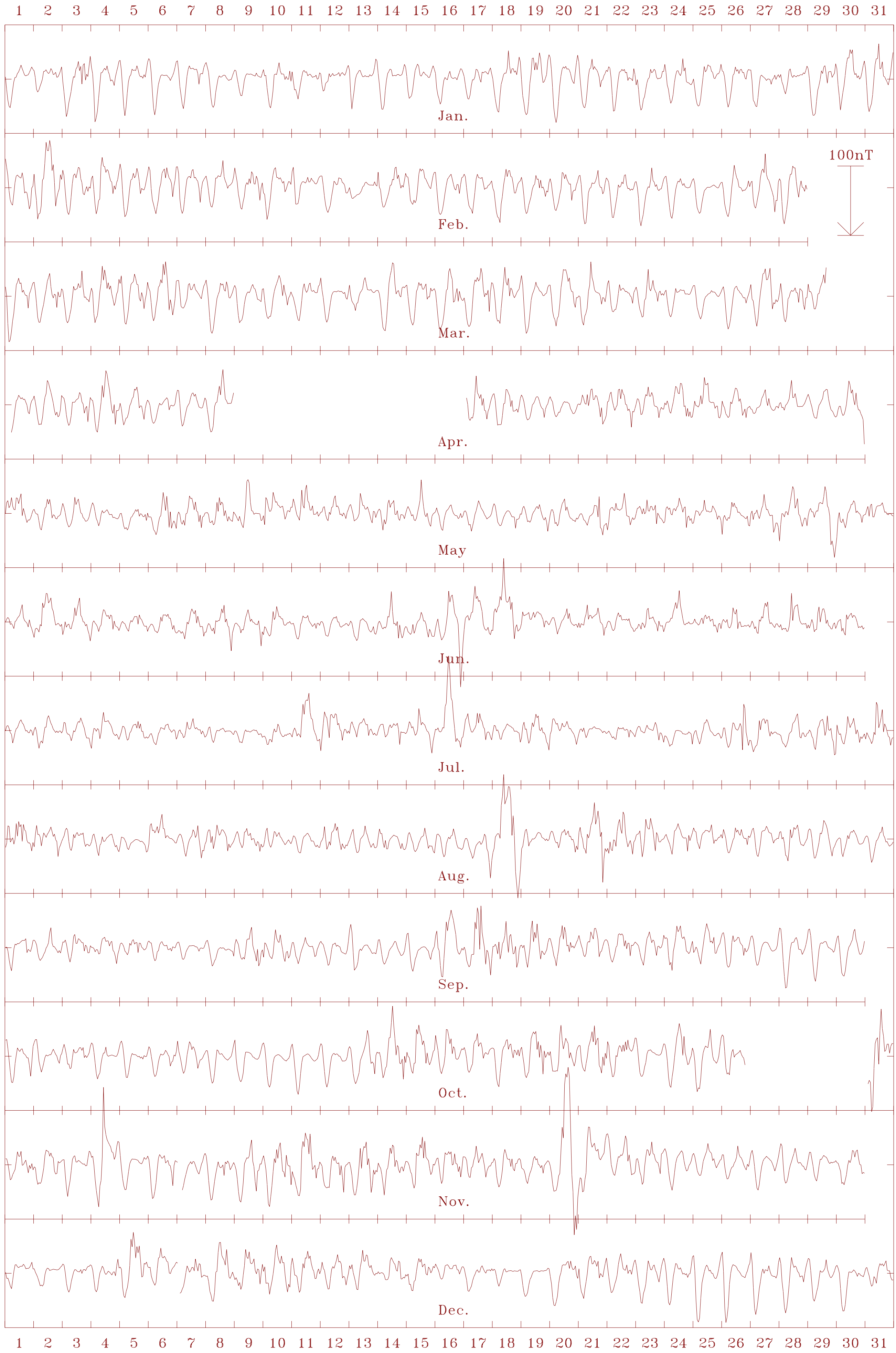
Gnangara 2003 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23243 nT



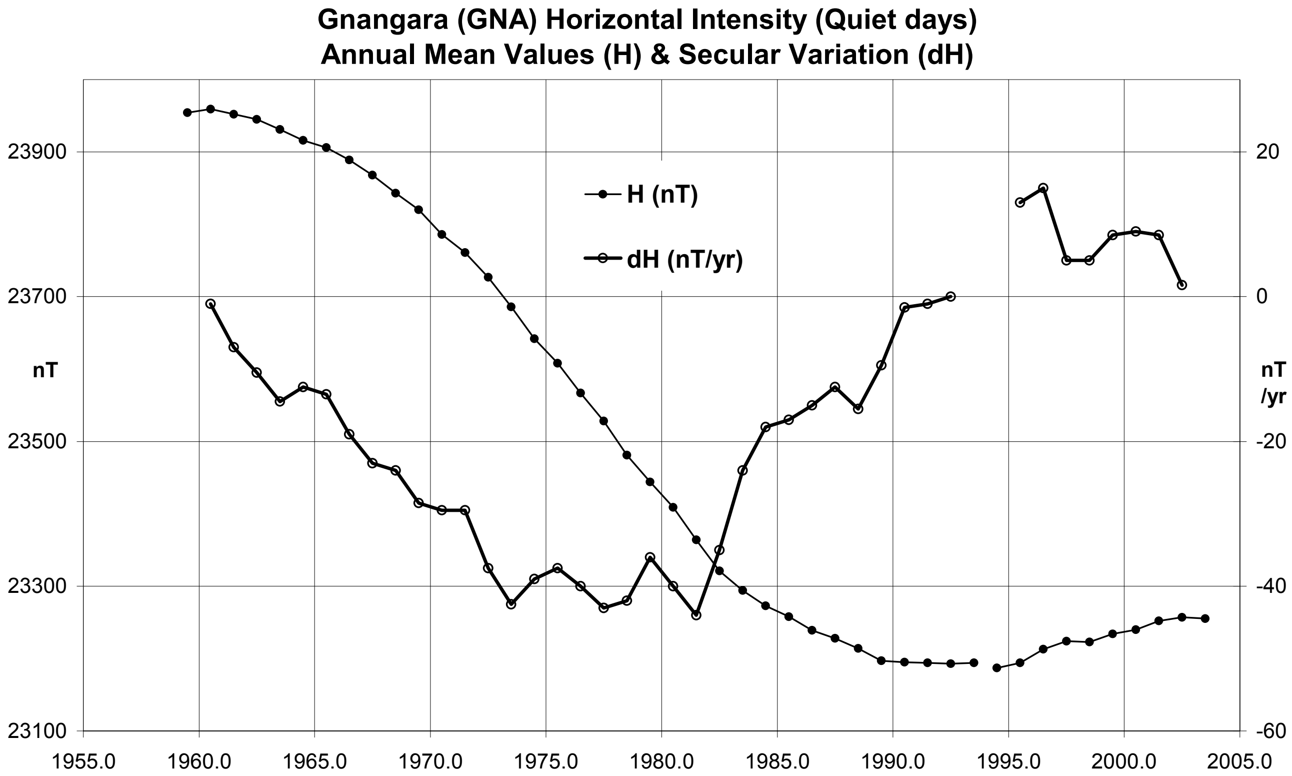
Gnangara 2003 Declination (east) (D). Scale: 1.00 min/mm. Mean: −2.02 deg.



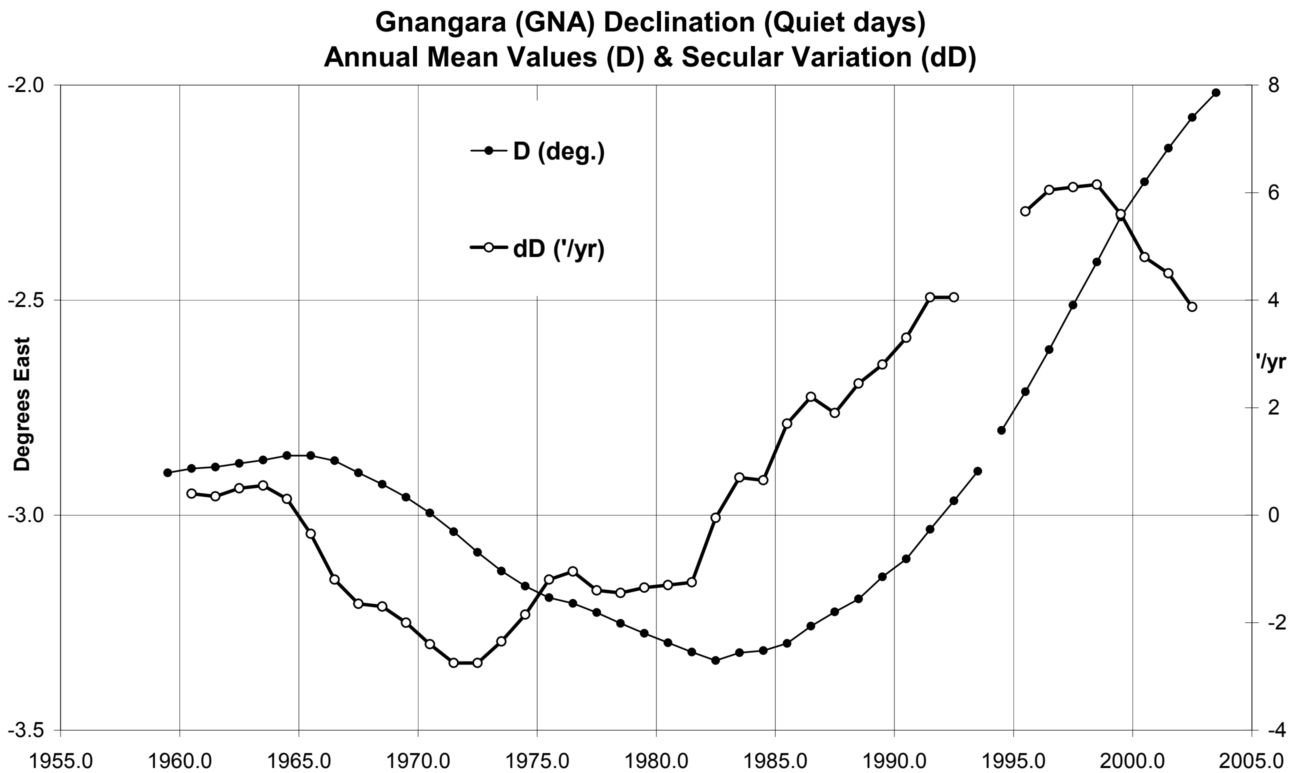
Gnangara 2003 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53601 nT



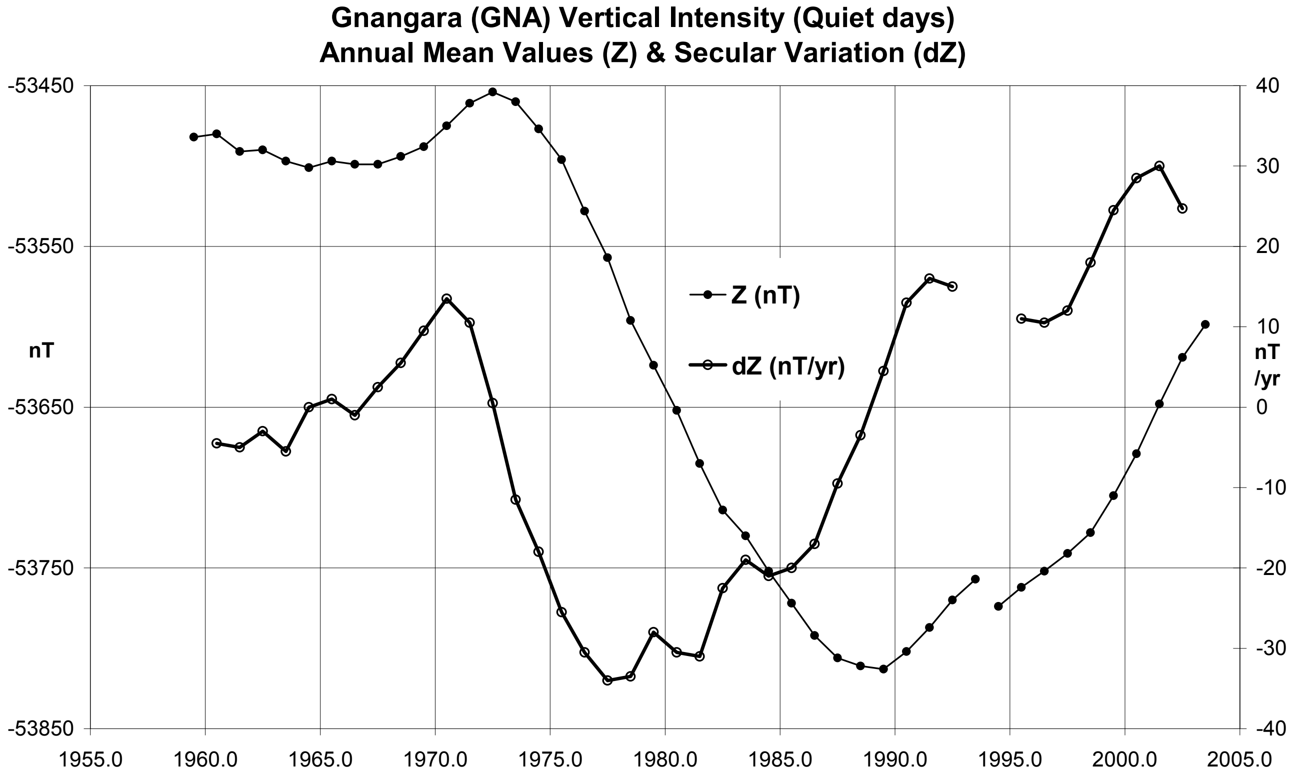
Gnangara 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58424 nT



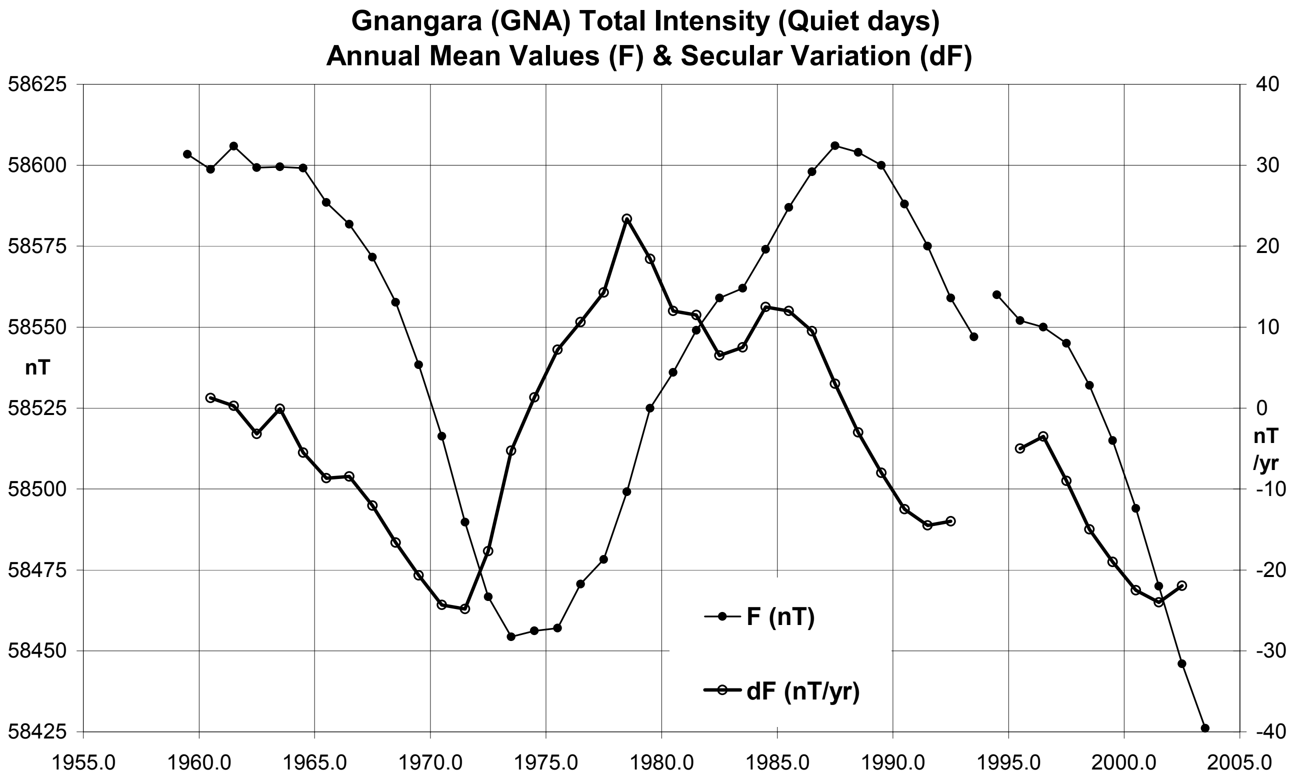
Gnangara (GNA) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT /yr
23900
23700
23500
23300
23100
20
0
-20
-40
-60
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0



Gnangara (GNA) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
D (deg.)
dD ('/yr)
Degrees East
'/yr
-2.0
-2.5
-3.0
-3.5
8
6
4
2
0
-2
-4
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0



Gnangara (GNA) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-53450
-53550
-53650
-53750
-53850
nT
40
30
20
10
0
-10
-20
-30
-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
58600
58575
58550
58525
58500
58475
58450
58425
nT
40
30
20
10
0
-10
-20
-30
-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
F (nT)
dF (nT/yr)

GNA – Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
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	8.8	-66	34.1	23252	23235	-871	-53648	58470	ABC
2002.5	Q	-2	4.5	-66	33.1	23257	23242	-842	-53619	58446	ABC
2003.5	Q	-2	1.1	-66	32.7	23255	23241	-819	-53599	58426	ABC
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	9.6	-66	36	23219	23203	-875	-53656	58465	ABC
2002.5	D	-2	4.9	-66	34.9	23227	23211	-844	-53627	58441	ABC
2003.5	D	-2	1.3	-66	34.5	23225	23210	-819	-53605	58420	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 2003

MAGNETIC OBSERVATORIES

VOLUME 51

Department of Industry, Tourism and Resources

Minister for Industry, Tourism & Resources: The Hon. Ian Macfarlane
Parliamentary Secretary: The Hon. Warren Entsch
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AUSTRALIA

Australian Government

Geoscience Australia

Magnetic results for 2003

Kakadu

Charters Towers

Learmonth

Alice Springs

Gnangara

Canberra

Macquarie Island

Casey

Mawson

– & –

Australian Repeat Station Network

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SUMMARY

During 2003 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 standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised 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 and principal magnetic storms were scaled with computer assistance, and rapid variations were hand-scaled, 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.

Three repeat stations were re-occupied during a field survey in Papua New Guinea and the south-western Pacific in October 2003.

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 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 2003.

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
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

End of Part 1

Contents continued …

Part 2

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 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 (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 *AUSTRALIAN MAGNETIC 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 earthquake seismology and nuclear monitoring group.

Key data for the principal observation pier (Absolute-House: AW) at the observatory are:

- 3-character IAGA code: CNB
- Commenced operation 1978
- Geographic latitude: 35° 18' 52.6" S
- Geographic longitude: 149° 21' 45.4" E
- Geomagnetic† : Lat. -42.53°; Long. 226.79°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of pier): 859 metres
- Lower limit for K index of 9: 450 nT.
- Azimuth of principal reference pillar (NW) from pier AW: 328° 37' 03"
- Distance to NW Pillar: 137.3 metres
- Observer in Charge: Liejun Wang (GA)

Variometers

During 2003 (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 measured 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) measured variations in Total Intensity. Until 16 November 2003 it was located in the SECONDARY VARIOMETER HOUSE with its sensor within a Helmholtz coil system (of the Littlemore AMO, decommissioned in 1995). It was moved to the western room of the VARIOMETER HOUSE on 17 Nov 2003 with its sensor mounted on a standard PPM tripod.

Late in November 2001 a LEMI 3-component fluxgate variometer was installed on a pier in the western room of the VARIOMETER HOUSE to serve as a reserve instrument should the principal variometer become unserviceable. It continued to operate there until 21 August 2003, then from 17 November to the end of 2003. Between 22 August and 16 November 2003 it operated in the MAGNETIC CALIBRATION FACILITY.

During the interval 5 − 8 Nov when building maintenance work was carried out in VARIOMETER HOUSE where the (principal) Narod fluxgate variometer was housed, data from the LEMI variometer, running in MAGNETIC CALIBRATION FACILITY, replaced the Narod variometer data.

The LEMI variometer stopped at 23:15:29 and re-started at 23:16:39 on 5 Nov 2003, resulting 1 minute data loss at 23:16. The lost data were recovered using the Narod variometer.

During the 4 minute period 00:39:00 − 00:42:00 on 18 November, and the 4 minute period 01:16:00 − 01:19 01 December 2003, the Narod data were contaminated by nearby activities. The data were recovered using the LEMI variometer data.

Absolute Instruments and Corrections

Throughout 2003 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 2003 was GSM90 Overhauser magnetometer with electronics no. 905926 and sensor no. 21867. (This sensor replaced no. 81241 in September 2002.) During 2003 this GSM90 magnetometer was used during regular absolute observations on pier AW in the ABSOLUTE HOUSE.

Observations with the GSM90 standard are used without correction.

The principal absolute magnetometers at the Canberra Magnetic Observatory also serve as the reference standards for the Australian observatory network. Their standardizations are traceable to classical instruments that were regularly calibrated by comparison the international standard. (See the *Magnetic Standards* section near the beginning of this report.)

Baselines

The variometers remained reasonably stable throughout 2003. Over the year baselines drifted by approximately:

7.4nT in X; 6.4nT in Y; and 3.5nT in Z.

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

−0.08 ± 0.67 in X; −0.01 +/-0.67 in Y; −0.03 +/-0.38 in Z.

CNB – Baselines (cont.)

There was less than 1.5 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.

There was a change of adopted baseline values on 05 and 08 Nov 2003 as the two variometers had different variometer models.

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 ensuring the transmission of 1-minute data from CNB (and other observatories) to INTERMAGNET.

The Narod RCF variometer was situated on pier (VE) in the VARIOMETER HOUSE that was maintained at a temperature of 26.5 ± 0.5°C throughout 2003 for baseline stability. The temperature variation of the principal variometer sensors was 25 ± 0.5°C. Data from the RCF were transmitted via optical fibre to the RECORDER HOUSE where they were recorded on an acquisition PC.

At the beginning of 2003 the GSM90 Total Intensity variometer, serving as an F-check on the vector variometer model, was located in the SECONDARY VARIOMETER HOUSE with its sensor positioned in the old AMO coil assembly. It was controlled from the RECORDER HOUSE, to where the data were transmitted via optical fibre and recorded on the acquisition computer. On 17 Nov 2003 it was relocated to VARIOMETER HOUSE.

See the CNB *Variometers* section of this report for a description of the relocation of the GSM90 to the VARIOMETER HOUSE and the deployment of a LEMI fluxgate variometer to serve as secondary vector instrument.

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.

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, CNB 2003

09 Jan	0010: Sudden change in F-check and F, probably caused by an internal door of Secondary Variometer House being left open.
13 Jan	~0130: The door of Secondary Variometer House closed, resulting in a change in F-check.
10 Feb	(late UT) to 11th: Tilers working on roof of Comparison and Absolute houses.
14 Apr	07:30−11:30 LT: Roof tilers working on Variometer House.
05 Jul	0215: Heater removed from Secondary Variometer House. This had no effect on the PPM data.
22 Jul	0230: The heater removed from the Seconday Variometer House was returned. Three ceiling light bulbs were replaced in Variometer House, causing two spikes in variometer data.
22 Aug	0020: LEMI vector variometer was installed in the *Magnetic Calibration Facility* and calibrated.

CNB – Significant Events (cont.)

05 Nov	to 08th: Tradesmen working near Variometer House caused contamination of Narod variometer data. During this period LEMI variometer data was used.
17 Nov	PPM was relocated to the room next to the Narod variometer in Variometer House. LEMI variometer was relocated to Secondary Variometer House from the Magnetic Calibration Facility. All work completed by 0300.
18 Nov	0039−0042: Contamination of Narod variometer data due to persons cleaning the room. LEMI variometer data was used.
01 Dec	0116−0119: Narod variometer data comtaminated by person(s) walking near the Variometer House. LEMI variometer data was used.

CNB Data losses in 2003

There were no 3-axis fluxgate variometer data lost in 2003 at the Canberra observatory as any data lost to the primary instrument were recovered from the secondary instrument.

The following total intensity variometer data were lost in 2003:

28 Mar	0508−0558 (51m)
24 Aug	0515−0733 (2h 19m)
	0735−1007 (2h 33m)
19 Sep	0626−0949 (3h 24m)
25 Oct	0216 to 27th / 2333 (2d 21h 18m)
27 Oct	2338−2341 (4m), 2343−2344 (2m), 2346 (1m),
	2348−2349 (2m)
16 Nov	2333 to 17th / 0024 (52m)
17 Nov	0026 (1m), 0029−0030 (2m)

Distribution of CNB data during 2003

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

K indices - semi-monthly by e-mail

- Adolph-Schmidt-Observatory Niemegk, Germany

K indices with Principal Magnetic Storms & 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 2003

1-minute & Hourly Mean Values

- 2002: WDC-A, Boulder, USA (19 March 2003)
- 2003: WDC-A, Boulder, USA (19 January 2004)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive data for CD-ROM sent to the INTERMAGNET GIN, Paris.
- 2002 data sent to Paris GIN: 19 March 2003
- 2003 data sent to Paris GIN: 19 March 2004

Canberra 2003 – Principal Magnetic Storms:

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.**
Feb. 01	13 ··	···	··	··	··	02(3)	6	21	135	64	05	18
18	02 ··	···	··	··	··	18(2)	6	16	112	21	18	18
Mar. 06	03 ··	···	··	··	··	06(5,6)	5	15	120	40	07	06
31	00 ··	···	··	··	··	31(5,6)	5	18	120	48	**01**	03
Apr. 29	12 ··	···	··	··	··	**01**(1,4,5)	5	17	164	51	**01**	21
May 06	06 ··	···	··	··	··	06(5,6), 07(3,4), 08(4), 09(3,4)	5	20	132	46	09	18
10	15 ··	···	··	··	··	10(3), 11(3,4,5)	5	14	88	38	11	21
27	15 ··	···	··	··	··	29(7,8)	7	40	321	89	31	18
Jun. 01	22 ··	···	··	··	··	02(3,4)	5	15	145	73	02	21
14	06 ··	···	··	··	··	14(4,5)	5	21	109	45	14	21
16	00 ··	···	··	··	··	18(4)	7	40	226	105	19	00
24	00 ··	···	··	··	··	24(4,5)	5	11	86	31	24	18
28	03 ··	···	··	··	··	28(4)	6	24	124	55	30	21
Jul. 11	03 ··	···	··	··	··	11(3,4), 12(1,2,3)	5	18	174	73	12	21
15	18 ··	···	··	··	··	16(4)	6	32	168	65	17	06
28	09 ··	···	··	··	··	30(5), 31(4), **01**(4,5)	5	20	121	53	**02**	03
Aug. 07	12 ··	···	··	··	··	07(7,8), 08(2)	5	16	134	45	08	21
17	14 22	ssc*	0.8*	36	-4	18(4)	6	36	245	111	19	03
21	00 ··	···	··	··	··	21(3,6,7,8), 22(4,5), 23(3,5)	5	24	127	71	23	21
Sep. 15	19 ··	···	··	··	··	16(5)	6	24.5	137	69	20	18
Oct. 14	06 ··	···	··	··	··	14(5,7,8), 15(3,4), 16(4), 17(4)	5	21	127	53	17	18
24	00 ··	···	··	··	··	24(6,8)	6	23	120	63	25	18
28	21 ··	···	··	··	··	29(3)	9	51	947	294	31	21
Nov. 09	06 ··	···	··	··	··	13(5)	6	23.9	203	70	17	03
20	08 02	ssc	11	106	34	20(6)	8	61.3	627	269	23	09
Dec. 05	02 ··	···	··	··	··	05(2,3,4,5,6)	5	21.6	147	55	06	21
08	06 ··	···	··	··	··	08(4,5), 09(3)	5	14.9	111	39	09	18

No Principal Magnetic Storms reported for Canberra in: Jan. 2003

CNB 2003 – Rapid Variation Phenomena

Sudden Storm Commencements (ssc) - CNB 2003

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Mar 20	0444	ssc	B	+24	+8	+1
Apr 08	0110	ssc	B	+32	+13	+12
Aug 17	1422	ssc*	A	+36	+6 *	-4
Oct 26	1908	ssc*	B	+10	+14 *	+1
29	0610	ssc*	A	+158 *	+48 *	+30 *

continued …

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Nov 04	0625	ssc	A	+133	+20	+18
15	0550	ssc	C	+49	+11	+4
20	0802	ssc	A	+106	+76	+34

No *ssc* reported: Jan., Feb., May, Jun., Jul., Sep., Dec.2003

CNB 2003 – Rapid Variation Phenomena (cont.)

Solar Flare Effects (sfe) - CNB 2003

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Jan 07	2329	2334	2359	+2	+8	+2	solar

No *sfe* reported: Feb., Mar., Apr., May., Jun., Jul., Aug., Sep., Oct., Nov., Dec. in 2003.

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 2003.

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 70-71.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1979.5	A	12	5.6	-66	5.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	8.6	-66	6.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	9.1	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	9.2	23665	23098	5148	-53540	58537	DFI
1996.5	A	12	34.2	-66	7.4	23684	23108	5154	-53507	58514	ABC
1997.5	A	12	34.2	-66	6.1	23695	23127	5157	-53476	58491	ABC
1998.5	A	12	34.2	-66	5.2	23698	23130	5157	-53444	58463	ABC
1999.5	A	12	34.1	-66	3.7	23709	23140	5159	-53403	58429	ABC
2000.5	A	12	34.2	-66	2.9	23706	23139	5160	-53367	58396	ABC
2001.5	A	12	34.7	-66	1.5	23716	23146	5164	-53327	58362	ABC
2002.5	A	12	35.1	-66	0.5	23718	23148	5168	-53291	58331	ABC
2003.5	A	12	35.5	-66	0.3	23710	23139	5169	-53264	58303	ABC
1979.5	Q	12	5.5	-66	5.3	23844	23315	4995	-53775	58824	DFI
1980.5	Q	12	8.6	-66	6.8	23813	23280	5010	-53769	58806	DFI
1981.5	Q	12	11.4	-66	8.3	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	8.7	23675	23108	5150	-53537	58538	DFI
1996.5	Q	12	34.2	-66	7.2	23689	23108	5155	-53506	58515	ABC
1997.5	Q	12	34.2	-66	5.6	23703	23135	5159	-53474	58492	ABC
1998.5	Q	12	34.3	-66	4.8	23706	23137	5159	-53443	58464	ABC
1999.5	Q	12	34.1	-66	3.2	23716	23148	5161	-53400	58430	ABC
2000.5	Q	12	34.3	-66	2.2	23718	23149	5162	-53365	58398	ABC
2001.5	Q	12	34.7	-66	0.9	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	-66	-0.5	23723	23152	5172	-53261	58306	ABC

continued on page 72 …

K indices & Daily K sums at Canberra (K=9 limit: 450 nT) for 2003

Date	January	February	March	April	May	June	Date
01	1122 2111 11	1000 3343 14	2213 4332 20	2223 2332 19	D 5445 5322 30	1332 4242 21	01
02	0112 2212 11	D 4464 4553 35	2213 3232 18	2334 4233 24	2424 3311 20	D 4455 4423 31	02
03	2132 3544 24	D 2223 4333 22	2122 3443 21	2233 3334 23	Q 1224 2211 15	3334 4324 26	03
04	3322 2122 17	D 3554 3232 27	D 4344 4433 29	D 3344 5444 31	Q 2112 2111 11	3224 3332 22	04
05	1221 3321 15	2223 4312 19	2123 3423 20	D 2322 4443 24	1322 2333 19	Q 2133 3321 18	05
06	Q 1111 0111 07	2233 3433 23	2224 5523 25	Q 1212 0311 11	3224 5543 28	2123 2332 18	06
07	Q 1211 1222 12	2222 4232 19	3223 3222 19	Q 0012 3200 08	D 4355 4333 30	2334 3323 23	07
08	Q 2120 1101 08	3332 3323 22	Q 1121 3431 16	3334 4322 24	D 4445 4443 32	3343 3444 28	08
09	Q 0000 1122 06	3232 3423 22	1221 2223 15	2443 5322 25	4455 5312 29	3333 3335 26	09
10	3222 3334 22	2343 2322 21	2232 4322 20	3334 3353 27	4454 1223 25	3244 3222 22	10
11	2221 2212 14	Q 2222 3321 17	2233 2312 18	2223 2333 20	4255 5322 28	2232 2221 16	11
12	2342 2221 18	1223 2422 18	Q 2222 2113 15	Q 2122 3211 14	3334 4333 26	Q 1121 2211 11	12
13	1222 1212 13	Q 1212 2012 11	3333 4122 21	Q 3323 3111 17	3334 4333 26	Q 1001 1123 09	13
14	2332 2221 17	3323 4433 25	2244 5333 26	1212 5323 19	3443 3432 26	1235 5442 26	14
15	1122 2212 13	D 3423 4323 24	3344 4333 27	3334 3113 21	2334 4333 25	3432 4332 24	15
16	Q 1012 2111 09	2323 4323 22	2324 5442 26	D 2245 4444 29	Q 2211 2121 12	D 3525 3355 31	16
17	1233 3211 16	2223 3223 19	D 2343 5434 28	2345 4432 27	Q 1322 3110 13	D 4446 4432 31	17
18	2333 4334 25	2654 3313 27	3334 4313 24	1324 4322 21	Q 1110 0232 10	D 3457 4443 34	18
19	2443 4432 26	2212 4323 19	2322 2221 16	Q 1211 2222 13	1222 2223 16	2223 2221 16	19
20	3323 3323 22	2343 3232 22	1334 4433 25	2221 2224 17	2233 3122 18	Q 1232 2422 18	20
21	2234 3322 21	2232 1322 17	3445 4233 28	2345 2333 25	2221 3444 22	4354 2423 27	21
22	D 2222 3325 21	1122 4322 17	2233 3113 18	2235 3343 25	4343 4432 27	Q 2233 1342 20	22
23	D 3322 3234 22	Q 2212 4322 18	3244 3332 24	2434 3231 22	1334 3422 22	4434 2232 24	23
24	2233 3433 23	Q 1113 2212 13	Q 2123 1110 11	2234 3443 25	2443 3443 27	3345 5212 25	24
25	D 3354 4322 26	Q 1121 2101 09	Q 0110 0211 06	D 3344 4323 26	3333 1323 21	2243 2442 23	25
26	D 3334 4313 24	1134 3224 20	Q 0222 1222 13	2243 4333 24	3142 2112 16	3234 5222 23	26
27	3310 1323 16	D 4334 5433 29	4344 3432 27	2323 3323 21	3334 3255 28	3444 4333 28	27
28	2222 3211 15	3124 4433 24	3342 2434 25	2335 3112 20	4344 4333 28	D 2426 4333 27	28
29	2123 4333 21		D 2333 3433 24	1110 4443 18	D 3244 5577 37	3334 3323 24	29
30	D 3225 4431 24		D 4434 3434 29	D 3444 3434 29	D 5433 3433 28	2353 3221 21	30
31	2335 3321 22		D 2334 5533 28		5641 2211 22		31
Mean K-sum	**17.5**	**20.5**	**21.4**	**21.6**	**23.1**	**23.1**	

Date	July	August	September	October	November	December	Date
01	2221 2111 12	D 4345 5333 30	1332 1232 17	1112 1113 11	4343 4333 27	2222 1211 13	01
02	1233 3231 18	2233 2343 22	2112 4212 15	1221 1123 13	2323 3342 22	2332 2001 13	02
03	1112 2333 16	2323 2222 18	2334 2232 21	2322 2322 18	2322 2213 17	Q 1111 1201 08	03
04	3324 3322 22	Q 1233 1222 16	2344 4344 28	Q 1121 3000 08	2366 2232 26	1011 1123 10	04
05	2333 3322 21	Q 2121 0101 08	3433 3322 23	0010 1222 08	Q 2111 1122 11	D 2555 5543 34	05
06	2212 3210 13	3453 3211 22	1213 2211 13	1112 2234 16	1111 2243 15	3334 3332 24	06
07	2143 4221 19	1212 4455 24	Q 1100 0210 05	3224 3322 21	2312 1111 12	1211 4433 19	07
08	Q 0000 0100 01	4544 3432 29	0001 1113 07	1112 1113 11	Q 0122 3422 16	D 2445 5443 31	08
09	Q 0101 1010 04	2243 3223 21	1234 4344 25	2211 1101 09	2234 5433 26	D 3354 4434 30	09
10	Q 1112 3111 11	3113 3221 16	4224 3332 23	Q 0010 0002 03	3334 4444 29	D 4344 4544 32	10
11	D 2355 4444 31	1111 1222 11	3323 2222 19	Q 0000 0000 00	D 4455 4544 35	D 4445 4433 31	11
12	D 5553 3332 29	3344 4422 26	2322 3111 15	Q 0011 1212 08	3344 3343 27	3333 4233 24	12
13	3232 2321 18	2332 3223 20	2332 0122 15	1222 2324 18	D 2335 6443 30	3333 4433 26	13
14	1232 2233 18	3342 1232 20	Q 1120 1101 07	D 2243 5455 30	3445 4333 29	3333 4443 27	14
15	4334 2134 24	1222 1222 14	0000 0033 06	3455 4333 30	D 3454 4433 30	3333 4233 24	15
16	D 3446 5433 32	Q 2203 2211 13	D 3344 6542 31	3235 3323 24	D 3344 5544 32	2223 1321 16	16
17	3224 3333 23	0001 4444 17	D 3445 6444 34	3345 4222 25	3334 4433 27	2222 2301 14	17
18	3322 2233 20	D 4367 5654 40	D 4445 4444 33	3333 4323 24	4333 4433 27	Q 1111 1100 06	18
19	3334 4334 27	3232 2211 16	D 3355 5332 29	2244 4443 27	2233 3322 20	Q 0110 1000 03	19
20	4333 3223 23	0222 2323 16	2345 4421 25	2244 3434 26	D 1366 7876 44	1224 3534 24	20
21	Q 1210 1020 07	D 2454 4555 34	4233 4322 23	D 4344 5444 32	5563 3332 30	4343 3433 27	21
22	Q 1022 1120 09	D 4445 5433 32	2334 3331 22	3445 4432 29	4312 3553 26	3344 3332 25	22
23	2112 1321 13	D 3354 5432 29	2323 3323 21	Q 3232 1101 13	3442 4243 26	2122 2211 13	23
24	1100 1113 08	2243 3242 22	D 3454 4333 29	1123 4646 27	2212 4323 19	1220 2332 15	24
25	0133 2000 09	3443 2311 21	3345 4332 27	4332 5313 24	3233 3312 20	Q 1122 3211 13	25
26	1334 3343 24	3213 3323 20	2244 3222 21	1223 1233 17	2111 3212 13	2222 2112 14	26
27	3344 3221 22	Q 1123 3222 16	2100 0011 05	2222 2310 14	Q 1212 1012 10	1323 2223 18	27
28	1113 4432 19	2233 2323 20	Q 0002 1200 05	3433 2324 24	Q 1112 3201 11	3323 2232 20	28
29	D 3444 4444 31	0213 3242 17	Q 1002 0001 04	D 4497 7687 52	Q 1122 2112 12	Q 2112 1300 10	29
30	3344 5332 27	2223 2221 16	Q 1121 3201 11	D 6653 5788 48	2222 3333 20	0211 1133 12	30
31	D 3345 4333 28	Q 1222 3211 14		D 7866 6433 43		2233 4433 24	31
Mean K-sum	**18.7**	**20.6**	**18.6**	**21.1**	**23.0**	**19.4**	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	10	56	91	66	20	5	0	0	0	0	0
February	5	25	81	74	31	6	2	0	0	0	0
March	5	28	75	84	48	8	0	0	0	0	0
April	6	26	67	84	48	9	0	0	0	0	0
May	3	34	57	76	54	21	1	2	0	0	0
June	2	20	71	79	50	15	2	1	0	0	0
July	23	48	54	79	35	8	1	0	0	0	0
August	8	36	86	63	36	16	2	1	0	0	0
September	31	38	58	60	42	9	2	0	0	0	0
October	25	44	59	53	37	12	8	5	4	1	0
November	3	36	56	76	46	13	7	2	1	0	0
December	16	49	59	74	39	11	0	0	0	0	0
ANNUAL TOTAL	**137**	**440**	**814**	**868**	**486**	**133**	**25**	**11**	**5**	**1**	**0**

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23158.6	5166.7	-53272.2	58317.6	23728.0	12° 34.6'	-65° 59.5'
	5xQ days	23167.8	5169.7	-53271.0	58320.5	23737.6	12° 34.7'	-65° 58.9'
	5xD days	23147.8	5164.6	-53272.5	58313.4	23717.0	12° 34.6'	-66° 00.1'
February	All days	23149.4	5166.9	-53271.2	58313.1	23719.0	12° 34.9'	-65° 59.9'
	5xQ days	23155.5	5169.2	-53269.1	58313.8	23725.5	12° 35.1'	-65° 59.5'
	5xD days	23135.0	5160.7	-53274.6	58309.9	23703.6	12° 34.5'	-66° 00.9'
March	All days	23138.9	5167.4	-53269.0	58306.9	23708.8	12° 35.3'	-66° 00.4'
	5xQ days	23151.9	5171.6	-53267.2	58310.8	23722.5	12° 35.5'	-65° 59.7'
	5xD days	23119.2	5160.7	-53270.2	58299.6	23688.2	12° 35.0'	-66° 01.6'
April	All days	23134.0	5169.1	-53269.3	58305.4	23704.5	12° 35.7'	-66° 00.7'
	5xQ days	23144.7	5170.1	-53266.2	58307.0	23715.2	12° 35.5'	-66° 00.0'
	5xD days	23126.2	5166.5	-53270.5	58303.2	23696.3	12° 35.6'	-66° 01.1'
May	All days	23130.7	5168.3	-53270.0	58304.6	23701.1	12° 35.7'	-66° 00.9'
	5xQ days	23144.0	5170.1	-53267.7	58308.0	23714.5	12° 35.5'	-66° 00.1'
	5xD days	23115.3	5167.5	-53269.3	58297.8	23685.9	12° 36.1'	-66° 01.7'
June	All days	23131.1	5169.0	-53270.7	58305.5	23701.6	12° 35.8'	-66° 00.9'
	5xQ days	23143.4	5171.7	-53266.9	58307.2	23714.2	12° 35.8'	-66° 00.1'
	5xD days	23107.6	5163.9	-53278.1	58302.6	23677.6	12° 35.8'	-66° 02.3'
July	All days	23134.7	5170.5	-53266.1	58302.9	23705.5	12° 35.9'	-66° 00.5'
	5xQ days	23147.0	5172.9	-53263.4	58305.5	23718.0	12° 35.8'	-65° 59.8'
	5xD days	23110.6	5166.9	-53272.2	58298.6	23681.1	12° 36.2'	-66° 02.0'
August	All days	23134.0	5170.4	-53263.0	58299.8	23704.8	12° 35.9'	-66° 00.5'
	5xQ days	23148.4	5172.7	-53259.7	58302.7	23719.3	12° 35.8'	-65° 59.6'
	5xD days	23109.4	5164.5	-53266.1	58292.3	23679.4	12° 35.9'	-66° 01.9'
September	All days	23140.6	5171.3	-53256.4	58296.4	23711.4	12° 35.8'	-65° 60.0'
	5xQ days	23150.9	5173.9	-53253.7	58298.3	23722.0	12° 35.9'	-65° 59.4'
	5xD days	23120.3	5165.2	-53259.5	58290.7	23690.3	12° 35.6'	-66° 01.2'
October	All days	23131.4	5168.1	-53253.9	58290.3	23701.7	12° 35.7'	-66° 00.5'
	5xQ days	23152.3	5174.0	-53251.5	58296.8	23723.4	12° 35.8'	-65° 59.2'
	5xD days	23073.3	5157.8	-53254.5	58266.9	23642.8	12° 36.1'	-66° 03.7'
November	All days	23135.4	5167.7	-53255.6	58293.3	23705.5	12° 35.5'	-66° 00.3'
	5xQ days	23155.3	5172.9	-53253.9	58300.1	23726.0	12° 35.6'	-65° 59.1'
	5xD days	23111.8	5154.1	-53248.3	58276.1	23679.5	12° 34.3'	-66° 01.5'
December	All days	23153.1	5169.6	-53249.4	58294.9	23723.2	12° 35.2'	-65° 59.2'
	5xQ days	23161.3	5172.8	-53246.0	58295.3	23731.9	12° 35.4'	-65° 58.6'
	5xD days	23139.5	5169.0	-53253.6	58293.3	23709.8	12° 35.5'	-66° 00.0'
Annual	All days	23139.3	5168.7	-53263.9	58302.6	23709.6	12° 35.5'	-66° 00.3'
Mean	5xQ days	23151.9	5171.8	-53261.4	58305.5	23722.5	12° 35.5'	-65° 59.5'
Values	5xD days	23118.0	5163.4	-53265.8	58295.4	23687.6	12° 35.4'	-66° 01.5'

(Calculated: 15:04 hrs., Mon., 20 Sep. 2004)

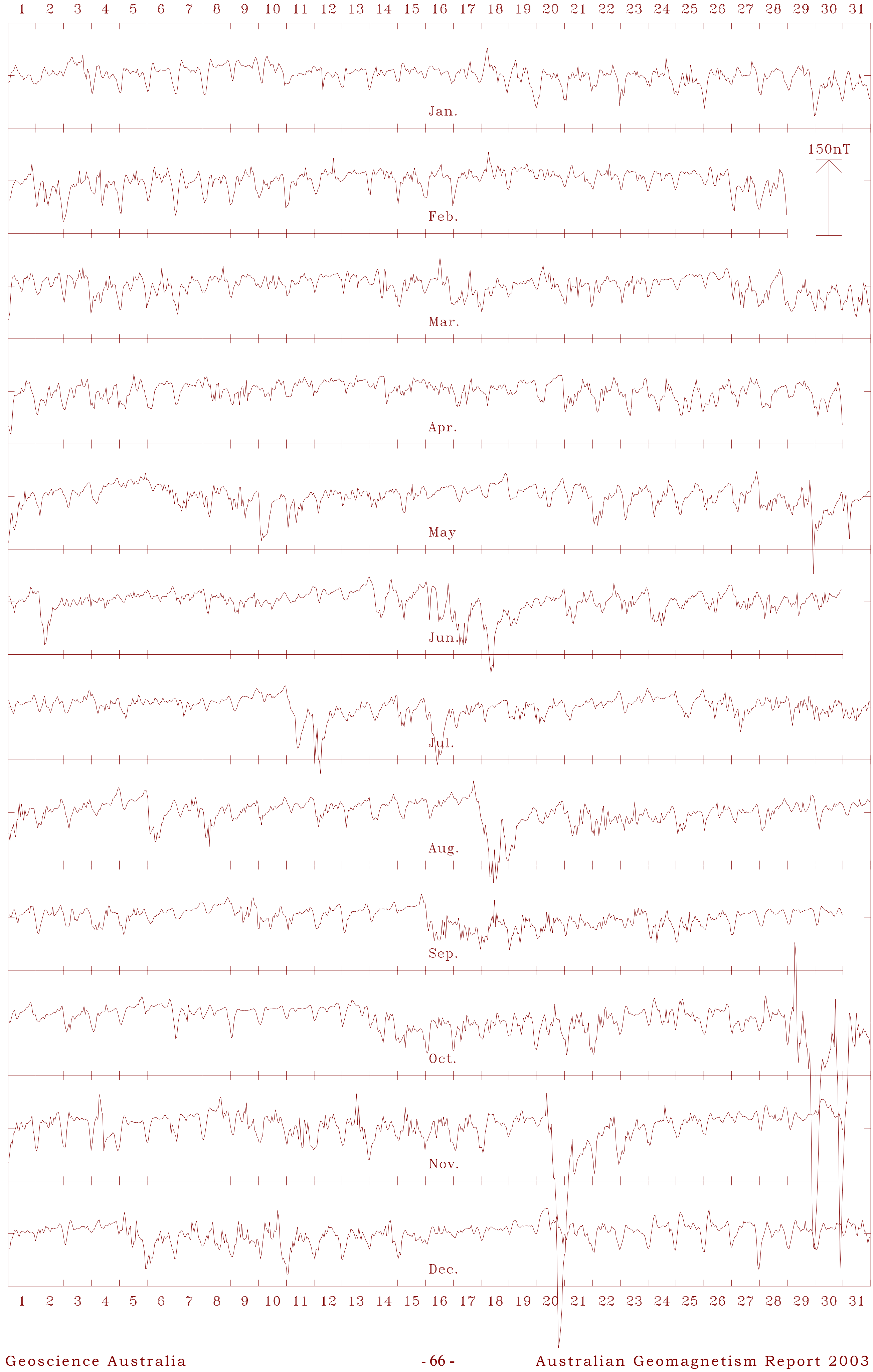
Hourly Mean Values

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

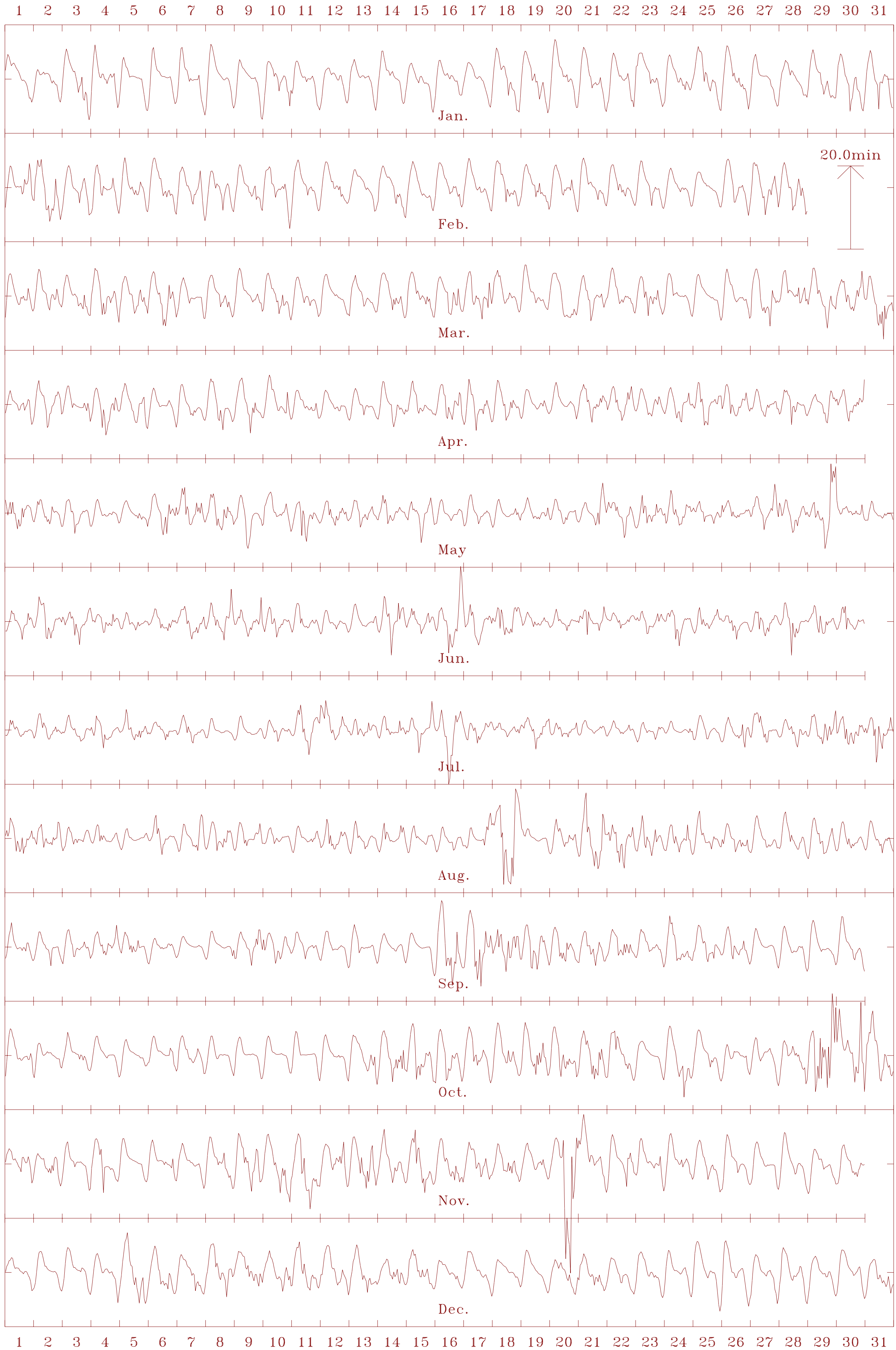
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

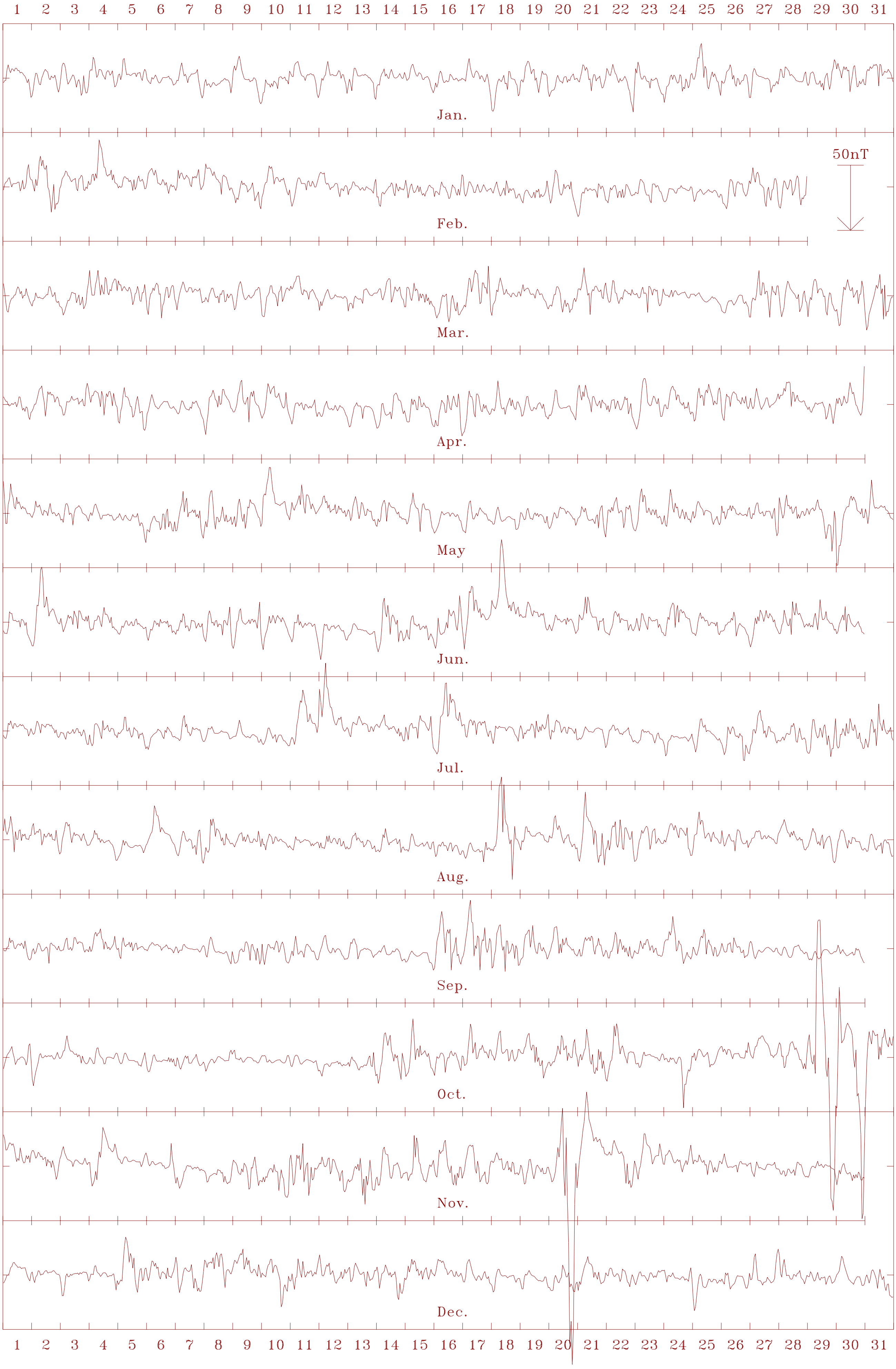
Canberra 2003 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 23710 nT



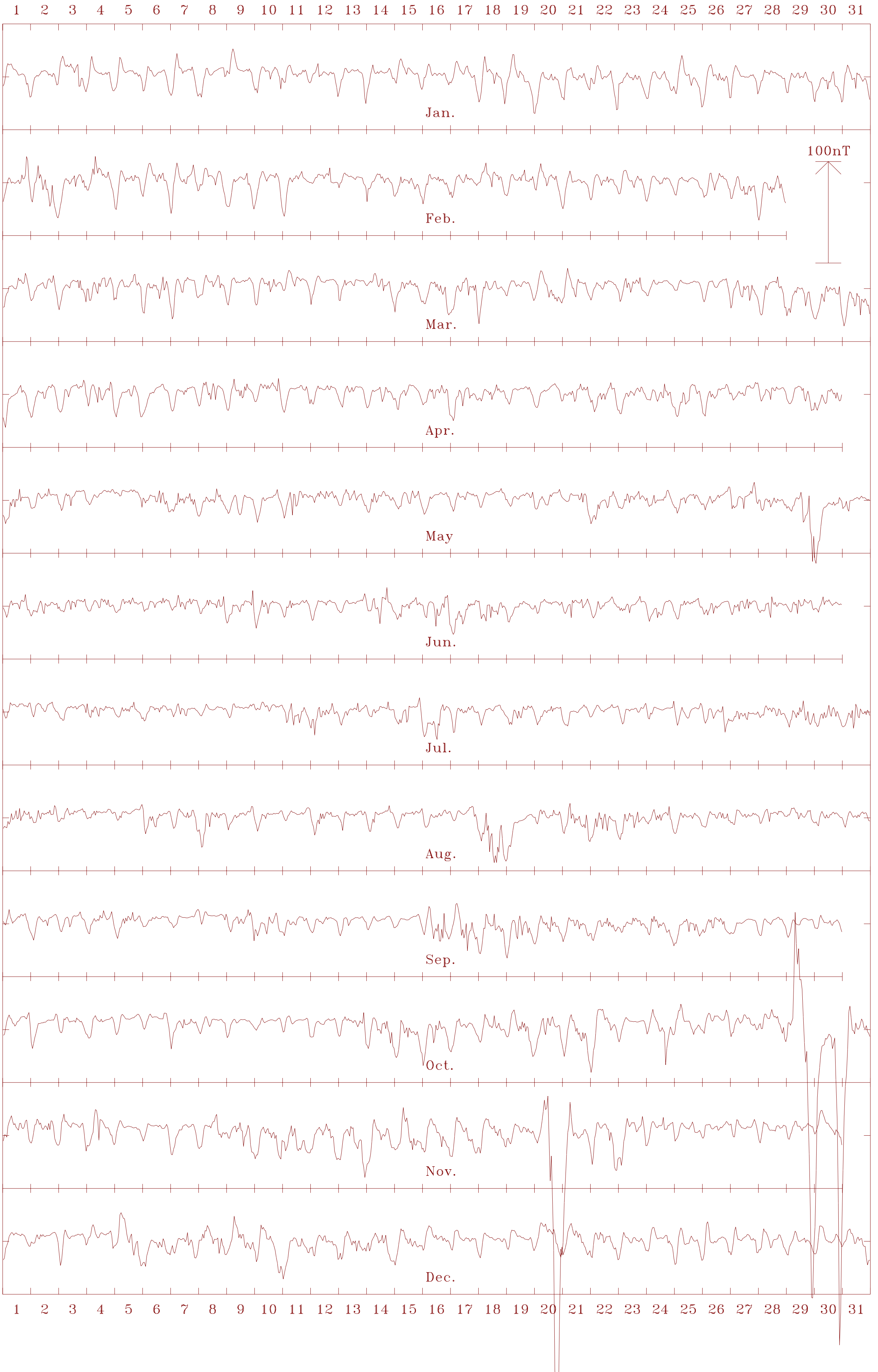
Canberra 2003 Declination (east) (D). Scale: 1.25 min/mm. Mean: 12.59 deg.

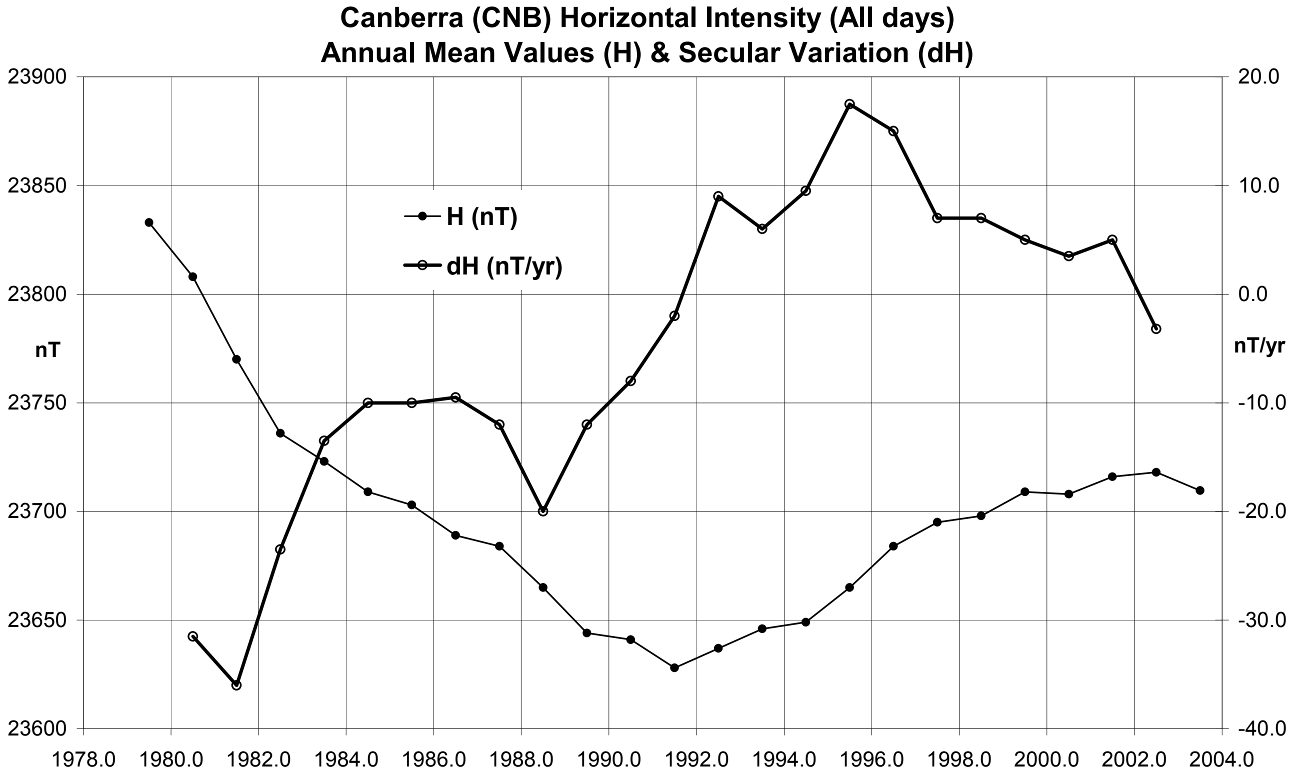


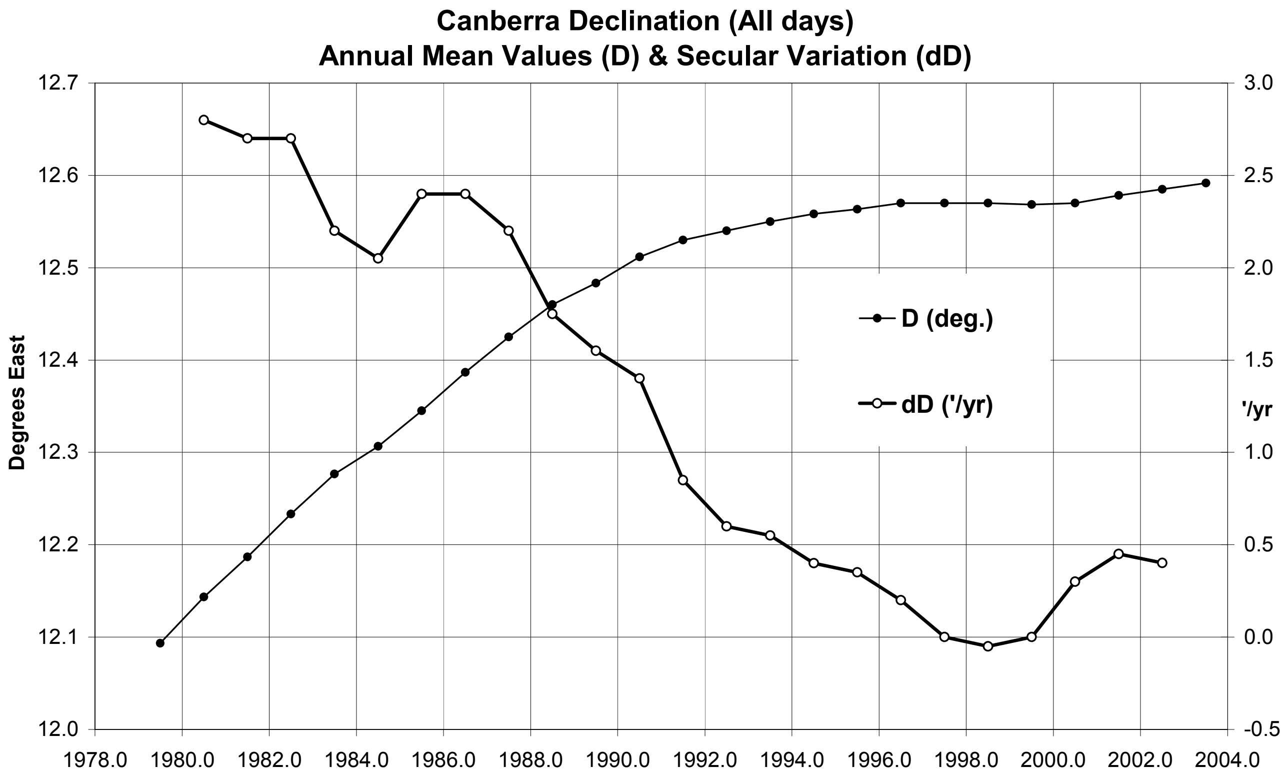
Canberra 2003 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −53264 nT

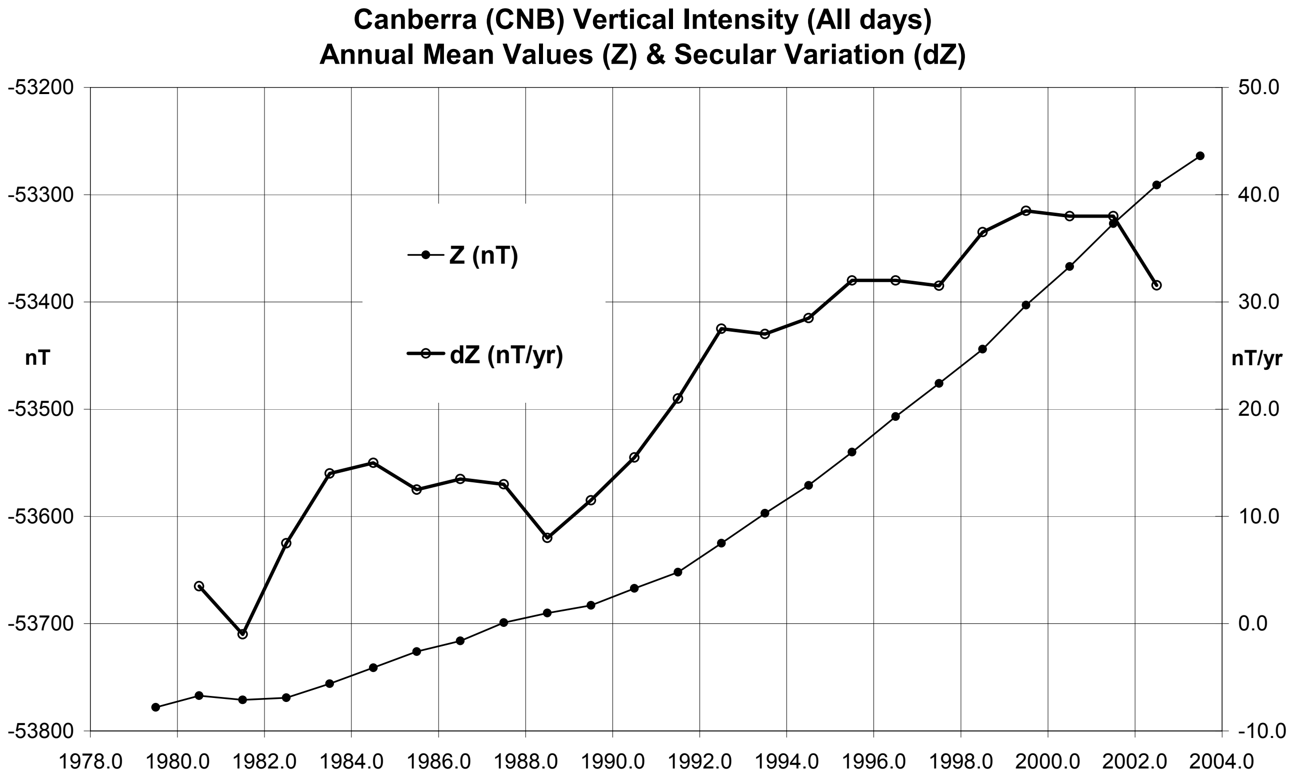


Canberra 2003 Total intensity (F). Scale: 5.0 nT/mm. Mean: 58303 nT

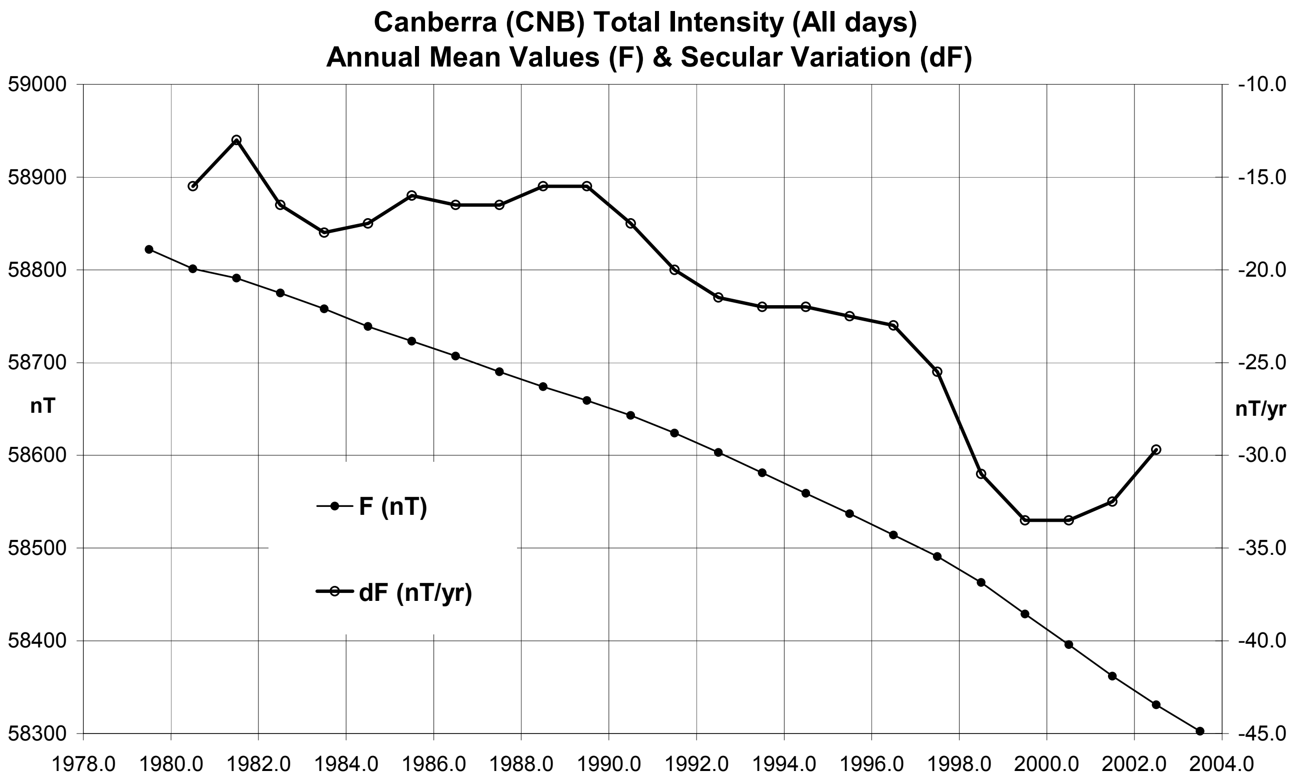



Canberra (CNB) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT/yr
23900
23850
23800
23750
23700
23650
23600
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
1978.0 1980.0 1982.0 1984.0 1986.0 1988.0 1990.0 1992.0 1994.0 1996.0 1998.0 2000.0 2002.0 2004.0


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



Canberra (CNB) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-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



Canberra (CNB) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
59000
58900
58800
58700
58600
58500
58400
58300
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
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

CNB – Annual Mean Values (cont.)

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

* 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. Details of the staffing at the observatory is in *AGR* 1994. 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 the principal observation pier (AE) of the observatory are:

- 3-character IAGA code: MCQ
- Commenced operation: 1952
- Geographic latitude: 54° 30' S
- Geographic longitude: 158° 57' E
- Geomagnetic† : Lat. -59.90°; Long. 244.04°

† Based on the IGRF 2000.0 model updated to 2003.5

- Elevation above mean sea level (top of pier): 8 metres
- Lower limit for K index of 9: 1500 nT.
- Azimuth of principal reference pillar (NMI) from pier AE: 353° 44' 13"
- Distance to Pillar NMI: ~200 metres
- Observers in Charge: Peter Pokorny (2002/03)
  Henry Banon (2003/04)

Variometers

The equipment employed to monitor magnetic variations at MCQ in 2003 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.

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).

The classical QHMs (serial 177‡, 178, 179 on Askania circle 640616) were available as backup for use on pier AE.

A pier difference of:

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

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 standard instruments (B0806H/100856 DIM and GSM90_003985/11690) were performed at Macquarie Island on 24 and 26 Mar 2003.

The results of the instrument comparisons were:

Travelling Stndrd		MCQ instrument		Inst. difference
GSM90_003985	–	Austral 525 PPM	=	+0.38nT (F)
B0806H/100856	–	E810_214/311847	=	+0.19' (Decl'n)
B0806H/100856	–	E810_214/311847	=	+0.04' (Incl'n)

Comparisons between the travelling standard instruments and the Australian Standard 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 Stndrd		MCQ instrument		Inst. correction
GSM90_905926*	–	Austral 525	=	+0.38nT (F)
E810_200/353756	–	E810_214/311847	=	+0.19' (Decl'n)
E810_200/353756	–	E810_214/311847	=	+0.04' (Incl'n)

* with sensor 21867.

At the mean 2003 field values at MCQ of 10820nT, 6435nT and -63175nT in X, Y and Z respectively, the instrument corrections adopted for the absolute magnetometers used at MCQ during 2003 convert to the baseline corrections:

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

These corrections have been applied to all MCQ 2003 final data including in this report.

‡ See *Absolute Magnetometers employed in 2003* on page 5 of this report.

Baselines

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

$\sigma_X = 1.5nT$ $\sigma_Y = 1.6nT$ $\sigma_Z = 0.9nT$.

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

$\sigma_F = 0.9nT$ $\sigma_D = 28''$ $\sigma_I = 5''$.)

The drifts applied to the X, Y, and Z baselines amounted to less than 10nT in any of these components throughout the 2003, with the X component showing the most drift and the Z component the least drift.

There was about 2nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM throughout the year.

Operations

The magnetic observers-in-charge at Macquarie Island in 2003 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 2003, weekly absolute calibrations were performed on the observation piers in the absolute house by the ANARE communications technical officers: Peter Pokorny (from March 2002) until the end 26 March 2003, then Henry Banon from 27 March 2003 (until 26 February 2004).

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).

A service visit was made to the observatory over the period 24 to 28 March 2003 by a Geomagnetism Project officer (AML). During the visit the data acquisition computer was replaced, instrument comparisons and tests were performed, pier differences and pier gradients were measured and azimuth mark angles checked.

Distribution of MCQ data during 2003

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP

Final 1-minute & Hourly Mean Values

- 2002 data: WDC-A, Boulder, USA (sent 04 June 2003)
- 2002 data: WDC-C1, Copenhagen (sent 04 June 2003
- 2003 data: WDC-A, Boulder, USA (sent 03 Apr. 2004)
- 2003 data: WDC-C1, Copenhagen (sent 03 Apr. 2004)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive data for INTERMAGNET CD-ROMs sent:
  – 2002 data: to the Paris GIN on 04 Jun. 2003.
  – 2003 data: to the Paris GIN on 03 Apr. 2003.

MCQ, 2003 – Significant Events:

03 Feb	OIC (PP) off station for 6 days beginning this day: no observation this week.
24 Feb	0559–0603: One-minute time marks disconnected to check cabling.
24 Mar	to 28th: Maintenance visit by Geomagnetism Project officer (AML) from GA.
24 Mar	Data acquisition PC replaced (resulting in some data losses see *Data Loss* section, this report).
25 Mar	0520 to 0336 / 26th: One-second data acquisition stalled. (The one-minute data continued unaffected.)
27 Mar	The new observer (HB) arrived and took over as Observer-in-Charge (from PP).
01 Jun	A large storm hit Macquarie Island causing damage to buildings and the coastline on the isthmus.

MCQ, 2003 – Significant Events (cont.)

03 Jul No observations were performed this week as the observer (HB) was stuck in Bauer Bay field hut. (A record cold day at Macquarie Is.: −9.3°C with snow and strong wind.)

23 Jul 0330–0400: Satellite data circuit off.

17 Sep 2300 to 0000 / 18th: Satellite data circuit off due to satellite frequency changes.

29 Oct K=9 magnetic storm: Declination swings through 12 degrees in 25 minutes.

08 Dec No contact with QNX PC (used to get the data from the acquisition PC via the AAD network) or e-mail.

09 Dec Began sending daily data to INTERMAGNET GIN in Edinburgh in IAGA2002 format.

11 Dec QNX system working again - caught up with data downloads.

13 Dec Absolute observations abandoned due to fog.

15 Dec 2130–2230: Possible magnetic interference during building inspection.

MCQ, 2003 – Data losses:

24 Mar 2152−2219 (28 min.), 2230 (1 min.), 2235 (1 min.) All channels: The data acquisition PC was replaced with a PC104 DOS PC.

16 Sep 0153 (1 min.) RCF channels: cause unknown.

11 Nov 0341-0343 (3 mins) RCF channels: cause unknown.

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 80-81.

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
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

continued on page 82 …

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	10844.2	6430.5	-63174.9	64420.7	12607.5	30° 40.1'	-78° 42.8'
	5xQ days	10858.8	6438.8	-63174.7	64423.7	12624.3	30° 40.0'	-78° 42.0'
	5xD days	10823.8	6422.5	-63181.6	64423.2	12585.9	30° 41.1'	-78° 44.1'
February	All days	10819.4	6425.0	-63178.0	64419.1	12583.3	30° 42.3'	-78° 44.1'
	5xQ days	10846.3	6436.9	-63176.5	64423.2	12612.6	30° 41.3'	-78° 42.6'
	5xD days	10787.0	6409.7	-63204.3	64438.1	12547.8	30° 43.2'	-78° 46.3'
March	All days	10802.1	6421.5	-63180.2	64418.0	12566.7	30° 43.9'	-78° 45.0'
	5xQ days	10836.3	6438.6	-63169.8	64415.1	12604.8	30° 43.1'	-78° 42.9'
	5xD days	10769.3	6401.5	-63184.6	64415.0	12528.4	30° 43.8'	-78° 47.1'
April	All days	10808.6	6431.3	-63176.4	64416.3	12577.3	30° 45.2'	-78° 44.4'
	5xQ days	10826.4	6435.7	-63175.6	64418.8	12594.8	30° 43.8'	-78° 43.5'
	5xD days	10777.7	6416.9	-63175.7	64409.1	12543.4	30° 46.2'	-78° 46.2'
May	All days	10811.8	6431.4	-63177.9	64418.4	12580.1	30° 44.8'	-78° 44.3'
	5xQ days	10835.7	6439.9	-63182.4	64427.5	12605.0	30° 43.4'	-78° 43.1'
	5xD days	10771.7	6418.0	-63183.2	64415.7	12538.9	30° 47.5'	-78° 46.5'
June	All days	10831.6	6441.3	-63176.0	64420.7	12602.2	30° 44.4'	-78° 43.1'
	5xQ days	10834.0	6443.4	-63176.6	64421.9	12605.3	30° 44.5'	-78° 43.0'
	5xD days	10797.0	6433.0	-63165.8	64404.2	12568.3	30° 47.3'	-78° 44.8'
July	All days	10828.3	6440.6	-63177.0	64421.1	12598.9	30° 44.7'	-78° 43.3'
	5xQ days	10841.0	6445.7	-63178.5	64425.1	12612.4	30° 44.1'	-78° 42.6'
	5xD days	10800.8	6431.6	-63169.7	64408.6	12570.8	30° 46.4'	-78° 44.7'
August	All days	10818.7	6439.0	-63171.5	64414.0	12589.9	30° 45.6'	-78° 43.7'
	5xQ days	10839.7	6445.9	-63170.2	64416.8	12611.5	30° 44.3'	-78° 42.6'
	5xD days	10744.2	6415.1	-63177.0	64404.9	12514.0	30° 50.6'	-78° 47.8'
September	All days	10814.7	6438.5	-63166.1	64408.0	12586.3	30° 46.1'	-78° 43.9'
	5xQ days	10838.6	6447.6	-63163.0	64409.8	12611.4	30° 44.9'	-78° 42.5'
	5xD days	10768.8	6418.4	-63179.2	64411.4	12536.6	30° 47.9'	-78° 46.6'
October	All days	10800.5	6429.8	-63179.8	64418.3	12569.8	30° 46.1'	-78° 44.9'
	5xQ days	10840.7	6450.5	-63160.8	64408.2	12614.7	30° 45.2'	-78° 42.3'
	5xD days	10697.8	6380.5	-63242.4	64458.6	12457.6	30° 49.1'	-78° 51.4'
November	All days	10800.4	6427.9	-63175.4	64413.8	12568.6	30° 45.6'	-78° 44.9'
	5xQ days	10841.9	6446.6	-63165.2	64412.3	12613.7	30° 44.1'	-78° 42.4'
	5xD days	10707.1	6380.1	-63201.1	64419.4	12464.3	30° 47.4'	-78° 50.6'
December	All days	10822.3	6442.3	-63156.2	64400.0	12594.7	30° 45.9'	-78° 43.3'
	5xQ days	10846.6	6455.5	-63151.8	64400.8	12622.3	30° 45.6'	-78° 41.8'
	5xD days	10785.1	6428.9	-63168.3	64404.4	12556.0	30° 48.0'	-78° 45.5'
Annual	All days	10816.9	6433.2	-63174.1	64415.7	12585.5	30° 44.5'	-78° 44.0'
Mean	5xQ days	10840.5	6443.8	-63170.4	64416.9	12611.1	30° 43.7'	-78° 42.6'
Values	5xD days	10769.2	6413.0	-63186.1	64417.7	12534.3	30° 46.6'	-78° 46.8'

(Calculated: 15:24 hrs., Thu., 12 Feb. 2004)

Hourly Mean Values

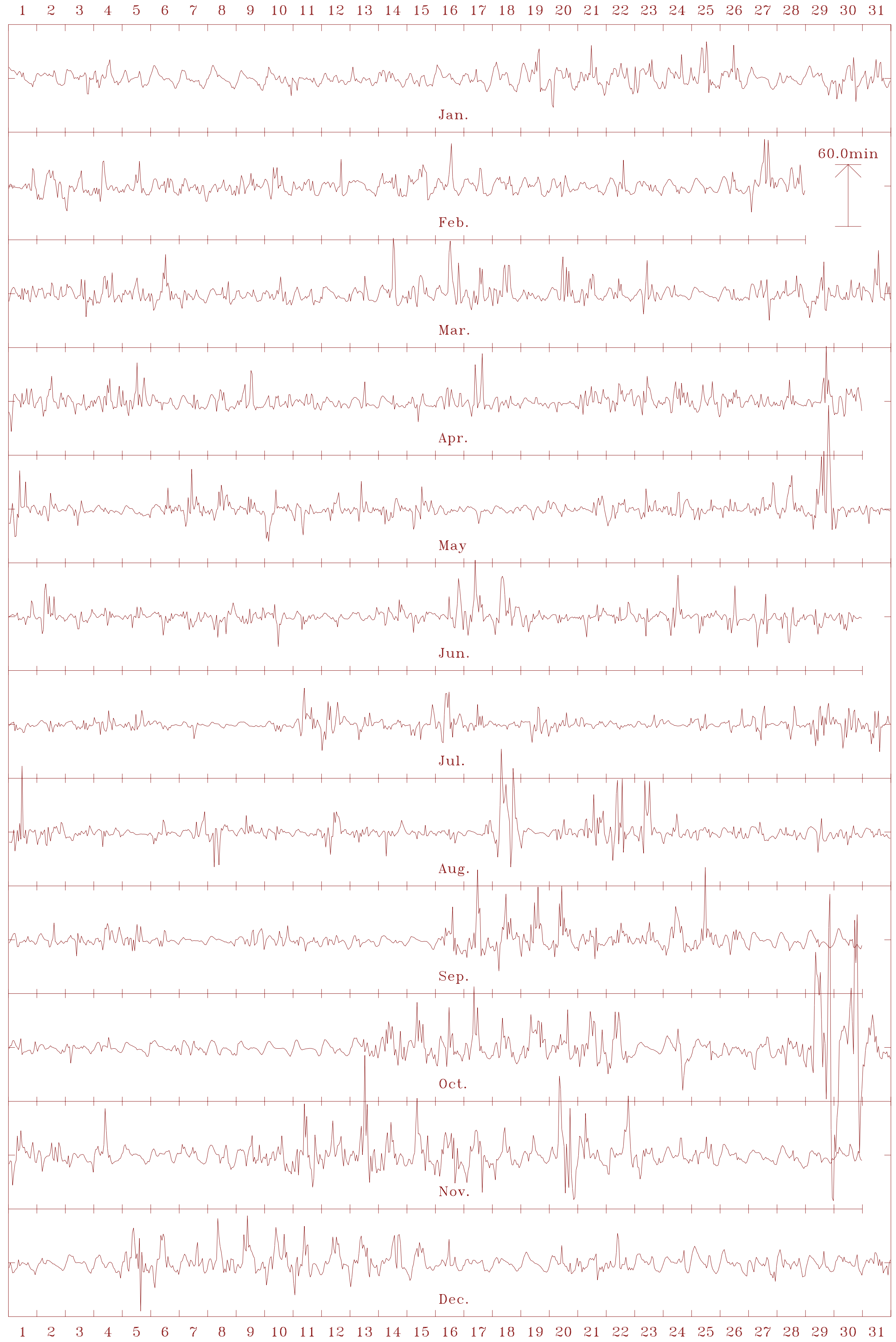
The charts on the following pages are plots of hourly mean values.

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.

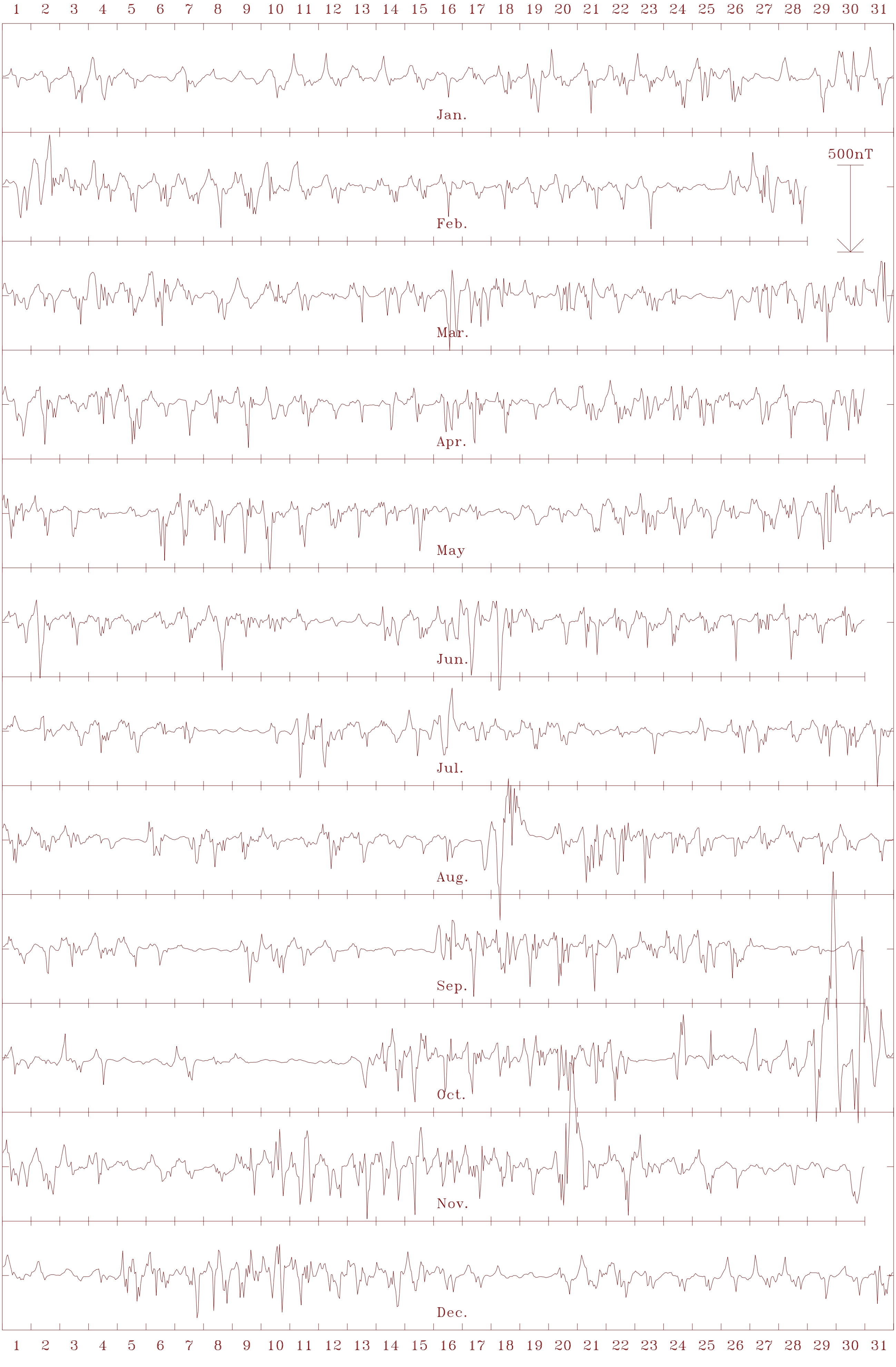
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Macquarie Is. 2003 Horizontal intensity (H). Scale: 50.0 nT/mm. Mean: 12586 nT

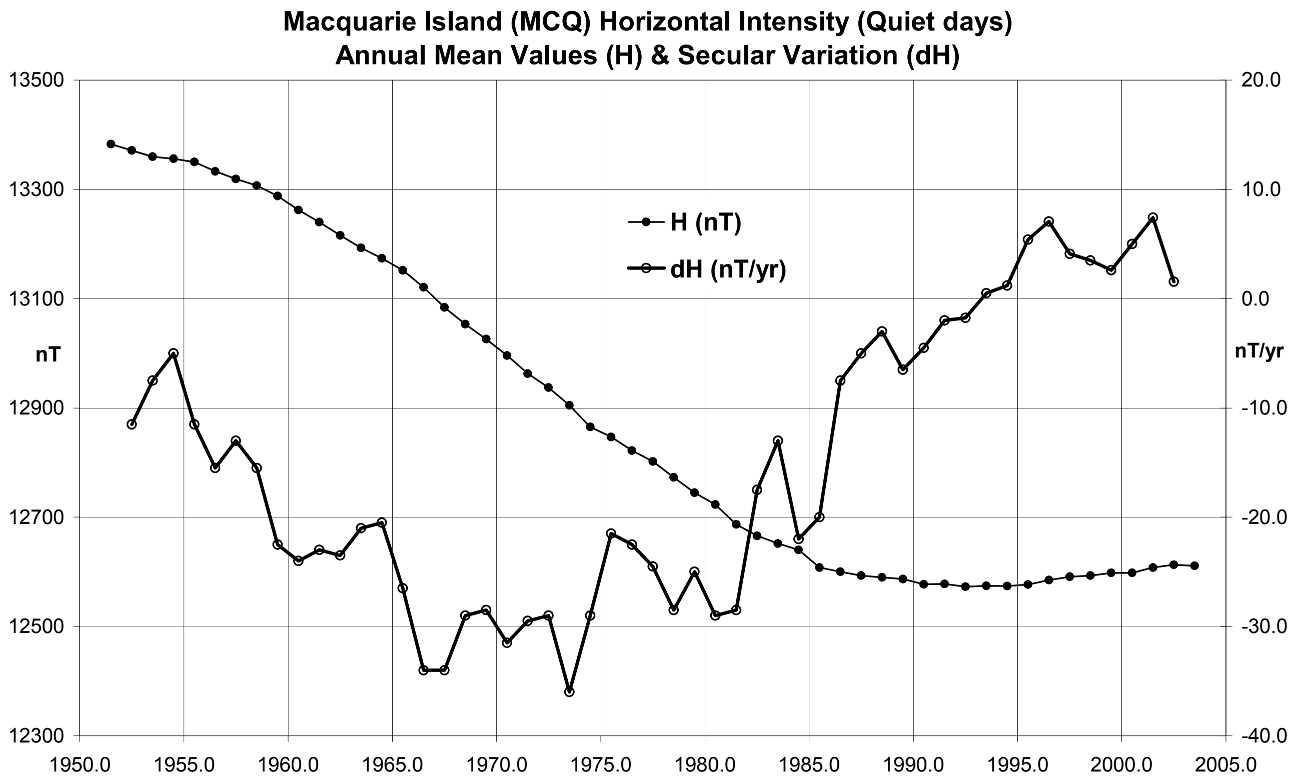
Macquarie Is. 2003 Declination (east) (D). Scale: 5.00 min/mm. Mean: 30.74 deg.

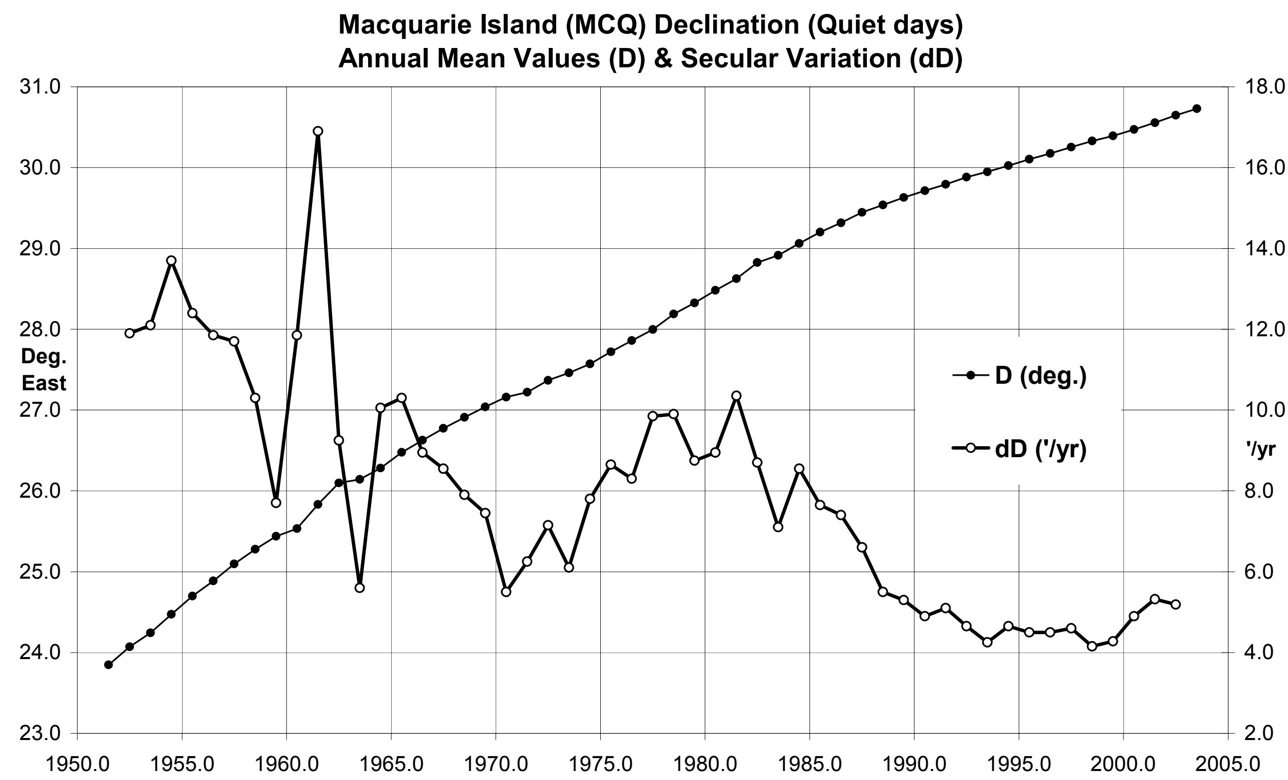


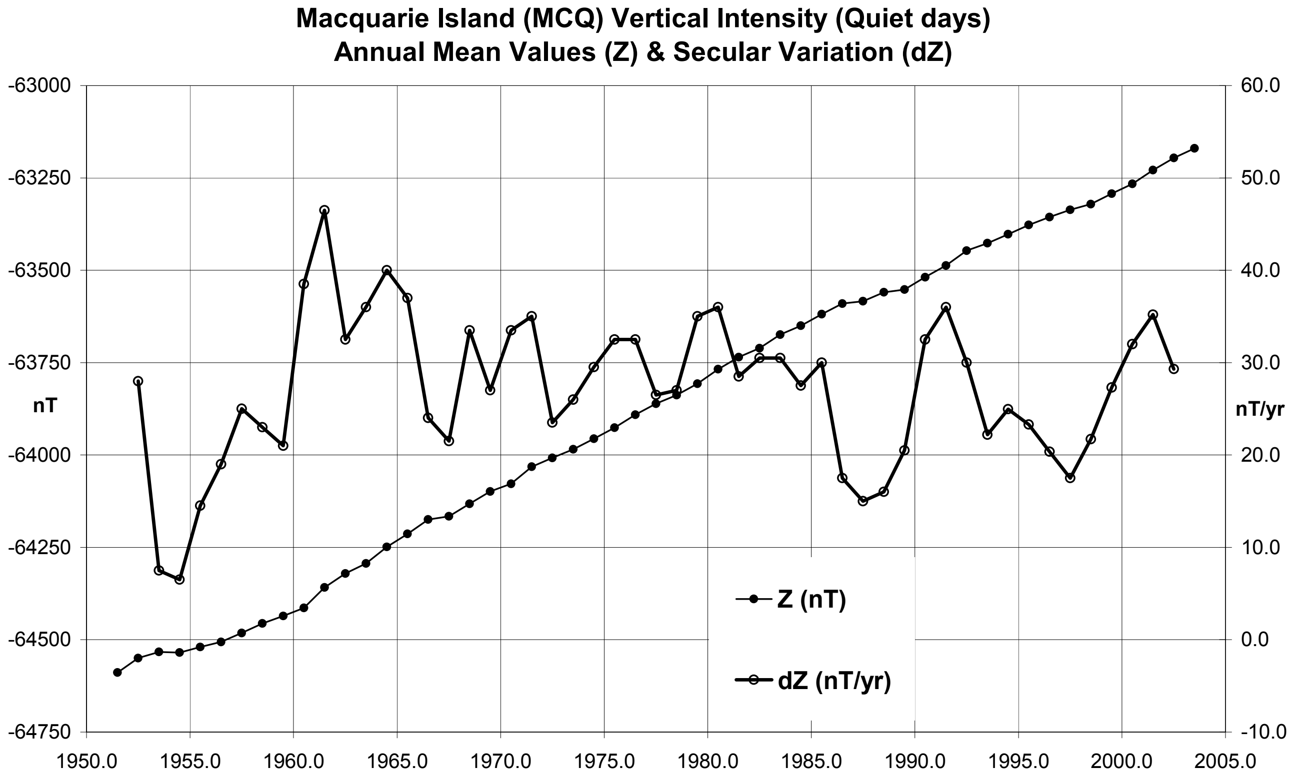
Macquarie Is. 2003 Vertical intensity (Z). Scale: 30.0 nT/mm. Mean: -63174 nT

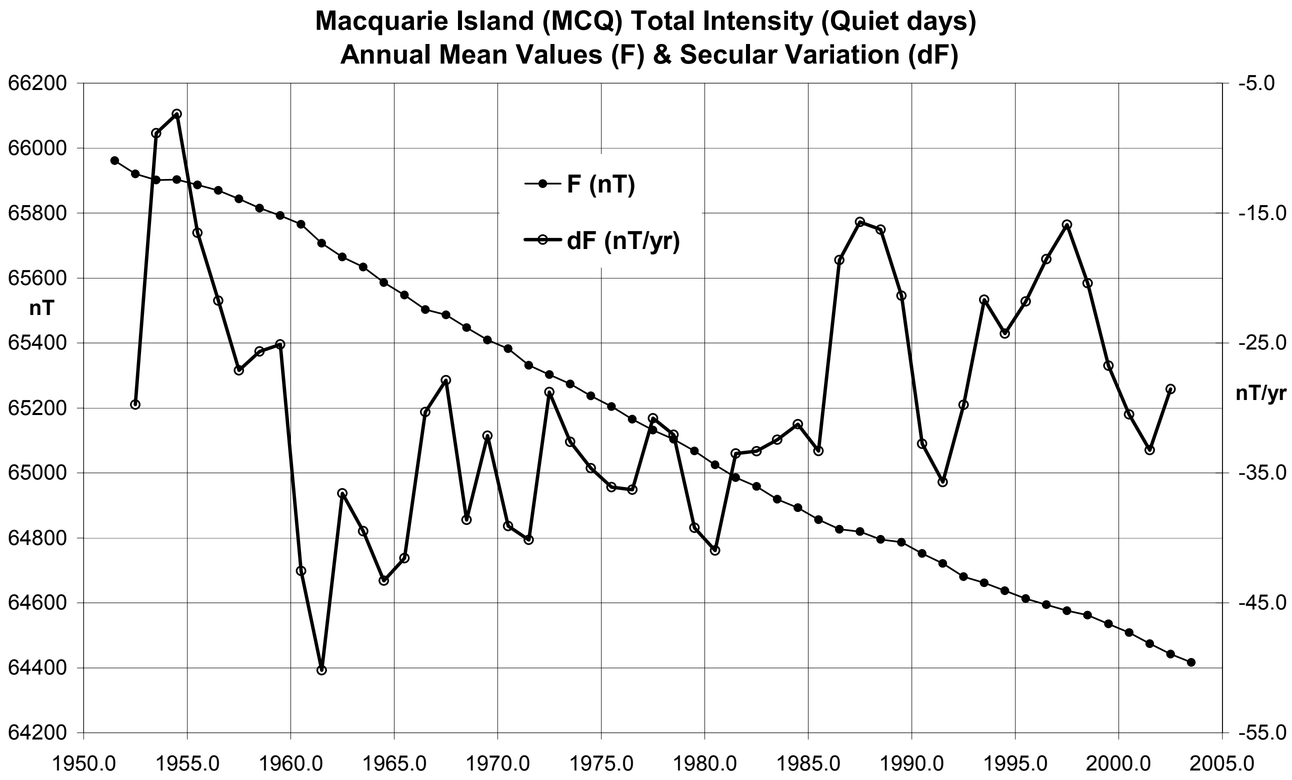


Macquarie Is. 2003 Total intensity (F). Scale: 30.0 nT/mm. Mean: 64416 nT


Macquarie Island (MCQ) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (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)
Deg.
East
'/yr
D (deg.)
dD ('/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)
-63000
-63250
-63500
-63750
-64000
-64250
-64500
-64750
nT
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
nT/yr
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)
66200
66000
65800
65600
65400
65200
65000
64800
64600
64400
64200
nT
-5.0
-15.0
-25.0
-35.0
-45.0
-55.0
nT/yr
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*
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
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

* 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 the principal observation pier of the Casey Station are:

- 3-character IAGA code: CSY
- Geographic latitude: 66° 17' S
- Geographic longitude: 110° 32' E
- Geomagnetic† : Lat. -76.37°; Long. 183.81°

  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of observation pier) 40 metres
- Azimuth of reference pillar (G11) from observation pier 307° 41' 02"
- Observer in Charge: Brent Harper (AAD)

Variometers

An Antarctic Division EDA FM105B fluxgate variometer, with the data acquired by PC, operated at Casey throughout 2003. The fluxgate sensors were housed on the hill about 300m west of the Casey Science building. Their sensors were aligned close to true north, true east and vertical. The temperatures were maintained at 20°C. Further description is in Crosthwaite (1999).

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 Antarctic Division, and Geometrics 816 no. 1024 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 standardization with the Australian Magnetic Standard held at Canberra, a correction of +1.2nT 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 $\Delta Y = -0.18$ nT $\Delta Z = -1.19$ 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 of the two instruments required the following corrections to DIM/PPM readings to produce equivalent QHM/PPM readings (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 desirable that a new absolute observation hut and pier is 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 89-90.

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

Casey Operations

The magnetic observer-in-charge at Casey in 2003 was an officer of the Australian Antarctic Division, of the 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.

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 converted into GA 1-second format from which calibrated minute, monthly and annual means were computed.

There was no PPM variometer operating at Casey in 2003.

Throughout 2003, AAD's ADAS acquisition system performed system tests daily at UT 0001, 1200−1201 and 1630−1631 which contaminated the variometer data. The data at these times have been removed from GA's data set used in final processing.

The variometer seemed to exhibit a high drift rate around late March and again in late September but then in the opposite sense. A possible cause might be that the Science building at Casey is heated during summer and is kept at about 10°C during winter: the heating was reduced in late March and increased in September. Investigations are continuing to understand the phenomenon.

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	-562.5	-9530.9	-63689.2	64401.0	9548.4	-93° 22.8'	-81° 28.4'
	5xQ days	-530.7	-9540.9	-63661.9	64375.1	9555.9	-93° 11.1'	-81° 27.8'
	5xD days	-620.9	-9515.0	-63737.9	64447.5	9536.2	-93° 44.0'	-81° 29.4'
February	All days	-588.5	-9525.6	-63700.3	64411.5	9544.4	-93° 32.2'	-81° 28.7'
	5xQ days	-626.8	-9509.7	-63708.6	64417.6	9530.8	-93° 46.3'	-81° 29.5'
	5xD days	-564.5	-9531.2	-63692.0	64403.9	9548.6	-93° 23.5'	-81° 28.4'
March	All days	-593.7	-9520.9	-63719.9	64430.2	9539.7	-93° 34.2'	-81° 29.1'
	5xQ days	-609.3	-9518.4	-63725.9	64435.8	9538.1	-93° 39.8'	-81° 29.3'
	5xD days	-587.3	-9522.6	-63721.9	64432.3	9541.0	-93° 31.9'	-81° 29.1'
April	All days	-609.5	-9514.8	-63740.5	64449.7	9534.5	-93° 40.0'	-81° 29.6'
	5xQ days	-612.7	-9510.0	-63731.8	64440.4	9529.9	-93° 41.2'	-81° 29.7'
	5xD days	-611.4	-9522.2	-63755.8	64465.9	9542.1	-93° 40.5'	-81° 29.3'
May	All days	-636.9	-9513.9	-63767.8	64476.8	9535.4	-93° 49.8'	-81° 29.7'
	5xQ days	-625.6	-9515.2	-63741.6	64451.0	9535.8	-93° 45.7'	-81° 29.5'
	5xD days	-633.0	-9488.6	-63795.9	64501.0	9510.1	-93° 49.1'	-81° 31.3'
June	All days	-636.5	-9513.2	-63763.4	64472.3	9534.7	-93° 49.7'	-81° 29.7'
	5xQ days	-623.0	-9514.9	-63748.8	64458.0	9535.3	-93° 44.8'	-81° 29.6'
	5xD days	-646.8	-9504.5	-63765.8	64473.6	9526.8	-93° 53.6'	-81° 30.2'
July	All days	-630.8	-9507.8	-63743.8	64452.1	9528.9	-93° 47.8'	-81° 29.9'
	5xQ days	-617.7	-9513.9	-63721.4	64430.7	9533.9	-93° 42.9'	-81° 29.4'
	5xD days	-659.9	-9504.6	-63764.8	64472.8	9527.9	-93° 58.4'	-81° 30.1'
August	All days	-628.5	-9507.9	-63745.1	64453.4	9528.9	-93° 46.9'	-81° 29.9'
	5xQ days	-623.1	-9506.3	-63731.0	64439.2	9526.8	-93° 45.0'	-81° 29.9'
	5xD days	-653.9	-9499.3	-63793.7	64500.6	9522.2	-93° 56.3'	-81° 30.6'
September	All days	-629.1	-9510.9	-63740.4	64449.2	9531.9	-93° 47.1'	-81° 29.7'
	5xQ days	-619.2	-9506.3	-63714.1	64422.4	9526.5	-93° 43.6'	-81° 29.8'
	5xD days	-650.1	-9508.2	-63789.4	64497.6	9530.9	-93° 54.7'	-81° 30.1'
October	All days	-603.6	-9504.9	-63729.0	64437.1	9525.4	-93° 38.1'	-81° 29.9'
	5xQ days	-598.5	-9506.0	-63699.6	64407.8	9525.0	-93° 36.2'	-81° 29.7'
	5xD days	-633.8	-9466.2	-63802.4	64505.4	9493.0	-93° 50.4'	-81° 32.2'
November	All days	-586.3	-9512.7	-63720.7	64429.8	9531.8	-93° 31.7'	-81° 29.5'
	5xQ days	-558.0	-9514.5	-63687.4	64396.7	9531.4	-93° 21.5'	-81° 29.3'
	5xD days	-626.3	-9477.0	-63778.9	64482.7	9499.7	-93° 47.0'	-81° 31.7'
December	All days	-593.2	-9514.3	-63701.5	64411.0	9533.7	-93° 34.1'	-81° 29.3'
	5xQ days	-586.2	-9514.9	-63677.6	64387.4	9533.4	-93° 31.6'	-81° 29.1'
	5xD days	-661.3	-9496.8	-63773.4	64480.5	9521.6	-93° 58.9'	-81° 30.5'
Annual	All days	-608.3	-9514.8	-63730.1	64439.5	9534.8	-93° 39.5'	-81° 29.5'
Mean	5xQ days	-602.6	-9514.3	-63712.5	64421.8	9533.6	-93° 37.5'	-81° 29.4'
Values	5xD days	-629.1	-9503.0	-63764.3	64472.0	9525.0	-93° 47.4'	-81° 30.2'

(Calculated: 16:50 hrs., Wed., 16 Feb. 2005)

Hourly Mean Values

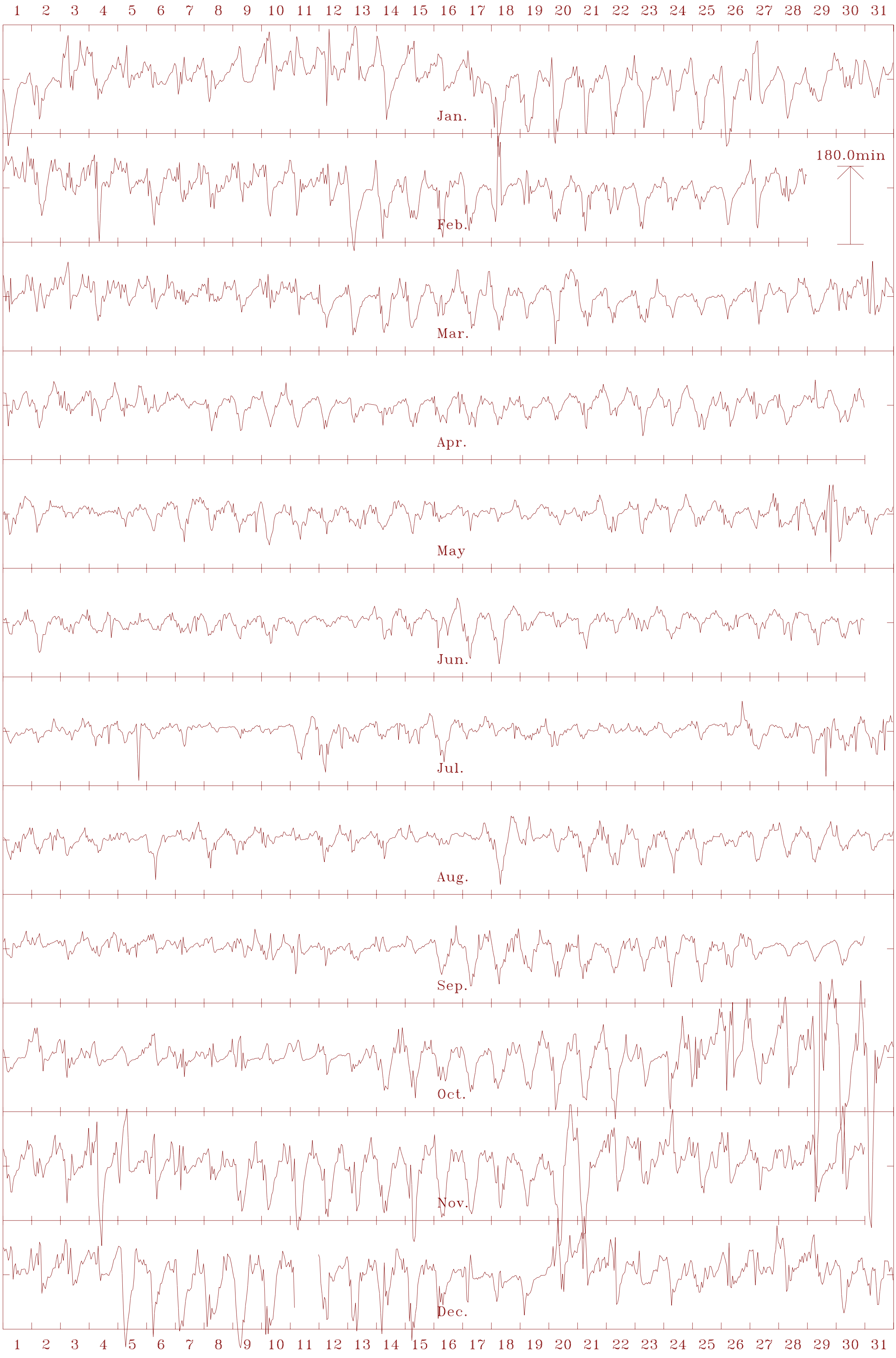
The charts on the following pages are plots of hourly mean values.

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.

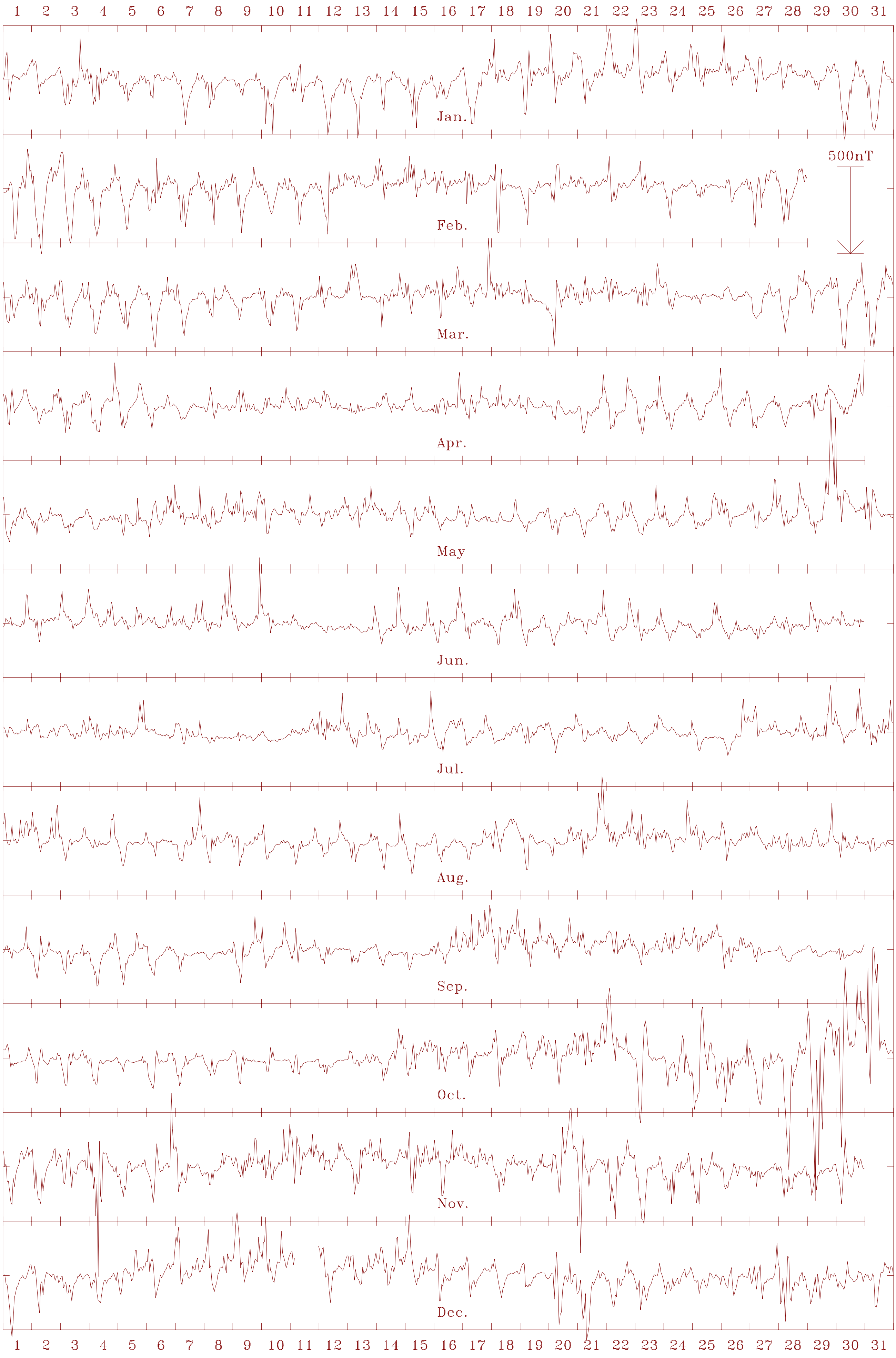
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Casey Stn. 2003 Horizontal intensity (H). Scale: 30.0 nT/mm. Mean: 9535 nT

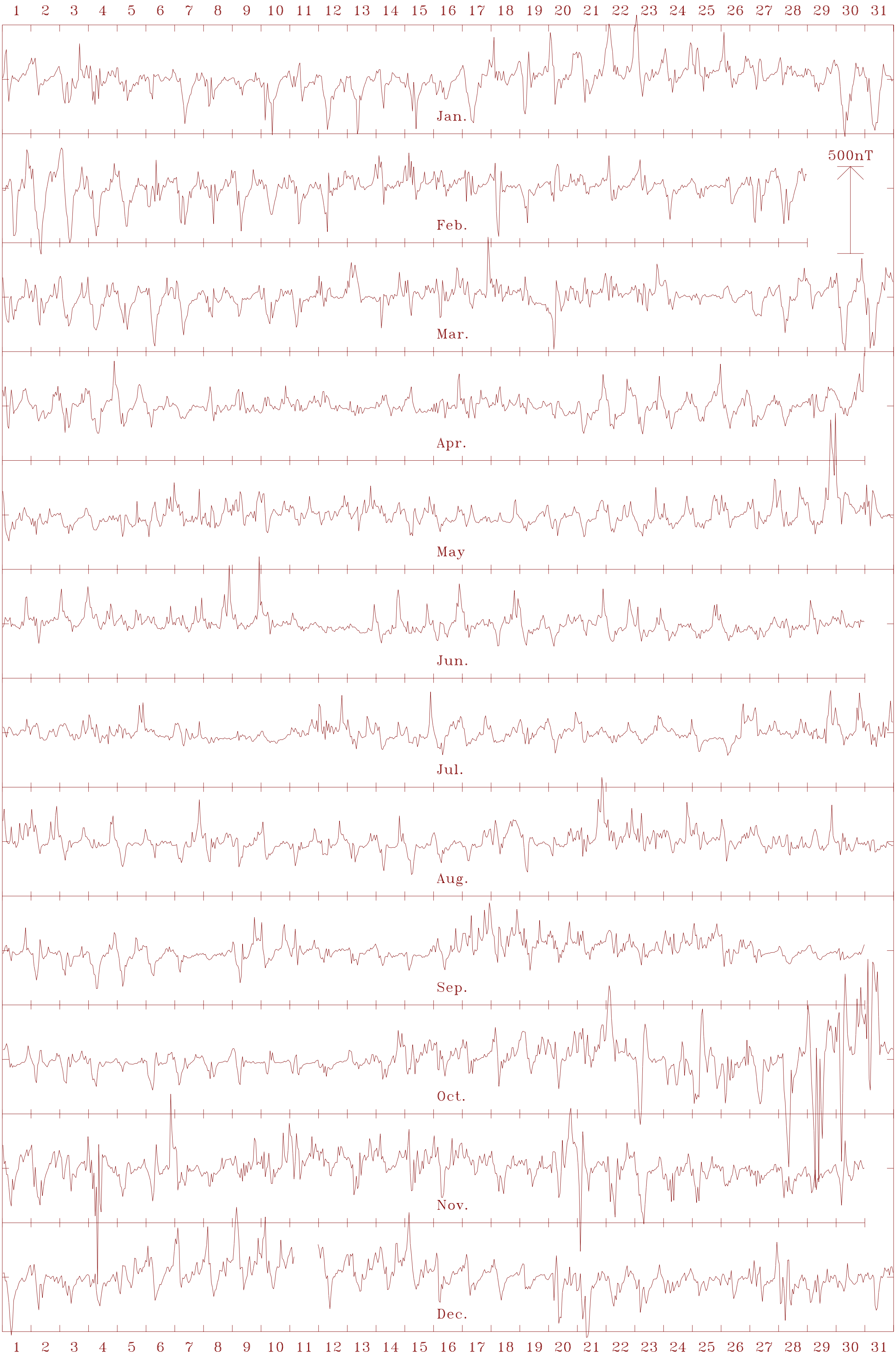
Casey Stn. 2003 Declination (east) (D). Scale: 12.0 min/mm. Mean: −93.66 deg.

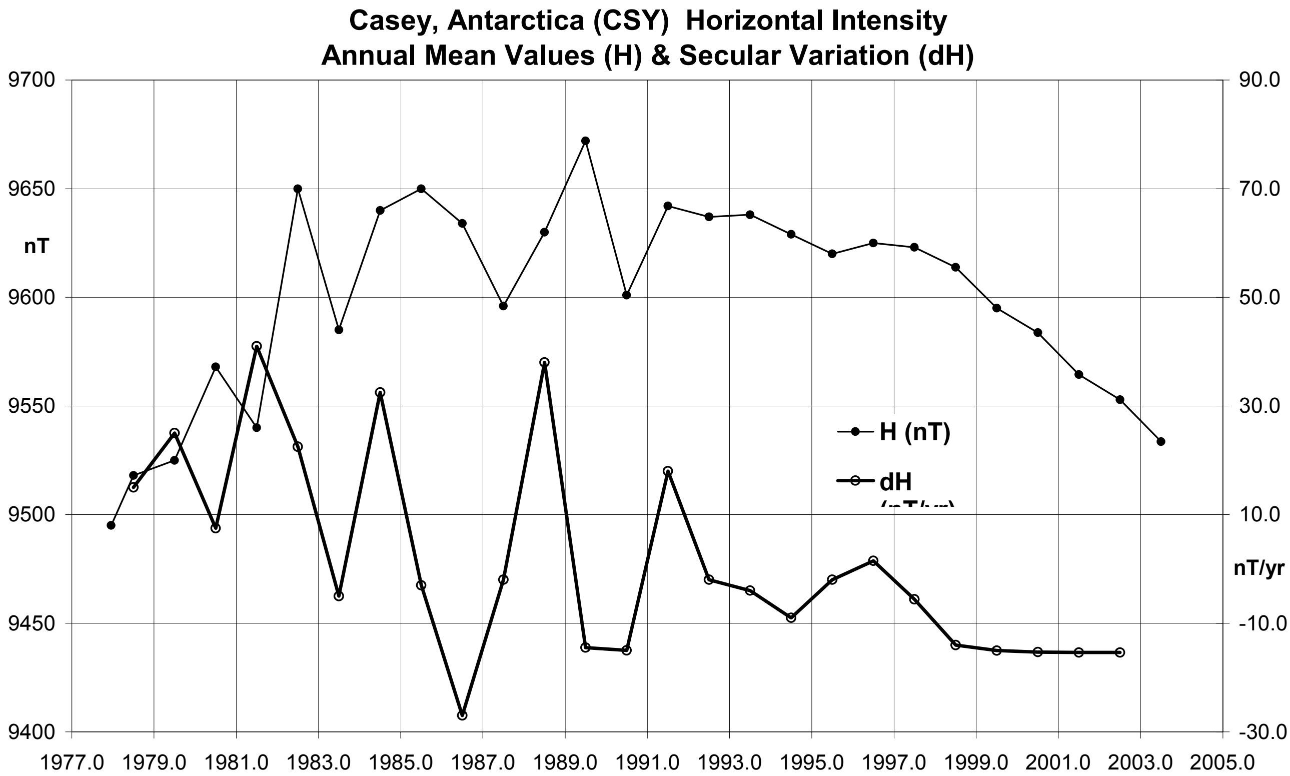


Casey Stn. 2003 Vertical intensity (Z). Scale: 30.0 nT/mm. Mean: -63730 nT

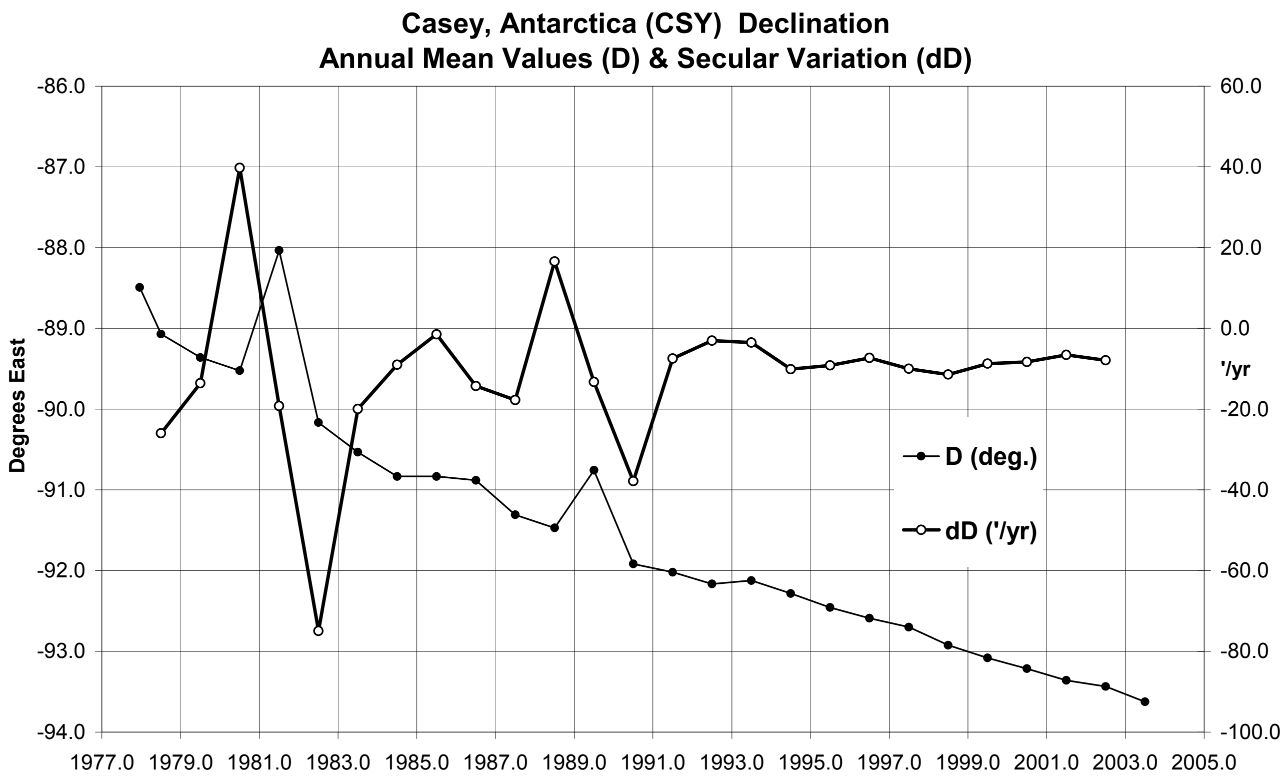


Casey Stn. 2003 Total intensity (F). Scale: 30.0 nT/mm. Mean: 64440 nT

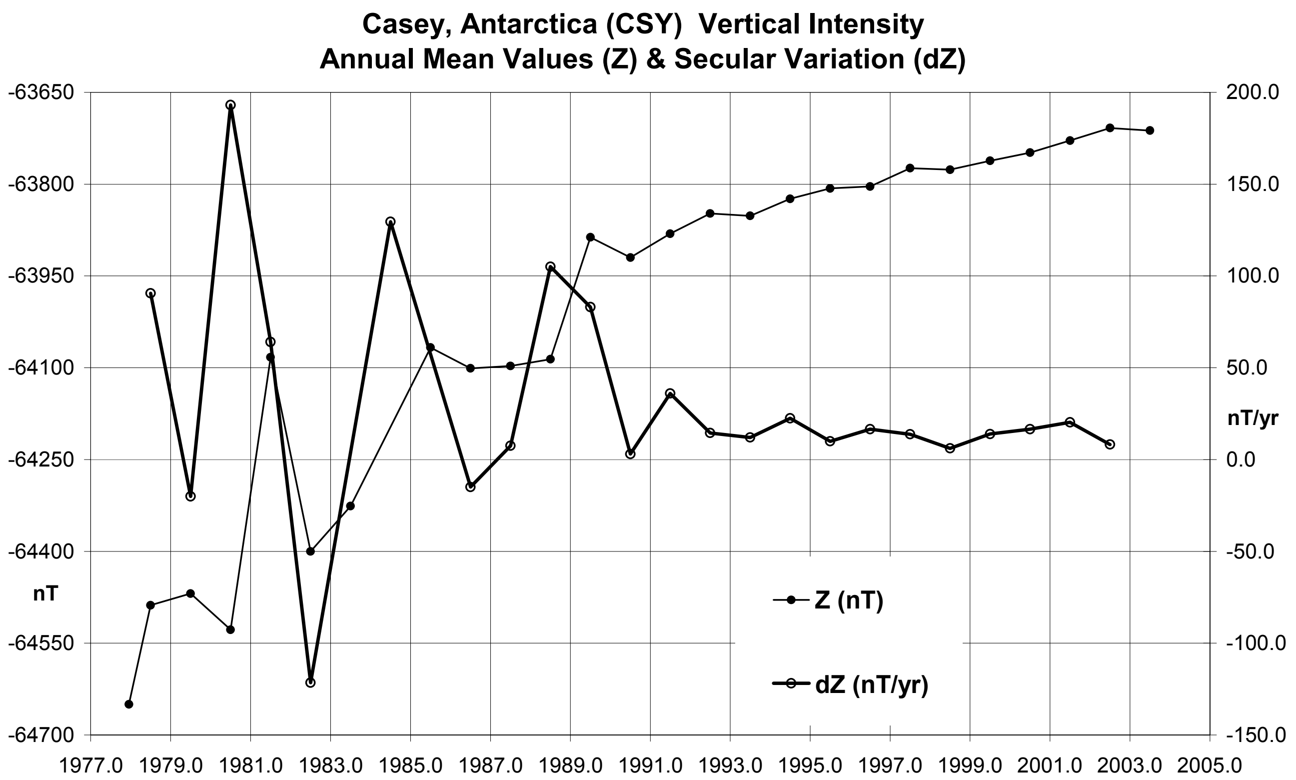




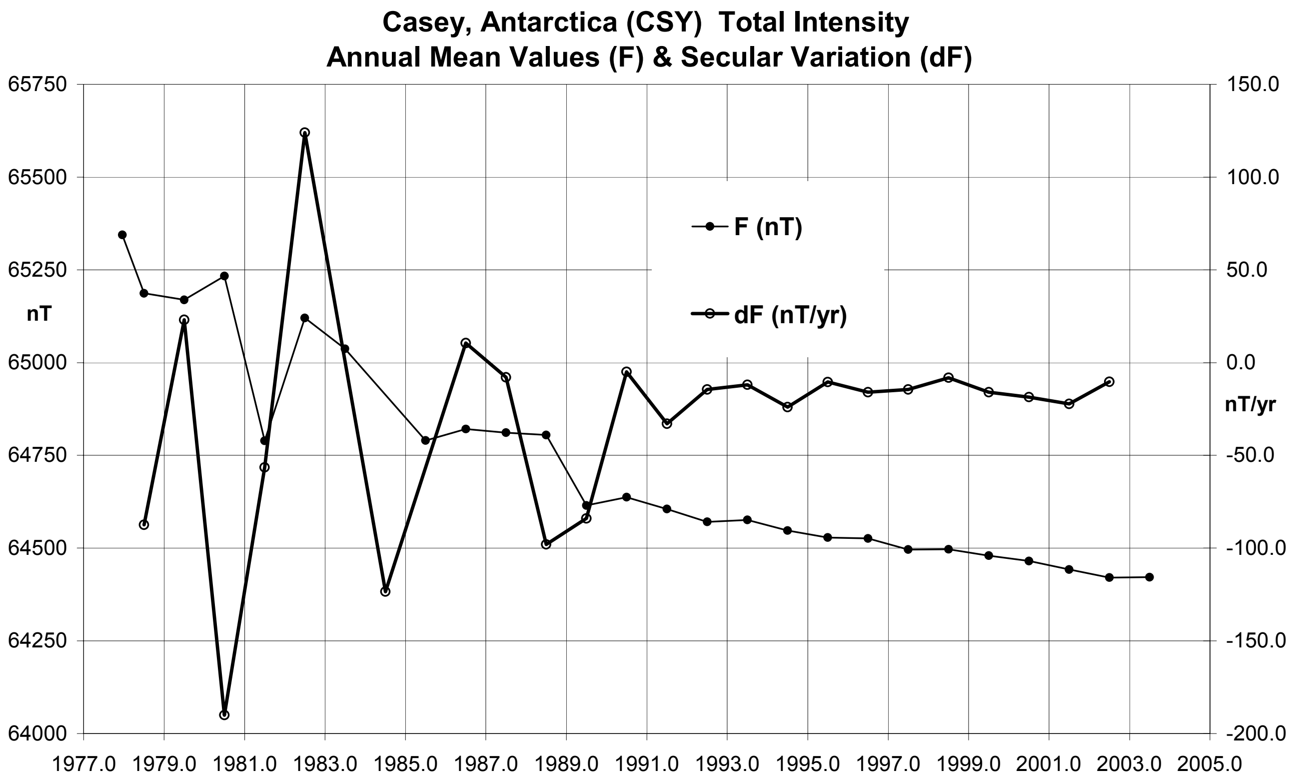
Casey, Antarctica (CSY) Horizontal Intensity
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH
9700
9650
9600
9550
9500
9450
9400
90.0
70.0
50.0
30.0
10.0
-10.0
-30.0
1977.0 1979.0 1981.0 1983.0 1985.0 1987.0 1989.0 1991.0 1993.0 1995.0 1997.0 1999.0 2001.0 2003.0 2005.0



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
nT
-64550
-64700
200.0
150.0
100.0
50.0
nT/yr
0.0
-50.0
-100.0
-150.0
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
Z (nT)
dZ (nT/yr)



Casey, Antarctica (CSY) Total Intensity
Annual Mean Values (F) & Secular Variation (dF)
65750
65500
65250
nT
65000
64750
64500
64250
64000
150.0
100.0
50.0
0.0
nT/yr
-50.0
-100.0
-150.0
-200.0
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
F (nT)
dF (nT/yr)

Significant Events: CSY, 2003

Apr.10 Heater in Absolute hut broken after a blizzard. Heater repaired using a larger stainless steel coil.

Jul. 25, Sept 07, Sep. 14, Sep. 15: A 20−30 minute cyclic pattern was present in the X, Y and Z variometer components.

Nov 28 PPM G816_1024 was dropped and broken. No absolute observations until January 2004

CSY 2003 – Data losses:

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 2003. These data were removed from the GA data set.

There was no PPM recording variations in total intensity at Casey during 2003. The periods of data loss that follow refer to EDA fluxgate variometer data.

Aug. 31 0213−0214 (2m), 0217−0238 (22m)

Dec 11 0403−0408 (6m); 0416−2252 (18h 37m)

Dec 24 0031−0038 (8m)

Distribution of CSY data during 2003

Preliminary Monthly Means for Project Ørsted

- Emailed monthly throughout 2003 to IPGP.

1-minute & Hourly Mean Values (WDC format)

- 2002: WDC-A, Boulder, USA (sent 13 May 2003)
- 2003: WDC-A, Boulder, USA (sent 02 Sep. 2004)

1-minute Values (INTERMAGNET format)

- 2002: INTERMAGNET GIN Paris (sent 14 May 2003)
- 2003: INTERMAGNET GIN Paris (sent 03 Sep. 2004)

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.

Casey & Davis Notes and Errata (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*.

MAWSON OBSERVATORY

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 the principal observation pier (A) of the observatory are:

- 3-character IAGA code: MAW
- Geographic latitude: 67° 36' 14" S
- Geographic longitude: 62° 52' 45" E
- Geomagnetic† : Lat. -73.09°; Long. 110.17°
  † Based on the IGRF 2000.0 model updated to 2003.5
- Elevation above mean sea level (top of pier A): 12 metres
- Lower limit for K index of 9: 1500 nT.
- Azimuth of principal reference mark (BMR89/1) from Pier A: 350° 36.9'
- Distance to azimuth mark BMR89/1: 112 metres
- Observers in Charge: Kerry Steinberner (2003, GA/BoM)
  Ray Hegarty (2004, GA/BoM)

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 2003. 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.

MAW – Variometers (cont.)

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 temperature varied by about 5.5°C during the year, and by at most 2°C between absolute observations (then only on unusual conditions).

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 fail. This system, also in the Variometer House, was tested during a service visit by a Geomagnetism project officer (PGC) in January 2003, but otherwise left powered off during 2003.

The F variometer performed poorly on many occasions during the latter half of 2003. It was not clear whether the problem was in the instrument or caused by some radio, electrical, or magnetic interference.

Absolute Instruments and Corrections

The principal absolute magnetometers used to calibrate the recording variometers at Mawson in 2003 were a Danish fluxgate magnetometer (D26035) mounted on a Zeiss 020B theodolite (serial 311542) and two Elsec model 770 PPMs (serial 199 was the primary instrument until 18 March 2003, and serial 210 was the primary instrument thereafter.)

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

Absolute Instruments and Corrections (cont.)

Instrument comparisons (which were corrected to the Australian Magnetic Standard held at Canberra) performed at Mawson in January 2003 indicated corrections to the absolute magnetometers in use at Mawson:

- +1.4 ± 1.5nT to Elsec 770/199. This was consistent with the correction of +1.6nT applied in 2001 and 2002.
- −0.2 ± 1.0nT for Elsec 770/210, consistent with a correction of −0.6nT ± 0.5nT measured in Canberra in January 2003.
- inconclusive values of +0.3 ± 0.3' in D, and −0.1 ± 0.1' in I) for DIM D26035/311542

This is consistent with a measured difference throughout 2003 of

$$F/E770\_210 = F/E770\_199 + 1.7 \pm 0.5nT.$$

Frequency tests indicated no difference between the E770 instruments and the Australian Standards, so the corrections are probably due to some small contamination in the sensors.

For standardization with the Australian Magnetic Standard held at Canberra the corrections applied in 2001 and 2002 have been retained to the end of March 2003, ie a correction of +1.6nT has been applied to the PPM readings, and corrections of zero have been applied to the DIM readings. These resulted in baseline corrections of:

$$\Delta X = +0.3 \text{ nT} \qquad \Delta Y = -0.5 \text{ nT} \qquad \Delta Z = -1.5 \text{ nT}.$$

Zero corrections have been applied from April 2003.

Secondary instruments were used monthly to maintain calibration in case of failure of the primary instruments. They included an Askania declinometer (serial 630332) and three horizontal magnetometers (QHM serial 300, 301, and 302). The declinometer and QMHs were used on Askania circle 611665.

The average α-parameter and H and D corrections to make the QHMs agree with baselines determined from the primary instruments during 2003 were:

QHM300: $\alpha = +12.6 \pm 0.4'$ $\Delta H = -0.8 \pm 1.3nT$, $\Delta D = -1.2 \pm 0.7'$

QHM301: $\alpha = -12.6 \pm 0.3'$ $\Delta H = +5.8 \pm 1.7nT$, $\Delta D = +1.0 \pm 0.8'$

QHM302: $\alpha = -01.4 \pm 0.3'$ $\Delta H = -2.8 \pm 1.9nT$, $\Delta D = +0.5 \pm 0.5'$

No corrections were applied to observations with these QHMs.

These calculations used the QHM constants in the table below:

QHM	K	k_1 (e-5)	k_2 (e-10)	α-factor	collimation
300	7828.0	39.4	69.0	2.22e5	22.5'
301	8230.5	39.7	90.0	0	72.5'
302	7690.1	42.0	90.0	0	27.0'

The average E-I-parameter and D correction to make the Askania declinometer agree with baselines determined from the primary instruments during 2003 were:

$$E\text{-}I = +1.5' \pm 0.4' \qquad \Delta D = +0.3' \pm 0.4'$$

Baselines

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

$$\sigma_X = 1.6nT \quad \sigma_Y = 1.6nT \quad \sigma_Z = 1.0nT.$$

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

$$\sigma_F = 1.0nT \quad \sigma_D = 17'' \quad \sigma_I = 7''.)$$

The adopted baselines fail to explain changes in F-check (the difference between the vector and scalar variometers); especially a 6nT drift from mid-January to the end of March 2003.

Operations

The 2003 observers were employed jointly by Geoscience Australia (GA) and the Bureau of Meteorology (BoM) and were members of the Australian National Antarctic Research Expedition (ANARE). The Mawson Station personnel changeover each summer, with varying amounts of overlap.

MAW – Operations (cont.)

The 2003 observer (KS) arrived at MAW in December 2002 and took over the responsibility for operating the observatory on 14 December 2002. The 2002 observer (AJ) departed in December 2002 after a brief changeover. The 2004 observer (RH) who arrived on 17 November 2003, assumed responsibility for the observatory on 20 November 2003, the day that the 2003 observer departed.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance as required. In 2003 the observer performed absolute observations once per 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 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 unacceptablel 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 2003, either corrupting data or the computer clock, or halting the computer outright as on days in March, April, June, August and September, and accounting for almost all of the 2.5% data loss for the year.

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.

A GA Geomagnetism Project officer (PGC) visited the observatory from 26 January to 2 February 2003. This was the first ongoing member of the GA Geomagnetism group to visit since the observing duties became part-time in 1998. Although most of the visit was used to install seismic equipment for the Comprehensive Test Ban Treaty Organisation, some time was spent comparing absolute magnetometers, establishing a set of sites around the observatory for absolute observations to check for encroachment of contamination in the future and reorganising the variometer building. A considerable amount of obsolete equipment was finally removed from the old geophysics office known as *Wombat* – most was discarded, but the OIC (KS) was left with the task of finalising the move of the office to the Aeronomy building.

During the maintenance visit the F-differences at several sites around the Absolute Pier were measured for future reference to monitor the magnetic integrity of the observatory:

F at Pier A	=	F at BMR85/2	+ 18.7	± 0.5 nT
F at Pier A	=	F at BMR89/1	+ 15.9	± 0.5 nT
F at Pier A	=	F at BMR89/2	+ 10.3	± 0.5 nT
F at Pier A	=	F at ShortPeg	− 1.9	± 0.5 nT

All non-Pier-A measurements were at taken 1.6m above ground level (Not above mark level).

On 15 September 2003, the OIC measured the vector difference between the Absolute Pier A and BMR89/2.

MAW – Operations (cont.)

Although the DIM results had some larger than expected χ^2 values and instrumental parameter variations, they may serve as benchmarks for future measurements:

D at Pier A = D at BMR89/2 − 3.1' ± 0.5'
I at Pier A = I at BMR89/2 − 0.7' ± 0.5'
F at Pier A = F at BMR89/2 + 10.4 ± 0.5 nT

The F-difference is consistent with the January measurements, even though there were some changes to the Mawson station environment (the installation of some wind turbines).

Plans to measure the vector difference to the remote station at mark LEE were not realised during 2003.

In January 2003, a round of angles using 7 marks confirmed that all marks except for the disused Mark-C (sometimes known as SOH) were stable. Mark-C readings had a small difference from 1989 measurements of 0.1', but there had been physical alterations to this artificial mark in the intervening interval.

MAW 2003 – Data Loss

Jan 27 0907−0908 (2 min) All channels: Maintenance.

Jan 29 0455 (1 min) All channels: Maintenance.

Mar 16 1701 to 19 / 0300 (2d 10h 00m) All channels: Although data acquisition continued, a blizzard caused undetermined timing errors.

Apr 13 0824 to 15 / 0339 (1d 19h 16m) All channels: Blizzard.

Apr 15 0340−0540 (121 min) F-channel only: Blizzard.

Apr 15 0549 (1 min) All channels: Maintenance.

Jun 24 1540 to 25 / 0810 (16h 31m): All channels. Blizzard

Aug 16 0803 to 18 / 0358 (1d 19h 56m) All channels: Blizzard

Sep 02 2313−2314 (2 min) All channels: Blizzard.

Sep 02 2326 to 05 / 1313 (2d 13h 48m) All channels: Blizzard.

Sep 29 0501−0505 (5 min) All channels: Maintenance recovery from blizzard malfunctions.

Oct 15 0900−0939 (40 min) All channels: Maintenance.

Problems in data:

Throughout 2003 the timing on the data was sometimes in error by up to, but not more than, 2 seconds.

Mawson, Antarctica 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 101-102.

Year	Days	D		I		H	X	Y	Z	F	Elts*
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
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	8.7	-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
1965.5		-61	12.6	-69	13.1	18356	8958	-16022	-48368	51734	DHZ
1966.5		-61	24.0	-69	9.6	18362	9014	-15997	-48235	51612	DHZ
1967.5		-61	34.4	-69	7.2	18374	9068	-15980	-48168	51553	DHZ
1968.5		-61	43.8	-69	5.2	18365	9107	-15948	-48060	51449	DHZ
1969.5		-61	53.0	-69	3.4	18353	9144	-15913	-47954	51346	DHZ
1970.5		-62	0.5	-69	0.4	18358	8621	-16208	-47840	51241	DHZ
1971.5		-62	5.3	-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	5.8	-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	4.4	-68	10.7	18475	8120	-16595	-46142	49703	XYZ
1989.5		-64	12.8	-68	9.7	18474	8160	-16574	-46099	49663	XYZ
1990.5		-64	21.1	-68	6.4	18492	8208	-16570	-46015	49592	XYZ
1991.5		-64	28.8	-68	4.2	18502	8250	-16561	-45957	49542	XYZ
1992.5	Q	-64	36.5	-68	-1.7	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	0.4	-67	55.3	18550	7838	-16813	-45731	49350	ABC
1996.5	Q	-65	9.2	-67	53.5	18561	7799	-16843	-45692	49318	ABC

continued …

MAW – Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
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	-5.2	-67	-48.2	18581	7532	-16986	-45540	49185	ABC
2003.5	Q	-66	14.7	-67	48.7	18570	7481	-16997	-45532	49174	ABC
1992.5	A	-64	36.9	-68	-2.8	18499	7930	-16712	-45894	49482	XYZ
1993.5	A	-64	44.2	-68	-0.7	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	0.9	-67	56.7	18532	7828	-16798	-45741	49352	ABC
1996.5	A	-65	9.8	-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	-5.8	-67	-49.3	18568	7524	-16975	-45546	49185	ABC
2003.5	A	-66	15.6	-67	50.7	18546	7466	-16976	-45546	49177	ABC
1992.5	D	-64	39.6	-68	-5.2	18466	7904	-16689	-45907	49482	XYZ
1993.5	D	-64	45.9	-68	-3.0	18476	7877	-16713	-45847	49430	ABC
1994.5	D	-64	55.3	-68	-1.9	18476	7831	-16734	-45804	49390	ABC
1995.5	D	-65	1.7	-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	-7.6	-67	-51.2	18540	7504	-16953	-45552	49180	ABC
2003.5	D	-66	17.4	-67	53.3	18510	7443	-16947	-45556	49173	ABC

* Elements ABC indicates non-aligned variometer orientation

Distribution of MAW data during 2003

Preliminary Monthly Means for Project Ørsted

- Sent monthly by e-mail to IPGP

1-minute & Hourly Mean Values (WDC format)

- 2002 data: WDC-A, Boulder, USA (sent 27 June 2003)
- 2003 data: WDC-A, Boulder, USA (sent 19 Apr. 2004)

1-minute Values (INTERMAGNET format)

- 2002 data: WDC-C1, Copenhagen, Den. (sent 27 June 2003)
- 2003 data: WDC-C1, Copenhagen, Den. (sent 19 Apr. 2004)

MAW Significant Events 2003

Dec 14 (2002) New OIC (KS) assumed responsibility for the magnetic observatory.

Jan 17 09:28:27: There was a sudden change in RCF B-channel of +300 counts (7.5nT). Unknown cause.

Jan 24 Radio modem in the variometer house failed causing communications to GA to cease.

Jan 26 to Feb 02: Geomagnetism Project officer (PGC) from GA performed inspections, calibrations, and seismic installations.

Jan 27 0900: A screen on one of the PCs in variometer house was replaced.

Jan 30 Radio modem in variometer house reconfigured to re-establish communications to GA.

Feb 04 Unexplained step in RCF variometer data. Adopted a reversal of the step on 16 March.

Mar 18 Adopted Elsec 770_210 in favour of 770_199 as the local standard-F instrument.

MAW Significant Events (cont.)

Aug 12 DIM theodolite vertical circle clamp tightened.

Aug 13 Variometer electrical cabinet door removed for replacement.

Oct 15 Variometer electrical cabinet door replaced using original hinges and screws as well as three additional aluminium screws.

Nov 17 New OIC (RH) arrived at the station.

Sep 15 Vector difference to BMR89/2 measured.

Nov 20 Finishing OIC (KS) departed the station and new OIC (RH) assumed responsibility for magnetic observatory.

Dec 16 04:38 Some undocumented disturbance to variometer just before observations.

2003 Throughout 2003, three wind turbine electricity generators were to be installed at Mawson; one of them 150m from the Absolute Pier A. The generators have a DC segment for AC/AC conversion. The expected effect is <0.1 nT at Pier A.

K indices

The table on the next page shows Mawson K indices for 2003. 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.

K indices & Daily K sums at Mawson Antarctica (K=9 limit: 1500 nT) for 2003

Date	January	February	March	April	May	June	Date
01	3433 3334 26	5543 4476 38	6333 3366 33	6653 3664 39	D 7565 5666 46	3555 3364 34	01
02	4333 4333 26	D 7666 6756 49	3543 3255 30	4565 3666 41	3553 2365 32	D 5766 4445 41	02
03	4344 4755 36	D 5454 4675 40	4343 3576 35	4434 3356 32	Q 4534 3455 33	6554 5367 41	03
04	6554 4355 37	D 4675 3366 40	D 5664 4466 41	D 5544 4576 40	Q 3432 2113 19	5565 5665 43	04
05	3432 4446 30	5554 4445 36	5534 3566 37	D 5544 3565 37	3332 3553 27	Q 4434 3355 31	05
06	Q 3333 2335 25	4444 4645 35	6664 5666 45	Q 3442 2444 27	4443 4667 38	3554 3556 36	06
07	Q 4433 3554 31	5444 4473 35	6544 4265 36	Q 4332 4321 22	D 6666 5775 48	6655 4446 40	07
08	Q 3332 1333 21	5544 4455 36	Q 4332 3445 28	3555 4422 30	D 7675 4678 50	4655 4777 45	08
09	Q 4441 2343 25	5543 4654 36	4553 3356 34	5564 4422 32	6665 4347 41	4664 4447 39	09
10	4543 4544 33	4664 3355 36	3543 3656 35	3564 4455 36	-756 3355 --	5455 4353 34	10
11	5532 3345 30	Q 5663 2333 31	5553 3312 27	3544 3466 35	6565 5534 39	4564 3344 33	11
12	3553 3343 29	2553 3466 34	Q 4333 2125 23	Q 6433 4331 27	3565 4576 41	Q 2342 3225 23	12
13	5434 2324 27	Q 4333 3215 24	6553 4121 27	Q 363- ---- --	4555 4467 40	Q 5432 2236 27	13
14	4563 3333 30	5534 4434 32	3445 5465 36	---- ---- --	5555 4776 44	3664 4555 38	14
15	5443 3343 29	D 6645 5555 41	6454 4545 37	-564 3224 --	4564 3556 38	6655 2456 39	15
16	Q 4333 3254 27	4564 4457 39	4454 55-- --	D 5555 4487 43	Q 5443 2245 29	D 3734 4467 38	16
17	3544 3223 26	6444 4334 32	D ---- ---- --	2465 5564 37	Q 5552 4342 30	D 6775 4426 41	17
18	4454 5434 33	4754 4327 36	---- ---- --	3664 4336 35	Q 3332 1254 23	D 6655 4577 45	18
19	4565 5355 38	4333 4347 31	-553 3333 --	Q 5442 2254 28	4552 3346 32	5554 4373 36	19
20	6544 4454 36	3564 4464 36	2455 5765 39	6662 3346 36	4444 3156 31	Q 3453 3445 31	20
21	5454 3336 33	3544 3466 35	5665 4237 38	6564 2475 39	6332 3566 34	6554 3447 38	21
22	D 5644 4447 38	4334 3433 27	6664 3247 38	5655 4565 41	8455 4463 39	Q 3454 2366 33	22
23	D 6533 4435 33	Q 5443 4355 33	4555 3466 38	3566 3475 39	3644 2555 34	7554 3365 38	23
24	6444 5666 41	Q 3323 3325 24	Q 5443 2233 26	5554 5457 40	5654 4367 40	6654 4--- --	24
25	D 4675 5434 38	Q 4232 2122 18	Q 3322 2221 17	D 4555 4477 41	6656 3446 40	---3 3546 --	25
26	D 6554 4355 37	3445 3336 31	Q 2432 3255 26	5444 3576 38	7444 3166 35	5454 4344 33	26
27	4521 1324 22	D 6554 5666 43	6565 4456 41	4663 2365 35	6453 3386 38	5555 4665 41	27
28	5673 3235 34	5345 3566 37	5554 3576 40	6664 2134 32	7555 4566 43	D 5666 4646 43	28
29	4343 4566 35		D 5564 3366 38	4441 4575 34	D 6654 6688 49	6666 3355 40	29
30	D 6565 5663 42		D 6554 4776 44	D 5555 4587 44	D 6543 3477 39	4665 3334 34	30
31	6655 4554 40		D 5555 6766 45		6852 3222 30		31
Mean K-sum	**31.9**	**34.5**	**34.6**	**35.6**	**36.7**	**37.0**	

Date	July	August	September	October	November	December	Date
01	3454 2245 29	D 7675 4567 47	4562 2474 34	4343 2145 26	7654 4566 43	5653 2236 32	01
02	5444 3335 31	6554 3575 40	5443 5336 33	4422 2365 28	5654 3475 39	4453 2233 26	02
03	6434 3367 36	5554 3376 38	---- ---- --	5653 3445 35	5653 4356 37	Q 3332 3334 24	03
04	6565 4456 41	Q 4443 2253 27	---- ---- --	Q 3343 2103 19	6477 4345 40	4532 3335 28	04
05	5664 4566 42	Q 2221 0136 17	---- 2445 --	2312 0225 17	Q 4321 2346 25	D 4675 7656 46	05
06	3333 4316 26	7464 3124 31	5433 3344 29	3322 2356 26	4432 3486 34	5555 5545 39	06
07	5454 3243 30	3332 4467 32	Q 3331 1214 18	6444 3466 37	4533 2444 29	5433 5555 35	07
08	Q 1111 1110 07	5775 3455 41	4210 1135 17	5433 2135 26	Q 4333 4453 29	D 4655 6565 42	08
09	Q 1442 2124 20	3544 4347 34	4334 4467 35	5332 2123 21	4544 5575 39	D 5655 6457 43	09
10	Q 3232 3234 22	6553 3344 33	7445 4366 39	Q 2120 1124 13	3655 5566 41	D 6655 5766 46	10
11	D 5564 3347 37	3333 3456 30	5634 3265 34	Q 4211 1024 15	D 6756 6776 50	D 6665 6656 46	11
12	D 8765 3345 41	6664 4575 43	4552 2223 25	Q 4122 3334 22	6555 4664 41	6554 4566 41	12
13	4554 3335 32	4543 3237 31	4432 2155 26	5432 3344 28	D 4455 6586 43	4555 5456 39	13
14	5454 3233 29	6443 2275 33	Q 4221 2235 21	D 4565 5577 44	4765 5456 42	4644 5675 41	14
15	7654 3277 41	3443 3336 29	4210 1155 19	3565 5576 42	D 4666 6766 47	7554 5656 43	15
16	D 5754 5457 42	Q 443- ---- --	D 6673 5465 42	6555 4667 44	D 5565 7657 46	4544 3465 35	16
17	6644 4256 37	---- ---- --	D 4675 6876 49	6564 4346 38	5665 5566 44	4432 3343 26	17
18	3553 3236 30	D -545 3666 --	D 5665 5866 47	4653 4556 38	5555 5765 43	Q 3442 2223 22	18
19	6445 3446 36	5544 2322 27	D 7565 5775 47	5664 5676 45	4544 4542 32	Q 4322 2213 19	19
20	4554 3237 33	2553 3446 32	5655 4666 43	5556 4577 44	D 3678 6775 49	3335 5655 35	20
21	Q 6532 1154 27	D 5675 5676 47	5454 4565 38	D 6565 6866 48	5564 3654 38	6654 4666 43	21
22	Q 5333 2251 24	D 7565 5667 47	5454 4472 35	6665 5632 39	5553 5766 42	5665 4555 41	22
23	4433 2445 29	D 5555 4565 40	3554 3352 30	Q 4232 2211 17	5664 4455 39	4434 4363 31	23
24	3220 1226 18	5555 4365 38	D 6764 5445 41	2335 6955 38	5433 4455 33	3532 3335 27	24
25	3453 2113 22	6764 3355 39	6575 4555 42	4442 5535 32	5664 3444 36	Q 4333 4323 25	25
26	4554 4565 38	6322 3555 31	4554 3666 39	5533 2255 30	4443 4445 32	4663 3335 33	26
27	6555 4464 39	Q 3244 3367 32	5332 1125 22	6655 3544 38	Q 3433 3143 24	5654 3336 35	27
28	4545 5446 37	5545 3353 33	Q 3133 2244 22	6666 3657 45	Q 3433 4323 25	6543 4454 35	28
29	D 4665 5587 46	2333 3473 28	Q 3223 1235 21	D 6699 7887 60	Q 5343 3335 29	Q 3234 4433 26	29
30	4565 4566 41	3653 3354 32	Q 2222 3335 22	D 9754 6777 52	4532 4654 33	4431 3373 28	30
31	D 7666 4676 48	Q 3442 3232 23		D 7775 6576 50		5335 4566 37	31
Mean K-sum	**32.6**	**34.1**	**32.2**	**34.1**	**37.5**	**34.5**	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	0	4	13	77	74	53	23	4	0	0	0
February	0	2	11	48	71	49	33	10	0	0	0
March	0	5	20	48	43	61	44	8	0	0	19
April	0	4	18	33	62	57	40	10	2	0	14
May	0	5	17	42	48	61	50	18	6	0	1
June	0	0	10	38	60	64	47	15	0	0	6
July	2	16	23	46	59	53	35	12	2	0	0
August	1	3	21	58	44	56	31	20	0	0	14
September	2	15	30	35	44	51	29	12	2	0	20
October	4	14	33	38	37	53	44	18	3	4	0
November	0	2	7	38	61	65	47	17	3	0	0
December	0	2	18	60	48	68	45	7	0	0	0
ANNUAL TOTAL	**9**	**72**	**221**	**561**	**651**	**691**	**468**	**151**	**18**	**4**	**74**

Monthly & 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	2003	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	7520.9	-16991.7	-45537.9	49183.3	18581.9	-66° 07.5'	-67° 48.1'
	5xQ days	7533.0	-17001.9	-45539.4	49190.0	18596.1	-66° 06.2'	-67° 47.2'
	5xD days	7502.0	-16984.3	-45528.8	49169.6	18567.6	-66° 10.2'	-67° 48.8'
February	All days	7501.4	-16979.8	-45548.9	49186.4	18563.1	-66° 09.9'	-67° 49.6'
	5xQ days	7495.0	-16985.8	-45545.3	49184.1	18565.9	-66° 11.4'	-67° 49.3'
	5xD days	7503.7	-16971.9	-45583.2	49215.9	18556.9	-66° 08.9'	-67° 50.9'
March	All days	7479.5	-16969.7	-45565.0	49194.5	18545.0	-66° 12.9'	-67° 51.2'
	5xQ days	7486.9	-16988.6	-45533.3	49172.7	18565.2	-66° 13.0'	-67° 49.1'
	5xD days	7479.3	-16959.1	-45607.9	49230.6	18535.3	-66° 12.1'	-67° 53.0'
April	All days	7459.3	-16967.8	-45559.5	49185.7	18535.1	-66° 16.2'	-67° 51.7'
	5xQ days	7481.7	-16999.8	-45536.1	49178.4	18573.4	-66° 14.7'	-67° 48.6'
	5xD days	7452.3	-16950.1	-45567.8	49186.3	18516.1	-66° 16.0'	-67° 53.2'
May	All days	7453.1	-16961.7	-45549.7	49173.7	18527.1	-66° 16.8'	-67° 52.0'
	5xQ days	7476.9	-16986.7	-45537.7	49174.6	18559.5	-66° 14.6'	-67° 49.6'
	5xD days	7437.2	-16935.9	-45546.7	49159.7	18497.2	-66° 17.5'	-67° 53.8'
June	All days	7450.4	-16971.6	-45545.3	49172.5	18535.0	-66° 18.0'	-67° 51.3'
	5xQ days	7469.1	-16986.3	-45531.3	49167.4	18555.9	-66° 15.9'	-67° 49.6'
	5xD days	7416.3	-16949.3	-45575.2	49187.6	18501.1	-66° 22.1'	-67° 54.3'
July	All days	7452.6	-16971.2	-45536.5	49164.5	18535.5	-66° 17.6'	-67° 51.1'
	5xQ days	7468.3	-16990.8	-45528.5	49166.1	18559.7	-66° 16.3'	-67° 49.3'
	5xD days	7412.7	-16927.7	-45561.4	49166.8	18479.8	-66° 21.1'	-67° 55.3'
August	All days	7446.0	-16970.1	-45546.4	49172.4	18531.9	-66° 18.6'	-67° 51.6'
	5xQ days	7463.9	-16990.0	-45517.9	49155.4	18557.3	-66° 17.0'	-67° 49.2'
	5xD days	7409.2	-16935.8	-45563.5	49171.0	18485.9	-66° 22.3'	-67° 55.0'
September	All days	7445.3	-16973.2	-45535.9	49163.6	18534.5	-66° 18.9'	-67° 51.1'
	5xQ days	7466.9	-16997.1	-45527.9	49167.6	18565.0	-66° 17.0'	-67° 48.9'
	5xD days	7410.9	-16930.2	-45541.4	49148.8	18481.4	-66° 21.6'	-67° 54.7'
October	All days	7455.9	-16977.6	-45551.5	49181.3	18542.9	-66° 17.5'	-67° 51.0'
	5xQ days	7468.5	-17001.2	-45525.6	49167.1	18569.3	-66° 17.1'	-67° 48.6'
	5xD days	7442.7	-16941.8	-45598.0	49210.7	18505.6	-66° 17.0'	-67° 54.7'
November	All days	7462.2	-16984.6	-45551.0	49184.1	18551.8	-66° 16.9'	-67° 50.4'
	5xQ days	7480.2	-17011.3	-45539.8	49185.5	18583.3	-66° 15.8'	-67° 48.1'
	5xD days	7414.1	-16909.7	-45516.5	49119.5	18464.4	-66° 19.5'	-67° 55.2'
December	All days	7468.6	-16998.0	-45524.1	49164.7	18566.6	-66° 16.8'	-67° 48.7'
	5xQ days	7475.3	-17020.6	-45525.3	49174.5	18589.9	-66° 17.4'	-67° 47.3'
	5xD days	7434.3	-16969.3	-45478.9	49108.1	18526.8	-66° 20.6'	-67° 50.1'
Annual	All days	7466.3	-16976.4	-45546.0	49177.2	18545.9	-66° 15.6'	-67° 50.7'
Mean	5xQ days	7480.5	-16996.7	-45532.3	49173.6	18570.0	-66° 14.7'	-67° 48.7'
Values	5xD days	7442.9	-16947.1	-45555.8	49172.9	18509.8	-66° 17.4'	-67° 53.2'

(Calculated: 14:10 hrs., Tue. 26 Oct. 2004)

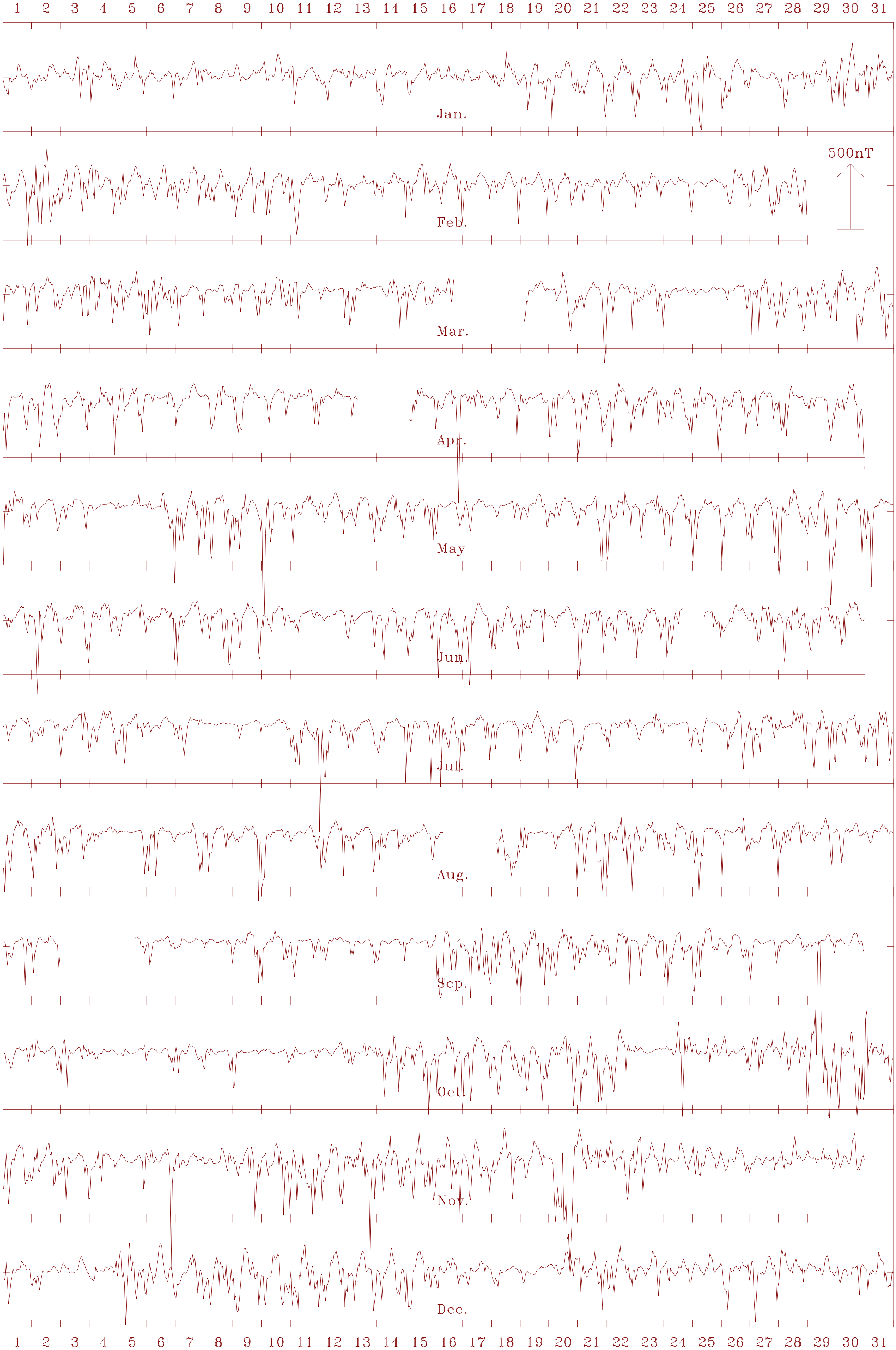
Hourly Mean Values

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

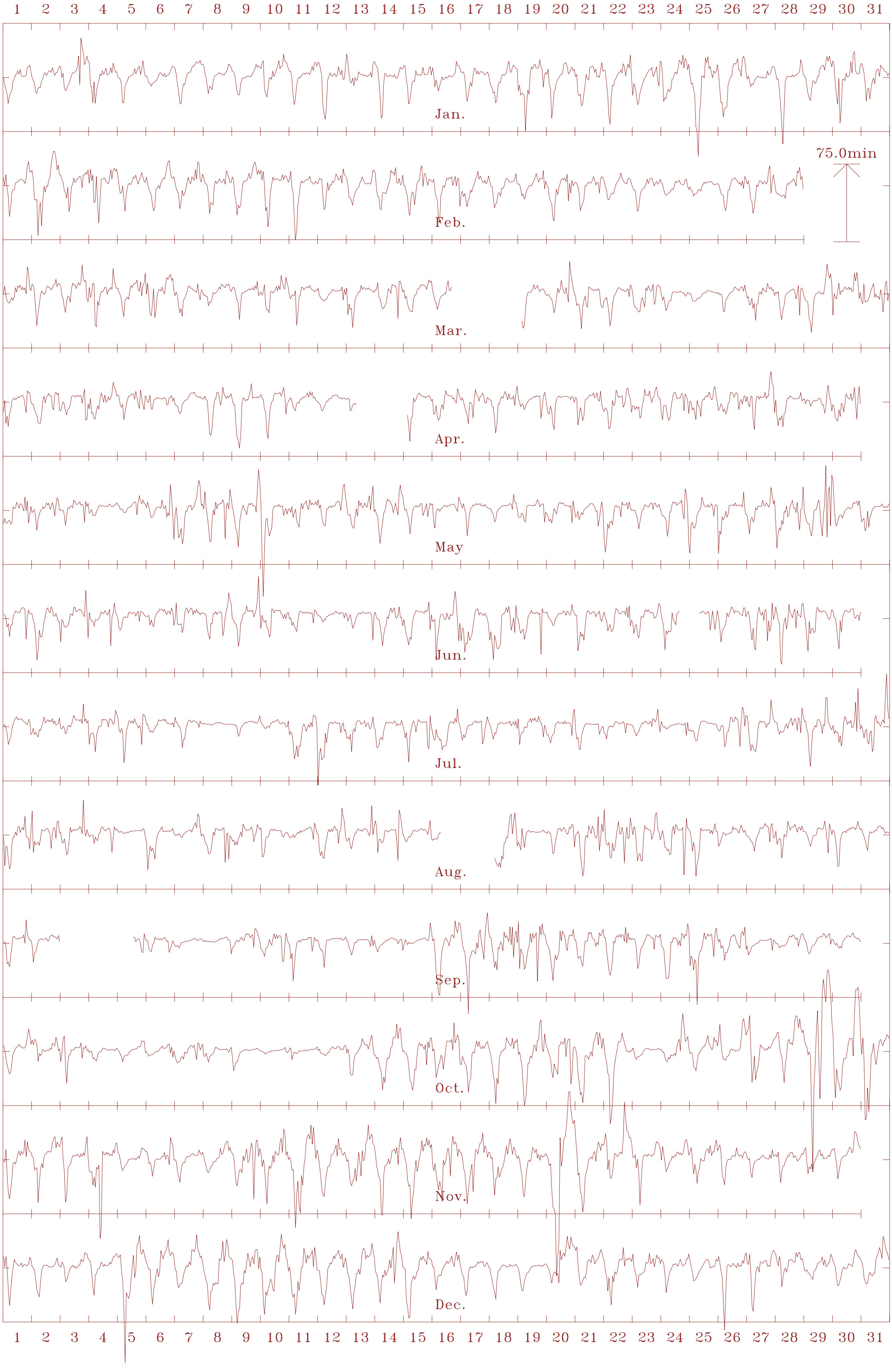
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

Mawson Stn. 2003 Horizontal intensity (H). Scale: 40.0 nT/mm. Mean: 18546 nT

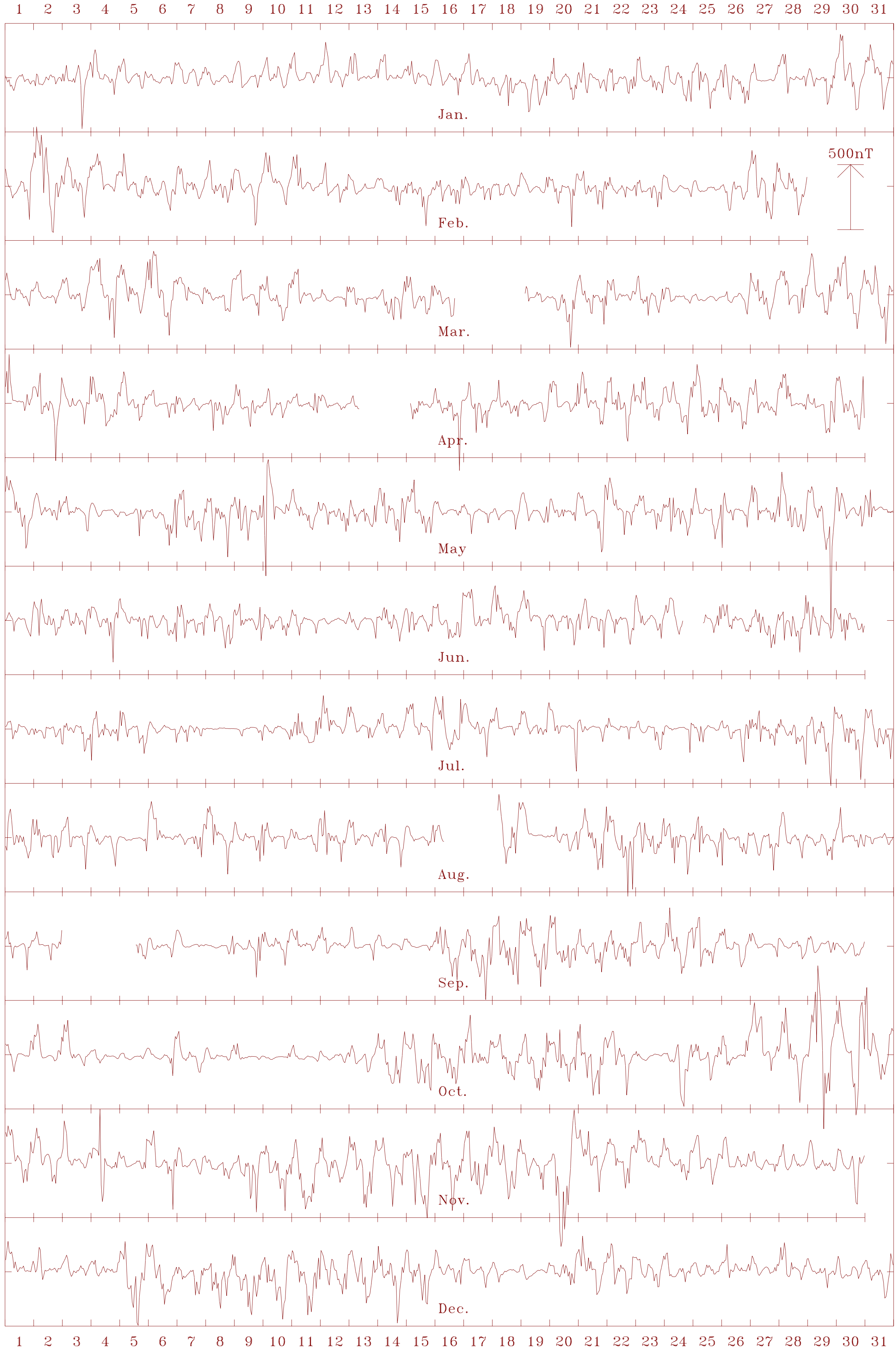


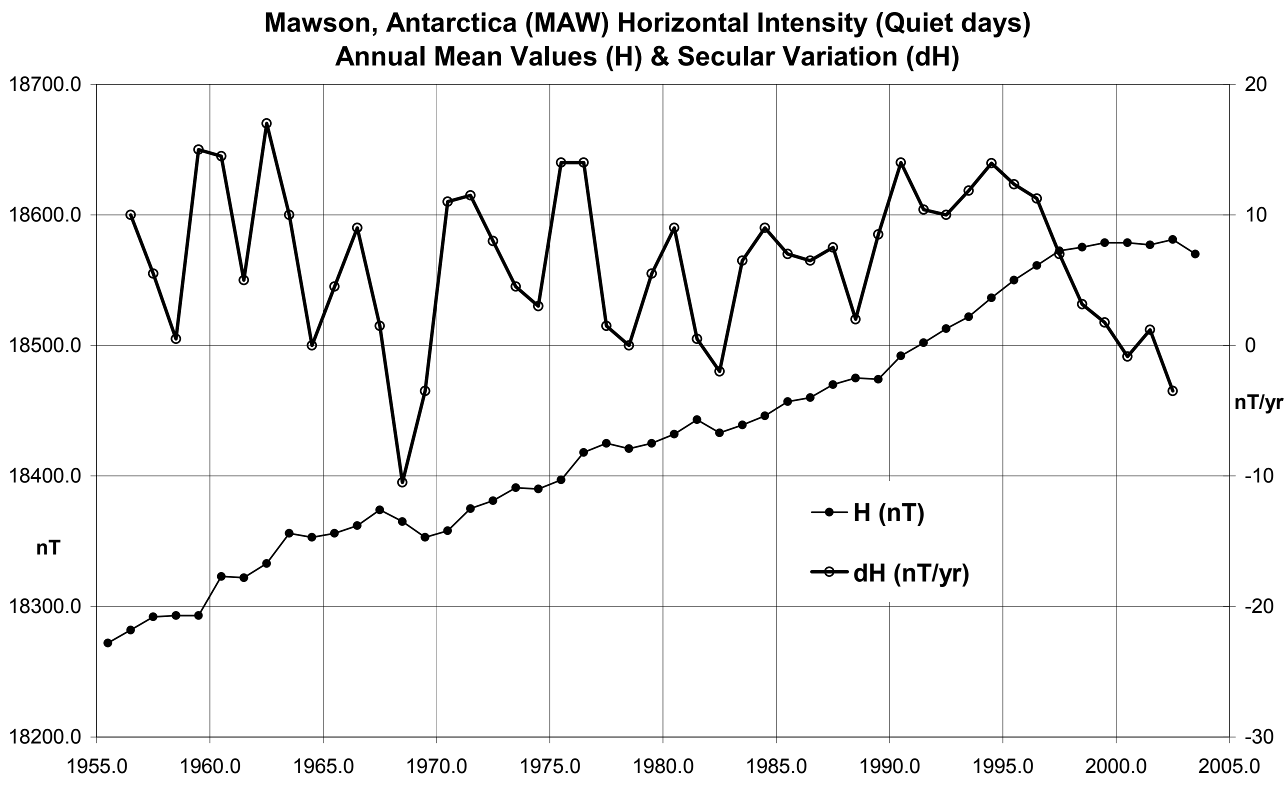
Mawson Stn. 2003 Declination (east) (D). Scale: 5.00 min/mm. Mean: −66.26 deg.



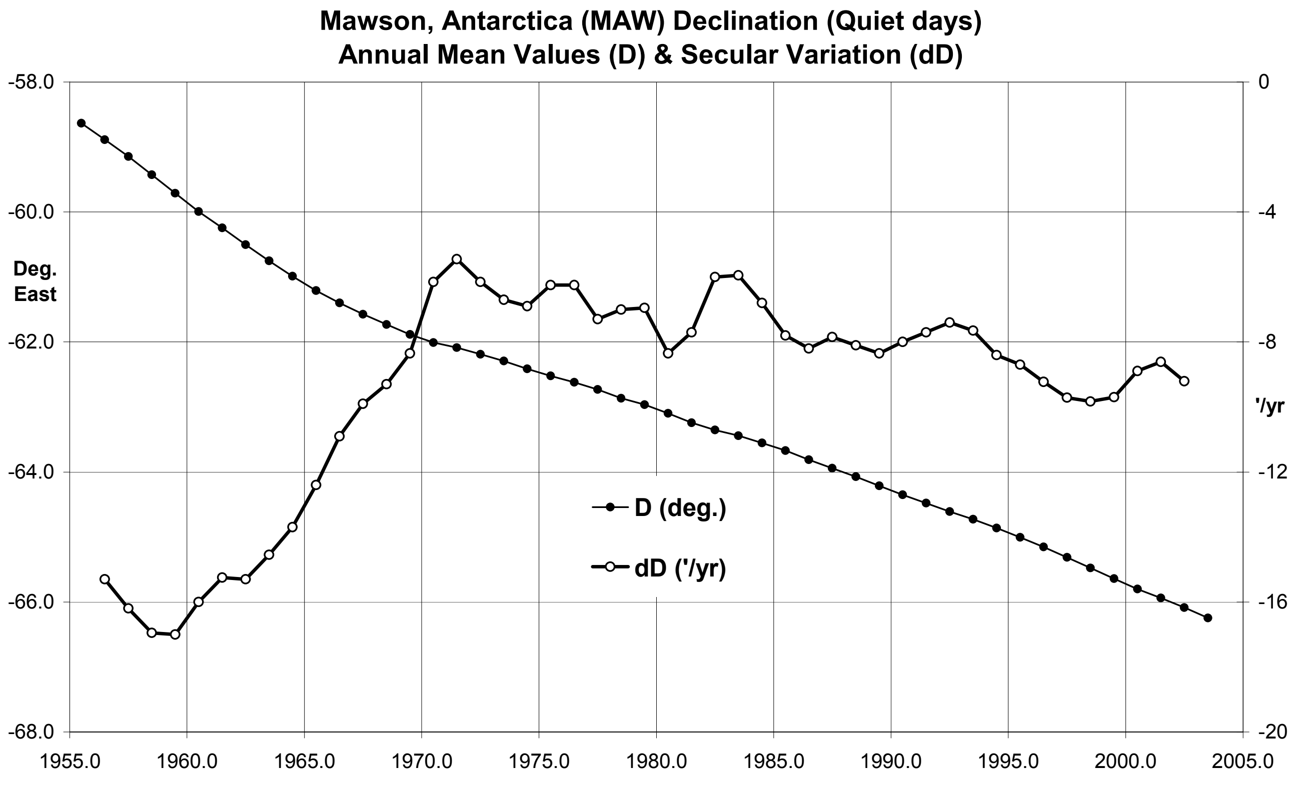
Mawson Stn. 2003 Vertical intensity (Z). Scale: 40.0 nT/mm. Mean: -45546 nT

Mawson Stn. 2003 Total intensity (F). Scale: 40.0 nT/mm. Mean: 49177 nT



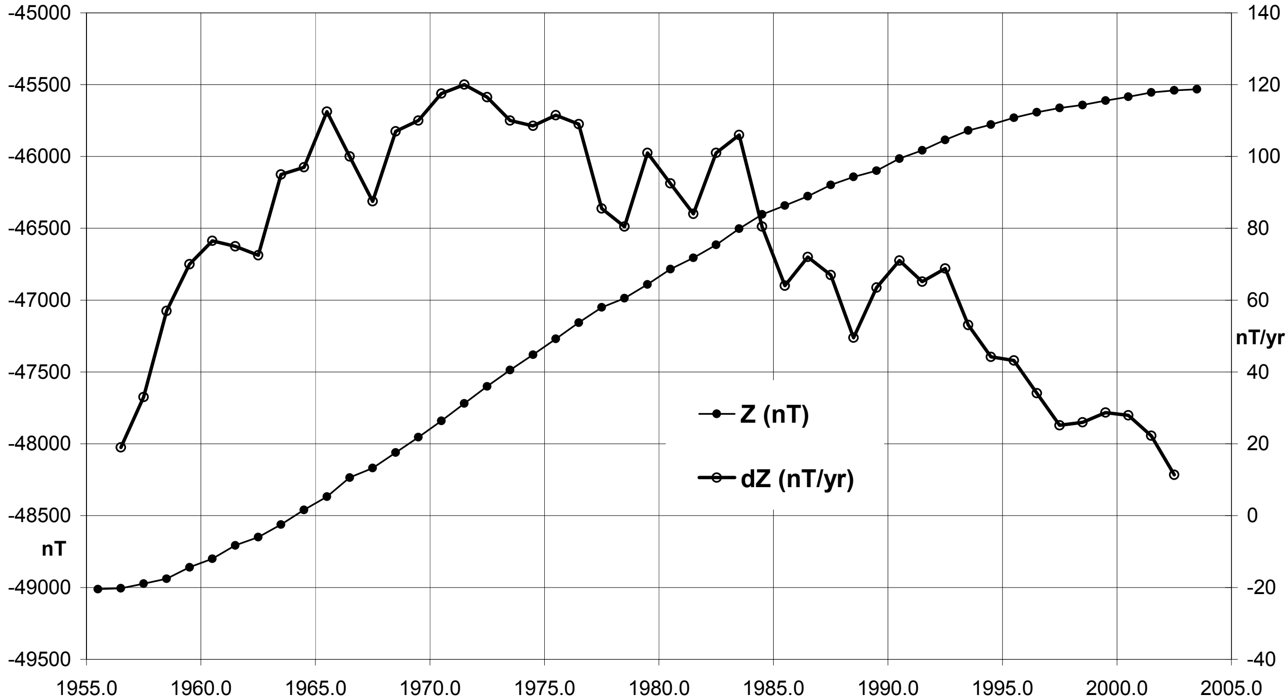


Mawson, Antarctica (MAW) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
18700.0
18600.0
18500.0
18400.0
18300.0
18200.0
20
10
0
-10
-20
-30
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0

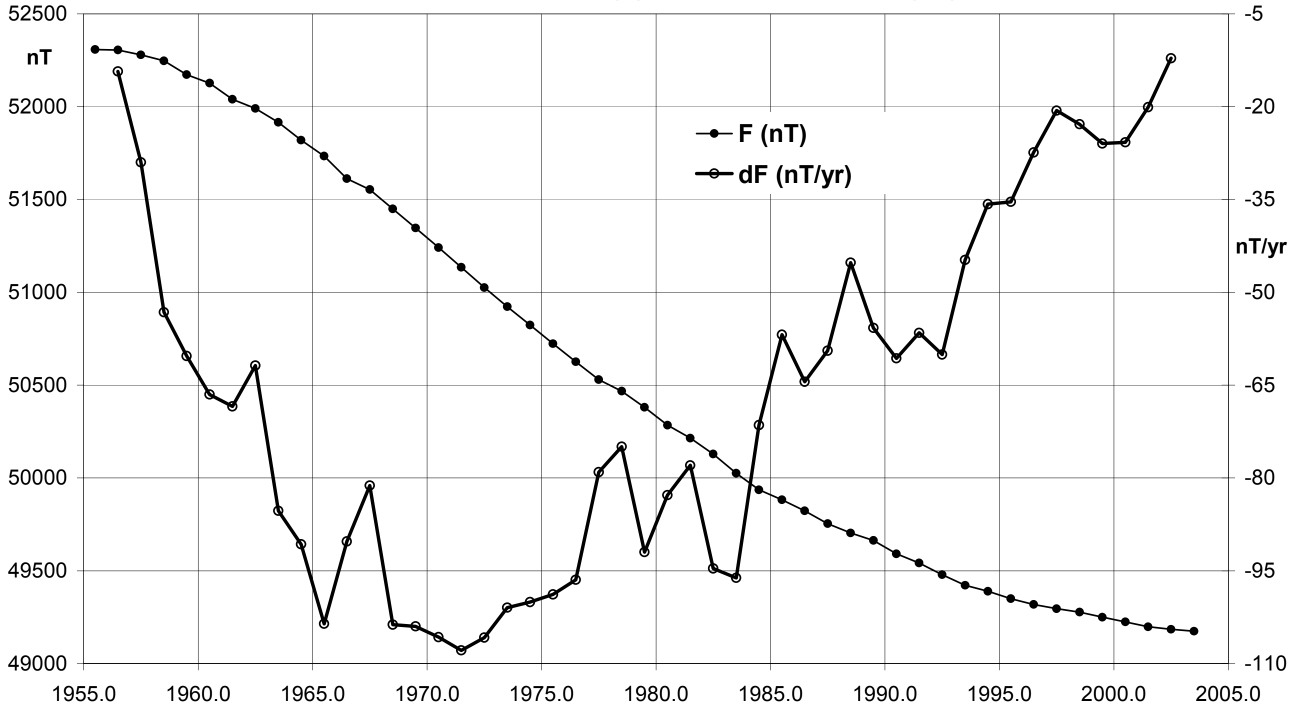


Mawson, Antarctica (MAW) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
Deg.
East
'/yr
D (deg.)
dD ('/yr)
-58.0
-60.0
-62.0
-64.0
-66.0
-68.0
0
-4
-8
-12
-16
-20
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0

Mawson, Antarctica (MAW) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)



Mawson, Antarctica (MAW) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)



MAW – 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.

Summary of data loss in the Australian observatories in 2003

The table below summarizes the 2003 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.

2003	KDU	CTA	LRM	ASP	GNA	CNB	MCQ	CSY	MAW
Jan	0	0	0	0	0	0	0	156	3
Feb	0	0	7 (4,250)	0 (5)	0	0	0	140	0
Mar	0	0	24 (10,818)	1 (19,392)	3,373	0 (51)	30 (29)	155	3,480
Apr	0	0	0	0	10,488 (10,493)	0	0	150	2,597 (2,718)
May	0	0	18 (0)	63 (347)	0	0	0	155	0
Jun	0	0 (7,242)	144 (1)	0	0	0	0	150	991
Jul	0	0 (22,746)	0	5 (6)	0	0	0	155	0
Aug	154 (22,383)	0 (19,270)	0	0	0	0 (292)	0	181	2636
Sep	0 (43,200)	0	0	0 (27,160)	0	0 (204)	1 (0)	150	3715
Oct	0 (42,724)	0	0	1 (23,449)	6,139 (7,445)	0 (4,168)	0	155	40
Nov	0 (42,240)	0	0	0 (43,200)	0 (5,795)	0 (55)	3 (0)	150	0
Dec	10,192 (12,065)	1,370 (1,372)	0	0 (44,640)	85 (1,827)	0	0	1282	0
3-axis variom.	10,346 (1.97%)	1370 (0.26%)	193 (0.037%)	70 (0.013%)	20,085 (3.82%)	0 (0.0%)	34 (0.006%)	2,979 (0.57%)	13,462 (2.56%)
Total field	162,612 (30.9%)	50,630 (9.63%)	15,069 (2.87%)	158,199 (30.1%)	28,933 (5.50%)	4770 (0.91%)	29 (0.006%)	no PPM	13,583 (2.58%)

International Quiet & Disturbed Days

2003	Quietest days 1 - 5					Quietest days 6 - 10					Most Disturbed days 1 - 5				
January	9	8	6	16	7	2	15A	17A	13A	5A	25	30	26	23	22*
February	25	24	13A	11A	23A	22A	17A	12A	7A	19A	2	4	27	3	15
March	25	24	26A	12A	8A	9A	2A	11A	19A	13A	17	31	30	29	4
April	7	12A	6A	13A	19A	27A	20A	28A	11A	26A	30	25	16	4	5
May	4	17A	18A	16A	3A	20A	19A	5A	23A	2A	29	30	1	8	7
June	12A	13A	5A	20A	22A	11A	6A	19A	25A	26A	18	17	28	16	2
July	8	9	22	21A	10A	24A	1A	25A	23A	6A	11	16	12	29	31
August	31	5A	16A	27A	4A	10A	11A	26A	15A	3A	18	21	22	1	23
September	28	14	29	7	30	15K	8K	27K	6A	13A	17	18	24	19	16
October	11	10	12	23	4K	5K	8	2A	9A	6A	29	30	31	14	21
November	28	27	29	5K	8A	26A	7A	19A	30A	3A	20	11	13	16	15
December	19	3	18	25	29K	30K	4K	24	2A	17A	10	11	5	8	9

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 & 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.

GA maintains a network of 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 3−4 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 2003 a Narod ring-core fluxgate magnetometer was used to monitor variations in three (nominally 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 batteries and solar panels or 240V ac mains power, depending on the location. Preliminary data processing and analysis was done on-site on a lap-top computer.

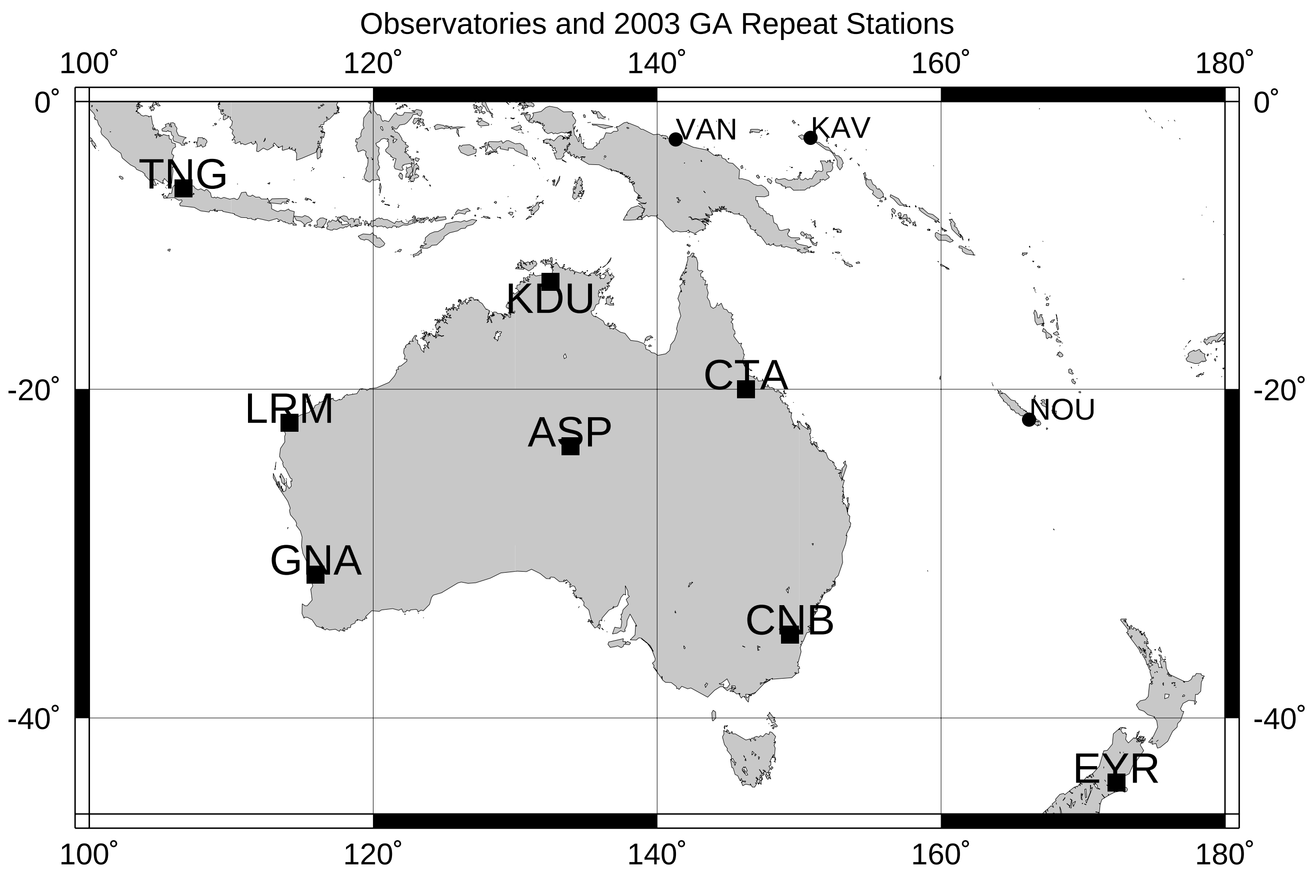
The variometer recordings were calibrated to observatory standard with a campaign of absolute magnetic observations made during each station occupation. Usually from 24 to 30 sets of absolute observations were performed on each primary repeat station. Vector field differences between the primary and secondary station at each site were also measured. Azimuths 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 2003 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 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 2003



Station occupations in 2003

Three repeat stations were re-occupied in October 2003: Kavieng (KAV) and Vanimo (VAN), both in Papua New Guinea; and Noumea (NOU) in New Caledonia. 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 2003 occupations and the average secular variation over the interval between the two most recent occupations for each station are shown in the tables below.

The results of the 2003 and earlier occupations of these stations are shown in the figures that follow the text.

Adopted Main Field Values at Time of Station Occupations

Station (site)	Occupation	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D	I
Kavieng (C)	2003/10/03	36243	3923	-13340	38819	36455	06° 10.6’	-20° 05.9’
Vanimo (B)	2003/10/08	36983	2709	-14747	39907	37082	04° 11.4’	-21° 41.2
Noumea (B)	2003/10/14	31360	7007	-35577	47940	32133	12° 35.7’	-47° 54.7

Average Secular Variation between two most recent Occupations

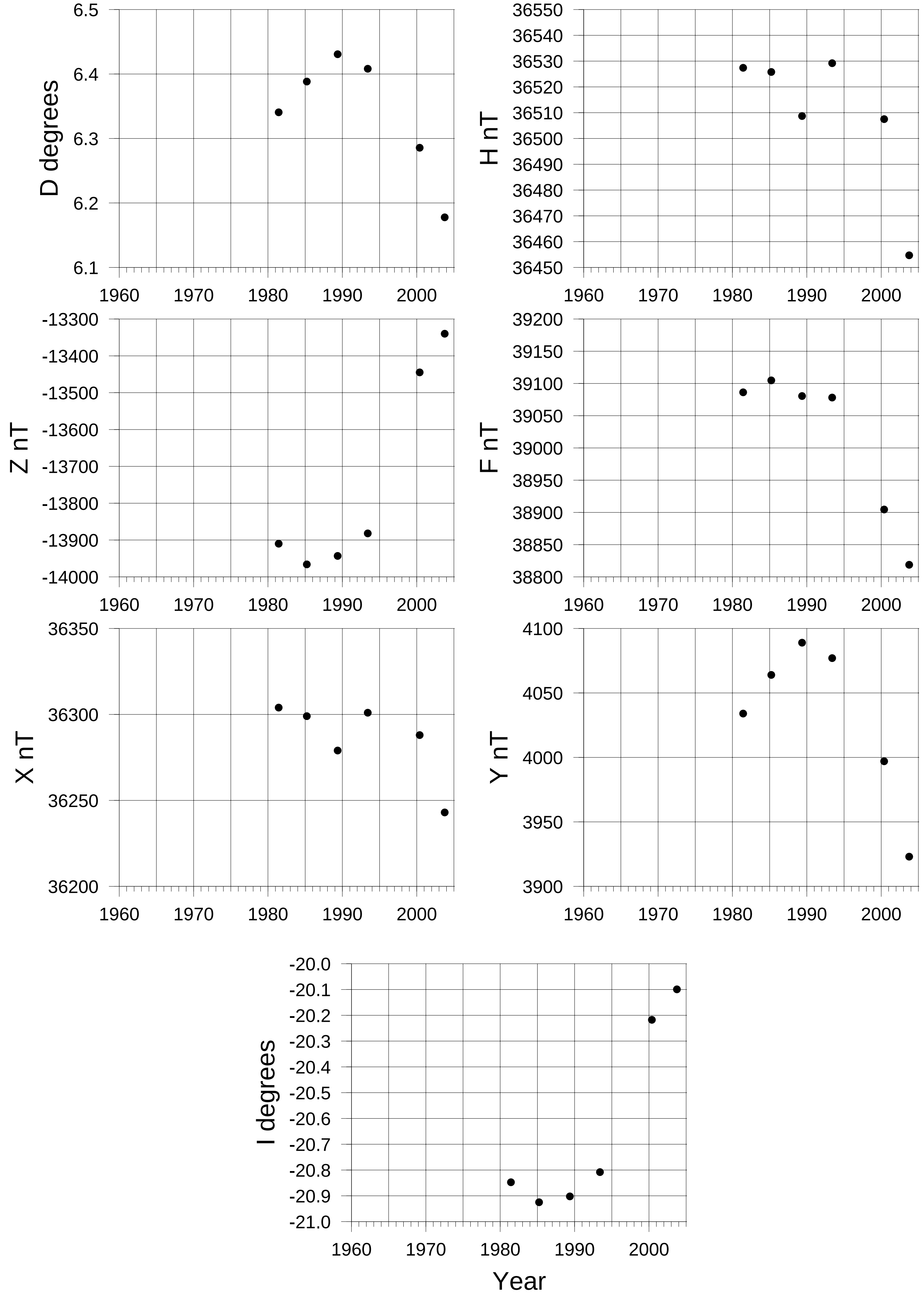
Station (site)	Previous occupation	ΔX (nT/yr)	ΔY (nT/yr)	ΔZ (nT/yr)	ΔF (nT/yr)	ΔH (nT/yr)	ΔD (′/yr)	ΔI (′/yr)
Kavieng (C)	2000/05/23	-17	19	31	-25	-15	1.9	2.1
Vanimo (B)	2000/05/30	-21	-14	25	-30	-22	-1.1	1.3
Noumea (B)	2000/05/11	-17	-17	33	-38	-20	-1.4	0.5

Australian Geomagnetic Reference Field

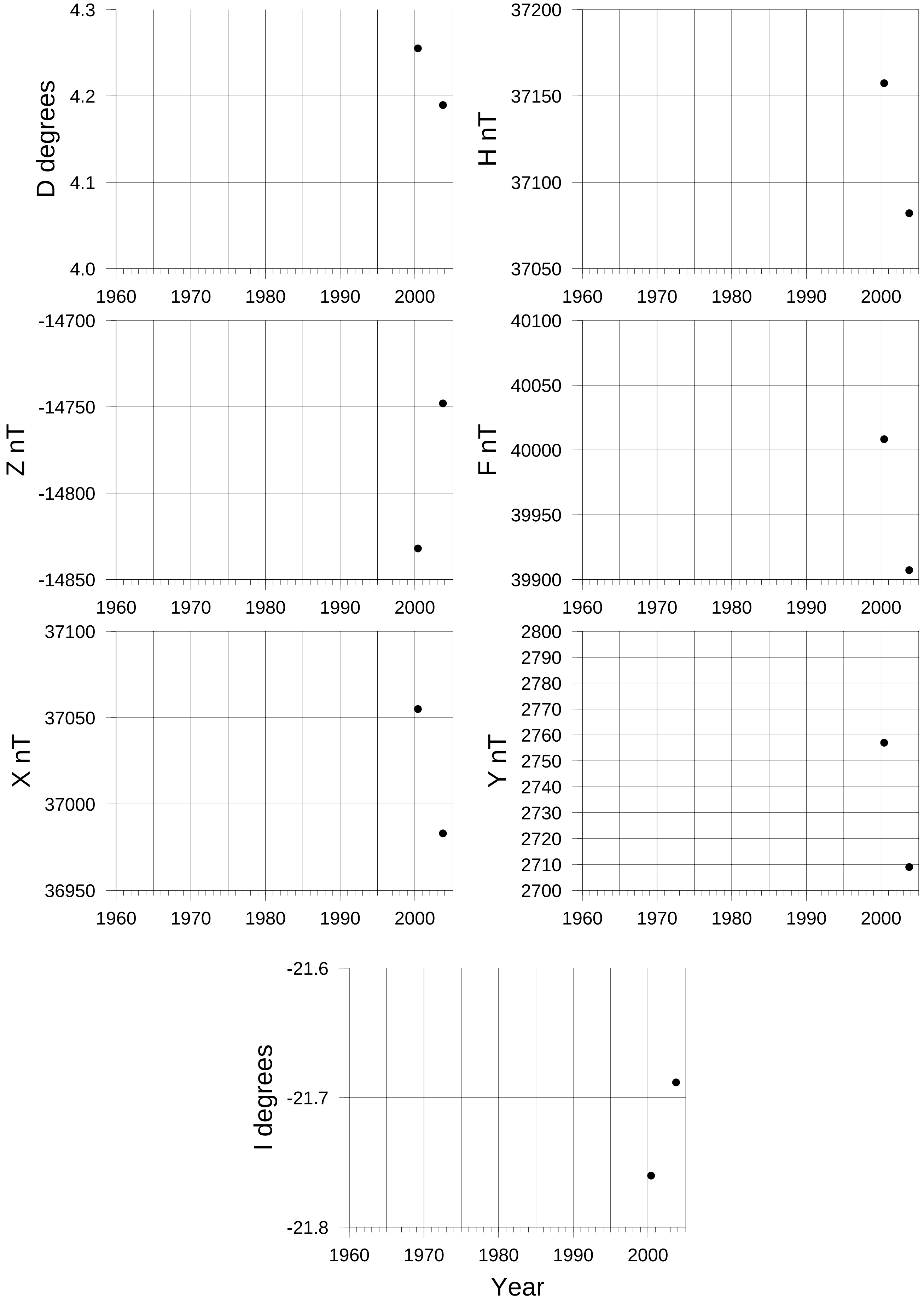
The latest revision of the Australian Geomagnetic Reference Field was for epoch 2000.0 (AGRF00) that was released in 2000 (Lewis, 2000). It is considered the best available geomagnetic field model for direction-finding applications in the Australian region. Charts in each of the magnetic elements X, Y, Z, F, H, D and I from the AGRF00 model are in the *AGR00*. The next AGRF model will be developed 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*.

KAV

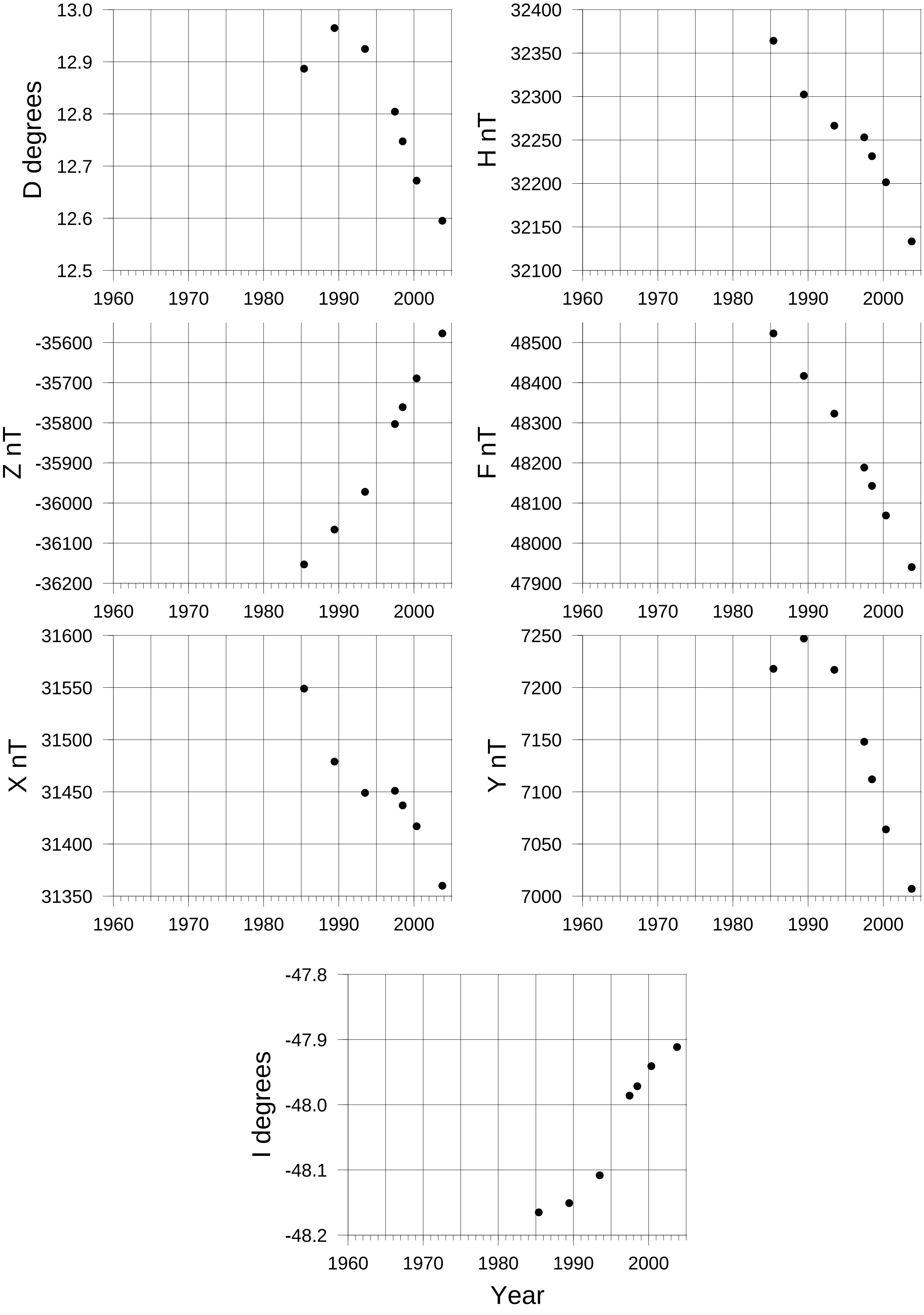

D degrees
H nT
Z nT
F nT
X nT
Y nT
I degrees
Year
1960
1970
1980
1990
2000

VAN



D degrees
4.3
4.2
4.1
4.0
H nT
37200
37150
37100
37050
Z nT
-14700
-14750
-14800
-14850
F nT
40100
40050
40000
39950
39900
X nT
37100
37050
37000
36950
Y nT
2800
2790
2780
2770
2760
2750
2740
2730
2720
2710
2700
I degrees
-21.6
-21.7
-21.8
1960
1970
1980
1990
2000
Year

NOUMEA B


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

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Geomagnetism Staff List 2003

Name	Classification	Responsibility
Charles E. Barton	GA Level 8	Section Head (until October 2003)
Peter A. Hopgood	GA Level 6	Project Leader
Peter G. Crosthwaite	GA Level 5	Digital acquisition, system and software development and maintenance; Kakadu & Gnangara observatories
Andrew M. Lewis	GA Level 5	Project Leader, Repeat Station Survey, Alice Springs & Learmonth observatories
Liejun Wang	GA Level 4	Data-base development; Canberra & Charters Towers observatories
Nick Bartzis	GA Level 2 (from 29 Oct. 2002)	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
Kim Stellmacher	Contracted by GA	Kakadu (to July 2003)
Anita Hudd	Contracted by GA	Kakadu (August to November 2003)
[Rory Lynch	Contracted by GA	Kakadu (from January 2004)]
Gerard (Hans) Van Reeken	Contracted by GA	Gnangara
Kerry Steinberner	Technical Officer 2 (on contract) (shared by GA & BoM)	Mawson (2003 observer) (from December 2002)
Ray Hegarty	Technical Officer 2 (on contract) (shared by GA & BoM)	Mawson (2004 observer) (from November 2003)
Peter Pokorny	Technical Officer 2 (AAD)	Macquarie Island (2002/03 observer)
Henry Banon	Technical Officer 2 (AAD)	Macquarie Island (2003/04 observer)
Brent Harper	Technical Officer 2 (AAD)	Casey, 2003 observer

End of Part 2