GEOSCIENCE AUSTRALIA

AUSTRALIAN GEOMAGNETISM REPORT 2000

MAGNETIC OBSERVATORIES

VOLUME 48

www.ga.gov.au • GEOSCIENCE AUSTRALIA • www.ga.gov.au

Department of Industry, Tourism and Resources

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

Geoscience Australia

Chief Executive Officer: Neil Williams

Minerals & Geohazards Division

Chief of Division: Chris Pigram
Associate Chief: Wally Johnson

Australian Geomagnetism Report 2000

Volume 48

Geomagnetism Section
Integrated Geophysical Network
Geoscience Australia
G.P.O. Box 378
Canberra, A.C.T., 2601
AUSTRALIA

GEOSCIENCE AUSTRALIA

Magnetic results for 2000

Alice Springs

Canberra

Charters Towers

Gnangara

Kakadu

Learmonth

Macquarie Island

Mawson

Casey

Davis

Australian Repeat Station Network

Compiled by P.A. Hopgood

with contributions by

A.M. Lewis, P.G. Crosthwaite, S.D. Dennis,

Liejun Wang and H. McCreadie

ISSN: 1447-5146 (Online format)

ISSN: 1035-1515 (Printed format)

SUMMARY

During 2000 the Australian Geological Survey Organisation (now Geoscience Australia) operated geomagnetic observatories at Alice Springs and Kakadu in the Northern Territory, Canberra in the Australian Capital Territory, Charters Towers in Queensland, Gnangara and Learmonth in Western Australia, Macquarie Island, Tasmania, in the sub-Antarctic, and Mawson in the Australian Antarctic Territory.

Magnetic recording also took place at the stations of Casey and Davis in the Australian Antarctic Territory. These operations were the joint responsibility of the Australian Antarctic Division of the Commonwealth Department of the Environment and Heritage and GA. Casey was operated at magnetic observatory standard. Davis magnetic station did not have sufficient absolute control to be considered observatory standard, so continued to be regarded as a variation station.

The magnetometers at the Canberra Magnetic Observatory are the Australian standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised to 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 and at Copenhagen, Denmark, as well as to INTERMAGNET. K indices, principal storms and rapid variations were hand-scaled for the Canberra and Gnangara observatories, and provided regularly to the International Service of Geomagnetic Indices. K indices were digitally scaled at the Mawson observatory.

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

A total of eight magnetic repeat stations were occupied in 2000.

Preparations were made for further upgrades to be made to the magnetic observatory at Tangerang and the upgrade of the observatory at Manado, Indonesia by GA's Geomagnetism group under an AusAID grant. This included the purchase of instrumentation and the training of staff from Indonesia's BMG, at GA.

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 2000.

ACRONYMS and ABBREVIATIONS

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

CONTENTS

CONTENTS Continued overleaf …

CONTENTS (continued)

This is the second volume of the *Australian Geomagnetism Report* to be made available in electronic format only.

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

The *Australian Geomagnetism Report* will continue to be published electronically and will be available on Geoscience Australia's web site: *http://www.ga.gov.au/*

ACTIVITIES & SERVICES 2000

Geomagnetic Observatories

The Geomagnetism Section of the Australian Geological Survey Organisation (now Geoscience Australia) operated nine permanent geomagnetic observatories in the Australian region during 2000. The observatories were located at:

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

Antarctic Operations

Geoscience Australia continued its contribution to the Australian National Antarctic Research Expedition (ANARE) in 2000 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 (as well as those stationed at Davis in Antarctica) were trained. Logistic support was provided by the Australian Antarctic Division, Department of the Environment and Heritage.

Two absolute observations were performed monthly by staff of the Australian Antarctic Division at Davis. These observations were reduced and used by GA staff, together with data supplied by the Antarctic Division from the variometers at these sites, to produce monthly mean values of the magnetic field.

Magnetic repeat station network

GA maintains a network of repeat stations covering continental Australia, its offshore islands, Papua New Guinea, and some south-west Pacific islands. In 2000 eight stations were re-occupied were at: Hobart, Norfolk Island, Weipa, Lord Howe Island, Noumea, Honiara, Kavieng and Vanimo.

Calibrations of compasses

GA continued to provide a compass calibration facility at cost recovery rates during 2000. 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, the construction of a purpose-designed Magnetic Calibration Facility building, to the south-east of the Canberra Magnetic Observatory compound, was completed in late 1999. The construction, installation and initial calibration of a Finnish designed 3-axis coil system was completed in December 1999. The facility was officially opened on 18 February, 2000.

Geomagnetism Workshop

On April 26-27, 2000, the *4th Australian Geomagnetism Workshop* (see McCreadie, 2000) was held at Geoscience Australia in Canberra. The workshop was organised jointly by AGSO and the Australian National University. The event attracted up to 100 participants from all parts of Australia, New Zealand and many from overseas.

At the workshop numerous aspects of geomagnetism were presented and discussed.

Following the Geomagnetism workshop there was a Palaeomagnetism workshop.

Indonesian Observatories

Geoscience Australia received an AusAID grant to further support the magnetic observatory at Tangerang near Jakarta and to upgrade the existing Tondano observatory near Manado on Sulawesi.. During 2000, GSM-19 Overhauser variometers and MG2KP steel-free theodolites with DMI fluxgate sensors were purchased for absolute observations at both observatories. A DMI 3-axis fluxgate variometer and a GSM-90 Overhauser variometer was also purchased for the Tondano observatory. This is in addition to the purchase of acquisition PCs and peripheral equipment.

In October 2000 GA hosted a two-week visit by three staff from BMG, Indonesia, to take delivery of the new instrumentation and receive training in its use.

One-minute data values from the Tangerang observatory have been transferred to Geoscience Australia on a daily basis since the observatory was first upgraded by GA staff in 1999 (see *AGR99*). These data will compliment data gained during repeat station occupations to produce more accurate AGRF models in the future.

DATA DISTRIBUTION 2000

During 2000 data from GA's observatory network was routinely provided in support of international programs.

INTERMAGNET

The regular transmission of near real-time preliminary 1-minute data to INTERMAGNET (see Trigg and Coles, 1994) from the Canberra magnetic observatory began late in October 1994, whilst that from the Gnangara observatory began in early 1995. Data from Alice Springs was transmitted from December 1999. During 2000 1-minute data from these three observatories were provided daily by e-mail to the INTERMAGNET GIN at Edinburgh, UK.

Final data from Canberra observatory since 1991, from Gnangara since 1994 and from Alice Springs since 2000, have been included on INTERMAGNET CD-ROMs of definitive magnetic observatory data.

Alice Springs was accepted as an INTERMAGNET observatory in late 1999. Daily e-mail transmissions of data from this observatory to the Edinburgh GIN commenced from 14 December 1999.

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, 2000 preliminary monthly mean values from most Australian observatories were provided by e-mail to IPGP, France.

Storms & Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 2000 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 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 2000, 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, commenced at the beginning of 2000. These replaced the Regional Warning Centre at Meudon Observatory (near Paris) which ceased its daily prediction service at the end of 1999. 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 2000 all routine K index information was sent by e-mail.

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 and WDC-C1, Copenhagen, during 2000 as indicated.

Observatory	WDC-A	WDC-C1
Kakadu	1996, 1997, 1998	
Charters Towers		
Alice Springs	1999	1999
Canberra	1999	1999
Gnangara	1999	1999
Learmonth	1999	
Macquarie Island		
Mawson		
Casey		
Davis		

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 *AGR98*. Beginning with *AGR99*, the report has only been available on GA's web site, from where it may be viewed and/or downloaded.

World Wide Web

Australian Geomagnetic information is available via the World Wide Web 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, on 8 November 2001 became simply Geoscience Australia (GA).

INSTRUMENTATION

During 2000 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 such that the first value *within* an hour, labelled 01^m, was the mean over the interval 00^m30^s to 01^m30^s, in accordance with IAGA resolution 12 adopted at the Canberra Assembly in December 1979. Hourly means were computed from minutes 00^m to 59^m.

Hourly, daily, monthly and annual means span the beginning and end of a UT period and so relate to the centre of the respective intervals.

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 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.

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] contains the scale-values;
- 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], [B] [Q] [q] 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.

Variometers in service at Australian Observatories in 2000

Observatory	Variometer/Serial no. (operational period)	Resolution (nT)	Acquisition interval (sec.)	Components recorded
ASP	Narod ring-core fluxgate/9004-3	0.025	1, 60	X, Y, Z‡
	GSM-19 Overhauser Magnetometer / BMR#1	0.01	10, 60	F
CNB	Narod ring-core fluxgate/9004-2	0.025	1, 60	NW, NE, Z†
	GEM Systems GSM-90 / 803810	0.01	1, 60	F
CTA	EDA FM105B fluxgate: 2887/3181* (until 27 Aug 2000)	0.2	1, 60	NW, NE, Z†
	DMI FGE (ver.G) S0210/E0227 (from 28 Aug 2000)	0.1	1, 60	NW, NE, Z†
	Elsec 820M3 PPM s/n 128 (until 20 Nov. 2000)	0.1	10, 60	F
	Elsec 820M3 PPM s/n 138 (from 05 Dec. 2000)	0.1	10, 60	F

Variometers in service at Australian Observatories in 2000 (cont.)

Observatory	Variometer/Serial no. (operational period)	Resolution (nT)	Acquisition interval (sec.)	Components recorded
GNA	DMI FGE (ver.D) S0160/E0167 Geometrics 856 No.50706	0.1 0.1	1, 60 10, 60	NW, NE, Z† F
KDU	EDA FM105B fluxgate 2884/5460* (until 31 May 2000) EDA FM105B fluxgate 3185/5460* (from 01 Jun until 11 Oct. 2000) DMI FGE fluxgate E0198/S0183 (from 14 Oct. 2000) Geometrics 856 No.50707	0.2 0.2 0.1 0.1	1, 60 1, 60 1, 60 10, 60	NW, NE, Z† NW, NE, Z† NW, NE, Z† F
LRM	Narod ring-core fluxgate No.9004-4 Geometrics 856 No.50708	0.025 0.1	1, 60 10, 60	NW, NE, Z F
MCQ	Narod ring-core fluxgate 9305-1 Elsec 820M3 PPM 140	0.025 0.1	1, 60 10, 60	A, B, C† F
MAW	Narod ring-core fluxgate 9004-1 Elsec 820M3 PPM 158	0.025 0.1	1, 60 10, 60	NW, NE, Z† F
DVS	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡
CSY	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡

* 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.
† Recorded components A, B & C or NW, NE, Z indicate non-aligned orientation. ‡ Installed before 1993.

Absolute magnetometers

Several types and models of absolute magnetometers were used to calibrate the variometers at the Australian magnetic observatories during 2000. The principal magnetometer combination was a D,I-fluxgate magnetometer (or 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.

Some of the instruments are described below. A summary of the absolute magnetometers that were in use at each of the Australian observatories during the year is in the table that follows.

MNS2 Proton Precession Magnetometer

The 'Magnetic Nuclear Standard' (type 2), or MNS2, proton precession magnetometer, was designed and constructed (Seers, 1979) at the BMR during the 1970's and continued to provide reliable service in 2000. An instrument of this type (serial no.3) that was housed at the Canberra Magnetic Observatory served as the Total Intensity standard for the Australian observatory network. (See *Magnetic Standards* below)

Declination & Inclination Magnetometer (DIM)

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 can be determined: its Declination when the sensor is level; its Inclination when the sensor is in the magnetic meridian.

In 2000 both Elsec 810 and Bartington MAG-01H fluxgate sensors and electronics were used together with Zeiss-Jena 020B and 010B non-magnetic theodolites.

Ancillary equipment

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

Absolute Magnetometers employed in 2000

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
ASP	DIM: Elsec 810/221; Zeiss 020B/313887* PPM: Elsec 770/193	D, I F	0.1' 1 nT
CNB	DIM: Elsec 810/200; Zeiss 020B/353756* PPM: MNS-2/no.3 PPM: GSM-90 no.905926 (new standard from 01 Jan 2001)	D, I F F	0.1' 0.1 nT 0.1 nT
CTA	DIM: Elsec 810/215; Zeiss 020B/313888* PPM: Geometrics 816/767	D, I F	0.1' 1 nT
GNA	DIM: Bartington MAG010H/B0725H; Zeiss 020B/355937* PPM: Geometrics 856 no. 50631 (sensor 28079922)	D, I F	0.1' 0.1 nT

Absolute Magnetometers employed in 2000 (cont.)

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
LRM	DIM: Bartington 0702H; Zeiss 020B/312714 PPM: Geometrics 856 no. 50471	D, I F	0.1' 0.1 nT
MCQ	DIM: Elsec 810/201; 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
MAW	DIM: Elsec 810/213; Zeiss 020B/352229* (until January 2000) Bartington 00766H; Zeiss 020B/313792 (from Jan 2000) PPM: Elsec 770/199 Elsec 770/206 (secondary) QHM Nos. 300, 301, 302 (secondary) Declinometer: Askania 630332 (secondary) Askania circle 611665 (for mounting QHM and Declinometer)	D,I D,I F F H D	0.1' 0.1' 1 nT 1 nT 0.1 nT 0.1'
CSY	DIM: Elsec 810/2591; Zeiss 020B/356514*† PPM: Geometrics 816/1024 QHM No. 493	D, I F H	0.1' 1 nT 0.1 nT
DVS	DIM: Elsec 810/213; Zeiss 020B/352229* (ex Mawson: January 2000) PPM: Geometrics 816/1025 QHM No. 492 (primary until to 19 Jan 2000)	D, I F H	0.1' 1 nT 0.1 nT

* DIM serial numbers are in the sequence DIM control module followed by Zeiss theodolite
† The DIM at Casey is an Antarctic Division instrument.

MAGNETIC STANDARDS

BMR/AGSO/GA has always maintained its own standards for Declination and Total Intensity. Since the late 1970s the Australian magnetic standards have been held at the Canberra Magnetic 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 has eliminated the need for International calibrations to maintain a Horizontal Intensity, H, standard. This has enabled the more rapid adoption of final instrument corrections.

Proton precession magnetometer MNS2 no.3 has served as the Total Intensity (F) standard since the late 1970s. 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 0.78nT too high.
This correction has been applied to 2000 Canberra F-baselines. Appropriate adjustments have also been made to the X, Y and Z baselines of the other observatories, to take account of the PPM MNS2 no. 3 correction, as the PPMs at these sites have been standardized for consistency with this instrument.

All absolute instruments were calibrated against Canberra DIM Elsec 810 no.200 with Zeiss020B theodolite no.353756 and PPM MNS2 no.3, 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.

DATA ACQUISITION

During 2000 data acquisition at all the Australian observatories was computer-based. Throughout the year data were recorded every second and every minute at all observatories.

The timing of the data acquisition was controlled by the DOS clock in the acquisition PCs. As 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 some 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 EDA FM105B and DMI FGE variometers, to digital values for recording on data acquisition PCs.

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

Digital data have been automatically retrieved from the observatories each day since March 1996. In 2000 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 the Geomagnetism Section at the GA headquarters in Canberra.

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 2000.

Australian Magnetic Observatories, 2000

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"	-22.05°	205.40°	15	K. Stellmacher
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-28.02°	220.77°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.42°	186.23°	4	M. McMullan; G.A. Steward [1]
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-32.91°	207.97°	557	W. Serone
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-41.90°	188.61°	60	E.P. Paull; O. McConnel [2]
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.65°	226.76°	859	Liejun Wang
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-59.98°	244.14°	8	J. Osanz
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.12°	109.59°	12	P. Johnson
Casey	CSY		66° 17'	110° 32'	-76.52°	183.65°	40	M. Hyde
Variation Station								
Davis	DVS		68° 34' 38"	77° 58' 23"	-76.39°	127.67°	29	D. Lehmann

† Geomagnetic coordinates are based on the 2000.0 International Geomagnetic Reference Field (IGRF) model in which the geomagnetic north pole position is 79.610°N, 288.428°E.

1 G.A. Steward replaced M. McMullan as OIC at Learmonth after 21 August 2000.

2 O. McConnel replaced E.P. Paull as OIC at Gnangara when the MGO closed on 28 April 2000.

Crustal Anomalies:

Crustal anomalies for 2000.5 epoch have been calculated for each of the Australian observatories and are shown in the table below. The crustal anomaly for each element is the difference between the All Days Annual Mean of the element at the observatory and the IGRF 2000 value at the location of the observatory with the secular variation model applied out to epoch 2000.5.

Obs'ty	Epoch 2000.5	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (° ')	I (° ')
CNB	2000 Annual Mean	23139	5160	-53367	58396	23708	12° 34.2'	-66° 02.9'
	IGRF00 for 2000.5	23149	5120	-53422	58447	23708	12° 28.3'	-66° 04.1'
	Crustal Anomaly	**-10**	**40**	**55**	**-51**	**-1**	**+00° 05.9'**	**+00° 01.3'**
ASP	2000 Annual Mean	29934	2668	-44282	53517	30052	05° 05.3'	-55° 54.5
	IGRF00 for 2000.5	29926	2668	-44315	53540	30044	05° 05.6'	-55° 51.8'
	Crustal Anomaly	**8**	**0**	**33**	**-23**	**8**	**-00° 00.3'**	**-00° 02.7'**
CTA	2000 Annual Mean	31520	4288	-37866	49455	31811	07° 44.8'	-49° 58.0'
	IGRF00 for 2000.5	31998	4399	-38073	49928	32299	07° 49.7'	-49° 41.4'
	Crustal Anomaly	**-478**	**-111.3**	**207**	**-473.4**	**-488.7**	**-00° 04.9'**	**-00° 16.6'**
GNA	2000 Annual Mean	23212	-903	-53682	58493	23230	-02° 13.6'	-66° 36.0'
	IGRF00 for 2000.5	23261	-807	-53803	58622	23275	-01° 59.2'	-66° 36.4'
	Crustal Anomaly	**-49**	**-96**	**121**	**-129**	**-45**	**-00° 14.4'**	**+00° 00.4'**

Crustal anomaly table (cont.)

Obs'ty	Epoch 2000.5	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (° ')	I (° ')
KDU	2000 Annual Mean	35356	2310	-30163	46531	35431	03° 44.3'	-40° 24.5'
	IGRF00 for 2000.5	35377	2326	-30176	46556	35453	03° 45.7'	-40° 24.2'
	Crustal Anomaly	**-21**	**-15**	**13**	**-25**	**-22**	**-00° 01.4'**	**-00° 00.3'**
LRM	2000 Annual Mean	29706	116	-44260	53305	29707	+00° 13.5'	-56° 07.9'
	IGRF00 for 2000.5	29762	150	-44447	53491	29762	+00° 17.3'	-56° 11.6'
	Crustal Anomaly	**-56**	**-33**	**186**	**-186**	**-56**	**-00° 03.8'**	**+00° 03.7'**
MAW	2000 Annual Mean	7610	-16935	-45594	49230	18566	-65° 48.2'	-67° 50.6'
	IGRF00 for 2000.5	7603	-16955	-45699	49333	18582	-65° 50.9'	-67° 52.4'
	Crustal Anomaly	**7**	**21**	**105**	**-103**	**-16**	**+00° 02.8'**	**+00° 01.8'**
MCQ	2000 Annual Mean	10847	6382	-63268	64507	12585	30° 28.4'	-78° 45.0'
	IGRF00 for 2000.5	10627	6365	-63579	64775	12387	30° 55.1'	-78° 58.5'
	Crustal Anomaly	**220**	**18**	**311**	**-267**	**198**	**-00° 26.7'**	**+00° 13.5'**
CSY	2000 Annual Mean	-538	-9571	-63759	64476	9587	-93° 13.2'	-81° 27.0'
	IGRF00 for 2000.5	-1364	-9301	-62843	63542	9401	-98° 20.7'	-81° 29.5'
	Crustal Anomaly	**826**	**-270**	**-916**	**934**	**186**	**+05° 07.5'**	**+00° 02.5'**
DVS	2000 Annual Mean	3258	-16439	-51664	54314	16759	-78° 47.4'	-72° 01.7'
	IGRF00 for 2000.5	3491	-16622	-51715	54433	16985	-78° 08.3'	-71° 49.1'
	Crustal Anomaly	**-233**	**183**	**51**	**-119**	**-226**	**-00° 39.1'**	**-00° 12.5'**

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 is 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 some 50m north and 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† latitude: -32.91°
- Geomagnetic† longitude: 207.97°
- 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)

† Based on the IGRF 2000 model.

Variometers

Variations in the X, Y and Z components of the magnetic field were recorded at Alice Springs in 2000 using a three-component Narod ring-core fluxgate (RCF) magnetometer and in the total magnetic field intensity (F) using a GEM system GSM-19 Overhauser-effect proton precession magnetometer (PPM). The six channels of variometer data, (three RCF channels, RCF head and electronics temperatures, and the PPM data), were recorded on an IBM compatible PC.

The recording, and variometer, electronic control equipment was housed in the temperature-controlled 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 between the sensor vaults and the control house passed through underground conduits.

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

Absolute Instruments

The principal absolute instruments employed at Alice Springs during 2000 were a D,I fluxgate magnetometer (DIM) and a 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. The PPM was Elsec model 770 no. 193.

Instrument corrections

The adopted instrument corrections applied to the absolute magnetometers used at Alice Springs in 2000 were determined from instrument comparisons that were performed in January 2001. A set of travelling standard instruments (Bartington MAG-01H serial 0610H with Zeiss 010B no. 160459 DIM and GSM90 no. 810881 PPM) was compared with the proposed Australian Magnetic Standard instruments (Elsec 810 no. 200 with Zeiss 020B no. 353756 DIM and GSM-90 no. 905926 PPM) at the Canberra Magnetic Observatory. The travelling standard was then compared with the Alice Springs instruments (Elsec 810 no. 221 with Zeiss 020B no. 313887 DIM and Elsec 770 no. 193 PPM) at the Alice Springs Observatory during the maintenance visit in January 2001.

The corrections to the Alice Springs absolute instruments, adopted to align them with the proposed Australian Magnetic Standard (see Canberra Observatory: Instrument Corrections, this report) were 0.1', -0.1', -3.0nT in D, I and F respectively. These translate to baseline corrections of **-3 nT, 1 nT** and **2 nT** in **X, Y** and **Z** respectively (when rounded to the nearest nT) at the mean field values at Alice Springs of: X=29935nT; Y=2660nT; Z=-44330nT. These corrections have been applied to the 2000 data in this report.

(To align the data with the Australian Magnetic Standard current for the year 2000, i.e. based on the corrected MNS2 no.3 PPM, an additional adjustment of between 0.1nT and 0.4nT in F must be applied to the GSM90 no. 905926 observations. When rounded to the nearest nT this translates to baseline adjustments in ΔX = 0nT, ΔY = 0nT and ΔZ = -1nT (maximum), and so ΔH = 0 nT. D and I remain unchanged.

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 14-15.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1992.708	A	4	58.4	-56	6.8	29938	29825	2595	-44575	53695	XYZ
1993.5	A	4	59.0	-56	5.5	29948	29835	2601	-44552	53682	XYZ
1994.5	A	5	0.1	-56	4.1	29957	29843	2612	-44528	53667	XYZ
1995.5	A	5	1.1	-56	1.7	29980	29865	2623	-44494	53652	XYZ
1996.5	A	5	2.0	-55	59.0	30007	29892	2633	-44458	53638	XYZ
1997.5	A	5	2.9	-55	56.6	30026	29910	2642	-44421	53617	XYZ
1998.5	A	5	4.1	-55	54.7	30034	29917	2653	-44379	53587	XYZ
1999.5	A	5	4.9	-55	51.9	30052	29934	2662	-44329	53555	XYZ
2000.5	A	5	5.5	-55	50.2	30052	29934	2667	-44282	53517	XYZ
1992.708	Q	4	58.4	-56	6.0	29950	29838	2596	-44572	53700	XYZ
1993.5	Q	4	59.0	-56	4.8	29959	29845	2603	-44550	53686	XYZ
1994.5	Q	5	0.2	-56	3.3	29971	29857	2614	-44524	53672	XYZ
1995.5	Q	5	1.1	-56	1.0	29991	29876	2623	-44492	53656	XYZ
1996.5	Q	5	2.0	-55	58.6	30013	29897	2633	-44458	53640	XYZ
1997.5	Q	5	2.9	-55	56.0	30035	29919	2643	-44419	53621	XYZ
1998.5	Q	5	4.1	-55	54.1	30043	29926	2654	-44377	53590	XYZ
1999.5	Q	5	4.9	-55	51.3	30061	29943	2663	-44326	53558	XYZ
2000.5	Q	5	5.6	-55	49.5	30065	29946	2669	-44279	53521	XYZ
1992.708	D	4	58.4	-56	8.1	29915	29803	2594	-44579	53686	XYZ
1993.5	D	4	58.9	-56	6.7	29928	29815	2599	-44556	53674	XYZ
1994.5	D	5	0.0	-56	5.1	29940	29826	2609	-44531	53660	XYZ
1995.5	D	5	1.1	-56	2.6	29965	29850	2621	-44497	53646	XYZ
1996.5	D	5	2.0	-55	59.5	29998	29883	2632	-44460	53634	XYZ
1997.5	D	5	2.8	-55	57.5	30011	29895	2640	-44423	53611	XYZ
1998.5	D	5	4	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	4.9	-55	53	30034	29916	2660	-44332	53548	XYZ
2000.5	D	5	5.5	-55	51.8	30026	29908	2664	-44287	53506	XYZ

ASP - Operations

Absolute observations were performed weekly (usually on Wednesday afternoons) by the local Observer in Charge, who was an officer at the nearby Australian Centre for Remote Sensing (ACRES) installation. The operation of the observatory was checked twice weekly (usually on Mondays and Fridays) by the observer.

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. 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.

The absolute observation data were sent weekly by post to GA in Canberra, where they were reduced and used to calibrate the variometer data.

Alice Springs 2000 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	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29942.1	2664.6	-44302.1	53537.9	30060.4	5° 5.1'	-55° 50.5'
	5xQ days	29950.6	2665.8	-44299.7	53540.7	30069.0	5° 5.2'	-55° 50.0'
	5xD days	29933.1	2659.1	-44305.1	53535.0	30050.9	5° 4.6'	-55° 51.1'
February	All days	29936.7	2664.8	-44296.3	53530.1	30055.1	5° 5.2'	-55° 50.6'
	5xQ days	29945.0	2668.1	-44293.2	53532.4	30063.6	5° 5.5'	-55° 50.0'
	5xD days	29915.0	2658.1	-44303.0	53523.1	30032.8	5° 4.7'	-55° 52.0'
March	All days	29942.8	2667.3	-44289.0	53527.6	30061.4	5° 5.4'	-55° 50.0'
	5xQ days	29951.4	2667.6	-44288.2	53531.7	30069.9	5° 5.4'	-55° 49.5'
	5xD days	29921.8	2663.7	-44294.4	53520.2	30040.1	5° 5.2'	-55° 51.3'
April	All days	29923.7	2666.6	-44288.2	53516.2	30042.3	5° 5.5'	-55° 51.0'
	5xQ days	29941.7	2668.6	-44284.1	53523.0	30060.4	5° 5.6'	-55° 49.9'
	5xD days	29886.8	2663.3	-44293.8	53500.0	30005.2	5° 5.5'	-55° 53.1'
May	All days	29931.4	2669.9	-44284.4	53517.5	30050.3	5° 5.8'	-55° 50.4'
	5xQ days	29947.1	2669.6	-44281.2	53523.6	30065.8	5° 5.6'	-55° 49.5'
	5xD days	29906.4	2668.9	-44286.7	53505.4	30025.2	5° 6.0'	-55° 51.8'
June	All days	29935.6	2669.8	-44282.8	53518.5	30054.4	5° 5.8'	-55° 50.1'
	5xQ days	29938.7	2668.7	-44281.8	53519.4	30057.4	5° 5.6'	-55° 49.9'
	5xD days	29927.6	2669.9	-44283.7	53514.8	30046.4	5° 5.9'	-55° 50.6'
July	All days	29922.4	2668.7	-44281.1	53509.8	30041.2	5° 5.8'	-55° 50.8'
	5xQ days	29939.0	2669.9	-44279.4	53517.7	30057.8	5° 5.8'	-55° 49.8'
	5xD days	29885.9	2668.2	-44283.3	53491.2	30004.8	5° 6.1'	-55° 52.8'
August	All days	29926.1	2671.0	-44279.4	53510.5	30045.1	5° 6.0'	-55° 50.5'
	5xQ days	29942.9	2672.0	-44276.4	53517.4	30061.9	5° 6.0'	-55° 49.5'
	5xD days	29892.5	2671.0	-44283.3	53495.0	30011.6	5° 6.4'	-55° 52.4'
September	All days	29926.6	2667.3	-44275.5	53507.4	30045.2	5° 5.6'	-55° 50.4'
	5xQ days	29940.6	2669.9	-44272.1	53512.5	30059.4	5° 5.7'	-55° 49.5'
	5xD days	29901.2	2664.3	-44279.7	53496.5	30019.6	5° 5.5'	-55° 51.9'
October	All days	29926.8	2663.4	-44274.6	53506.5	30045.1	5° 5.1'	-55° 50.3'
	5xQ days	29939.7	2662.7	-44271.6	53511.2	30057.8	5° 4.9'	-55° 49.5'
	5xD days	29883.1	2658.3	-44283.7	53489.4	30001.1	5° 5.0'	-55° 53.0'
November	All days	29937.0	2667.5	-44269.2	53508.0	30055.7	5° 5.5'	-55° 49.6'
	5xQ days	29955.2	2669.2	-44265.6	53515.3	30073.9	5° 5.5'	-55° 48.5'
	5xD days	29897.5	2662.0	-44276.9	53491.9	30015.8	5° 5.3'	-55° 52.0'
December	All days	29951.9	2668.5	-44262.8	53511.0	30070.6	5° 5.5'	-55° 48.6'
	5xQ days	29959.4	2672.1	-44257.5	53511.0	30078.3	5° 5.8'	-55° 47.9'
	5xD days	29940.3	2665.7	-44267.2	53508.0	30058.7	5° 5.3'	-55° 49.3'
Annual	All days	29933.6	2667.5	-44282.1	53516.7	30052.2	5° 5.5'	-55° 50.2'
Mean	5xQ days	29945.9	2668.7	-44279.2	53521.3	30064.6	5° 5.6'	-55° 49.5'
Values	5xD days	29907.6	2664.4	-44286.7	53505.9	30026.0	5° 5.5'	-55° 51.8'

(Calculated: 15:12 hrs., Thu. 05 Jul. 2001)

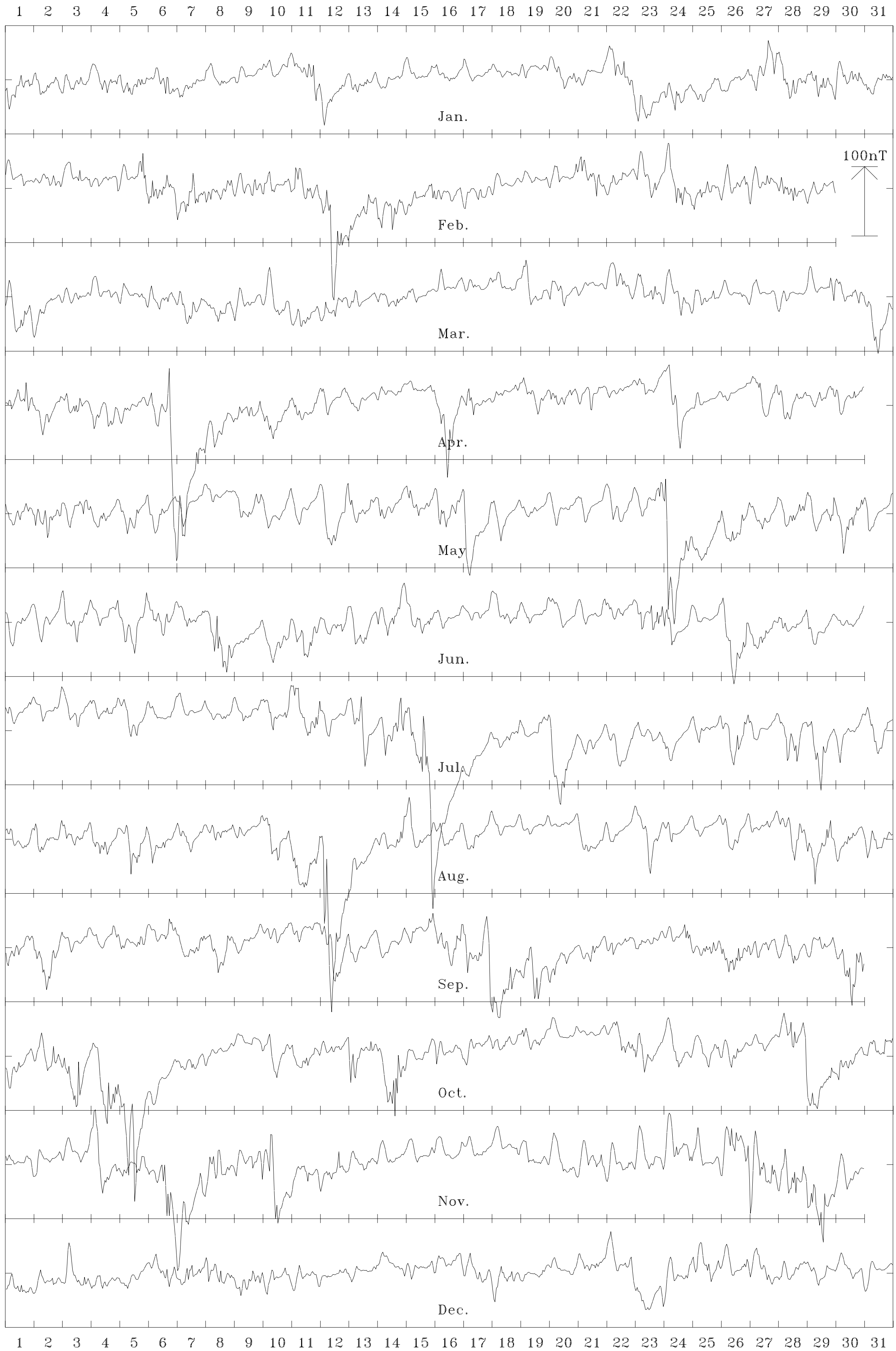
Hourly Mean Values

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

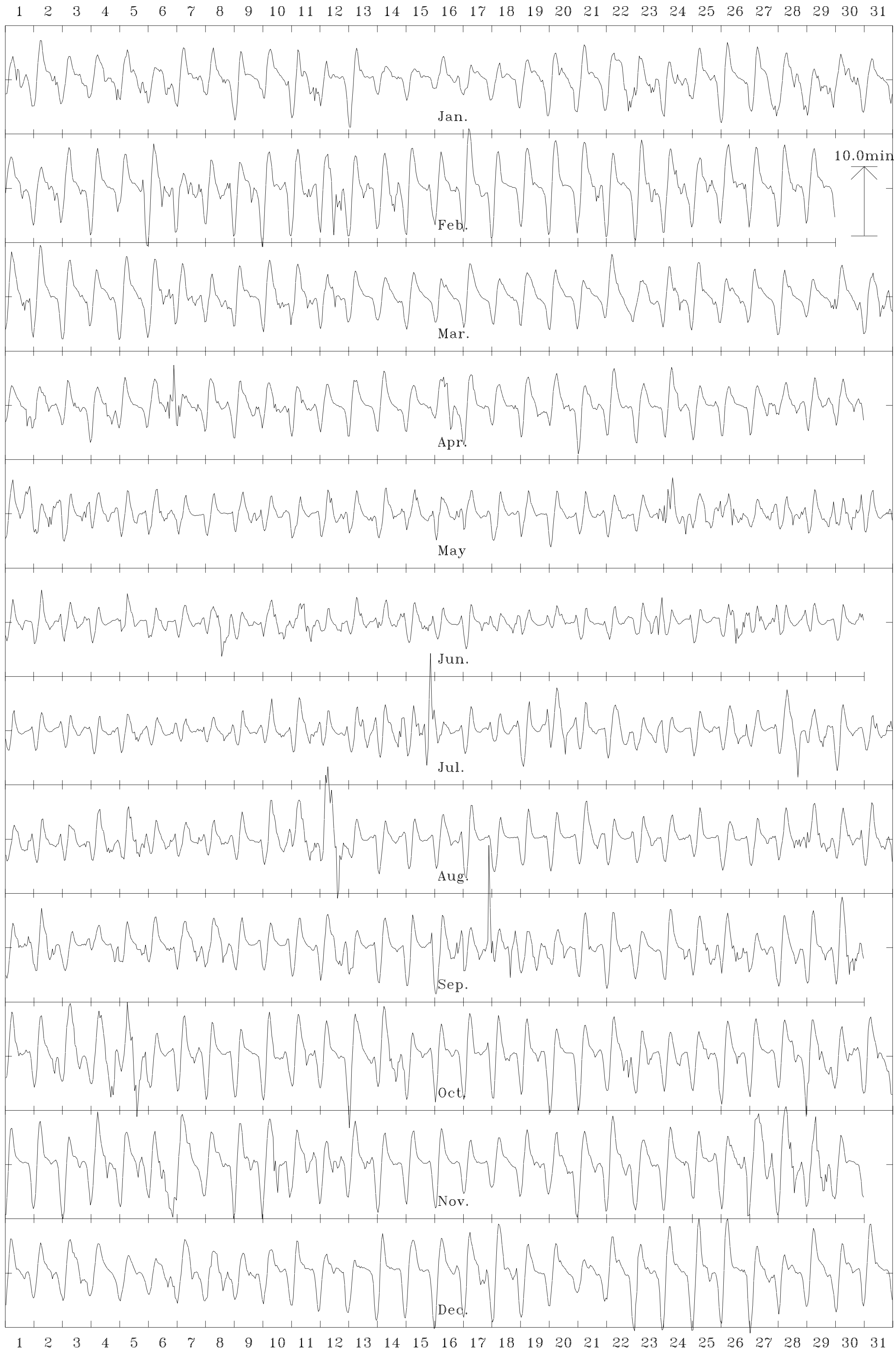
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

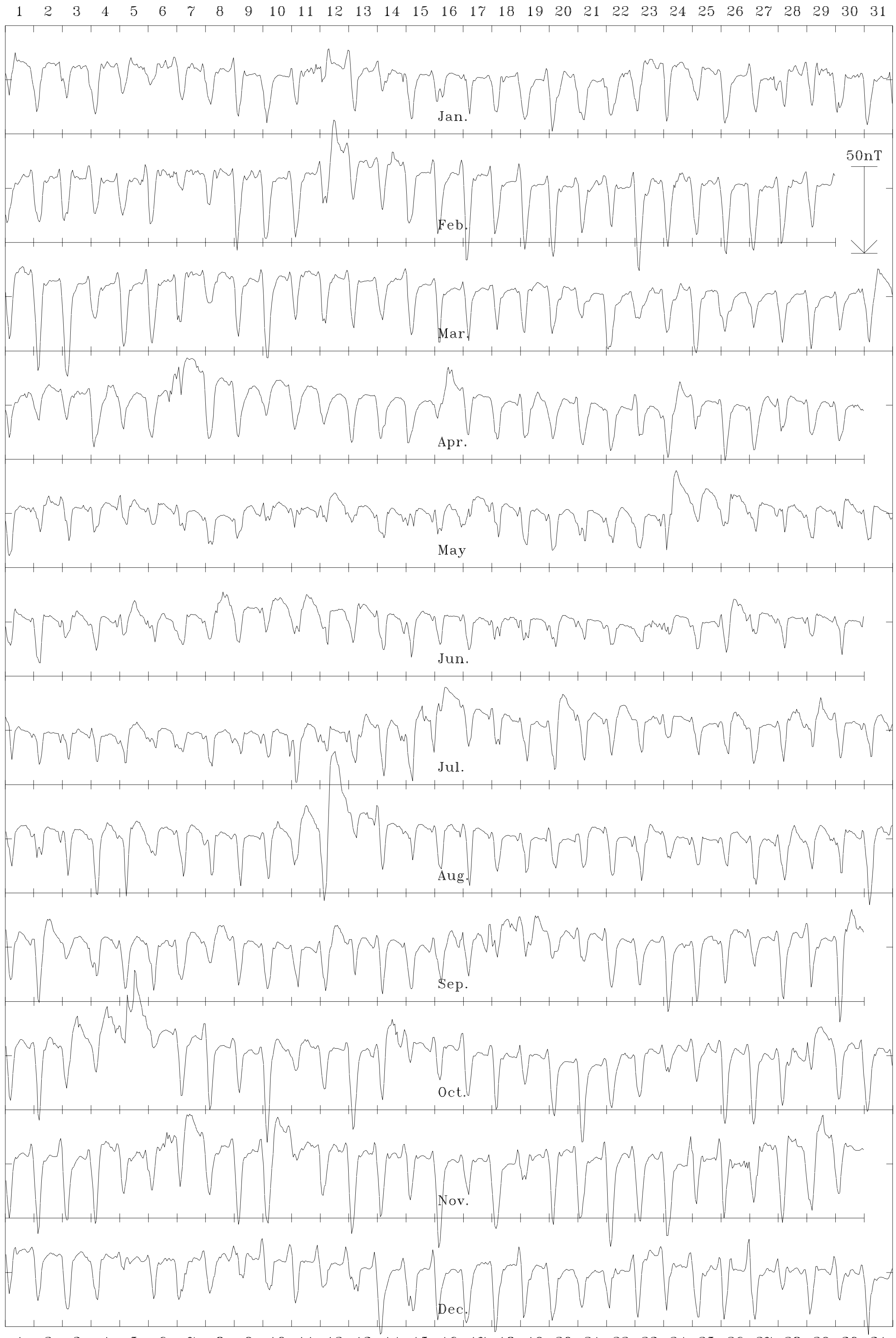
Alice Springs 2000 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 30052 nT



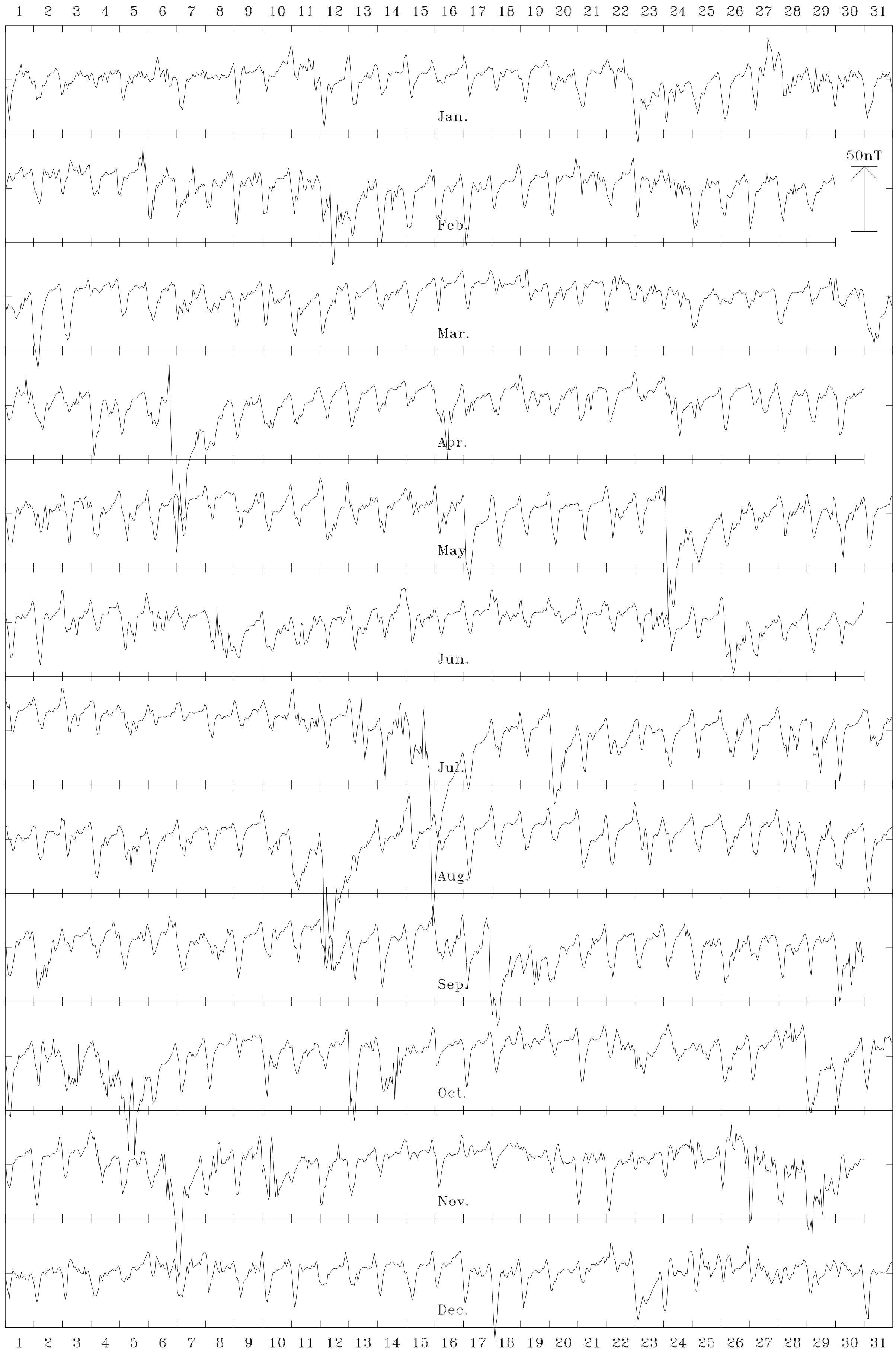
Alice Springs 2000 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.09 deg.

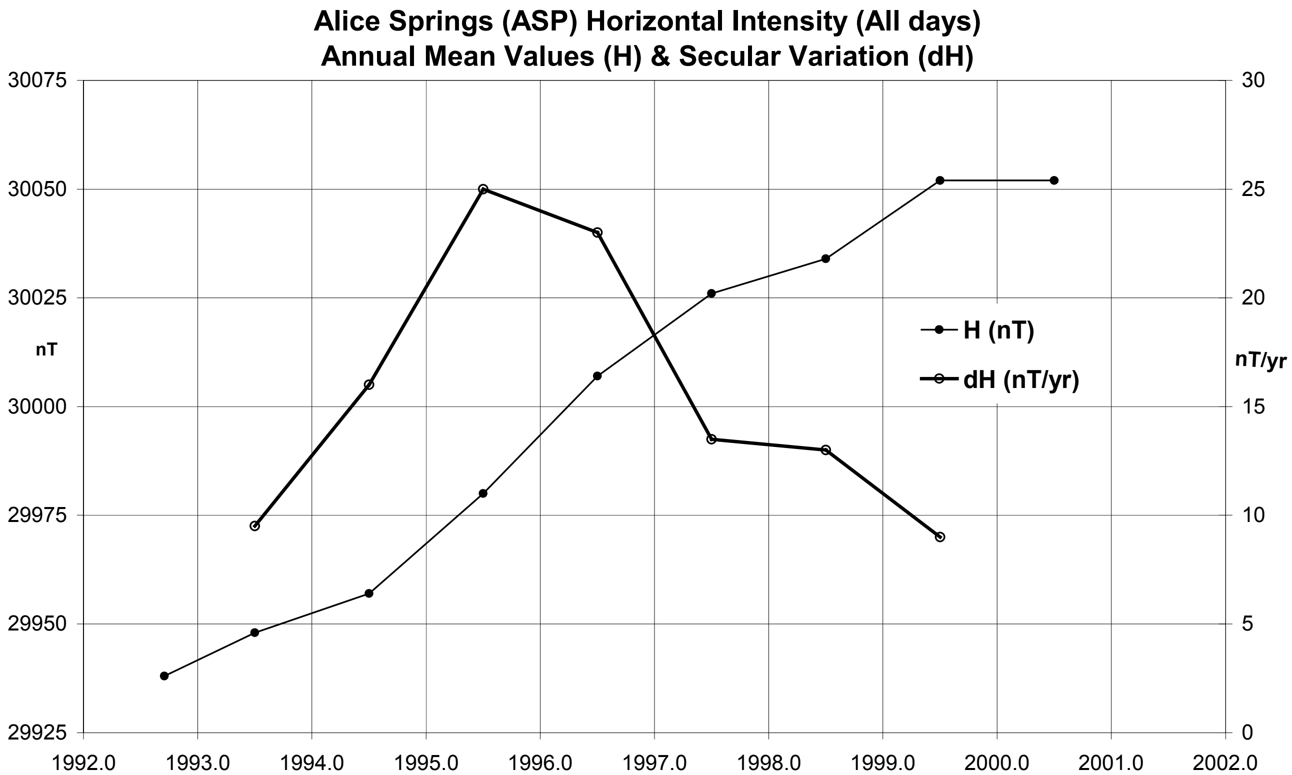


Alice Springs 2000 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44282 nT

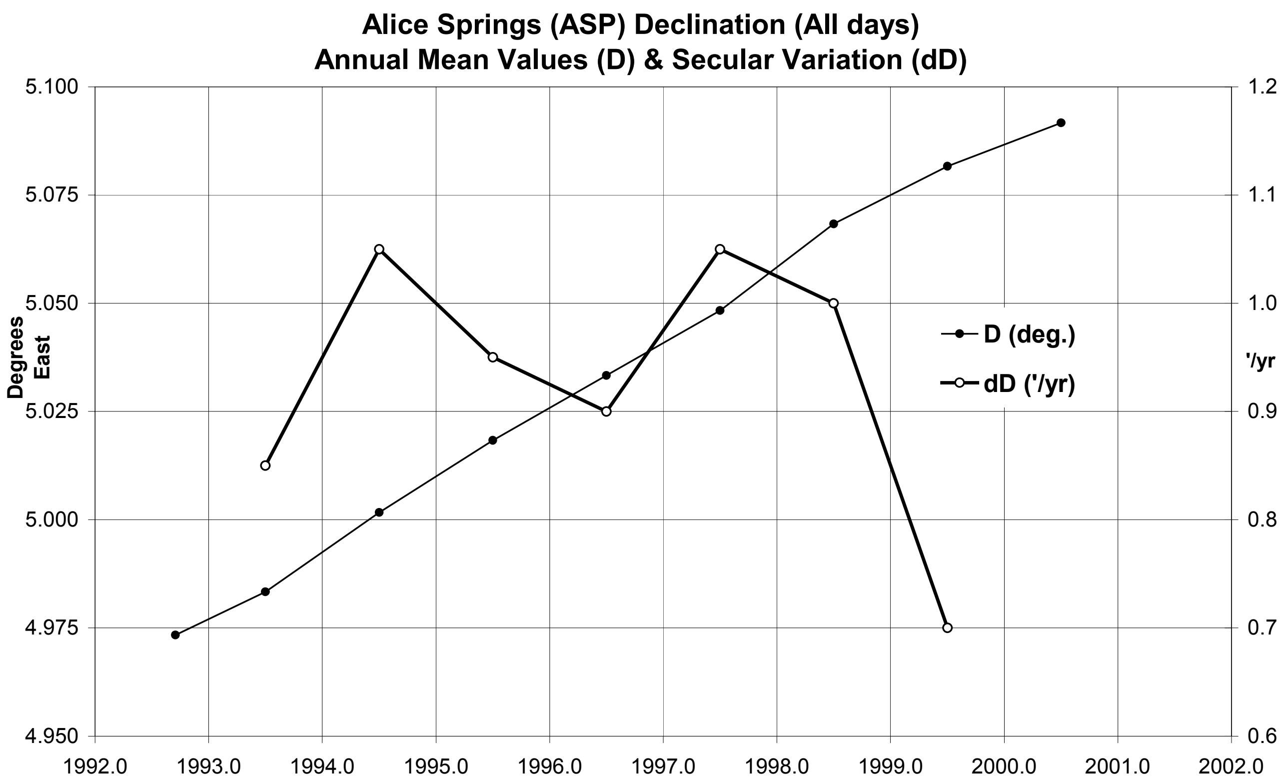


Alice Springs 2000 Total intensity (F). Scale: 4.0 nT/mm. Mean: 53517 nT

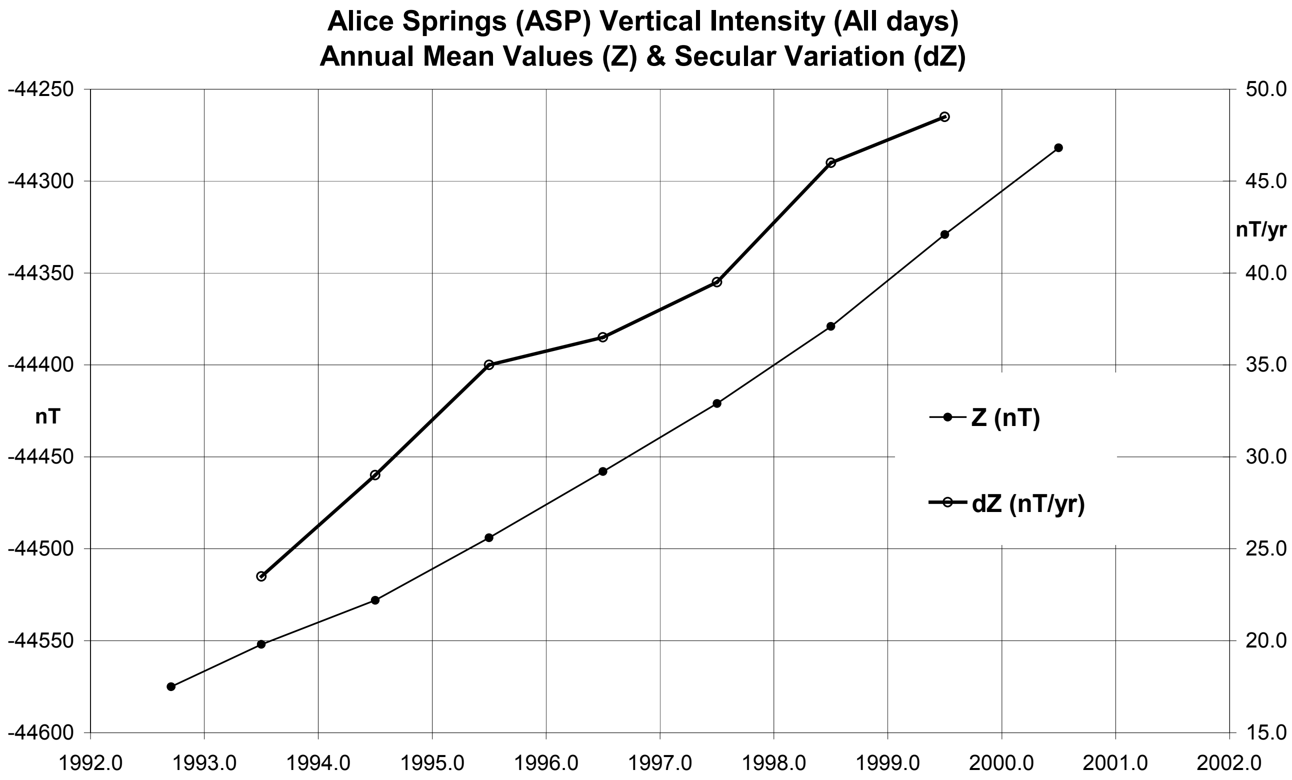


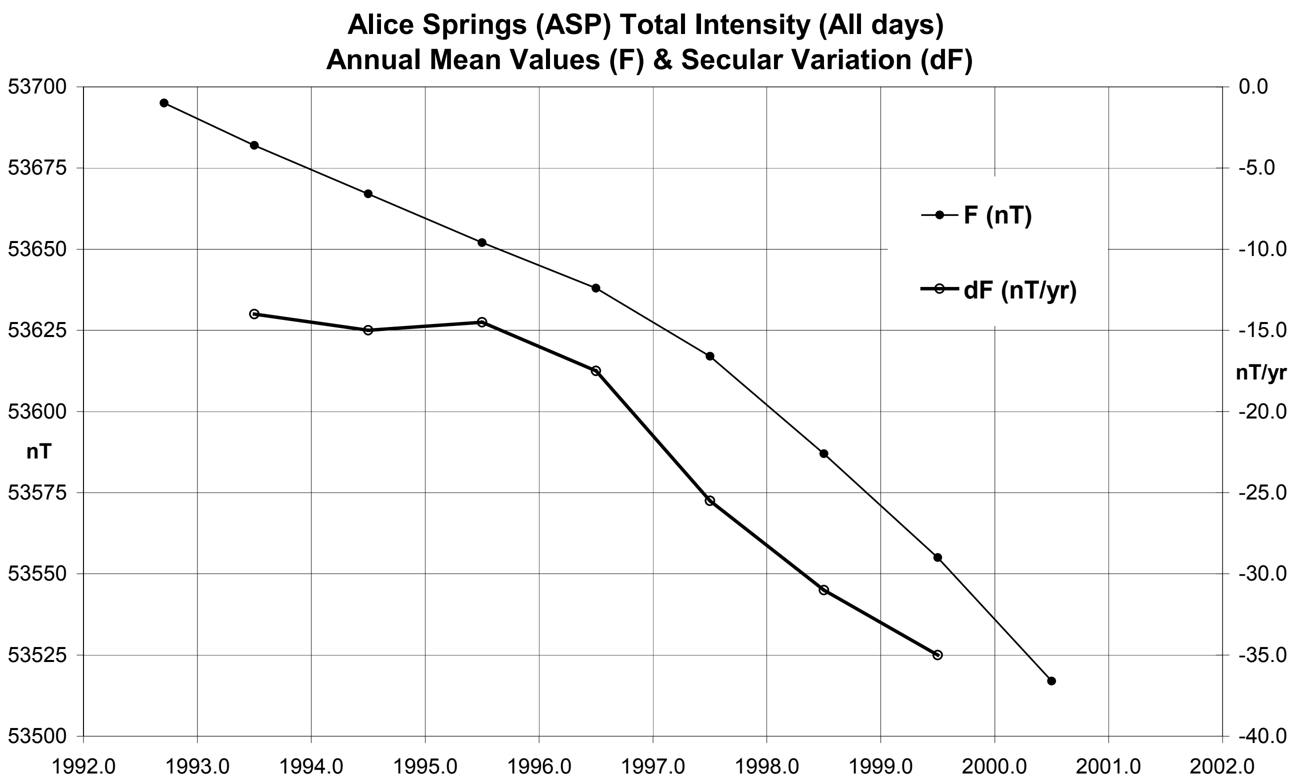


Alice Springs (ASP) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
30075
30050
30025
30000
29975
29950
29925
30
25
20
15
10
5
0
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0



Alice Springs (ASP) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
5.100
5.075
5.050
5.025
5.000
4.975
4.950
1.2
1.1
1.0
0.9
0.8
0.7
0.6
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0


Alice Springs (ASP) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
nT
nT/yr
Z (nT)
dZ (nT/yr)
-44250
-44300
-44350
-44400
-44450
-44500
-44550
-44600
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0


Alice Springs (ASP) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
nT
nT/yr
F (nT)
dF (nT/yr)
53700
53675
53650
53625
53600
53575
53550
53525
53500
0.0
-5.0
-10.0
-15.0
-20.0
-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

ASP - Significant Events 2000

Dec 14 1999	Commenced daily e-mail transmission of 1-minute data to Edinburgh INTERMAGNET GIN.
20 Jan	Key to control hut misplaced, send a new key.
25 Jan	Original key to hut re-located.
26 Jan	Electrical storm - some noise on 1-second data 02:30 - 06:00 UT.
10 May	ASP data appears on BGS intermag WWW site.
16 May	Remote disk house keeping on ASP PC.
19 May	PC Re-boot, reason unknown. ~ 08:00 UT.
15 Jun	Multiple re-boots - mains power problems.
27 Jul	PC Re-boot ~01:40 UT.
28 Jul	Send new absolute instrument carry case

PC re-boot ~05:34 UT.

Oct/Nov	Correspondence regarding real time satellite data transmission to Toyo Kamei from WDC-Kyoto.
Dec	Commence planning and arrangements for improving thermal insulation for ASP control hut.

ASP Data losses in 2000:

19 May	XYZF 0803-0803 (1 min.) PC Reboot
15 Jun	XYZF 1036-1036 (1 min.) PC Reboot
15 Jun	XYZF 1239-1239 (1 min.) PC Reboot
15 Jun	XYZF 1250-1250 (1 min.) PC Reboot
15 Jun	XYZF 1259-1259 (1 min.) PC Reboot
15 Jun	XYZF 1303-1304 (2 min.) PC Reboot
26 Jul	XYZF 0140-0140 (1 min.) PC Reboot
28 Jul	XYZF 0533-0533 (1 min.) PC Reboot

Distribution of ASP data during 2000

Preliminary Monthly Means for Project Ørsted

- To IPGP by email:
  - 1999; Jan-Jun 2000 data sent July 2000
  - sent monthly from July 2000

1-minute & Hourly Mean Values

- 1999: WDC-A, Boulder, USA (12 Sep 2000)
- 1999 Intermagnet Paris GIN (11 Sep 2000)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive 1999 data for CD-ROM sent to the INTERMAGNET GIN, Paris (11 Sep., 2000)

CANBERRA OBSERVATORY

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

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

The observatory comprises six buildings: a Recorder House; a Sensor House 80m‡ to the west; an Absolute House 65m‡ NE of the Recorder House; a Comparison House 12m west of the Absolute House; a Variometer House 85m NW of the Recorder House; a Test House 230m‡ north of the Recorder House. Other structures on the site include a sheltered external observation site, four azimuth pillars and a seismic vault. The latter houses seismometers operated by GA's earthquake seismology and nuclear monitoring group.

The construction of a building to house large coils for magnetometer calibrations was completed late in 1999. Support for the construction and provision of instrumentation for this *National Magnetic Calibration Facility* was provided by the Australian department of Defence.

‡ Distances determined by GPS survey.

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

- 3-character IAGA code: CNB
- Commenced operation 1978
- Geographic latitude: 35° 18' 52.6" S
- Geographic longitude: 149° 21' 45.4" E
- Geomagnetic† latitude: -42.65°
- Geomagnetic† longitude: 226.76°
- Elevation above mean sea level (top of pier): 859 metres
- Lower limit for K index of 9: 450 nT.
- Azimuth of principal reference pillar (NW) from pier AW: 328° 37' 03"
- Distance to NW Pillar: 137.3 metres
- Observers in Charge: Liejun Wang (GA)

† Based on the IGRF 2000 model.

Variometers

During 2000 (since November 1995) a Narod ring-core fluxgate (RCF) variometer operated as the principal variometer at the observatory. It measured variations in three orthogonal components of the magnetic field, and was aligned to measure the (magnetic) north-west; north-east and vertical field components.

A GEM Systems GSM-90 Overhauser effect magnetometer recorded variations in total intensity. The sensor of this instrument was located within the Helmholtz coil system of the Littlemore AMO (decommissioned in 1995) in the observatory's 'Sensor House'. With new controlling electronics this comprised a second three component variometer.

Absolute Instruments

Throughout 2000 absolute observations were regularly performed at Canberra with a Declination & Inclination Magnetometer (DIM) and a Proton Precession Magnetometer (PPM).

The DIM used was an Elsec 810 (no. 200) controller with a Zeiss 020B (no. 353756) non-magnetic theodolite. This instrument was routinely used on pier AW.

The PPM used was MNS2 no. 3. This PPM had been in service at CNB for many years, principally within the Helmholtz coils of Proton Vector Magnetometer (PVM) serial A situated on pier AE in the Absolute House. Although the PVM was not routinely used in 2000, the sensor of the PPM remained in the coils on pier AE during absolute measurements of total intensity.

CNB - Absolute Instruments (cont.)

On 5 September 2000 a GSM90 Overhauser magnetometer (electronic 905926 and sensor 81241) was introduced into the weekly observation routine as a second absolute PPM instrument. The sensor of this instrument was located on pier AW during absolute observations. The GSM90 will replace MNS2 as the Canberra Observatory and Australian standard PPM in 2001.

Pier differences

As pier AW is the principal reference location at the Canberra observatory, it was necessary to apply an adjustment to F measurements that were performed on pier AE. To convert the F absolute observations performed with the PPM with its sensor in the PVM coil assembly, on pier AE, to the standard pier AW, the pier difference applied to them was:

$$F_{AW} = F_{AE\ (within\ PVM)} + 0.75nT$$

Using the MNS2 No. 3 PPM, this pier difference was redetermined to be +0.82nT on 09 Feb. 1999. The adopted value was not changed.

Instrument corrections

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

In consideration of numerous intercomparisons between DIMs (and other magnetometers), zero corrections have been applied to absolute observations performed with the DIM Elsec 810/200; Zeiss 020B/353756.

Based on oscillation frequency tests performed in 1995, a theoretical adjustment of -0.8nT (at Canberra) has been adopted to correct the MNS2 no.3 to the 1986 CODATA proton gyromagnetic ratio standard (accepted as the IAGA standard since 1992).

At the field intensities at Canberra, corrections of 0.0', 0.0' and -0.8nT in D, I and F respectively resulted in respective corrections to X, Y and Z of -0.3nT, -0.1nT and +0.7nT. These corrections have been applied to the results in this report. (The 0.75nT pier difference was taken into account prior to the application of the instrument corrections.)

The results of performing regular absolute observations with the two total field instruments between September and December 2000 have indicated only a small difference between the old standard MNS2 no. 3 and the new standard GSM90 no.905926/81241 proposed for use from 2001. Taking into account the difference between Pier AW and within the PVM coils on Pier AE (but not the PGR correction to the MNS2 PPM) it was found that:

$$F(MNS2)_{AE\ (within\ PVM)\ adjusted\ to\ AW} = F(GSM90)_{AW} + 0.9nT$$

Observations with the new standard GSM90 were (and will in the future be) performed on Pier AW.

Including the –0.8nT PGR correction to the MNS2 PPM resulted in:

$$F(MNS2)_{old\ standard} = F(GSM90)_{new\ standard} + 0.1nT$$

This result is complemented by the direct comparison of the two standard instruments on Pier AW:

$$F(MNS2)_{uncorrected} = F(GSM90)_{new\ standard} + 1.2nT$$

Once again including the –0.8nT PGR correction to the MNS2 PPM results in:

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

In view of the uncertainties no difference between the old and new F-standards will be adopted.

Operations

Absolute observations were performed weekly (routinely on Tuesdays) by staff of the Geomagnetism Section on a roster. The rostered duties also included producing magnetograms for a week, hand scaling and distribution of the previous week's K indices, and ensuring the provision of 1-minute data from CNB, (GNA and ASP) to INTERMAGNET.

The Narod RCF variometer was situated on pier (VE) in the 'Variometer House' that was maintained as near as possible to set temperatures of 25°C in summer and 15°C in winter for baseline stability. Data from the RCF were transmitted via optical fibre to the Recorder House where they were recorded on an acquisition PC.

The GSM90 Total Intensity variometer was located in the Sensor House with its sensor positioned in the old AMO coil assembly. It was controlled from the Recorder House where the data were also recorded.

During March and April 2000 the walls and ceiling of the variometer house where the RCF variometer operated, had insulation installed to minimise data variations caused by temperature changes. Unfortunately an unacceptable degree of contamination was introduced to the recording instrumentation, necessitating the inhibition of its processing.

Shortly after 0000UT each day before late July 2000, digital data were retrieved semi-automatically via modems and telephone line from the observatory to GA in Canberra.

On 20 July 2000 a real-time data link between the CNB observatory and GA in Canberra was established via modems and the telephone line. Digital data were retrieved automatically from the observatory to GA every 10 minutes.

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

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

Significant Events 2000

Until July	Tests were carried out intermittently in preparation for the UHF data-link between CNB observatory and GA Canberra.
Jan 11	The heater controller sensor was shifted to just under the Narod RCF electronics in the Variometer House.
Mar 20	Work to insulate the inside the variometer house began. Data was contaminated during the time that workers were in or near the hut.
Apr 06	Insulation work was completed by this day.
Apr 10	Re-installing power and data cable terminator.
Jul 20	Real time link between the observatory to head office was established.

Distribution of CNB data during 2000

K indices - weekly by e-mail

- IPS Radio & Space Services, Sydney.
- Regional Warning Centre, Meudon (via Paris) (ceased after 02 Jan. 2000)
- British Geological Survey, Edinburgh.
- International Service of Geomagnetic Indices, Paris.
- Royal Observatory of Belgium, Brussels
- CLS, CNES (French Space Agency), Toulouse

CNB - Data Distribution (cont.)

K indices - semi-monthly by e-mail

- Adolph-Schmidt-Observatory Niemegk, Germany

K indices with Principal Magnetic Storms & Rapid Variations - monthly by post

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

Preliminary Monthly Means for Project Ørsted

- To IPGP by email:
  - 1999; Jan-Jun 2000 data sent July 2000
  - sent monthly from July 2000

1-minute & Hourly Mean Values

- 1999: WDC-A, Boulder, USA (18 Sep. 2000)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive 1999 data for CD-ROM sent to the INTERMAGNET GIN, Paris (14 Sep. 2000)

CNB Data losses in 2000

Jan 23 2342 (1m) RCF channels:

Feb 04 0145-0146 (2m) RCF channels:

Feb 07 0456-0458 (3m), 0503 (1m); F-channel

Mar 21 0436-0452 (17m) RCF channels:

Data losses (cont.)

The processing of data over the following intervals, during the period when the RCF vault was having insulation material installed, was inhibited:

Mar 22 0058 – 0306 (2h 09m)

Mar 22 2317 to Mar 23/0349 (4h 33m)

Mar 23 2150 to Mar 24/0252 (5h 03m)

Mar 28 2331 to Mar 29/0154 (2h 24m)

Mar 30 0058 – 0433 (3h 36m)

Mar 30 2302 to Mar 31/0433 (5h 32m)

Apr 03 0112 – 0433 (3h 22m)

Apr 03 2331 to Apr 04/0418 (4h 28m)

Apr 04 2248 to Apr 05/0613 (7h 26m)

Apr 06 0210 – 0237 (28m)

Apr 10 0112 – 0223 (1h 12m)

K indices

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

The table on page 20 shows K indices for Canberra for 2000.

These have been 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).

Canberra Annual Mean Values

The table below gives annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z & F are on pages 26-27.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1979.5	A	12	5.6	-66	5.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	8.6	-66	6.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	9.1	23770	23234	5018	-53771	58791	DFI
1982.5	A	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	DFI
1983.5	A	12	16.6	-66	11.3	23723	23180	5044	-53756	58758	DFI
1984.5	A	12	18.4	-66	11.7	23709	23164	5054	-53741	58739	DFI
1985.5	A	12	20.7	-66	11.6	23703	23155	5067	-53726	58723	DFI
1986.5	A	12	23.2	-66	12.1	23689	23137	5081	-53716	58707	DFI
1987.5	A	12	25.5	-66	12.0	23684	23129	5096	-53699	58690	DFI
1988.5	A	12	27.6	-66	12.8	23665	23107	5106	-53690	58674	DFI
1989.5	A	12	29.0	-66	13.8	23644	23085	5111	-53683	58659	DFI
1990.5	A	12	30.7	-66	13.6	23641	23079	5121	-53667	58643	DFI
1991.5	A	12	31.8	-66	13.9	23628	23066	5126	-53652	58624	DFI
1992.5	A	12	32.4	-66	12.8	23637	23073	5132	-53625	58603	DFI
1993.5	A	12	33.0	-66	11.6	23646	23081	5138	-53597	58581	DFI
1994.5	A	12	33.5	-66	10.8	23649	23083	5142	-53571	58559	DFI
1995.5	A	12	33.8	-66	9.2	23665	23098	5148	-53540	58537	DFI
1996.5	A	12	34.2	-66	7.4	23684	23108	5154	-53507	58514	ABC
1997.5	A	12	34.2	-66	6.1	23695	23127	5157	-53476	58491	ABC
1998.5	A	12	34.2	-66	5.2	23698	23130	5157	-53444	58463	ABC
1999.5	A	12	34.1	-66	3.7	23709	23140	5159	-53403	58429	ABC
2000.5	A	12	34.2	-66	2.9	23706	23139	5160	-53367	58396	ABC
1979.5	Q	12	5.5	-66	5.3	23844	23315	4995	-53775	58824	DFI
1980.5	Q	12	8.6	-66	6.8	23813	23280	5010	-53769	58806	DFI
1981.5	Q	12	11.4	-66	8.3	23783	23246	5022	-53767	58792	DFI
1982.5	Q	12	14.1	-66	10.1	23749	23210	5033	-53766	58778	DFI
1983.5	Q	12	16.5	-66	10.7	23734	23191	5046	-53753	58760	DFI
1984.5	Q	12	18.5	-66	11.1	23719	23174	5056	-53739	58741	DFI
1985.5	Q	12	20.7	-66	11.1	23713	23164	5070	-53724	58724	DFI
1986.5	Q	12	23.2	-66	11.6	23697	23146	5083	-53714	58709	DFI
1987.5	Q	12	25.5	-66	11.6	23690	23136	5097	-53698	58691	DFI
1988.5	Q	12	27.7	-66	12.2	23675	23118	5109	-53687	58676	DFI

continued …

Canberra Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1989.5	Q	12	29.1	-66	13.0	23657	23098	5114	-53680	58662	DFI
1990.5	Q	12	30.8	-66	12.8	23653	23092	5125	-53663	58645	DFI
1991.5	Q	12	31.8	-66	12.9	23645	23082	5130	-53647	58627	DFI
1992.5	Q	12	32.5	-66	12.1	23649	23085	5135	-53622	58605	DFI
1993.5	Q	12	33.0	-66	11.1	23655	23090	5140	-53594	58583	DFI
1994.5	Q	12	33.6	-66	10.2	23661	23095	5145	-53568	58561	DFI
1995.5	Q	12	33.9	-66	8.7	23675	23108	5150	-53537	58538	DFI
1996.5	Q	12	34.2	-66	7.2	23689	23108	5155	-53506	58515	ABC
1997.5	Q	12	34.2	-66	5.6	23703	23135	5159	-53474	58492	ABC
1998.5	Q	12	34.3	-66	4.8	23706	23137	5159	-53443	58464	ABC
1999.5	Q	12	34.1	-66	3.2	23716	23148	5161	-53400	58430	ABC
2000.5	Q	12	34.3	-66	2.2	23718	23149	5162	-53365	58398	ABC
1979.5	D	12	5.6	-66	6.9	23816	23287	4990	-53782	58819	DFI
1980.5	D	12	8.4	-66	7.8	23792	23260	5004	-53770	58798	DFI
1981.5	D	12	11.1	-66	10.3	23750	23215	5013	-53776	58787	DFI
1982.5	D	12	13.7	-66	12.4	23710	23172	5022	-53773	58769	DFI
1983.5	D	12	16.6	-66	12.3	23706	23163	5040	-53760	58754	DFI
1984.5	D	12	18.4	-66	12.7	23691	23146	5049	-53745	58735	DFI
1985.5	D	12	20.5	-66	12.4	23690	23142	5064	-53729	58719	DFI
1986.5	D	12	23.3	-66	12.9	23675	23123	5079	-53717	58703	DFI
1987.5	D	12	25.5	-66	12.6	23674	23120	5094	-53701	58688	DFI
1988.5	D	12	27.5	-66	13.8	23647	23091	5102	-53693	58670	DFI
1989.5	D	12	29.0	-66	15.5	23615	23057	5105	-53690	58654	DFI
1990.5	D	12	30.5	-66	14.8	23619	23059	5116	-53671	58639	DFI
1991.5	D	12	31.6	-66	15.5	23600	23038	5119	-53658	58618	DFI
1992.5	D	12	32.3	-66	14.1	23615	23052	5127	-53630	58600	DFI
1993.5	D	12	33.0	-66	12.7	23628	23064	5134	-53601	58578	DFI
1994.5	D	12	33.4	-66	11.8	23633	23068	5138	-53574	58555	DFI
1995.5	D	12	33.8	-66	10.0	23652	23086	5145	-53542	58533	DFI
1996.5	D	12	34.2	-66	7.9	23676	23108	5152	-53508	58512	ABC
1997.5	D	12	34.1	-66	6.9	23683	23115	5154	-53479	58488	ABC
1998.5	D	12	34.2	-66	6.4	23678	23110	5153	-53450	58459	ABC
1999.5	D	12	34.1	-66	4.6	23692	23124	5156	-53407	58427	ABC
2000.5	D	12	34.2	-66	4.2	23685	23117	5155	-53372	58392	ABC

Elements ABC indicates non-aligned variometer orientation

Principal Magnetic Storms: Canberra 2000

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. 27	14 ··	···	··	··	··	27(8)	5	19.5	127	50	29	14
Feb. 11	23 ··	···	··	··	··	12(4)	7	36.0	163	84	12	21
Mar.		No	Principal			Magnetic		Storms				
Apr. 06	16 42	ssc	+5.2	+54	0	06(7,8), 07(1)	7	25.7	486	70	07	09
May 23	18 ··	···	··	··	··	24(1,2)	6	22.1	275	76	24	21
Jun. 08	09 12	ssc*	-3.9*	+48	+15	08(4,5)	5	16.2	110	41	08	23
Jul. 15	12 ··	···	··	··	··	15(5,7,8)	7	64.0	376	156	16	09
Aug. 12	03 ··	···	··	··	··	12(2,3)	7	34.3	299	141	13	09
Sep. 17	12 ··	···	··	··	··	17(8)	7	41.5	316	155	18	18
Oct. 05	03 27	ssc*	+2.1*	+30	+6	05(3,4)	7	43.1	183	62	05	23
Nov. 06	09 ··	···	··	··	··	06(4,5,6,7)	5	24.1	257	83	07	12
10	06 ··	···	··	··	··	10(3,4)	6	21.0	227	56	10	15
26	05 ··	···	··	··	··	26(8), 27(1,2,3,4,5)	5	28.5	223	72	27	21
28	03 ··	···	··	··	··	29(3)	6	23.6	200	92	29	18
Dec.		No	Principal			Magnetic		Storms				

K indices & Daily K sums at Canberra (K=9 limit: 450 nT) for 2000

Date	January	February	March	April	May	June	Date
01	D 3343 4333 26	1221 3121 13	D 3333 2322 21	2223 3443 23	2332 2232 19	2331 2202 15	01
02	3333 2333 23	1111 2312 12	2211 2101 10	2222 3012 14	3214 4233 22	2332 2213 18	02
03	2223 2322 18	2222 3322 18	1101 2111 08	2233 3211 17	1222 1342 17	2224 4222 20	03
04	2233 3233 21	Q 1221 1111 10	Q 0001 1211 06	D 3420 4341 21	1113 3111 12	2330 0234 17	04
05	3332 3433 24	1111 1354 17	0101 1223 10	1210 0101 06	1132 4011 13	D 3233 4223 22	05
06	3223 4433 24	D 1111 1111 08	1232 2322 17	D 2232 3677 32	3323 2222 19	2222 3301 15	06
07	2222 2222 16	D 3334 4333 26	D 1123 3113 15	D 7552 3422 30	Q 0121 1011 07	1122 1112 11	07
08	Q 1122 2200 10	2323 3332 21	D 1212 2321 14	2133 3211 16	Q 1111 1111 08	D 1335 5443 28	08
09	Q 0010 0000 01	1131 4412 17	0000 2010 03	2222 3333 20	2212 2322 16	Q 0211 1101 07	09
10	1211 1233 14	2232 2212 16	1123 2223 16	2333 3223 21	1211 1111 09	3224 3222 20	10
11	D 2223 4454 26	3423 3334 25	1111 3112 11	2231 1121 13	Q 1110 2011 07	1125 5331 21	11
12	3222 1212 15	D 5557 6432 37	D 2343 4212 21	1220 1112 10	2243 2123 19	2331 3322 19	12
13	2232 2211 15	3233 4322 22	1110 0012 06	1110 0000 03	3222 2232 18	1123 2111 12	13
14	2211 1221 12	D 2343 5443 28	1113 1211 11	Q 0001 0110 03	2211 2121 12	D 2231 3333 20	14
15	2221 2112 13	3331 1224 19	Q 0000 0110 02	0011 1121 07	3223 1212 16	3222 3332 20	15
16	2132 1212 14	1211 3221 13	Q 0100 0012 04	D 2335 4222 23	1423 2222 18	Q 1111 0001 05	16
17	Q 1010 0010 03	Q 0012 3221 11	2222 1000 09	2332 1111 14	D 3331 1012 14	Q 1000 1211 06	17
18	Q 1110 0200 05	Q 0011 1000 03	0111 1122 09	Q 1210 0021 07	3212 0001 09	1002 2333 14	18
19	1121 1122 11	Q 0113 0001 06	2322 1111 13	2322 3211 16	1121 1101 08	1210 0110 06	19
20	1222 2222 15	Q 0122 0014 10	2223 3001 13	3322 3221 18	Q 1100 1011 05	1111 1000 05	20
21	Q 1000 0001 02	3443 3422 25	1120 1010 06	1113 2111 11	Q 1111 1001 06	1101 1112 08	21
22	1233 3343 22	2220 3122 14	2231 3222 17	Q 1122 1001 08	1222 2212 14	2223 2121 15	22
23	D 4343 4211 22	2133 4312 19	2323 3422 21	1122 1112 11	D 2332 2244 22	D 2311 4243 20	23
24	1334 2212 18	D 3435 3444 30	1212 4312 16	D 2434 4212 22	D 6655 4442 36	4331 1002 14	24
25	1321 1221 13	4333 4323 25	1121 1320 11	Q 1112 1021 09	D 2344 2223 22	Q 1110 0111 06	25
26	2321 1112 13	3233 2232 20	Q 0110 1211 07	Q 0021 0010 04	2345 3320 22	D 3444 5444 32	26
27	2232 4245 24	2323 3321 19	Q 0100 0001 02	3123 2323 19	2123 2332 18	2223 3222 18	27
28	D 4444 4323 28	2423 4311 20	1211 0000 05	4332 3312 21	2123 3321 17	3312 1221 15	28
29	D 3344 4443 29	0122 1111 09	0001 0034 08	2222 2223 17	D 2221 2333 18	3230 1101 11	29
30	2232 3333 21		3221 3335 22	2320 2321 15	2244 4334 26	Q 1002 1220 08	30
31	3212 2222 16		D 3533 4243 27		2311 1111 11		31
Mean K-sum	**16.6**	**17.7**	**11.6**	**15.0**	**15.5**	**14.9**	

Date	July	August	September	October	November	December	Date
01	2022 1011 09	2222 1322 16	3344 2232 23	3333 1122 18	2231 1122 14	2222 3320 16	01
02	Q 0011 0100 03	1222 1121 12	3344 4312 24	0121 2522 15	Q 2100 2011 07	0011 2311 09	02
03	1112 3122 13	1223 2221 15	1310 1133 13	3434 5312 25	Q 0000 2111 05	2342 3332 22	03
04	1102 2110 08	2333 3222 20	0122 2343 17	D 2345 5463 32	3543 3233 26	2332 2123 18	04
05	0134 3310 15	D 2334 4323 24	1101 2232 12	D 3477 6544 40	3321 3432 21	2222 2101 12	05
06	Q 1011 2111 08	3222 2222 17	2010 2333 14	Q 2121 1011 09	D 2235 5554 31	1233 2433 21	06
07	Q 1111 0111 07	2113 2121 13	2223 3332 20	1222 3100 11	D 3354 3343 28	D 2343 3223 22	07
08	1101 1210 07	2121 2222 14	1133 4323 20	Q 0000 1111 04	2565 3223 28	D 4333 4333 26	08
09	0012 2101 07	1221 1102 10	Q 1221 2000 08	Q 1111 1212 10	2111 4324 18	D 3323 2323 21	09
10	1242 3221 17	1244 3224 22	Q 0103 2011 08	1222 1112 12	D 3466 5233 32	D 2332 1222 17	10
11	D 3534 4333 28	D 3445 3334 29	Q 0111 1211 08	3322 4131 19	2423 4333 24	2222 2112 14	11
12	2202 0100 07	D 4776 6643 43	2235 4344 27	1211 2114 13	2343 3422 23	1121 1211 10	12
13	1125 5411 20	3531 1112 17	3322 1201 14	D 5432 3332 25	1322 3212 16	1111 1002 07	13
14	D 1233 3453 24	1111 2333 15	Q 1221 0212 11	D 2344 6533 30	1111 1111 08	Q 1021 0101 06	14
15	D 2434 7677 40	3512 2111 16	1421 0235 18	2321 2223 17	Q 1111 1011 07	Q 1011 1000 04	15
16	D 4443 3111 21	1231 3111 13	D 2423 3345 26	4121 1211 13	Q 0110 0022 06	1221 2212 13	16
17	2222 1000 09	1223 1011 11	D 3423 4457 32	2222 1221 14	Q 1122 0100 07	1121 3232 15	17
18	1210 2212 11	Q 1000 0000 01	D 5545 5632 35	2223 3123 18	0100 2222 09	1222 2322 16	18
19	1000 1313 09	Q 0000 0110 02	D 2234 5322 23	1222 3222 16	1222 1101 10	1112 1111 09	19
20	D 3445 4112 24	0001 0200 03	2311 3112 14	Q 1111 0111 07	1222 1321 14	Q 0011 0111 05	20
21	1110 1111 07	1213 1213 14	2323 3211 17	Q 0000 2201 05	1122 2222 14	1102 2212 11	21
22	0213 1311 12	Q 1110 0000 03	Q 2221 1121 12	0034 4443 22	1212 2322 15	1221 2125 16	22
23	2211 2432 17	0013 1200 07	2221 1211 12	3334 2112 19	1102 1111 08	D 4342 2212 20	23
24	Q 1110 0000 03	2321 1111 12	1101 1333 13	2224 3122 18	1323 2233 19	3122 2122 15	24
25	Q 1111 1211 09	Q 0100 0011 03	3233 3433 24	0212 3113 13	2110 0121 08	2222 4313 19	25
26	1242 4233 21	Q 1211 1101 08	3433 4323 25	1222 3121 14	0343 4345 26	1222 1122 13	26
27	2111 0012 08	1110 3212 11	2233 2233 20	1111 1011 07	D 5555 5342 34	2121 2322 15	27
28	1244 4521 23	D 1114 3332 18	2223 3212 17	0035 4236 23	2555 5334 32	2131 3221 15	28
29	3235 5212 23	D 4344 3442 28	1113 3212 14	D 4433 3331 24	D 3565 5332 32	2222 0222 14	29
30	2211 3111 12	3223 2112 16	D 2345 5455 33	2323 2321 18	1222 1221 13	Q 1122 2111 11	30
31	2233 1232 18	2223 2322 18		1123 2433 19		Q 0011 1001 04	31
Mean K-sum	**14.2**	**14.5**	**18.5**	**17.1**	**17.8**	**14.1**	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	24	49	89	59	25	2	0	0	0	0	0
February	16	60	60	62	26	6	1	1	0	0	0
March	54	84	64	37	7	2	0	0	0	0	0
April	30	66	79	47	11	3	1	3	0	0	0
May	16	81	84	44	18	3	2	0	0	0	0
June	30	69	70	50	16	5	0	0	0	0	0
July	38	94	53	31	20	8	1	3	0	0	0
August	37	75	71	41	16	3	3	2	0	0	0
September	16	53	68	65	23	13	1	1	0	0	0
October	20	71	71	49	23	8	4	2	0	0	0
November	23	61	67	46	17	22	4	0	0	0	0
December	22	76	100	41	8	1	0	0	0	0	0
ANNUAL TOTAL	**326**	**839**	**876**	**572**	**210**	**76**	**17**	**12**	**0**	**0**	**0**

Canberra 2000 Monthly & Annual Mean Values

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

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

CANBERRA	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23149.6	5157.3	-53381.8	58413.3	23717.2	12° 33.6'	-66° 2.7'
	5xQ days	23157.0	5159.5	-53380.2	58415.0	23724.8	12° 33.6'	-66° 2.2'
	5xD days	23139.8	5153.1	-53381.5	58408.9	23706.6	12° 33.3'	-66° 3.2'
February	All days	23140.4	5158.0	-53379.3	58407.5	23708.3	12° 33.9'	-66° 3.1'
	5xQ days	23146.7	5161.7	-53378.5	58409.5	23715.3	12° 34.3'	-66° 2.7'
	5xD days	23124.8	5149.7	-53382.1	58403.1	23691.3	12° 33.3'	-66° 4.1'
March	All days	23147.1	5160.1	-53373.7	58405.2	23715.3	12° 34.0'	-66° 2.6'
	5xQ days	23154.7	5161.1	-53370.6	58405.4	23722.9	12° 33.9'	-66° 2.1'
	5xD days	23129.9	5154.6	-53382.1	58405.6	23697.3	12° 33.8'	-66° 3.8'
April	All days	23127.9	5159.4	-53374.3	58398.1	23696.4	12° 34.5'	-66° 3.6'
	5xQ days	23142.0	5162.4	-53371.0	58400.9	23710.8	12° 34.5'	-66° 2.8'
	5xD days	23095.2	5154.4	-53379.9	58389.9	23663.4	12° 34.9'	-66° 5.5'
May	All days	23136.4	5161.7	-53370.0	58397.7	23705.2	12° 34.6'	-66° 3.0'
	5xQ days	23150.6	5163.7	-53366.8	58400.6	23719.5	12° 34.4'	-66° 2.2'
	5xD days	23114.5	5160.1	-53374.2	58392.7	23683.5	12° 35.1'	-66° 4.3'
June	All days	23140.7	5162.7	-53367.2	58396.9	23709.6	12° 34.6'	-66° 2.7'
	5xQ days	23144.1	5162.5	-53365.4	58396.6	23712.8	12° 34.5'	-66° 2.5'
	5xD days	23134.1	5161.6	-53368.4	58395.4	23702.9	12° 34.7'	-66° 3.1'
July	All days	23129.0	5159.2	-53366.9	58391.7	23697.4	12° 34.5'	-66° 3.4'
	5xQ days	23144.9	5161.9	-53363.3	58395.0	23713.5	12° 34.4'	-66° 2.4'
	5xD days	23094.8	5157.4	-53367.7	58378.8	23663.6	12° 35.3'	-66° 5.2'
August	All days	23131.5	5160.5	-53367.7	58393.6	23700.2	12° 34.6'	-66° 3.3'
	5xQ days	23146.1	5161.8	-53362.5	58394.7	23714.7	12° 34.3'	-66° 2.4'
	5xD days	23103.4	5156.3	-53376.6	58390.2	23671.8	12° 34.9'	-66° 5.0'
September	All days	23133.4	5159.5	-53361.3	58388.3	23701.8	12° 34.4'	-66° 3.0'
	5xQ days	23145.4	5161.7	-53359.4	58391.6	23714.0	12° 34.3'	-66° 2.3'
	5xD days	23107.8	5155.7	-53366.4	58382.6	23676.0	12° 34.7'	-66° 4.5'
October	All days	23133.0	5157.3	-53362.1	58388.8	23701.0	12° 34.1'	-66° 3.1'
	5xQ days	23139.7	5161.8	-53360.1	58390.0	23708.4	12° 34.5'	-66° 2.6'
	5xD days	23098.3	5146.5	-53371.6	58382.8	23664.7	12° 33.6'	-66° 5.3'
November	All days	23143.4	5161.1	-53356.0	58387.7	23711.9	12° 34.3'	-66° 2.4'
	5xQ days	23156.9	5164.3	-53350.8	58388.5	23725.8	12° 34.3'	-66° 1.5'
	5xD days	23113.7	5151.7	-53365.7	58383.9	23680.8	12° 33.9'	-66° 4.3'
December	All days	23158.3	5160.5	-53348.6	58386.8	23726.3	12° 33.7'	-66° 1.4'
	5xQ days	23161.1	5164.1	-53345.8	58385.6	23729.8	12° 34.2'	-66° 1.1'
	5xD days	23152.4	5155.7	-53351.9	58387.0	23719.5	12° 33.2'	-66° 1.8'
Annual	All days	23139.2	5159.8	-53367.4	58396.3	23707.5	12° 34.2'	-66° 2.9'
Mean	5xQ days	23149.1	5162.2	-53364.5	58397.8	23717.7	12° 34.3'	-66° 2.2'
Values	5xD days	23117.4	5154.7	-53372.3	58391.7	23685.1	12° 34.2'	-66° 4.2'

(Calculated:13:48 hrs., Fri. 30 Nov. 2001)

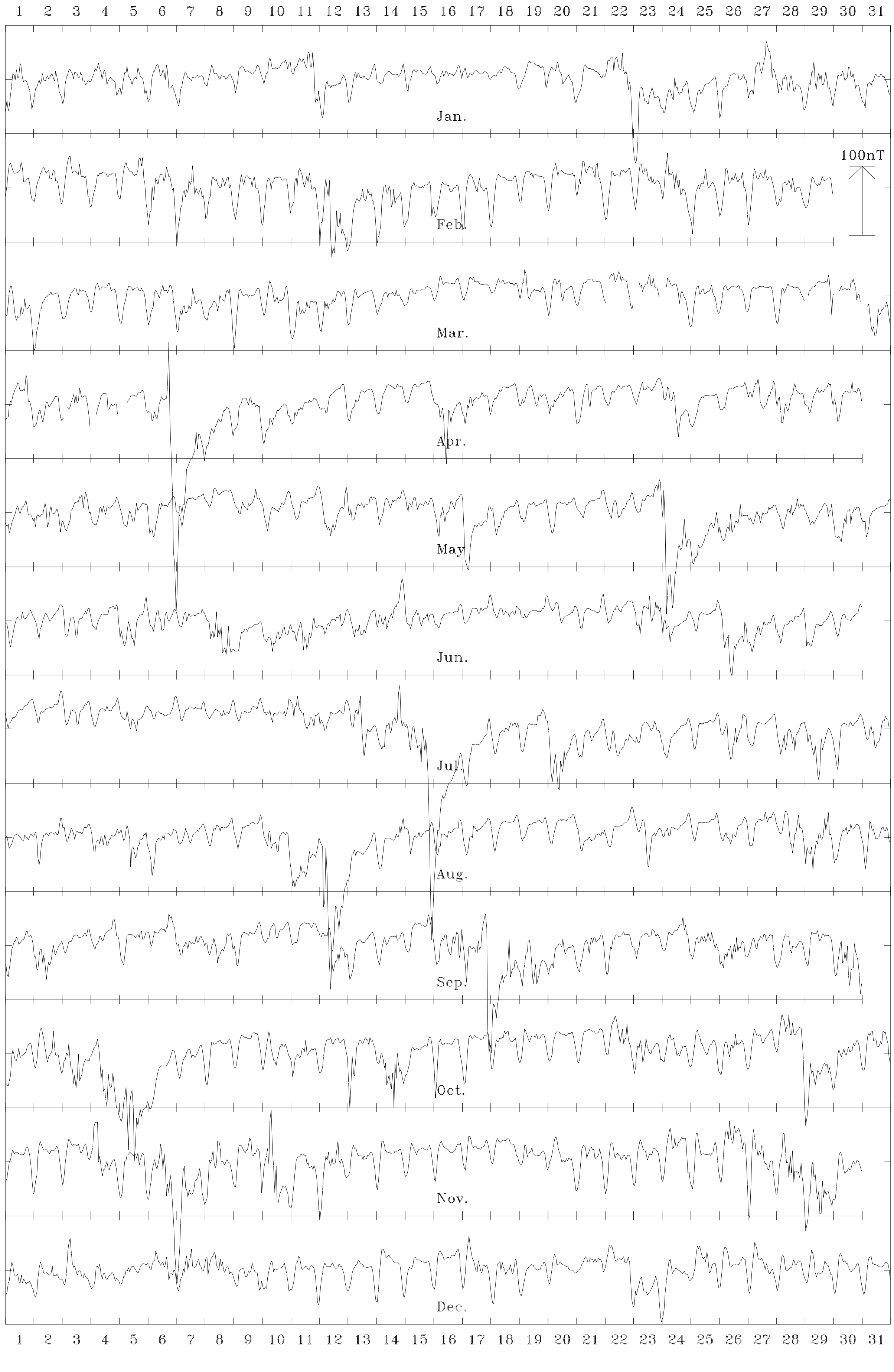
Hourly Mean Values

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

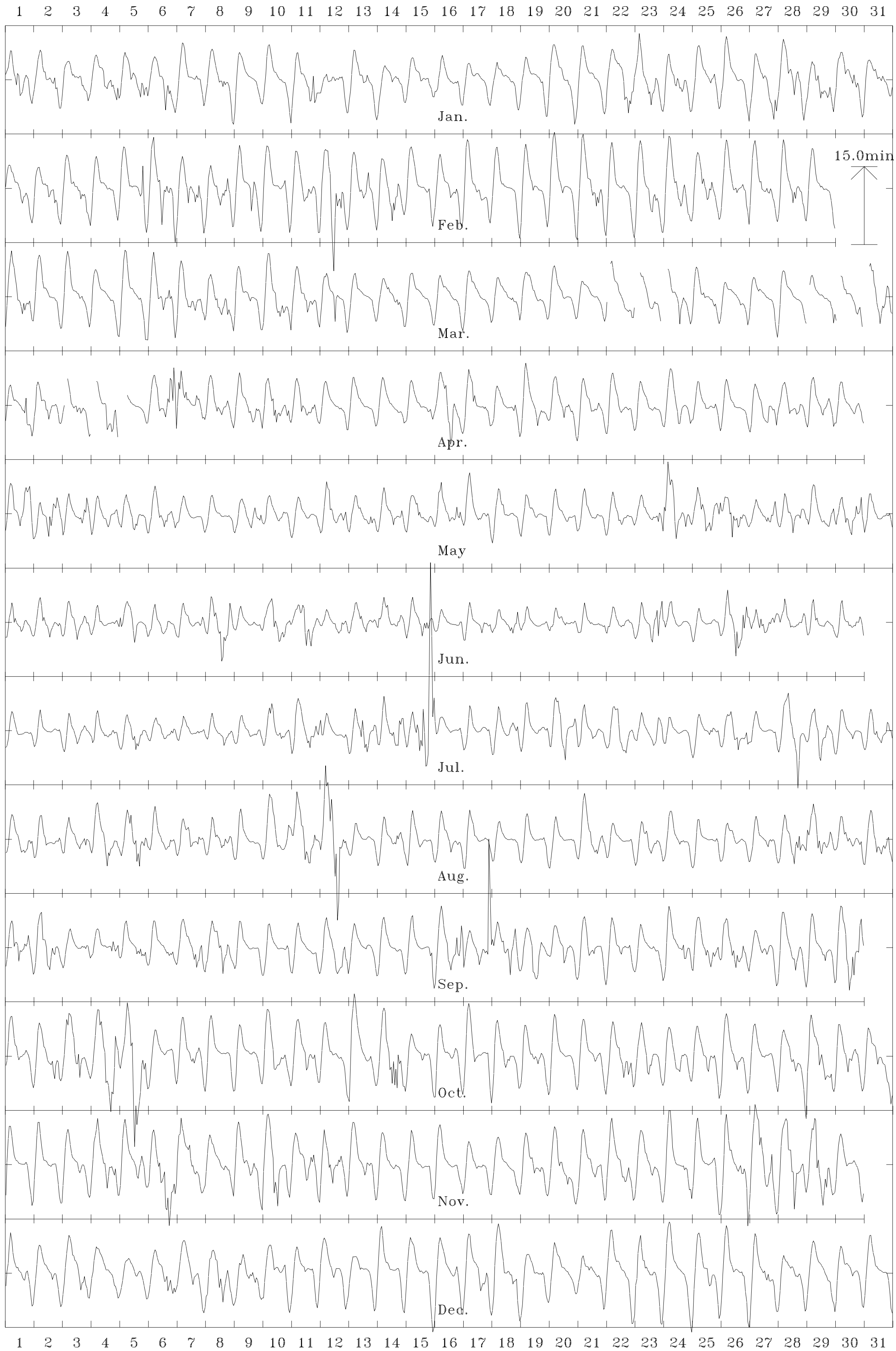
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

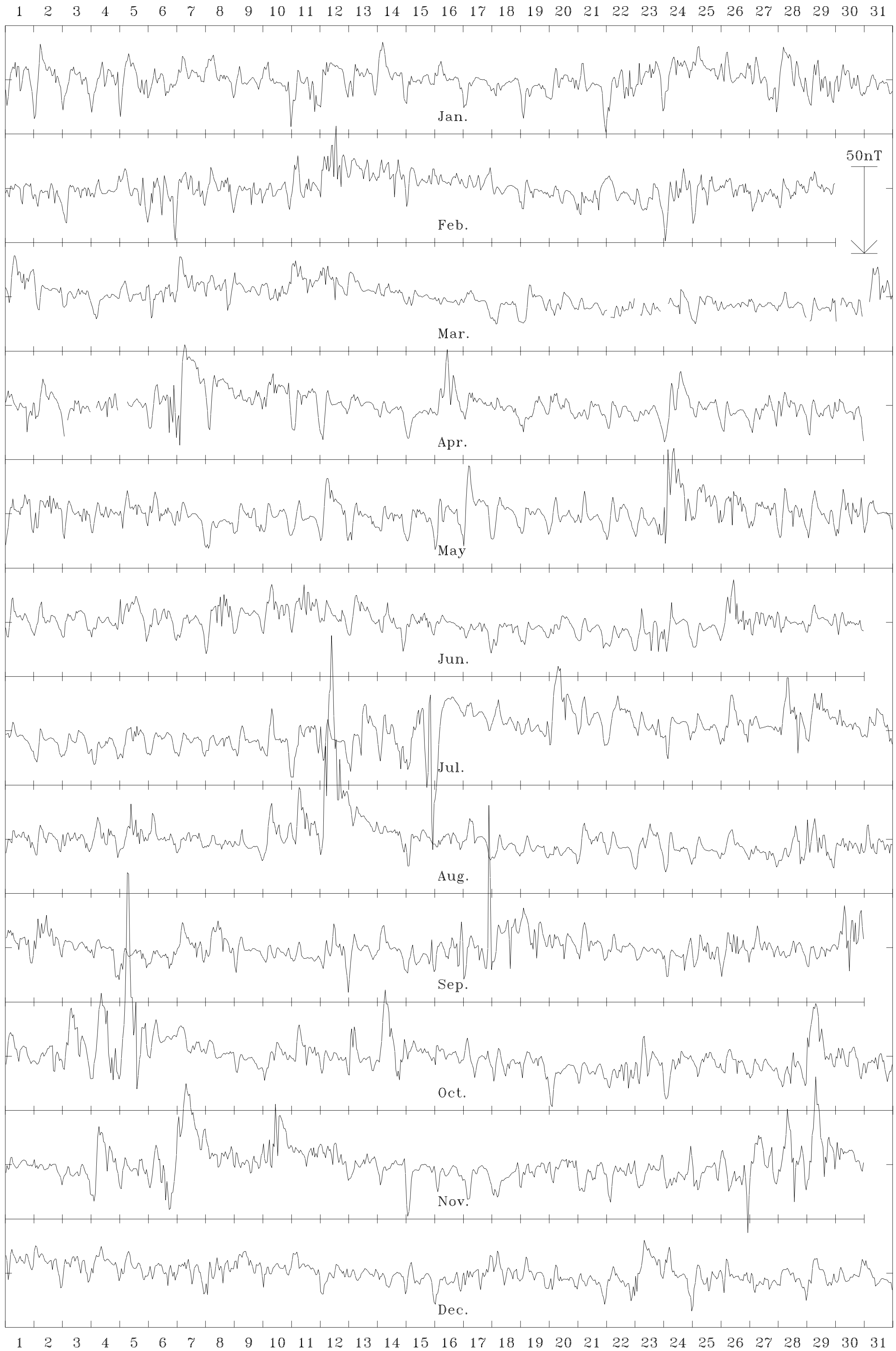
Canberra 2000 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23708 nT



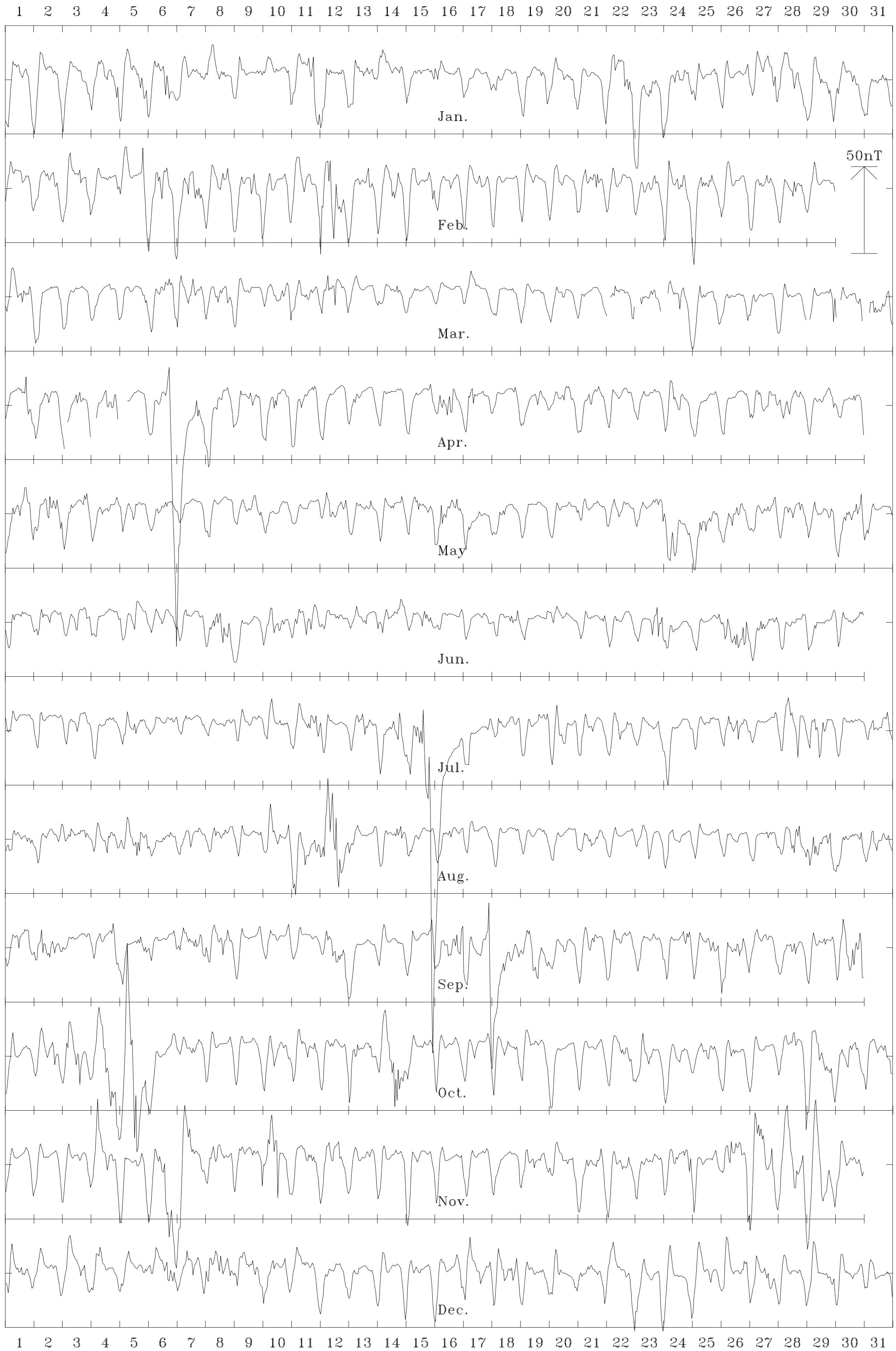
Canberra 2000 Declination (east) (D). Scale: 1.00 min/mm. Mean: 12.57 deg.

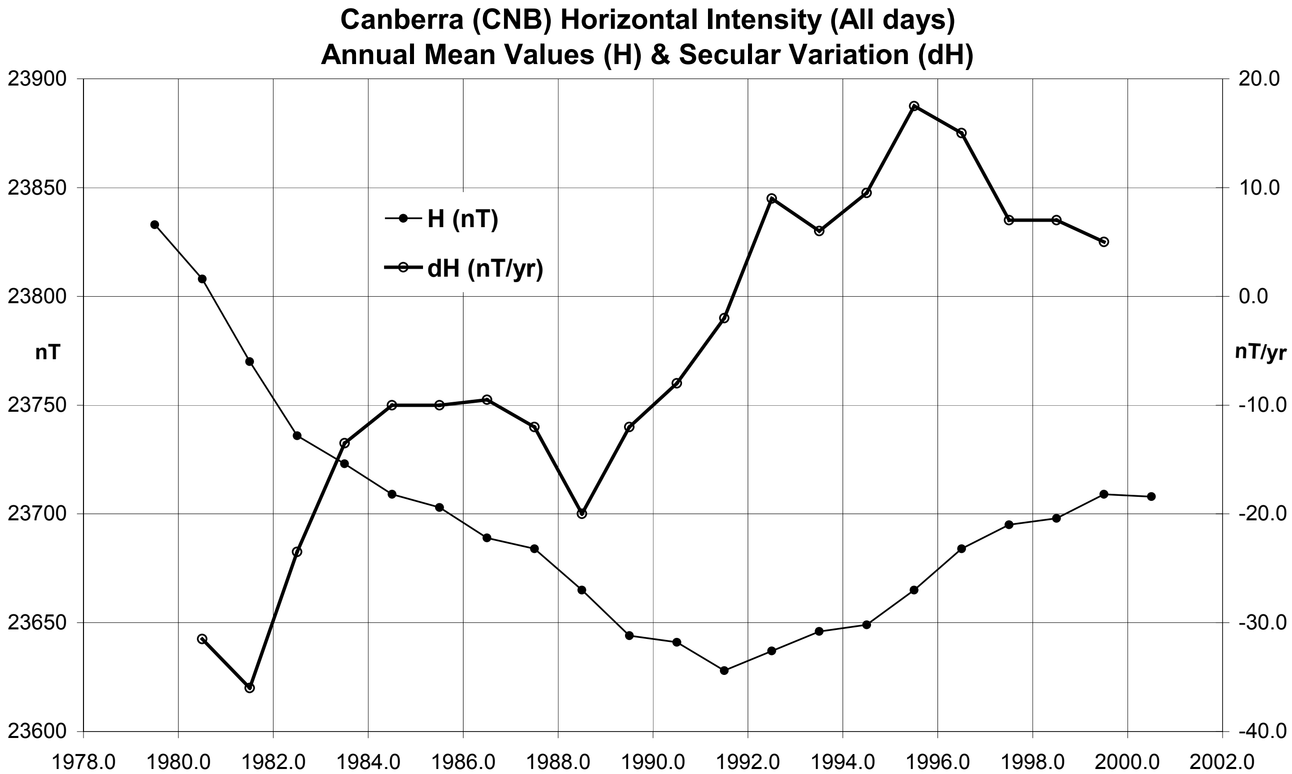


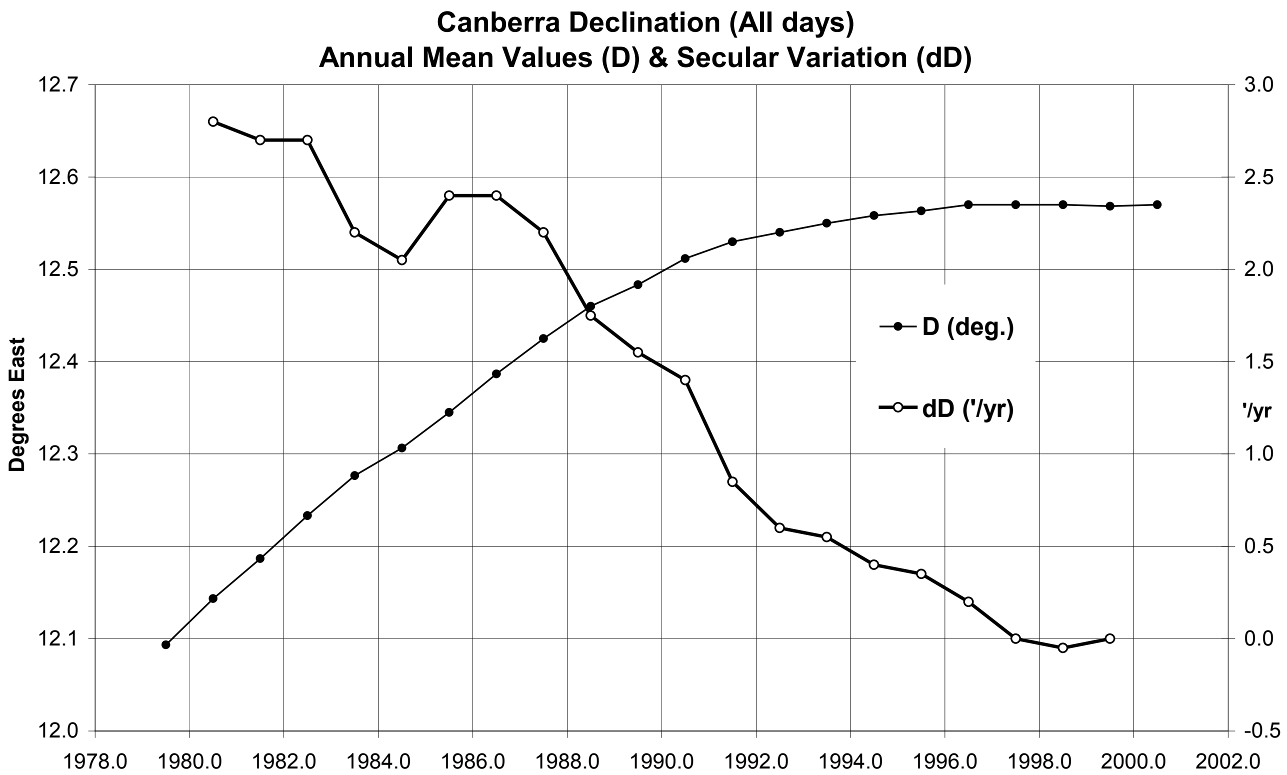
Canberra 2000 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −53367 nT

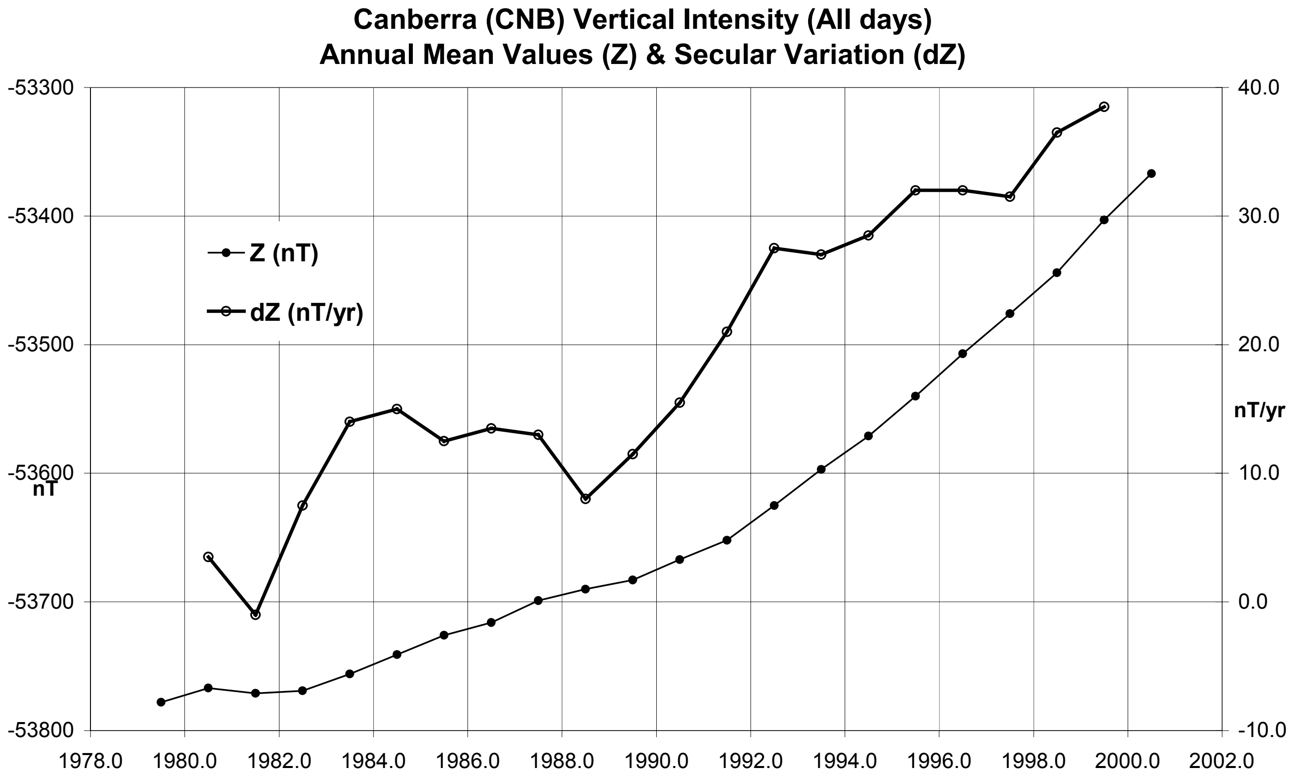


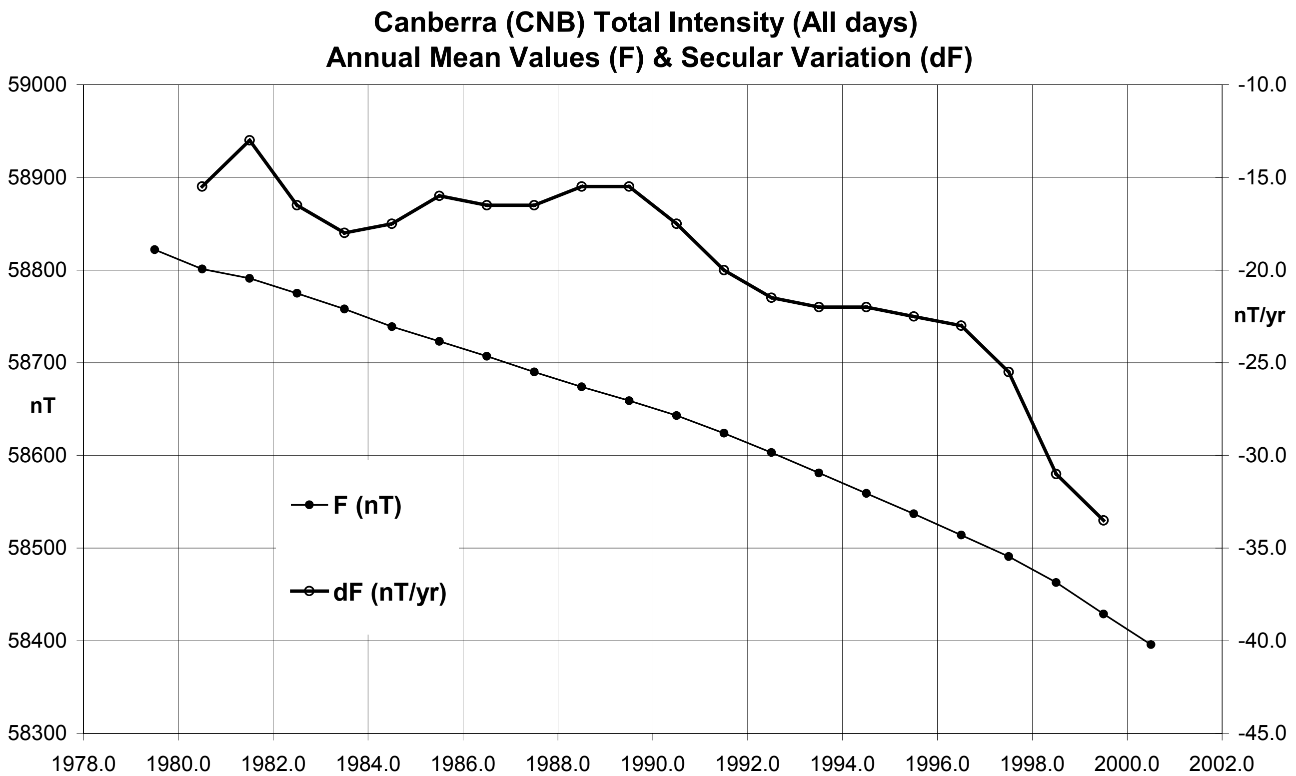
Canberra 2000 Total intensity (F). Scale: 3.0 nT/mm. Mean: 58396 nT




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


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


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


Canberra (CNB) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
59000
58900
58800
58700
58600
58500
58400
58300
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
1978.0
1980.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0

CNB - Rapid Variation Phenomena 2000

Sudden Storm Commencements (ssc) - CNB 2000

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Feb 05	1545	ssc	B	+18	0	+3
11	0300	ssc*	B	+30	-9 *	+9
20	2139	ssc*	B	+15	-42 *	+15
Apr 06	1642	ssc	B	+54	+36	0
Jun 04	1500	ssc	A	+15	+6	+3
08	0912	ssc*	B	+48	-27 *	+15
Jul 13	0942	ssc	B	+33	+3	+6
19	1530	ssc	B	+24	+9	0
28	0633	ssc	B	+27	+18	0
Sep 06	1700	ssc*	B	+30 *	+15	0
15	0448	ssc	B	+36	+12	0

CNB 2000 ssc (cont.)

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Oct 05	0327	ssc*	B	+30	+15 *	+6
12	2230	ssc*	B	+6	-39 *	+15
28	0954	ssc	B	+51	+6	+15
31	1715	ssc	B	+31	+15	+9

Solar Flare Effects (sfe) - CNB 2000

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Jun. 18	0157	0200	0206	+6	0	0	solar
Sep 03	0409	0412	0418	+21	+9	+3	solar
Nov 24	0457	0501	0524	12	33	6	solar

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 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 27°C in winter to about 29°C in summer. There was no discernible diurnal temperature variation in the tunnel. The control electronics associated with the variometers 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† latitude: -28.02°
- Geomagnetic† longitude: 220.77°
- 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 (Uni. of Qld)

† Based on the IGRF 2000 model.

Variometers

Since its commissioning in mid-1983 the principal variometers employed at the Charters Towers observatory were EDA model FM-105B 3-component fluxgate magnetometers, the sensor heads of which were located on concrete blocks in the mine tunnel. The unit that was operating at the beginning of 2000 was installed in August 1998. 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. Temperature of both the EDA sensor and electronics were monitored with LM35C sensors.

On 27 August 2000, the EDA variometer (sensor 2887, electronics 3181) was replaced by a non-suspended DMI FGE (Ver.G) fluxgate variometer (sensor S0210, electronics E0227).

Prior to installation at Charters Towers, the DMI fluxgate magnetometer was calibrated in August 2000 at the Magnetic Calibration Facility at Canberra Observatory. The results are summarised in the following table.

Vario-meter Channel	Scale-value nT/count	Sensor Temp. coeff nT/deg.C	Electronics Temp. coeff nT/deg.C
X	0.032000	-0.2539	0.1632
Y	0.032696	-0.6327	0.0576
Z	0.032562	0.1364	0.1900

The 3-axis sensor head of this instrument was installed on concrete blocks in the mine tunnel, with one axis vertical, and two horizontal, each aligned at 45° to, and on either side of, the magnetic declination. This was achieved by setting the X and Y coils-offsets equal and rotating the instrument until the X and Y ordinates were equal.

There was also a cycling proton precession magnetometer monitoring variations in the magnetic total intensity, F. Elsec 820 no. 128 PPM that was employed until damaged by lightning on 20 Nov 2000. It was replaced by a similar unit with s/n 138. The PPM sensor was suspended from the ceiling of the tunnel.

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.

Data Recording

From the beginning of the year until 27 Aug. 2000, mean data values over 1-second and 1-minute intervals were recorded in the variables A (NW), B (NE), C (Z), as well as the EDA sensor & electronics temperatures. Analogue outputs from the EDA and LM35C temperature sensors were input to an ADAM 4017 A/D module mounted within the EDA electronics case. The digital output from the ADAM was recorded on an IBM compatible PC.

Analogue outputs of A (X-coil), B (Y-coil), C (Z-coil) from the DMI FGE 3-channel fluxgate, and the fluxgate head and electronics temperature channels, were also converted to digital data with an ADAM 4017 A/D converter mounted inside the electronics console. These digital data together with the digital PPM data were recorded on an IBM compatible PC.

The digital readings from the Elsec 820 PPM acquired every 10-seconds were input directly to the PC. Timing was generated by the PC.

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

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

Absolute Instruments

Throughout 2000 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.

Instrument Corrections

As no absolute magnetometer intercomparisons were performed at Charters Towers magnetic observatory from 1999 to 2000, no corrections have been applied to the CTA mean values in this report.

Operations

The officer in charge at CTA observatory performed most routine operations during 2000. Tasks included:

- weekly performance of a set of absolute observations
- weekly system check until tunnel collapsed on 20 or 21 January 2000, and then after the tunnel was cleared from 21 Jun until 23 Aug 2000.
- Temperature check about every 3 days from 30 August until the end of the year.
- mailing the observations & log-sheet to GA, Canberra, each week

The clocks on the acquisition PC were regularly checked/corrected remotely from GA in Canberra.

During a service visit to CTA by a staff member from GA in Canberra, between 27-31 Aug. 2000, the EDA FM105B variometer was replaced by a Danish Meteorological Institute (DMI) variometer.

Comparison absolute observations were also performed during the service visit.

Significant Events 2000

Jan 20	between 2100 and 0400 on 21st about 20m of the tunnel, in which the variometers and recording instruments were housed ,collapsed. Although the instrumentation was not physically accessible it continued to function. The acquisition PC could be accessed through modems enabling the time to be corrected as required and data to be transmitted to head office in Canberra. System checks could not be performed until the tunnel was cleared on 21 June 2000.
May 23	0115: Work started to clear and repair the collapsed tunnel. Power supply to instruments was switched off from time to time. Data were intermittently contaminated during the work.
Jun 20	Tunnel cleared and safe to enter. Variometer system check performed on 21st .
Jun 30	2100 to 01 Jul. at 0050: Earthwork on Towers Hill above the tunnel caused data contamination.
Jul 30	2225 to 31st at 0800: Electrical work in tunnel. Personnel moving near variometer sensors – possible contamination.
Aug 03	Tunnel repairs completed with lights being restored.
Aug 27	2235: Last record produced by EDA FM105B variometer before the instrument was removed from the pier and replaced by a DMI variometer.
Aug 28	0218: Recording of data produced by the new DMI variometer commenced. (The recording PPM continued operation throughout the fluxgate variometer changeover.)
Nov 17	2100-2300; also on 18th 0045-0530 and 2100 to 19th at 0600: Work on tunnel ventilation carried out. There may be some contamination of data.
Nov 20	Data acquisition stopped when PC was damaged by a lighting strike.
Nov 24	0447: New PC was installed.
Dec 05	2359: Elsec820 s/n 138 PPM was installed to replace unit damaged by lightning.
Dec 08	2349: Residual current breaker turned back on.
Dec 27	2330: PPM repaired.

Distribution of CTA data during 2000

1-minute & Hourly Mean Values

- no data distributed in 2000

Preliminary Monthly Means for Project Ørsted

- To IPGP by email:
  - 1998; 1999; Jan-Jun 2000 data sent July 2000
  - sent monthly from July 2000

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 36-37.

No 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
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
1983.729	D	7	39.9	-50	18.7	31769	31485	4237	-38281	49746	XYZ
1984.5	D	7	41.8	-50	19.4	31756	31470	4253	-38283	49740	XYZ
1985.5	D	7	43.1	-50	18.9	31761	31474	4266	-38277	49739	XYZ
1986.5	D	7	44.4	-50	19.3	31752	31463	4276	-38276	49732	XYZ
1987.5	D	7	45.4	-50	18.9	31757	31467	4286	-38272	49732	XYZ
1988.5	D	7	46.3	-50	20.4	31731	31439	4291	-38274	49716	XYZ
1989.5	D	7	46.9	-50	22.2	31696	31404	4292	-38272	49693	XYZ
1990.5	D	7	47.1	-50	21.1	31707	31415	4295	-38263	49693	XYZ
1991.5	D	7	47.4	-50	21.8	31687	31394	4295	-38253	49672	XYZ
1992.5	D	7	47.3	-50	19.5	31706	31414	4297	-38225	49663	XYZ
1993.5	D	7	47.4	-50	17.2	31723	31430	4299	-38191	49648	XYZ
1994.5	D	7	47.6	-50	15.1	31730	31437	4302	-38154	49624	XYZ
1995.5	D	7	47.7	-50	12.0	31755	31462	4307	-38114	49609	XYZ
1996.5	D	7	47.4	-50	8.6	31784	31491	4308	-38072	49595	XYZ
1997.5	D	7	47.0	-50	6.4	31788	31495	4305	-38026	49563	XYZ
1998.5	D	7	46.5	-50	4.4	31782	31490	4299	-37976	49520	XYZ
1999.5	D	7	45.5	-50	1.0	31797	31506	4293	-37916	49484	XYZ
2000.5	D	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	ABC

Charters Towers 2000 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	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31531.6	4289.0	-37887.2	49478.0	31821.9	7° 44.8'	-49° 58.4'
	5xQ days	31542.0	4291.4	-37885.1	49483.3	31832.6	7° 44.9'	-49° 57.7'
	5xD days	31520.4	4283.9	-37887.7	49470.9	31810.2	7° 44.4'	-49° 59.0'
February	All days	31523.7	4288.7	-37880.2	49467.6	31814.1	7° 44.8'	-49° 58.5'
	5xQ days	31532.5	4292.0	-37877.7	49471.6	31823.3	7° 45.1'	-49° 57.9'
	5xD days	31502.7	4283.2	-37883.7	49456.5	31792.5	7° 44.6'	-49° 59.8'
March	All days	31531.8	4292.1	-37873.3	49467.8	31822.6	7° 45.1'	-49° 57.7'
	5xQ days	31540.2	4292.5	-37872.8	49472.8	31830.9	7° 45.0'	-49° 57.2'
	5xD days	31508.8	4286.0	-37877.3	49455.7	31799.0	7° 44.8'	-49° 59.1'
April	All days	31510.6	4289.6	-37874.1	49454.7	31801.2	7° 45.1'	-49° 58.9'
	5xQ days	31526.3	4291.3	-37870.7	49462.3	31817.0	7° 45.1'	-49° 57.9'
	5xD days	31474.3	4286.6	-37878.7	49434.9	31764.9	7° 45.3'	-50° 1.0'
May	All days	31517.7	4290.4	-37869.5	49455.8	31808.3	7° 45.1'	-49° 58.3'
	5xQ days	31533.9	4291.4	-37867.2	49464.4	31824.5	7° 45.0'	-49° 57.3'
	5xD days	31486.4	4289.0	-37871.0	49436.9	31777.2	7° 45.4'	-50° .0'
June	All days	31523.0	4290.6	-37864.3	49455.2	31813.7	7° 45.1'	-49° 57.8'
	5xQ days	31527.9	4290.6	-37863.3	49457.6	31818.5	7° 45.0'	-49° 57.5'
	5xD days	31512.2	4289.8	-37864.5	49448.4	31802.8	7° 45.1'	-49° 58.4'
July	All days	31509.9	4286.4	-37864.8	49446.9	31800.1	7° 44.8'	-49° 58.5'
	5xQ days	31527.3	4288.7	-37863.5	49457.2	31817.7	7° 44.8'	-49° 57.5'
	5xD days	31476.2	4285.4	-37868.0	49427.8	31766.6	7° 45.2'	-50° .5'
August	All days	31510.8	4286.8	-37862.5	49445.7	31801.0	7° 44.8'	-49° 58.4'
	5xQ days	31526.8	4287.4	-37858.7	49453.0	31817.0	7° 44.7'	-49° 57.4'
	5xD days	31473.5	4284.9	-37869.2	49426.9	31763.9	7° 45.2'	-50° .6'
September	All days	31513.6	4286.3	-37858.7	49444.5	31803.8	7° 44.7'	-49° 58.1'
	5xQ days	31527.4	4290.0	-37857.3	49452.5	31817.9	7° 44.9'	-49° 57.2'
	5xD days	31484.6	4280.9	-37862.0	49428.1	31774.3	7° 44.6'	-49° 59.8'
October	All days	31512.0	4282.0	-37857.2	49442.0	31801.6	7° 44.3'	-49° 58.1'
	5xQ days	31523.7	4284.3	-37854.1	49447.3	31813.5	7° 44.4'	-49° 57.3'
	5xD days	31467.2	4274.7	-37866.0	49419.6	31756.2	7° 44.2'	-50° .9'
November	All days	31521.8	4284.7	-37853.5	49445.7	31811.7	7° 44.4'	-49° 57.4'
	5xQ days	31543.8	4288.5	-37849.7	49457.1	31834.0	7° 44.5'	-49° 56.0'
	5xD days	31483.0	4277.7	-37857.6	49423.4	31772.3	7° 44.3'	-49° 59.7'
December	All days	31537.4	4287.2	-37846.9	49450.7	31827.5	7° 44.5'	-49° 56.3'
	5xQ days	31545.7	4291.1	-37843.9	49454.1	31836.2	7° 44.8'	-49° 55.7'
	5xD days	31526.5	4284.6	-37850.0	49445.9	31816.3	7° 44.4'	-49° 57.0"
Annual	All days	31520.3	4287.8	-37866.0	49454.5	31810.6	7° 44.8'	-49° 58.0'
Mean	5xQ days	31533.1	4289.9	-37863.7	49461.1	31823.6	7° 44.8'	-49° 57.2'
Values	5xD days	31493.0	4283.9	-37869.6	49439.6	31783.0	7° 44.8'	-49° 59.6'

(Calculated:17:09 hrs., Tue. 03 Apr. 2001)

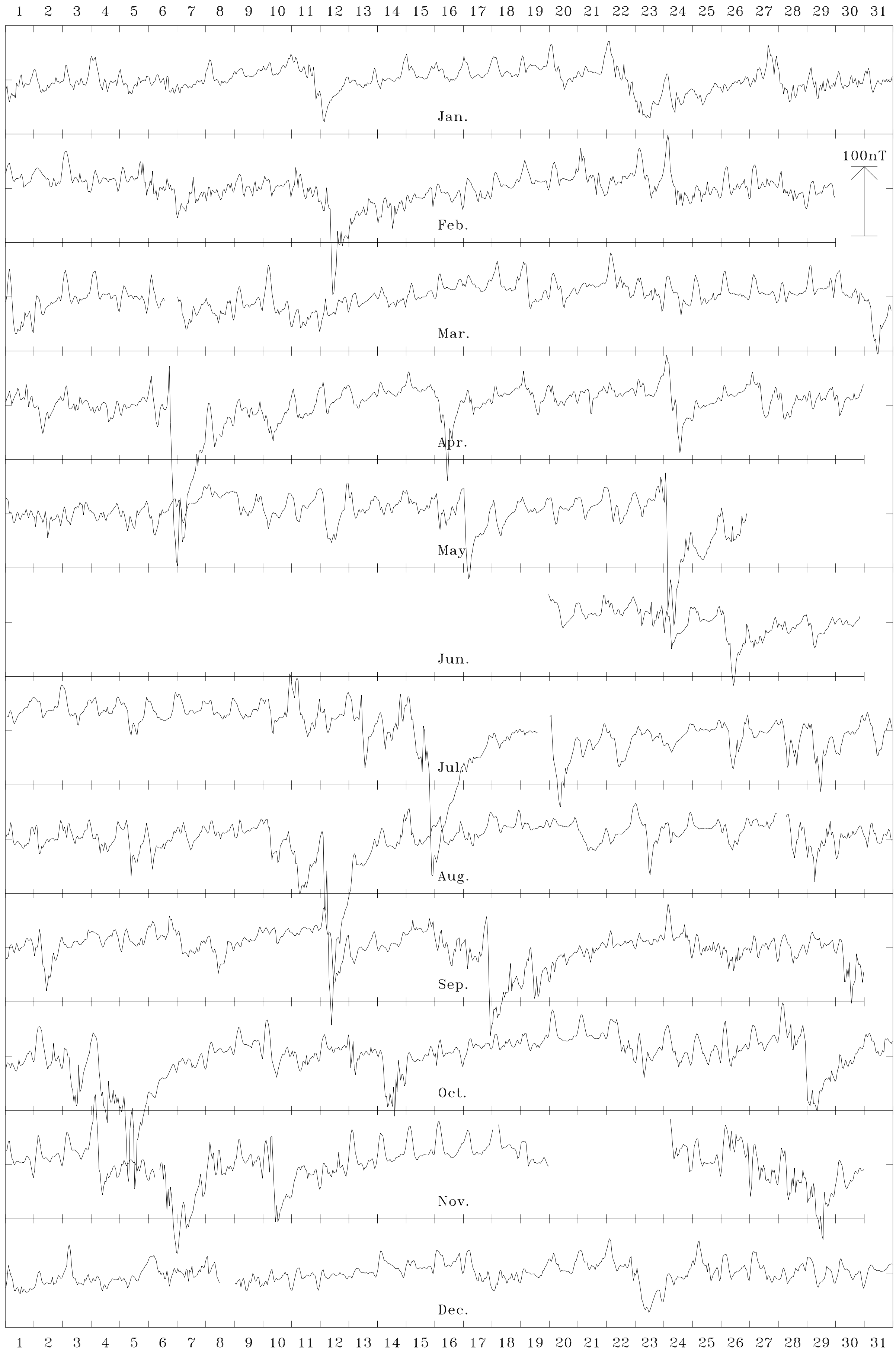
Hourly Mean Values

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

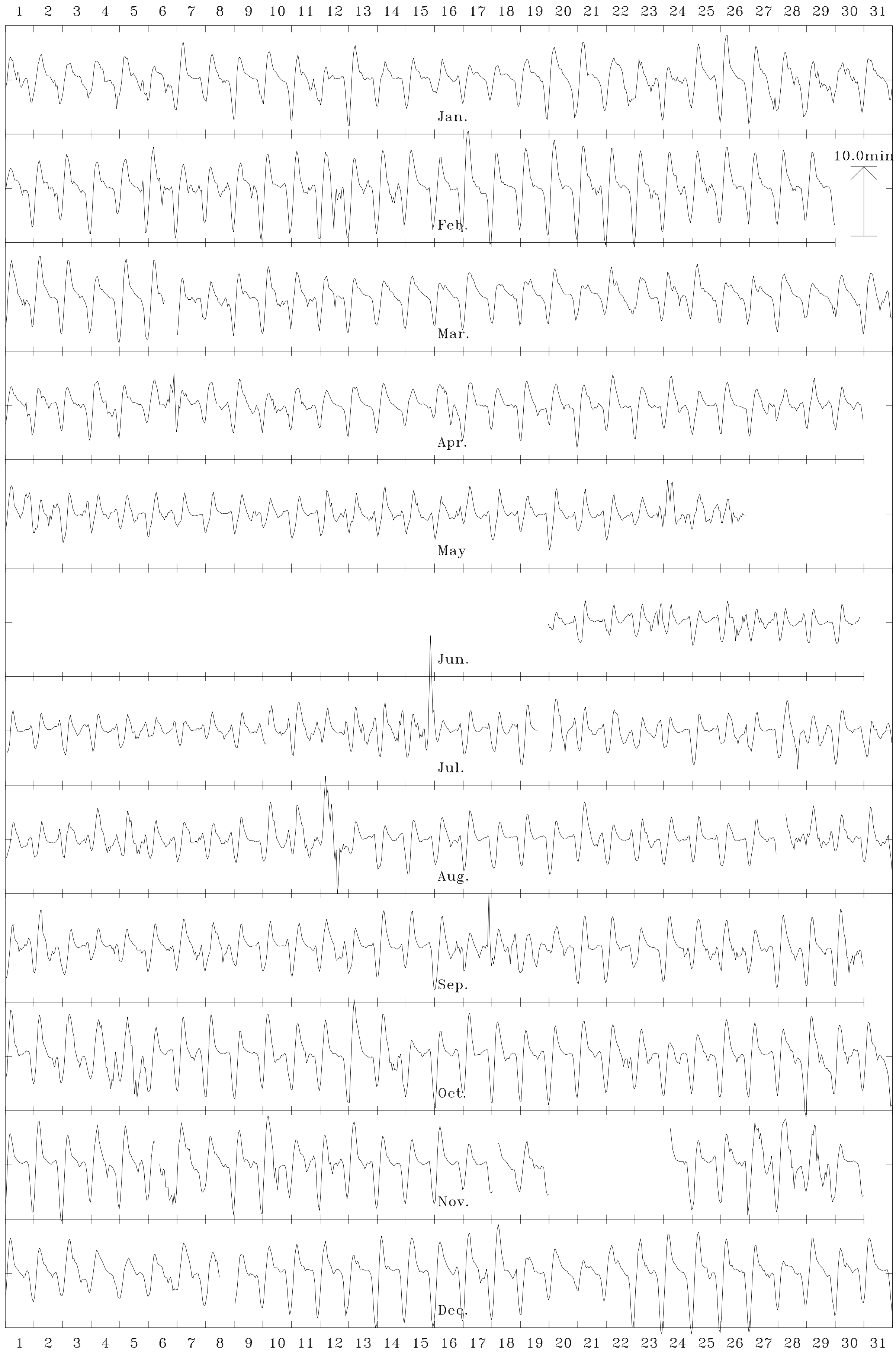
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

Charters Towers 2000 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 31811 nT

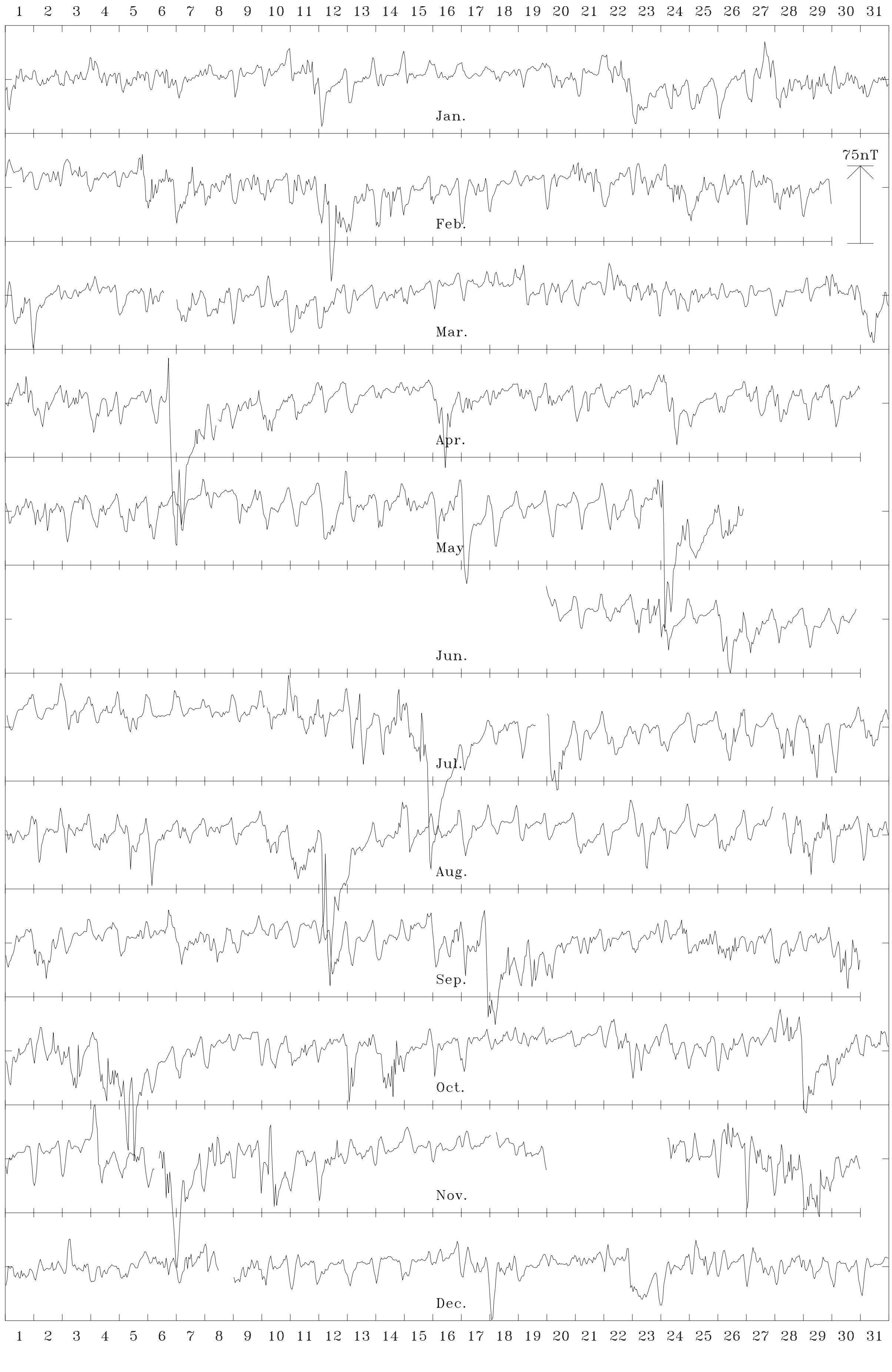


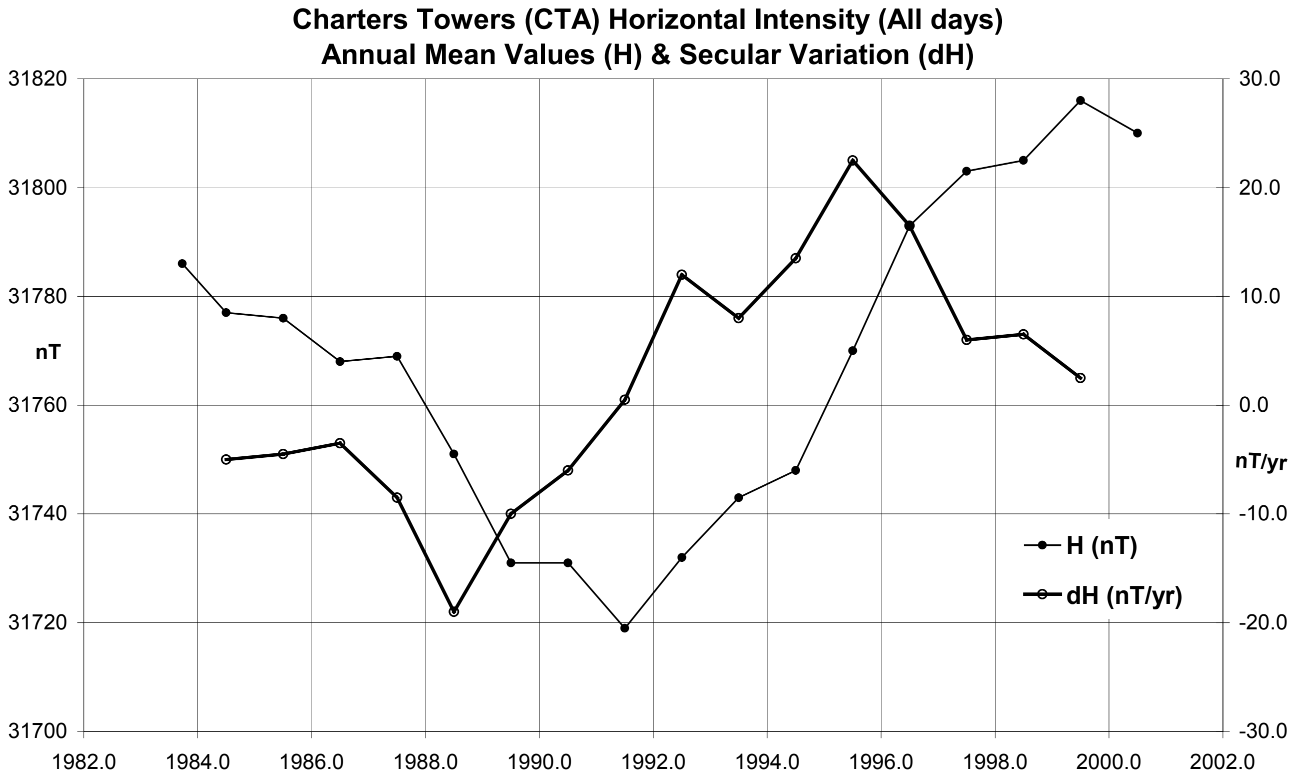
Charters Towers 2000 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.75 deg.

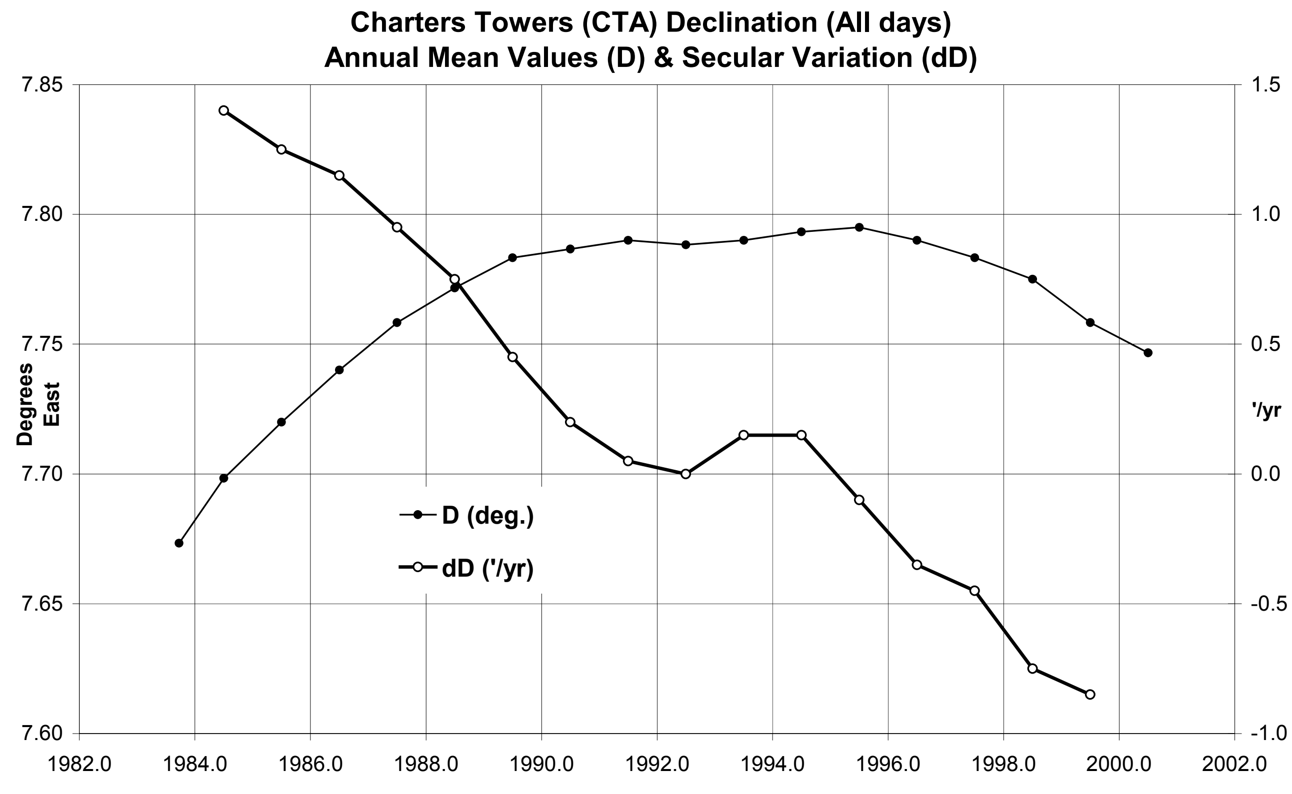


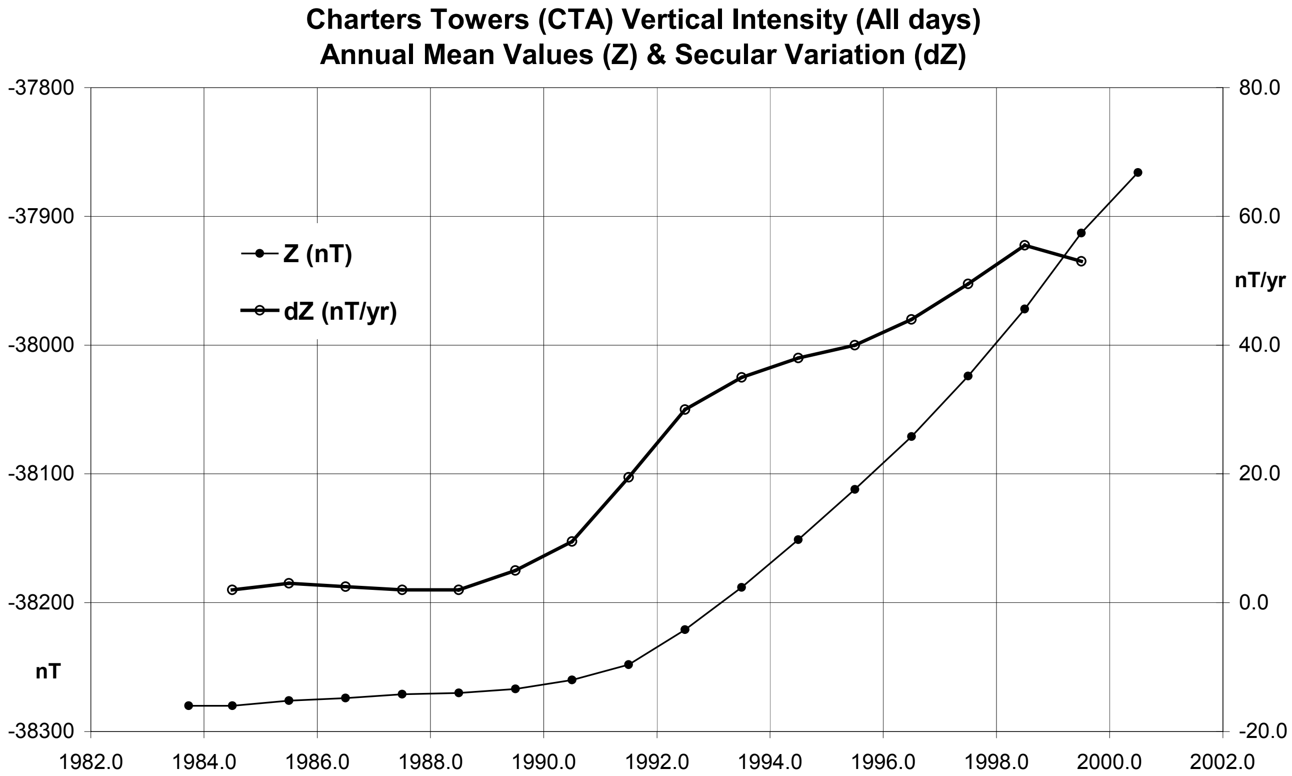
Charters Towers 2000 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −37866 nT

Charters Towers 2000 Total intensity (F). Scale: 5.0 nT/mm. Mean: 49455 nT

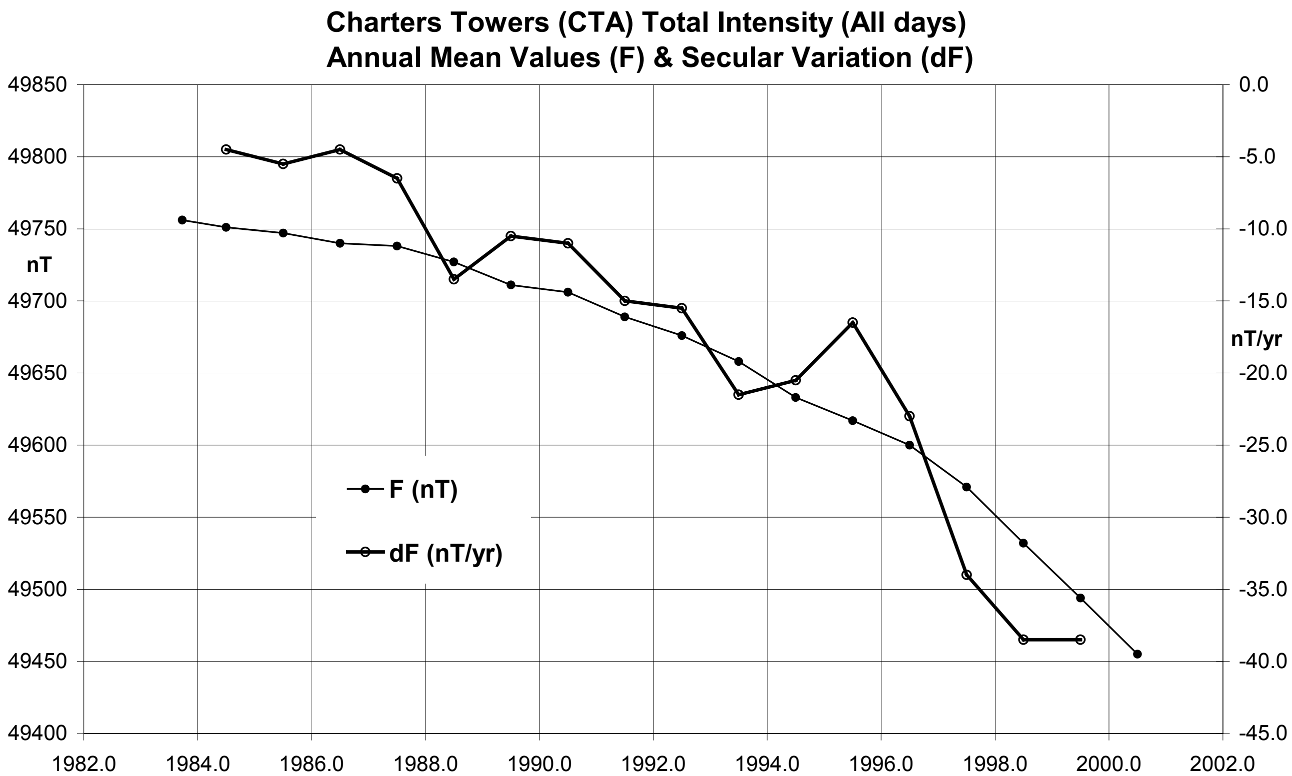



Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
31820
31800
31780
31760
31740
31720
31700
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0


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



Charters Towers (CTA) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-37800
-37900
-38000
-38100
-38200
-38300
nT
80.0
60.0
40.0
20.0
0.0
-20.0
nT/yr
Z (nT)
dZ (nT/yr)
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0



Charters Towers (CTA) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
49850
49800
49750
49700
49650
49600
49550
49500
49450
49400
nT
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
nT/yr
F (nT)
dF (nT/yr)
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0

CTA Data losses in 2000

Jan 04	0804 (1m): System re-booted.
Mar 06	1400-2359 (10h): Data drifting - cause unknown. Processing of data inhibited.
Apr 08	1000-1059 (1h): Data drifting - cause unknown. Processing of data inhibited.
May 26	2200 to Jun 19/2259 (24d 01h): Processing of data, contaminated during repairs to collapsed tunnel, was inhibited. During this period no data (all channels) were acquired during the intervals: May 26/2200 to 27/0543 (7h 44m); Jun 11, 0608-0709 (1h 02m); Jun 13, 0037-0548 (5h 12m); Jun 14, 0641-0659 (19m).
Jun 30	2100 to Jul 01/0059 (4h): Processing of data, contaminated by earthworks on the hill above the tunnel, was inhibited.
Jul 10	0300-0359 (1h): Processing of data, contaminated by activities near sensors, was inhibited.
Jul 19	1455 to 20/0047 (9h 53m) All channels lost: Power failure.
Aug 27	2236 to 28/0102 (1h 27m): No 3-axis fluxgate variometer data after EDA FM105B ceased and before DMI FGE commenced. (PPM continued.)
Aug 28	0103-0626 (5h 24m) and 2310-2339 (30m): Processing of data, contaminated during setting up new DMI FGE 3-axis variometer, was inhibited. Whilst the new variometer was being set up no data were acquired during the following intervals: 0059-0103 (5m): PPM channel only; 0226-0229 (4m): All channels;
Aug 28 (cont. from previous column)	0351-0353 (3m): DMI channels only; 0356-0400 (5m): DMI channels only; 0409-0422 (14m): All channels; 0516-0521 (6m): PPM channel only; 0516-0530 (15m): DMI channels only; 0523-0525 (3m): PPM channel only; 0529-0530 (2m): PPM channel only.
Aug 29	0202-0222 (21m): PPM data lost by tidying the control room.
Sep 03	0405-0419 (15m): Processing of data, contaminated by activities near sensors, was inhibited.
Oct 24	0348-0414 (27m) and 0418-0430 (13m) DMI channels: Power failure on data opto-isolator.
Nov 06	0556-0603 (8m); 0605-0657 (53m); 0659-0729 (31m); 0735 (1m); 0737-0912 (1h 36m) DMI channels only: UPS failure.
Nov 18	0030-0529 (5h): Processing of data, contaminated by activities near sensors, was inhibited.
Nov 20	0000 to 24/0446 (4d 04h 47m): Acquisition PC damaged by lighting strike.
Nov 24	0446-0459 (14m) Processing of data inhibited.
Nov 20	0000 to Dec 04/0413 (14d 04h 14m) PPM channel: PPM damaged by lighting strike.
Dec 04 & 05	0415 (1m); 0420-0445 (26m); 0447-0453 (7m); 0455-0721 (2h 27m); 0723 to 05/0142 (18h 20m); 0146 (1m); 0148-0149 (2m); 0154-0157 (4m); 2335 (1m): PPM channel only data lost.
Dec 08	1146-2349 (12h 04m) All channels: UPS plug dropped off main power supply board.
Dec 26	2127-2255 (1h 29m); 2314 (1m); 2320-2321 (2m); 2325-2327 (3m): PPM channel only lost.

GNANGARA OBSERVATORY

The Gnangara Magnetic Observatory is located approximately 27km to the north-east of the city of Perth in Western Australia, within the Gnangara pine plantation. 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 2000 the observatory comprised a Variometer/Recorder Vault and an Absolute House approximately 70m north east of the Recorder Vault. The site is on well drained sand with low natural magnetic gradients of less than 1 nT/m, although numerous artificial features have introduced higher gradients.

The Variometer Vault is partially underground, and partially buried under sand. It is approximately 10m x 5m and provides a secure, temperature and physically stable environment. This vault houses the recording equipment, fluxgate variometer sensor and electronics, total field variometer electronics, GPS clock, backup power supply, telephone, and alarm system. There were also two small below-ground vaults on the observatory site. Each of these was approximately 20m from the Recorder Vault: one to its north-west and one to its south-west, and connected to the latter by underground conduits. The vault to the north west 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. The annual temperature range in the Variometer Vault has been measured (in previous years) to drift from around 15°C in winter to 28°C in summer. The standard temperature was 20°C.

There were also four azimuth reference marks on the site.

Key data for the principal observation pier (B) of the observatory are:

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic‡ latitude: 31° 46' 48" S
- Geographic‡ longitude: 115° 56' 48" E
- Geomagnetic† latitude: -41.90°
- Geomagnetic† longitude: 188.61°
- 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 B: 70 metres
- Observer in Charge: E.P. Paull (MGO) to April 2000; O. McConnel (GA) from May 2000

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

† Based on the IGRF 2000 model.

Variometers

Throughout 2000 magnetic field variations were monitored with a Danish Meteorological Institute suspended 3-component FGE model (version D – with sensor no. S0160 & electronics no. E0167) fluxgate variometer, that was located in the Variometer Vault. Two of its sensors were horizontal and 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.

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

Throughout 2000, 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 downloads. The telephone and equipment was protected from lightning and powered through a UPS.

The acquisition computer clock was synchronised to the 1-second pulse from a GPS clock, but the time code from the GPS was not used.

Timing errors were normally less than 0.1s. Exceptions to this were:

- 1-second correction applied at 0018 10 Feb. 2000 that had probably persisted since a system restart on 30 January due to an operational oversight.
- 1-second correction applied on 8 Aug. 2000 shortly after the installation of a new UPS.
- 44-second correction applied on 5 December shortly after power was reconnected to the observatory after vandalism.

Absolute Instruments

Declination and Inclination Magnetometer (DIM) Bartington Mag-010H/0725H with Zeiss020B/355937 was employed regularly throughout 2000. It was used on Pier B in the Absolute House.

PPM Geometrics 856/50631 with sensor 28079922 was employed throughout 2000 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 remained in place between weekly observations.

Instrument Corrections

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′, 0.0′ in D and I, have been applied to the DIM Bartington Mag-010H/0725H with Zeiss020B/355937, used at GNA during 2000.

A composite correction has been applied to the absolute PPM used at GNA on the auxiliary pier during 2000. The components of this correction are:

- +1.32nT correction relative to the Australian Standard F (MNS2 no. 3)
- -0.78nT correction to the MNS2 no. 3
- -5.6nT auxiliary pier adjustment to Pier B

This (together with the zero corrections to the DIM) has been applied as a vector pier difference of (-2.00, +0.09, +4.65) nT in (X,Y,Z) to all Gnangara data in this report.

Baselines

The scale values and orientation of the variometer sensors were determined from a campaign of absolute observations performed in June 1999. Zero temperature coefficients were applied to 2000 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 is less than 0.1nT. The standard deviations of the differences between the absolute measurements in 2000 and the derived values from the variometer data and model are:

X = 1.1 nT	Y = 1.9 nT	Z = 0.6 nT
F = 0.5 nT	D = 0.28'	I = 0.07'

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM in 2000 varied from -1.3nT to +1.3nT, with a standard deviation of 0.5nT.

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

Operations

The Gnangara magnetic observatory was operated by the staff at Geoscience Australia's Mundaring Geophysical Observatory (MGO), until the latter's closure at the end of April 2000. MGO was located 30km. east of Perth and 25km. from Gnangara. After the closure of MGO it was operated by an out-posted (ex-MGO) GA staff member.

Absolute observations were performed weekly on a roster by the OIC at the MGO and a contract observer. (Prior to its closure, staff at MGO were also responsible for running GA's seismograph network in Western Australia.) The routine production of magnetograms; the scaling of principal magnetic storms, rapid variations and K indices; and the distribution of data, was performed by staff at GA headquarters in Canberra.

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 the observatory. These raw data were retrieved by modem directly from the observatory to GA, Canberra.

Timing was derived from a GPS receiver with antenna at west of vault.

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 is a problem with vandalism. Considerable data was lost in 2000 through vandalism: power cables cut; fires lit; path-pavers stolen; cars damaged. By the end of 2000 the observers no longer felt safe at the site, and a security firm was engaged to attend during weekly absolute observations. Data was also occasionally corrupted by the presence of motor vehicles.

In March 2000, staff from GA, Canberra, visited the observatory and installed an external reference tripod site. This was located on the site of the original absolute hut (demolished in mid-1998). The mark is a brass peg resined into concrete, to just above ground level. The external site also serves as an additional and secure azimuth reference mark visible from Pier B through a hole in the current absolute hut wall, made during the visit. The results of azimuth measurements from Pier B to the external tripod site (D), although inconsistent, is about 215° at a distance of 95m. The other three marks are susceptible to vandalism.

Significant Events 2000

10 Mar	to 17th: Maintenance visit by GA, Canberra staff (HMC). Additional azimuth mark installed, including view hole through absolute building wall.
05 Apr	Sand dumped onto variometer vault to assist maintenance of even temperature.
05 Apr	0507-0509: New UPS installed.
28 Apr	Mundaring Geophysical Observatory closed down (thereby reducing support for Gnangara Magnetic Observatory).
14 Jul	Lightning damaged UPS and telephone line.
19 Jul	Maitec LYNX 800 UPS (no. 05089) returned to GA, Canberra for repair.
20 Jul	Telephone lines repaired - normal data telemetry resumed.
08 Aug	0345-0348: UPS reinstalled.
05 Sep	Observer's car was vandalised during observations. Further observations abandoned pending security arrangements put in place.
17 Nov	Power cables vandalised.
05 Dec	System re-started after cables repaired.
mid-Dec	Fire damaged telephone lines. Fence and gate also damaged.
29 Dec	Vehicle entry gate found destroyed by fire to posts.

Distribution of GNA data during 2000

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

- 1999: WDC-A, Boulder, USA (21 Nov. 2000)

Preliminary Monthly Means for Project Ørsted

- To IPGP by email:
  - 1999; Jan-Oct 2000 data sent December 2000

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- Definitive 1999 data for the INTERMAGNET CD-ROM to the Paris INTERMAGNET GIN (17 Nov. 2000)

Data loss in 2000:

Jan 30	0927-0955 (29m) All channels: Power failure.
Feb 01	0023-0038 (16m) PPM only: Unknown cause.
Feb 22	0735 (1m) PPM only: Unknown cause.
Mar 13	0100-0259 (2h 00m) All channels: Data corrupted during service visit.
Apr 05	0404-0506 (1h 03m) All channels: Load of sand dumped; new UPS installed; system restart.
	0514 (1m) PPM only: System maintenance.
	2114 to 07/0924 (1d 12h 11m) PPM only: Probable incorrect PPM settings caused memory overflow after new UPS was installed.
Jul 14	1234 to 17/0718 (2d 18h 45m) All channels: UPS damaged by lightning, system halted.

Data loss (cont.)

Jul 17	0717 (1m) PPM only: Unknown cause.
Jul 19	2357 to 20/0029 (33m) All channels: Removal of UPS for repair.
Jul 26	0047-0500 (4h 14m) All channels: Unknown reason.
Aug 08	0344-0358 (0h 15m) All channels: UPS reinstalled.
Oct 11	0318-0434 (1h 17m) DMI channels: Unknown change in variometer.
Oct 16	0346-0405 (0h 20m) All channels: Data corrupted by security vehicle parked nearby.
Nov 17	2256 to Dec 05 0042 (17d 01h 47m) Power to observatory cut through vandalism to cables.
Dec 19	0147-0149 (3m) PPM only: Unknown cause.
	0344-0347 (4m) DMI channels only: Unknown. cause.

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 2000. These have been 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).

Rapid Variation Phenomena

Solar Flare Effects (sfe) - GNA 2000

Month & date		U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Mar.	02	0820	0828	0831	-10	+8	+2	solar
	24	0741	0752	0759	+5	+24	+16	solar
Jun.	18	0157	0203	0209	+5	0	+3	solar

Sudden Storm Commencements (ssc) - GNA 2000

Month & date		U.T.	Type & Quality		Chief movement (nT) H	D	Z
Jan.	11	1426	ssc	B	+24	+9	+5
Feb.	05	1545	ssc	B	+15	+6	+9
	11	0258	ssc*	B	+9	-39 *	-18 *
	11	2354	ssc*	A	+21	+75 *	+39
	20	2139	ssc*	B	+15	+18 *	-6 *
Apr.	06	1640	ssc	A	+69	+59	+50 *
Jun	04	1503	ssc	A	+15	+12	+11
	08	0909	ssc*	B	+60	-30 *	+21 *
	23	1303	ssc	B	+18	-21	-9
Jul.	10	0637	ssc	B	+30	+48	+36
	13	0947	ssc	B	+25	+14	+9
	19	1527	ssc	B	+36	+9	+12
	28	0633	ssc	A	+32	+66	+48
Sep.	06	1703	ssc	C	+27	+18	+18
Oct.	05	0324	ssc*	C	-10 *	-24 *	+15 *
	12	2227	ssc*	C	+12	-28 *	-15 *
	28	0954	ssc	C	+45	+21	+21
	31	1715	ssc	A	+51	+24	+27

The Principal Magnetic Storms scaled from Gnangara magnetograms for 2000 are on page 50.

K indices & Daily K sums at Gnangara (K=9 limit: 450 nT) for 2000

Date	January	February	March	April	May	June	Date
01	D 4333 4333 26	2121 3222 15	D 3233 3433 24	2212 2444 21	3322 2333 21	3221 3102 14	01
02	3323 2433 23	2112 2322 15	2122 1112 12	3222 3032 17	3224 4335 26	2231 2113 15	02
03	3133 2322 19	3121 3123 16	2001 2132 11	2223 3212 17	2221 1454 21	3224 4231 21	03
04	2234 3334 24	Q 1121 1112 10	Q 2000 1211 07	D 4321 4343 24	2211 3222 15	2321 0244 18	04
05	2233 2333 21	2111 1255 18	0000 1212 06	2210 0211 09	2122 4113 16	D 5333 4232 25	05
06	3324 4434 27	D 4433 3453 29	2232 3333 21	D 2232 3666 30	3223 3233 21	3222 3311 17	06
07	3212 2333 19	D 4334 5544 32	D 3232 3224 21	D 7452 2522 29	Q 1121 0011 07	1222 1122 13	07
08	Q 2122 3301 14	3322 3442 23	D 3113 3343 21	2133 3233 20	Q 1011 0012 06	D 1336 6454 32	08
09	Q 1100 0003 05	2221 4422 19	1000 1011 04	2223 4334 23	2211 2323 16	Q 1222 1101 10	09
10	3111 1224 15	2222 2212 15	1213 2234 18	2133 2333 20	1111 1122 10	3333 3322 22	10
11	D 3212 3454 24	3423 4335 27	1111 4122 13	2121 2131 13	Q 1100 2022 08	2224 4431 22	11
12	4322 1224 20	D 5457 6532 37	D 3333 3222 21	2110 0111 07	1243 2234 21	3221 3232 18	12
13	3212 2312 16	4223 4432 24	2110 0022 08	1210 0000 04	4222 2232 19	1123 2221 14	13
14	3211 1222 14	D 3234 5534 29	2123 1222 15	Q 0010 0210 04	3211 3132 16	D 4331 3344 25	14
15	2211 1112 11	4332 2144 23	Q 1100 0110 04	1111 1132 11	3332 1211 16	5322 3242 23	15
16	2111 1122 11	2111 1221 11	Q 0000 0002 02	D 2244 4333 25	2423 2233 21	Q 1220 0002 07	16
17	Q 1101 1011 06	Q 0112 3111 10	2221 1000 08	2232 1222 16	D 4422 1132 19	Q 1100 1322 10	17
18	Q 1011 0101 05	Q 1011 0001 04	1111 1122 10	Q 1220 0032 10	3211 1011 10	1011 1343 14	18
19	1111 0233 12	Q 1112 0111 08	2222 1111 12	2322 2221 16	1221 1111 10	1100 0111 05	19
20	1122 2232 15	Q 1111 0014 09	1022 2101 09	3321 2332 19	Q 2110 1111 08	1222 1000 08	20
21	Q 1110 1000 04	4433 4532 28	1020 1111 07	2113 2222 15	Q 1221 0011 08	0011 1123 09	21
22	2232 4444 25	2211 2112 12	2131 2233 17	Q 1122 1011 09	1223 2222 16	4333 2121 19	22
23	D 4433 3311 22	3103 4313 18	3222 3422 20	2122 1112 12	D 2322 2254 22	D 2421 4244 23	23
24	2224 3213 19	D 3435 4444 31	2232 4313 20	D 1334 4331 22	D 7554 4552 37	4341 1112 17	24
25	1211 1332 14	3233 3323 22	3221 1441 18	Q 1121 0131 10	D 2334 3234 24	Q 2111 0122 10	25
26	2211 1113 12	3233 2343 23	Q 1011 0211 07	Q 0110 0001 03	2234 3330 20	D 3244 6355 32	26
27	3122 3346 24	3333 3332 23	Q 2110 0100 05	3122 3323 19	3212 2433 20	3222 3233 20	27
28	D 6334 3434 30	3233 5212 21	2221 0000 07	3232 3232 20	2233 3332 21	2221 1233 16	28
29	D 3233 3553 27	2221 2101 11	1110 0034 10	3232 2333 21	D 2121 2453 20	3221 1101 11	29
30	3221 3343 21		3221 2242 18	3321 1333 19	3234 5344 28	Q 1002 1131 09	30
31	3111 2323 16		D 3333 4333 25		2231 1122 14		31
Mean K-sum	17.5	19.4	12.9	16.2	17.3	16.6	

Date	July	August	September	October	November	December	Date
01	2122 0011 09	2102 2443 18	3333 3343 25	4233 1222 19	4221 1222 16	---- ---- --	01
02	Q 1110 0110 05	2222 1121 13	4334 4412 25	1122 2543 20	Q 2100 2111 08	---- ---- --	02
03	2122 3123 16	3232 2222 18	1211 0133 12	4345 5313 28	Q 1000 2221 08	---- ---- --	03
04	2101 2122 11	2332 3322 20	2221 2353 20	D 2334 5554 31	3343 5433 28	---- ---- --	04
05	1123 3311 15	D 2344 4533 28	1111 2332 14	D 3466 7645 41	5311 3533 24	-222 2112 --	05
06	Q 1111 2121 10	3222 3323 20	2120 2332 15	Q 2111 1011 08	D 2126 5566 33	2133 2324 20	06
07	Q 2121 0121 10	2223 2132 17	3222 2333 20	1112 3230 13	D 4444 3244 29	D 2333 3233 22	07
08	1112 1210 09	2231 3221 16	1123 5433 22	Q 0000 0111 03	3455 3222 26	D 5333 3433 27	08
09	1211 2112 11	1111 0011 06	Q 2221 2100 10	Q 2100 1222 10	2212 3333 19	D 3334 3333 25	09
10	1252 2231 18	2244 3334 25	Q 0102 0030 06	2123 2313 17	D 3355 5233 29	D 3232 1223 18	10
11	D 3433 3353 27	D 3334 4334 27	Q 0001 1212 07	3212 4241 19	3323 4443 26	3222 1122 15	11
12	3212 0111 11	D 4766 7553 43	2234 4354 27	1002 2103 09	3334 4422 25	2111 1232 13	12
13	1224 5422 22	3531 1123 19	3311 2212 15	D 6533 3342 29	2222 2233 18	2212 1012 11	13
14	D 2333 ---- --	1110 1333 13	Q 2221 0211 11	D 3234 7644 33	2111 1111 09	Q 1121 1112 10	14
15	D ---- ---- --	3302 1111 12	1321 1135 17	3322 1213 17	Q 2111 1021 09	Q 1012 1101 07	15
16	D ---- ---- --	1231 2122 14	D 3333 3445 28	4211 2223 17	Q 1110 1012 07	1121 2222 13	16
17	---2 1001 --	2222 1021 12	D 5322 5458 34	3111 2232 15	Q ---- ---- --	3221 3232 18	17
18	1210 1223 12	Q 1000 0010 02	D 7445 4652 37	2212 3222 16	---- ---- --	2222 1322 16	18
19	2100 0324 12	Q 2000 0121 06	D 2234 5333 25	2222 3322 18	---- ---- --	2112 1122 12	19
20	D 5335 5122 26	0000 0211 04	3311 3212 16	Q 1111 0101 06	---- ---- --	Q 2111 0101 07	20
21	2111 1111 09	2123 1223 16	3233 3212 19	Q 1000 2211 07	---- ---- --	1112 2212 12	21
22	1113 2332 16	Q 1000 0001 02	Q 2220 1132 13	1023 4453 22	---- ---- --	2110 1125 13	22
23	2111 2553 20	0012 2211 09	3221 1211 13	3324 2123 20	---- ---- --	D 5322 2222 20	23
24	Q 3110 0111 08	3221 0101 10	1211 1353 17	3124 3122 18	---- ---- --	3121 1122 13	24
25	Q 2111 1111 09	Q 0100 0121 05	3233 4444 27	2222 3222 17	---- ---- --	3211 4312 17	25
26	2243 4244 25	Q 1111 2111 09	4334 4434 29	2222 4221 17	---- ---- --	2221 1233 16	26
27	2101 0012 07	1110 3222 12	3222 2322 18	2112 1102 10	D ---- ---- --	2221 2432 18	27
28	2254 3531 25	D 2234 3444 26	2223 3322 19	1124 4335 23	---- ---- --	3222 3222 18	28
29	2311 3132 16	D 5344 3343 29	2113 3232 17	D 5334 3343 28	D ---- ---- --	2321 1212 14	29
30	3235 6222 25	3233 2122 18	D 2254 6544 32	4333 2422 23	---- ---- --	Q 2122 2111 12	30
31	2233 1233 19	3123 3423 21		2233 2433 22		Q 1111 1001 06	31
Mean K-sum	14.9	15.8	19.7	18.6	19.6	15.1	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	16	65	63	73	26	3	2	0	0	0	0
February	10	55	61	57	33	14	1	1	0	0	0
March	47	71	72	46	12	0	0	0	0	0	0
April	25	55	81	59	14	2	3	1	0	0	0
May	13	63	86	54	22	9	0	1	0	0	0
June	22	63	72	51	24	5	3	0	0	0	0
July	20	84	63	37	9	11	1	0	0	0	23
August	36	60	70	53	20	5	2	2	0	0	0
September	14	45	69	66	28	14	2	1	1	0	0
October	19	52	79	53	27	11	5	2	0	0	0
November	8	29	33	29	16	10	3	0	0	0	112
December	8	69	89	41	5	3	0	0	0	0	33
ANNUAL TOTAL	**238**	**711**	**838**	**619**	**236**	**87**	**22**	**8**	**1**	**0**	**168**

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 48-49.

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	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	XYZ
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	XYZ
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	XYZ
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	XYZ
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	XYZ
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	XYZ
2000.5	A	-2	13.6	-66	36	23230	23212	-903	-53682	58493	XYZ
1959.5	Q	-2	54.1	-65	52.4	23954	23923	-1213	-53482	58603	DHZ
1960.5	Q	-2	53.5	-65	52.1	23959	23928	-1209	-53480	58599	DHZ
1961.5	Q	-2	53.3	-65	52.7	23952	23922	-1207	-53491	58606	DHZ
1962.5	Q	-2	52.8	-65	53.0	23945	23915	-1203	-53490	58599	DHZ
1963.5	Q	-2	52.3	-65	54.0	23931	23901	-1199	-53497	58600	DHZ
1964.5	Q	-2	51.7	-65	54.9	23916	23886	-1194	-53501	58599	DHZ
1965.5	Q	-2	51.7	-65	55.3	23906	23876	-1194	-53497	58589	DHZ
1966.5	Q	-2	52.4	-65	56.3	23889	23859	-1198	-53499	58582	DHZ
1967.5	Q	-2	54.1	-65	57.4	23868	23837	-1208	-53499	58572	DHZ
1968.5	Q	-2	55.7	-65	58.6	23843	23812	-1218	-53494	58558	DHZ
1969.5	Q	-2	57.5	-65	59.7	23820	23788	-1229	-53488	58538	DHZ
1970.5	Q	-2	59.7	-66	1.2	23786	23754	-1243	-53475	58516	DHZ
1971.5	Q	-3	2.3	-66	2.2	23761	23728	-1259	-53461	58490	DHZ
1972.5	Q	-3	5.2	-66	3.9	23727	23693	-1278	-53454	58467	DHZ
1973.5	Q	-3	7.8	-66	6.2	23686	23651	-1293	-53460	58454	DHZ
1974.5	Q	-3	9.9	-66	9.0	23642	23606	-1305	-53477	58456	DHZ
1975.5	Q	-3	11.5	-66	11.3	23608	23571	-1314	-53496	58457	DHZ
1976.5	Q	-3	12.3	-66	14.2	23567	23530	-1318	-53528	58471	DHZ
1977.5	Q	-3	13.6	-66	17.0	23528	23491	-1324	-53557	58478	DHZ
1978.5	Q	-3	15.1	-66	20.5	23481	23443	-1332	-53596	58499	DHZ
1979.5	Q	-3	16.5	-66	23.1	23444	23406	-1339	-53624	58525	DHZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1346	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.9	-66	36.5	23258	23219	-1338	-53772	58587	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ
1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	8.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	6.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	2.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23165	-1173	-53757	58547	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	XYZ
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	XYZ
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	XYZ
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	XYZ
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	XYZ
1999.5	Q	-2	18.4	-66	36.3	23224	23215	-935	-53705	58515	XYZ
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	XYZ
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	XYZ
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	XYZ
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	XYZ
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	XYZ
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	XYZ
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	XYZ
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	XYZ

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

Gnangara 2000 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	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23219.9	-920.5	-53694.2	58507.1	23238.1	-2° 16.2'	-66° 35.9'
	5xQ days	23227.0	-919.1	-53692.2	58508.0	23245.2	-2° 16.0'	-66° 35.4'
	5xD days	23211.9	-921.6	-53695.5	58505.1	23230.2	-2° 16.4'	-66° 36.3'
February	All days	23211.3	-917.4	-53689.9	58499.7	23229.4	-2° 15.8'	-66° 36.2'
	5xQ days	23218.2	-915.9	-53687.6	58500.3	23236.3	-2° 15.5'	-66° 35.8'
	5xD days	23194.5	-919.2	-53697.4	58499.9	23212.7	-2° 16.2'	-66° 37.3'
March	All days	23217.2	-910.9	-53683.2	58495.8	23235.1	-2° 14.8'	-66° 35.8'
	5xQ days	23225.0	-909.9	-53681.7	58497.4	23242.9	-2° 14.6'	-66° 35.3'
	5xD days	23199.4	-914.4	-53689.7	58494.7	23217.4	-2° 15.4'	-66° 36.9'
April	All days	23198.1	-906.5	-53686.2	58490.9	23215.8	-2° 14.3'	-66° 36.9'
	5xQ days	23212.8	-904.7	-53682.8	58493.6	23230.5	-2° 13.9'	-66° 36.0'
	5xD days	23164.8	-908.3	-53691.8	58482.9	23182.6	-2° 14.7'	-66° 38.8'
May	All days	23207.2	-904.7	-53684.8	58493.2	23224.8	-2° 14.0'	-66° 36.4'
	5xQ days	23222.9	-905.5	-53681.2	58496.2	23240.6	-2° 14.0'	-66° 35.4'
	5xD days	23183.5	-903.8	-53689.0	58487.6	23201.2	-2° 14.0'	-66° 37.7'
June	All days	23212.7	-901.6	-53682.0	58492.7	23230.2	-2° 13.5'	-66° 36.0'
	5xQ days	23216.0	-902.5	-53679.7	58491.9	23233.6	-2° 13.6'	-66° 35.8'
	5xD days	23205.2	-900.6	-53684.6	58492.1	23222.7	-2° 13.3'	-66° 36.5'
July	All days	23207.4	-899.3	-53681.6	58490.2	23224.8	-2° 13.1'	-66° 36.3'
	5xQ days	23216.8	-899.1	-53678.2	58490.9	23234.2	-2° 13.1'	-66° 35.7'
	5xD days	23193.8	-898.1	-53684.4	58487.4	23211.2	-2° 13.0'	-66° 37.1'
August	All days	23204.4	-896.8	-53681.8	58489.2	23221.8	-2° 12.8'	-66° 36.5'
	5xQ days	23221.4	-897.2	-53676.9	58491.5	23238.7	-2° 12.8'	-66° 35.4'
	5xD days	23173.3	-895.1	-53690.2	58484.6	23190.6	-2° 12.7'	-66° 38.3'
September	All days	23207.1	-895.9	-53676.2	58485.1	23224.4	-2° 12.6'	-66° 36.2'
	5xQ days	23220.4	-894.8	-53674.0	58488.3	23237.7	-2° 12.4'	-66° 35.4'
	5xD days	23183.2	-895.2	-53677.9	58477.2	23200.5	-2° 12.7'	-66° 37.5'
October	All days	23206.8	-895.5	-53680.2	58488.7	23224.1	-2° 12.6'	-66° 36.3'
	5xQ days	23217.0	-895.9	-53677.0	58489.8	23234.3	-2° 12.6'	-66° 35.7'
	5xD days	23166.3	-897.5	-53693.2	58484.5	23183.7	-2° 13.1'	-66° 38.8'
November	All days	23216.1	-892.1	-53675.4	58487.9	23233.3	-2° 12.0'	-66° 35.7'
	5xQ days	23233.6	-890.4	-53671.2	58490.9	23250.7	-2° 11.7'	-66° 34.6'
	5xD days	23182.9	-894.7	-53687.4	58485.8	23200.2	-2° 12.6'	-66° 37.7'
December	All days	23236.4	-890.5	-53668.9	58490.0	23253.5	-2° 11.7'	-66° 34.4'
	5xQ days	23240.1	-889.3	-53663.8	58486.8	23257.2	-2° 11.5'	-66° 34.1'
	5xD days	23226.1	-893.3	-53676.8	58493.1	23243.3	-2° 12.2'	-66° 35.2'
Annual	All days	23212.1	-902.7	-53682.0	58492.5	23229.6	-2° 13.6'	-66° 36.0'
Mean	5xQ days	23222.6	-902.0	-53678.9	58493.8	23240.1	-2° 13.5'	-66° 35.4'
Values	5xD days	23190.4	-903.5	-53688.1	58489.6	23208.0	-2° 13.9'	-66° 37.3'

(Calculated: 14:32 hrs., Tue. 21 May 2002)

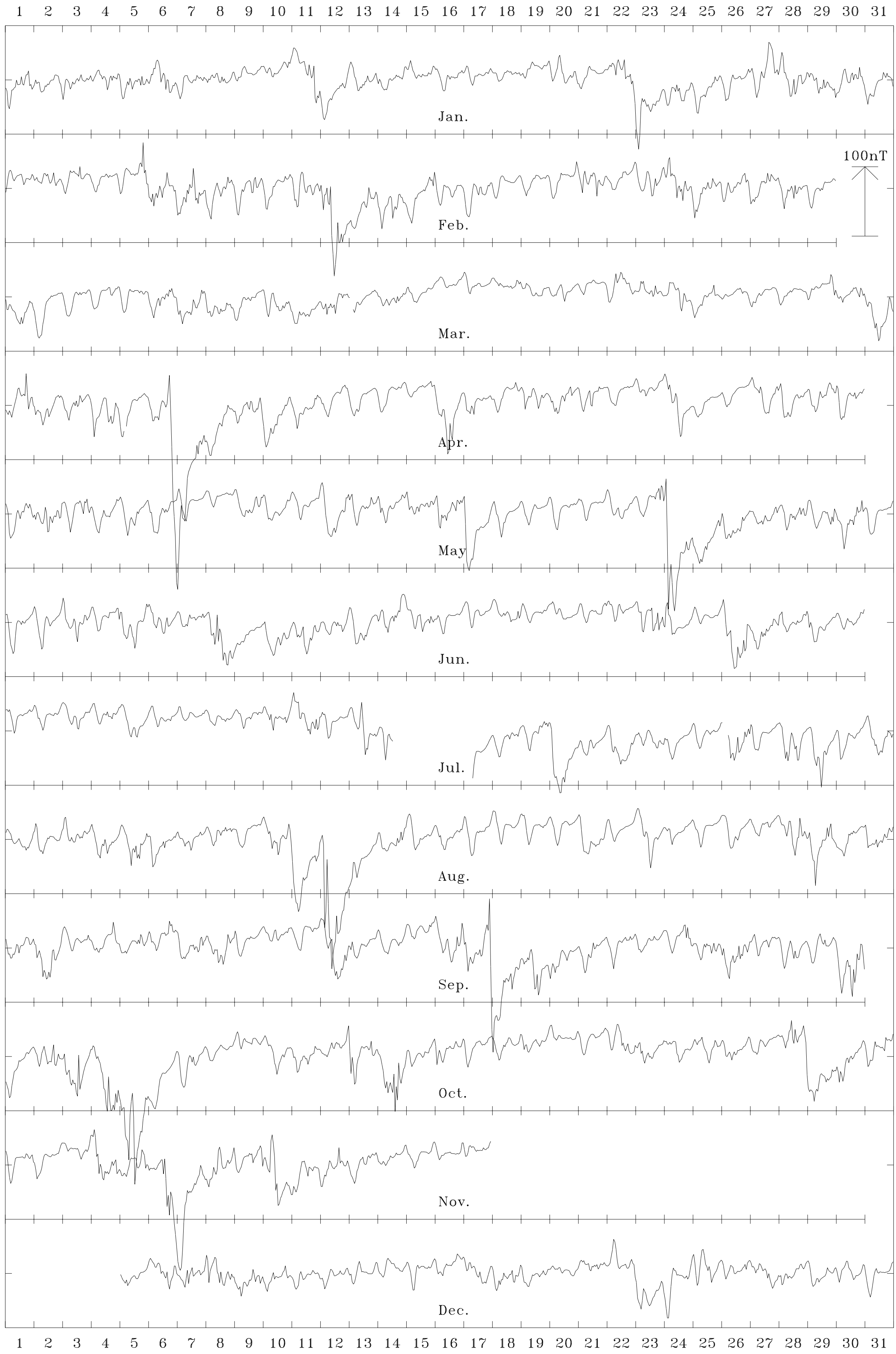
Hourly Mean Values

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.

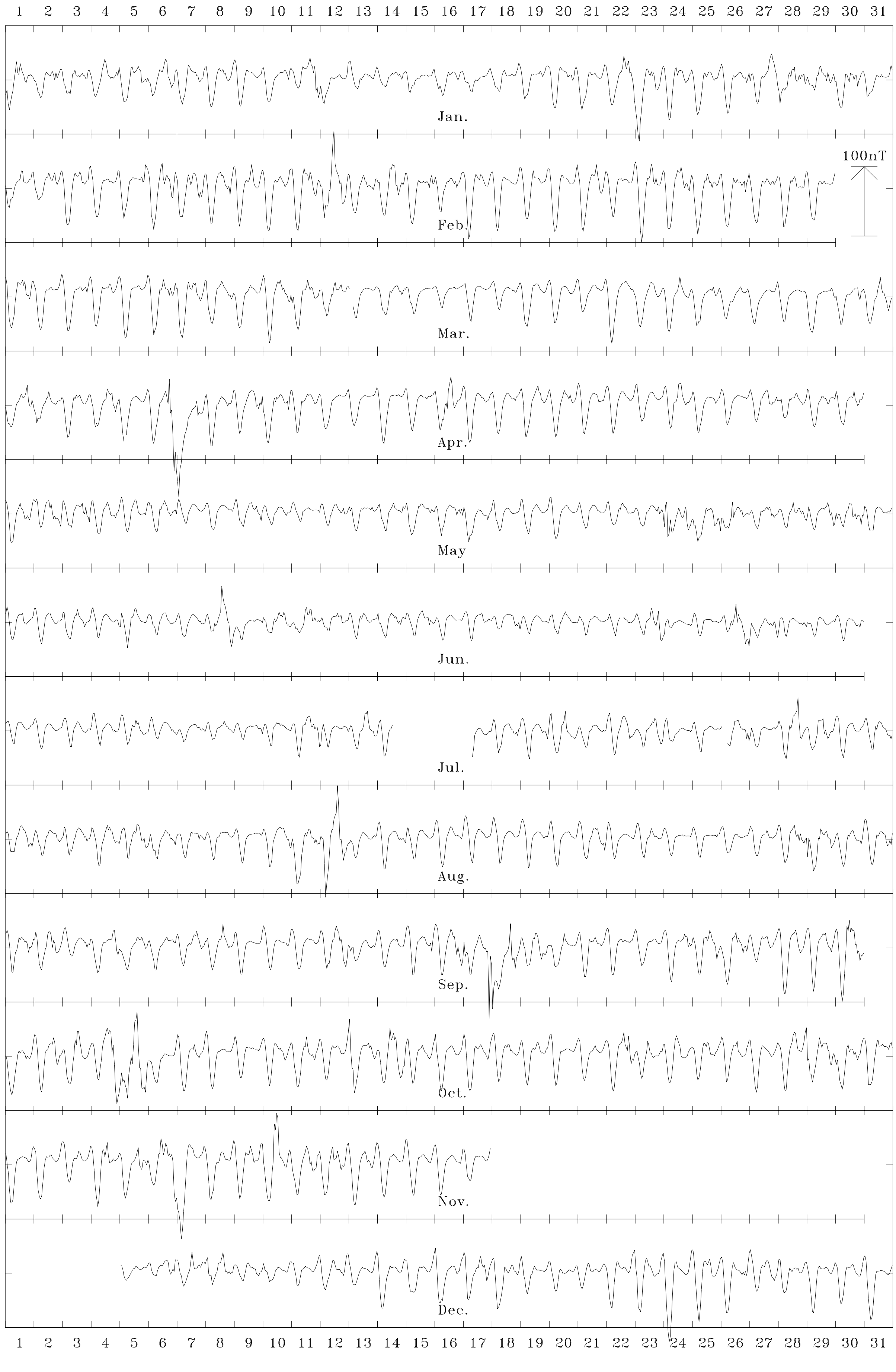
Gnangara 2000 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23230 nT

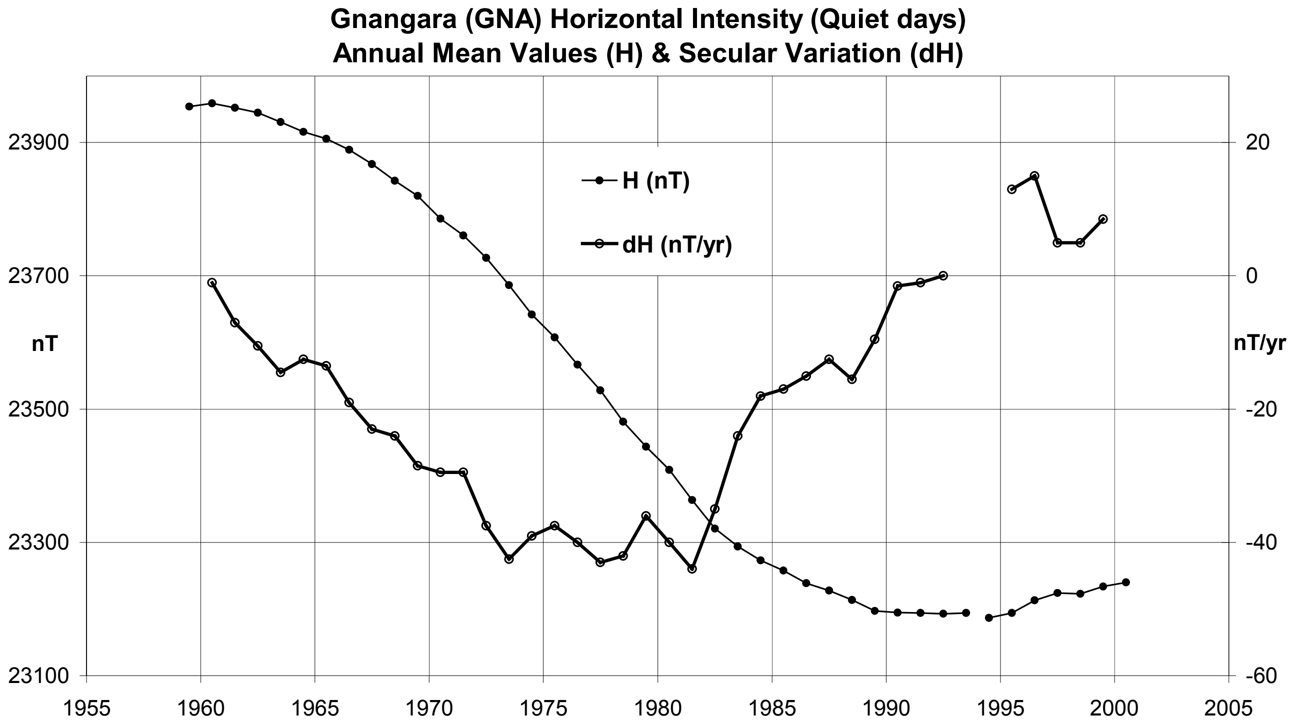


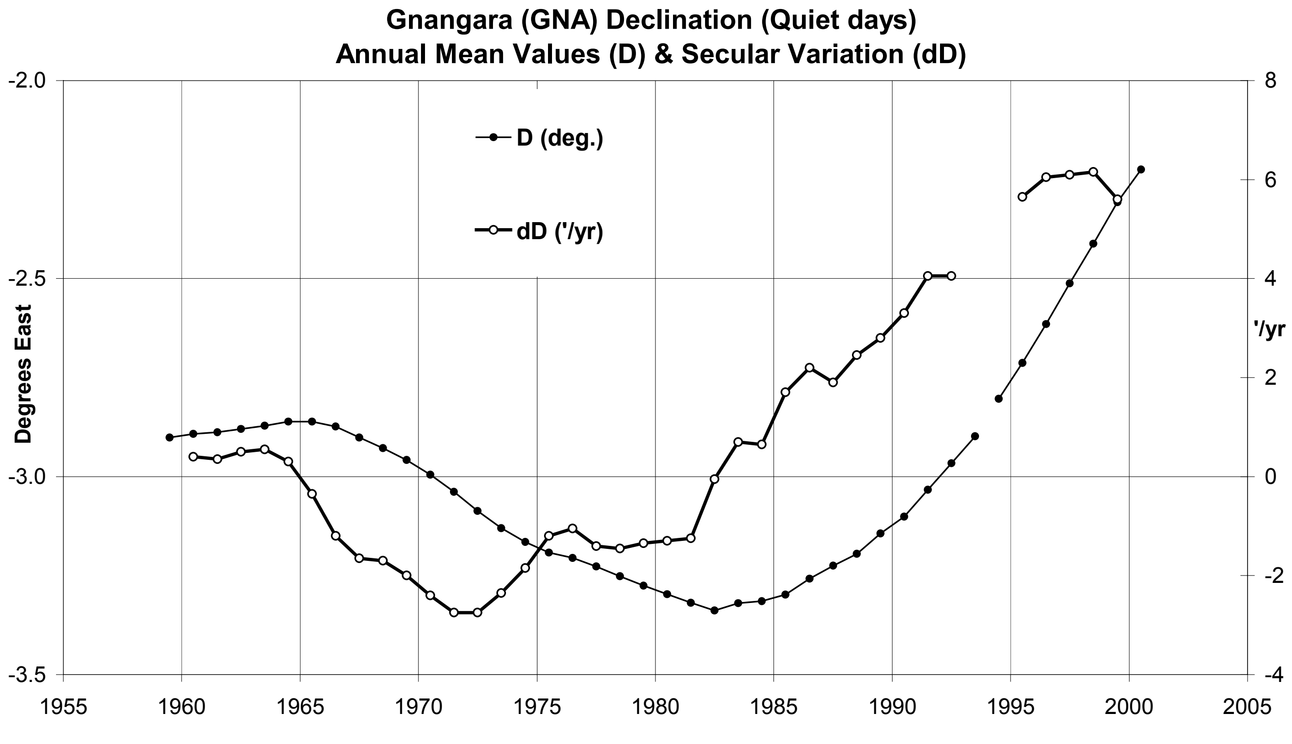
Gnangara 2000 Declination (east) (D). Scale: 1.00 min/mm. Mean: −2.23 deg.

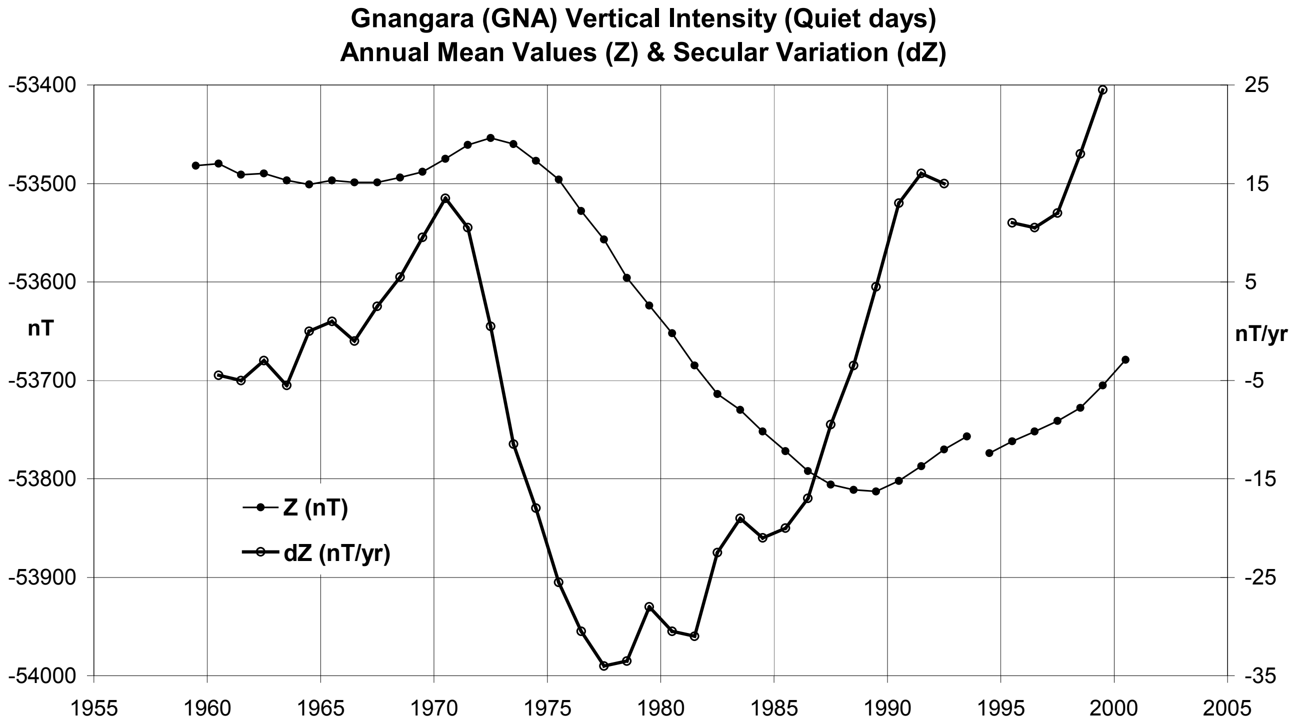
Gnangara 2000 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53682 nT

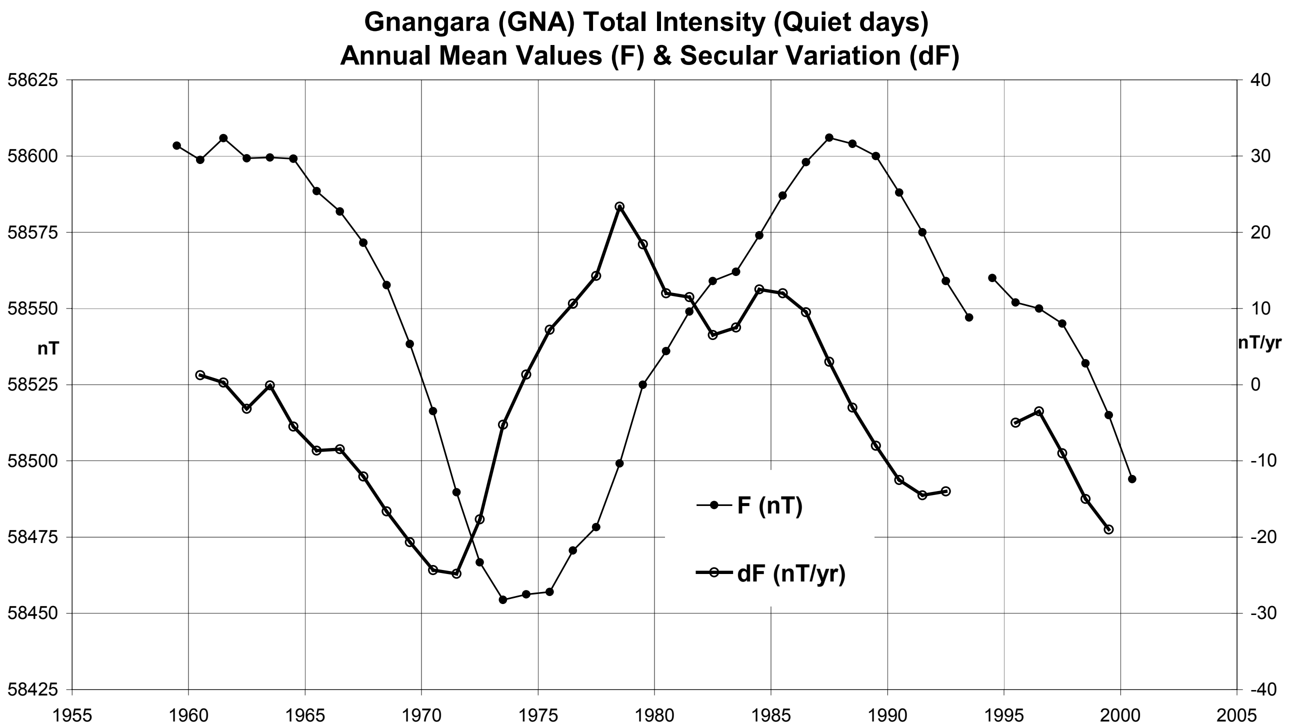
Gnangara 2000 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58493 nT




Gnangara (GNA) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT/yr
23100
23300
23500
23700
23900
-60
-40
-20
0
20
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


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
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


Gnangara (GNA) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-53400
-53500
-53600
-53700
-53800
-53900
-54000
nT
25
15
5
-5
-15
-25
-35
nT/yr
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
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
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
F (nT)
dF (nT/yr)

Principal Magnetic Storms - Gnangara, 2000

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. 27	14 ··	···	··	··	··	27(8), 28(1)	6	23.0	99	130	30	03
Feb. 05	15 45	ssc	+0.9	+15	+9	05(7,8)	5	23.3	134	124	07	24
11	23 54	ssc*	+11.1*	+21	+39	12(1,2,3,4,5)	5	31.4	197	278	12	18
Mar.		No	Principal			Magnetic		Storms				
Apr. 06	16 40	ssc	+8.7	+69	+50	07(1)	7	31.3	369	130	07	09
May 23	17 ··	···	··	··	··	24(1)	7	34.9	246	167	24	21
Jun. 26	06 ··	···	··	··	··	26(5)	6	19.3	86	128	26	24
Jul.		No	Principal			Magnetic		Storms				
Aug. 12	02 ··	···	··	··	··	12(2,5)	7	41.2	217	280	12	24
Sep. 15	19 ··	···	··	··	··	17(8)	8	66	316	336	18	21
Oct. 02	15 ··	···	··	··	··	02(6), 03(4,5)	5	19.3	118	113	03	18
04	03 ··	···	··	··	··	05(5)	7	51.5	220	289	05	24
12	22 27	ssc*	-4.1*	+12	-15*	13(1)	6	23.4	100	129	13	06
14	06 ··	···	··	··	··	14(5)	7	37.6	123	205	13	24
28	19 ··	···	··	··	··	28(8), 29(1)	5	22.9	124	96	29	06
Nov. 06	10 ··	···	··	··	··	06(4,7)	6	31.5	200	149	07	09
10	06 ··	···	··	··	··	10(3,4,5)	5	28.3	172	225	12	18
Dec.		No	Principal			Magnetic		Storms				

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 passed through 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† latitude: -22.05°
- Geomagnetic† longitude: 205.40°
- 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

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

- Observer in Charge: Kim Stellmacher

Variometers

Variations in the magnetic NW, NE and vertical components of the magnetic field were monitored at Kakadu in 2000 using a succession of three 3-axis fluxgate magnetometers[1].: two EDA FM105B fluxgate magnetometers and a DMI FGE magnetometer. All fluxgate magnetometers were aligned with the Z fluxgate sensor vertical, and the horizontal fluxgate sensors aligned at 45° to the declination value at installation.

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

Analogue variometer data from the three fluxgate channels, together with the fluxgate sensor head and electronics temperature channels, were converted to digital data with an ADAM 4017 A/D converter mounted inside the fluxgate electronics consoles. These digital data together with the digital PPM data were recorded on an IBM compatible PC.

The recording and variometer-control equipment was located in the air-conditioned control house set to 23°C.

The variometer sensor heads were located in the concrete underground vaults: the fluxgate heads 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. Due to a faulty temperature-sensor, the EDA fluxgate head temperature was not monitored until the temperature-sensor was replaced on 31 May 2000.

The equipment was protected from power blackouts, surges and lightning strikes by an uninterruptible power supply, a mains filter, a surge absorber, and an isolation transformer until 01 Jun. 2000. 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 the ADAM A/D, 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. A fibre-optic connection between the computer and modem seems to have been removed prior to 2000.

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 rod (later discovered to be copper-coated steel), designed to protect an area of 80m radius about the sphere. The rod was installed in a 24m x 200mm bore hole, considered deep enough to reach the dry season water table, next to the control hut using 15 bags of Ground Enhancing Material. The mast was fastened to 3 steel star pickets (replaced by stainless steel pegs on a visit in 2000) and stainless steel wire. In addition, 48m of 50mm x 0.5mm copper ribbon was buried in a shallow trench towards the Absolute Shelter, and 17m in the opposite direction. This was in addition to the aluminium power cables buried in shallow trenches 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.

The EDA no. 2884 variometer sensitivity and alignment model was determined from 13 DIF observation sets performed on 04 May 1998 during a magnetic storm (see *AGR 1998*). This model was not altered when EDA no. 3185 was brought into service, as there were no calibrations made to enable its re-determination. No temperature coefficients were applied to data produced by either EDA unit.

The DMI variometer sensitivity, alignment, and temperature sensitivity model was measured at the Canberra Magnetic Calibration Facility before dispatch to Kakadu. The inter-axial angles were measured to be < 1', the tilt of the (suspended) Z axis < 2', and of the horizontal axes < 1'. The instrument was aligned at 45° to the declination at Kakadu by setting the X and Y offsets equal and rotating the instrument until the X and Y ordinates were equal. Tests in the Canberra Magnetic Calibration Facility showed that the azimuth error using this method and this instrument was < 0.25°.

The adopted EDA variometer baselines for 2000 have standard errors no greater than: 1.1nT in F, X, & Z; 2.6nT in Y; 0.3' in D; and 0.1' in I. During the period of operation of EDA no. 2884, F-check (the difference between the EDA and PPM variometers) plots using the adopted baselines (including drifts) exhibited a variation in a 3.5nT range with daily variations of approximately 1nT. F-check varied in a 4nT range during the operation of EDA no. 3185, with daily variations within a 2-3nT range.

The adopted DMI variometer baselines for 2000 have standard errors no greater than: 0.5nT in F, X, & Z; 0.8nT in Y; 0.1' in D & I. F-check varied in a 2nT range, with a daily variation <0.5nT, during the operation of the DMI variometer in 2000. The majority of the variation occurred during an unexplained event at 2045-2130 on 19 December.

F-check is more scattered during the southern summer/monsoon season because of lightning-induced spikes on the PPM data, particularly in the (local-time) afternoon/evening.

Absolute Instruments

The principal absolute magnetometers used at Kakadu in 2000 were a DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on Zeiss 020B non-magnetic theodolite (no. 359142), and a proton precession magnetometer, PPM: Elsec model 770 (no. 189).

As described in the *AGR98*, the best way to use the 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 2000.

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.

Instrument corrections

Instrument corrections that were applied to the absolute magnetometers used at Kakadu in 2000 were determined through a series of instrument comparisons performed in October 2000. These comparisons were consistent with those performed in May 1998.

Corrections applied to the absolute magnetometers were: 0.0' and 0.0' in D and I as measured by the DIM; and -2.6nT in F as measured by Elsec 770 PPM no. 189. The PPM correction comprised a raw difference from the Australian Standard PPM: MNS2 no.3, and a correction of -0.8nT to the latter. At the mean magnetic field levels at KDU the above corrections resulted in baseline adjustments of:

$\Delta X = -2.0$nT $\Delta Y = -0.1$nT $\Delta Z = +1.7$nT.

These instrument corrections have been applied to the 2000 data in this report.

[1] EDA FM105B no. 2884 with sensor no. 5460 was used from 01 Jan. to 31 May 2000;. EDA FM105B no. 3185 with repaired (the lid and temperature sensor were replaced) sensor no. 5460 was used from 01 Jun. to 11 Oct; and suspended DMI FGE magnetometer no. E0198 with sensor no. S0183 was used from 14 Oct. to 31 Dec. 2000.

During the year, the difference between the KDU absolute Elsec 770 proton magnetometer and variometer Geometrics 856 proton magnetometer varied smoothly by 3nT, the peak and trough occurring approximately in mid-summer and mid-winter respectively. This may be due to an undetermined temperature coefficient of the absolute Elsec 770 magnetometer. No corrections have been made to the data to correct for this effect.

Operations

Although some lightning protection measures were included in the original construction of the observatory in 1995, that were enhanced in both December 1998 and October 1999, the Kakadu observatory has suffered damage from lightning a number of times. Damage from electrical storms was avoided during the 1998/1999, 1999/2000 and 2000/2001 wet seasons.

During a service visit in May 2000 evidence of rodents in the fluxgate sensor vault indicated the risk of cable damage.

EDA no. 2884 variometer data were lost on numerous occasions throughout 2000 due to unreliable connections inside the electronics console. An attempt was made to correct the problem by replacing the ADAM card on 8 April, but the output was noisy and still unreliable. An attempt was made to replace the EDA electronics and sensor during the visit from 29 May to 2 June. Although tested in Canberra, the new system did not function and the original sensor no. 5460 (with a new lid and temperature sensor) was reinstalled along with the new electronics console no. 3185. Suspected weak connections in the cable were repaired.

During this visit the steel posts to anchor the Dynasphere lightning protection mast were replaced with stainless steel.

EDA no. 3185 variometer data were lost from 1 October also due to unreliable connections in the electronics console.

On a service visit from 11 to 15 October, the EDA variometer was replaced[2] with a DMI FGE suspended fluxgate variometer no. E0198/S0183. 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 Geometrics total field variometer failed on occasions during August and September due to hang-ups in the firmware and incorrect parameters on re-installation.

Until 13 October 2000, no external clock was attached to the acquisition computer. The clock in the acquisition PC was routinely checked and set remotely on week-days (except during periods of communications loss 7-14 Jan., 23 Mar. to 5 Apr., and on several occasions when the time synchronisation software on GA computers was not functioning). During 2000 the maximum remote time correction made prior to 13 October was 1.5 seconds (on 06 April, after 15 days of communications loss). Time corrections between 1 and 2 seconds were made in twice in February, once in March and twice in June. All other time corrections were less than 1 second, generally only a few tenths of a second. No time corrections were applied to the data.

During the installation of the DMI magnetometer, a GPS clock was attached to the acquisition computer on 13 October 2000. Only the 1-second time pulse from the clock was used (and not the actual data stream from the clock). This kept the acquisition clock to within 0.1 seconds of UTC, except for a +1 second adjustment on 27 November after a system restart.

The control house containing the variometer electronics was maintained at a temperature of about 23°C. The diurnal temperature variation of the EDA electronics exhibited an amplitude of 0.5-1.5°C. There was also a smaller amplitude temperature variation at about a 1-hour period from the cycling air-conditioner. The extra insulation around the DMI electronics allowed the electronics temperature to vary with a typical daily cycle of less than 0.1°C. The DMI sensor temperature varied with a typical daily cycle of less than 0.2°C.

EDA no. 2884 electronics temperature was 29.5±0.2°C from 01 Jan. to 23 Mar., 29.2±0.2°C until 31 Mar. and 30.0±0.4°C until 31 May. As in 1999, the EDA sensor no. 5460 head temperature channel was not functioning during this period.

EDA no. 3185 electronics temperature was 28.0±0.5°C from 01 June, drifting to 27.5±0.5°C on 11 October. During this period, the temperature of the sensor, although buried, rose steadily from 26.6°C to 33.2°C over 130 days or 0.05°C/day.

DMI electronics no. E0198 electronics temperature was quite stable on a daily basis: 27.6±0.5°C from 14 Oct. to the end of 2000. The temperature of DMI sensor no. S0183, although buried underground, varied between 32.2°C to 28.8°C during this period, excluding the first week after installation when the system was settling down. During this time, the most rapid and prolonged temperature change was a cooling of 3.3°C over 9 days from 26 Nov. or 0.4°C/day.

When possible, absolute observations were performed weekly by the local observer in charge. The operation of the observatory was checked weekly by the observer. Completed absolute observation forms were sent weekly to GA in Canberra by post, and 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.

Distribution of KDU data during 2000

1-minute & Hourly Mean Values

- 1996: WDC-A, Boulder, USA (30 Nov. 2000)
- 1997: WDC-A, Boulder, USA (05 Dec. 2000)
- 1998: WDC-A, Boulder, USA (22 Dec. 2000)

Significant Events 2000

Jan 01	to 26th: Observatory unattended.
Jan 09	to 14th: No data communications.
Feb 23	to Mar 23: Observatory unattended.
Mar 23	to Apr 05: Data communications disabled by lightning strike.
Apr 08	Troublesome EDA/ADAM card was replaced.
Apr 12	the new EDA/ADAM card was reinstalled to eliminate noise on data.
May 29	to Jun 02: Service visit during which the EDA electronics and head temperature sensor were both replaced. Lightning tower supports were replaced with non-magnetic (stainless-steel) ones.
Oct 01	EDA variometer failed.
Oct 11	to 15th: Service visit to install new DMI FGE fluxgate variometer.
Nov 03	and 27th: Acquisition timing parameters were adjusted slightly to prevent occasional minutes of data being split into two.

[2] The offset settings on EDA console no. 3185 on decommissioning were X High 465.9 Y High 497.6 Z Low 607.8. The offset settings on DMI electronics no. E0198 on installation were X Course B Fine C Y Course B Fine C and Z Course E Fine 2. The Course and Fine offset adjustments were calibrated at installation to be X 4096 and 65612 counts per division, Y 4080 and 65653 counts per division, and Z 4098 and 65630 counts per division.

Data losses in 2000:

Feb 01 1209 to 02/0122 (13h 14m) XYZ data loss: Loose EDA/ADAM card.

Feb 16 0155 to 20/0559 (4d 04h 05m) XYZ data loss: Loose EDA/ADAM card.

Mar 30 1113-1128 (16m) XYZ data loss: Loose EDA/ADAM card.

Mar 31 1055 to Apr 08/0510 (7d 18h 16m) XYZ data loss: Loose EDA/ADAM card replaced.

Apr 08 0511 to 12/0011 (3d 19h 01m) XYZ data loss: See notes below.

May 29 0501 to 31/2359 (2d 18h 59m) XYZ data unusable: System under repair.

Jun 01 0025-0035 (11m) XYZ data spike: Loose EDA/ADAM card.

Oct 01 2100 to 13/2359 (12d 03h 00m) XYZ loss: Loose EDA/ADAM card. EDA replaced by DMI FGE magnetometer.

Notes on data loss: 08-12 April 2002

Apr 08 0510 to 10/0700 (2d 01h 51m): XYZ data noisy and uncalibrated: Loose EDA/ADAM card.

Apr 09 1150-1200 (11m); 1235-1245 (11m) XYZ data spikes: Loose EDA/ADAM card.

Apr 10 0701 to 12/0011 (1d 17h 11m) XYZ data noisy and unusable: Loose EDA/ADAM card.

Apr 12 0012 to May 29/0500 (47d 04d 49m) XYZ data noisy but useable: Loose EDA/ADAM card.

Loss of redundant F channel data

Feb 02 0104 (1m): System restart.

Apr 12 0010 (1m): System restart.

May 30 0539-0540 (2m): System under repair.

Jun 01 0043-0049 (7m): System under repair.

Jun 01 1650-2220 (5h 31m): System under repair.

Aug 26 2049 to Sep 13/0144 (17d 04h 56m): PPM failed.

Sep 13 0154 (1m): PPM re-installation.

Sep 13 1747 20/0058 (6d 07h 12m): PPM memory full after incorrect installation.

Oct 11 0606-0607 (2m); 2148-2150 (2m): System under repair.

Oct 12 0200-0300 (1h 01m); 0430-0700 (2h 31m); 0857-0858 (2m): System under repair.

Nov 27 0528-0529 (2m): System restart.

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 59-60.

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
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
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

- Elements ABC indicates non-aligned variometer orientation

Kakadu 2000 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	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35359.6	2311.0	-30188.0	46550.6	35435.1	3° 44.4'	-40° 25.7'
	5xQ days	35371.5	2312.3	-30185.6	46558.1	35447.0	3° 44.4'	-40° 25.0'
	5xD days	35345.9	2306.2	-30190.9	46541.9	35421.1	3° 44.0'	-40° 26.5'
February	All days	35355.4	2310.0	-30181.8	46543.3	35430.8	3° 44.3'	-40° 25.6'
	5xQ days	35368.3	2313.7	-30181.8	46553.3	35443.9	3° 44.6'	-40° 24.9'
	5xD days	35331.7	2305.7	-30184.0	46526.5	35406.8	3° 44.0'	-40° 26.8'
March	All days	35368.9	2312.7	-30173.9	46548.6	35444.4	3° 44.5'	-40° 24.5'
	5xQ days	35377.1	2313.2	-30173.8	46554.8	35452.7	3° 44.5'	-40° 24.1'
	5xD days	35348.7	2308.2	-30177.6	46535.4	35424.0	3° 44.2'	-40° 25.7'
April	All days	35357.4	2312.2	-30168.8	46536.5	35432.9	3° 44.5'	-40° 24.7'
	5xQ days	35362.9	2312.7	-30168.9	46540.8	35438.4	3° 44.5'	-40° 24.5'
	5xD days	35331.0	2311.3	-30170.8	46517.8	35406.6	3° 44.6'	-40° 26.1'
May	All days	35352.6	2311.0	-30166.6	46531.4	35428.1	3° 44.4'	-40° 24.8'
	5xQ days	35369.5	2311.1	-30164.4	46542.9	35445.0	3° 44.3'	-40° 23.9'
	5xD days	35323.6	2310.1	-30168.2	46510.4	35399.1	3° 44.5'	-40° 26.3'
June	All days	35356.3	2309.2	-30162.4	46531.4	35431.6	3° 44.2'	-40° 24.4'
	5xQ days	35360.3	2308.9	-30161.8	46534.0	35435.6	3° 44.2'	-40° 24.2'
	5xD days	35348.4	2309.0	-30162.2	46525.3	35423.7	3° 44.2'	-40° 24.8'
July	All days	35343.3	2311.7	-30161.0	46520.8	35418.8	3° 44.5'	-40° 25.0'
	5xQ days	35361.2	2313.7	-30159.5	46533.5	35436.8	3° 44.6'	-40° 24.0'
	5xD days	35305.3	2310.3	-30163.7	46493.6	35380.8	3° 44.6'	-40° 26.9'
August	All days	35346.1	2312.8	-30157.1	46520.4	35421.7	3° 44.6'	-40° 24.6'
	5xQ days	35364.9	2312.9	-30153.4	46532.3	35440.5	3° 44.5'	-40° 23.5'
	5xD days	35310.0	2310.6	-30159.5	46494.5	35385.5	3° 44.6'	-40° 26.5'
September	All days	35347.5	2311.4	-30151.1	46517.5	35423.0	3° 44.5'	-40° 24.2'
	5xQ days	35364.3	2313.2	-30148.3	46528.5	35439.8	3° 44.5'	-40° 23.2'
	5xD days	35317.7	2307.5	-30155.8	46497.7	35393.0	3° 44.3'	-40° 25.9'
October	All days	35353.4	2306.7	-30151.7	46522.1	35428.6	3° 44.0'	-40° 24.0'
	5xQ days	35381.2	2306.8	-30147.1	46540.3	35456.3	3° 43.8'	-40° 22.4'
	5xD days	35297.9	2301.1	-30156.6	46482.9	35372.9	3° 43.8'	-40° 26.9'
November	All days	35356.1	2307.8	-30150.8	46523.7	35431.4	3° 44.1'	-40° 23.8'
	5xQ days	35378.1	2309.7	-30147.5	46538.3	35453.4	3° 44.1'	-40° 22.6'
	5xD days	35311.9	2302.2	-30155.8	46493.1	35386.9	3° 43.8'	-40° 26.2'
December	All days	35370.9	2307.8	-30144.8	46531.0	35446.1	3° 44.0'	-40° 22.8'
	5xQ days	35380.9	2309.2	-30141.4	46536.5	35456.2	3° 44.1'	-40° 22.1'
	5xD days	35359.4	2306.7	-30146.8	46523.5	35434.5	3° 43.9'	-40° 23.4'
Annual	All days	35355.6	2310.4	-30163.2	46531.4	35431.0	3° 44.3'	-40° 24.5'
Mean	5xQ days	35370.0	2311.4	-30161.1	46541.1	35445.5	3° 44.3'	-40° 23.7'
Values	5xD days	35327.6	2307.4	-30166.0	46511.9	35402.9	3° 44.2'	-40° 26.0'

(Calculated:11:46 hrs., Mon. 03 Jun. 2002)

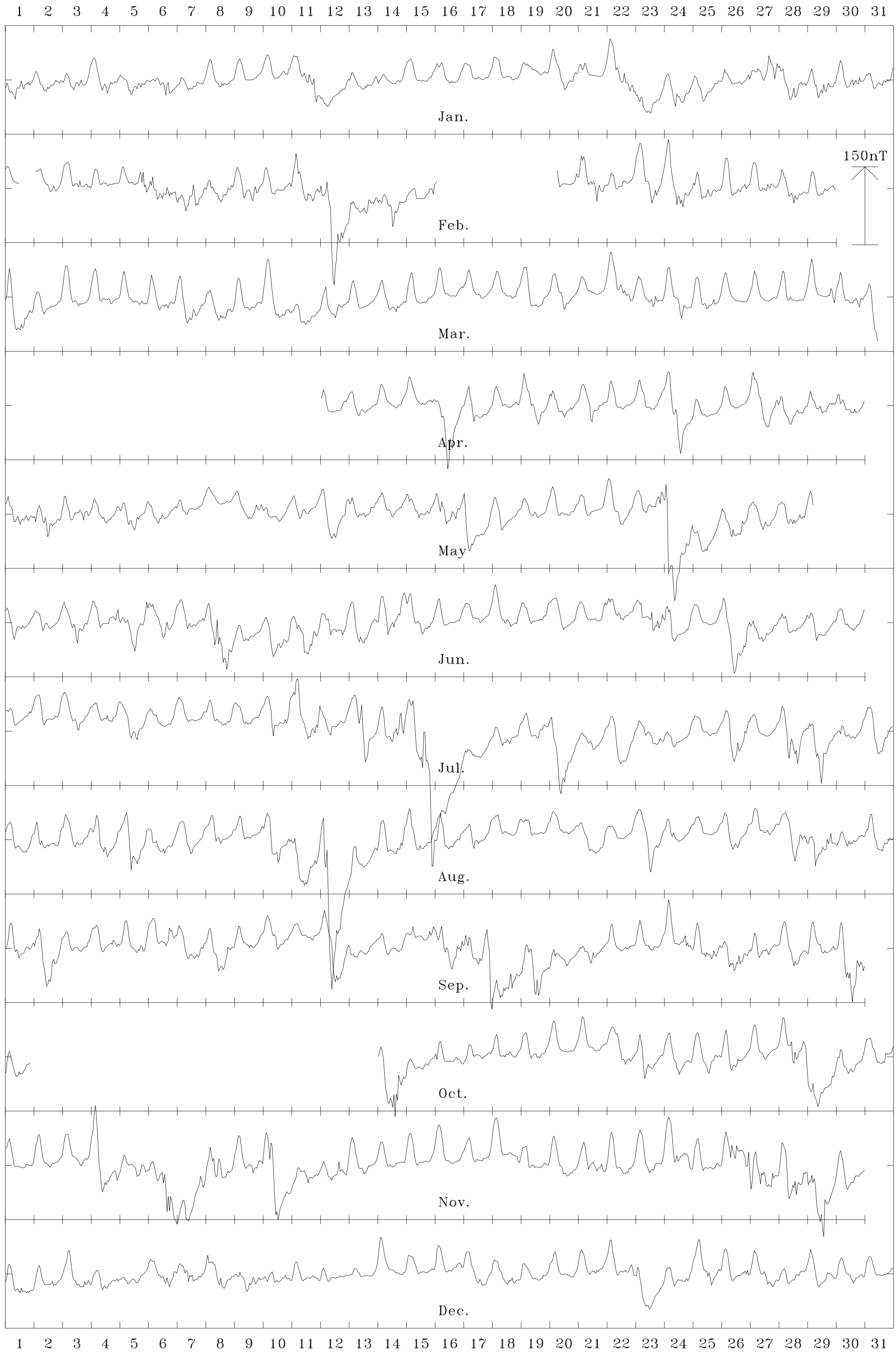
Hourly Mean Values

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.

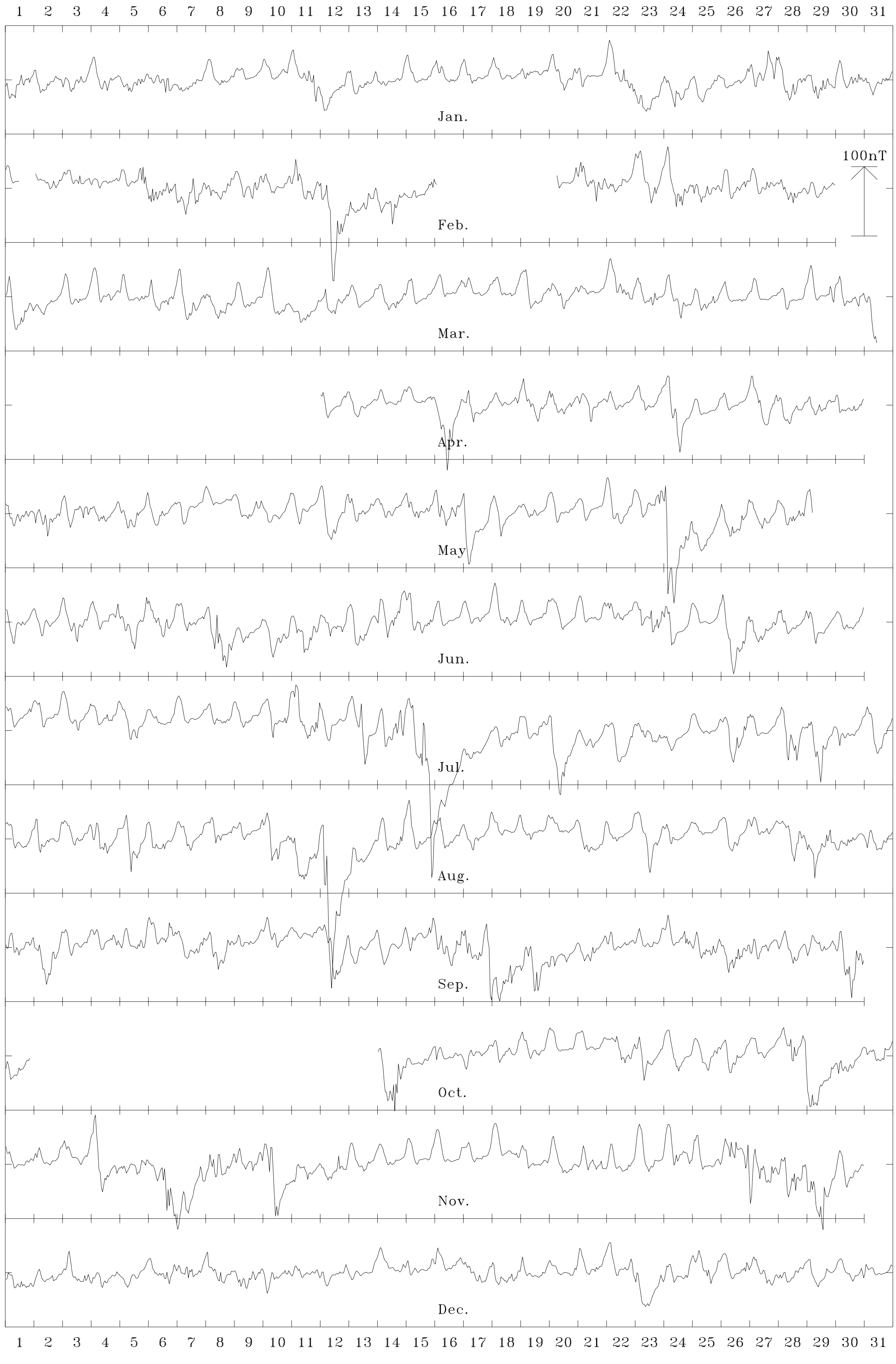
Kakadu, NT 2000 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 35431 nT

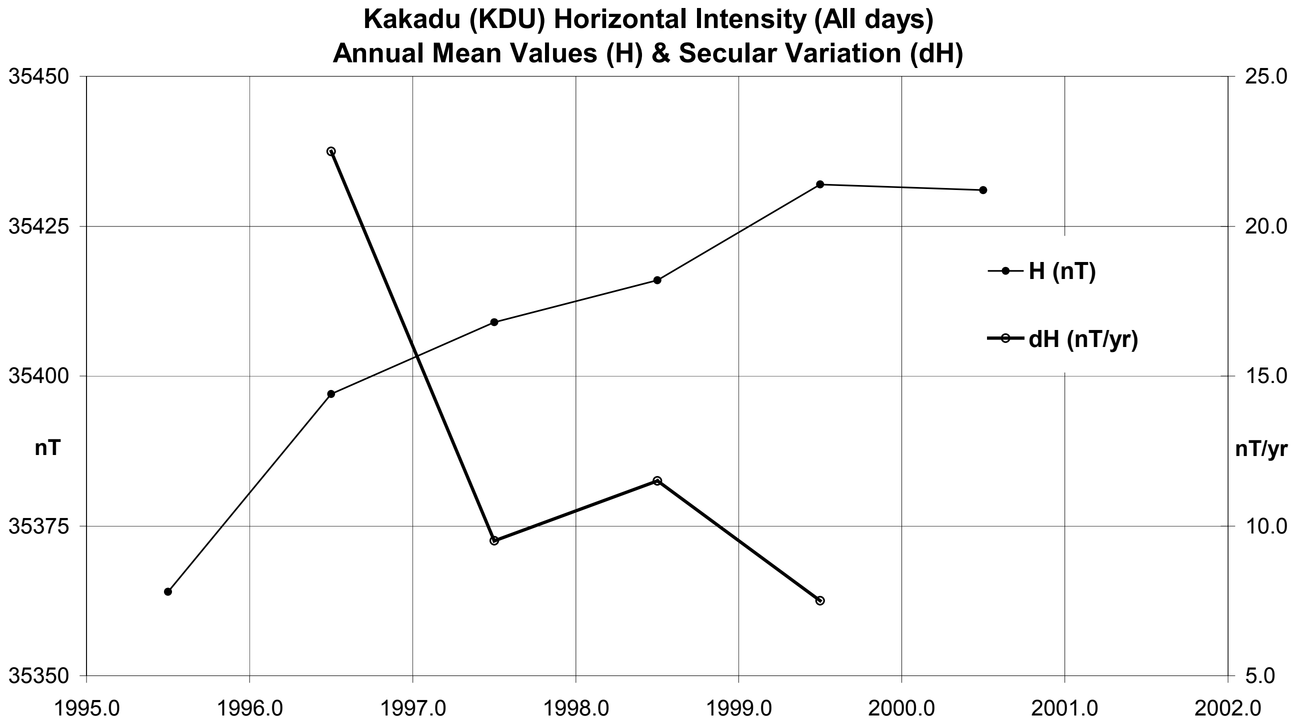


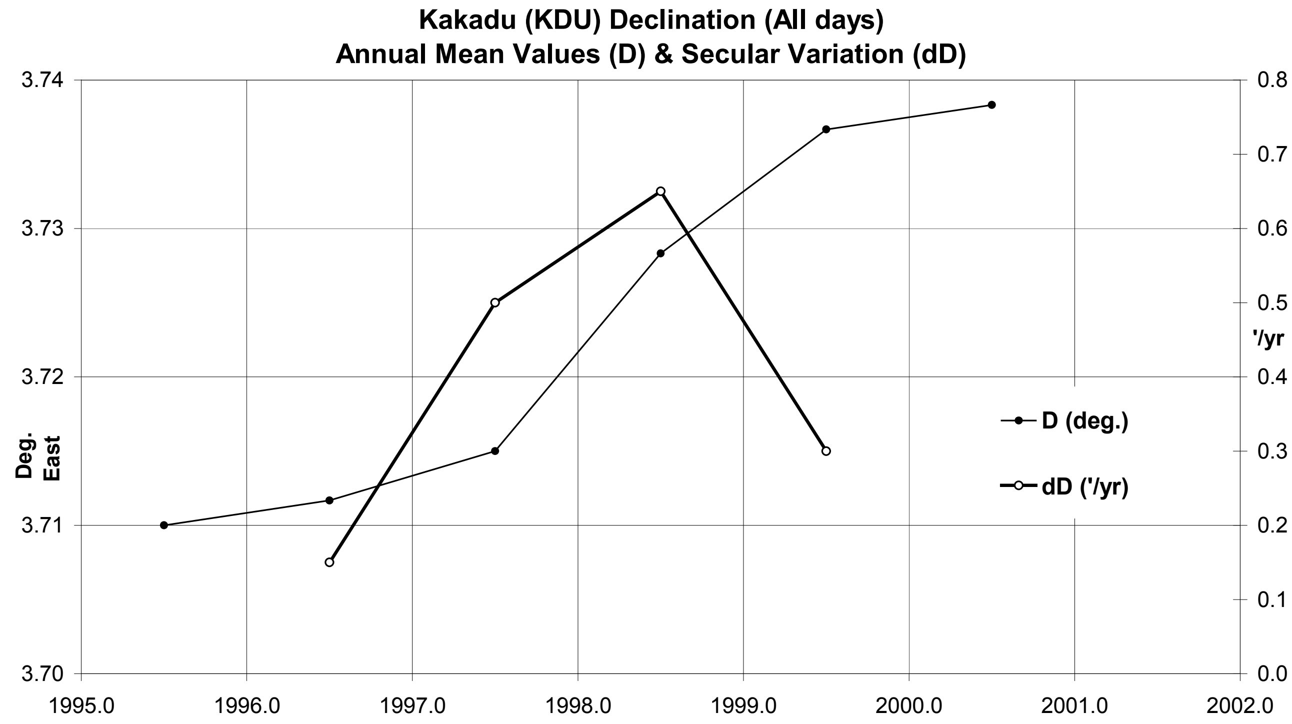
Kakadu, NT 2000 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.74 deg.

Kakadu, NT 2000 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −30163 nT

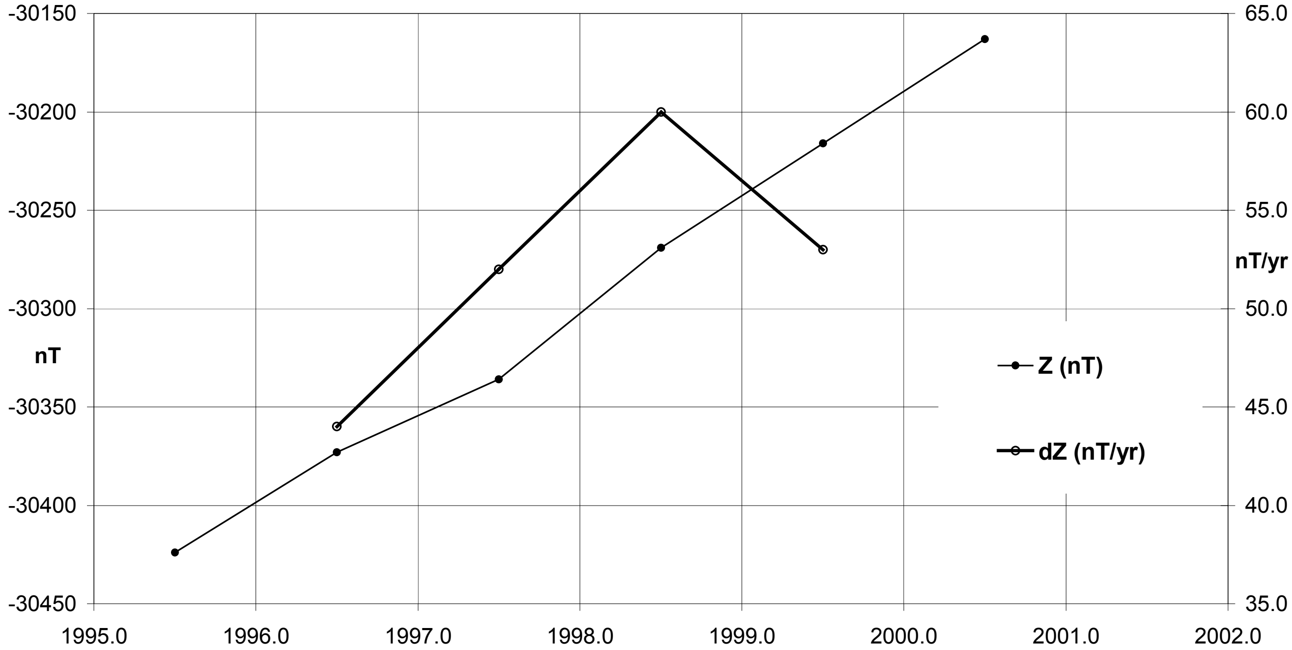
Kakadu, NT 2000 Total intensity (F). Scale: 7.5 nT/mm. Mean: 46531 nT



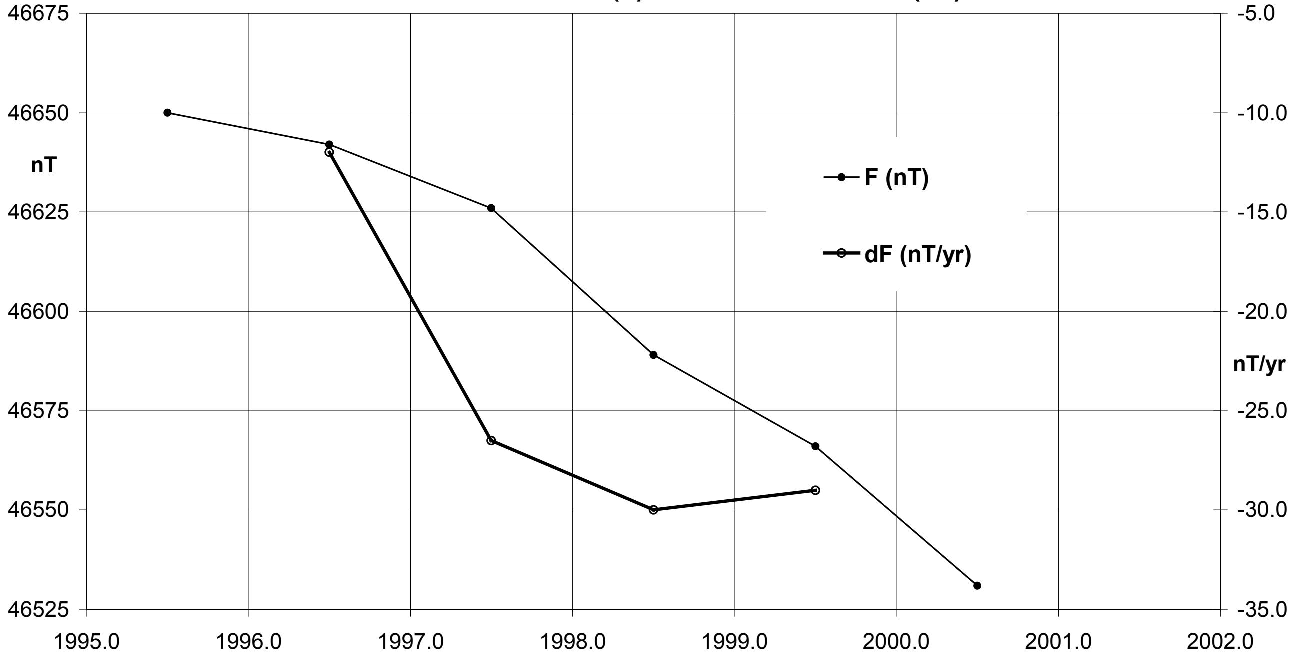

Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
35450
35425
35400
35375
35350
nT
25.0
20.0
15.0
10.0
5.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
H (nT)
dH (nT/yr)


Kakadu (KDU) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
3.74
3.73
3.72
3.71
3.70
Deg. East
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
'/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
D (deg.)
dD ('/yr)

Kakadu (KDU) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)



Kakadu (KDU) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)



Learmonth, Western Australia, is situated on Australia's North West Cape overlooking the Exmouth Gulf to the east and Cape Range to the west. The nearest town is Exmouth, approximately 35km to the north. Learmonth is approximately 1100km north of the city of Perth. 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 on the solar observatory site in late November 1986 from when it has operated continuously. More details of the observatory's history are in *AGR 1994*.

The variometer sensors were housed in small underground concrete vaults located within the perimeter of the solar observatory compound. The fluxgate sensor vault, approximately 50 metres to the east of the LSO buildings, was set into the ground by about two-thirds of its 1m depth and had a 100mm thick concrete lid. Temperature stability was improved by filling the vault with polystyrene beads and covering it with soil. A similar vault housed the proton magnetometer sensor. Sensor cables, that ran underground from the vaults to the electronics console, were protected by PVC conduits.

The control electronics and acquisition PC were located within the central or Radio Solar Telescope Network building of the solar observatory.

Absolute observations were performed at a site about 200 metres south of the solar observatory, situated on Royal Australian Air Force property. It consisted of a concrete observation pier within a roofed shelter with brick walls on two sides to the same height as the pier.

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
- Geomagnetic† latitude: -32.42°
- Geomagnetic† longitude: 186.23°
- 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"
- Observers in Charge: M.W. McMullan (to 21 Aug. 2000)
  G.A. Steward (from 22 Aug. 2000)
  both of IPS Radio & Space Services

† Based on the IGRF 2000 model.

Variometers

A Narod Ring Core 3-axis fluxgate (RCF) variometer was used to monitor magnetic variations in the magnetic NW, NE and vertical directions throughout 2000. (The instrument was initially installed on 12 Feb. 1999.) The RCF contained its own temperature sensors.

During 2000 a Geometrics model 856 (no. 50708) proton precession magnetometer (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.

Data Recording

Throughout 2000 the five channels of digital data output from the RCF (three orthogonal magnetic channels, sensor temperature and electronics temperature) were recorded at 1-second intervals. The digital data from the variometer PPM was recorded at 10-second intervals. The data from both instruments were recorded on an IBM compatible PC running MS-DOS-based data acquisition, control and display software. Timing was generated by the software (DOS) clock of the PC which was kept synchronized to 1-second pulses from a GPS clock. (The uncalibrated data from the RCF were also recorded by IPS.)

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

Absolute Instruments

Throughout 2000 the local OICs performed regular 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.

Instrument corrections

The corrections applied to the Learmonth absolute instruments were derived from instrument comparisons made at Learmonth during a maintenance visit in June 1999. A set of travelling standard absolute instruments (GSM90 PPM no.810882 and Bartington 0610H/160459 DIM) were compared to the Australian standard instruments at the Canberra Observatory both before and after comparisons at Learmonth against the Learmonth absolute instruments.

The corrections adopted to the absolute magnetometers used at LRM during 2000 were: 0.0′, 0.0′ and 0nT in D I, and F respectively. These translate to corrections:

$$\Delta X = 0 \text{ nT} \qquad \Delta Y = 0 \text{ nT} \qquad \Delta Z = 0 \text{ nT}.$$

Operations

The OIC at LRM magnetic observatory performed all routine operations at the observatory during 2000. The tasks included:

- performance of a set of absolute observations each week;
- mailing observation sheets to GA, Canberra each week;
- ad hoc instrument checks, system re-sets etc.

1-second values and 1-minute mean values 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.

Temperature coefficients for the Narod fluxgate variometer were set to zero for 2000. Any temperature dependence of the variometer sensors and electronics contributed to baseline drifts over the year.

DIM absolute observations were performed using the *offset* method (see *Kakadu Observatory – Absolute Instruments*, this report) throughout 2000. The absolute observations were processed at GA in Canberra, where final data calibration and adoptions were made.

The NW channel of the RCF developed a fault at 17:00:40 UT on 01 Feb. 2000. This resulted in all subsequent calibrated 1-minute data having to be derived after computing an estimate of the faulty channel from the two functional RCF magnetic channels and the variometer PPM channel. As the variometer PPM was recorded at 10-second intervals only 1-minute mean data could be derived in this way. This means that calibrated 1-second data from Learmonth are not available after 01 Feb 2000.

Distribution of LRM data during 2000

Final Monthly Means for Project Ørsted

- 1998 data: IPGP by e-mail (Jul. 2000)
- 1999 data: IPGP by e-mail (Dec. 2000)

1-minute & Hourly Mean Values

- 1999: WDC-A, Boulder, USA (07 Dec. 2000)

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 68-69.

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
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 (1)
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	D	0	13.4	-56	9.5	29679	29679	116	-44264	53294	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
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	A	0	13.5	-56	7.9	29707	29706	116	-44260	53305	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.

Learmonth 2000 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	2000	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29710.0	95.7	-44277.0	53321.2	29710.2	+0° 11.1'	-56° 8.3'
	5xQ days	29719.5	96.2	-44274.0	53324.0	29719.7	+0° 11.1'	-56° 7.7'
	5xD days	29700.1	95.6	-44279.8	53318.0	29700.3	+0° 11.1'	-56° 8.9'
February	All days	29705.2	97.8	-44271.5	53313.9	29705.4	+0° 11.3'	-56° 8.3'
	5xQ days	29714.3	97.9	-44268.8	53316.8	29714.5	+0° 11.3'	-56° 7.8'
	5xD days	29683.4	95.6	-44276.6	53306.0	29683.5	+0° 11.1'	-56° 9.7'
March	All days	29713.5	103.2	-44263.3	53311.8	29713.6	+0° 11.9'	-56° 7.6'
	5xQ days	29721.3	105.7	-44262.9	53315.8	29721.5	+0° 12.2'	-56° 7.2'
	5xD days	29693.5	98.8	-44267.4	53304.1	29693.7	+0° 11.4'	-56° 8.8'
April	All days	29692.4	109.7	-44263.2	53300.0	29692.6	+0° 12.7'	-56° 8.7'
	5xQ days	29709.1	111.4	-44260.2	53306.8	29709.3	+0° 12.9'	-56° 7.7'
	5xD days	29654.6	108.4	-44268.8	53283.5	29654.8	+0° 12.6'	-56° 11.0'
May	All days	29702.5	112.7	-44259.5	53302.5	29702.7	+0° 13.0'	-56° 8.1'
	5xQ days	29718.9	112.3	-44258.1	53310.4	29719.1	+0° 13.0'	-56° 7.1'
	5xD days	29676.8	116.0	-44261.6	53290.0	29677.1	+0° 13.4'	-56° 9.5'
June	All days	29715.9	114.6	-44256.7	53307.6	29716.2	+0° 13.3'	-56° 7.2'
	5xQ days	29720.7	113.6	-44257.3	53310.8	29720.9	+0° 13.1'	-56° 7.0'
	5xD days	29705.2	114.8	-44254.9	53300.1	29705.4	+0° 13.3'	-56° 7.7'
July	All days	29698.6	118.8	-44258.5	53299.5	29698.8	+0° 13.8'	-56° 8.2'
	5xQ days	29715.9	118.1	-44256.6	53307.6	29716.2	+0° 13.7'	-56° 7.2'
	5xD days	29661.5	118.5	-44261.5	53281.3	29661.7	+0° 13.7'	-56° 10.3'
August	All days	29703.8	118.4	-44254.3	53299.0	29704.1	+0° 13.7'	-56° 7.8'
	5xQ days	29722.3	116.3	-44251.2	53306.7	29722.5	+0° 13.4'	-56° 6.7'
	5xD days	29670.2	119.5	-44256.7	53282.3	29670.5	+0° 13.9'	-56° 9.7'
September	All days	29700.2	127.3	-44255.3	53297.8	29700.5	+0° 14.7'	-56° 8.0'
	5xQ days	29714.5	126.9	-44253.2	53304.0	29714.8	+0° 14.7'	-56° 7.2'
	5xD days	29672.0	130.8	-44259.5	53285.5	29672.3	+0° 15.2'	-56° 9.7'
October	All days	29697.3	128.3	-44259.9	53300.0	29697.6	+0° 14.9'	-56° 8.3'
	5xQ days	29709.3	129.0	-44259.5	53306.4	29709.6	+0° 14.9'	-56° 7.7'
	5xD days	29649.2	129.8	-44267.9	53279.9	29649.5	+0° 15.0'	-56° 11.2'
November	All days	29710.6	131.5	-44254.4	53302.8	29710.9	+0° 15.2'	-56° 7.4'
	5xQ days	29729.4	131.5	-44251.9	53311.2	29729.7	+0° 15.2'	-56° 6.3'
	5xD days	29670.1	129.9	-44262.7	53287.1	29670.4	+0° 15.1'	-56° 9.9'
December	All days	29725.8	137.8	-44250.8	53308.3	29726.2	+0° 15.9'	-56° 6.5'
	5xQ days	29733.4	141.1	-44246.4	53308.9	29733.7	+0° 16.3'	-56° 5.9'
	5xD days	29713.8	133.6	-44253.9	53304.2	29714.1	+0° 15.5'	-56° 7.2'
Annual	All days	29706.3	116.3	-44260.4	53305.4	29706.6	+0° 13.5'	-56° 7.9'
Mean	5xQ days	29719.1	116.7	-44258.3	53310.8	29719.3	+0° 13.5'	-56° 7.1'
Values	5xD days	29679.2	115.9	-44264.3	53293.5	29679.4	+0° 13.4'	-56° 9.5'

(Calculated:15:13 hrs., Tue. 29 May. 2001)

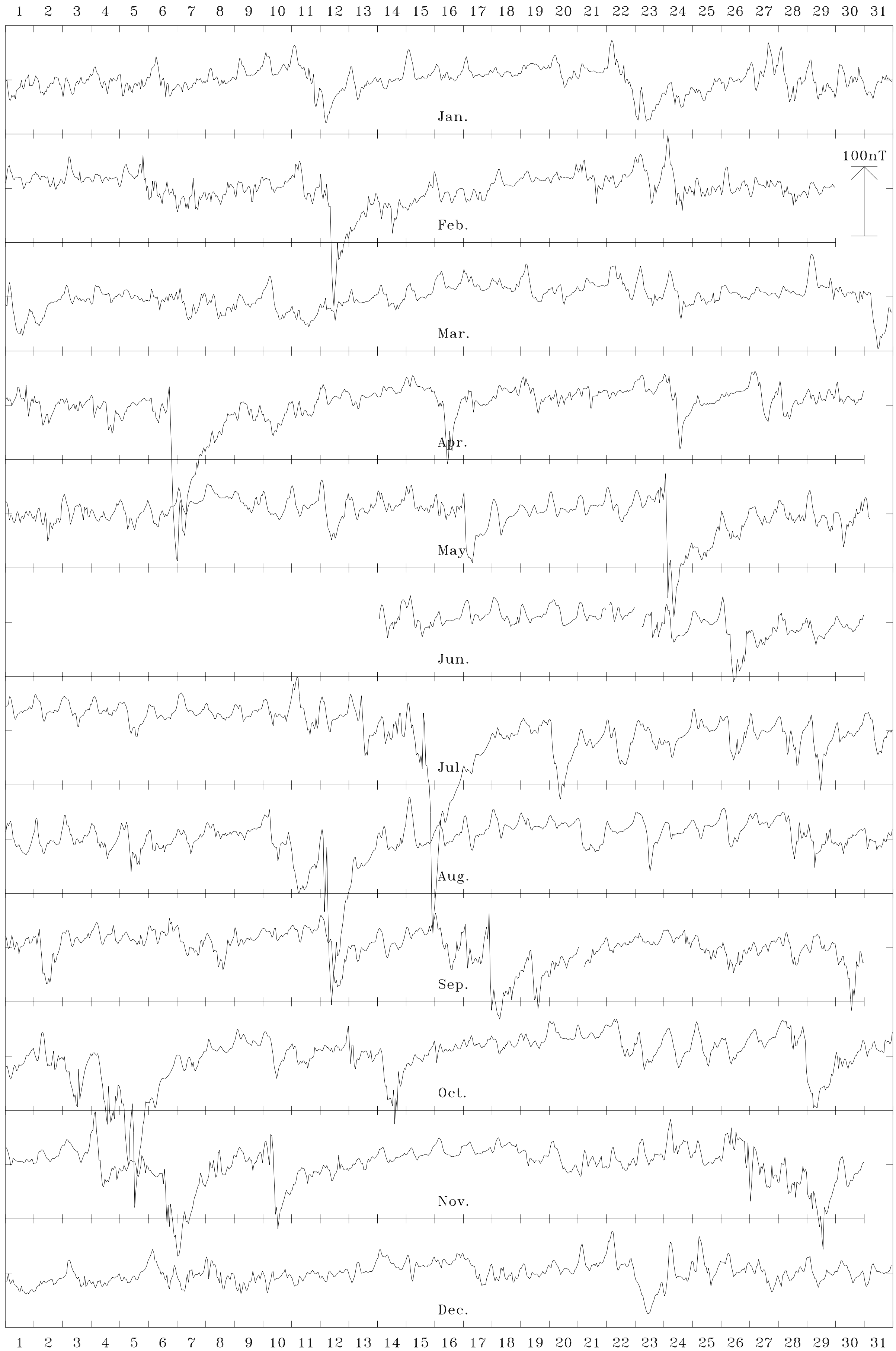
Hourly Mean Values

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

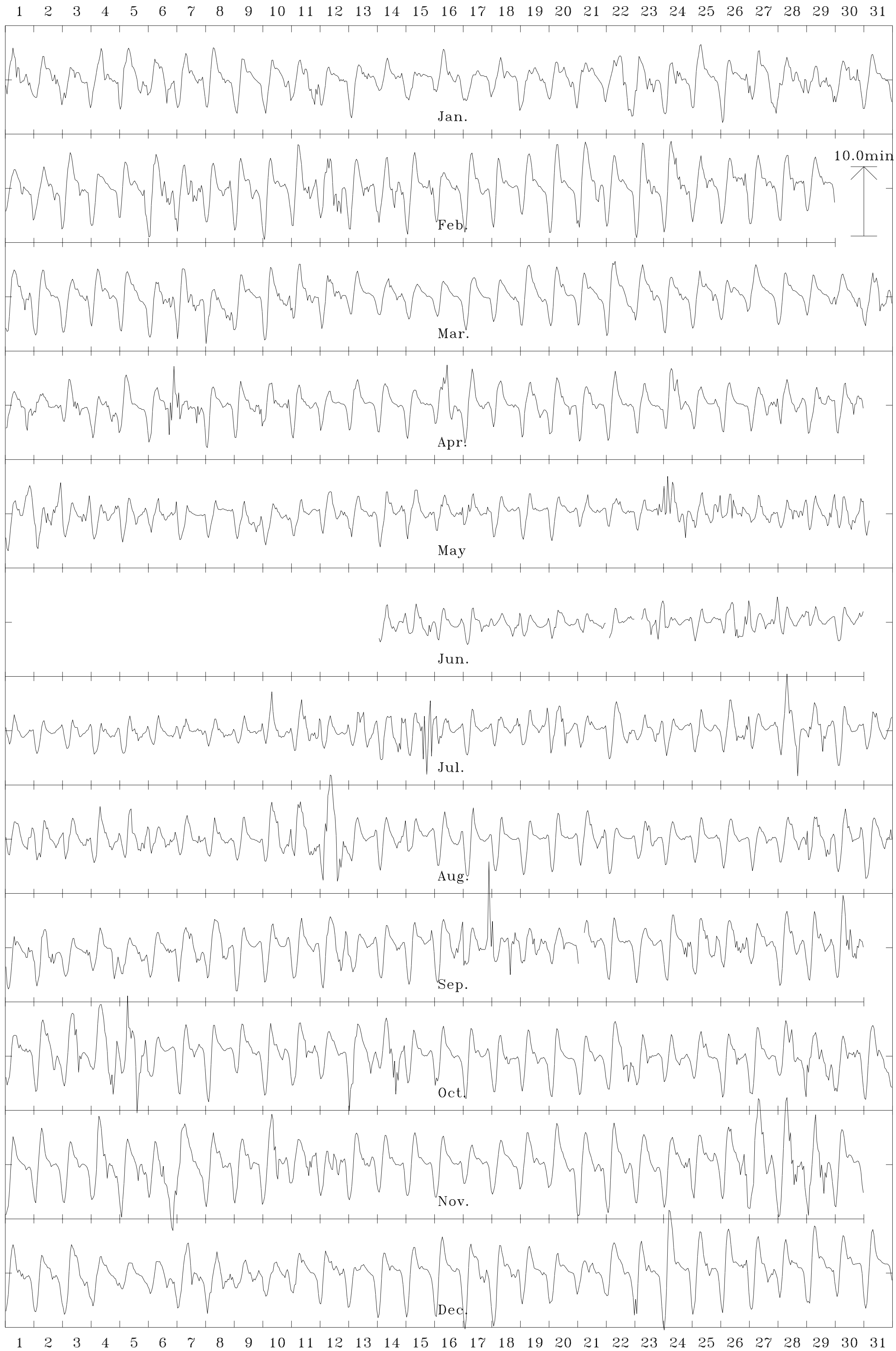
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

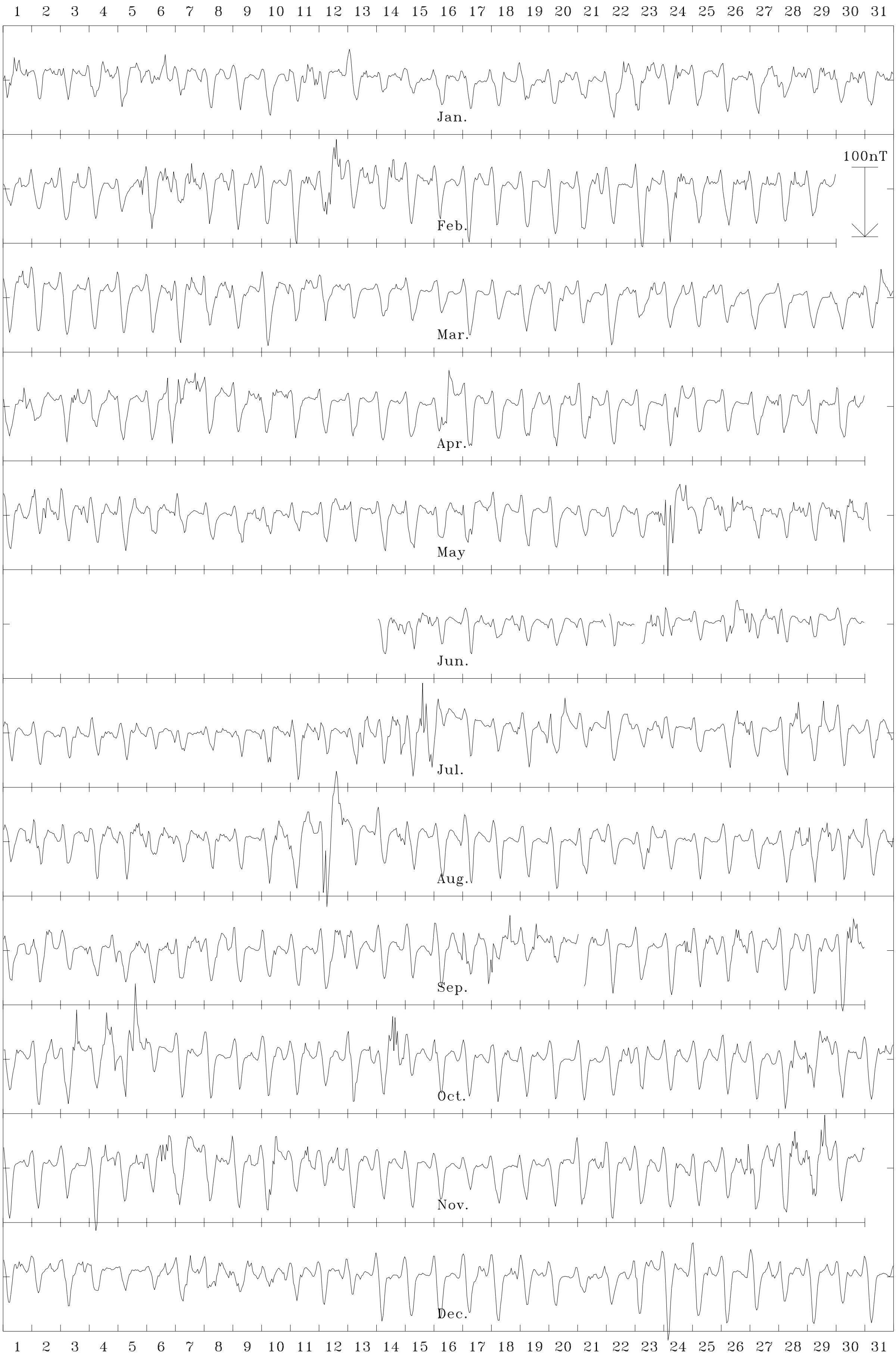
Learmonth 2000 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29707 nT



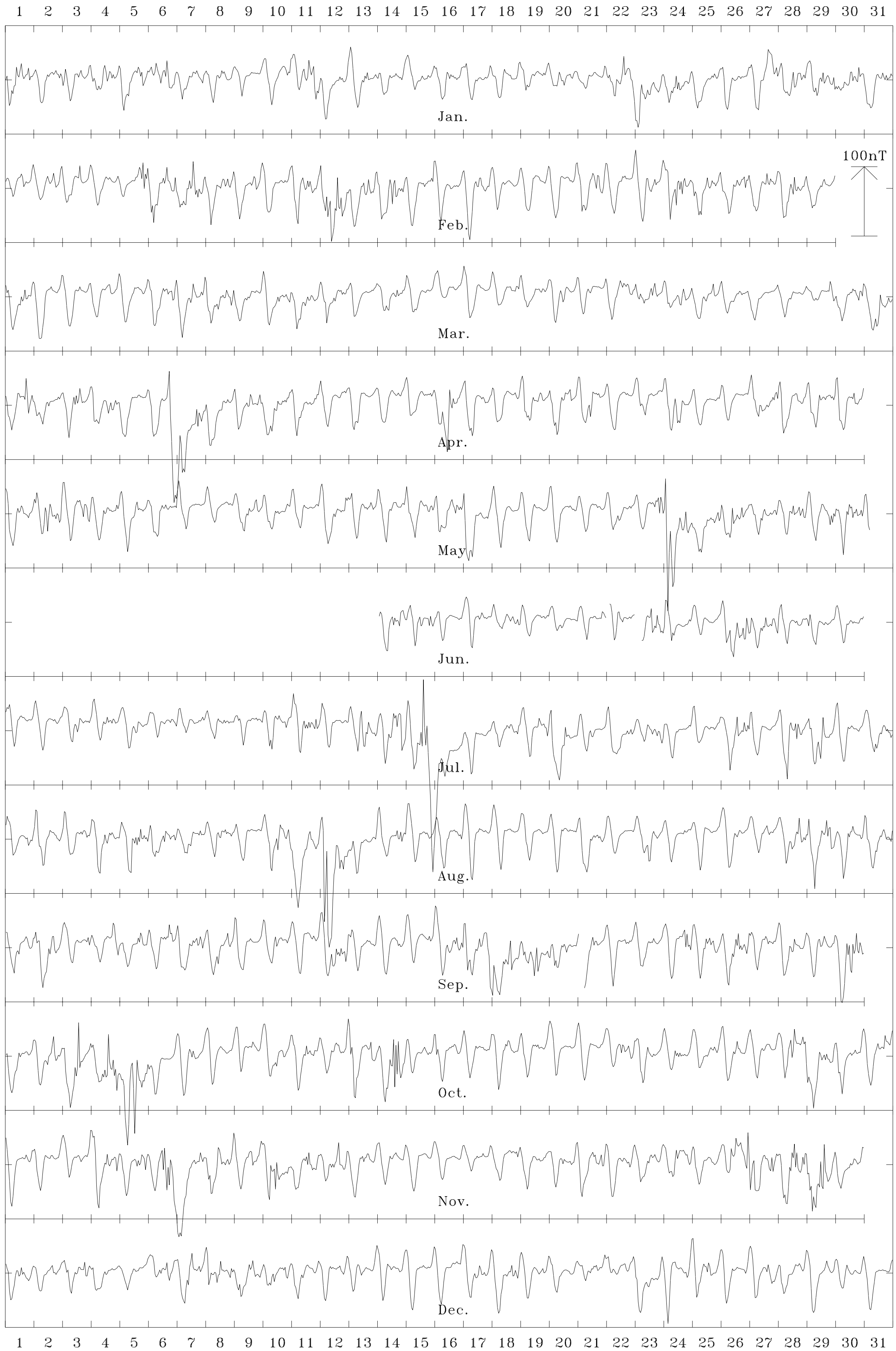
Learmonth 2000 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.22 deg.

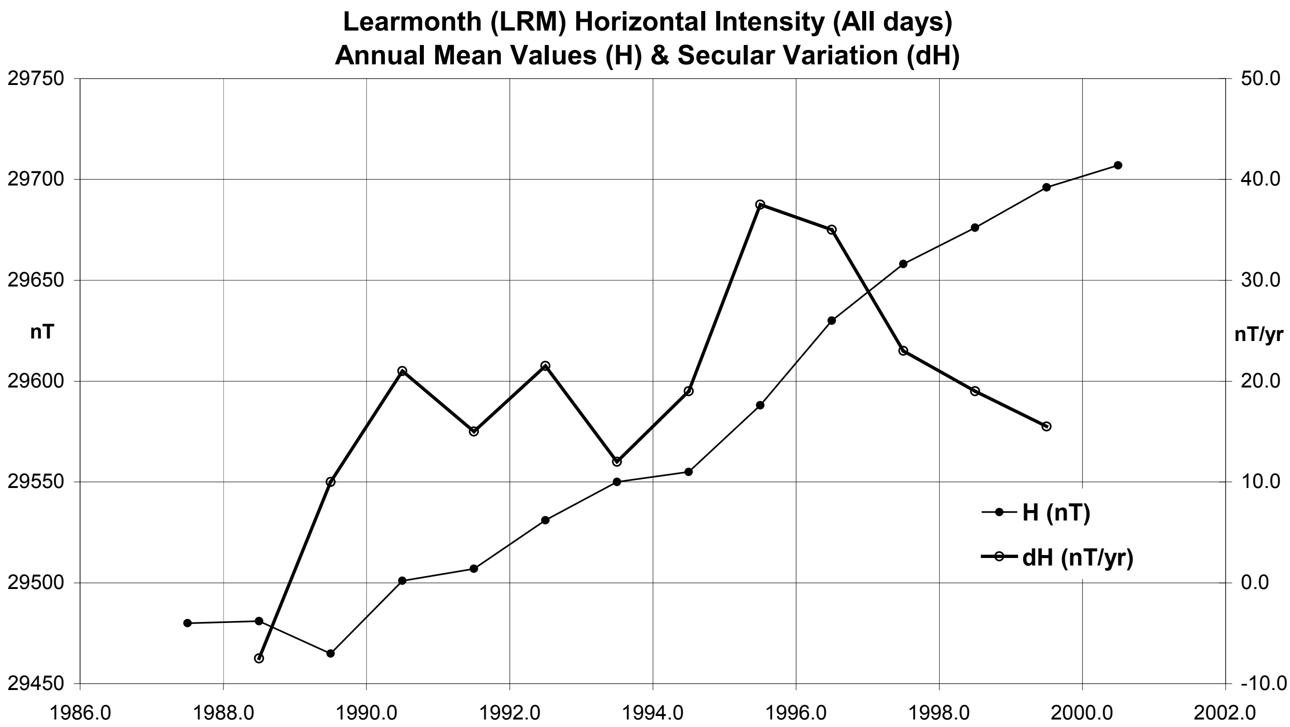


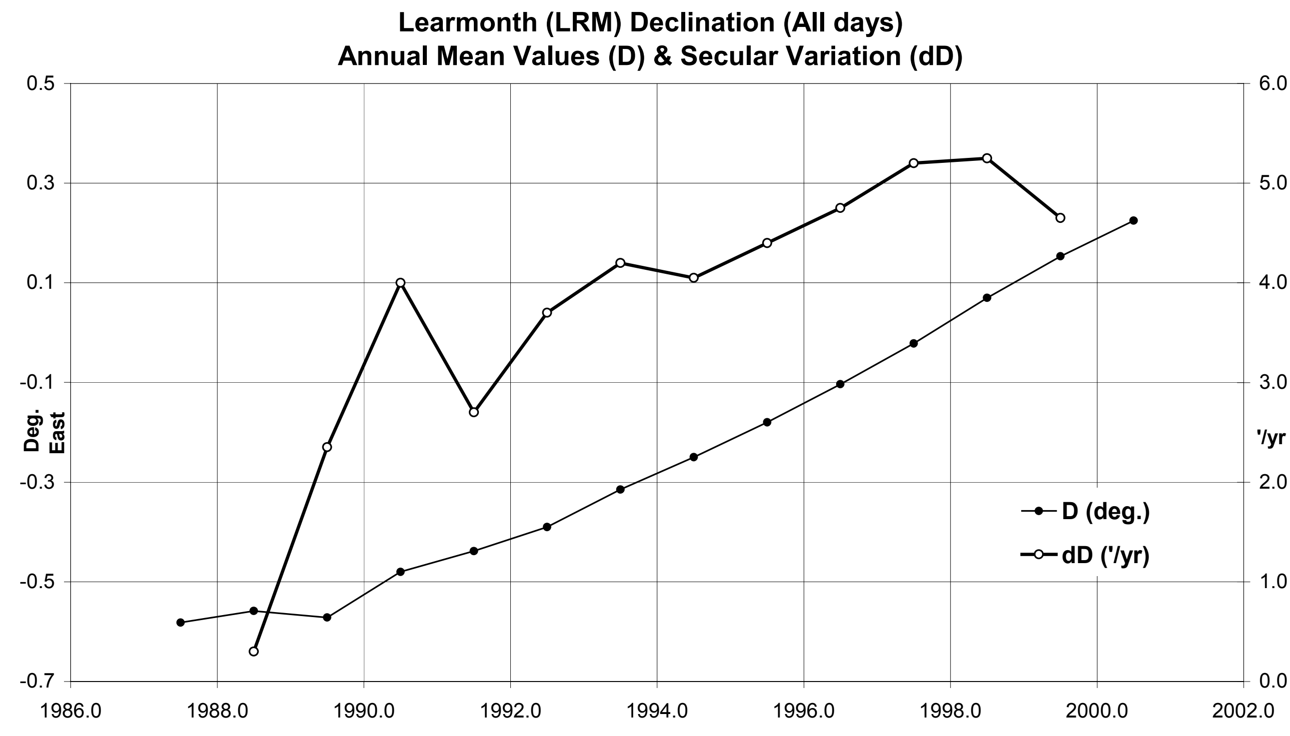
Learmonth 2000 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −44260 nT

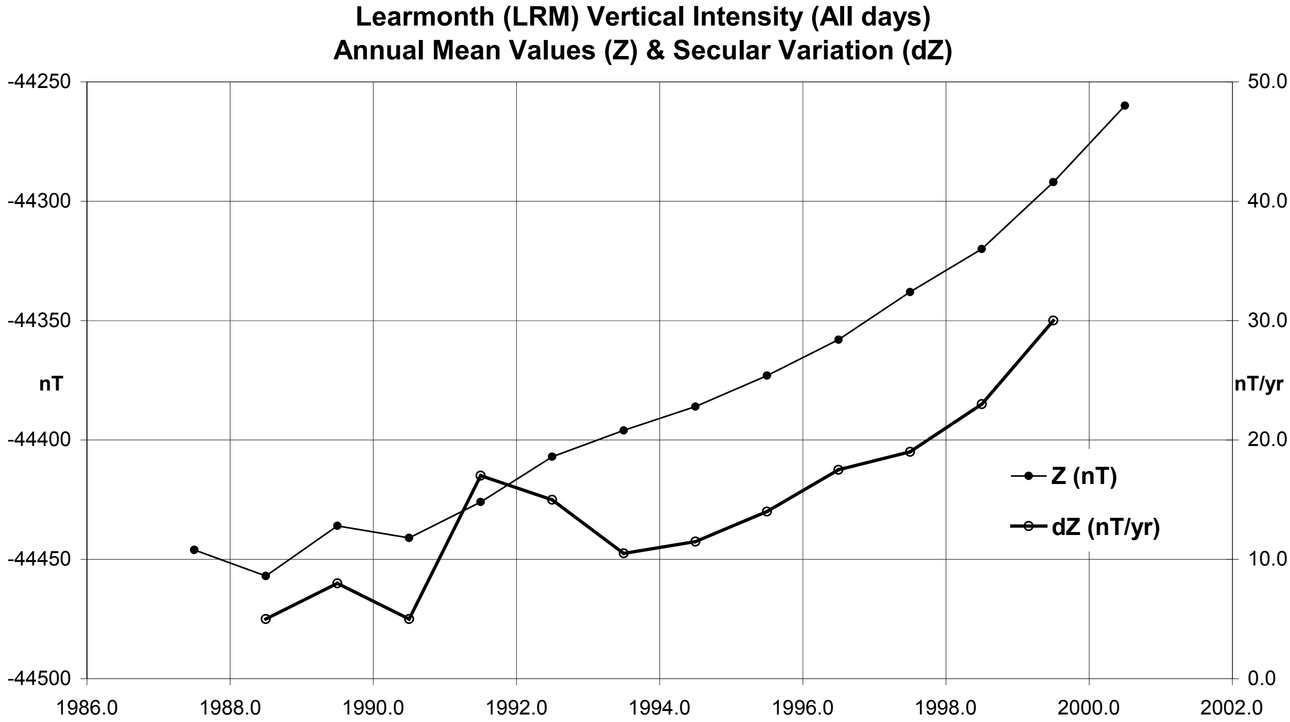


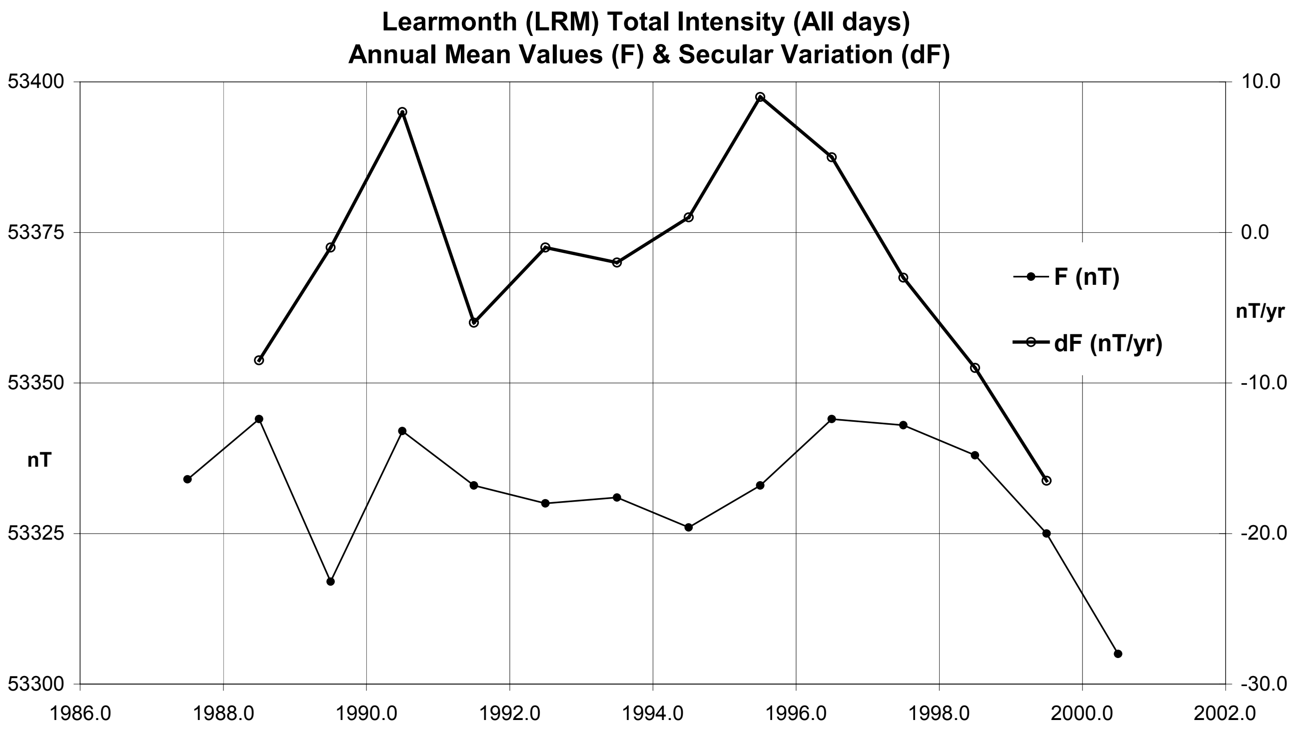
Learmonth 2000 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53305 nT




Learmonth (LRM) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)


Learmonth (LRM) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Deg. East
'/yr
D (deg.)
dD ('/yr)


Learmonth (LRM) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-44250
-44300
-44350
-44400
-44450
-44500
nT
50.0
40.0
30.0
20.0
10.0
0.0
nT/yr
Z (nT)
dZ (nT/yr)
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0


Learmonth (LRM) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53400
53375
53350
53325
53300
nT
10.0
0.0
-10.0
-20.0
-30.0
nT/yr
F (nT)
dF (nT/yr)
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0

LRM - Significant Events 2000

07 Jan Variometer PPM started to become noisy.

10 Jan Variometer PPM noise ceased abruptly at approximately 0200 UT.

01 Feb 17:00:40. A fault developed in the A (NW) channel of the RCF variometer, resulting in a sudden jump, increased noise, and commencement of a roughly linear drift of approximately 1 nT per day.

04 Mar 1050-1150: Spikes apparent on PPM variometer.

06 Mar 0130-1200: Electronics temperature rose by 6.5 deg.C.

27 Apr 0440 & 0540: Variometer data contaminated - possibly by a vehicle near the sensors.

31 May Vehicular activity associated with earthworks near the sensors began to contaminate data at 0510-0700. This continued during daylight hours for most days until 14 June.
Level shifts without absolute control mean that the night-time data are unreliable until end of work on 14 June, so data processing was inhibited until 0100 on 14 June.
No absolute observations were performed between 17 May and 06 June 2000 on account of the vehicular activity.

11 Aug Computer re-booted.

Significant Events (cont.)

13 Aug Computer re-booted.

16 Aug Last observation by retiring OIC: Maurice McMullan.

22 Aug First observation by new OIC: Graham Steward.

29 Aug Computer re-booted.

21 Sep Crane near variometer contaminated variometer data. Data processing inhibited 0100–0500.

LRM significant data loss in 2000

27 Apr. 0431–0534 (1h 04m) All channels: Data contaminated during earthworks.

31 May 0510 to 14 Jun / 0100 (13d 19h 49m) All channels: : Data contaminated during earthworks.

21 Jun. 2330 to 22 / 0230 (3h) All channels: Data contaminated during earthworks.

22 Jun 2330 to 23 / 0500 (5h 30m) All channels: Data contaminated during earthworks.

11 Aug 0307–0313 (7 min); 0335–0340 (6 mins);
0406–0412 (7 min) All channels: PC re-boots.

13 Aug 1340–1341 (2 min) All channels: PC re-booted

14 Aug 0144 (1 min) All channels: PC re-booted

29Aug 2242 (1 min) All channels: PC re-booted

21 Sep 0100–0500 (4 hrs.) All channels: Data contaminated by crane near variometer sensors.

End of Part 1