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MAGNETIC OBSERVATORIES

VOLUME 51

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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 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 (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABC
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABC
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABC
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABC
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABC
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABC
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABC
2002.5	A	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	ABC
2003.5	A	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	ABC
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)

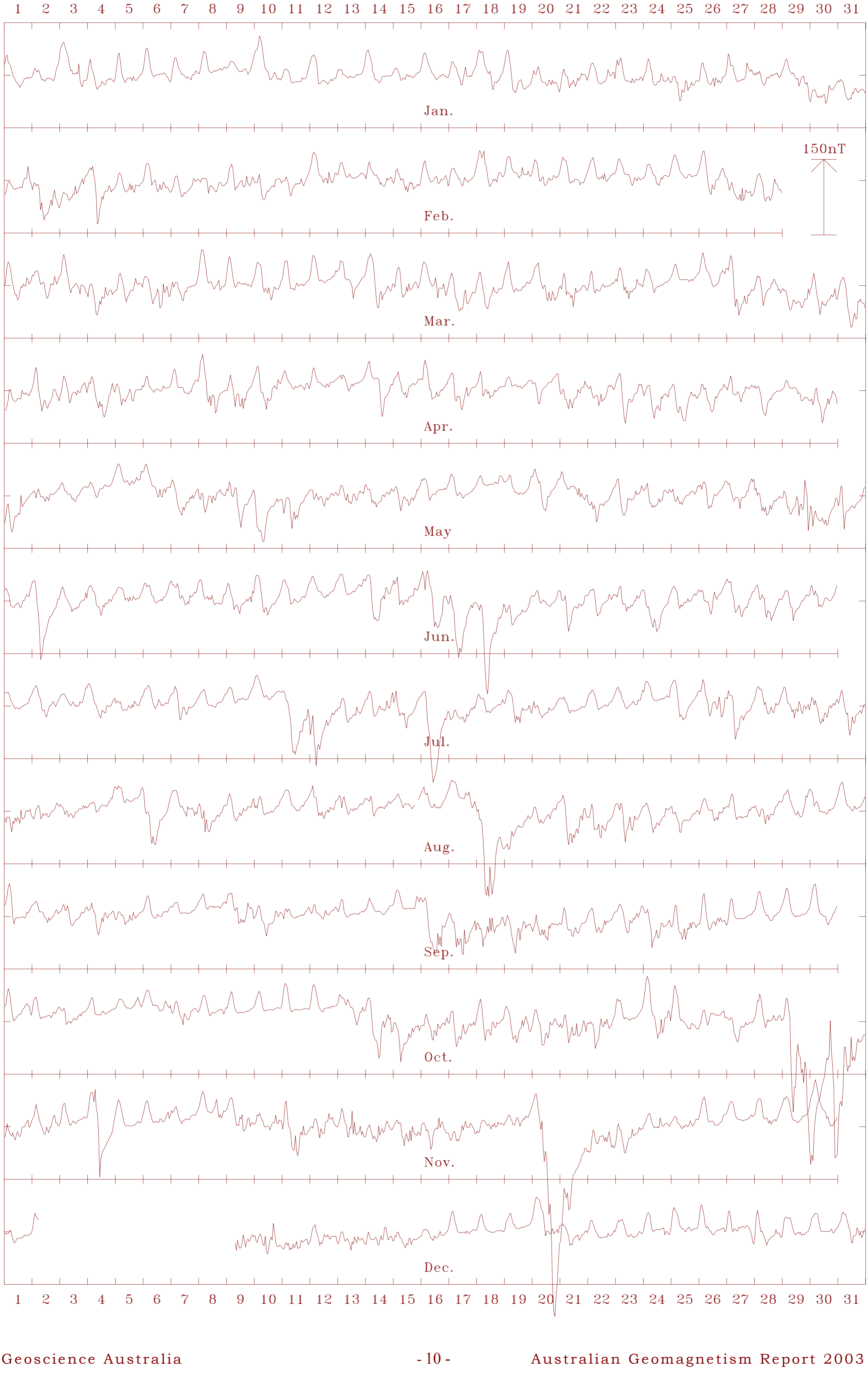
Hourly Mean Values

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.

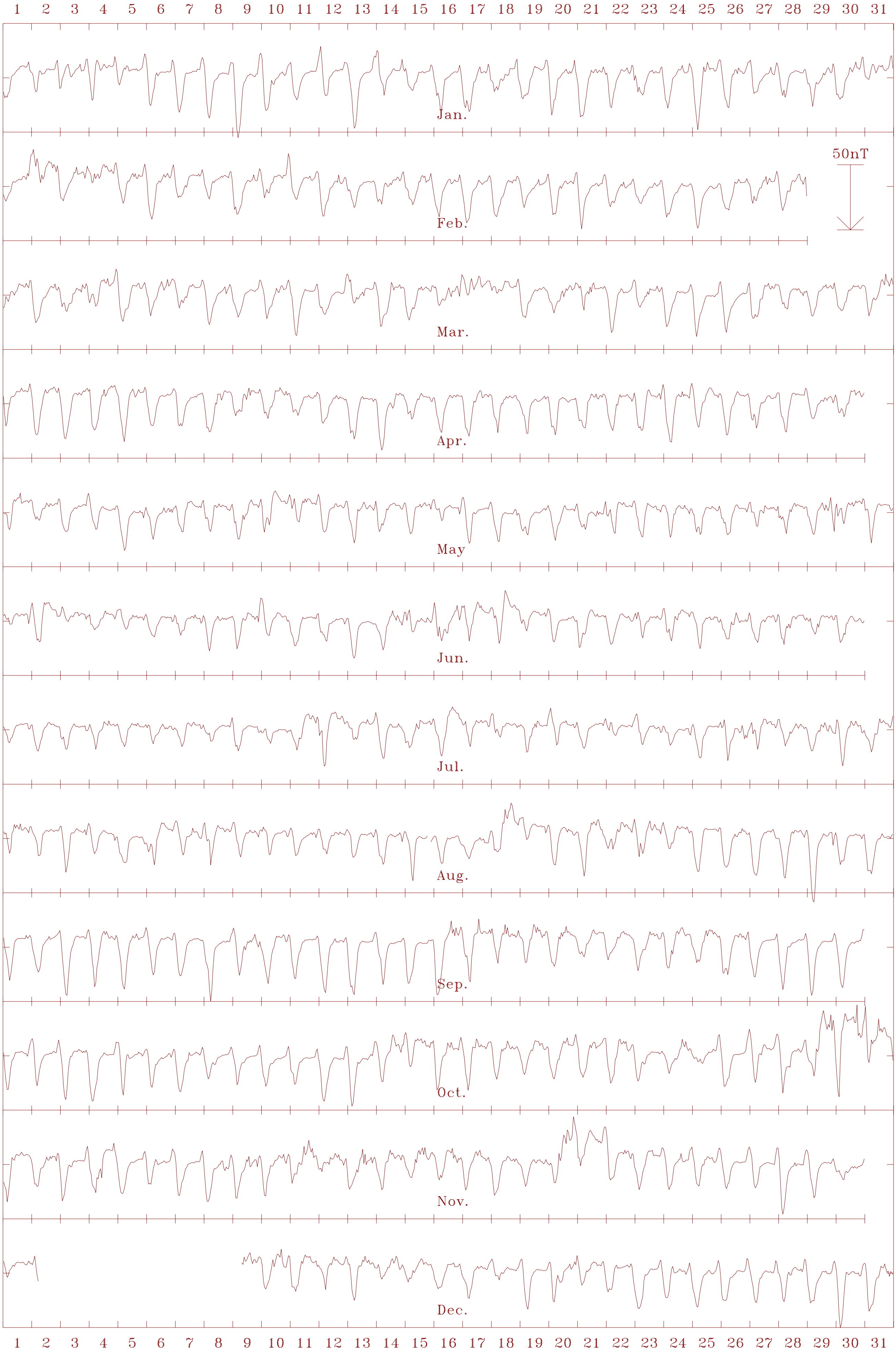
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

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

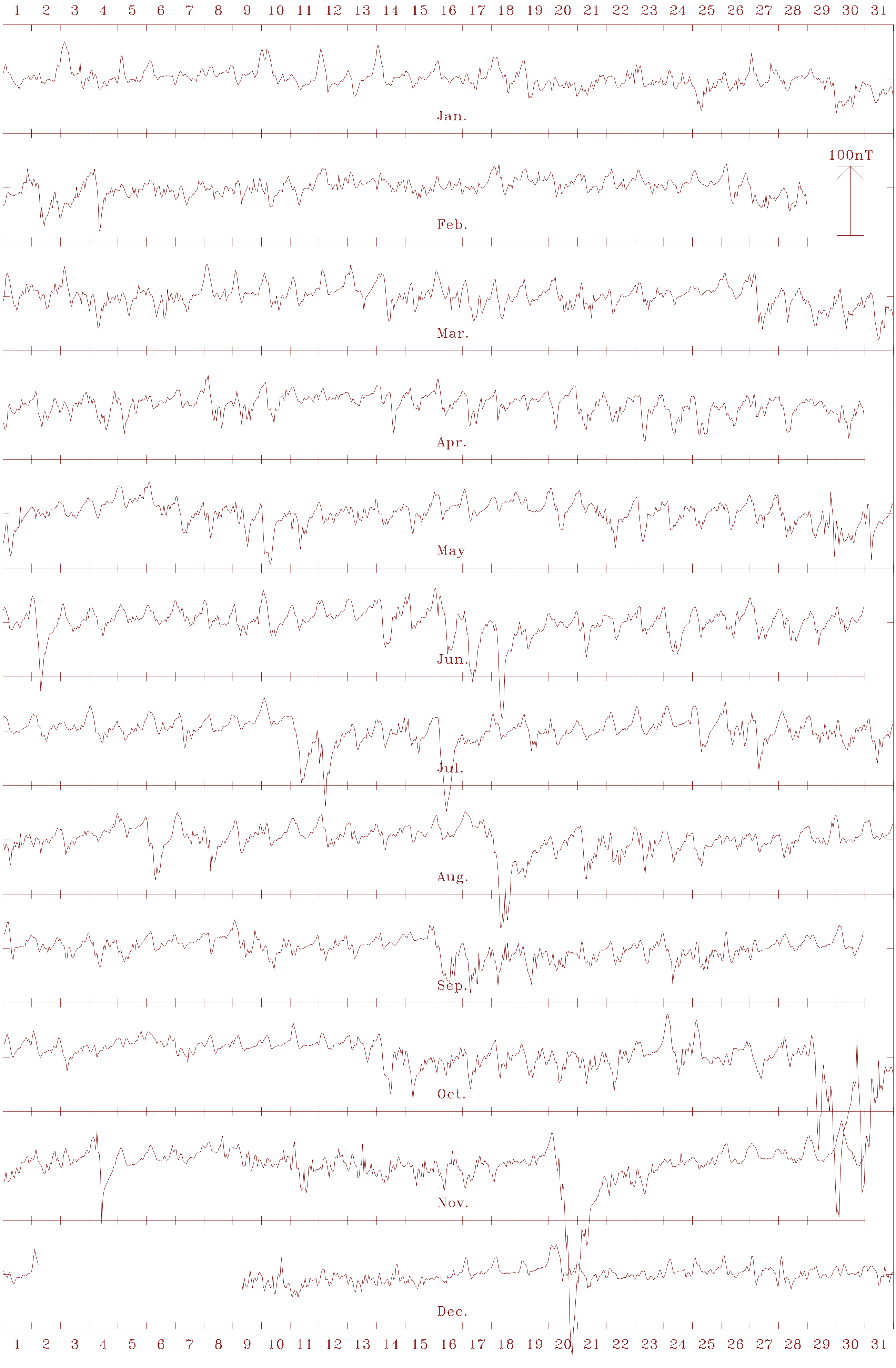


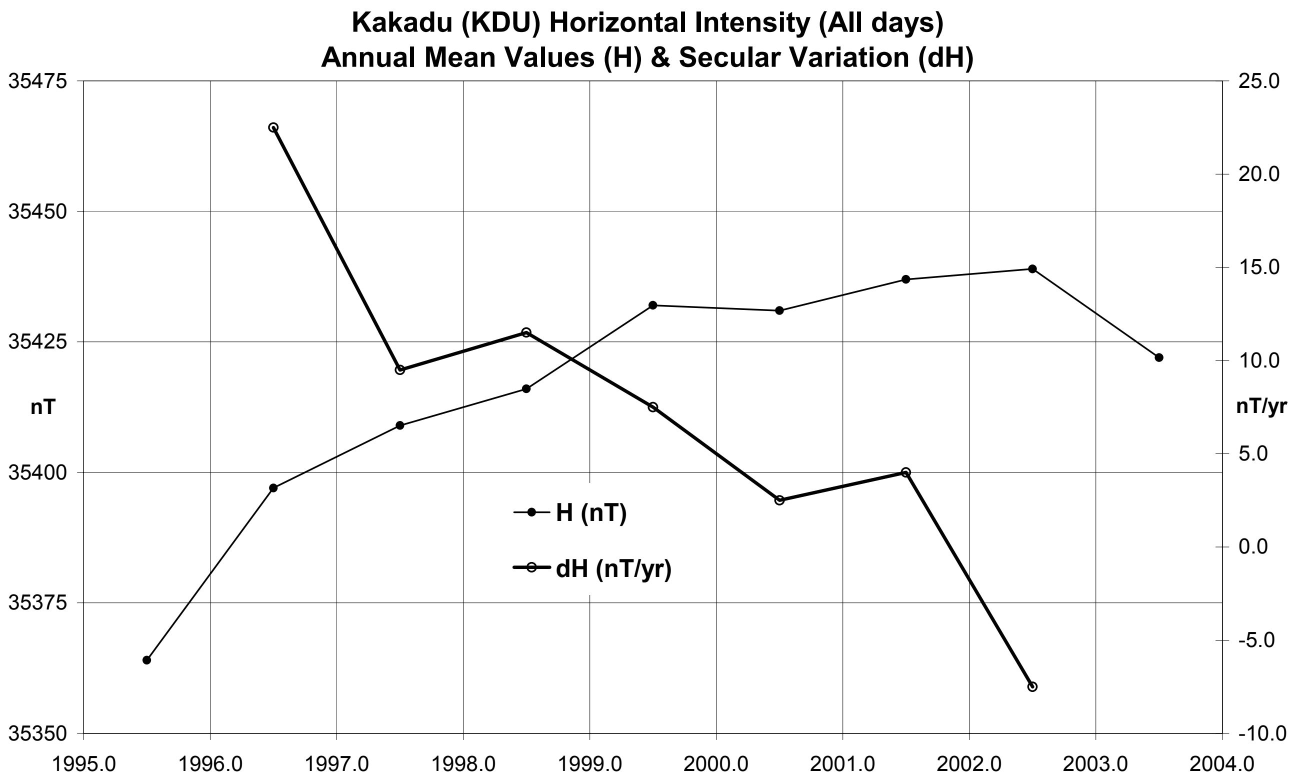
Kakadu, NT 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.74 deg.

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

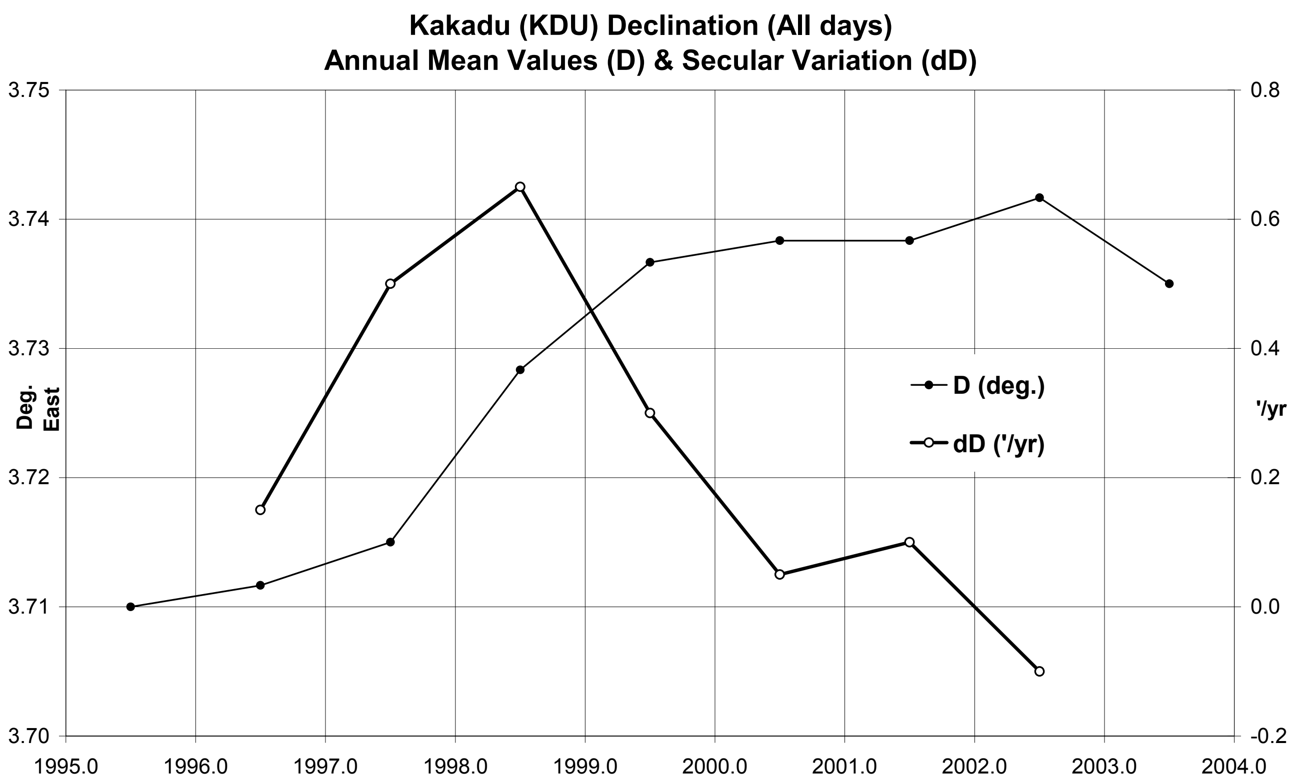


Kakadu, NT 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 46449 nT

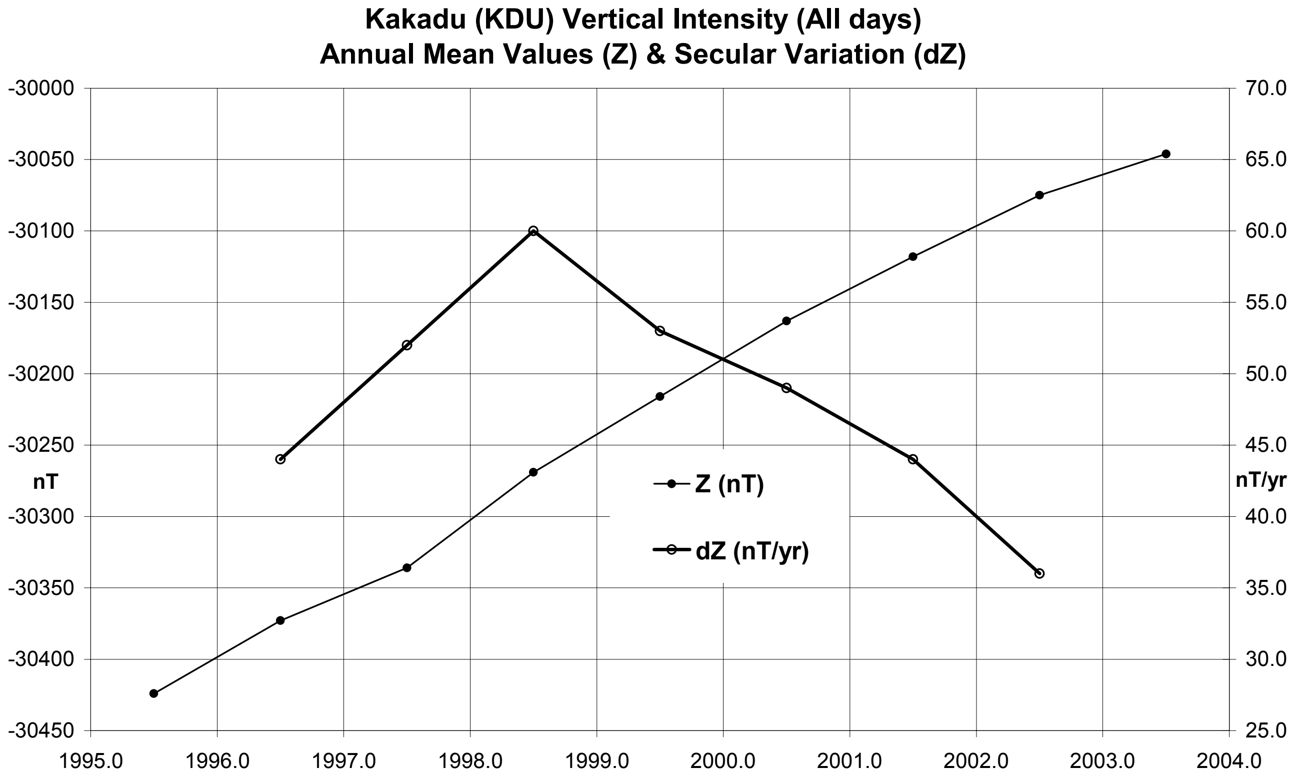




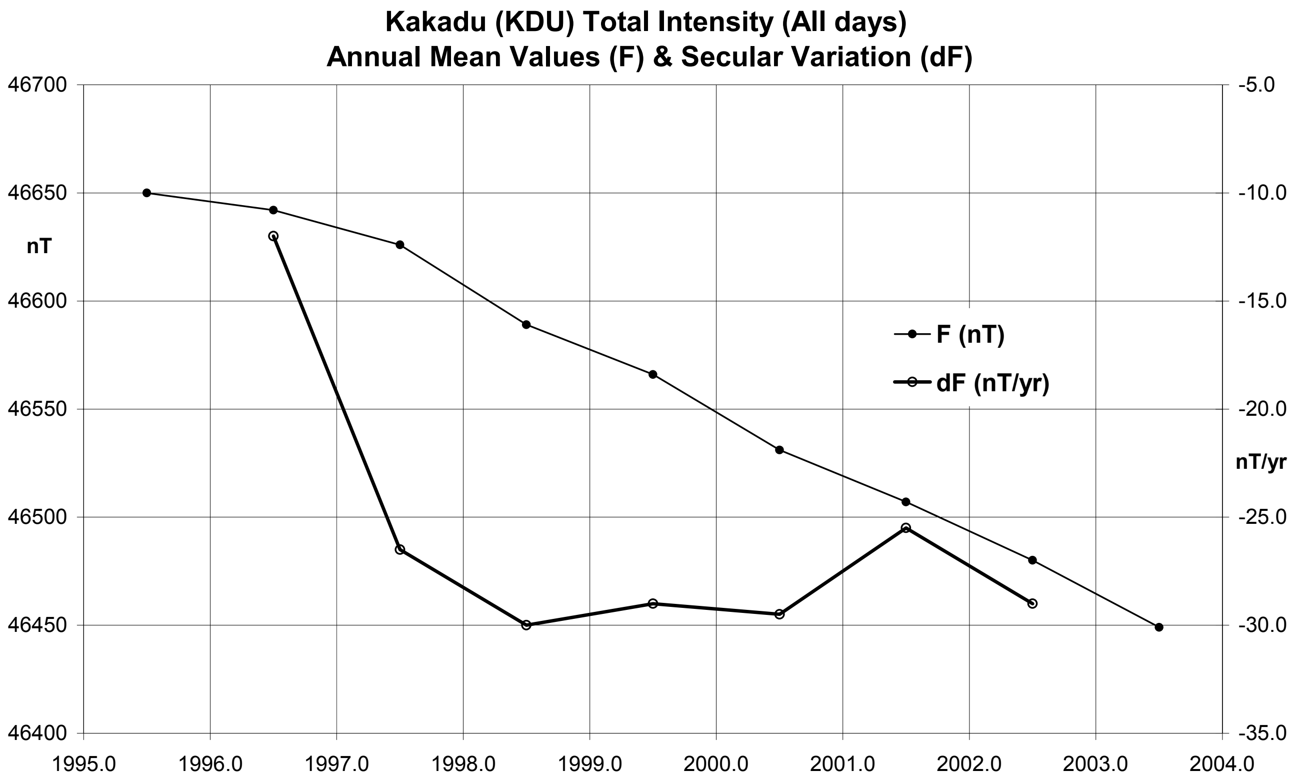
Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
35475
35450
35425
35400
35375
35350
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0



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)
-30000
-30050
-30100
-30150
-30200
-30250
nT
-30300
-30350
-30400
-30450
70.0
65.0
60.0
55.0
50.0
45.0
nT/yr
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
Z (nT)
dZ (nT/yr)



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

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)

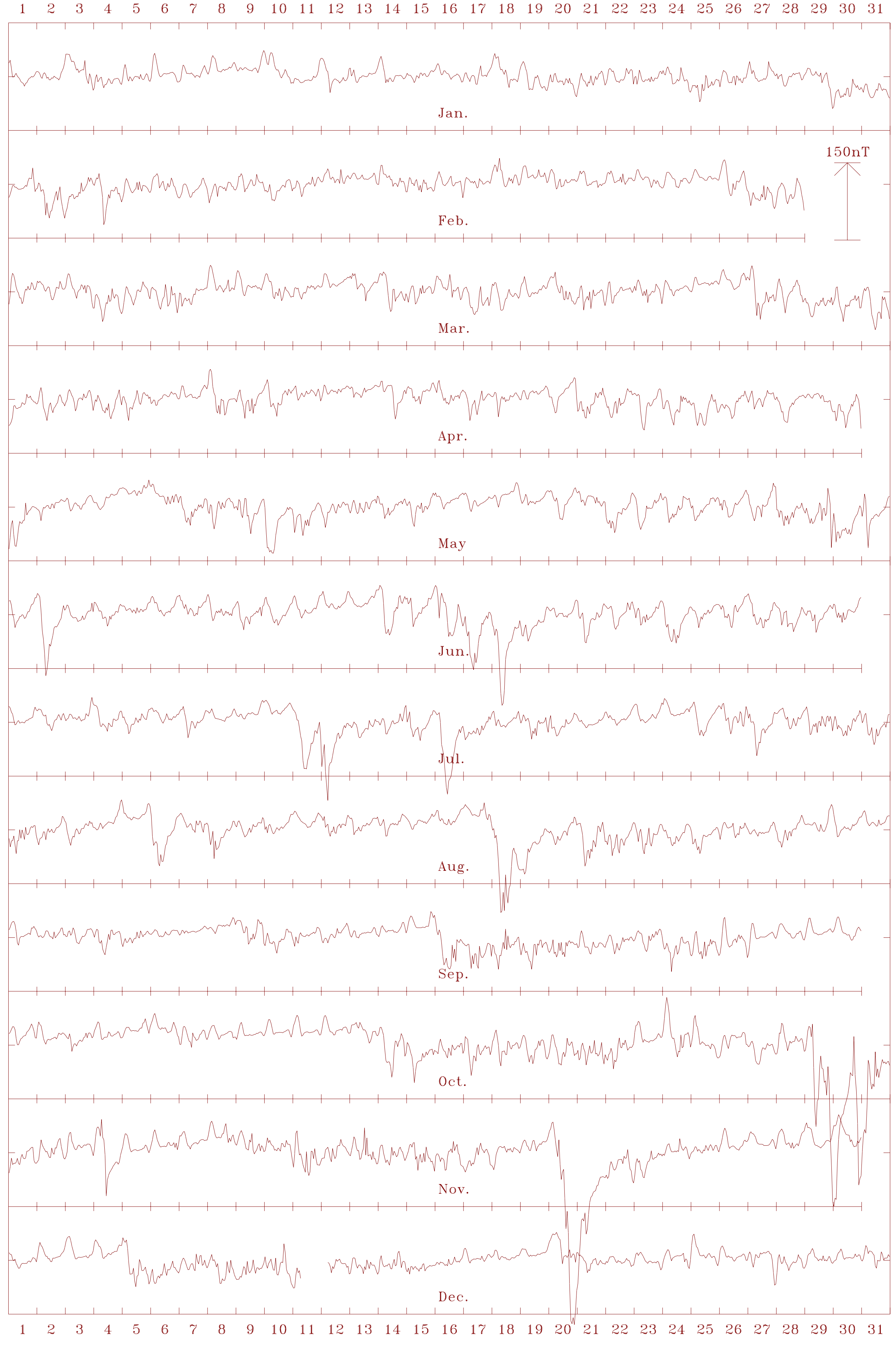
Hourly Mean Values

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.

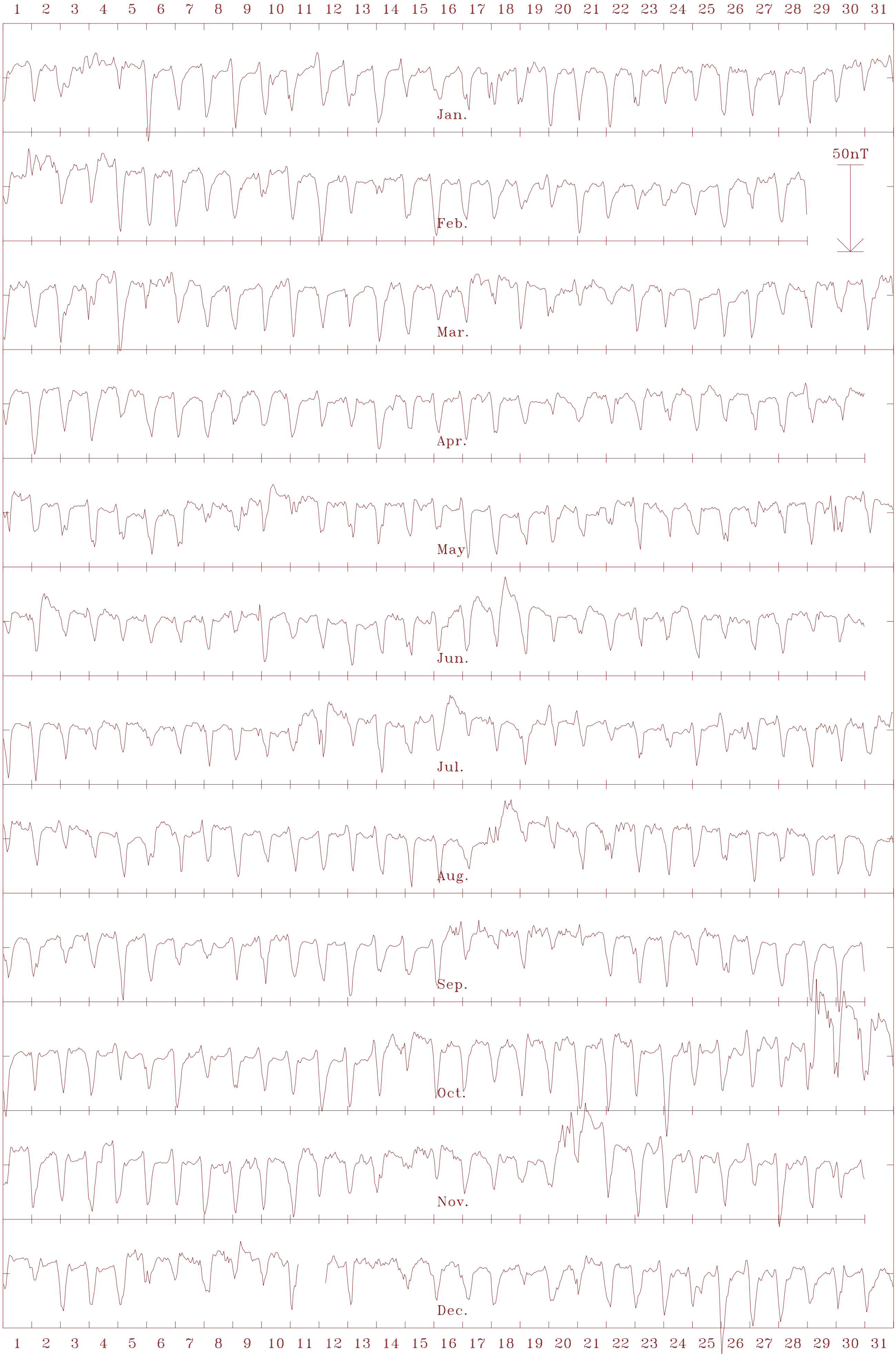
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

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

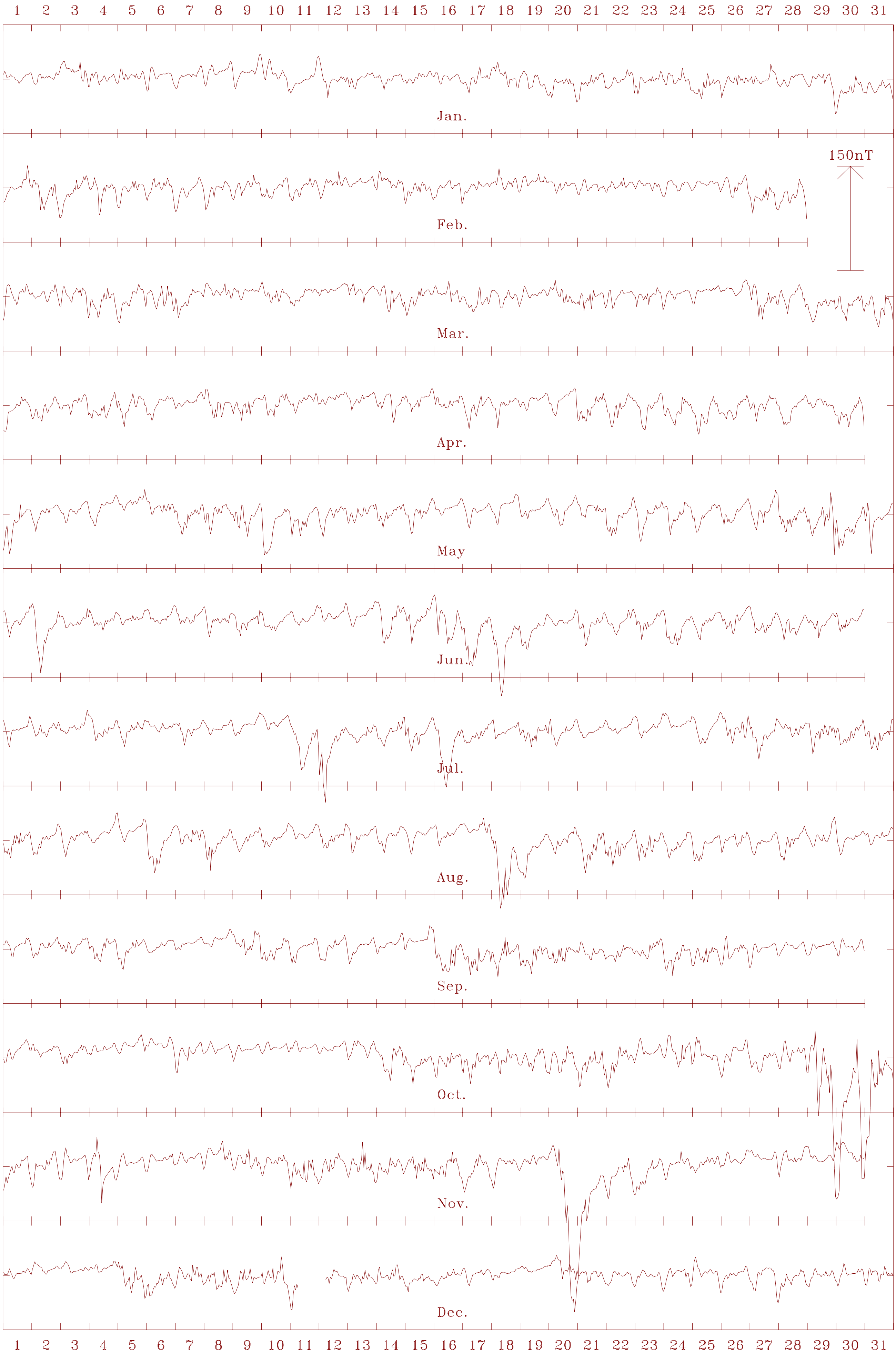


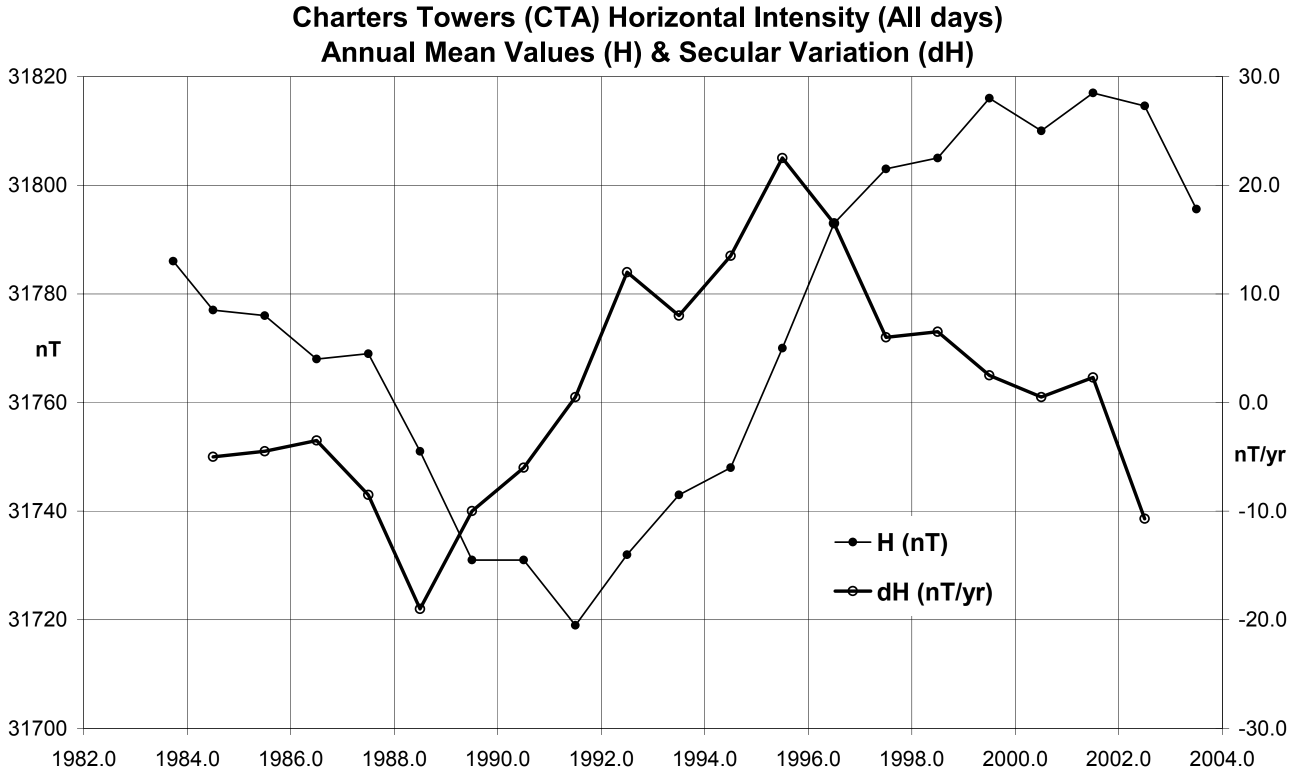
Charters Towers 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.73 deg.

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

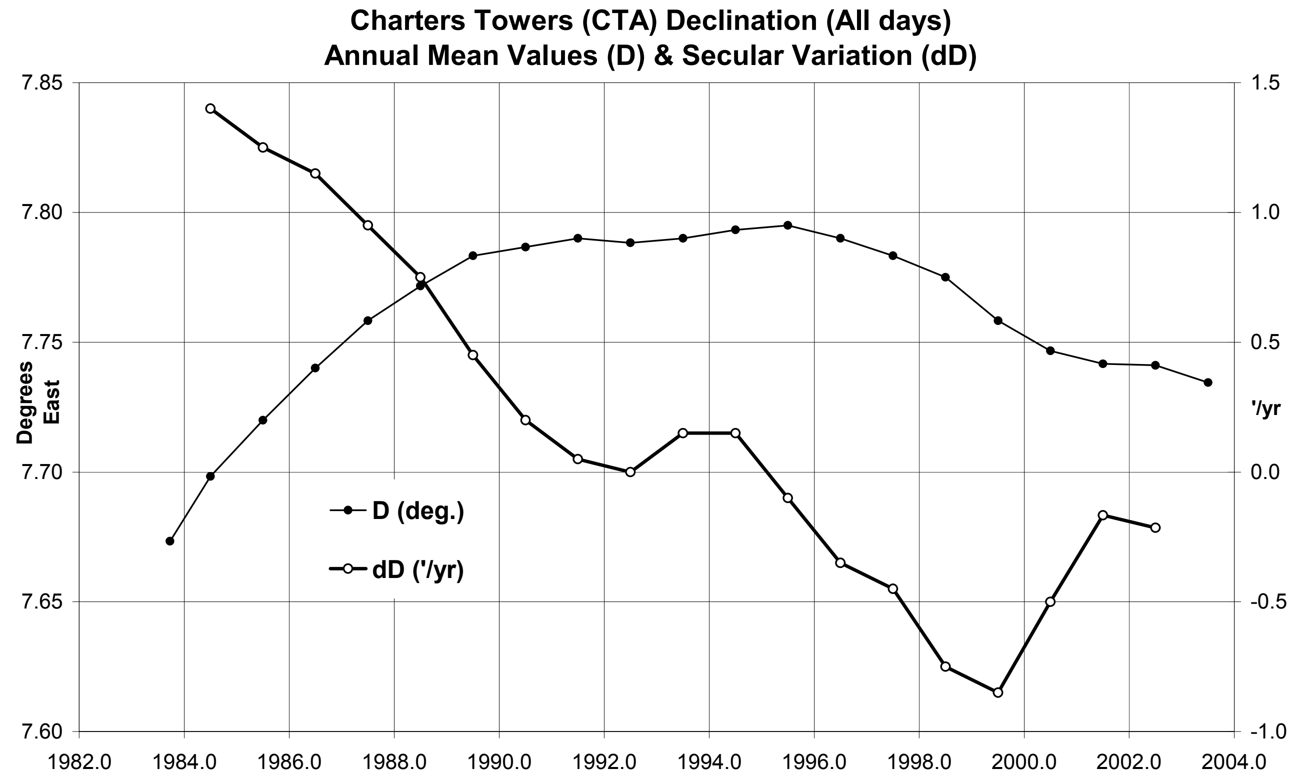


Charters Towers 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 49357 nT

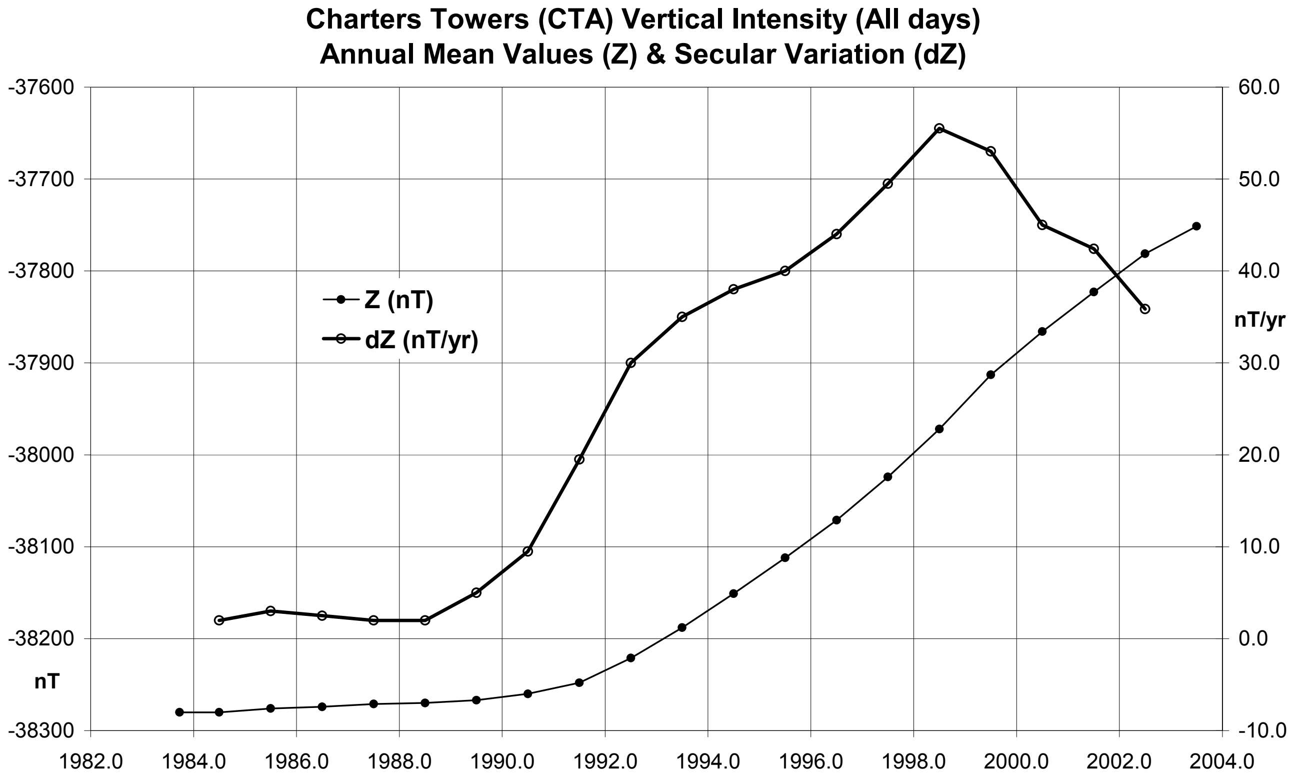




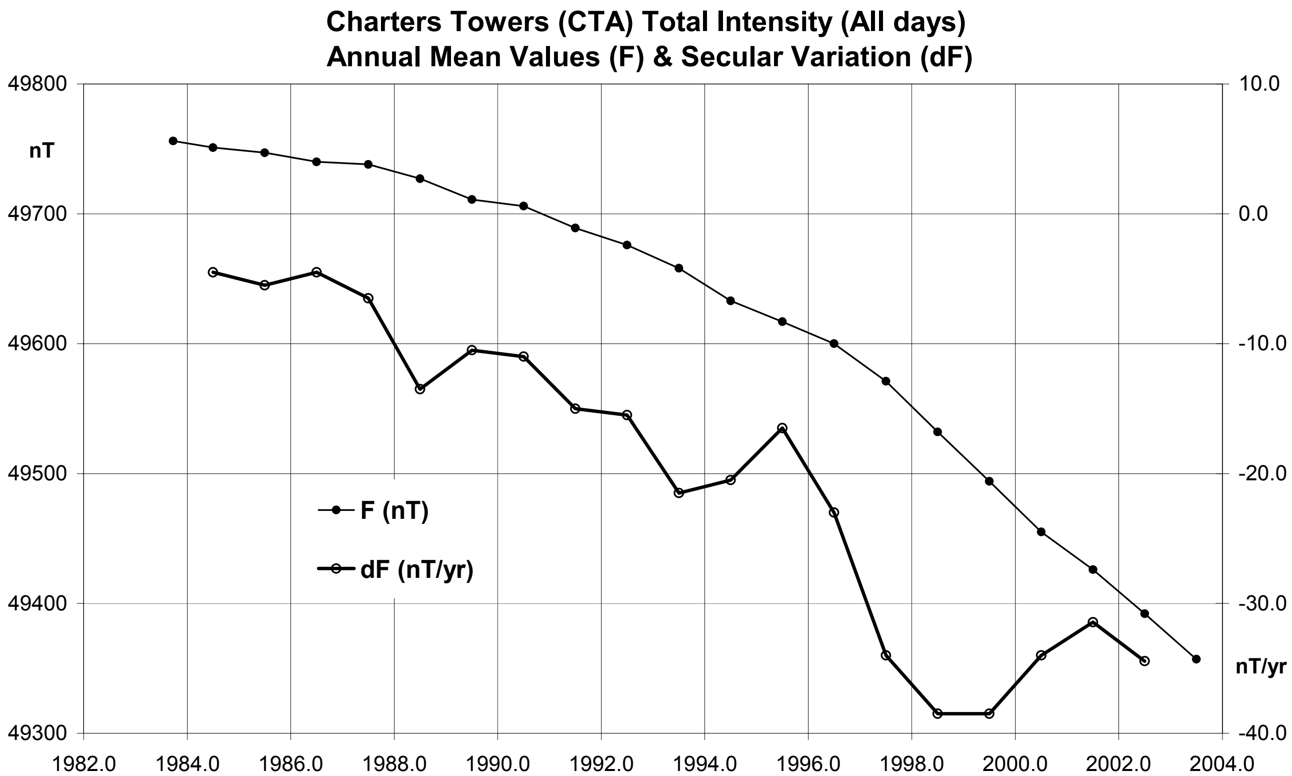
Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
31820
31800
31780
31760
31740
31720
31700
nT
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
nT/yr
H (nT)
dH (nT/yr)
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0



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



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



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

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)

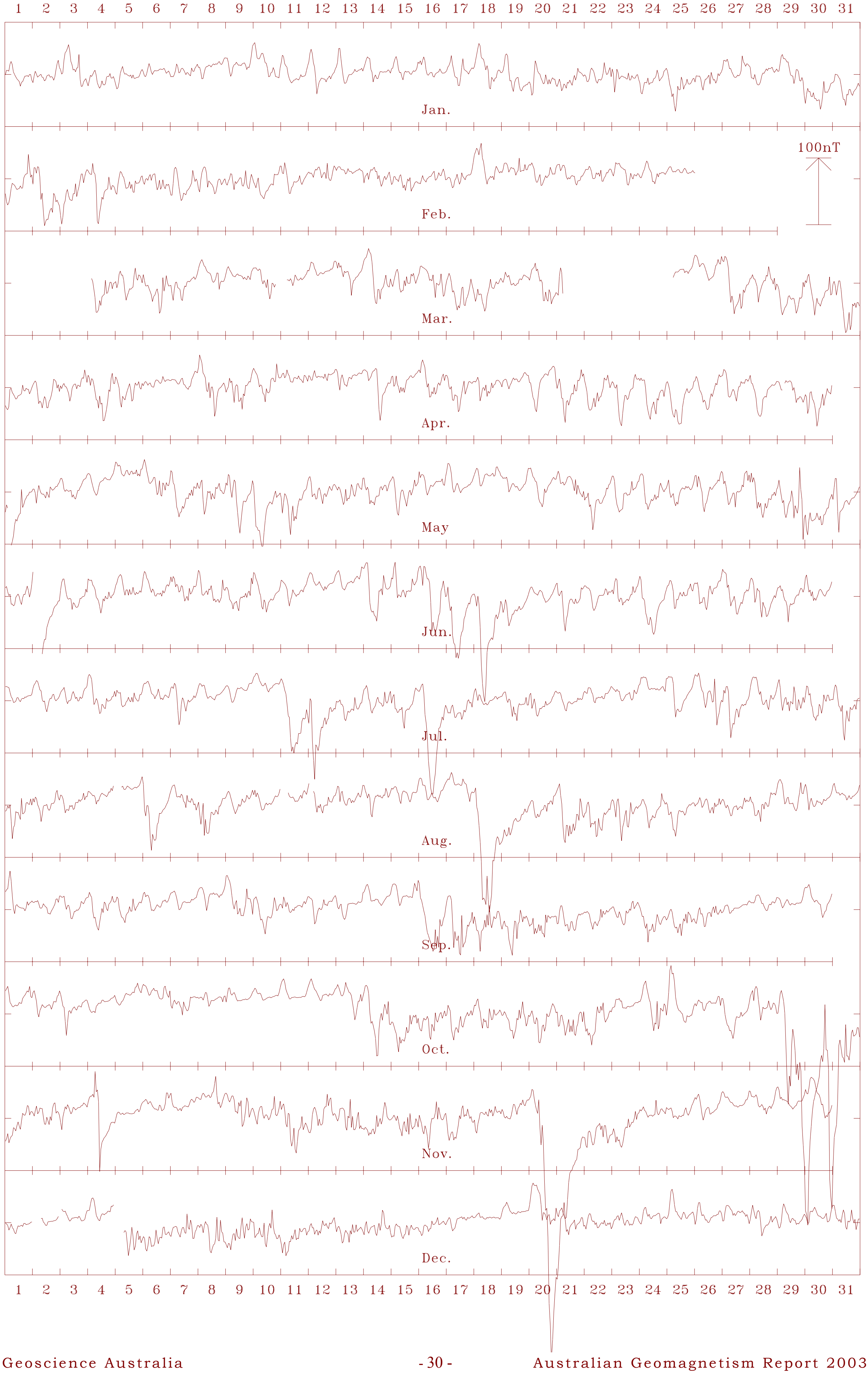
Hourly Mean Values

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

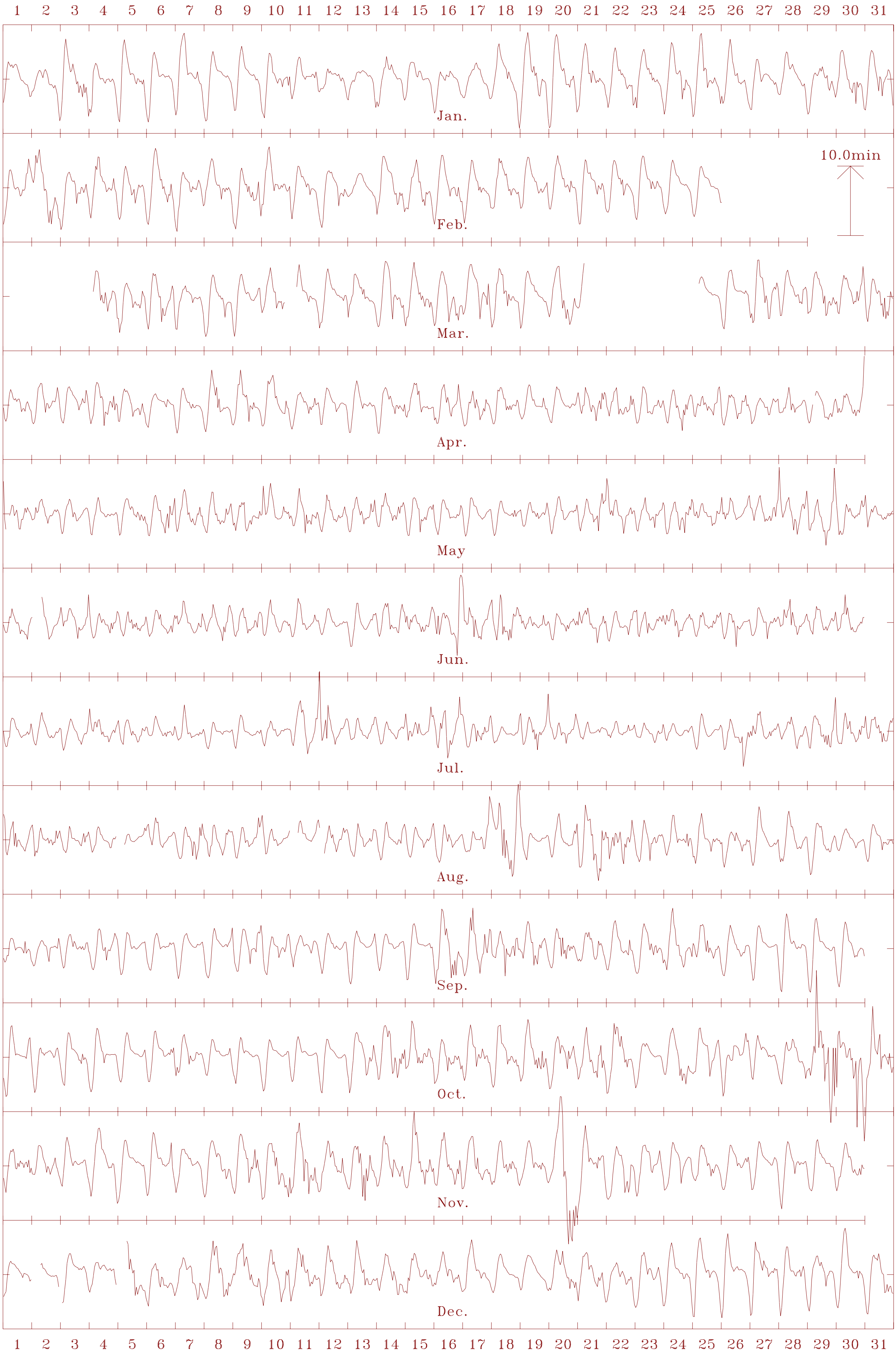
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

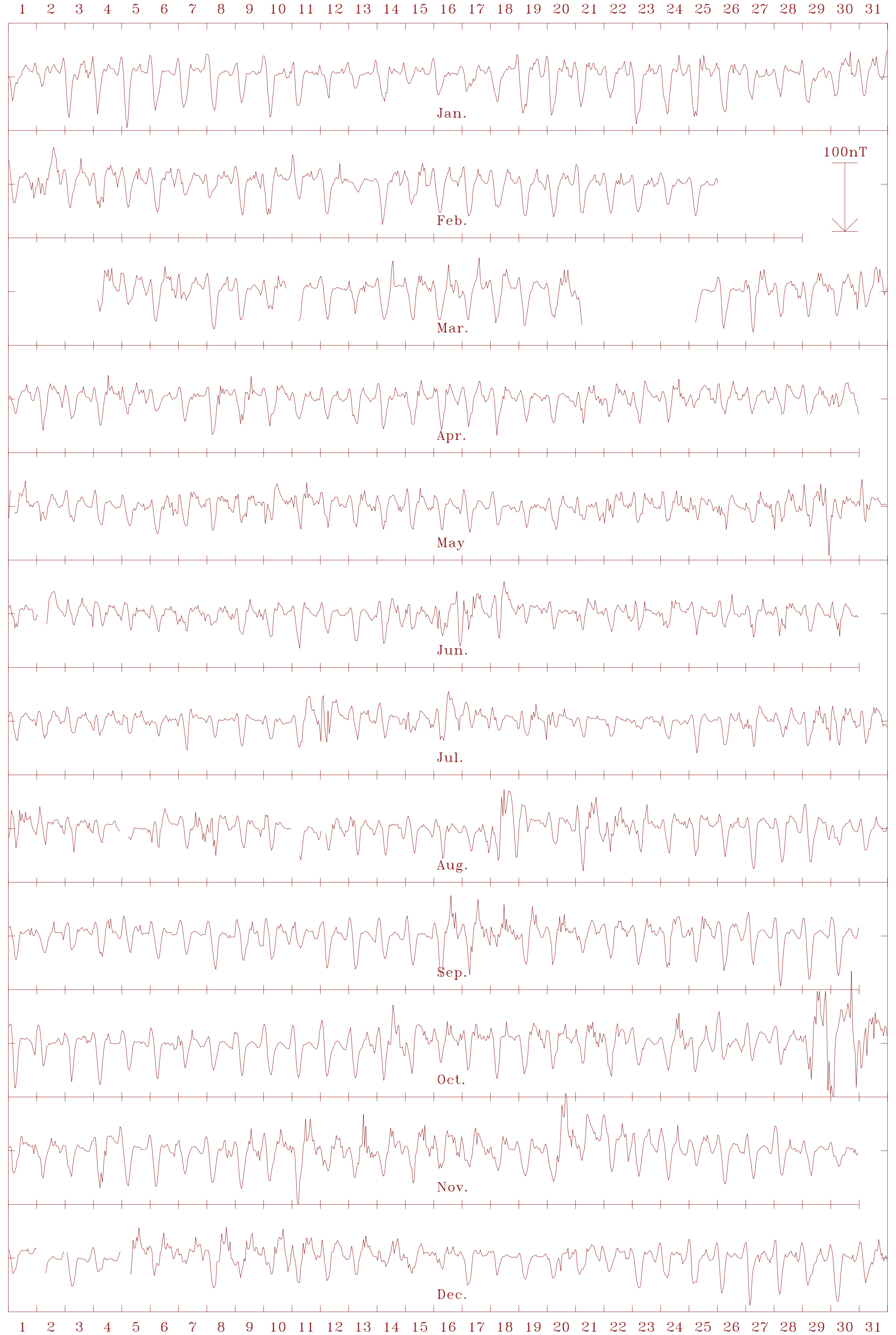
Learmonth 2003 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29737 nT



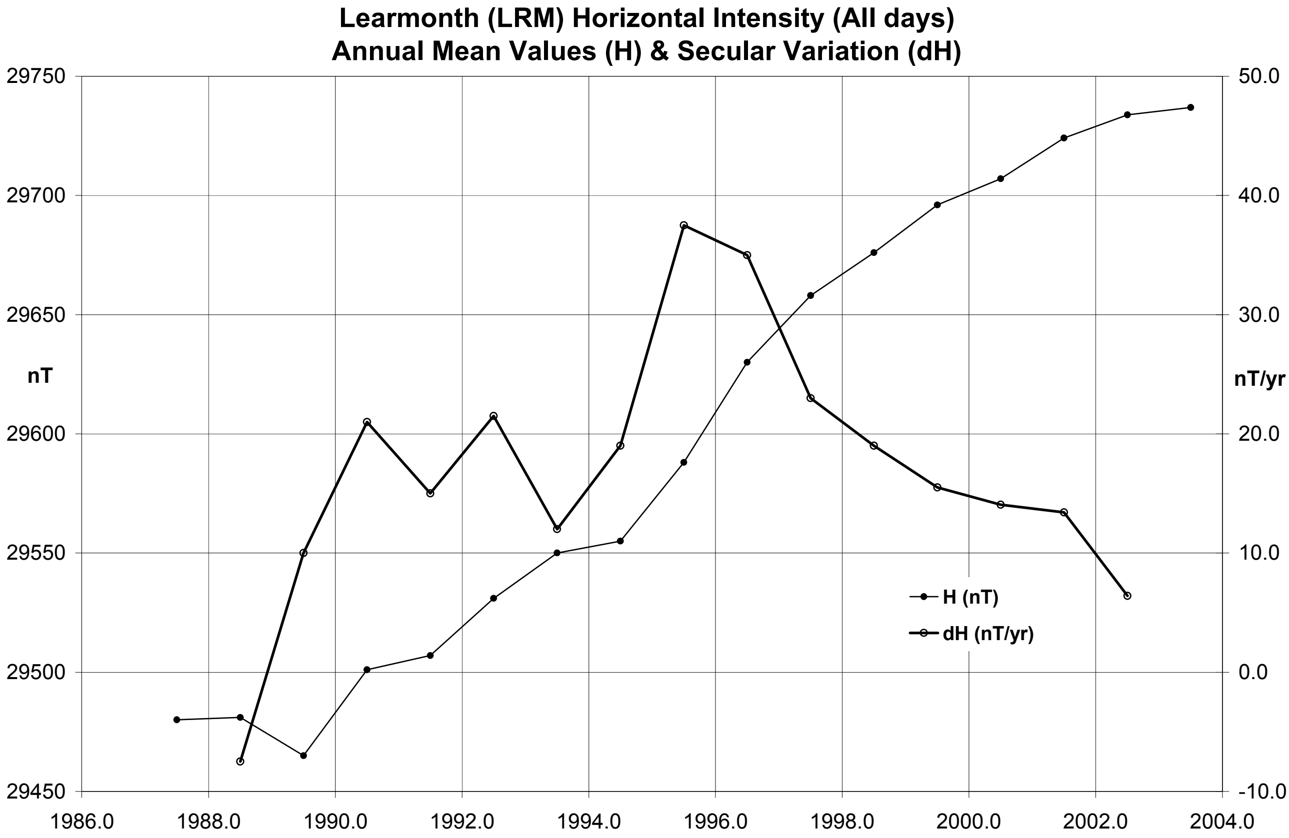
Learmonth 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.40 deg.

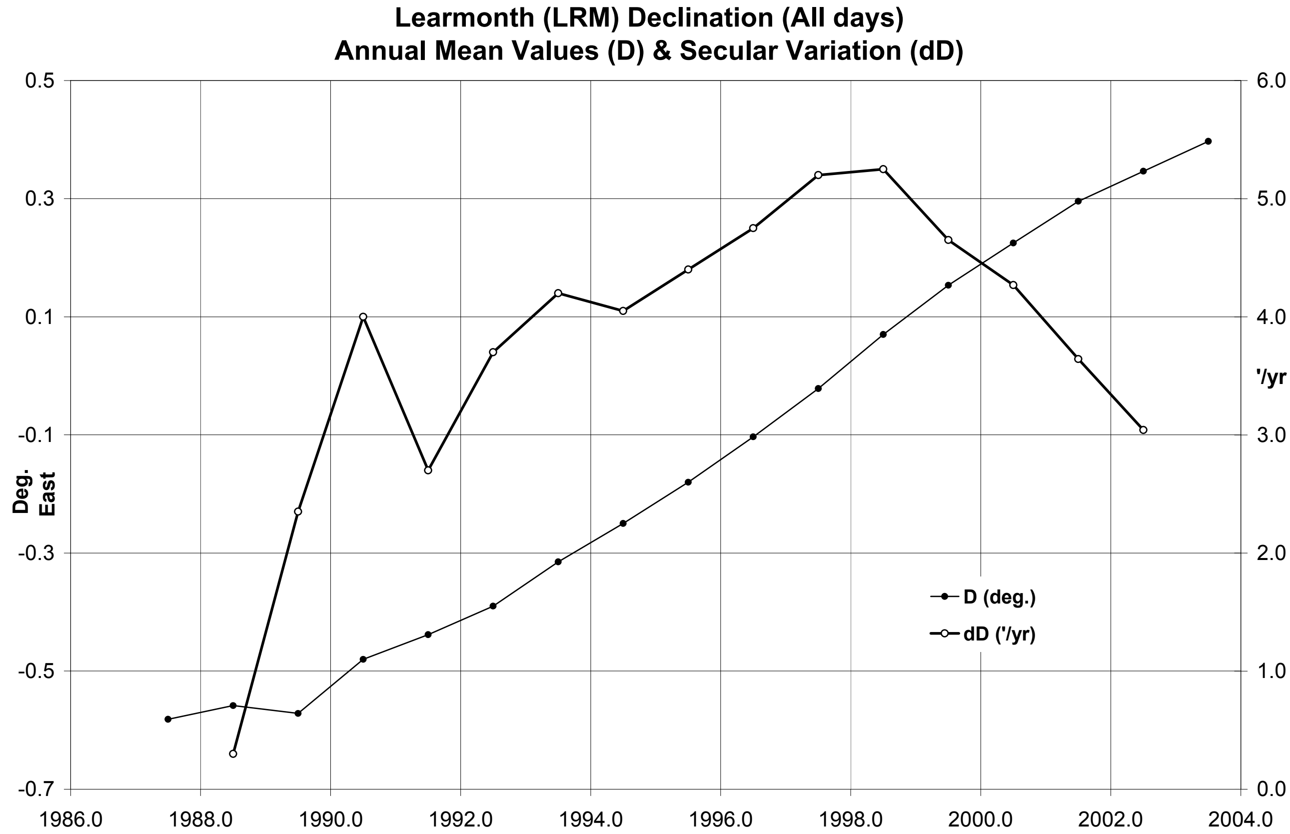


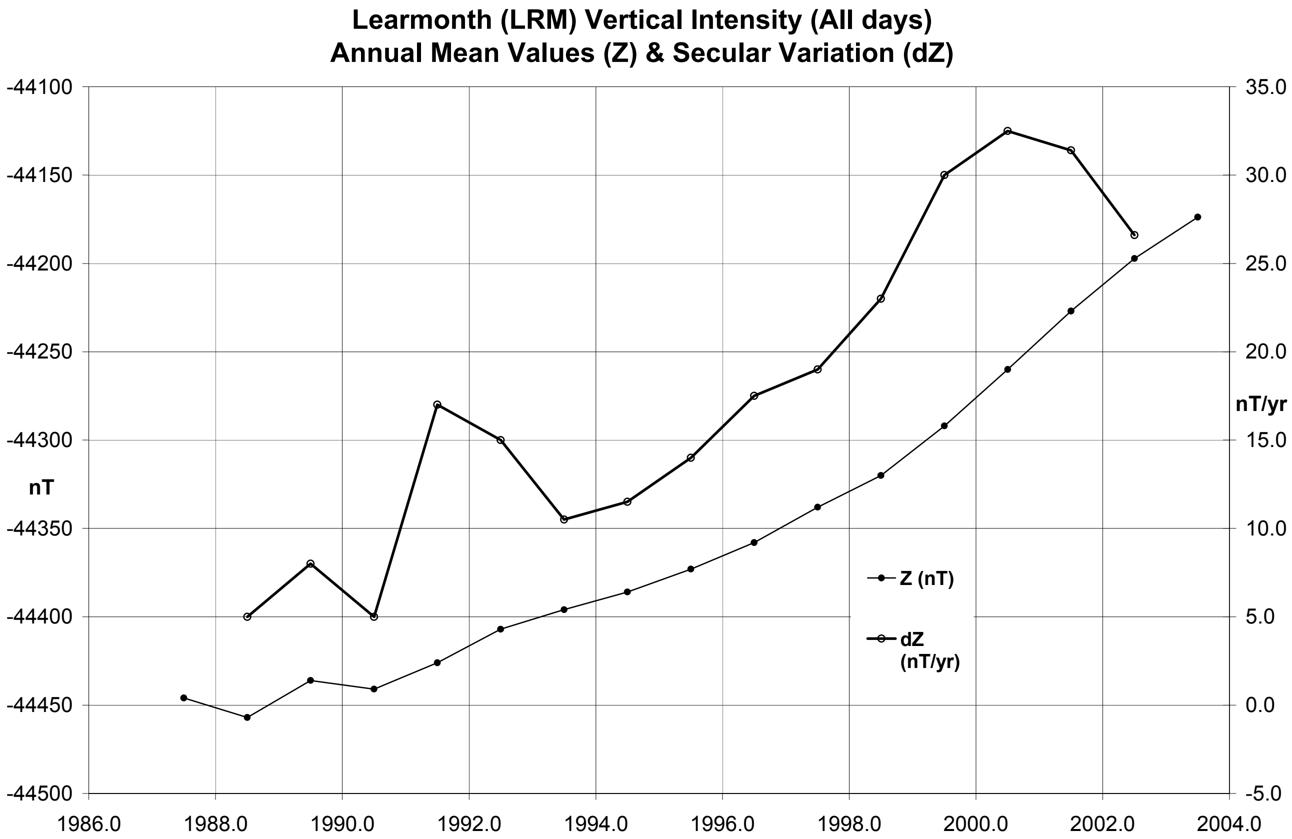
Learmonth 2003 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: -44174 nT



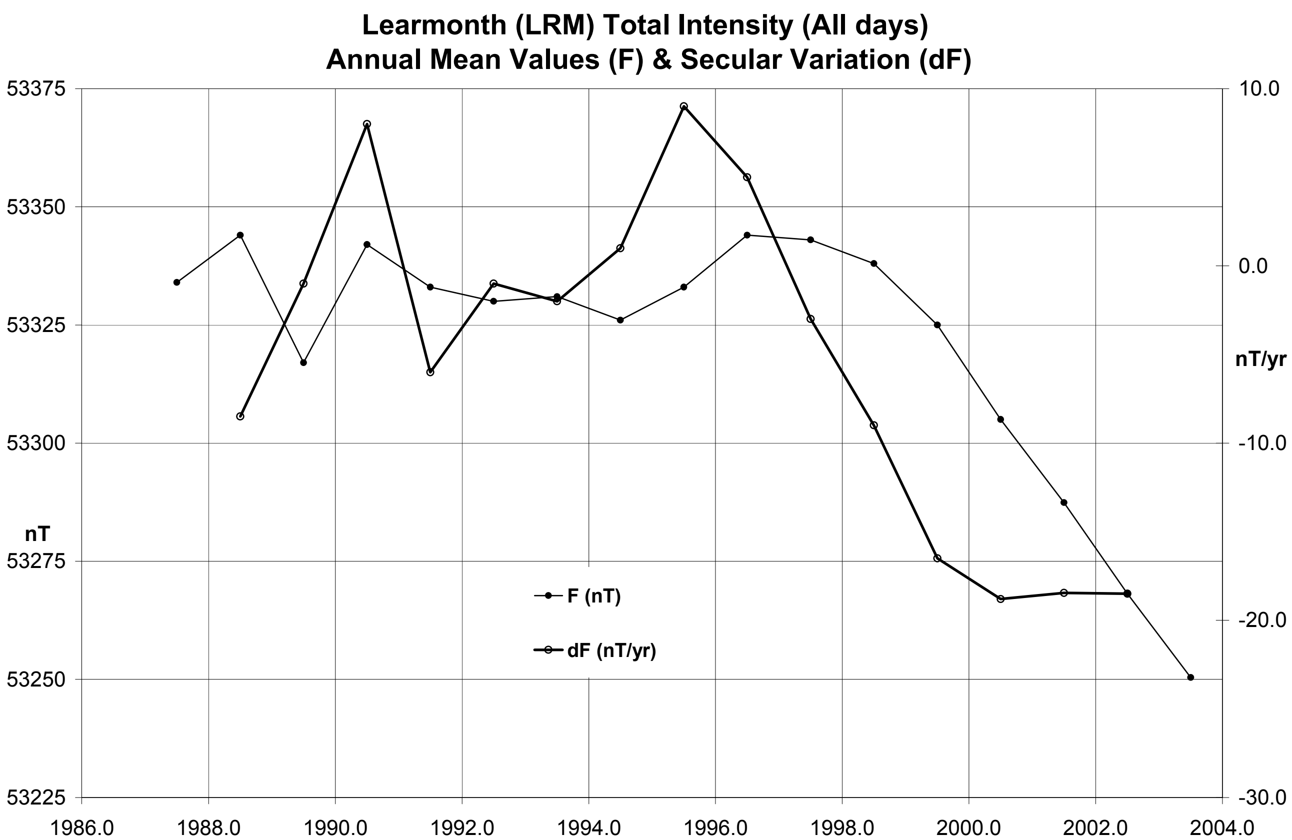
Learmonth 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53250 nT


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


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



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
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
Z (nT)
dZ (nT/yr)



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
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
F (nT)
dF (nT/yr)

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)

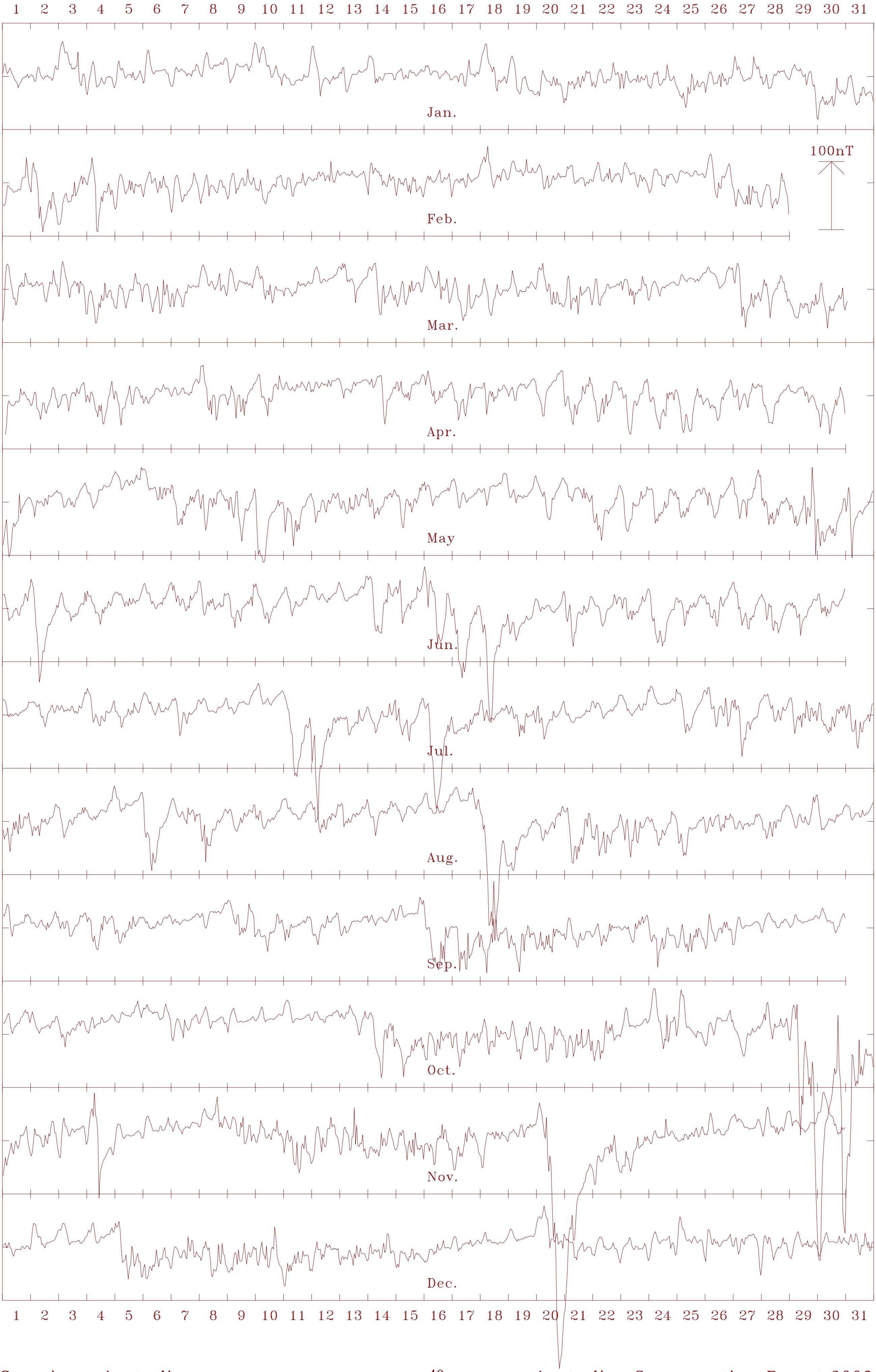
Hourly Mean Values

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

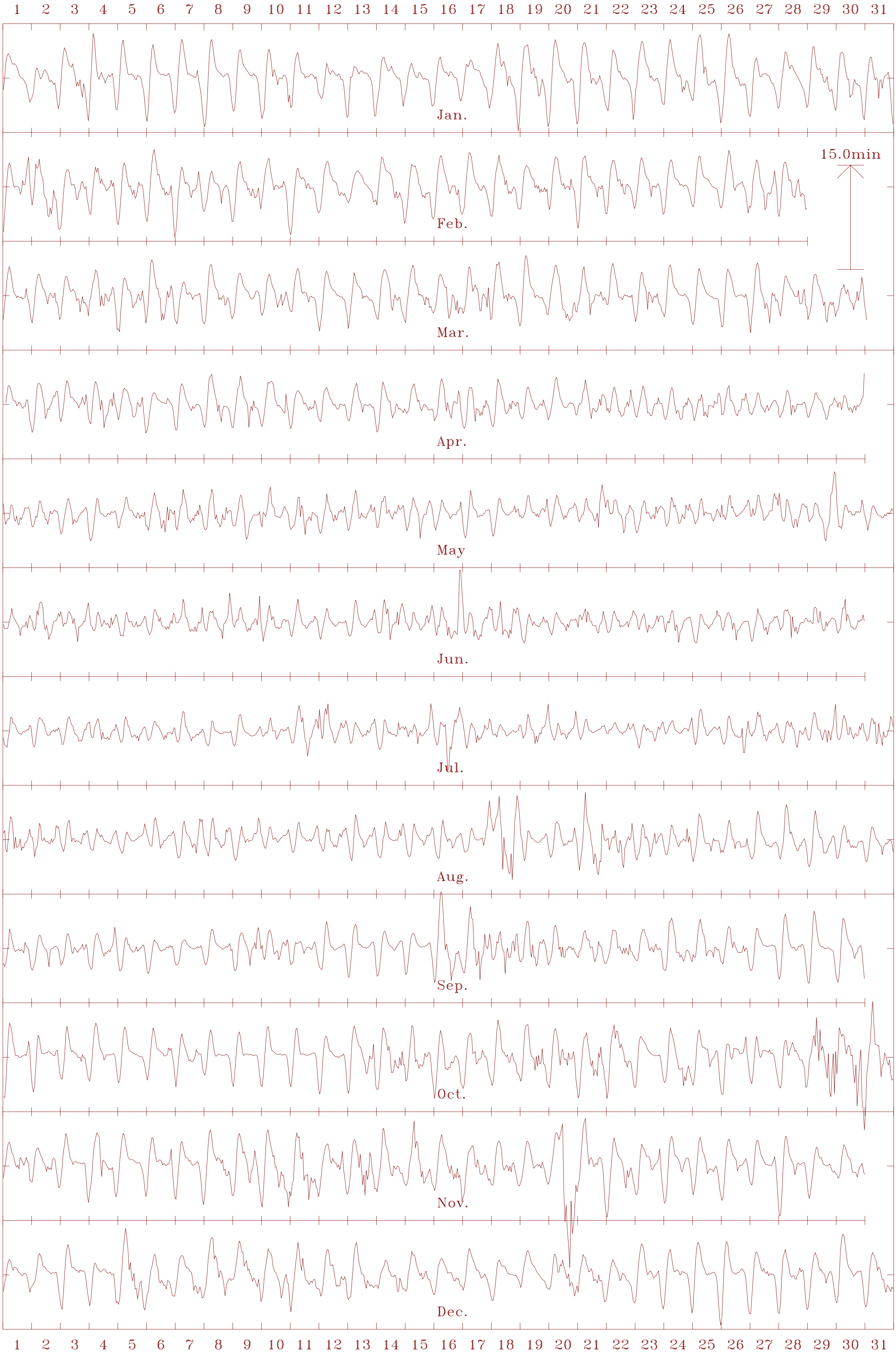
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

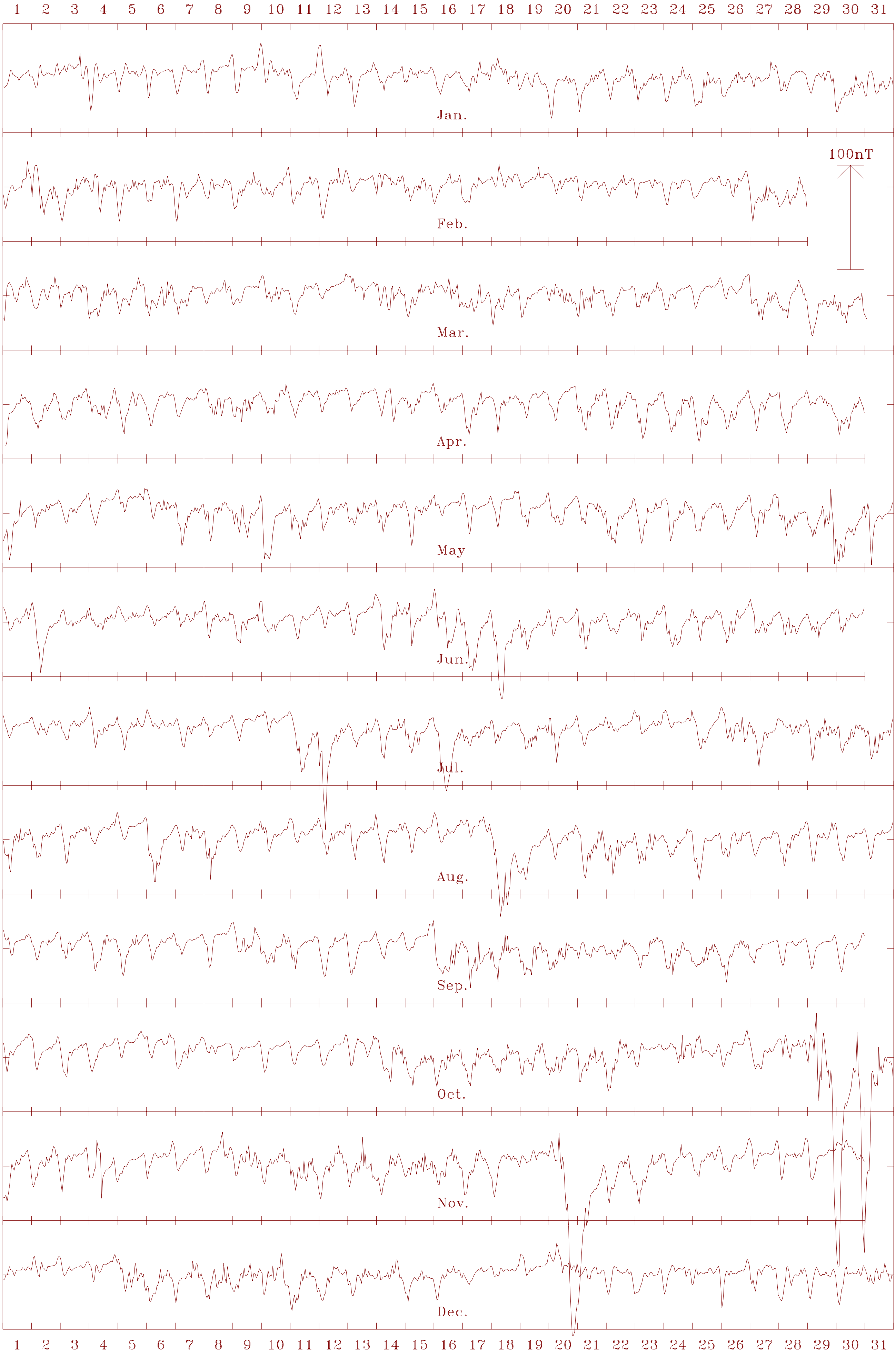


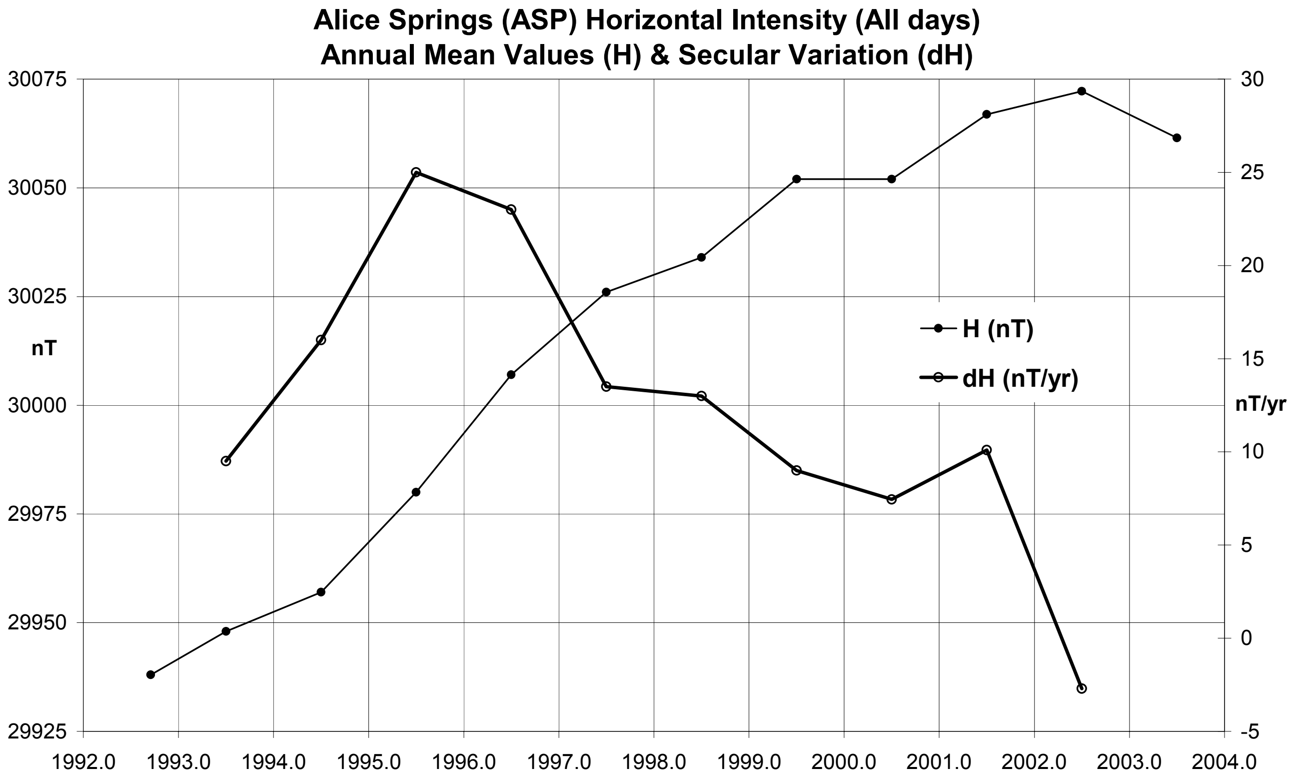
Alice Springs 2003 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.12 deg.

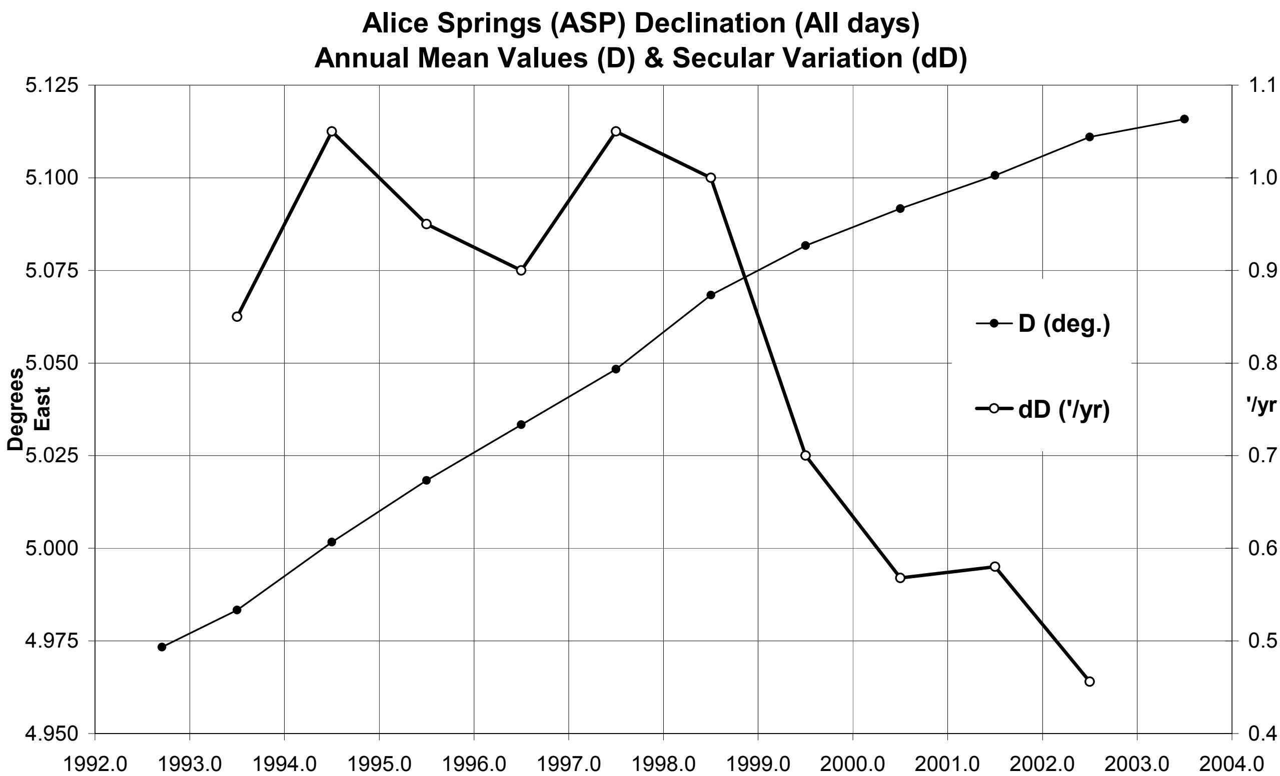


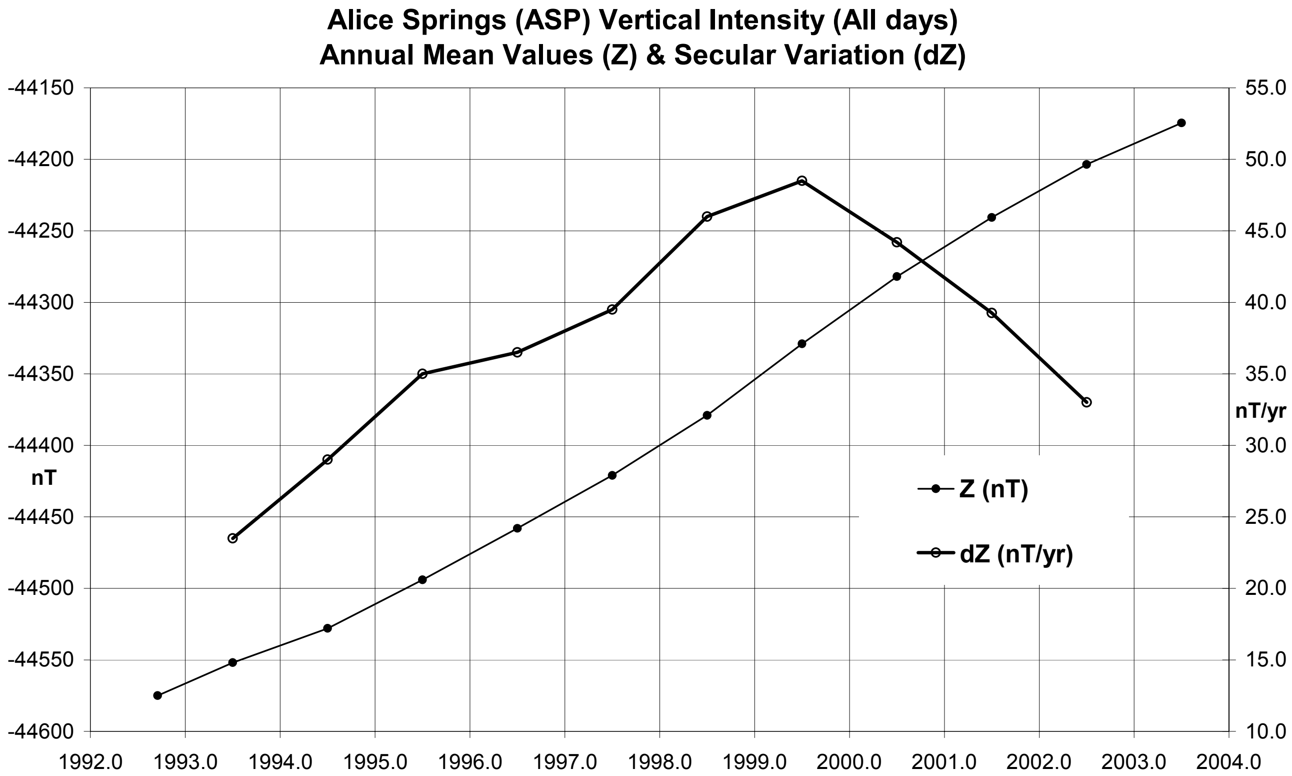
Alice Springs 2003 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44175 nT

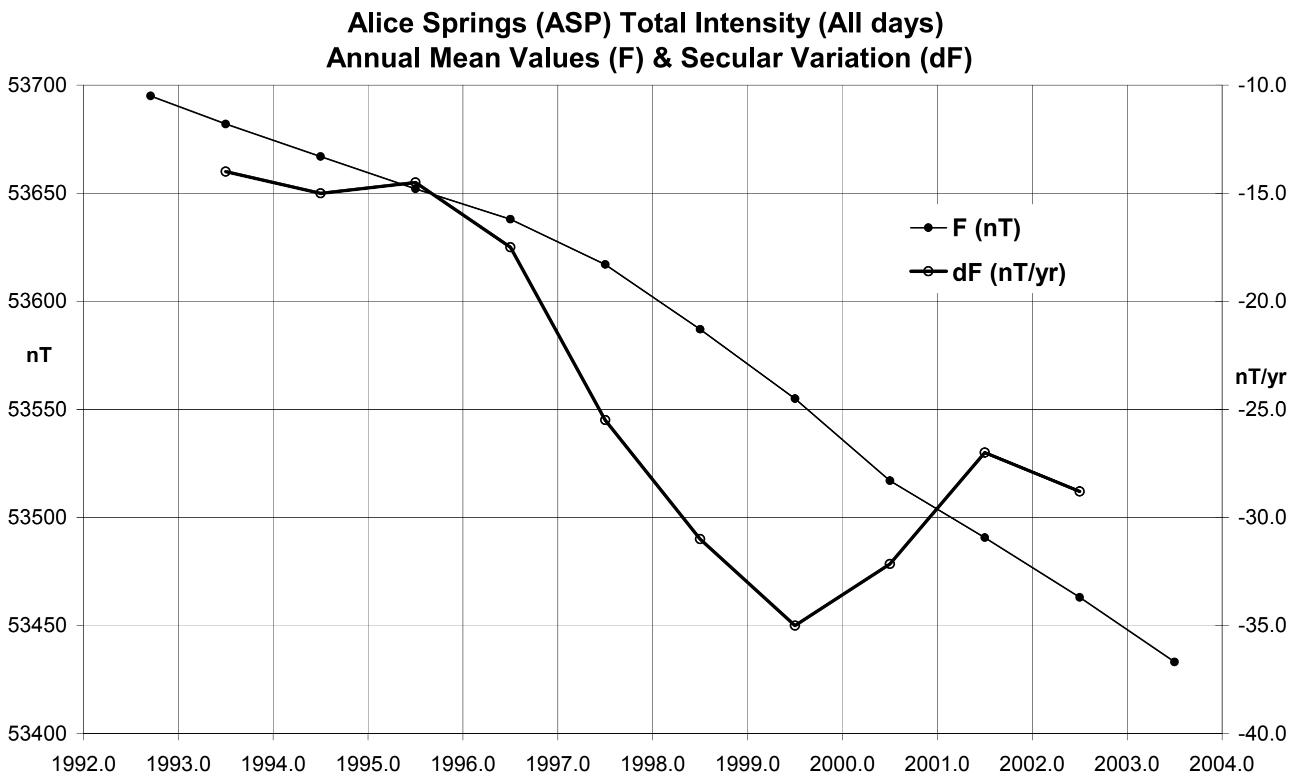
Alice Springs 2003 Total intensity (F). Scale: 5.0 nT/mm. Mean: 53433 nT




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

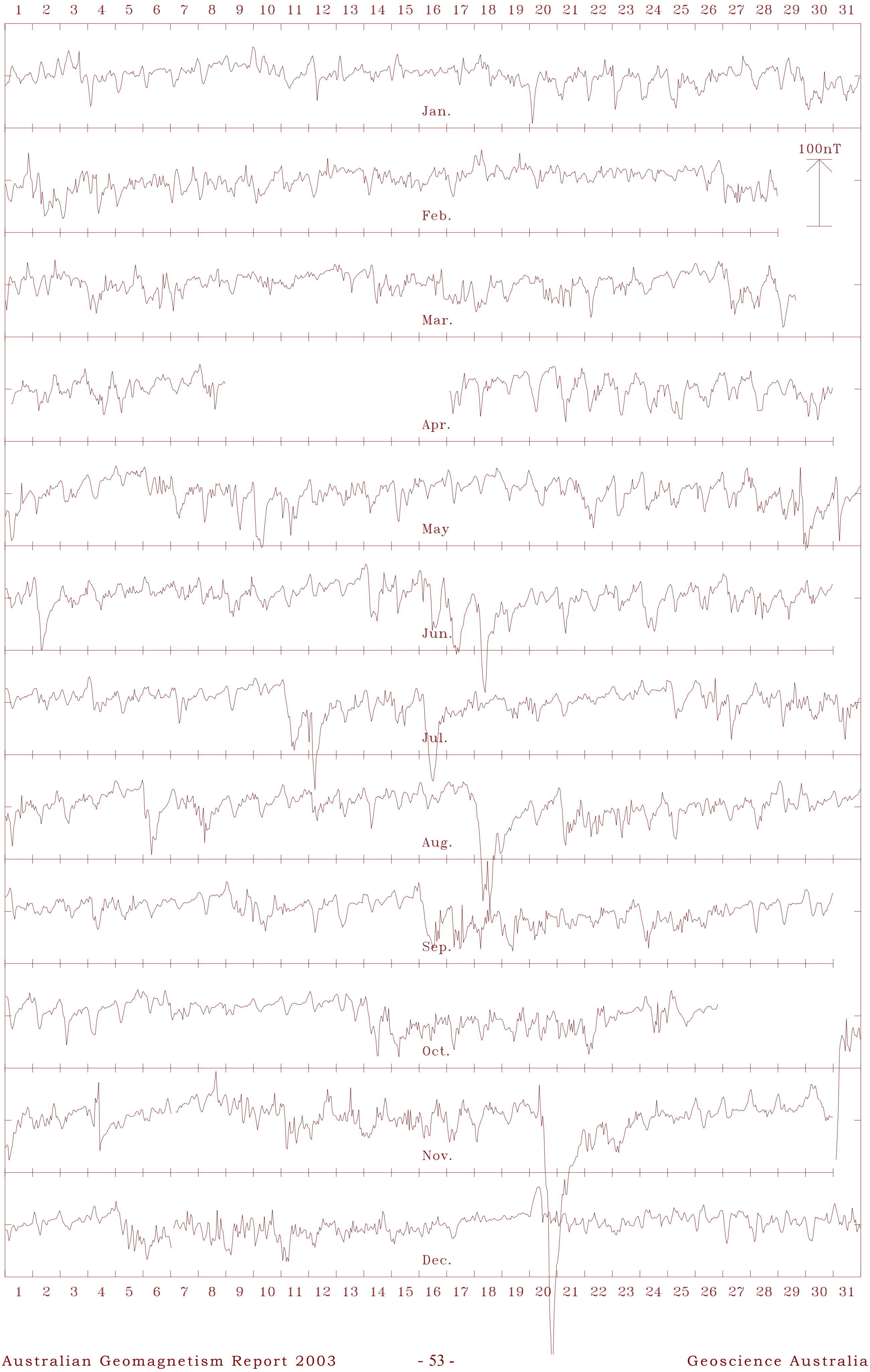
Hourly Mean Values

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

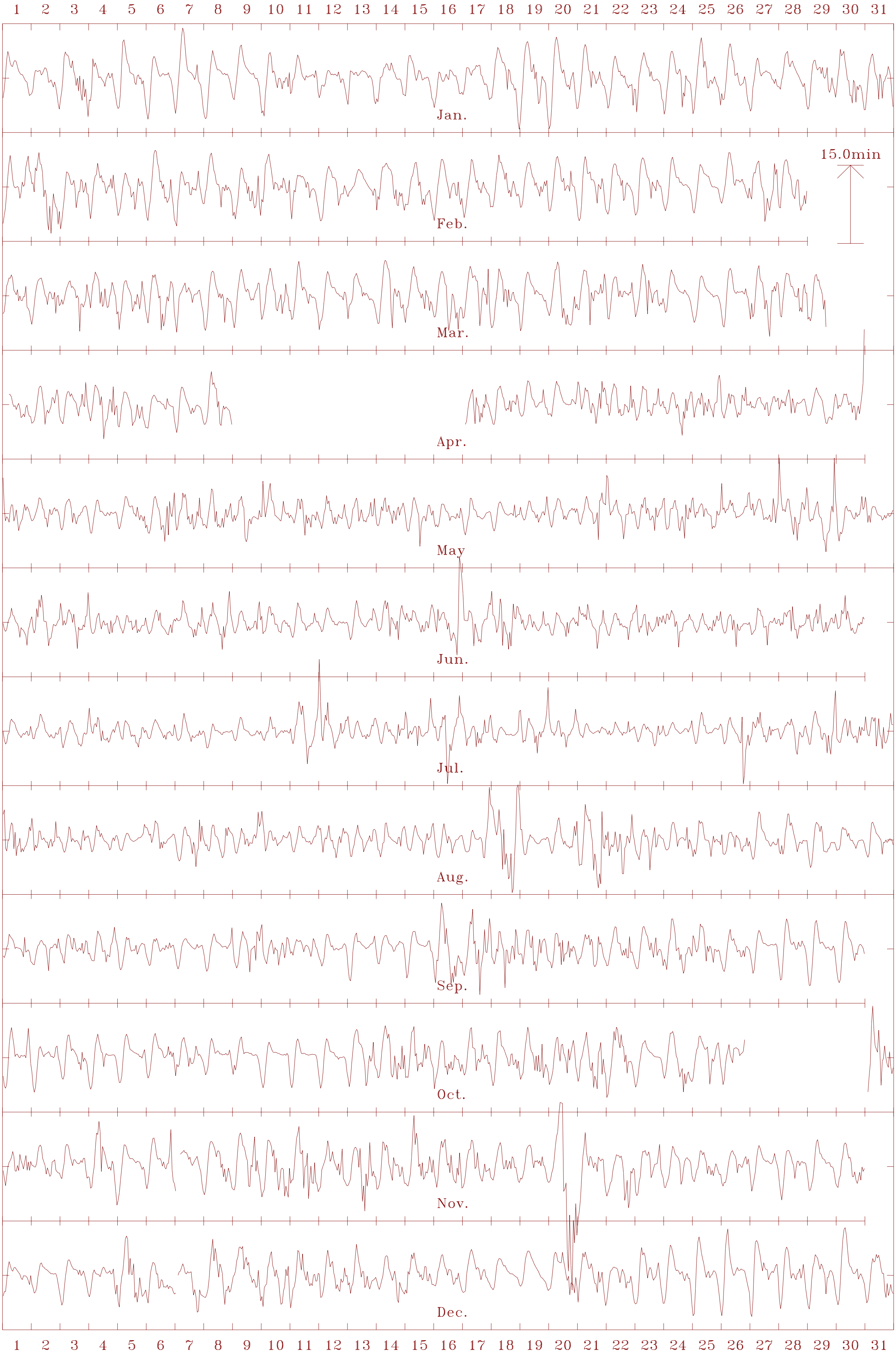
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

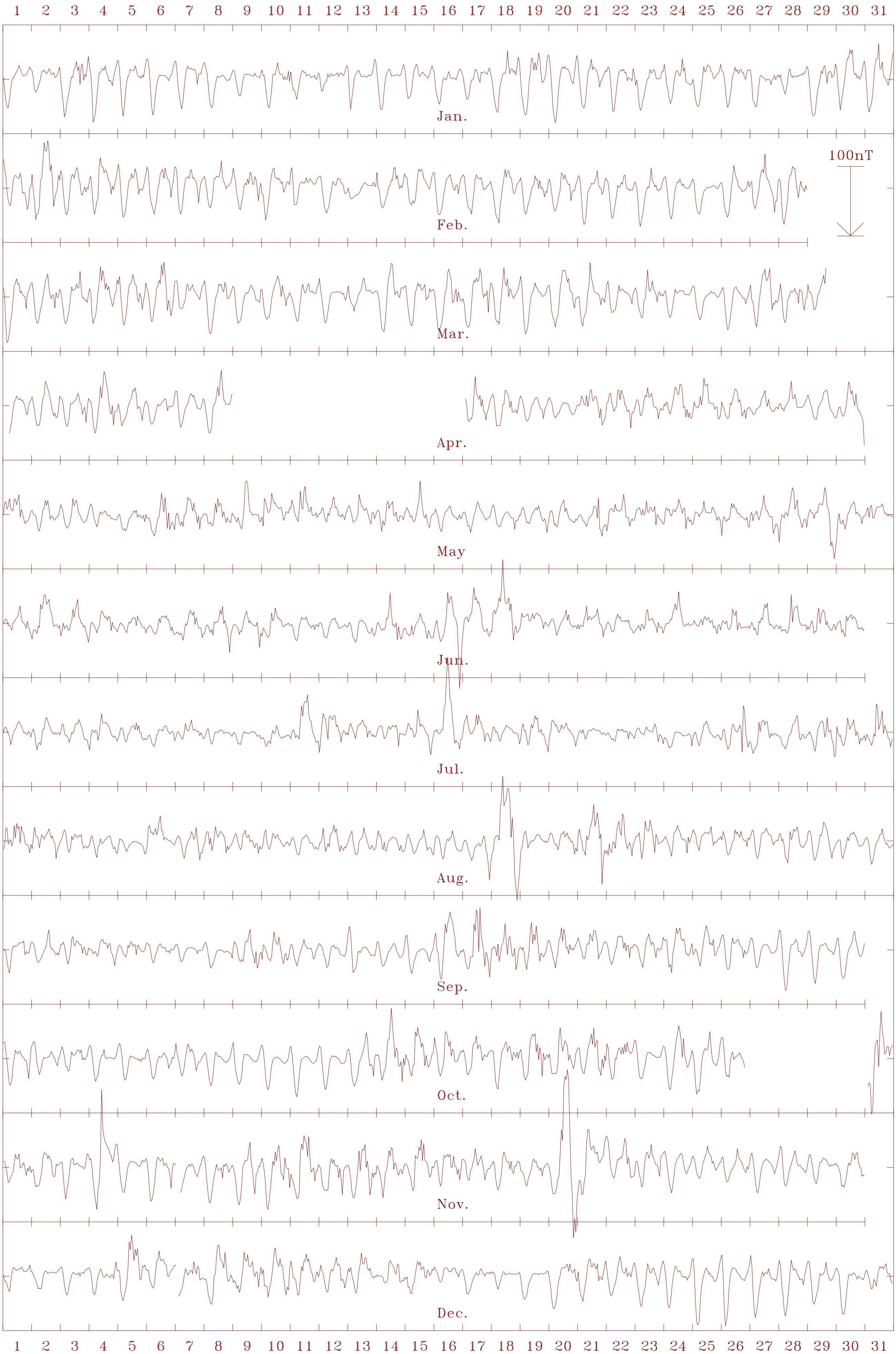
Gnangara 2003 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23243 nT



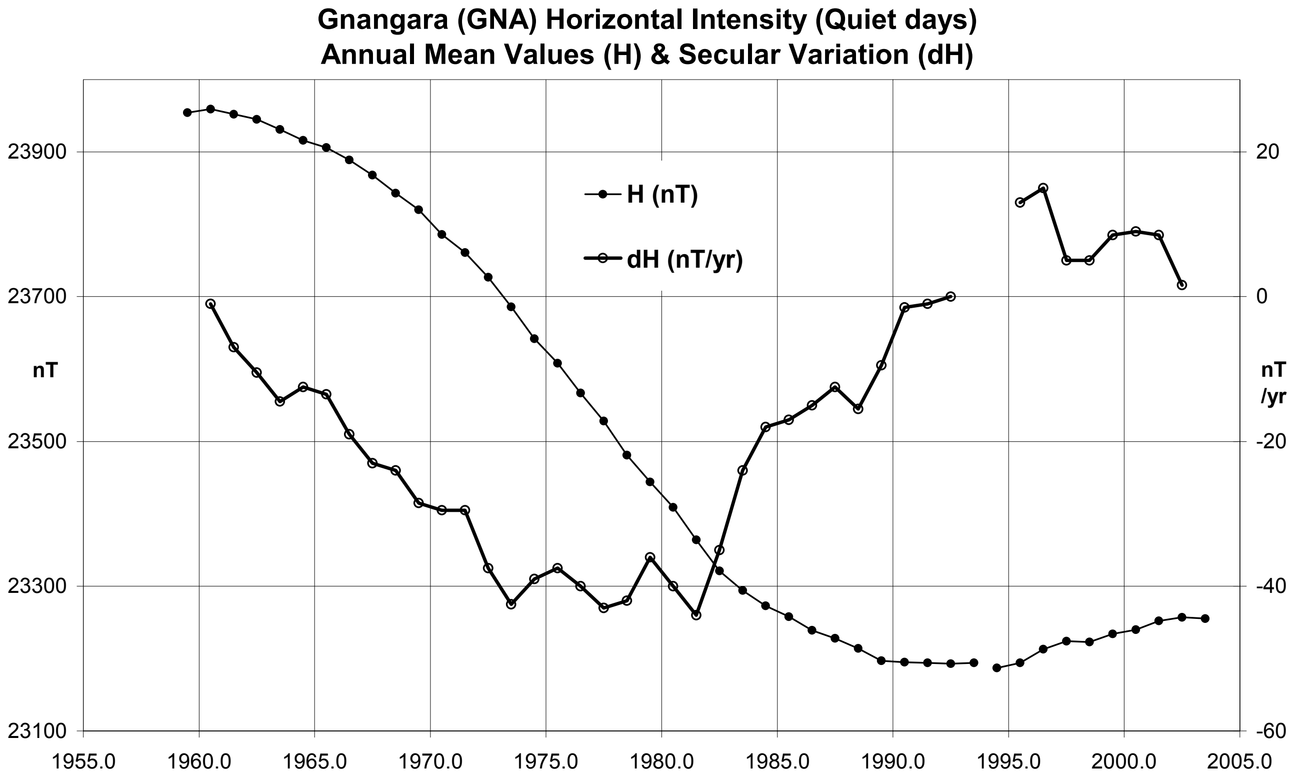
Gnangara 2003 Declination (east) (D). Scale: 1.00 min/mm. Mean: −2.02 deg.

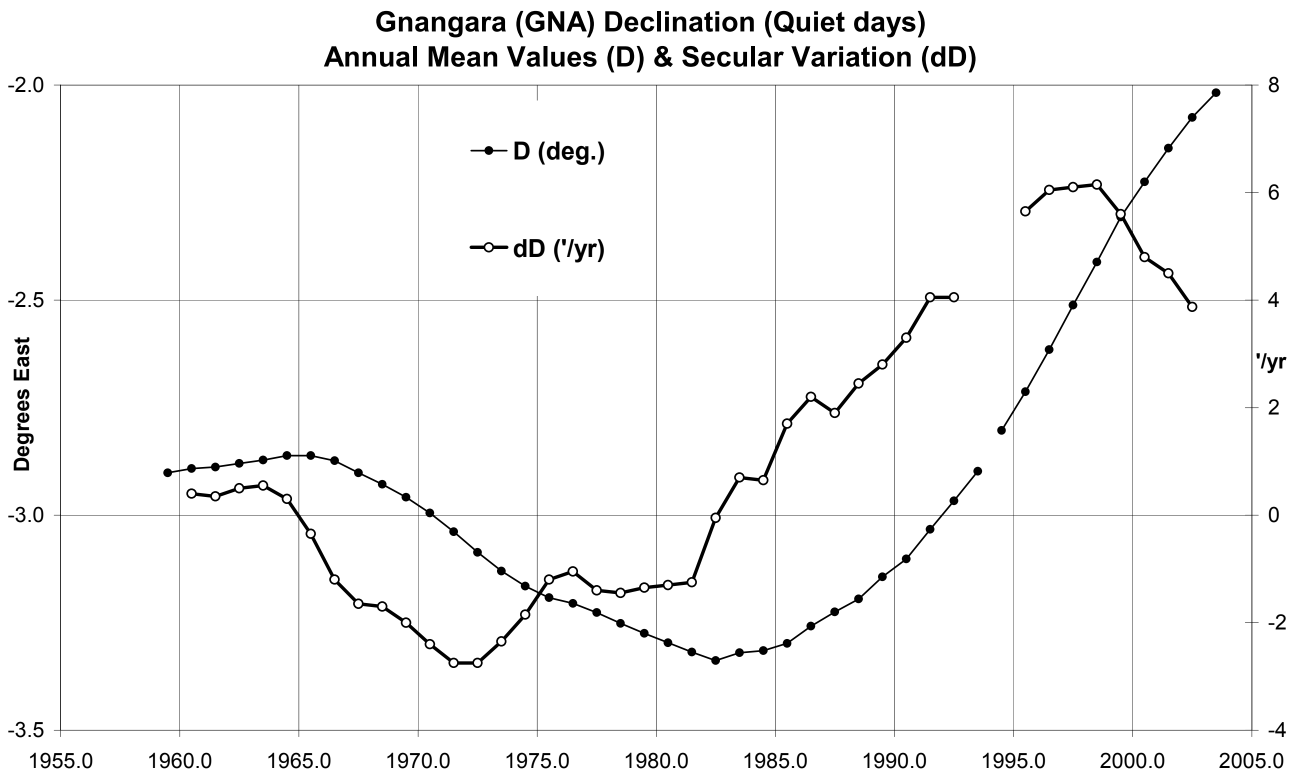


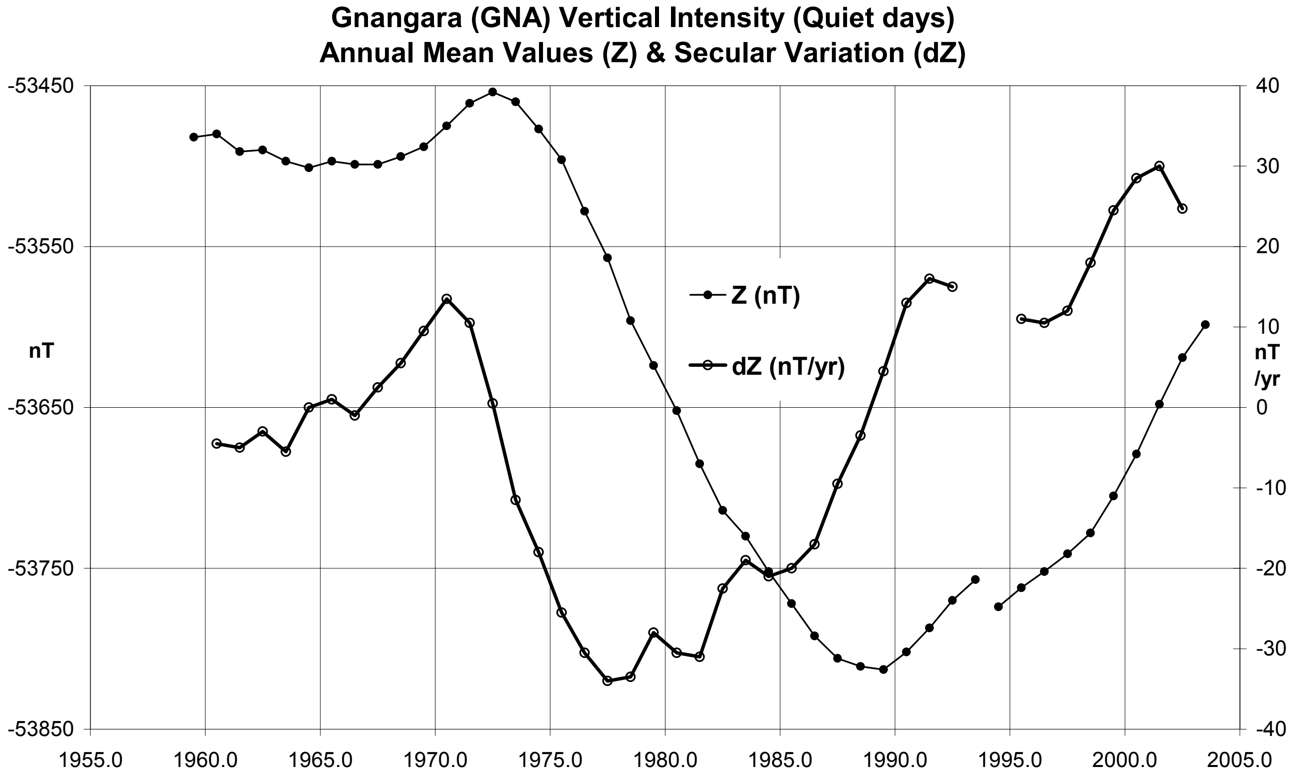
Gnangara 2003 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53601 nT

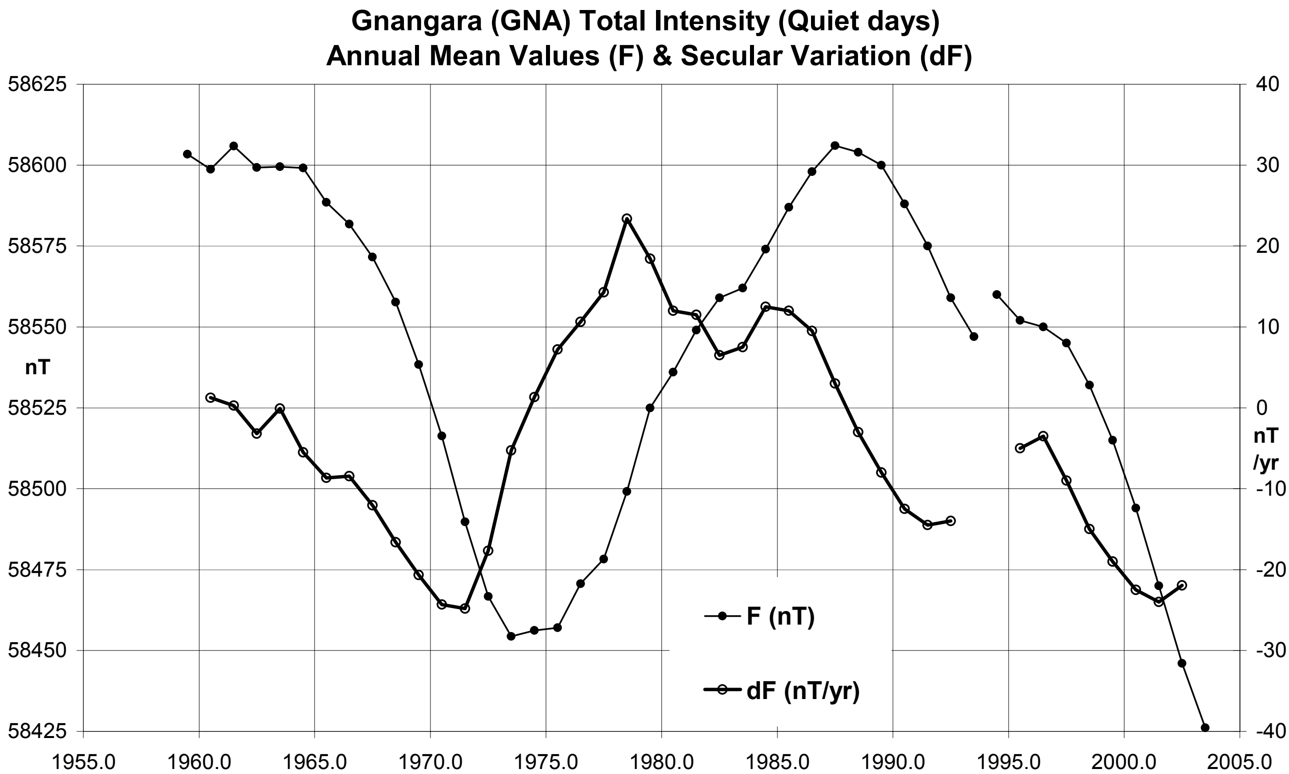


Gnangara 2003 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58424 nT


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