Australian Government
Geoscience Australia

AUSTRALIAN GEOMAGNETISM REPORT 2001

MAGNETIC OBSERVATORIES

VOLUME 49

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Geoscience Australia

Chief Executive Officer: Neil Williams

Minerals & Geohazards Division

Chief of Division: Chris Pigram
Associate Chief: Wally Johnson

Australian Geomagnetism Report

2001

Volume 49

Geomagnetism Section
Geoscience Australia Earth Monitoring
Geoscience Australia
G.P.O. Box 378
Canberra, A.C.T., 2601
AUSTRALIA

Australian Government
Geoscience Australia

Magnetic results for 2001

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, Liejun Wang

and A.D. Costar

ISSN: 1447-5146 (Online format)

ISSN: 1035-1515 (Printed format)

SUMMARY

During 2001 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. In 2001 Geoscience Australia ceased support for the processing of geomagnetic data acquired at the Davis station.

The absolute magnetometers in routine service at the Canberra Magnetic Observatory also serve as the Australian standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised 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, am and aa indices, while those from Gnangara contributed to the global am index.

No magnetic repeat stations were occupied in 2001.

Further upgrades were made to the magnetic observatory at Tangerang and the upgrade of the observatory at Manado, Indonesia took place in 2001. This was carried out by GA’s Geomagnetism group under an AusAID grant. It included the purchase of instrumentation and the training of staff from Indonesia’s BMG, at GA in 2000.

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 2001.

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

End of Part 1

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Part 2

End of Part 2

This is the third 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/*

Released: 5 May 2004

Part 1

ACTIVITIES & SERVICES 2001

Geomagnetic Observatories

The Geomagnetism Section of the Australian Geological Survey Organisation (now Geoscience Australia) operated nine permanent geomagnetic observatories in the Australian region during 2001. 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 2001 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 the one 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. During 2001 this activity was ceased by Geoscience Australia.

Magnetic repeat station network

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

No stations were re-occupied in 2001.

For descriptions of the repeat station survey operations, instrumentation, data acquisition and reduction, and stations occupied in 2000, see the *AGR*2000. That volume also includes a description of the Australian Geomagnetic Reference Field (AGRF) model, that includes a secular variation model, for epoch 2000. Charts of the AGRF model are in *AGR*2000. Repeat station survey data, magnetic observatory data, together with other available data are used to derive the AGRF models. The volumes AGR93 – AGR97 include a listing of all AGRF models produced.

Calibrations of compasses

GA continued to provide a compass calibration facility at cost recovery rates during 2001. 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 *National Magnetic Calibration Facility* building, in the south-east of the Canberra Magnetic Observatory compound, was completed in late 1999. The construction, installation and initial calibration of a Finnish designed large 3-axis coil system was completed in December 1999. The facility was officially opened on 18 February 2000.

Fine tuning of the instrumentation was performed during March 2001, by a member of the Lviv Centre of the Institute of Space Research of National Academy of Science and National Space Agency of Ukraine.

Indonesian Observatories

As part of an AusAID funded project, in 2001 Geoscience Australia undertook work to assist in the upgrade of the two Indonesian Geomagnetic Observatories at Tangerang (TNG) near Jakarta on Java and Tondano (TND) near Manado on Sulawesi.

The project involved providing a set of absolute instruments for each of the two observatories and a new variometer system for the Tondano observatory. (This project followed on from an earlier AusAID funded project in which exchange visits and joint repeat station survey work were undertaken in both Australia and Indonesia and a variometer system was provided for Tangerang observatory.) The instrumentation provided to the Indonesian observatories was purchased in 2000.

The absolute instruments provided to each observatory comprised Danish Meteorological Institute DIMs (TNG: D000901; TND: D000902) mounted on MG2KP theodolites (TNG: 34589; TND: 37764) and GEM GSM19 total field magnetometers (TNG: 006997; TND: 006998) with omni-directional sensors and non magnetic tripods.

The variometer system for Tondano observatory included a Danish Meteorological Institute Model FGE three axis fluxgate (non suspended, E0234, S0214) with ADAM4017 analogue to digital converter, GEM GSM90 variometer PPM (006999), data acquisition hardware and software, GPS clock, data processing hardware and software, back-up power and lightning protection, together with a pre-fabricated fibre-glass and marble absolute pier built at Geoscience Australia.

The equipment was installed during a visit to the observatories by two GA staff from 23 April to 15 May 2001. At Tondano, the existing variometer and office buildings were used to house the variometer system. The system was calibrated using the new absolute pier and absolute instruments and the local staff were trained in the using the new equipment and the acquisition and processing software.

Systems were established to transmit the variometer and weekly absolute observation data from Tondano to GA head office via the internet so that assistance could be provided in the calibration and maintenance of the new observatory. The Tangerang variometer and absolute data are also transmitted to GA via the internet. (One-minute and one-second data values from Tangerang have been transferred to GA 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.

During 2001 data from GA's observatory network was routinely provided in support of international programs.

INTERMAGNET

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

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

Ørsted Satellite Support

Since October 1994, preliminary monthly mean values from Australian observatories have been provided to the Ørsted satellite project within about a fortnight after the end of each month. In support of the Ørsted satellite project, 2001 preliminary monthly mean values from all Australian observatories were provided by e-mail to IPGP, France.

Storms & Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 2001 were provided monthly to:

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

Indices of Magnetic Disturbance

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

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

During 2001, K indices for CNB were provided semi-monthly to the Adolf-Schmidt-Observatorium (Niemegk, Germany) for the derivation of global geomagnetic activity indicators such as the ‘planetary’ Kp index.

The weekly provision of CNB K indices to CLS, CNES, Toulouse, France and the Brussels observatory, Belgium, continued throughout 2001. 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 2001 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 2001 as indicated.

Observatory	WDC-A	WDC-C1
Kakadu	1999, 2000	
Charters Towers	1998, 1999, 2000	1998
Alice Springs	2000	2000
Canberra	2000	2000
Gnangara	2000	2000
Learmonth	2000	1999, 2000
Macquarie Island	1998, 1999, 2000	1998, 1999, 2000
Mawson	1998, 1999, 2000	1998, 1999, 2000
Casey		1999, 2000
Davis		1999, 2000

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.

Notes and Errata

The *AGR1999* and *AGR2000* both show the same incorrect value in the table entitled Gnangara Annual Mean Values that appears on page 40 and page 42 in the respective volumes.

The H component value given for the International Quiet Day mean for 1999.5 incorrectly shown as 23224 (in nT) should read **23234**.

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 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 2001 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 2001

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 no. 11435 BMR#1 (until 12 Oct 01)	0.01	10, 60	F
	GSM-90 Overhauser no. 708729 (from 31 Oct 2001)	"	"	"
CNB	Narod ring-core fluxgate/9004-2	0.025	1, 60	NW, NE, Z†
	GEM Systems GSM-90 / 81225	0.01	1, 60	F
CTA	DMI FGE (ver.G) S0210/E0227 (to 04 Feb 2001)	0.1	1, 60	NW, NE, Z†
	DMI FGE (ver.G) S0210/E0199 (07-21 Feb 2001)	"	"	"
	DMI FGE (ver.G) S0210/E0227 (from 21 Feb 2001)	"	"	"
	Elsec 820M3 PPM s/n 138	0.1	10, 60	F
GNA	DMI FGE (ver.D) S0160/E0167	0.1	1, 60	NW, NE, Z†
	Geometrics 856 No.50706	0.1	10, 60	F
KDU	DMI FGE fluxgate E0198/S0183	0.1	1, 60	NW, NE, Z†
	Geometrics 856 No.50707	0.1	10, 60	F
LRM	Narod fluxgate s/n 9004-04 (until 12 Aug. 2001)	0.025	1, 60	NW, NE, Z
	Bartington MAG03 s/n 504 (14 Aug - 12 Dec 2001)	0.02	1,60	NW, NE, Z
	DMI s/n E0254/S0277 (from 12 Dec. 2001)	0.03	1,60	NW, NE, Z
	Geometrics 856 no.50708	0.1	10, 60	F
MCQ	Narod ring-core fluxgate 9305-1	0.025	1, 60	A, B, C†
	Elsec 820M3 PPM 140	0.1	10, 60	F
MAW	Narod ring-core fluxgate 9004-1	0.025	1, 60	NW, NE, Z†
	Elsec 820M3 PPM 158	0.1	10, 60	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 2001. The principal magnetometer combination was a D,I-fluxgate magnetometer (or Declination and Inclination Magnetometer – DIM) that measured the magnetic field direction, complimented by a PPM to measure the total field intensity. At some observatories, older classical QHMs were still available for use as backup should the primary instruments become unserviceable.

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

In 2001 both Elsec 810 and Bartington MAG-01H fluxgate sensors and electronics were used together with Zeiss-Jena 020B and 010B non-magnetic theodolites.

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

Magnetic Standards

BMR/AGSO/GA has always maintained its own standards for Declination and Total Intensity. Since the late 1970s the Australian magnetic standard absolute magnetometers have been held at the Canberra Magnetic Observatory where they are in routine use for the calibration of that observatory. During 1993, a Declination and Inclination magnetometer (DIM) replaced classical magnetometers as the primary Declination and Inclination standard for Australia. (Details of the magnetometers that served as standards prior to 1993 can be found in *AGR*s *1993-1997*.) The adoption of the DIM as the Inclination standard 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 served as the Total Intensity (F) standard from the late 1970s until 2000. In January 1995 its crystal oscillator frequency was found to be 13.4ppm below the (CODATA 1986) value recommended by IAGA for use from 1992. This resulted in F readings at Canberra that were theoretically 0.78nT too high. This correction was subsequently taken into account when standardizing total field absolute instruments deployed at all Australian observatories. The instrument was described in *AGR*s 1993-2000.

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

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

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

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

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

Ancillary equipment

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

Data Acquisition

During 2001 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 most observatories the PC clocks were kept corrected by synchronizing them with 1-second GPS clock pulses.

Analogue to digital PC cards or external ADAM A/D converters were used to convert analogue data, produced by GA's DMI FGE variometers, to digital values for recording on data acquisition PCs. The AAD's EDA FM105B variometers at Casey and Davis acquired data via their Analogue Data Acquisition System (ADAS).

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

Digital data have been retrieved automatically from the observatories each day since March 1996. In 2001 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.

Absolute Magnetometers employed in 2001

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
ASP	DIM: Elsec 810/221; Zeiss 020B/313887* PPM: Elsec 770/193 (until 20 Nov 2001) GSM-19 Overhauser / 11435 BMR#1 (from 21 Nov. 2001))	D, I F F	0.1' 1 nT 0.01 nT
CNB	DIM: Elsec 810/200; Zeiss 020B/353756* PPM: GSM-90 no.905926, sensor 81241 (new Australian standard from 01 Jan 2001)	D, I F	0.1' 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
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 (to late March 2001); Zeiss 020B/311847* Elsec 810/214 (from late March 2001); 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: Bartington 00766H; Zeiss 020B/313792 (to late Feb. 2001)) DMI D26035; Zeiss 020B/311542 (from late Feb. 2001) 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 F F H D	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* (to 22 Feb 2001) Bartington B0766H (sensor 457); Zeiss 020B/313792 (ex MAW) (from 07 Mar 2001) PPM: Geometrics 816/1025 QHM No. 492 (secondary)	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 OBSERVATORIES

The locations of the observatories are shown on the front cover (page i) 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 2001.

Australian Magnetic Observatories, 2001

Observatory	IAGA code	Year begun	Geographic Coordinates Latitude S	Geographic Coordinates Longitude E	Geomagnetic† Lat.	Geomagnetic† Long.	Elev'n (m)	Observer in Charge
Kakadu	KDU	1995	12° 41' 11"	132° 28' 20"	-21.99°	205.44°	15	K. Stellmacher
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-27.96°	220.80°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.36°	186.28°	4	G.A. Steward
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-32.85°	208.01°	557	W. Serone
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-41.83°	188.66°	60	O. McConnel H. VanReeken
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.60°	226.77°	859	Liejun Wang
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-59.94°	244.09°	8	D. Gillies M. Eccles
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.11°	109.84°	12	M. Purvins
Casey	CSY		66° 17'	110° 32'	-76.46°	183.72°	40	A. Breed
Variation Station								
Davis	DVS		68° 34' 38"	77° 58' 23"	-76.36°	127.94°	29	M. Terkildsen

† Geomagnetic coordinates are based on the 2000.0 International Geomagnetic Reference Field (IGRF) model updated to 2001.5 with magnetic north pole position of 79.672°N, 288.380°E.

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 approximately 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† : Lat. -32.85°; Long. 208.01°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of pier): 557 metres
- Lower limit for K index of 9: 350 nT.
- Azimuth of principal reference pillar (B) from Pier G: 255° 00' 50"
- Distance to Pillar B: 85 metres
- Observer in Charge: W. Serone (ACRES)

Variometers

Variations in the X, Y and Z components of the magnetic field were recorded at Alice Springs in 2001 using a three-component Narod ring-core fluxgate (RCF) magnetometer and in the total magnetic field intensity (F) using GEM system Overhauser-effect proton precession magnetometers (PPMs).

A GSM-19 was employed until 21 October, after which a GSM90 was installed. The latter suffered from cable and noise problems throughout the remainder of the year causing significant data losses

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. In January 2001 the temperature stability of the control house was improved by installing a layer of 75mm high-density polystyrene foam on all internal walls and the ceiling.

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

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

Absolute Instruments and Corrections

The principal absolute instruments employed at Alice Springs during 2001 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. Elsec model 770 no. 193 PPM operated until 14 November 2001 when it failed. It was replaced on 21November with a GEM model GSM19 no 11435 Overhauser effect PPM.

The Alice Springs DIM failed on 29 August and was returned to GA headquarters where it remained between 04 September and 03 October 2001. The instrument was repaired (by re-connecting the cable between fluxgate sensor and electronics), the theodolite was given routine mechanical and optical maintenance and instrument comparisons were carried out at the Canberra Observatory.

The adopted instrument corrections applied to the absolute magnetometers used at Alice Springs in 2001 were determined from instrument comparisons that were performed in January, September and November 2001. 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 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 and February 2001. The Alice Springs DIM was again compared to the Australian Standard DIM at the Canberra Observatory after service and repair in September 2001. These instrument comparisons yielded adopted instrument differences of 0.0', 0.0' and -3.0nT for D I and F respectively, in the sense
Instrument difference = Stnd. Instrument – ASP instrument.

The GSM-19 no. 11435 magnetometer, which was used as the absolute total field instrument at Alice Springs from 21 November 2001, was compared to the Australian Standard GSM90 no. 905926 at the Canberra Observatory on 15 November 2001. The comparisons yielded an adopted instrument difference of 1.5nT, in the sense
F (GSM90 no. 905926) = F(GSM19 no. 11435) + 1.5nT

Baselines

The instrument differences in the previous section translate to corrections of **-1.68nT, -0.15nT** and **2.48nT** in X, Y and Z respectively at the mean field values at Alice Springs for 2001 of: X=29950nT; Y=2675nT and Z=-44240nT. These instrument corrections have been applied to the 2001 data in this report covering the period 01 Jan 2001 until 0242UT 21 November 2001.

The adopted ASP absolute instrument differences of 0.0' 0.0' and 1.5nT in D, I and F respectively yield corrections of **0.84nT**, **0.08nT** and **-1.24nT** in X, Y and Z respectively at the (previously listed) mean field values at Alice Springs. These corrections have been applied to the ASP data from 0242UT on 21 November 2001.

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
2001.5	A	5	6.0	-55	48.0	30067	29948	2673	-44241	53491	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

continued …

ASP Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
2001.5	Q	5	6.1	-55	47.3	30078	29959	2675	-44239	53495	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	4.0	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	4.9	-55	53.0	30034	29916	2660	-44332	53548	XYZ
2000.5	D	5	5.5	-55	51.8	30026	29908	2664	-44287	53506	XYZ
2001.5	D	5	5.8	-55	49.4	30043	29924	2669	-44245	53480	XYZ

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

Daily files of both 1-minute and 1-second resolution data were automatically retrieved from Alice Springs to GA in Canberra by modems via a telephone line connection. The data were then automatically e-mailed to the Intermagnet Geomagnetic Information Node at Edinburgh and made available on the GA web site.

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 observatory was affected by a nearby lightning strike on 24 November which caused the data recording to stall and damaged the GPS clock. The GPS system was removed and sent to GA for repair. In the absence of the GPS, system timing was maintained through routine daily checks via telemetry.

Significant Events 2001 - ASP

- all Jan — OIC on leave: No absolute observations performed.
- 19 Jan — System rebooted after UPS failed.
- 23 Jan — Foam insulation unloaded at observatory.
- 31 Jan — to 09 Feb: Service visit by GA staff - Foam insulation installed; control hut painted; safety tie down bar on absolute pier installed; instrument comparisons; GPS survey; mark azimuths checked.
- 04 Apr — First observation with new absolute PPM stand
- 09 May — OIC absent: No absolute observations performed.
- 07 Aug — GSM19 variometer PPM began to intermittently fail recording readings.
- 29 Aug — DIM malfunctioned and sent to GA for repair.
- 03 Oct — DIM returned to ASP after repair and service at GA.
- 08 Oct — System tests to investigate problem with GSM19 variometer PPM
- 12 Oct — GSM19 total field variometer electronics was returned to GA for repair. (The sensor head and cable were left in place.)
- 31 Oct — Data acquisition PC was replaced and GSM90 no. 708729 was installed as total-field variometer PPM, with original cable and head from GSM19 system. GSM90 starts off satisfactorily but quickly began producing noisy data.
- 08 Nov — to 11th: Unexplained baseline jumps and noise on all Narod RCF channels.
- 12 Nov — GSM90 variometer PPM switched off since as it was not functioning correctly.
- 20 Nov — 22nd: Service visit by GA staff to repair GSM90 PPM.
- 21 Nov — Introduce GSM19 no.11435 into absolute observation routine to replace Elsec770 no. 193.
- 24 Nov — Observatory struck by lightning. All recording magnetometers stalled and GPS clock was damaged.
- 26 Nov — All equipment reset and re-booted. The GPS system was removed and sent to GA for repair.
- 08 Dec — GSM90 variometer PPM went bad again. Noise on XYZ RCF variometer channels 06-08hrs. UT.
- 25 Dec — 1315-1500: Noise on all channels RCF variometer, probably due to nearby lightning strikes.

Data loss in 2001 - ASP

- 19 Jan — 1553 (1 min) All channels: PC rebooted.
- 03 Feb — 2337-2351 (5 min) RCF only: Contaminated data omitted from processing.
- 05 Feb — 0451 (1 min) All channels: PC rebooted
- 05 Oct — 0742 (1 min) RCF channels only
- 31 Oct — 0000-0251 (2h 52m) All channels; 0312 (1min) RCF channels: Equipment upgrades.
- 08 Nov — 2151-2208 (18m) RCF channels: Contaminated data omitted from processing.
- 11 Nov — 0215-0340 (1h 26m); 0645-0720 (41m) RCF channels: Contaminated data omitted from processing.
- 20 Nov — 0206-0227 (22m); 0248-0252 (5m) RCF channels: Contaminated data omitted from processing.
- 21 Nov — 0613 (1min) RCF channels only.
- 24 Nov — 0845 to Nov 25 @ 2359 (1d 15h 15m) All channels: lightning strike.
- 26 Nov — 0000-0341 (3h 42m); 0349-0350 (2m) RCF channels: same lightning strike.

… continued on page 16

Monthly & Annual Mean Values, 2001

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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29956.7	2667.1	-44255.8	53507.9	30075.2	5° 05.3'	-55° 48.1'
	5xQ days	29967.8	2672.5	-44253.8	53512.7	30086.8	5° 05.8'	-55° 47.4'
	5xD days	29945.9	2662.5	-44257.1	53502.7	30064.0	5° 04.9'	-55° 48.7'
February	All days	29957.8	2671.6	-44250.1	53504.0	30076.7	5° 05.8'	-55° 47.8'
	5xQ days	29963.4	2674.0	-44249.6	53506.8	30082.5	5° 06.0'	-55° 47.4'
	5xD days	29947.6	2669.5	-44251.0	53499.0	30066.4	5° 05.6'	-55° 48.3'
March	All days	29940.0	2669.4	-44249.2	53493.2	30058.8	5° 05.7'	-55° 48.7'
	5xQ days	29960.0	2672.9	-44244.4	53500.6	30079.0	5° 05.9'	-55° 47.4'
	5xD days	29881.8	2661.0	-44257.1	53466.8	30000.0	5° 05.3'	-55° 52.1'
April	All days	29922.5	2670.8	-44255.3	53488.6	30041.5	5° 06.0'	-55° 49.8'
	5xQ days	29938.4	2673.8	-44252.4	53495.1	30057.6	5° 06.2'	-55° 48.9'
	5xD days	29897.0	2667.7	-44259.9	53477.9	30015.8	5° 05.9'	-55° 51.4'
May	All days	29946.6	2674.3	-44247.0	53495.3	30065.7	5° 06.2'	-55° 48.2'
	5xQ days	29956.0	2675.9	-44244.1	53498.2	30075.2	5° 06.3'	-55° 47.6'
	5xD days	29918.9	2670.7	-44252.9	53484.5	30037.9	5° 06.1'	-55° 49.9'
June	All days	29951.1	2674.0	-44241.1	53493.0	30070.2	5° 06.1'	-55° 47.8'
	5xQ days	29957.7	2674.4	-44238.9	53494.8	30076.8	5° 06.1'	-55° 47.4'
	5xD days	29937.4	2673.9	-44242.8	53486.7	30056.6	5° 06.2'	-55° 48.6'
July	All days	29954.2	2675.3	-44237.7	53491.9	30073.5	5° 06.2'	-55° 47.5'
	5xQ days	29959.5	2675.4	-44236.7	53494.1	30078.7	5° 06.2'	-55° 47.2'
	5xD days	29949.3	2674.6	-44238.1	53489.4	30068.5	5° 06.2'	-55° 47.8'
August	All days	29953.4	2675.1	-44232.5	53487.2	30072.6	5° 06.2'	-55° 47.4'
	5xQ days	29958.2	2675.0	-44232.0	53489.4	30077.3	5° 06.1'	-55° 47.1'
	5xD days	29944.1	2671.2	-44235.0	53483.8	30063.0	5° 05.9'	-55° 48.0'
September	All days	29951.6	2678.0	-44227.9	53482.5	30071.1	5° 06.6'	-55° 47.3'
	5xQ days	29963.3	2679.8	-44226.1	53487.6	30082.9	5° 06.6'	-55° 46.6'
	5xD days	29935.7	2677.4	-44231.2	53476.3	30055.2	5° 06.6'	-55° 48.2'
October	All days	29929.7	2673.1	-44231.8	53473.3	30048.9	5° 06.2'	-55° 48.6'
	5xQ days	29955.2	2676.1	-44226.1	53482.9	30074.5	5° 06.3'	-55° 47.0'
	5xD days	29881.6	2662.8	-44241.6	53453.9	30000.0	5° 05.5'	-55° 51.5'
November	All days	29944.2	2674.7	-44231.8	53481.5	30063.5	5° 06.3'	-55° 47.8'
	5xQ days	29960.4	2676.2	-44228.7	53488.0	30079.7	5° 06.3'	-55° 46.8'
	5xD days	29892.5	2669.5	-44240.6	53459.5	30011.5	5° 06.2'	-55° 50.9'
December	All days	29965.5	2673.5	-44227.2	53489.5	30084.5	5° 05.9'	-55° 46.5'
	5xQ days	29967.7	2674.4	-44229.8	53493.0	30086.9	5° 06.0'	-55° 46.5'
	5xD days	29954.8	2670.7	-44228.4	53484.4	30073.7	5° 05.7'	-55° 47.1'
Annual	All days	29947.8	2673.1	-44240.6	53490.7	30066.9	5° 06.0'	-55° 47.9'
Mean	5xQ days	29959.0	2675.0	-44238.5	53495.3	30078.2	5° 06.1'	-55° 47.3'
Values	5xD days	29923.9	2669.3	-44244.6	53480.4	30042.7	5° 05.8'	-55° 49.4'

(Calculated: 13:54 hrs., Fri. 22 Feb. 2002)

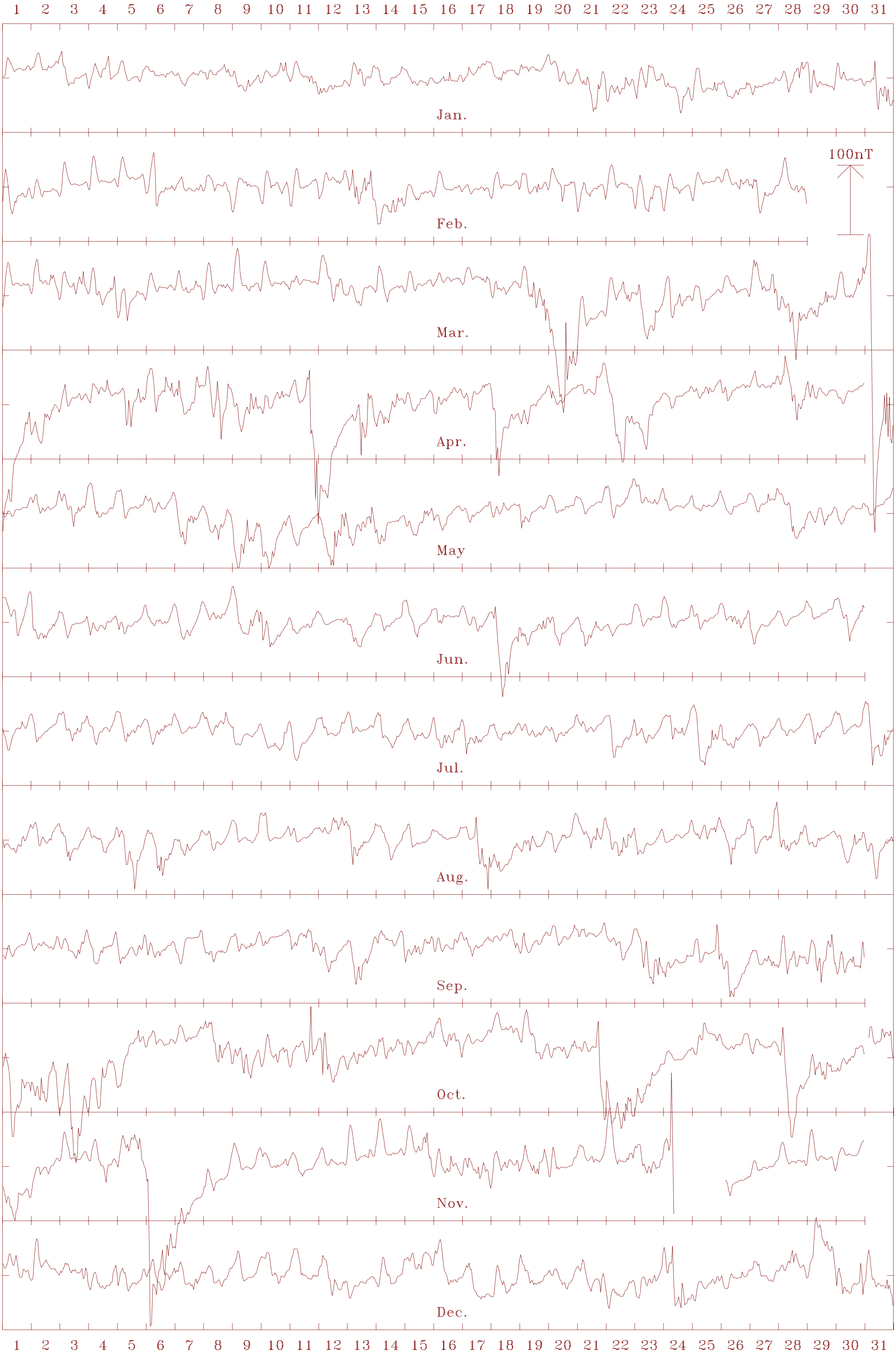
Hourly Mean Values

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.

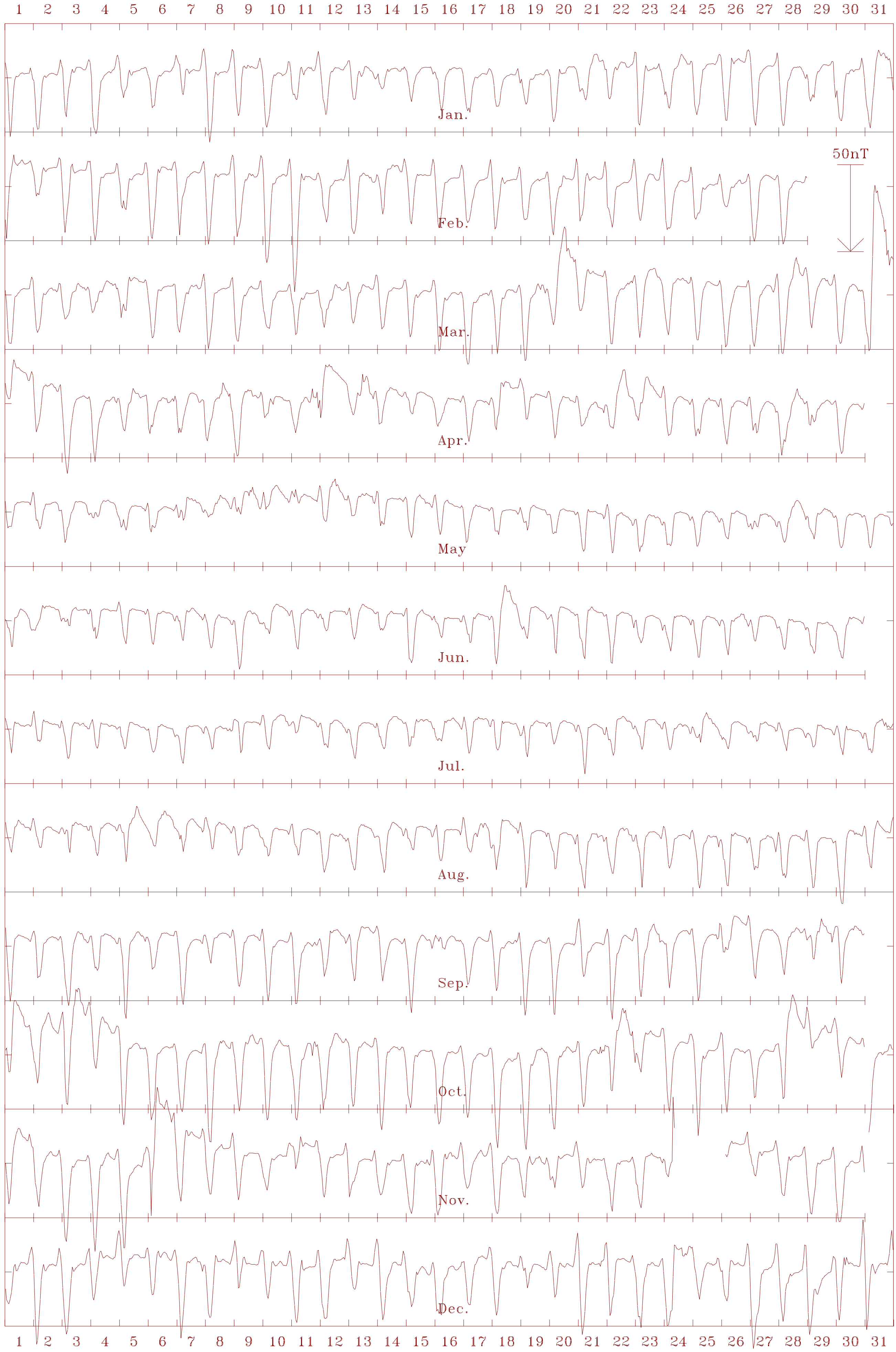
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Alice Springs 2001 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 30067 nT

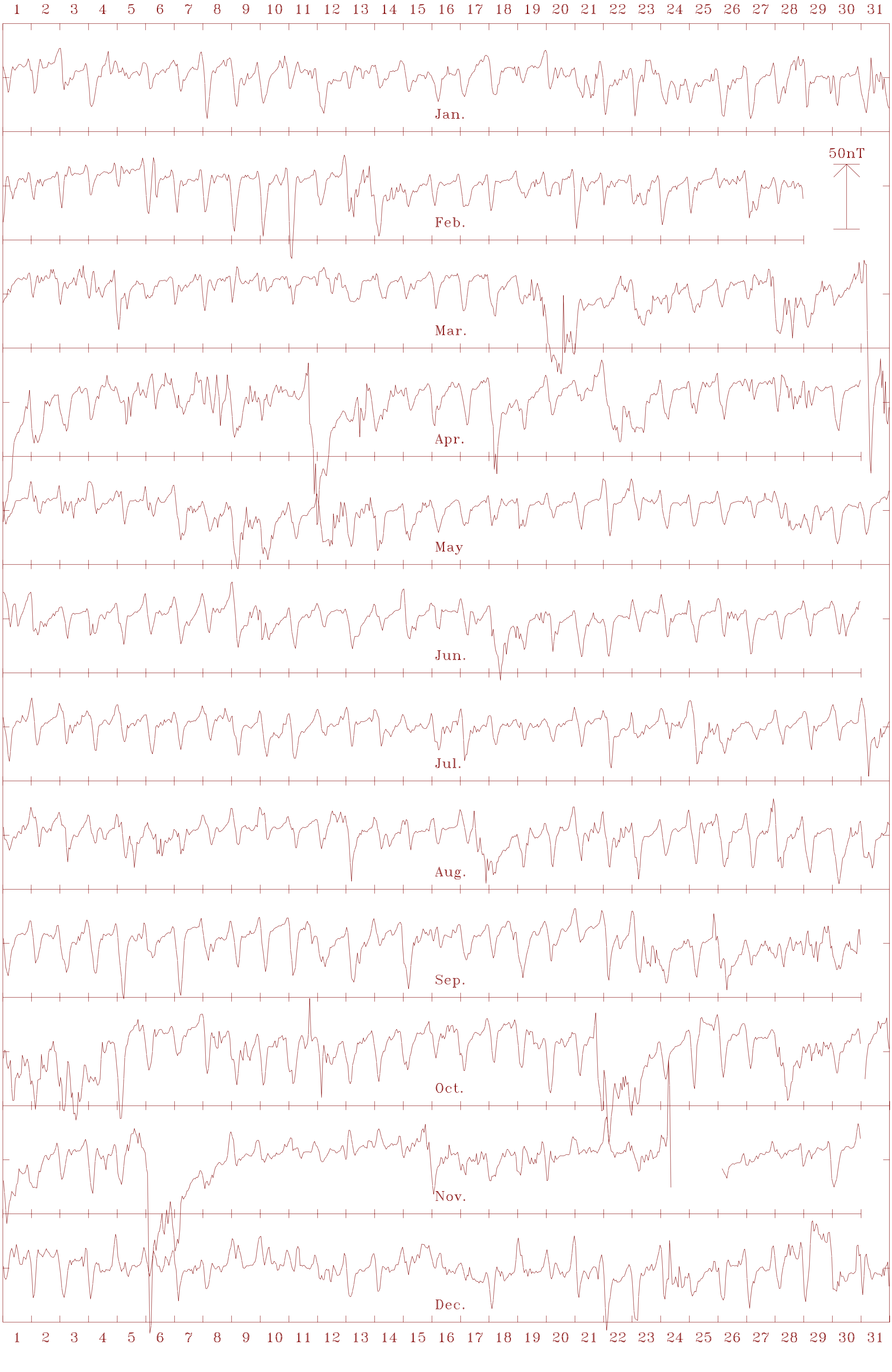


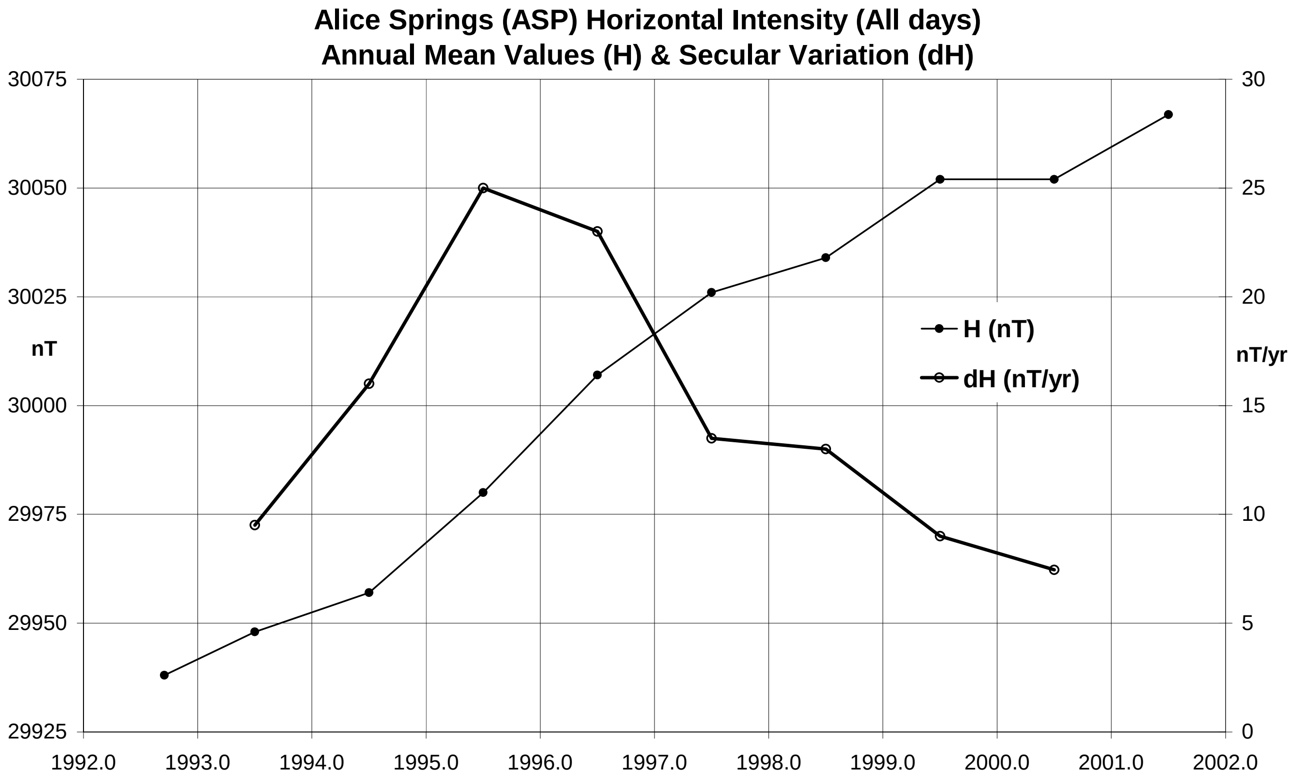
Alice Springs 2001 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.10 deg.

Alice Springs 2001 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44241 nT



Alice Springs 2001 Total intensity (F). Scale: 4.0 nT/mm. Mean: 53491 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
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1994.0
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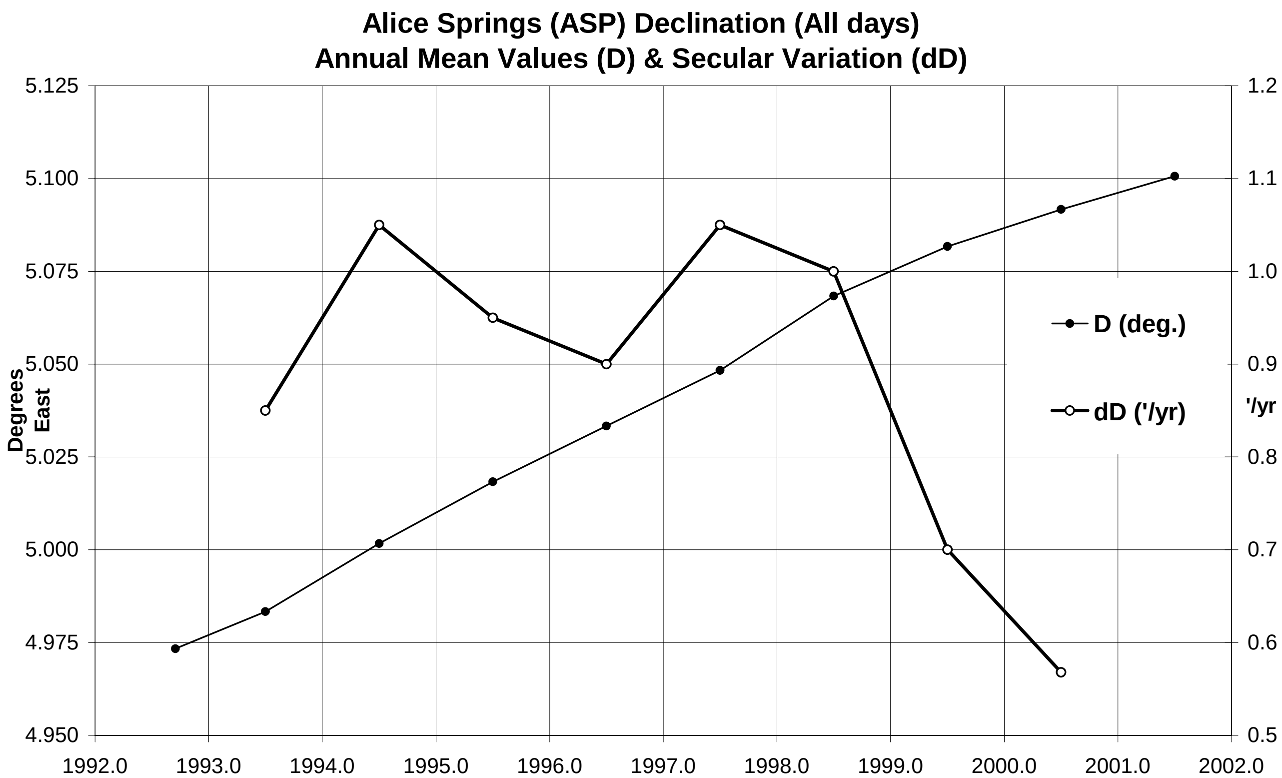
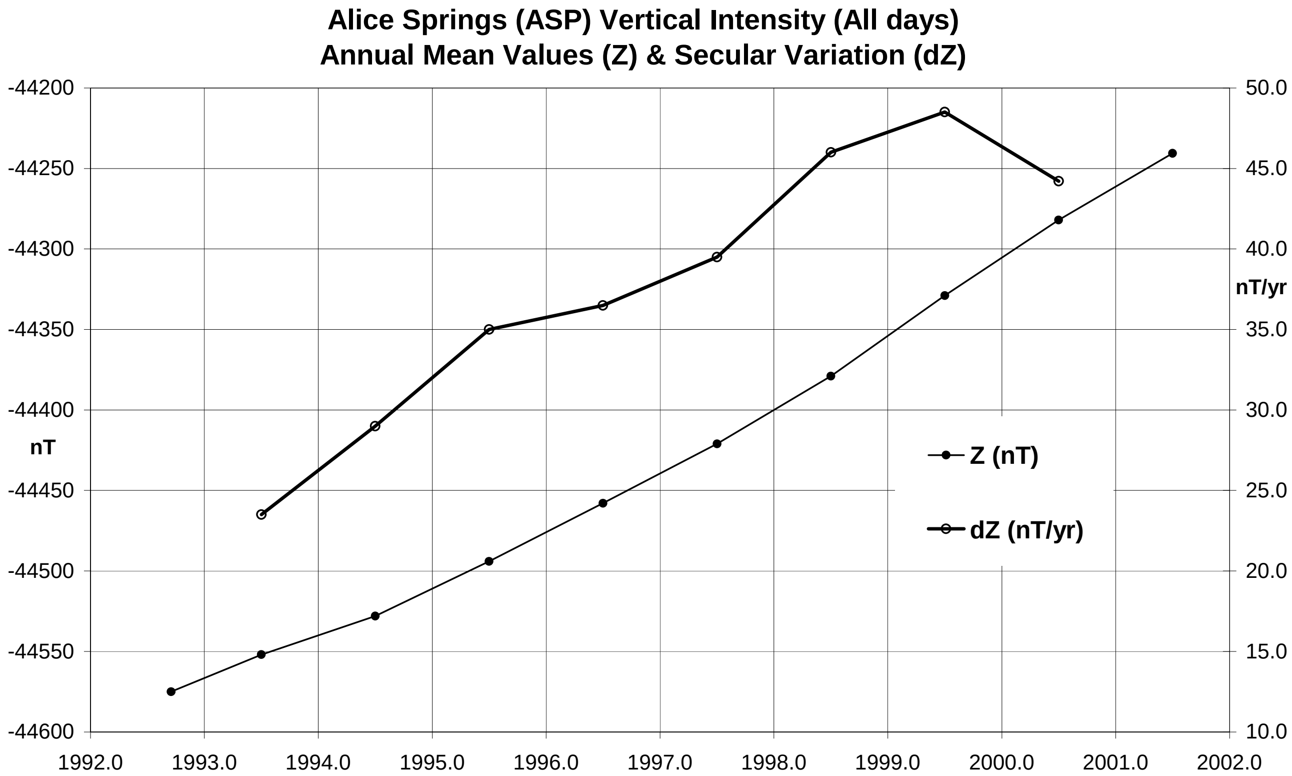
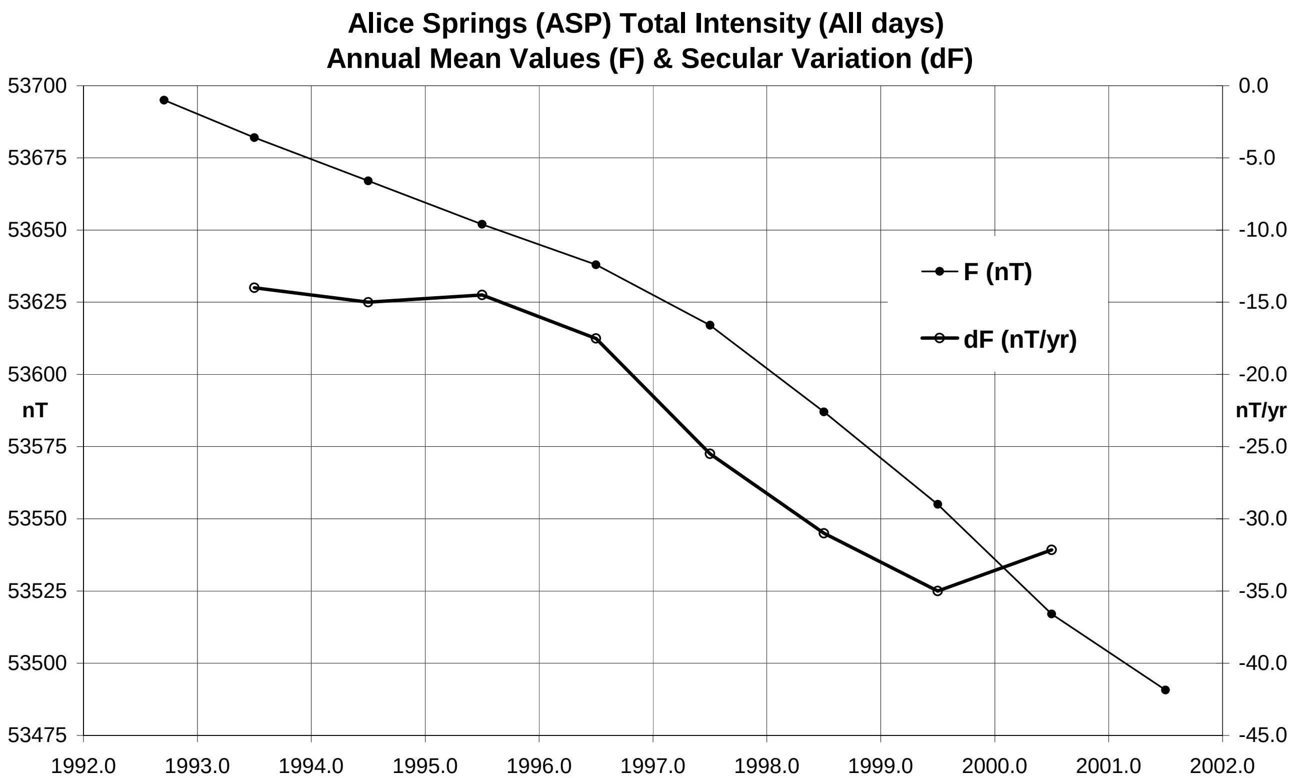
1998.0
1999.0
2000.0
2001.0
2002.0


Alice Springs (ASP) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
5.125
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
0.5
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)
-44200
-44250
-44300
-44350
-44400
-44450
-44500
-44550
-44600
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0



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
53475
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0

ASP Data loss in 2001 (cont.)

In addition to the above data losses, there was major loss of total field variometer data due to instrumental problems.
The F channel only data losses at ASP in 2001 were:

25 Jan 0607 to 31 Jan @ 0359 (5d 21h 53m) GSM19 failure.

05 Feb:	8m;	06 Feb:	7m;	07 Aug:	1m;
10 Aug:	1m;	11 Aug:	3m;	12 Aug:	6m;
13 Aug:	9m;	14 Aug:	14m;	15 Aug:	12m;
16 Aug:	18m;	17 Aug:	10m;	18 Aug:	11m;
19 Aug:	11m;	20 Aug:	21m;	21 Aug:	20m;
22 Aug:	18m;	23 Aug:	34m;	24 Aug:	39m;
25 Aug:	81m;	26 Aug:	42m;	27 Aug:	37m;
28 Aug:	61m;	29 Aug:	85m;	30 Aug:	159m;
31 Aug:	142m;	01 Sep:	129m;	02 Sep:	141m;
03 Sep:	206m;	04 Sep:	226m;	05 Sep:	323m;
06 Sep:	369m;	07 Sep:	351m;	08 Sep:	255m;
09 Sep:	349m;	10 Sep:	287m;	11 Sep:	280m;
12 Sep:	308m;	13 Sep:	365m;	14 Sep:	389m;
15 Sep:	382m;	16 Sep:	438m;	17 Sep:	415m;
18 Sep:	514m;	19 Sep:	523m;	20 Sep:	530m;
21 Sep:	567m;	22 Sep:	508m;	23 Sep:	557m;
24 Sep:	600m;	25 Sep:	549m;	26 Sep:	548m;
27 Sep:	588m;	28 Sep:	630m;	29 Sep:	628m;
30 Sep:	644m;	01 Oct:	566m;	02 Oct:	645m;
03 Oct:	592m;	04 Oct:	658m;	05 Oct:	698m;
06 Oct:	774m;	07 Oct:	778m;	08 Oct:	298m;
09 Oct:	387m;	10 Oct:	309m;	11 Oct:	423m;
12 Oct	1248m;	13-30 Oct: all F-channel data lost			
31 Oct:	1412m;	01 Nov:	1418m;	02 Nov:	1419m;
03 Nov:	1413m;	04 Nov:	1424m;	05 Nov:	1435m;
06 Nov:	1434m;	07 Nov:	1437m;	08 Nov:	1433m;
09 Nov:	1436m;	10-20 Nov: all F-channel data lost			
26 Nov:	231m	21 Nov:	242 m	08 Dec:	747m;
09 Dec:	1039m;	10 Dec:	1062m;	11 Dec:	1031m;
12 Dec:	1045m;	13 Dec:	1082m;	14 Dec:	1020m;
15 Dec:	1086m;	16 Dec:	1037m;	17 Dec:	1013m;
18 Dec:	1039m;	19 Dec:	1069m;	20 Dec:	1063m;
21 Dec:	1082m;	22 Dec:	1088m;	23 Dec:	1048m;
24 Dec:	1059m;	25 Dec:	1069m;	26 Dec:	1020m;
27 Dec:	1004m;	28 Dec:	1007m;	29 Dec:	1005m;
30 Dec:	955m;	31 Dec:	981m.		

Distribution of ASP data during 2001

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2001

1-minute & Hourly Mean Values

- 2000: WDC-A, Boulder, USA (20 Jun 2001)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive 2000 data for CD-ROM sent to the INTERMAGNET Paris GIN (21 Jun 2001)

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 seven principal buildings: a Recorder House; a (PPM) 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; and the *National Magnetic Calibration Facility* 100m east 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.

‡ 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[†] : Lat. -42.60°; Long. 226.77°

† Based on the IGRF 2000.0 model updated to 2001.5

- Elevation above mean sea level (top of pier): 859 metres
- Lower limit for K index of 9: 450 nT.
- Azimuth of principal reference pillar (NW) from pier AW: 328° 37' 03"
- Distance to NW Pillar: 137.3 metres
- Observers in Charge: Liejun Wang (GA)

Variometers

During 2001 (since November 1995) a Narod ring-core fluxgate (RCF) variometer operated as the principal variometer at the observatory. It was located on the pier in the eastern room of the Variometer House. It measured variations in three orthogonal components of the magnetic field, and was aligned to measure the (magnetic) north-west; north-east and vertical field components.

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.

Late in November 2001 a LEMI 3-component fluxgate variometer was installed on the pier in the western room of the Variometer House. This instrument served as reserve should the principal variometer become unserviceable.

Absolute Instruments and Corrections

Throughout 2001 absolute observations were regularly performed at Canberra with a Declination & Inclination Magnetometer (DIM) and a total field magnetometer.

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

The principal total field instrument used was GSM90 Overhauser magnetometer with electronics no. 905926 and sensor no. 81241. This magnetometer had been used routinely on Absolute House pier Aw, in parallel with PPM MNS2 no. 3, since 5 September 2000. From 2001 it replaced the PPM MNS2 no. 3 that had been in service for many years, principally within the Helmholtz coils of Proton Vector Magnetometer (PVM) serial A situated on pier AE in the Absolute House.

As detailed in the *AGR2000*, application of the new total field standard based on the GSM90 Overhauser magnetometer described above, produce results theoretically close to those based on the obsolete MNS2 no. 3 PPM. (See the *Magnetic Standards* section near the beginning of this report.) In view of the uncertainties, no difference between the old and new F-standards have been adopted. The new GSM90 standard is applied without correction.

The principal absolute magnetometers at the Canberra Magnetic Observatory also serve as the reference standards for the Australian observatory network. Their standardizations are traceable to classical instruments that were regularly calibrated by comparison the international standard.

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 (and other observatories) 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.

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

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

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

Significant Events, CNB 2001

Apr 23	Data telemetry swapped from PST Telstra line to Radio Modem Link.
Nov 23	UPS failure causing data loss (1470 minutes).
Nov 27	LEMI fluxgate variometer was installed on pier in western room of variometer hut.
Dec 19	New UPS installed.

CNB Data losses in 2001

Jan 29	0129 (1 min) All channels 0357, 0814, 0833, 1406, 1410, 1440, 2359 (7 min) F only
Feb 20	2204 to 21/0240 (4h 37m) F only
Mar 09	0338 to 13/0134 (3d 21h 57m) F only
Nov 21	0520-0527 (8 min); 0730-0735 (6 min) All channels
Nov 22	0307 to 23/0336 (1d 00h 30m), 23/0338 (1m) All channels: UPS failure
Nov 27	2351-2359 (9 min) All channels
Dec 19	2240 (1 min), 2242-2244 (3 min)

Distribution of CNB data during 2001

K indices - weekly by e-mail

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

K indices - semi-monthly by e-mail

- Adolph-Schmidt-Observatory Niemegk, Germany

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

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

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2001

1-minute & Hourly Mean Values

- 2000: WDC-A, Boulder, USA (19 Apr. 2001)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive 2000 data for CD-ROM sent to the INTERMAGNET GIN, Paris (04 May 2001)

K indices

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

The table on the next page shows K indices for Canberra for 2001.

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).

K indices & Daily K sums at Canberra (K=9 limit: 450 nT) for 2001

Date	January	February	March	April	May	June	Date
01	Q 1122 1011 09	2222 2112 14	2220 0121 10	4541 2244 26	Q 1000 0000 01	0003 2112 09	01
02	Q 1000 2113 08	1121 0111 08	1112 2332 15	3233 3334 24	1122 1110 09	D 3322 3332 21	02
03	2333 3122 19	Q 1020 0000 03	1114 4232 18	1220 0321 11	2104 2211 13	2120 0011 07	03
04	2233 4322 21	Q 0111 0010 04	1233 3344 23	2121 4442 20	1233 1111 13	3211 1211 12	04
05	1110 1112 08	1111 1111 08	3232 2222 18	1044 3333 21	Q 0000 0011 02	2211 0000 06	05
06	Q 1222 2211 13	D 2254 2233 23	1211 1111 09	2143 2334 22	0011 1112 07	1111 2221 11	06
07	1021 1211 09	2221 1122 13	1212 2211 12	3322 2442 22	1233 3331 19	1213 3110 12	07
08	2221 1233 16	0222 0222 12	1112 1222 12	D 3125 5366 31	1022 4433 19	1222 1211 12	08
09	2112 3111 12	1122 2111 11	1231 2211 13	2343 2431 22	D 3333 5543 29	D 1322 3344 22	09
10	1110 2322 12	1122 2200 10	1321 1120 11	3212 2322 17	D 2344 3231 22	D 4343 2221 21	10
11	1121 2322 14	2122 1012 11	Q 1110 1010 05	D 1122 4767 30	1011 0112 07	4322 2222 19	11
12	2232 2000 11	2111 2212 12	1122 3323 17	D 4344 3200 20	D 1324 5354 27	Q 2221 0022 11	12
13	2133 2111 14	D 2443 3343 26	2223 2112 15	D 1136 5553 29	D 3322 3343 23	2322 2222 17	13
14	1322 1122 14	D 1222 4332 19	2312 2112 14	3234 3431 23	3341 0111 14	2311 0012 10	14
15	1123 3122 15	1123 2111 12	Q 0110 0001 03	2233 3212 18	1244 1331 19	2322 0000 09	15
16	1121 4111 12	0111 1111 07	Q 0000 1111 04	2211 3211 13	2233 1001 12	2331 0001 10	16
17	0211 2331 13	Q 1000 0211 05	Q 0110 1222 09	1112 1221 11	2321 0112 12	0012 2111 08	17
18	1133 2121 14	Q 0111 1110 06	2222 1112 13	D 5553 2322 27	2212 2102 12	D 1456 4423 29	18
19	Q 1220 1012 09	1122 2321 14	D 1123 4554 25	Q 1212 2110 10	4320 1010 11	3101 2232 14	19
20	1233 3233 20	1114 3212 15	D 3365 7542 35	3321 2001 12	0111 1200 06	3233 2300 16	20
21	D 1334 3433 24	2132 3101 13	2221 1001 09	1102 1323 13	Q 0101 1000 03	D 1132 2321 15	21
22	3332 2322 20	1122 1211 11	1121 3333 17	3244 4532 27	1111 1211 09	Q 2000 0001 03	22
23	D 1214 3334 21	D 2332 3311 18	D 3434 3422 25	2245 2111 18	1211 1111 09	Q 0200 1001 04	23
24	D 3214 4433 24	1211 2100 08	1343 4320 20	Q 1222 1002 10	2201 1001 07	1112 1211 10	24
25	2121 0121 10	Q 1001 0011 04	1222 1011 10	Q 1002 3211 10	1011 1211 08	2112 1111 10	25
26	2242 3222 19	1211 1322 13	Q 1111 2001 07	1132 0122 12	1111 0000 04	0122 3333 17	26
27	2121 0101 08	D 3323 3211 18	3323 1345 24	Q 1110 1111 07	0000 1321 07	3210 0100 07	27
28	1132 3333 19	1123 4322 18	D 2255 5423 28	1534 5433 28	D 1213 3322 17	Q 0000 0000 00	28
29	D 2422 1122 16		2333 3322 21	3221 3211 15	2211 2200 10	Q 0000 0000 00	29
30	Q 2211 0101 08		2322 2233 19	Q 0000 0000 00	Q 0000 1001 02	0003 2021 08	30
31	D 0044 4443 23		D 6774 6776 50		Q 0000 0000 00		31
Mean K-sum	14.7	12.0	16.5	18.3	11.4	11.7	

Date	July	August	September	October	November	December	Date
01	2200 0211 08	2113 1311 13	Q 2211 0000 06	D 3355 4424 30	D 3323 4321 21	1223 3322 18	01
02	Q 1111 1010 06	1121 1210 09	0000 1312 07	D 3363 4444 31	1231 3102 13	1122 2221 13	02
03	0113 3121 12	1242 1121 14	1223 3334 21	D 3256 5544 34	Q 1110 0000 03	0222 2233 16	03
04	1111 1211 09	0000 1320 06	2332 2222 18	3235 2321 21	0122 2210 10	3222 2132 17	04
05	1122 1221 12	D 1224 3221 17	1110 2320 10	0112 1332 13	1023 2443 19	2212 1112 12	05
06	1112 2221 12	D 2235 5322 24	1122 1111 10	2233 2011 14	D 6763 4654 41	2233 2223 19	06
07	Q 1111 1111 08	1113 1111 10	Q 0000 0002 02	Q 0011 1002 05	D 3313 1223 18	2211 2312 14	07
08	D 2121 1233 15	1113 1100 08	1111 1210 08	2222 4424 22	2222 1111 12	2121 2011 10	08
09	3200 1021 09	1210 3222 13	Q 1002 1110 06	2234 4322 22	1211 1112 10	Q 1111 0002 06	09
10	0113 2331 14	2221 0011 09	Q 2100 0000 03	1112 3232 15	1111 1123 11	Q 0121 3221 12	10
11	1200 1010 05	Q 2100 0001 04	1101 3333 15	1221 3554 23	1113 0111 09	Q 0121 2232 13	11
12	1112 2221 12	0014 2333 16	2243 3212 19	5644 5223 31	1102 1000 05	2334 3222 21	12
13	0101 0011 04	D 2433 3222 21	2434 2310 19	2233 2111 15	1010 0210 05	Q 2220 0100 07	13
14	3322 2300 15	1223 3212 16	3222 2103 15	1321 2223 16	Q 2121 2111 11	0212 2223 14	14
15	1112 3322 15	Q 0101 0120 05	D 3223 3332 21	2422 1111 14	0112 2442 16	2222 3224 19	15
16	D 1213 2212 14	Q 0011 0000 02	1111 1322 12	2233 3222 19	1222 4311 16	2453 2221 21	16
17	D 3322 3221 18	D 0003 4555 22	1233 2112 15	Q 1111 0001 05	1322 4332 20	D 2322 2232 18	17
18	1232 1210 12	2240 2223 17	2211 2342 17	Q 1000 1111 05	2213 3212 16	2223 2221 16	18
19	0112 3220 11	0343 1110 13	3411 1121 14	4221 3322 19	D 2222 2343 20	2223 1122 15	19
20	Q 0112 2100 07	0112 1112 09	1112 1112 10	1223 3222 17	1321 0001 08	Q 1112 2111 10	20
21	Q 1210 2100 07	1223 2322 17	Q 1111 1012 08	D 2221 2567 27	0111 2111 08	D 1222 2433 19	21
22	2222 1111 12	D 1224 4333 22	2224 4210 17	D 5535 5555 38	1--- ---- --	2122 1012 11	22
23	3223 2213 18	3221 1101 11	D 1345 4553 30	3331 3211 17	-123 2323 --	1213 2313 16	23
24	2332 3223 20	Q 1101 1000 04	2221 1121 12	Q 1100 0000 02	D 2486 7625 40	D 2363 3422 25	24
25	D 3445 3432 28	0113 3222 14	1310 1066 18	0042 1122 12	2333 2111 16	2122 1222 14	25
26	4333 3122 21	2243 2114 19	D 5344 0222 22	Q 0211 0022 08	2121 0001 07	1211 1112 10	26
27	2233 2123 18	1211 3133 15	1222 1332 16	1211 2101 09	Q 2011 0112 08	1111 1111 08	27
28	Q 2320 1000 08	2212 3121 14	1243 3323 21	1544 5333 28	Q 1010 1112 07	1132 3112 14	28
29	3332 2112 17	Q 1223 0011 10	D 2325 3445 28	2333 3334 24	1121 1010 07	2644 3323 27	29
30	2211 1123 13	0112 2431 14	D 2232 4343 23	1222 1211 12	Q 1000 0011 03	D 3433 3235 26	30
31	D 3442 4433 27	2224 2312 18		0011 3333 14		D 3221 1333 18	31
Mean K-sum	13.1	13.1	14.8	18.1	13.6	15.5	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	20	83	79	50	16	0	0	0	0	0	0
February	30	93	69	24	7	1	0	0	0	0	0
March	23	76	75	42	15	8	4	5	0	0	0
April	23	56	64	50	28	13	4	2	0	0	0
May	64	89	42	36	13	4	0	0	0	0	0
June	63	62	70	35	8	1	1	0	0	0	0
July	33	86	76	44	8	1	0	0	0	0	0
August	44	80	69	37	13	5	0	0	0	0	0
September	35	70	67	43	17	6	2	0	0	0	0
October	26	57	69	48	23	20	4	1	0	0	0
November	37	87	57	30	11	2	5	2	1	0	8
December	13	66	112	45	8	2	2	0	0	0	0
ANNUAL TOTAL	**411**	**905**	**849**	**484**	**167**	**63**	**22**	**10**	**1**	**0**	**8**

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
2001.5	A	12	34.7	-66	1.5	23716	23146	5164	-53327	58362	ABC
1979.5	Q	12	5.5	-66	5.3	23844	23315	4995	-53775	58824	DFI
1980.5	Q	12	8.6	-66	6.8	23813	23280	5010	-53769	58806	DFI
1981.5	Q	12	11.4	-66	8.3	23783	23246	5022	-53767	58792	DFI
1982.5	Q	12	14.1	-66	10.1	23749	23210	5033	-53766	58778	DFI
1983.5	Q	12	16.5	-66	10.7	23734	23191	5046	-53753	58760	DFI
1984.5	Q	12	18.5	-66	11.1	23719	23174	5056	-53739	58741	DFI
1985.5	Q	12	20.7	-66	11.1	23713	23164	5070	-53724	58724	DFI
1986.5	Q	12	23.2	-66	11.6	23697	23146	5083	-53714	58709	DFI
1987.5	Q	12	25.5	-66	11.6	23690	23136	5097	-53698	58691	DFI
1988.5	Q	12	27.7	-66	12.2	23675	23118	5109	-53687	58676	DFI
1989.5	Q	12	29.1	-66	13.0	23657	23098	5114	-53680	58662	DFI
1990.5	Q	12	30.8	-66	12.8	23653	23092	5125	-53663	58645	DFI
1991.5	Q	12	31.8	-66	12.9	23645	23082	5130	-53647	58627	DFI
1992.5	Q	12	32.5	-66	12.1	23649	23085	5135	-53622	58605	DFI
1993.5	Q	12	33.0	-66	11.1	23655	23090	5140	-53594	58583	DFI
1994.5	Q	12	33.6	-66	10.2	23661	23095	5145	-53568	58561	DFI
1995.5	Q	12	33.9	-66	8.7	23675	23108	5150	-53537	58538	DFI
1996.5	Q	12	34.2	-66	7.2	23689	23108	5155	-53506	58515	ABC
1997.5	Q	12	34.2	-66	5.6	23703	23135	5159	-53474	58492	ABC
1998.5	Q	12	34.3	-66	4.8	23706	23137	5159	-53443	58464	ABC
1999.5	Q	12	34.1	-66	3.2	23716	23148	5161	-53400	58430	ABC
2000.5	Q	12	34.3	-66	2.2	23718	23149	5162	-53365	58398	ABC
2001.5	Q	12	34.7	-66	0.9	23726	23156	5167	-53324	58364	ABC
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

continued …

CNB Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1998.5	D	12	34.2	-66	6.4	23678	23110	5153	-53450	58459	ABC
1999.5	D	12	34.1	-66	4.6	23692	23124	5156	-53407	58427	ABC
2000.5	D	12	34.2	-66	4.2	23685	23117	5155	-53372	58392	ABC
2001.5	D	12	34.6	-66	2.7	23695	23126	5159	-53331	58358	ABC

Elements ABC indicates non-aligned variometer orientation

Principal Magnetic Storms: Canberra 2001

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.		No	Principal			Magnetic		Storms				
Feb.		No	Principal			Magnetic		Storms				
Mar. 19	11 ··	···	··	··	··	20(5)	7	36.3	228	100	20	23
30	21 ··	···	··	··	··	31(2,3,6,7)	7	58.2	500	382	01	09
Apr. 08	09 ··	···	··	··	··	08(7,8)	6	26.1	116	71	08	23
11	13 ··	···	··	··	··	11(6,8)	7	30.1	380	90	12	18
13	07 33	ssc	0.9	27	3	13(4)	6	29.6	154	85	13	22
May 08	09 ··	···	··	··	··	09(5,6)	5	21.2	127	45	10	03
12	03 ··	···	··	··	··	12(5,7)	5	16.4	108	39	14	09
Jun. 18	03 ··	···	··	··	··	18(4)	6	19.0	122	61	19	03
Jul.		No	Principal			Magnetic		Storms				
Aug. 06	06 ··	···	··	··	··	06(4,5)	5	10.6	73	29	07	03
17	11 03	ssc	-1.7	+33	+9	17(6,7,8)	5	14.3	135	49	18	09
Sep. 23	04 ··	···	··	··	··	23(4,6,7)	5	18.7	106	53	24	06
25	20 24	ssc*	+16.1*	+60	-18	25(7,8)	6	22.8	164	48	26	12
30	12 ··	···	··	··	··	02(3), 03(4)	6	33.5	224	85	04	21
Oct. 11	12 ··	···	··	··	··	12(2)	6	22.5	210	64	12	21
21	16 48	ssc*	+6.5*	+69	+6	21(8)	7	34.0	335	81	23	09
28	03 18	ssc*	+3.0*	+78	+9	28(2,5)	5	22.8	184	66	29	03
Nov. 05	09 ··	···	··	··	··	06(2)	7	43.3	351	248	07	06
24	05 00	ssc	+0.8	+51	+6	24(3)	8	40.0	524	161	25	12
Dec. 23	22 ··	···	··	··	··	24(3)	6	18.8'	169	67	25	12

CNB - Rapid Variation Phenomena 2001

Sudden Storm Commencements (ssc) - CNB 2001

Month & date	U.T.	Type & Quality	Chief movement (nT) H	D	Z
Jan 17	1630	ssc* A	+21 *	+12 *	0
23	1048	ssc* B	+54	+9 *	+12
31	0806	ssc B	+54	+12	+9
Mar 22	1345	ssc B	+27	+3	+6
Apr 04	1457	ssc C	+54	+18	+9
13	0733	ssc C	+27	+6	+3
28	0500	ssc* C	+63 *	+18	+6
May 27	1458	ssc A	+21	+9	+3
Aug 03	0715	ssc C	+39	-12	+9
12	1118	ssc C	+42	+6	+9
17	1103	ssc C	+33	-12	+9
Aug 27	1951	ssc C	+27	+24	0
Sep 25	2024	ssc* C	+60	+111 *	-18
Oct 21	1648	ssc* b	+69	+45 *	+6
25	0848	ssc b	+51	+3	+9
28	0318	ssc* b	+78	+21 *	+9
31	1348	ssc b	+30	0	+6
Nov 15	1509	ssc b	+27	+3	+6
24	0500	ssc b	+51	+6	+6
Dec 29	0539	ssc b	+111	+15	+12
30	2009	ssc b	+21	+18	+6

Canberra 2001 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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23159.2	5161.9	-53339.3	58378.7	23727.5	12° 33.9'	-66° 01.1'
	5xQ days	23167.7	5166.6	-53338.1	58381.4	23736.8	12° 34.3'	-66° 00.6'
	5xD days	23150.7	5156.1	-53337.4	58373.1	23717.9	12° 33.3'	-66° 01.6'
February	All days	23155.9	5164.1	-53334.4	58373.2	23724.8	12° 34.3'	-66° 01.1'
	5xQ days	23161.0	5165.6	-53333.0	58374.0	23730.1	12° 34.4'	-66° 00.8'
	5xD days	23148.8	5161.2	-53336.0	58371.5	23717.2	12° 34.1'	-66° 01.6'
March	All days	23138.1	5162.8	-53334.4	58366.0	23707.1	12° 34.7'	-66° 02.1'
	5xQ days	23155.7	5166.1	-53329.6	58368.8	23725.0	12° 34.6'	-66° 01.0'
	5xD days	23087.7	5152.4	-53345.8	58355.6	23655.7	12° 34.8'	-66° 05.1'
April	All days	23123.9	5161.7	-53342.4	58367.6	23693.0	12° 35.0'	-66° 03.0'
	5xQ days	23138.2	5165.7	-53340.2	58371.6	23707.8	12° 35.1'	-66° 02.2'
	5xD days	23100.7	5158.3	-53345.4	58360.8	23669.6	12° 35.3'	-66° 04.4'
May	All days	23145.3	5166.3	-53333.5	58368.3	23714.9	12° 35.0'	-66° 01.7'
	5xQ days	23153.4	5168.1	-53330.9	58369.3	23723.2	12° 35.0'	-66° 01.1'
	5xD days	23122.3	5160.2	-53339.1	58363.7	23691.1	12° 34.8'	-66° 03.1'
June	All days	23148.2	5167.4	-53328.1	58364.6	23718.0	12° 35.0'	-66° 01.4'
	5xQ days	23154.6	5168.8	-53325.7	58365.1	23724.5	12° 35.0'	-66° 00.9'
	5xD days	23134.8	5166.1	-53332.0	58362.8	23704.6	12° 35.3'	-66° 02.2'
July	All days	23152.6	5167.6	-53322.9	58361.6	23722.3	12° 34.9'	-66° 01.0'
	5xQ days	23157.7	5167.6	-53321.7	58362.5	23727.3	12° 34.8'	-66° 00.7'
	5xD days	23148.0	5166.6	-53323.6	58360.4	23717.5	12° 34.9'	-66° 01.3'
August	All days	23151.1	5166.5	-53318.6	58357.0	23720.6	12° 34.8'	-66° 01.0'
	5xQ days	23155.3	5167.6	-53317.5	58357.7	23724.9	12° 34.8'	-66° 00.7'
	5xD days	23143.0	5162.0	-53319.9	58354.6	23711.8	12° 34.4'	-66° 01.5'
September	All days	23150.2	5168.1	-53315.9	58354.4	23720.1	12° 35.1'	-66° 01.0'
	5xQ days	23161.2	5169.6	-53313.9	58357.0	23731.1	12° 34.9'	-66° 00.3'
	5xD days	23137.4	5166.2	-53317.6	58350.7	23707.1	12° 35.2'	-66° 01.7'
October	All days	23130.0	5160.8	-53322.3	58351.5	23698.8	12° 34.7'	-66° 02.3'
	5xQ days	23149.1	5166.5	-53316.4	58354.2	23718.6	12° 34.9'	-66° 01.0'
	5xD days	23089.7	5145.3	-53328.3	58339.7	23656.1	12° 33.7'	-66° 04.7'
November	All days	23139.4	5163.0	-53320.5	58353.8	23708.4	12° 34.7'	-66° 01.7'
	5xQ days	23155.5	5166.3	-53315.3	58355.8	23724.9	12° 34.6'	-66° 00.7'
	5xD days	23097.4	5154.7	-53337.2	58351.8	23665.7	12° 34.8'	-66° 04.4'
December	All days	23163.3	5164.0	-53310.3	58354.1	23732.0	12° 34.1'	-66° 00.2'
	5xQ days	23163.2	5163.7	-53308.4	58352.2	23731.8	12° 34.0'	-66° 00.1'
	5xD days	23156.3	5162.1	-53312.3	58353.0	23724.8	12° 34.0'	-66° 00.6'
Annual	All days	23146.4	5164.5	-53326.9	58362.5	23715.6	12° 34.7'	-66° 01.5'
Mean	5xQ days	23156.0	5166.9	-53324.2	58364.1	23725.5	12° 34.7'	-66° 00.9'
Values	5xD days	23126.4	5159.3	-53331.2	58358.1	23694.9	12° 34.6'	-66° 02.7'

(Calculated:15:59 hrs., Mon. 24 Feb. 2003)

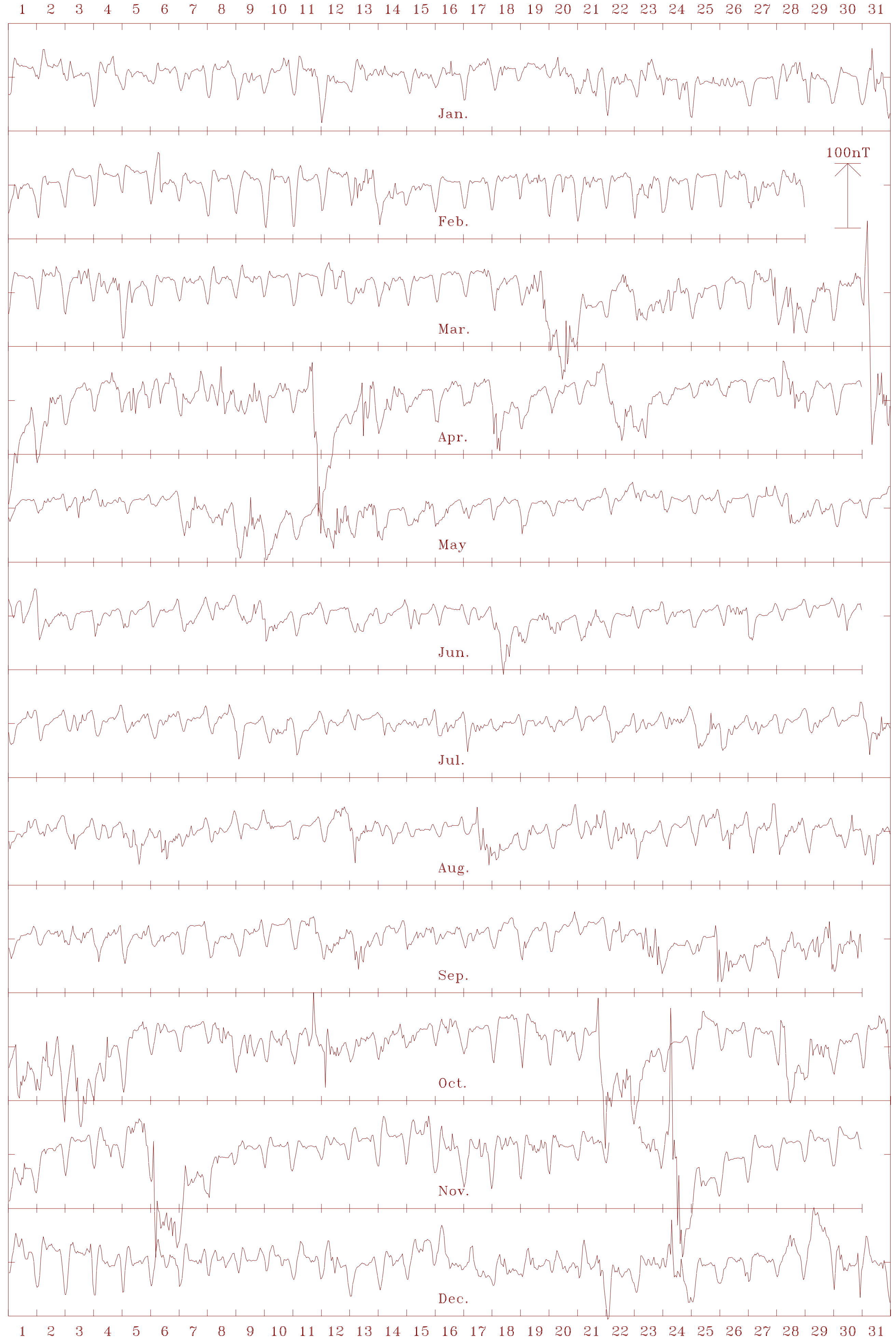
Hourly Mean Values

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.

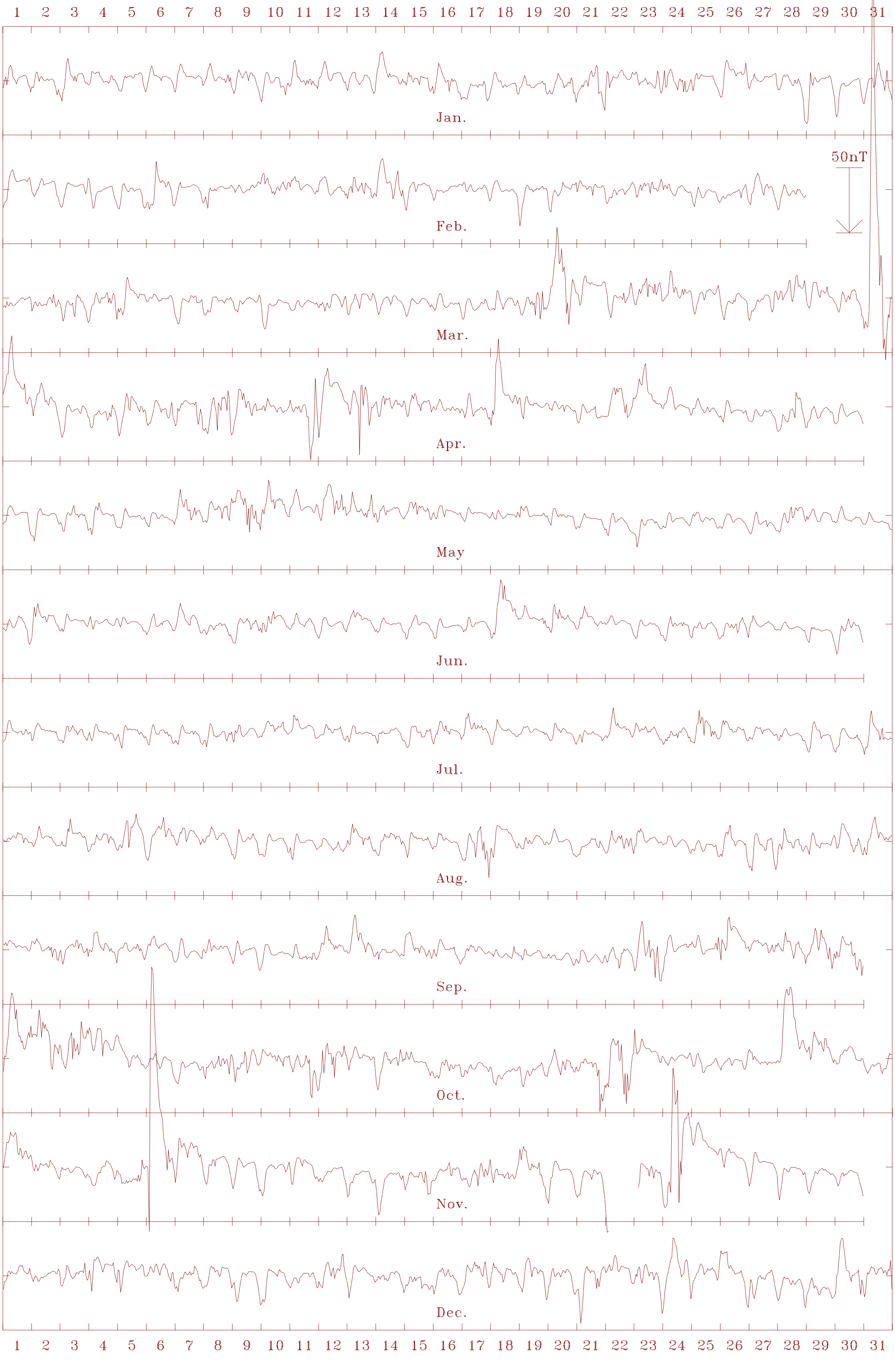
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Canberra 2001 Horizontal intensity (H). Scale: 8.0 nT/mm. Mean: 23716 nT

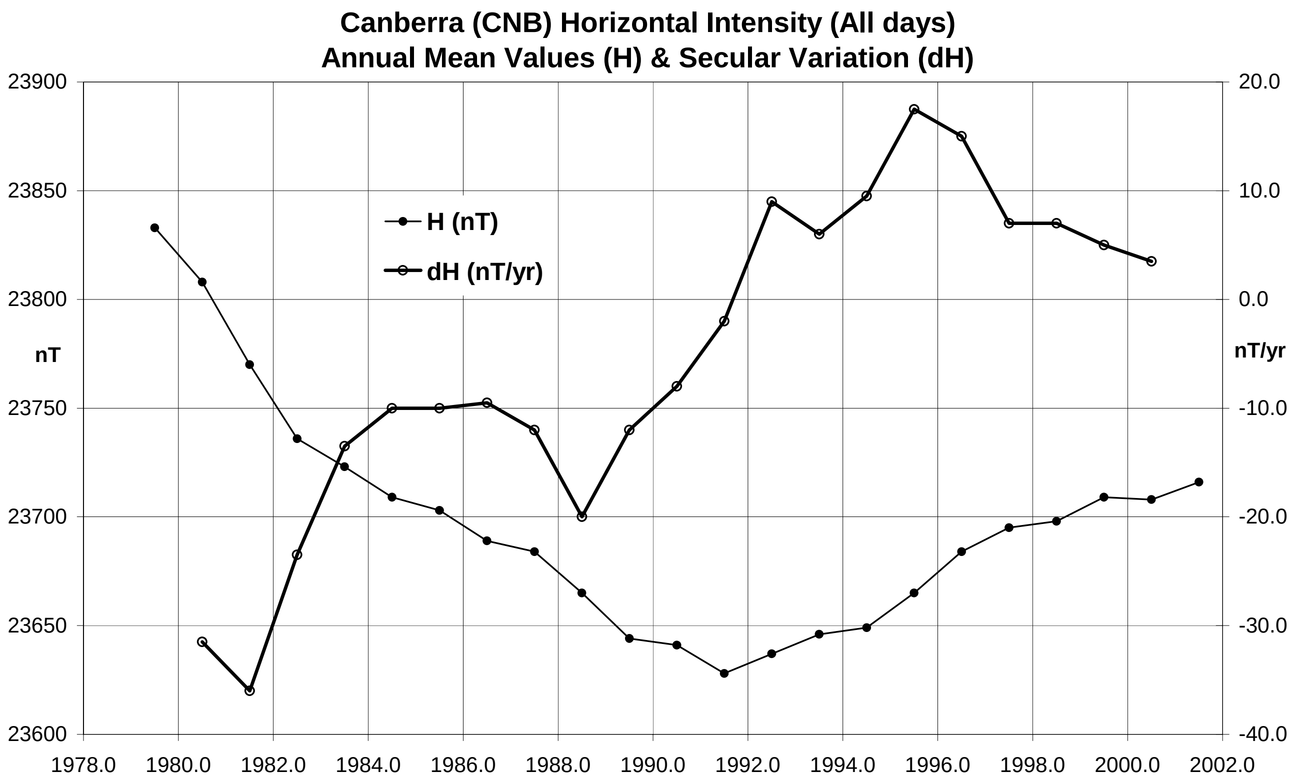


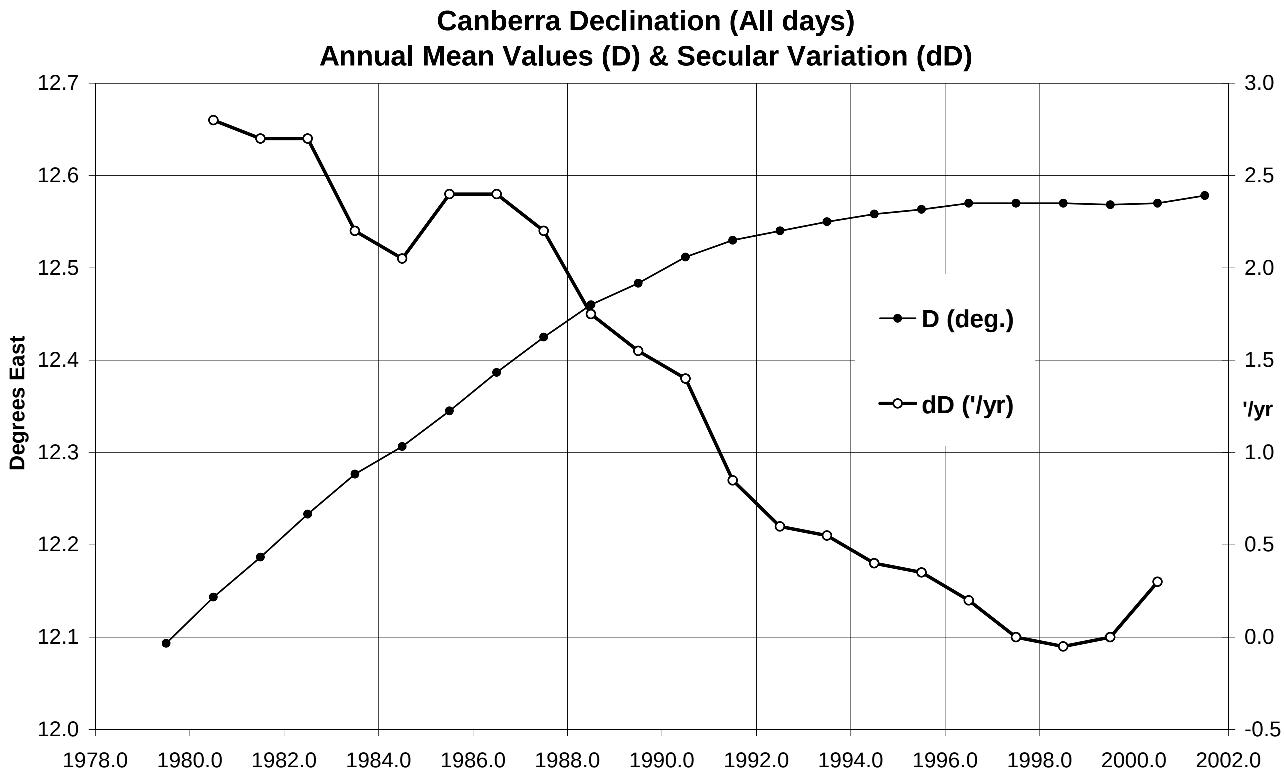
Canberra 2001 Declination (east) (D). Scale: 1.00 min/mm. Mean: 12.58 deg.

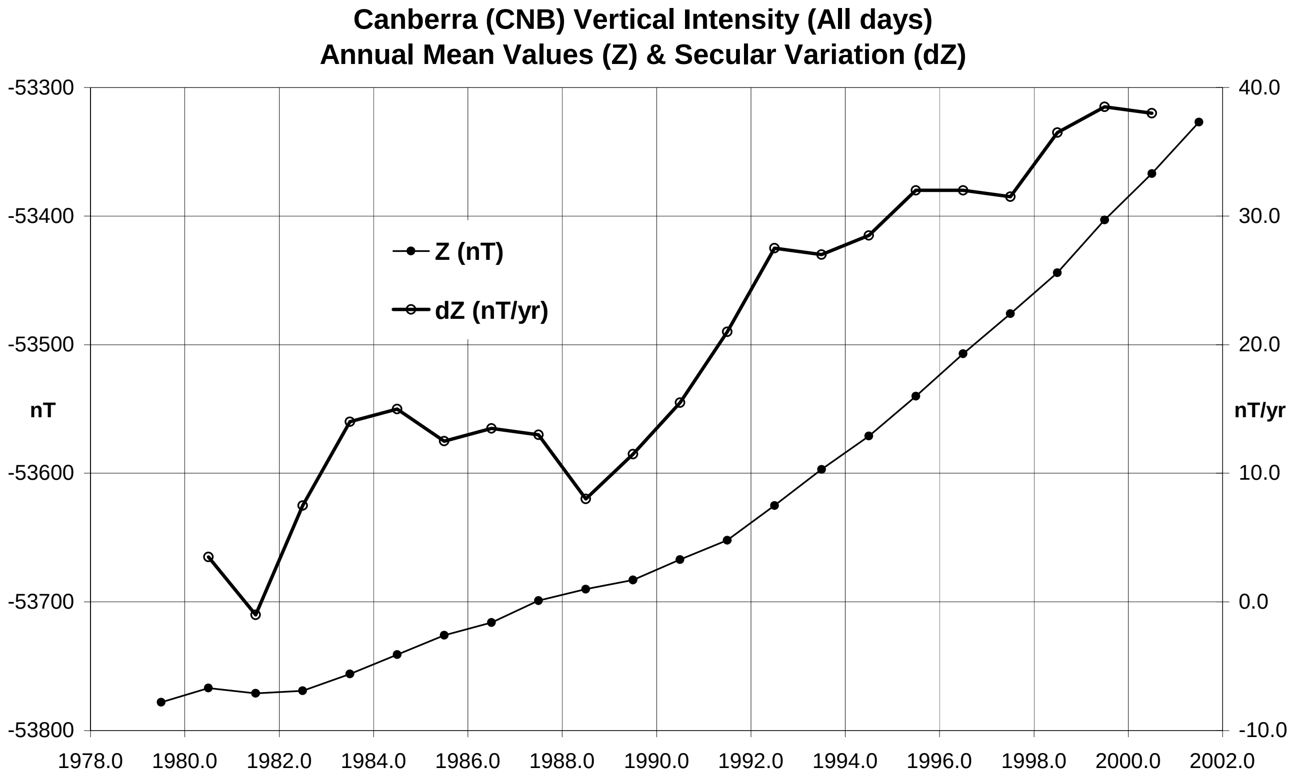
Canberra 2001 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −53327 nT

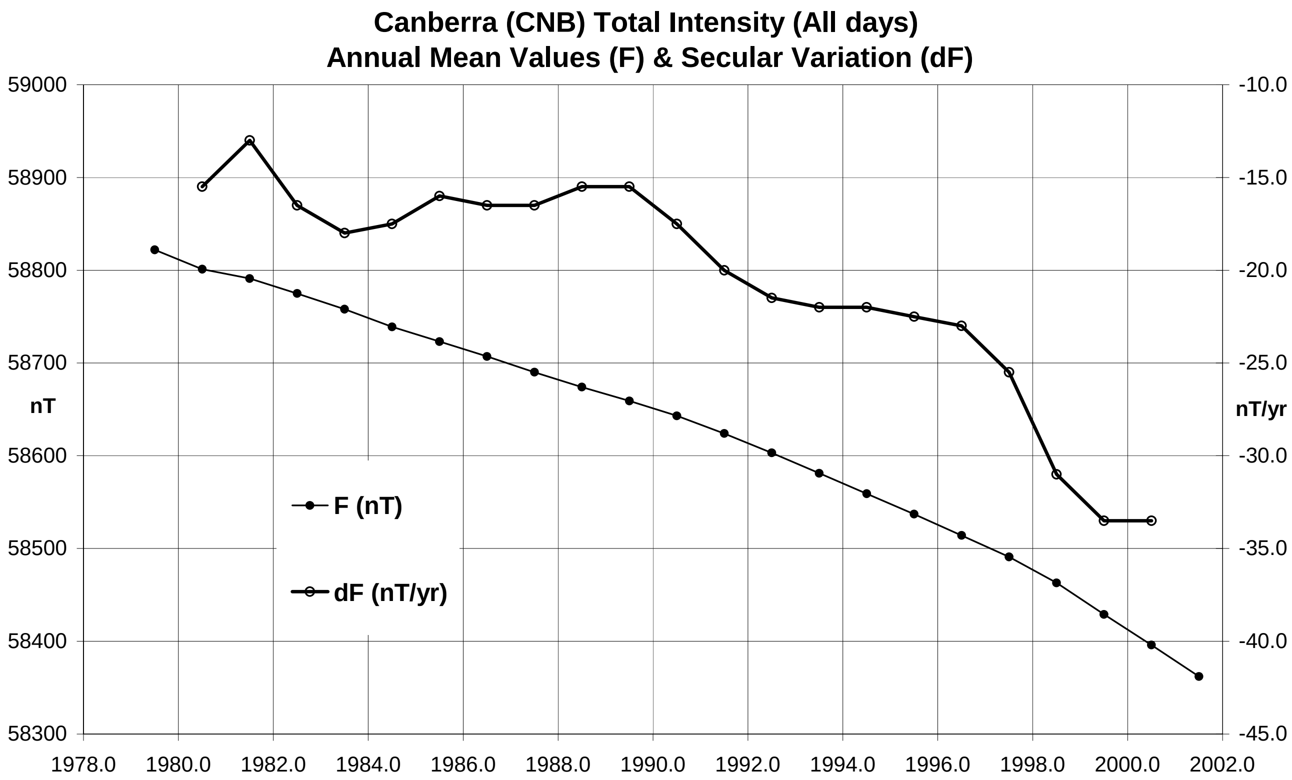


Canberra 2001 Total intensity (F). Scale: 4.0 nT/mm. Mean: 58363 nT


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 2001 (cont.)

Solar Flare Effects (sfe) - CNB 2001

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confirmation
Jun. 23	0406	0408	0410	-8	+5	-3	solar
Sep 09	2042	2045	2051	+6	0	0	solar
Oct 19	0054	0110	0145	-33	-18	0	solar
Nov 05	0252	0254	0256	+2	+3	0	solar
08	0700	0704	0709	+5	+6	0	solar
30	0103	0108	0115	-6	0	0	solar
Dec 11	0803	0809	0824	+15	+6	0	solar
28	0345	0351	0403	+4	+3	0	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 and recording equipment at Charters Towers were located within a disused gold mine tunnel approximately 100m into the northern side of Towers Hill on the site of the University of Queensland's Seismograph Station. The hilly area on the outskirts of the town where the observatory was located is approximately 1.7km SW of the town centre.

Although not controlled, the temperature within the tunnel where the variometers were located, varied very little over the year: from about 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† : Lat. -27.96°; Long. 220.80°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of pier): 370 metres
- Lower limit for K index of 9: 300 nT.
- Azimuth of principal reference PO spire from pier C: 34° 40' 45"
- Distance to PO Spire: 1.75km.
- Observer in Charge: J.M. Millican (Uni. of Qld.)

Variometers

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

From 28 August 2000, and throughout 2001, the principal variometer employed at CTA observatory was a DMI FGE suspended 3-component fluxgate magnetometer (electronics E0227, sensor S0210). The sensor head of the instrument was located on the same concrete blocks in the mine tunnel that the EDA FM-105B sensors were previously. Its sensors were aligned with two of them horizontal, aligned at an approximately equal angle on either side of the magnetic meridian (magnetically NW and NE), and the third sensor vertical.

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

The DMI electronics unit (E0227) dial offsets were:
X-coil: A (coarse), C(fine); Y-coil: A (coarse), C (fine);
Z-coil: 1 (coarse), C (fine).

DMI electronics unit E0227 failed at 1400 on 04 Feb 2001. A spare DMI electronics unit (E0199) was deployed between 2300 on 07 Feb. to 2300 on 21 Feb 2001. E0227 was repaired at GA headquarters and reinstalled at 2300 on 21 Feb 2001.

There was also a cycling proton precession magnetometer monitoring variations in the magnetic total intensity, F. Elsec 820 no. 138 PPM was employed throughout 2001. 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.

Throughout 2001 mean data values over 1-second and 1-minute intervals were recorded in the components A (NW), B (NE), C (Z), as well as the DMI variometer sensor & electronics temperatures. Analogue outputs of A (X-coil), B (Y-coil), C (Z-coil) from the DMI FGE 3-channel fluxgate, along with the fluxgate head and electronics temperature channels, were converted to digital data with an ADAM 4017 A/D converter mounted inside the electronics console. 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.

Absolute Instruments and Corrections

Throughout 2001 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.

By regular intercomparisons of 'travelling' standard absolute magnetometers at Canberra and at Charters Towers, the following corrections to the abovementioned absolute magnetometers used at CTA have been determined to align them with the Australian Magnetic Standard.

Year	D(')	I(')	F(nT)
1995	+0.2	+0.05	+1.4
1996	0.0	0.0	+1.0
1997	0.1	+0.04	+1.27
1998	-0.2	+0.05	+0.6

As no absolute magnetometer intercomparisons were performed at Charters Towers magnetic observatory from 1999 to 2001, the instrument corrections for 2001 was taken as the average between 1995 to 1998, ie:

D = 0.0'   I = 0.0'   F = 1.0nT

These magnetometer corrections translate to baseline value adjustments of:

X = 0.0 nT   Y = 0.0 nT   Z = 0.0 nT

Operations

The officer in charge at CTA observatory performed most routine operations during 2001. Tasks included:

- weekly performance of a set of absolute observations
- Temperature check about 3 times each week
- 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.

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.

Distribution of CTA data during 2001

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

- 1998: to WDC-A, Boulder USA on 06 Jun. 2001
- 1999: to WDC-A, Boulder USA on 04 Apr. 2001
- 2000: to WDC-A, Boulder USA on 04 Apr. 2001

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2001

1-minute Values (in INTERMAGNET format)

- 1998: to WDC-C1, Copenhagen on 06 Jun. 2001

Significant Events 2001

Feb 04 Earthmoving equipment began operating at about 2200UT some 150m to north of variometers.

DMI electronics unit E0227 failed at 1325UT and then entered an unstable phase at 19:35 UT.

Feb 07 0600: Spare electronics unit E0199 started operation.

Feb 21 2323: Original DMI electronics E0227 put back into service repair.

May 07 0500 (approx.): PPM data became very noisy

May 24 PPM fault rectified by replacement of sensor head (with s/n 28079907).

Nov 10 UPS stopped working.

Nov 26 2200: Tradesmen began repairing tunnel timber, causing data contamination.

Dec 03 0435: Tunnel repair work completed.

CTA Data losses in 2001

Data loss due to instrument failure, UPS failure and system reboots:

Feb 07 0425-0427 (3m) DMI channels only

Feb 21 2315-2316 (2m) DMI channels only

May 01 1230 to 02/0040 (12h 11m) All channels

May 11 0029-0035 (7m) F only

May 21 0109-0134 (26m), 0136-0149 (14m) F only

May 24 2345 to 25/0006 (22m) F only

Nov 09 0223-0224 (2m); 0230 to 10/0440 (1d 02h 11m) All channels: UPS failed

Nov 10 0857-0859 (3m) All channels
0441-0444 (4m); 0900-2037 (11h 38m) F only

Dec 10 0455-0529 (35m) All channels
0530-2109 (15h 40m) F only

Dec 11 0316-0351 (36m), 0411-0419 (9m) All channels
0352-0410 (19m); 0420-0441 (22m) F only

Dec12 0716-0855 (01h 40m) All channels
0856-2131 (12h 36m) F only

Data contaminated by activities near variometers such as tunnel repairs so processing inhibited (total 10d 03h 42m).

Feb 04 1325 to 07/0935 (2d 20h 11m)

Feb 21 2136-2331 (01h 55m)

Mar 10 0404-0411 (8m)

Mar 17 0405 (1m), 0504-0505 (02m)

Mar 23 0110-0117 (8m), 0211 (1m)

Nov 26 2200 to Dec 03/0459 (6d 07h 00m)

Dec 05 0436-0439 (4m)

Dec 11 0215-0219 (5m)

Dec 12 0713-0719 (7m)

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.

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

Year	Days	D		I		H	X	Y	Z	F	Elts
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
1983.729	A	7	40.4	-50	17.7	31786	31501	4244	-38280	49756	XYZ
1984.5	A	7	41.9	-50	18.2	31777	31491	4256	-38280	49751	XYZ
1985.5	A	7	43.2	-50	18.0	31776	31488	4268	-38276	49747	XYZ
1986.5	A	7	44.4	-50	18.4	31768	31479	4278	-38274	49740	XYZ
1987.5	A	7	45.5	-50	18.2	31769	31478	4288	-38271	49738	XYZ
1988.5	A	7	46.3	-50	19.2	31751	31459	4294	-38270	49727	XYZ
1989.5	A	7	47.0	-50	20.1	31731	31439	4297	-38267	49711	XYZ
1990.5	A	7	47.2	-50	19.8	31731	31438	4299	-38260	49706	XYZ
1991.5	A	7	47.4	-50	19.8	31719	31427	4299	-38248	49689	XYZ
1992.5	A	7	47.3	-50	18.0	31732	31439	4300	-38221	49676	XYZ
1993.5	A	7	47.4	-50	15.9	31743	31450	4303	-38188	49658	XYZ
1994.5	A	7	47.6	-50	14.1	31748	31455	4305	-38151	49633	XYZ
1995.5	A	7	47.7	-50	11.1	31770	31476	4309	-38112	49617	XYZ
1996.5	A	7	47.4	-50	8.1	31793	31500	4309	-38071	49600	XYZ
1997.5	A	7	47.0	-50	5.5	31803	31510	4307	-38024	49571	XYZ
1998.5	A	7	46.5	-50	3.0	31805	31513	4302	-37972	49532	XYZ
1999.5	A	7	45.5	-49	59.8	31816	31525	4295	-37913	49494	XYZ
2000.5	A	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	ABC
2001.5	A	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	ABC
1983.729	Q	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	XYZ
1984.5	Q	7	41.9	-50	17.5	31788	31502	4258	-38278	49756	XYZ
1985.5	Q	7	43.2	-50	17.4	31787	31499	4270	-38274	49752	XYZ
1986.5	Q	7	44.4	-50	17.8	31778	31489	4280	-38272	49745	XYZ
1987.5	Q	7	45.5	-50	17.7	31776	31486	4289	-38269	49742	XYZ
1988.5	Q	7	46.4	-50	18.3	31764	31472	4296	-38268	49733	XYZ
1989.5	Q	7	47.0	-50	19.1	31746	31454	4299	-38265	49719	XYZ
1990.5	Q	7	47.3	-50	18.8	31746	31454	4302	-38257	49714	XYZ
1991.5	Q	7	47.3	-50	18.6	31739	31446	4301	-38244	49698	XYZ
1992.5	Q	7	47.4	-50	17.1	31746	31453	4303	-38218	49683	XYZ
1993.5	Q	7	47.4	-50	15.3	31754	31461	4304	-38185	49663	XYZ
1994.5	Q	7	47.6	-50	13.2	31762	31469	4307	-38148	49640	XYZ
1995.5	Q	7	47.7	-50	10.4	31781	31488	4310	-38109	49622	XYZ
1996.5	Q	7	47.4	-50	7.7	31799	31506	4310	-38070	49603	XYZ
1997.5	Q	7	46.9	-50	4.9	31812	31519	4308	-38023	49576	XYZ
1998.5	Q	7	46.4	-50	2.5	31815	31522	4303	-37971	49537	XYZ
1999.5	Q	7	45.5	-49	59.3	31825	31534	4296	-37911	49499	XYZ
2000.5	Q	7	44.8	-49	57.2	31823	31533	4290	-37864	49461	ABC
2001.5	Q	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	ABC
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
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABC

Charters Towers 2001 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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31543.1	4287.9	-37840.5	49449.5	31833.2	7° 44.5'	-49° 55.7'
	5xQ days	31554.6	4293.9	-37841.3	49458.0	31845.4	7° 44.9'	-49° 55.1'
	5xD days	31533.4	4283.0	-37839.2	49441.9	31822.9	7° 44.1'	-49° 56.2'
February	All days	31539.3	4292.3	-37834.9	49443.2	31830.1	7° 45.0'	-49° 55.6'
	5xQ days	31547.4	4296.8	-37834.9	49448.8	31838.7	7° 45.4'	-49° 55.1'
	5xD days	31526.0	4288.6	-37836.3	49435.5	31816.4	7° 44.8'	-49° 56.4'
March	All days	31520.6	4287.5	-37833.3	49429.7	31810.9	7° 44.8'	-49° 56.5'
	5xQ days	31542.0	4291.9	-37829.2	49440.5	31832.6	7° 44.9'	-49° 55.2'
	5xD days	31460.6	4277.8	-37839.4	49395.3	31750.1	7° 44.6'	-50° 00.1'
April	All days	31504.1	4283.9	-37837.1	49421.7	31794.0	7° 44.6'	-49° 57.6'
	5xQ days	31520.6	4286.3	-37832.7	49429.1	31810.7	7° 44.6'	-49° 56.5'
	5xD days	31476.8	4280.4	-37841.5	49407.4	31766.5	7° 44.6'	-49° 59.3'
May	All days	31528.3	4287.0	-37828.8	49431.0	31818.4	7° 44.6'	-49° 55.9'
	5xQ days	31538.1	4289.1	-37826.2	49435.4	31828.4	7° 44.7'	-49° 55.3'
	5xD days	31501.2	4282.3	-37833.7	49417.1	31791.0	7° 44.5'	-49° 57.6'
June	All days	31531.7	4287.2	-37822.7	49428.6	31821.8	7° 44.6'	-49° 55.5'
	5xQ days	31538.7	4289.5	-37821.4	49432.3	31829.1	7° 44.7'	-49° 55.0'
	5xD days	31518.3	4285.9	-37823.8	49420.8	31808.4	7° 44.6'	-49° 56.2'
July	All days	31535.0	4285.4	-37819.2	49427.8	31824.8	7° 44.3'	-49° 55.2'
	5xQ days	31539.8	4285.5	-37818.4	49430.3	31829.6	7° 44.3'	-49° 54.9'
	5xD days	31529.8	4284.1	-37819.7	49424.8	31819.5	7° 44.3'	-49° 55.5'
August	All days	31533.9	4284.5	-37814.3	49423.3	31823.6	7° 44.2'	-49° 55.0'
	5xQ days	31538.7	4285.0	-37812.8	49425.2	31828.4	7° 44.2'	-49° 54.7'
	5xD days	31525.6	4281.1	-37815.1	49418.4	31815.0	7° 44.0'	-49° 55.5'
September	All days	31531.2	4287.1	-37810.4	49418.9	31821.3	7° 44.6'	-49° 55.0'
	5xQ days	31543.7	4290.4	-37808.9	49426.0	31834.1	7° 44.7'	-49° 54.2'
	5xD days	31514.1	4284.0	-37815.0	49411.2	31803.9	7° 44.5'	-49° 56.1'
October	All days	31508.0	4281.8	-37813.6	49406.0	31797.6	7° 44.3'	-49° 56.4'
	5xQ days	31534.0	4285.7	-37808.1	49418.8	31824.0	7° 44.4'	-49° 54.7'
	5xD days	31459.5	4269.2	-37821.2	49379.8	31747.8	7° 43.7'	-49° 59.4'
November	All days	31512.8	4282.1	-37814.4	49409.8	31802.4	7° 44.3'	-49° 56.1'
	5xQ days	31545.3	4288.1	-37809.6	49427.3	31835.4	7° 44.5'	-49° 54.2'
	5xD days	31456.6	4273.6	-37822.8	49379.6	31745.6	7° 44.2'	-49° 59.5'
December	All days	31537.7	4283.3	-37807.1	49420.2	31827.2	7° 44.1'	-49° 54.5'
	5xQ days	31539.9	4283.6	-37808.2	49422.4	31829.5	7° 44.1'	-49° 54.4'
	5xD days	31525.3	4280.8	-37808.2	49412.9	31814.6	7° 44.0'	-49° 55.2'
Annual	All days	31527.1	4285.8	-37823.0	49425.8	31817.1	7° 44.5'	-49° 55.7'
Mean	5xQ days	31540.2	4288.8	-37821.0	49432.8	31830.5	7° 44.6'	-49° 54.9'
Values	5xD days	31502.3	4280.9	-37826.3	49412.1	31791.8	7° 44.3'	-49° 57.2'

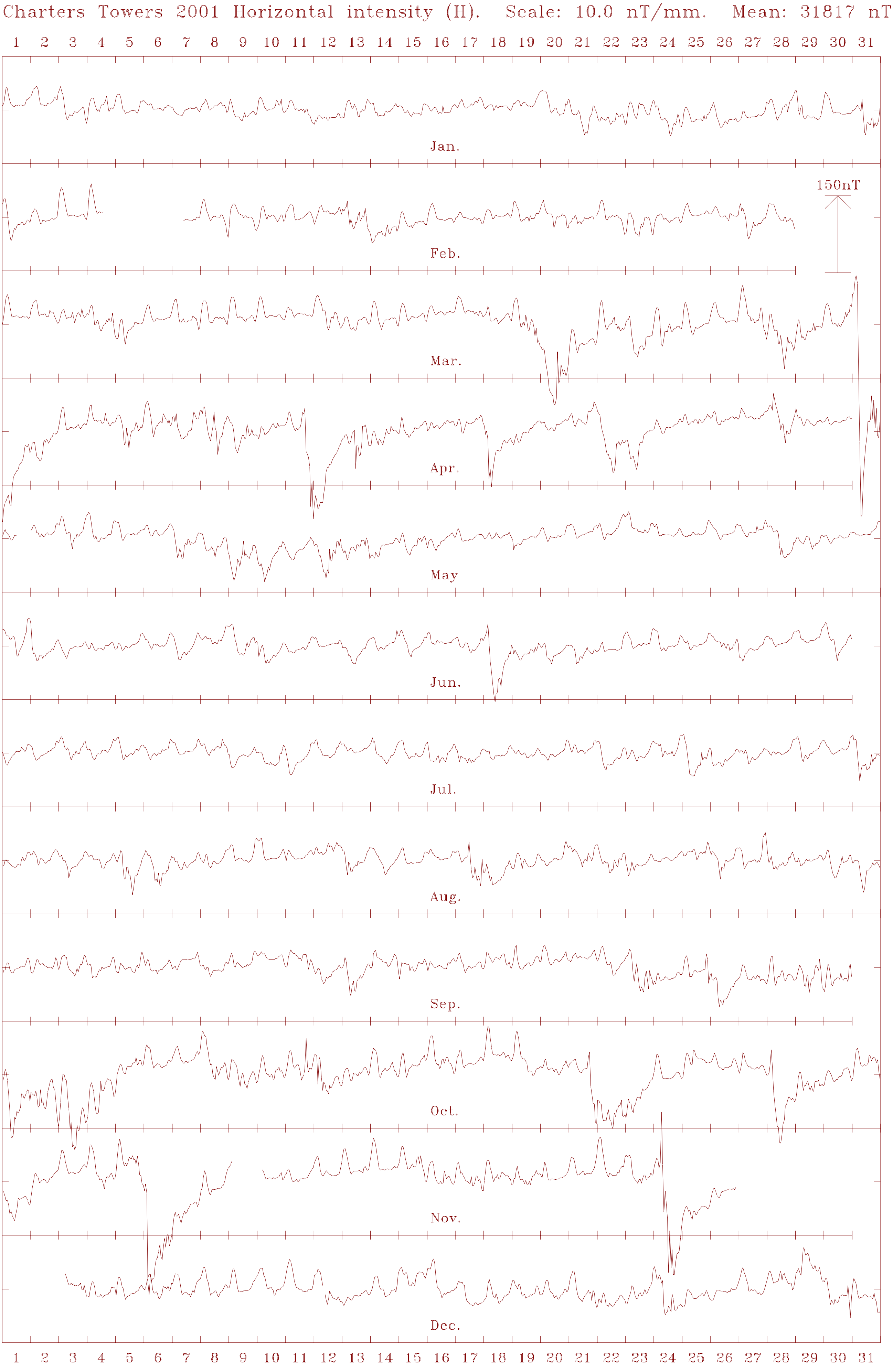
(Calculated:14:34 hrs., Tue. 11 Mar. 2003)

Hourly Mean Values

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

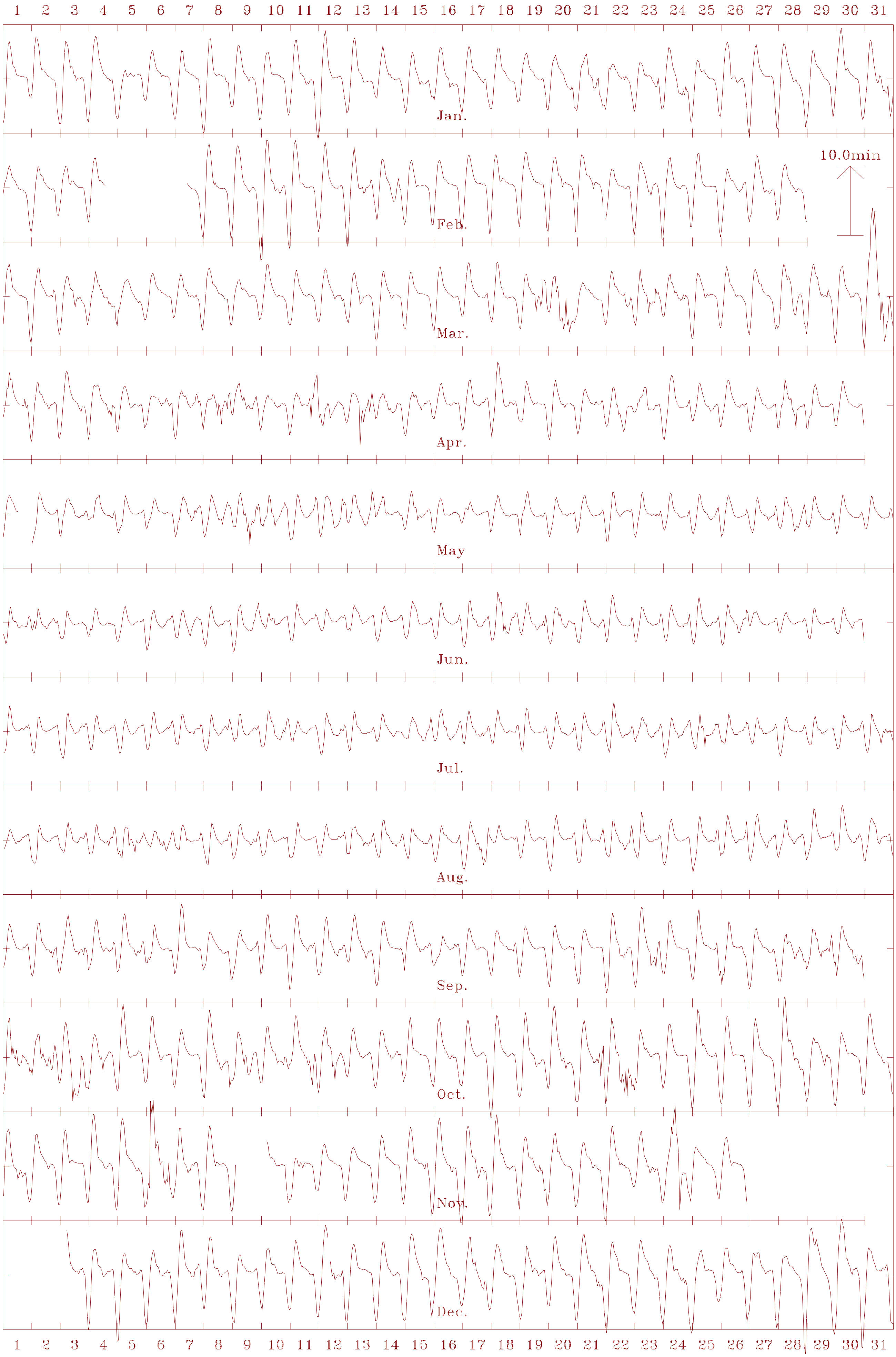
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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



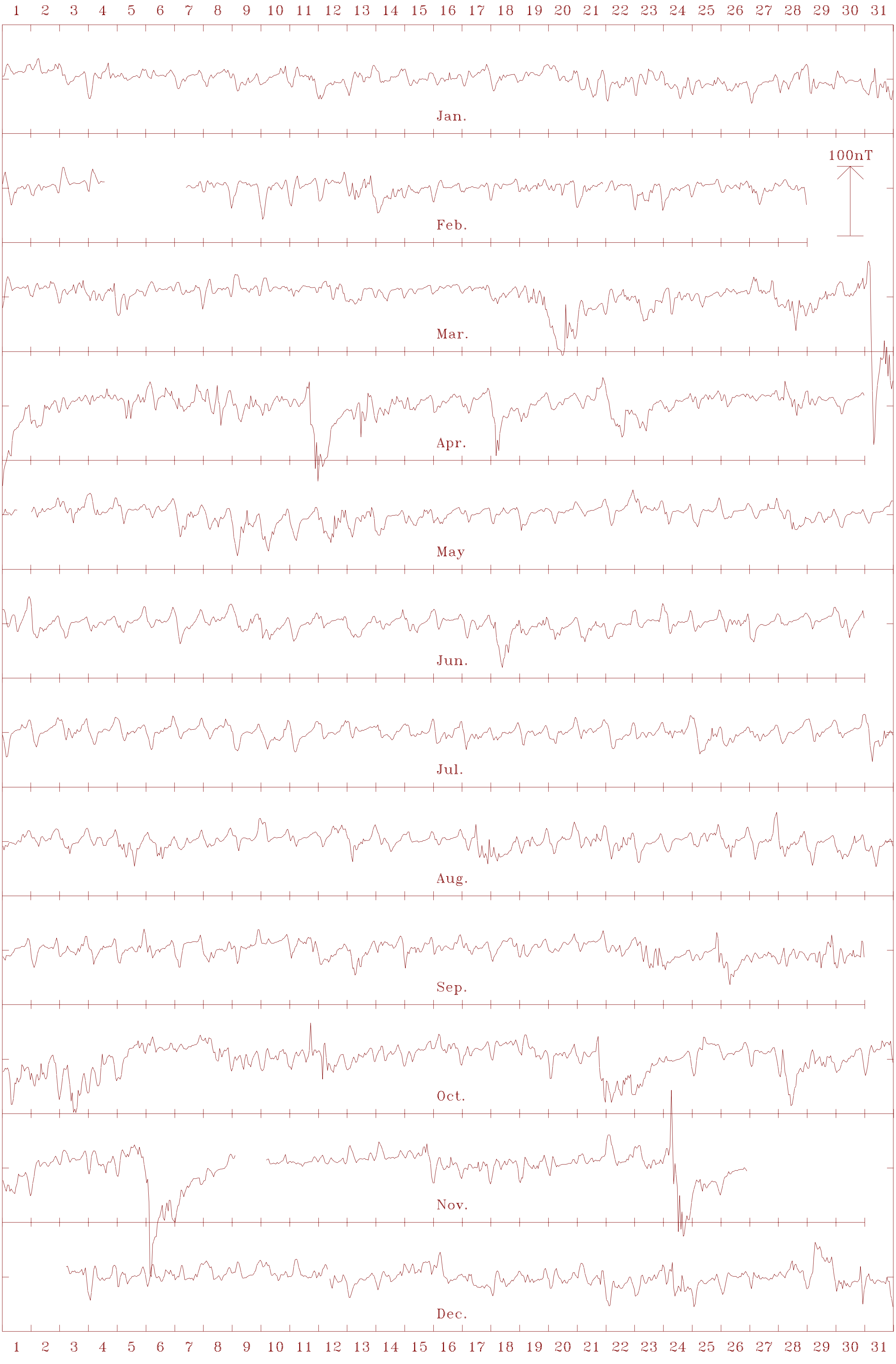
Charters Towers 2001 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 31817 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
150nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.

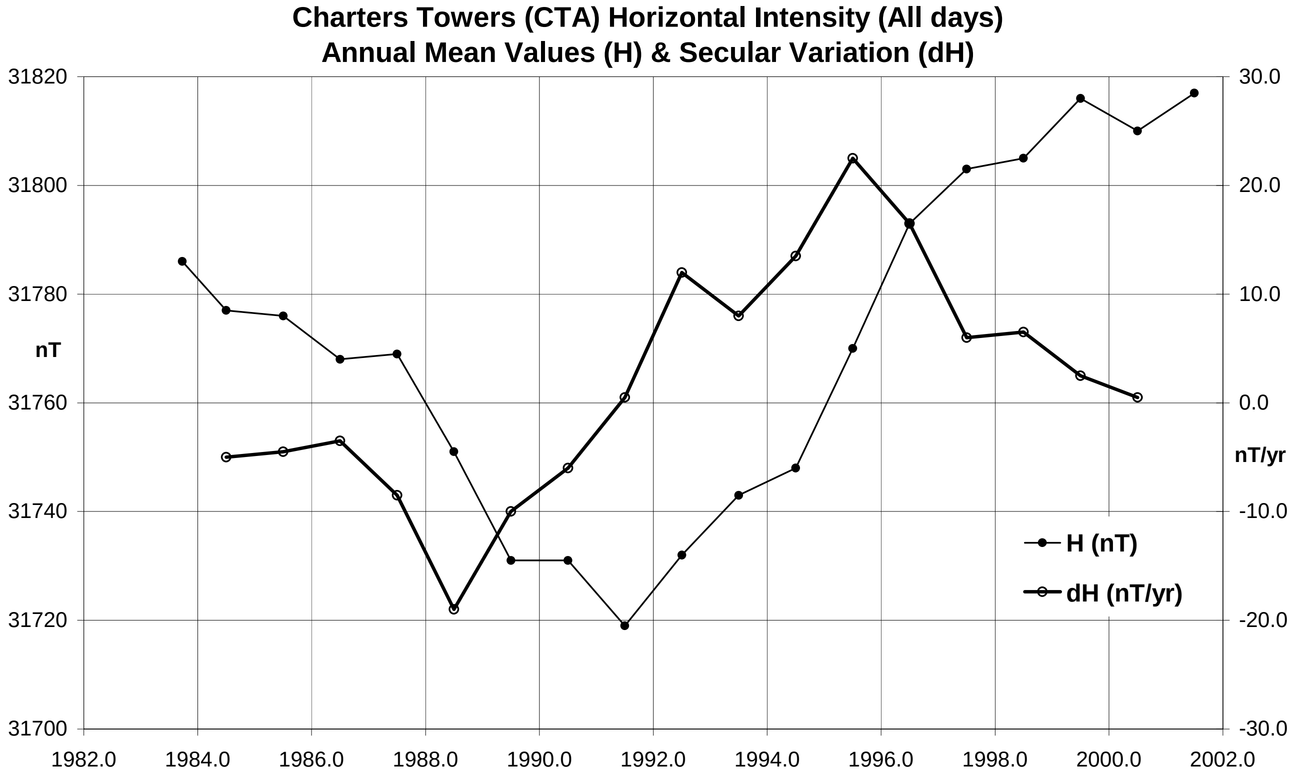
Charters Towers 2001 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.74 deg.

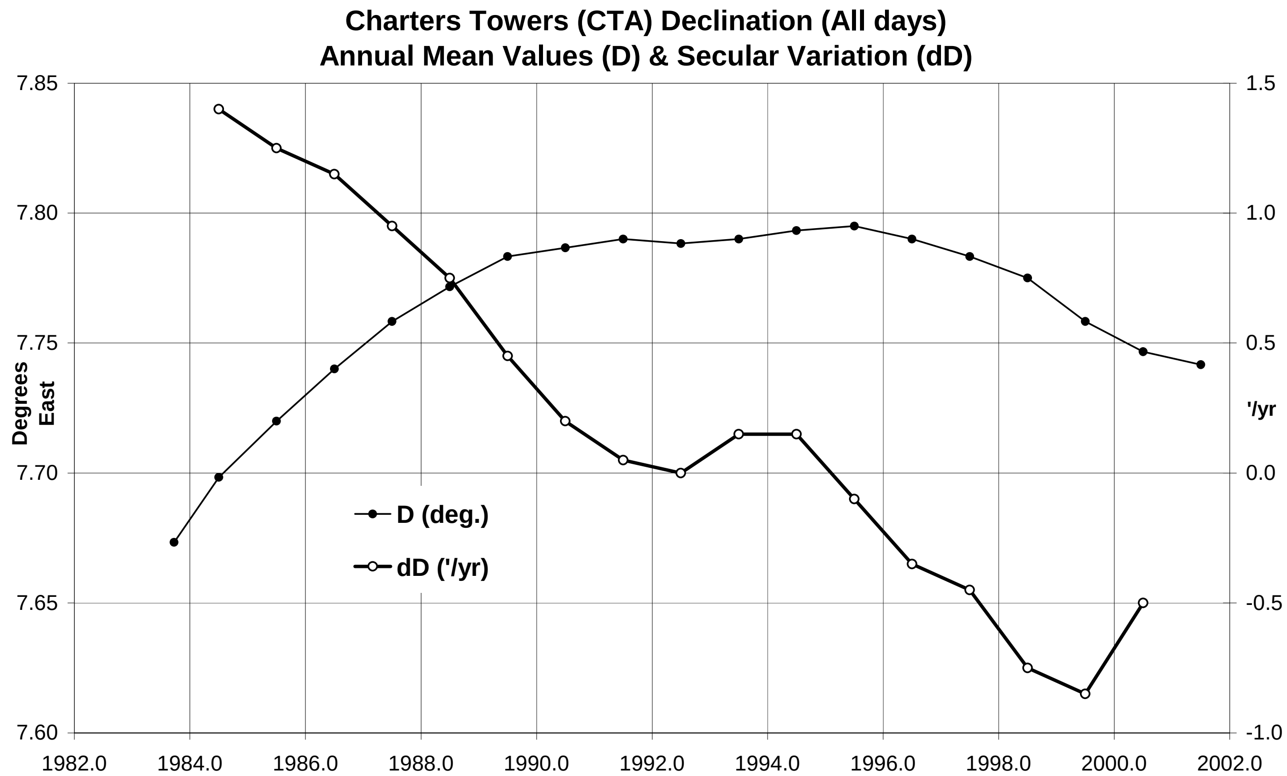


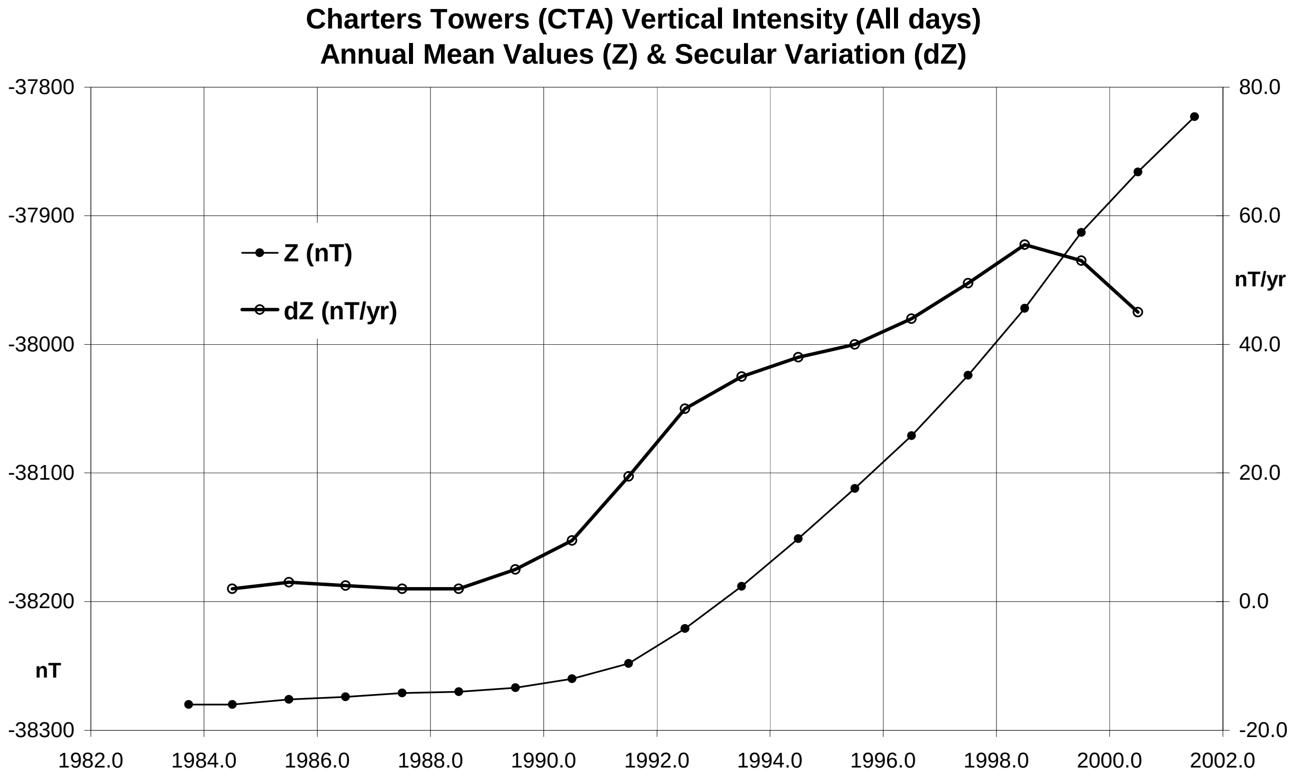
Charters Towers 2001 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -37823 nT

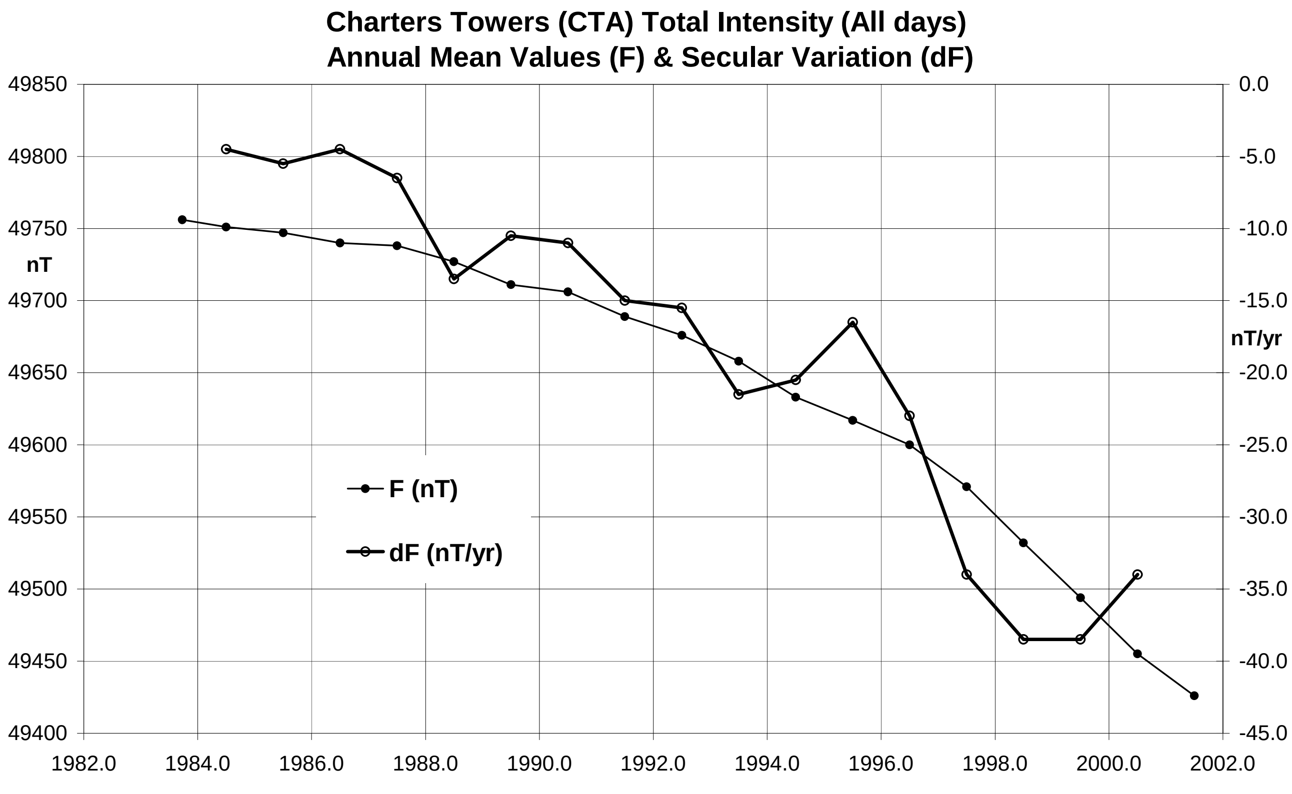
Charters Towers 2001 Total intensity (F). Scale: 7.5 nT/mm. Mean: 49426 nT




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)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-37800
-37900
-38000
-38100
-38200
-38300
80.0
60.0
40.0
20.0
0.0
-20.0
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) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
49850
49800
49750
49700
49650
49600
49550
49500
49450
49400
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0

GNANGARA OBSERVATORY

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

The observatory was built on the north-eastern part of an approximately 260m x 140m (3.6 hectare) site. In 2001 the observatory comprised a Variometer/Recorder Vault and an Absolute House approximately 70m north east of the former. The site is on well drained sand with low natural magnetic gradients of less than 1nT/m, although numerous artificial features have introduced higher gradients.

The Variometer Vault is partially underground, and partially buried 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. A small pit, connected by underground conduit and approximately 20m north-west of the Variometer Vault, housed the total field variometer sensor. As the sensor vaults were below the ground, the diurnal temperature changes of the variometers were kept to a minimum.

There were also four azimuth reference marks on the site.

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

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic‡ latitude: 31° 46' 48" S
- Geographic‡ longitude: 115° 56' 48" E
- Geomagnetic† : Lat. -41.83°; Long. 188.66°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of pier): 60 metres
- Lower limit for K index of 9: 450 nT.
- Azimuth of principal reference pillar (N) from pier B: 315° 21' 42"
- Distance to Pillar B: 70 metres
- Observer in Charge: O. McConnel (GA) and G. van Reeken

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

Variometers

Throughout 2001 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).

The annual temperature range in the Variometer Vault varied from around 15°C in winter to 28°C in summer and the maximum rate of change of temperature was < 0.1°C/day. The F variometer PPM sensor would have had temperature changes greater than this.

Throughout 2001, the fluxgate magnetic channels and sensor and electronics temperatures were sampled and recorded on a PC every 1-second, and the PPM every 10-seconds. 1-minute means of the magnetic components and temperatures were also recorded.

The acquisition computer was accessible via a modem for remote control and data retrieval. The telephone and equipment 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. with the exception of a +10-second correction applied at 2357UT 18 Dec. 2001. The error developed from 2211UT on 17 December for unknown reasons but there appeared to be a change in the clock rate at some stage during the 24-hour period.

Absolute Instruments and Corrections

Declination and Inclination Magnetometer (DIM) Bartington Mag-010H/0725H with Zeiss020B/355937 was employed regularly throughout 2001. It was used on Pier B in the Absolute House. The Bartington Mag-01H was left on the x 1 scale throughout all observations

PPM Geometrics 856/50631 with sensor 28079922 was employed throughout 2001 to perform absolute observations in total intensity, F. The PPM sensor was located on the auxiliary pier (a wall bracket - Pier C) in the same building as Pier B.

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

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

Corrections of 0.0′, 0.0′ in D and I, have been applied to the Bartington Mag-010H/0725H with Zeiss020B/355937 absolute DIM used on Pier B at GNA during 2001.

A composite correction has been applied to the absolute PPM used at GNA on the auxiliary pier during 2001. The components of this correction are:

- 0.0nT correction relative to the new Australian Total Field Standard (GEM Systems GSM90 No. 905926 with Sensor No 81241)
- -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 (-2.2, +0.1, +5.1) nT in (X,Y,Z) to all Gnangara data in this report. The adoption of the new F standard changes X, Y, and Z data by less than 0.5nT.

Baselines

The scale values and orientation of the variometer sensors were determined from a sequence of absolute observations performed in June 1999. No temperature corrections were applied to 2001 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 2001 and the derived values from the variometer data and model are:

X = 0.9 nT	Y = 1.7 nT	Z = 0.7 nT
F = 0.6 nT	D = 0.25'	I = 0.05'

The daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM in 2001 varied from -1.1nT to +1.4nT, 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 an out-posted GA staff member. Absolute observations were performed on a roster by the OIC and a contract observer.

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 shortly after 00UT each day.

The routine processing of absolute observations, 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.

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

Absolute observations were performed weekly. The stainless steel security door was left open in the same position during observations. Careful examination of absolute observations on 20 and 27 March 2001 indicated that the timepiece used for absolute observations was 1-minute in error. It is not known how often this problem occurred, and it must have added to the scatter in the absolute observations, but probably not the average value. No actual time corrections were made to the observation data.

The feet in the base of the theodolite were adjusted on several occasions. On 23 April 2001, tests showed that the mark reading using the DIM varied by 10' with gentle pressure on the theodolite. The theodolite feet were wound in to minimum extension to reduce the problem. The theodolite base was removed from service on 01 May 2001 and sent to GA, Canberra, where the feet were tightened. The base was returned to Gnangara on 15 May 2001.

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 an increasing problem with vandalism. Considerable data was lost in 2000 due to vandalism (power cables cut, fires, 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 to ensure the observer's safety. Although there were no problems with vandalism in 2001, a search for an alternative site began.

An operational oversight allowed the acquisition PC's disc to fill on 10 August, and data collection failed. The system could barely respond to remote investigation, and the cause of the problem could not be determined. The DT2805 analogue-to-digital converter board was changed on 15 August, but this did not fix the problem. The problem was finally found remotely and data collection recommenced on 16 August. No baseline shift was evident from the change of DT2805 board.

Significant Events 2001

23 Jan	DIM theodolite base adjusted.
23 Apr	DIM theodolite base adjusted.
01 May	to 15 May DIM out of service while adjustments to the base made.
10 Aug	Acquisition computer disc full and data collection failed.
15 Aug	Changed the acquisition computer. A DT2805 analogue-to-digital converter used to digitise the variometer data channels.
16 Aug	Acquisition computer disc tidied and data collection recommenced at 0528UT with 15s sample rate. 1s sample rate recommenced at 0129 17 Aug 2001.
18 Dec	Unexplained 10s drift in the acquisition computer clock.

Distribution of GNA data during 2001

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

- 2000: WDC-A, Boulder, USA (10 April 2001)

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2001

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- Definitive 2000 data for the INTERMAGNET CD-ROM to the DMI (18 April 2001)

Data loss in 2001:

Aug 10	1436 to 16 / 0527 (5d 14h 52m) All channels: Acquisition PC disc full.

K indices

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

The table on page 42 shows K indices for Gnangara for 2001. 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 2001

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Jun. 23	0404	0406	0410	+8	+3	+3	solar
Oct. 19	0054	0110	0145	+3	+150	0	solar
Nov. 08	0700	0704	0709	+9	+15	+12	solar
30	0103	0108	0115	0	+15	+9	solar
Dec. 11	0800	0809	0824	+6	+30	+18	solar
28	0345	0351	0403	+3	+6	+3	solar

Sudden Storm Commencements (ssc) - GNA 2001

Month & date		U.T.	Type & Quality		Chief movement (nT) H	D	Z
Jan.	17	1630	ssc	A	+24	+15	+15
	23	1048	ssc	B	+42	+12	+12
	31	0806	ssc	B	+45	+33	+33
Mar.	22	1345	ssc	B	+21	+9	+12
Apr.	04	1457	ssc	C	+51	+33	+33
	13	0733	ssc	C	+24	+24	+21
	18	0500	ssc*	C	+30 *	+45 *	+30 *
May	27	1500	ssc	A	+21	+12	+15
Aug.	03	0715	ssc	C	+30	+30	+27
	17	1103	ssc	C	+24	+12	+9
	27	1948	ssc	C	+36	+30	+27
Sep.	14	0206	ssc*	C	+14	+35 *	+15
	25	2024	ssc*	C	+84	+115 *	+81
Oct.	21	1648	ssc	B	+75	+51	+33
	25	0848	ssc	B	+39	+30	+27
	28	0318	ssc*	B	+30	-18 *	+3
	31	1348	ssc	B	+24	+6	+12
Nov.	15	1509	ssc	B	+27	+15	+18
	24	0500	ssc*	B	+27	+24 *	+18
Dec.	29	0539	ssc	B	+63	+36	+39
	30	2009	ssc*	B	+42	+48 *	+33

Principal Magnetic Storms - Gnangara, 2001

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.				No	Principal			Magnetic		Storms				
Feb.				No	Principal			Magnetic		Storms				
Mar.	19	11	··	···	··	··	··	20(5)	8	58.0	209	302	20	23
	30	21	··	···	··	··	··	31(1,2,6,7,8)	6	48.0	363	283	**01**	09
Apr.	08	11	··	···	··	··	··	08(5,7,8)	6	34.7	137	235	08	22
	11	13	··	···	··	··	··	11(6,8)	7	43.1	370	262	12	18
	13	07	33	ssc	+3.5	+33	+21	13(4)	6	24.4	136	147	13	22
May	08	09	··	···	··	··	··	09(6)	6	21.7	90	113	10	03
	12	06	··	···	··	··	··	12(5,7)	5	18.8	108	134	14	09
Jun.	18	03	··	···	··	··	··	18(4)	6	17.1	123	133	19	03
Jul.	25	03	··	···	··	··	··	25(4,6)	5	15.8	83	89	26	16
Aug.	06	03	··	···	··	··	··	06(4,5)	5	13.5	57	92	07	03
	17	11	03	ssc	+1.3	+24	+9	17(7,8)	6	26.6	140	129	18	09
Sep.	23	04	··	···	··	··	··	23(7)	6	20.0	96	133	24	06
	25	20	24	ssc*	+15.5*	+84	+81	25(8), 26(1)	6	32.9	176	145	26	12
	30	12	··	···	··	··	··	3(4)	7	33.2	172	249	**04**	21
Oct.	11	12	··	···	··	··	··	11(6,7), 12(1,2,5)	5	26.8	177	147	13	03
	21	16	48	ssc	+7.5	+75	+33	21(8)	7	35.5	266	194	23	09
	28	03	18	ssc*	-2.6*	+30	+3	28(5)	6	26.2	147	179	29	03
Nov.	05	09	··	···	··	··	··	06(1)	9	92.6	426	401	07	06
	24	05	00	ssc*	+3.5*	+27	+18	24(3)	8	69.1	466	418	25	12
Dec.				No	Principal			Magnetic		Storms				

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.
See also *Notes & Errata* on page 1 of this report

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC

continued …

Gnangara Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	ABC
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	ABC
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	ABC
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	ABC
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	ABC
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	ABC
2000.5	A	-2	13.6	-66	36	23230	23212	-903	-53682	58493	ABC
2001.5	A	-2	9.0	-66	34.7	23241	23225	-872	-53651	58468	ABC
1959.5	Q	-2	54.1	-65	52.4	23954	23923	-1213	-53482	58603	DHZ
1960.5	Q	-2	53.5	-65	52.1	23959	23928	-1209	-53480	58599	DHZ
1961.5	Q	-2	53.3	-65	52.7	23952	23922	-1207	-53491	58606	DHZ
1962.5	Q	-2	52.8	-65	53.0	23945	23915	-1203	-53490	58599	DHZ
1963.5	Q	-2	52.3	-65	54.0	23931	23901	-1199	-53497	58600	DHZ
1964.5	Q	-2	51.7	-65	54.9	23916	23886	-1194	-53501	58599	DHZ
1965.5	Q	-2	51.7	-65	55.3	23906	23876	-1194	-53497	58589	DHZ
1966.5	Q	-2	52.4	-65	56.3	23889	23859	-1198	-53499	58582	DHZ
1967.5	Q	-2	54.1	-65	57.4	23868	23837	-1208	-53499	58572	DHZ
1968.5	Q	-2	55.7	-65	58.6	23843	23812	-1218	-53494	58558	DHZ
1969.5	Q	-2	57.5	-65	59.7	23820	23788	-1229	-53488	58538	DHZ
1970.5	Q	-2	59.7	-66	1.2	23786	23754	-1243	-53475	58516	DHZ
1971.5	Q	-3	2.3	-66	2.2	23761	23728	-1259	-53461	58490	DHZ
1972.5	Q	-3	5.2	-66	3.9	23727	23693	-1278	-53454	58467	DHZ
1973.5	Q	-3	7.8	-66	6.2	23686	23651	-1293	-53460	58454	DHZ
1974.5	Q	-3	9.9	-66	9.0	23642	23606	-1305	-53477	58456	DHZ
1975.5	Q	-3	11.5	-66	11.3	23608	23571	-1314	-53496	58457	DHZ
1976.5	Q	-3	12.3	-66	14.2	23567	23530	-1318	-53528	58471	DHZ
1977.5	Q	-3	13.6	-66	17.0	23528	23491	-1324	-53557	58478	DHZ
1978.5	Q	-3	15.1	-66	20.5	23481	23443	-1332	-53596	58499	DHZ
1979.5	Q	-3	16.5	-66	23.1	23444	23406	-1339	-53624	58525	DHZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1346	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.9	-66	36.5	23258	23219	-1338	-53772	58587	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ
1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	8.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	6.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	2.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23165	-1173	-53757	58547	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	ABC
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	ABC
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	ABC
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	ABC
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	ABC
1999.5	Q	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	ABC
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	ABC
2001.5	Q	-2	8.8	-66	34.1	23252	23235	-871	-53648	58470	ABC
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	ABC
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	ABC
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	ABC
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	ABC
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	ABC
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	ABC
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	ABC
2001.5	D	-2	9.6	-66	36	23219	23203	-875	-53656	58465	ABC

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

K indices & Daily K sums at Gnangara (K=9 limit: 450 nT) for 2001

Date	January	February	March	April	May	June	Date
01	Q 1011 0011 05	2222 2112 14	3111 0222 12	5431 2345 27	Q 1110 0010 04	0003 3123 12	01
02	Q 1110 2123 11	2221 0111 10	2011 1333 14	4334 3442 27	1121 0110 07	D 5332 3333 25	02
03	3222 3112 16	Q 1111 0001 05	2113 3333 19	2110 0322 11	2113 1221 13	2210 0012 08	03
04	2123 4432 21	Q 2111 0021 08	2232 2444 23	2222 4442 22	1232 1011 11	3220 1212 13	04
05	2211 1122 12	1011 1111 07	5333 1323 23	2144 3343 24	Q 1000 0021 04	1211 0011 07	05
06	Q 2211 2111 11	D 2344 1233 22	2112 1231 13	2242 2444 24	0111 0012 06	1111 2133 13	06
07	2111 1122 11	3221 1112 13	2122 1322 15	4322 2544 26	1222 3231 16	3223 3111 16	07
08	2212 1353 19	1112 0222 11	2112 1233 15	D 3124 6466 32	1022 3343 18	1221 1112 11	08
09	2122 3122 15	2112 2221 13	2121 2311 13	3334 3541 26	D 3323 5653 30	D 2332 3444 25	09
10	1111 2323 14	2212 2221 14	1211 1220 10	3322 3332 21	D 4343 2332 24	D 5433 2322 24	10
11	3112 3322 17	2122 1112 12	Q 1011 1000 04	D 3132 3767 32	2111 1224 14	3322 2222 18	11
12	3222 1101 12	2111 2212 12	0022 3344 18	D 5444 3211 24	D 3223 5454 28	Q 1222 1022 12	12
13	2122 3111 13	D 4442 4344 29	2213 2111 13	D 2136 4544 29	D 3322 4444 26	3232 1221 16	13
14	2222 1132 15	D 2222 4443 23	2212 2122 14	2233 3322 20	4231 0131 15	2111 0123 11	14
15	2213 3213 17	2112 2212 13	Q 1010 0011 04	2223 3232 19	1234 1342 20	2222 0010 09	15
16	2121 4211 14	1111 1221 10	Q 0000 0101 02	3121 2212 14	2233 0001 11	2231 0021 11	16
17	2211 1322 14	Q 2101 1211 09	Q 0010 1331 09	1112 1333 15	2211 0112 10	1122 3221 14	17
18	1123 1011 10	Q 1100 1211 07	2222 2213 16	D 5644 1332 28	2222 2113 15	D 1446 3233 26	18
19	Q 2210 1122 11	1122 2221 13	D 1013 4554 23	Q 1111 2102 09	3221 1021 12	3110 2233 15	19
20	1133 2223 17	2113 4121 15	D 4355 8643 38	2221 3011 12	0121 1211 09	3342 3200 17	20
21	D 3234 3334 25	2122 3111 13	2121 1101 09	2110 1333 14	Q 0111 2101 07	D 1222 2332 17	21
22	4332 2333 23	2121 1211 11	1111 3432 16	4243 5643 31	1111 1212 10	Q 1101 1111 07	22
23	D 3214 3353 24	D 2322 3322 19	D 3324 4532 26	3334 2211 19	2221 1222 14	Q 0100 1011 04	23
24	D 3214 4543 26	1112 2101 09	2332 4331 21	Q 2131 1011 10	2211 1101 09	2221 1212 13	24
25	2211 0332 14	Q 0010 0021 04	1222 1011 10	Q 2012 3122 13	1221 1321 13	1221 1111 10	25
26	2242 3132 19	1111 1533 16	Q 1110 2011 07	0121 1132 11	1212 0010 07	1212 3343 19	26
27	2111 0112 09	D 4333 3312 22	4323 1345 25	Q 1121 1110 08	0001 1422 10	4220 0100 09	27
28	1222 2333 18	1112 4233 17	D 3145 4534 29	1434 6343 28	D 2223 3323 20	Q 0100 0000 01	28
29	D 4432 1123 20		2233 3332 21	4332 3211 19	3201 3210 12	Q 0000 0001 01	29
30	Q 3211 1102 11		3222 2333 20	Q 1000 0000 01	Q 0000 0010 01	1223 2032 15	30
31	D 1144 4452 25		D 6655 4666 44		Q 0000 0000 00		31
Mean K-sum	**15.8**	**13.3**	**17.0**	**19.9**	**12.8**	**13.3**	

Date	July	August	September	October	November	December	Date
01	2111 1222 12	2113 1311 13	Q 2211 0111 09	D 5345 5445 35	D 4224 4321 22	2123 3213 17	01
02	Q 1101 1021 07	1111 1211 09	0001 1322 09	D 3354 3444 30	2221 3202 14	2121 1223 14	02
03	1112 2231 13	1242 1232 17	2122 2324 18	D 3247 6544 35	Q 2100 0010 04	0211 2353 17	03
04	1101 0201 06	0101 2421 11	2222 2332 18	3135 2421 21	1112 1211 10	4222 2132 18	04
05	1121 1242 14	D 1124 4332 20	2221 2321 15	0112 1332 13	1023 2454 21	4312 1232 18	05
06	1111 2231 12	D 2235 5423 26	1122 0021 09	2232 2021 14	D 9864 5665 49	3222 2334 21	06
07	Q 1011 1111 07	2223 1111 13	Q 1000 0113 06	Q 1010 1002 05	D 4212 2333 20	2210 2322 14	07
08	D 2221 1234 17	1112 1101 08	2121 1220 11	3123 4424 23	2222 1012 12	2212 2111 12	08
09	4110 0021 09	1211 2213 13	Q 1011 1100 05	4223 3321 20	2112 1122 12	Q 1101 0012 06	09
10	0112 2232 13	3120 ---- --	Q 1100 0111 05	1112 3232 15	3111 1113 12	Q 1222 2212 14	10
11	2210 0110 07	Q ---- ---- --	1101 3442 16	2121 3554 23	1113 0111 09	Q 1231 1122 13	11
12	0022 2132 12	---- ---- --	2332 2323 20	5544 5334 33	2001 1001 05	3224 3254 25	12
13	0111 0012 06	D ---- ---- --	2333 3320 19	3123 2321 17	2110 0321 10	Q 2111 0100 06	13
14	4222 3311 18	---- ---- --	3221 2114 16	2222 2343 20	Q 1120 0010 05	1212 2323 16	14
15	1112 3333 17	Q ---- ---- --	D 4222 3342 22	4222 0102 13	0001 1452 13	3222 3124 19	15
16	D 2212 2313 16	Q --11 1000 --	2110 1332 13	3232 3223 20	2222 3312 17	3342 2222 20	16
17	D 3322 2222 18	D 0003 3466 22	2222 1003 12	Q 1111 0012 07	2222 3333 20	D 3322 3333 22	17
18	1231 2321 15	2341 3222 19	3221 1342 18	Q 2000 1121 07	2212 2213 15	3223 2312 18	18
19	1113 2232 15	0233 1121 13	3311 1122 14	2221 3422 18	D 3122 3353 22	3122 1212 14	19
20	Q 1122 1201 10	1011 2112 09	2002 1112 09	1132 3233 18	1122 0001 07	Q 1112 1112 10	20
21	Q 1211 2101 09	1213 1323 16	Q 2000 1003 06	D 2111 2667 26	1111 1212 10	D 2122 2453 21	21
22	2222 2112 14	D 2134 4344 25	2223 3210 15	D 6435 6665 41	2223 1122 15	3223 1112 15	22
23	3332 2322 20	2120 1111 09	D 2234 4564 30	5221 3211 17	3322 3333 22	2123 1213 15	23
24	3332 3332 22	Q 1101 0000 03	3211 1131 13	Q 0100 0000 01	D 3587 8625 44	D 2353 4333 26	24
25	D 2435 2532 26	1112 2242 15	1210 1056 16	0043 0121 11	2234 2102 16	3112 1313 15	25
26	4323 3132 21	3233 2124 20	D 6343 1223 24	Q 2111 0022 09	2121 0001 07	1112 1222 12	26
27	3333 2222 20	2211 3244 19	2112 1333 16	2201 2011 09	Q 1101 0112 07	2101 1222 11	27
28	Q 2232 1000 10	3211 2221 14	3142 3323 21	3444 6333 30	Q 1000 0012 04	0121 3113 12	28
29	3332 2111 16	Q 2113 1001 09	D 3224 3455 28	2233 2323 20	2111 2010 08	1433 3223 21	29
30	2232 1233 18	1112 2431 15	D 3222 4455 27	3112 1212 13	Q 2000 0022 06	D 4422 3245 26	30
31	D 3333 4533 27	2213 3212 16		0000 3243 12		D 4211 1344 20	31
Mean K-sum	**14.4**	**14.8**	**15.3**	**18.6**	**14.6**	**16.4**	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	10	83	84	50	17	4	0	0	0	0	0
February	17	94	78	20	14	1	0	0	0	0	0
March	27	69	63	52	19	11	6	0	1	0	0
April	16	52	59	56	39	8	8	2	0	0	0
May	49	80	66	34	14	4	1	0	0	0	0
June	43	67	74	44	9	2	1	0	0	0	0
July	23	78	85	52	7	3	0	0	0	0	0
August	20	77	55	30	16	2	2	0	0	0	46
September	32	63	75	45	16	6	3	0	0	0	0
October	31	49	67	48	28	15	8	2	0	0	0
November	43	71	71	30	9	7	4	1	3	1	0
December	10	68	96	53	16	5	0	0	0	0	0
ANNUAL TOTAL	**321**	**851**	**873**	**514**	**204**	**68**	**33**	**5**	**4**	**1**	**46**

Gnangara 2001 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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23235.7	-887.5	-53661.2	58482.5	23252.7	-2° 11.2'	-66° 34.3'
	5xQ days	23245.2	-883.7	-53657.4	58482.8	23262.0	-2° 10.6'	-66° 33.7'
	5xD days	23224.4	-892.2	-53664.8	58481.5	23241.6	-2° 12.0'	-66° 35.0'
February	All days	23234.0	-882.6	-53653.8	58475.0	23250.8	-2° 10.5'	-66° 34.2'
	5xQ days	23239.0	-881.3	-53653.5	58476.7	23255.8	-2° 10.3'	-66° 34.0'
	5xD days	23225.2	-884.1	-53655.8	58473.4	23242.1	-2° 10.8'	-66° 34.8'
March	All days	23215.6	-880.7	-53654.6	58468.4	23232.3	-2° 10.4'	-66° 35.3'
	5xQ days	23234.2	-878.3	-53648.1	58469.8	23250.8	-2° 09.9'	-66° 34.1'
	5xD days	23160.5	-888.5	-53669.6	58460.5	23177.5	-2° 11.8'	-66° 38.6'
April	All days	23201.5	-876.9	-53663.0	58470.5	23218.1	-2° 09.9'	-66° 36.2'
	5xQ days	23216.6	-875.5	-53661.2	58474.8	23233.1	-2° 09.6'	-66° 35.4'
	5xD days	23177.0	-879.7	-53666.2	58463.8	23193.7	-2° 10.4'	-66° 37.6'
May	All days	23222.6	-873.5	-53655.7	58472.1	23239.0	-2° 09.3'	-66° 34.9'
	5xQ days	23229.9	-873.6	-53653.1	58472.7	23246.4	-2° 09.2'	-66° 34.5'
	5xD days	23198.5	-874.2	-53662.6	58468.8	23214.9	-2° 09.5'	-66° 36.4'
June	All days	23227.0	-872.5	-53651.2	58469.7	23243.4	-2° 09.1'	-66° 34.6'
	5xQ days	23232.7	-873.3	-53650.2	58471.1	23249.1	-2° 09.2'	-66° 34.2'
	5xD days	23215.0	-871.6	-53654.5	58468.0	23231.4	-2° 09.0'	-66° 35.3'
July	All days	23231.4	-870.1	-53646.3	58466.9	23247.7	-2° 08.7'	-66° 34.2'
	5xQ days	23236.0	-870.5	-53646.2	58468.6	23252.3	-2° 08.7'	-66° 34.0'
	5xD days	23226.8	-869.8	-53647.2	58465.9	23243.1	-2° 08.7'	-66° 34.5'
August	All days	23228.6	-868.0	-53643.9	58463.6	23244.8	-2° 08.4'	-66° 34.3'
	5xQ days	23236.0	-866.4	-53641.8	58464.6	23252.2	-2° 08.1'	-66° 33.9'
	5xD days	23219.7	-872.4	-53649.7	58465.4	23236.1	-2° 09.1'	-66° 34.9'
September	All days	23229.6	-865.9	-53639.0	58459.5	23245.7	-2° 08.1'	-66° 34.2'
	5xQ days	23240.3	-864.2	-53637.2	58462.0	23256.4	-2° 07.8'	-66° 33.5'
	5xD days	23213.6	-867.7	-53640.4	58454.4	23229.8	-2° 08.4'	-66° 35.1'
October	All days	23207.9	-866.2	-53649.1	58460.2	23224.1	-2° 08.2'	-66° 35.6'
	5xQ days	23230.8	-861.7	-53642.2	58462.8	23246.8	-2° 07.5'	-66° 34.2'
	5xD days	23164.1	-873.4	-53657.5	58450.5	23180.6	-2° 09.6'	-66° 38.1'
November	All days	23218.6	-862.4	-53650.0	58465.1	23234.6	-2° 07.6'	-66° 35.0'
	5xQ days	23237.7	-860.8	-53646.4	58469.4	23253.7	-2° 07.3'	-66° 33.9'
	5xD days	23170.6	-866.6	-53664.6	58459.6	23186.9	-2° 08.5'	-66° 37.9'
December	All days	23244.1	-859.9	-53641.6	58467.5	23260.1	-2° 07.1'	-66° 33.4'
	5xQ days	23244.9	-857.5	-53640.9	58467.1	23260.7	-2° 06.8'	-66° 33.4'
	5xD days	23235.0	-861.9	-53643.6	58465.8	23251.0	-2° 07.5'	-66° 34.0'
Annual	All days	23224.7	-872.2	-53650.8	58468.4	23241.1	-2° 09.0'	-66° 34.7'
Mean	5xQ days	23235.3	-870.6	-53648.2	58470.2	23251.6	-2° 08.7'	-66° 34.1'
Values	5xD days	23202.5	-875.2	-53656.4	58464.8	23219.0	-2° 09.6'	-66° 36.0'

(Calculated: 12:13 hrs., Mon. 31 Mar. 2003)

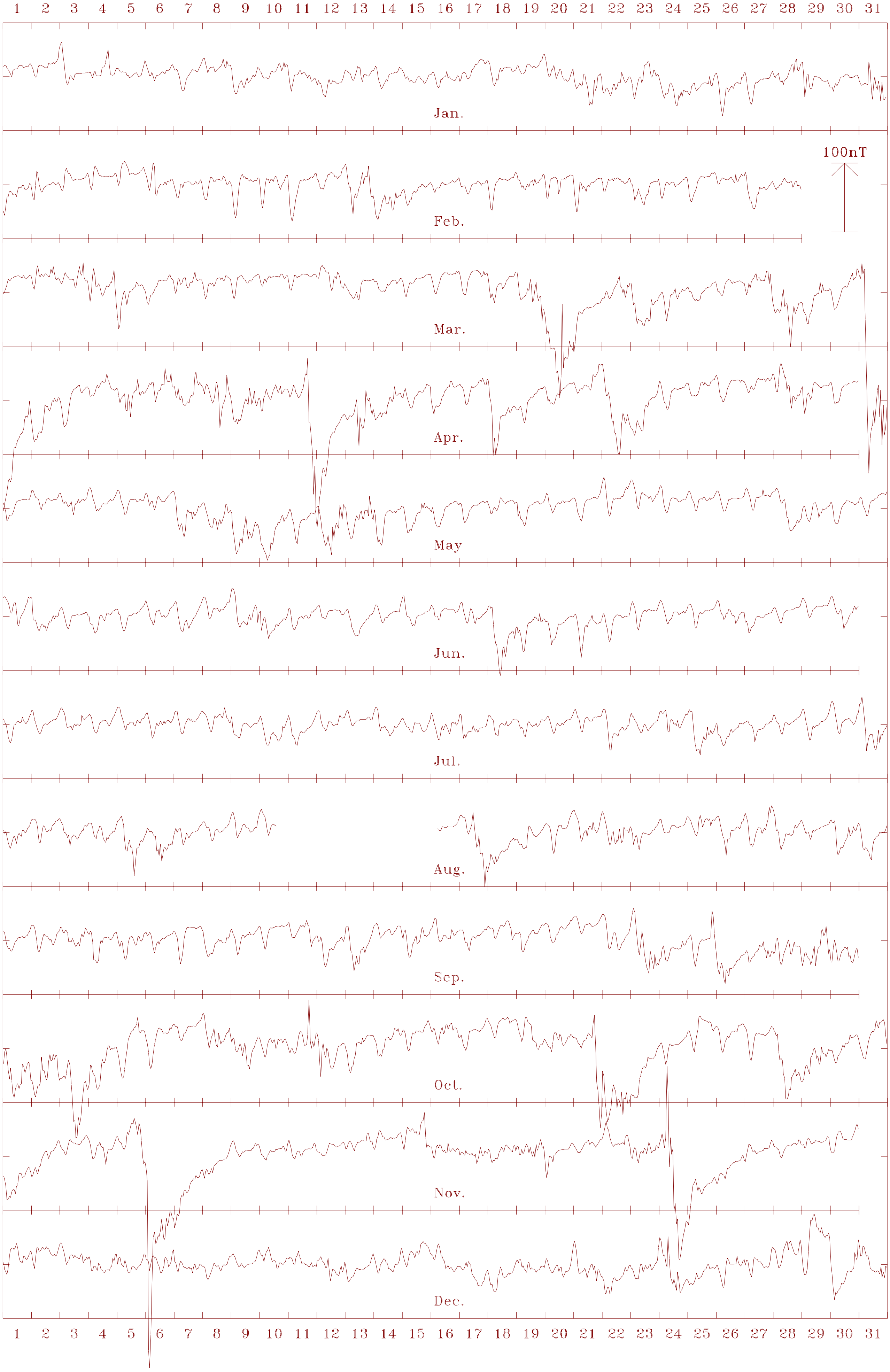
Hourly Mean Values

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 2001 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23241 nT

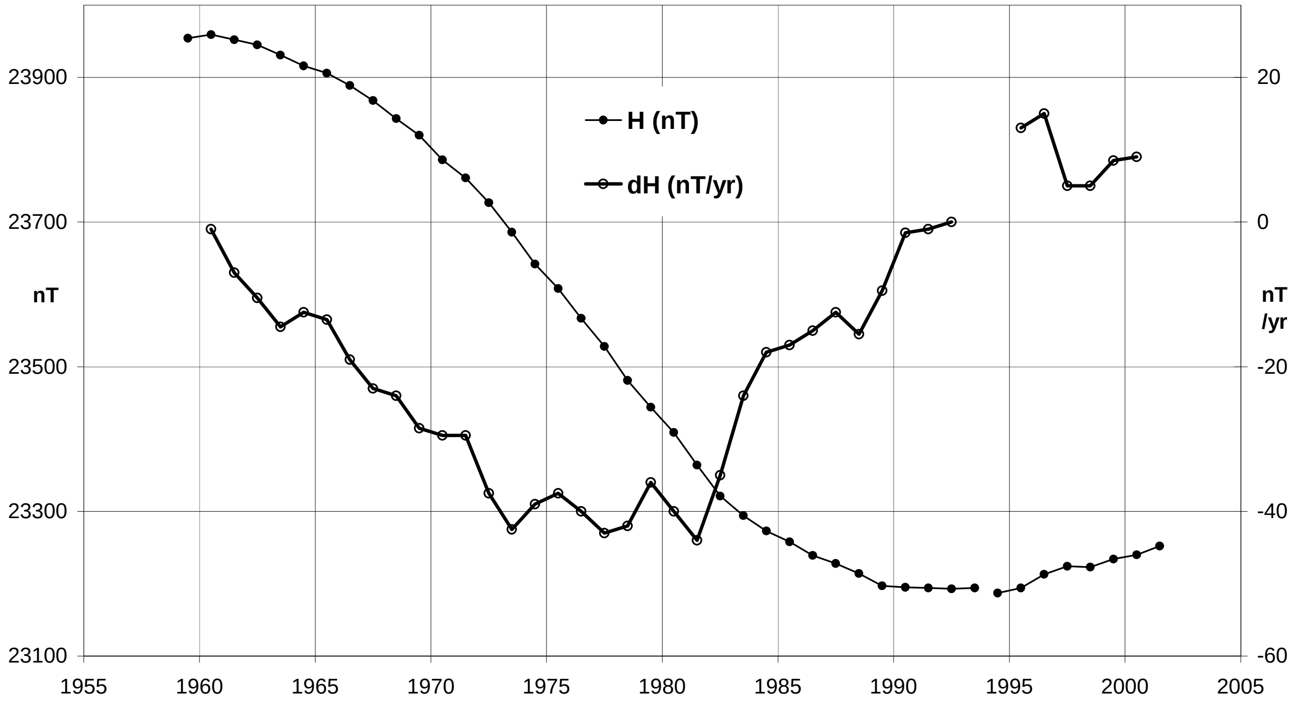



Gnangara 2001 Declination (east) (D). Scale: 1.00 min/mm. Mean: −2.15 deg.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
15.0min
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.

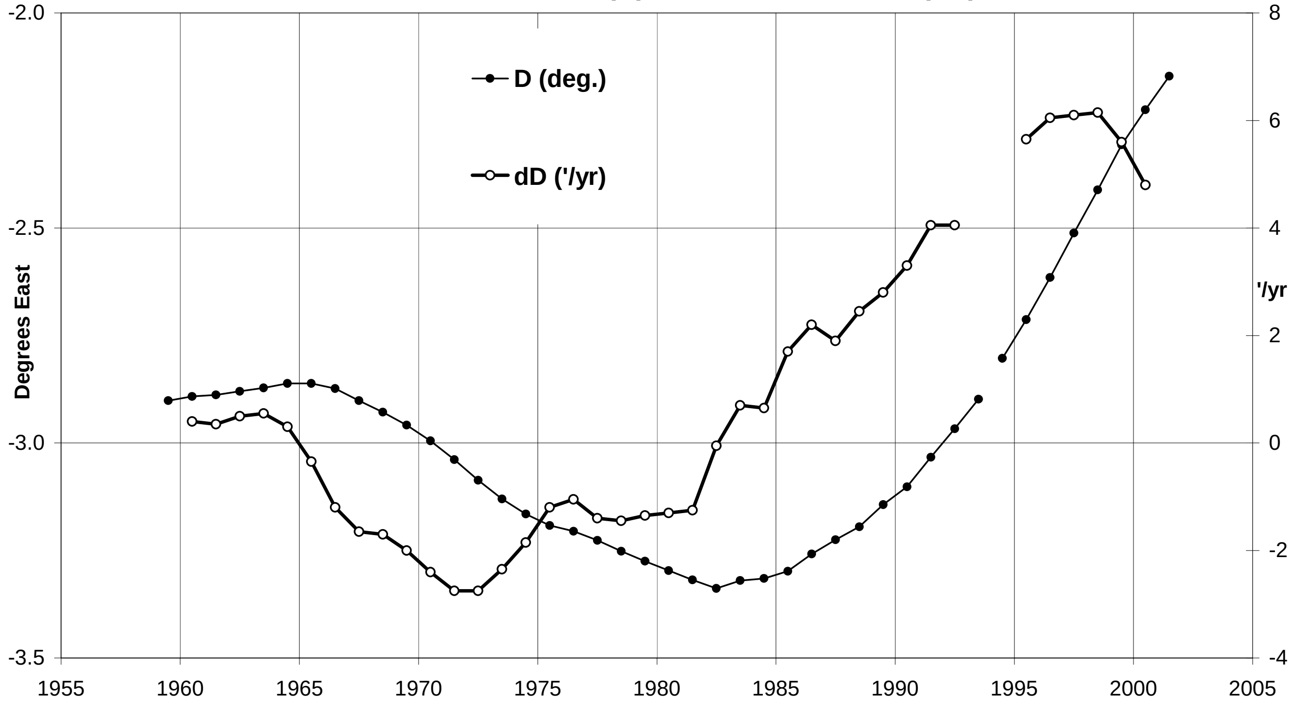
Gnangara 2001 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: -53651 nT

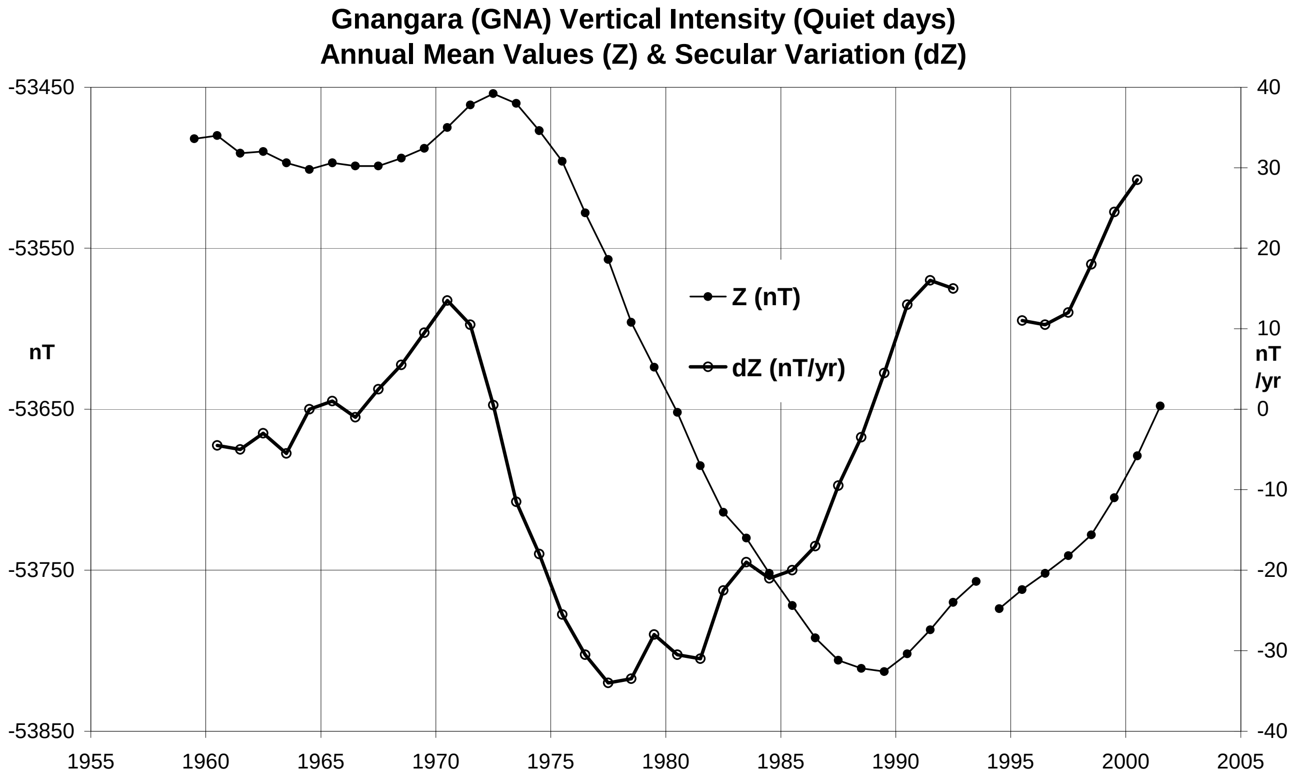
Gnangara 2001 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58468 nT

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

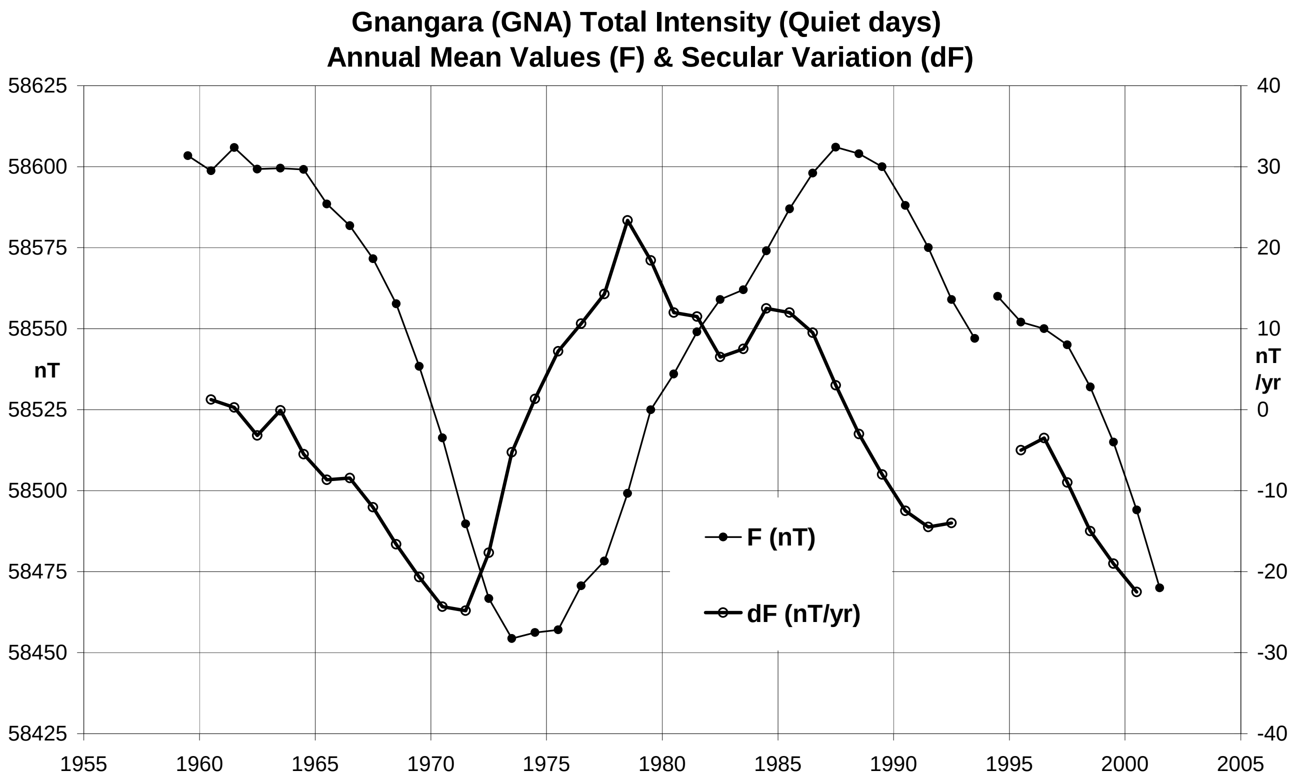


Gnangara (GNA) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)





Gnangara (GNA) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-53450
-53550
-53650
-53750
-53850
nT
40
30
20
10
0
-10
-20
-30
-40
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)

End of Part 1

Australian Government
Geoscience Australia

AUSTRALIAN GEOMAGNETISM REPORT 2001

MAGNETIC OBSERVATORIES

VOLUME 49

Department of Industry, Tourism and Resources

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

2001

Volume 49

Geomagnetism Section
Geoscience Australia Earth Monitoring
Geoscience Australia
G.P.O. Box 378
Canberra, A.C.T., 2601
AUSTRALIA

Australian Government

Geoscience Australia

Magnetic results for 2001

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, Liejun Wang

and A.D. Costar

ISSN: 1447-5146 (Online format)

ISSN: 1035-1515 (Printed format)

SUMMARY

During 2001 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. In 2001 Geoscience Australia ceased support for the processing of geomagnetic data acquired at the Davis station.

The absolute magnetometers in routine service at the Canberra Magnetic Observatory also serve as the Australian standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised 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, am and aa indices, while those from Gnangara contributed to the global am index.

No magnetic repeat stations were occupied in 2001.

Further upgrades were made to the magnetic observatory at Tangerang and the upgrade of the observatory at Manado, Indonesia took place in 2001. This was carried out by GA’s Geomagnetism group under an AusAID grant. It included the purchase of instrumentation and the training of staff from Indonesia’s BMG, at GA in 2000.

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 2001.

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

End of Part 1

Contents continued …

Part 2

End of Part 2

This is the third 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/*

Released: 5 May 2004

Part 2

KAKADU OBSERVATORY

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

The observatory comprises:

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

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

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

- 3-character IAGA code: KDU
- Commenced operation: 05 March 1995
- Geographic ‡ latitude: 12° 41' 10.9" S
- Geographic ‡ longitude: 132° 28' 20.5" E
- Geomagnetic† : Lat. -21.99°; Long. 205.44°
- 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 updated to 2001.5.
‡ 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 2001 using a suspended 3-axis linear-fluxgate DMI FGE magnetometer with sensor no. S0183 and electronics no. E0198. An analogue-to-digital converter was integrated with the electronics module.

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

Analogue variometer 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 analogue-to-digital converter mounted inside the fluxgate electronics module. 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 DMI fluxgate head in the northern vault (the one nearest the Absolute Shelter); and the PPM head in the southern vault. Both vaults were completely buried in soil to minimise head temperature fluctuations. Both the fluxgate and PPM electronics consoles were placed in their own partially insulated plastic box, resting on the concrete base in the vault, with some bricks for heat-sinks to minimise temperature fluctuations. This proved to be effective in reducing the amplitude of temperature fluctuations with periods of the order of hours.

The equipment was protected from power blackouts, surges and lightning strikes by a mains filter, an uninterruptible power supply and a surge absorber. The variometer PPM cable was a double-screened marine armoured cable, with the outer shield (armour) earthed, and the inner shield attached to equipment earth. The data connections between the acquisition computer and both the ADAM A/D and the PPM variometer were via fibre-optic modems and several metres of fibre-optic cable to isolate damage from lightning entering the system through any one piece of equipment.

The observatory was also protected from lightning by an ERICO System 3000 (Advanced Integrated Lightning Protection), consisting of a Dynasphere Air Termination unit, mast, and copper-coated steel rod designed to protect an 80m radius area around the sphere. There were also lengths of copper ribbon and aluminium power cables buried in a shallow trenches towards the Absolute Shelter, in the opposite direction, and from the control hut to and around both variometer sensor pits, and a conducting loop around the Control Hut. All of these lightning protection components were connected together. (See *AGR2000* for further details.)

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

Baselines

The adopted DMI variometer baselines for 2001 have standard errors of 0.4nT in F, X, and Z, 0.9nT in Y, 5" in D and 2" in I.

When the PPM was working properly, F-check varied in a 2nT range during 2001. When the PPM was working very well, the daily range in F-check was less than 0.2nT.

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

Absolute Instruments & Corrections

The principal absolute magnetometers used at Kakadu in 2001 were a declination-inclination magnetometer, DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on a Zeiss 020B non-magnetic theodolite (no. 359142), and a proton precession magnetometer, PPM: Elsec model 770 (no. 189).

As described in the *AGR1998*, the best way to use this DIM was to take all readings on the x10 scale, but to switch to the x1 scale while rotating the theodolite. Additionally, the theodolite should be rotated so that the objective lens passes exclusively through positive field values (or alternatively exclusively through negative field values). This method was used at KDU throughout 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.

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

Instrument corrections that were applied to the absolute magnetometers used at Kakadu in 2001 were determined through a series of instrument comparisons performed in October 2000. These comparisons were consistent with those performed in May 1998.

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

The corrections adopted for the Kakadu absolute instruments for 2001 were 0.0′, 0.0′ in D and I for the DIM, and −2.3 nT in F for the PPM. At the mean magnetic field values at Kakadu these translate to corrections of:

$\Delta X = -1.7nT \quad \Delta Y = -0.1nT \quad \Delta Z = +1.5nT.$

These instrument corrections have been applied to the 2001 data in this report. (The change in F standard from previous reports results in a change in X and Z baselines of only a few tenths nT.)

During 2000, the difference between the KDU absolute Elsec 770 PPM and variometer Geometrics 856 PPM varied smoothly within a 3nT range, the peak and trough occurring approximately in mid-summer and mid-winter respectively. This could have been due to an undetermined temperature coefficient of the absolute Elsec 770 PPM. The performance of the Geometrics 856 during 2001 was not good enough to confirm this behaviour. No corrections have been made to the data to correct this effect.

Operations

1-second and 1-minute mean magnetic data were acquired at the Kakadu observatory in 2001. Accurate timing was maintained by a GPS clock attached to the acquisition computer. 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.

Although some lightning protection measures were included in the original construction of the Kakadu observatory in 1995, that were enhanced in both December 1998 and October 1999, the 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. However, on 14 October 2001, damage (probably from lightning entering through the power and/or telephone lines) caused the computer, modem, power, and telecommunications to fail.

A faulty UPS caused erratic behaviour of the DMI fluxgate variometer and degraded data quality from 0034 on 19 September 2001 until the UPS was replaced at 0346 on 30 September 2001.

No data were collected from 14 October (electrical storm damage) until 02 November 2001, when the acquisition computer and modem were replaced. It appears that the acquisition time was not set correctly at that time. A -07m06s time correction was made at 00:23:00 on 7 November. This same correction has been applied to all data from 02 November to that time. Accurate timing was not possible until 21 November when telecommunications were restored and daily remote time corrections were made. It is likely that there were clock errors of up to 10s from 2 November until the computer clock rate was adjusted on 28 November. On 8 December, a replacement GPS clock was installed and excellent timing resumed as before 14 October. (Timing is accurate to 0.1s when the GPS clock is working).

On 24 December 2001, the DMI fluxgate variometer suddenly behaved erratically: the electronics temperature increased, the baselines changed (F-check changed by 80nT and then drifted by 20nT/day) and noise on all magnetic channels developed. No vector data from 00:25:33 on 24 December is valid observatory-quality data, although it may serve as degraded variation data. The F variometer continued unaffected.

Communications to the observatory (for data telemetry and time checking & correction) were poor from 12 May 2001 throughout the rest of May and June, probably due to a line fault between the PABX in the ranger's station and the geophysics hut. Communications was lost on 14 October (following damage from electrical storm) until 21 November 2001.

During a service visit on 11 July, the fluxgate pit was uncovered by mistake (while investigating the variometer-F problem). There was some temporary disturbance to the data, but no apparent long term baseline shift.

The Geometrics total field variometer generally behaved poorly during 2001. This was particularly the case from 04-28 May and from 6 June to 11 July. Although the sensor was replaced on 11 July, it is likely that a simultaneous change in cable capacitance to 6.3nF improved signal strength and decreased noise. It failed on 9 August after a power failure and did not function again until 28 August (except for two brief periods due to hang-ups in the firmware and incorrect parameters on re-installation). The F-check data quality monitoring was therefore poor for much of 2001.

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 mail, 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 when it was operational, otherwise they were sent on floppy disc by mail weekly.

The control house containing the variometer electronics was maintained at a temperature of about 23°C. The DMI electronics and sensor temperatures varied with a typical daily variation of less than 0.2°C. DMI electronics no. E0198 temperature was 27.0±1.0°C during 2001.

continued …

KDU Operations (cont.)

The DMI sensor no. S0183, although buried underground, varied between 26.5°C to 33.5°C during 2001. The most rapid and prolonged temperature change was a warming during September of 0.1°C/day.

Significant Events 2001

Feb 19 until Mar 21: Observatory unattended.

Apr 04 Rain cap on northern (fluxgate sensor) vault removed and refitted to insert foam in an attempt to reduce diurnal temperature variations.

May 03 Considerable degradation of variometer PPM performance.

May 12 Telecommunications failed, apparently due to line fault from PABX to Geophysical Observatory. The connection remained poor and intermittent throughout May and June.

Jun 06 Attempt to fix variometer-F data problem by exchanging PPM electronics (from G856 #50707 to #50702) failed, and the original system #50707 left in place.

Jul 11 Visit by GA officer to correct PPM variometer. PPM variometer electronics found to be satisfactory. Fluxgate vault was mistakenly disturbed. Replaced G856 #50707 sensor with one from #50702 and changed G856 settings to capacitance 063 (=6.3nF) obtaining signal strength > 10. Both pits reburied, with no apparent change to baselines of fluxgate-variometer. The diurnal temperature range of the fluxgate electronics increased after this time, for no known reason.

Aug 09 Power failure. F-variometer did not restart when power supply resumed.

Aug 15 F-variometer reset but memory filled same day and data ceased.

Aug 23 F-variometer reset but memory filled same day and data acquisition ceased.

Aug 29 F-variometer reset.

Sep 17 UPS misbehaving. This caused the variometer baselines to change suddenly on Sep 19 and become slightly unstable.

Sep 30 UPS replaced and variometer stabilised.

Oct 14 Mains power supply and telecommunications failed during an electrical storm.

Oct 16 Mains power supply resumed (open circuit breaker outside the observatory), but still no telecommunications. Acquisition computer and modem had also failed.

Nov 02 Replacement acquisition computer and modem installed, but still no telecommunications.

Nov 07 Time check by local operator indicated the acquisition time is 07m 06s fast. Corrected at 00:23:00.

Nov 15 Acquisition computer accidentally switched off while copying data to floppy disc. Small data loss.

Nov 21 Acquisition time 6 seconds out: this was corrected. Telecommunications fixed.

Nov 22 GPS clock appears to have failed - probably on October 14.

Dec 08 GPS clock replaced and working. Receiver found to have actually failed.

Dec 18 Contract observer absent until late January 2002.

Dec 24 DMI variometer suddenly became erratic and noisy.

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 58-59.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABC
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABC
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABC
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABC
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABC
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABC
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABC
1995.583	Q	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	ABC
1996.728	Q	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	ABC
1997.455	Q	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	ABC
1998.5	Q	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	ABC
1999.5	Q	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	ABC
2000.5	Q	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	ABC
2001.5	Q	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	ABC
1995.583	D	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	ABC
1996.728	D	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	ABC
1997.455	D	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	ABC
1998.5	D	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	ABC
1999.5	D	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	ABC
2000.5	D	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	ABC
2001.5	D	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	ABC

- Elements ABC indicates non-aligned variometer orientation

Kakadu 2001 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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35374.9	2308.8	-30138.1	46529.7	35450.1	3° 44.1'	-40° 22.2'
	5xQ days	35387.5	2313.1	-30137.3	46539.0	35463.0	3° 44.4'	-40° 21.5'
	5xD days	35363.9	2305.1	-30138.0	46521.1	35438.9	3° 43.8'	-40° 22.7'
February	All days	35376.9	2309.7	-30132.1	46527.4	35452.2	3° 44.1'	-40° 21.7'
	5xQ days	35383.3	2312.3	-30131.1	46531.8	35458.8	3° 44.3'	-40° 21.4'
	5xD days	35366.6	2308.0	-30132.7	46520.0	35441.9	3° 44.0'	-40° 22.3'
March	All days	35357.6	2309.4	-30129.1	46510.9	35433.0	3° 44.2'	-40° 22.5'
	5xQ days	35381.7	2311.5	-30124.8	46526.5	35457.1	3° 44.3'	-40° 21.1'
	5xD days	35292.8	2302.0	-30133.2	46463.9	35367.8	3° 43.9'	-40° 25.9'
April	All days	35337.6	2309.0	-30130.3	46496.4	35413.0	3° 44.3'	-40° 23.5'
	5xQ days	35356.1	2309.9	-30126.4	46508.0	35431.5	3° 44.3'	-40° 22.4'
	5xD days	35307.9	2306.7	-30134.9	46476.7	35383.2	3° 44.3'	-40° 25.2'
May	All days	35362.2	2311.5	-30122.4	46510.1	35437.7	3° 44.4'	-40° 21.9'
	5xQ days	35373.2	2312.7	-30120.2	46517.1	35448.7	3° 44.4'	-40° 21.2'
	5xD days	35332.8	2308.6	-30125.6	46489.7	35408.2	3° 44.3'	-40° 23.5'
June	All days	35366.8	2311.9	-30118.0	46510.8	35442.3	3° 44.4'	-40° 21.4'
	5xQ days	35372.3	2313.5	-30116.7	46514.2	35447.9	3° 44.5'	-40° 21.1'
	5xD days	35354.5	2311.9	-30118.2	46501.6	35430.0	3° 44.5'	-40° 22.0'
July	All days	35369.9	2312.4	-30113.7	46510.3	35445.4	3° 44.4'	-40° 21.0'
	5xQ days	35375.4	2311.9	-30112.9	46514.0	35450.9	3° 44.3'	-40° 20.7'
	5xD days	35363.8	2311.4	-30114.6	46506.3	35439.3	3° 44.4'	-40° 21.4'
August	All days	35368.4	2311.4	-30109.7	46506.5	35443.8	3° 44.3'	-40° 20.9'
	5xQ days	35373.4	2310.9	-30109.0	46509.9	35448.8	3° 44.3'	-40° 20.6'
	5xD days	35357.6	2309.2	-30111.3	46499.3	35432.9	3° 44.2'	-40° 21.5'
September	All days	35369.2	2311.2	-30103.5	46503.2	35444.6	3° 44.3'	-40° 20.5'
	5xQ days	35382.6	2312.8	-30101.2	46512.0	35458.2	3° 44.4'	-40° 19.7'
	5xD days	35348.9	2310.2	-30106.5	46489.6	35424.3	3° 44.4'	-40° 21.6'
October	All days	35335.4	2307.4	-30106.3	46479.1	35410.7	3° 44.2'	-40° 22.3'
	5xQ days	35379.7	2311.4	-30102.4	46510.5	35455.2	3° 44.3'	-40° 19.9'
	5xD days	35282.2	2301.8	-30113.8	46443.2	35357.2	3° 44.0'	-40° 25.3'
November	All days	35350.8	2310.2	-30108.8	46492.6	35426.2	3° 44.3'	-40° 21.7'
	5xQ days	35373.9	2312.0	-30106.0	46508.4	35449.4	3° 44.4'	-40° 20.4'
	5xD days	35280.0	2304.1	-30116.4	46443.4	35355.2	3° 44.2'	-40° 25.5'
December	All days	35375.2	2311.1	-30104.1	46508.1	35450.6	3° 44.3'	-40° 20.2'
	5xQ days	35374.8	2311.1	-30105.6	46508.7	35450.2	3° 44.3'	-40° 20.3'
	5xD days	35365.2	2307.6	-30104.4	46500.5	35440.4	3° 44.0'	-40° 20.7'
Annual	All days	35362.1	2310.3	-30118.0	46507.1	35437.5	3° 44.3'	-40° 21.7'
Mean	5xQ days	35376.2	2311.9	-30116.1	46516.7	35451.6	3° 44.3'	-40° 20.9'
Values	5xD days	35334.7	2307.2	-30120.8	46487.9	35409.9	3° 44.2'	-40° 23.1'

(Calculated:10:28 hrs., Thu. 03 Apr. 2003)

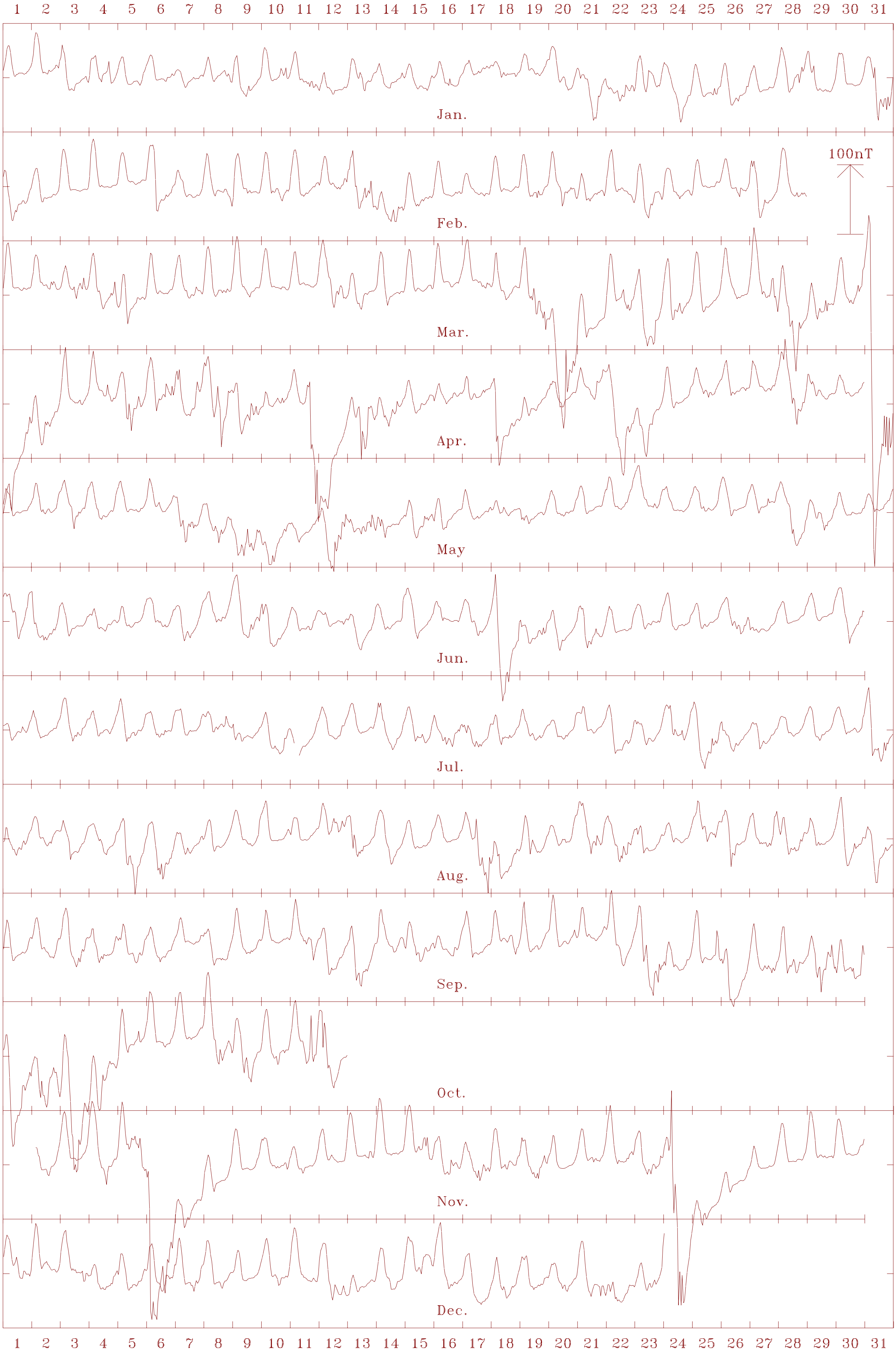
Hourly Mean Values

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

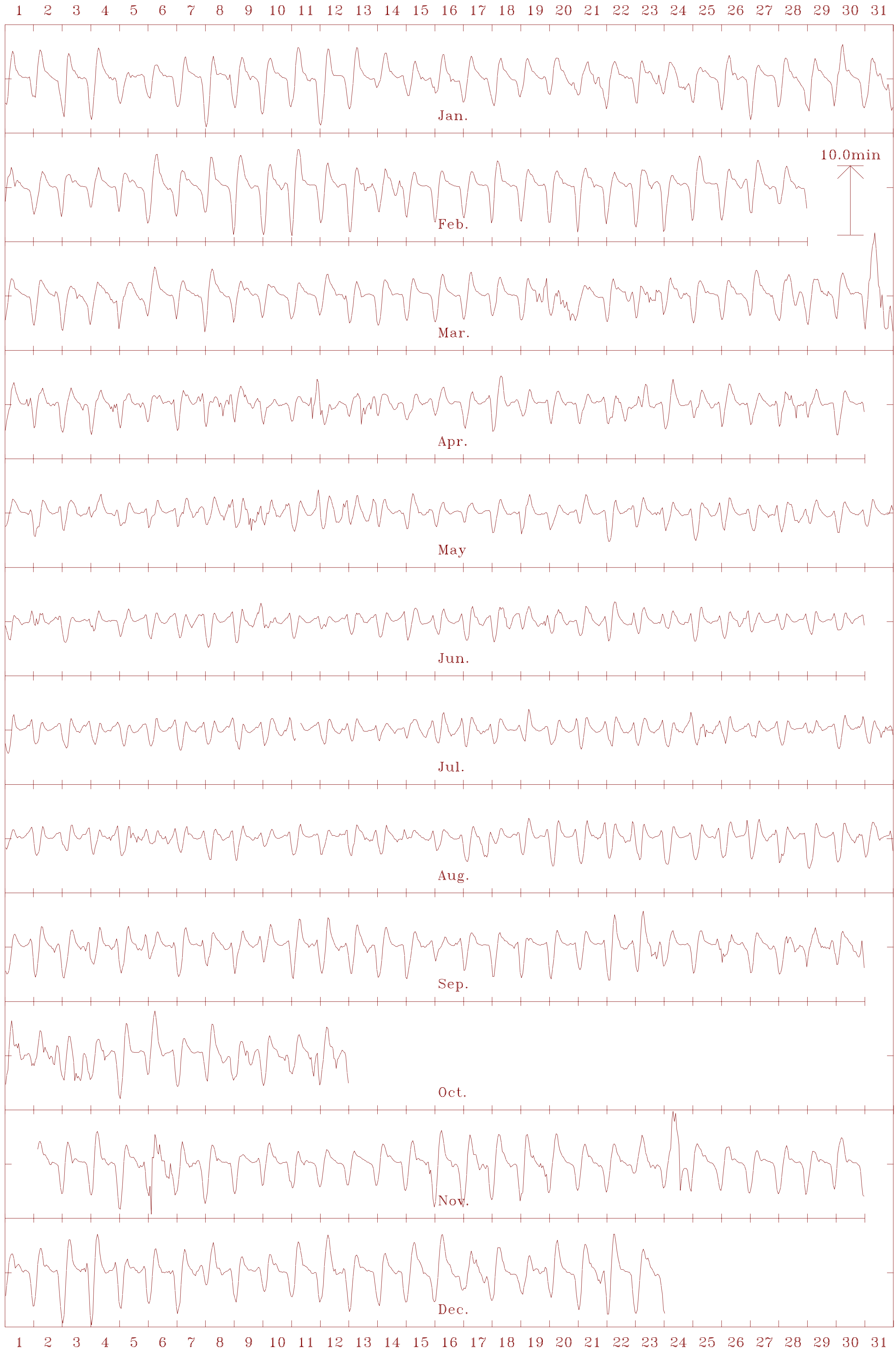
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

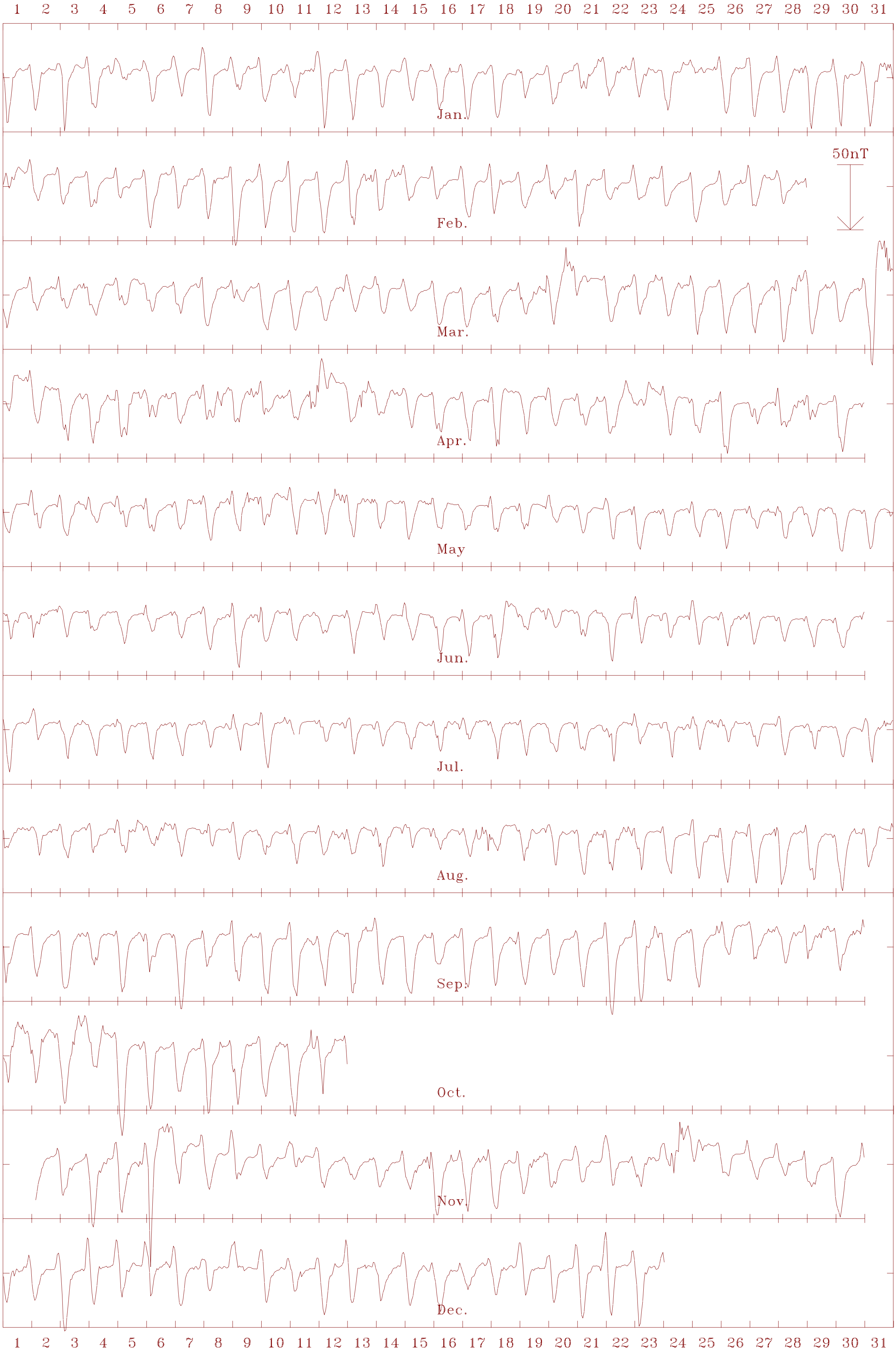
Kakadu, NT 2001 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 35438 nT

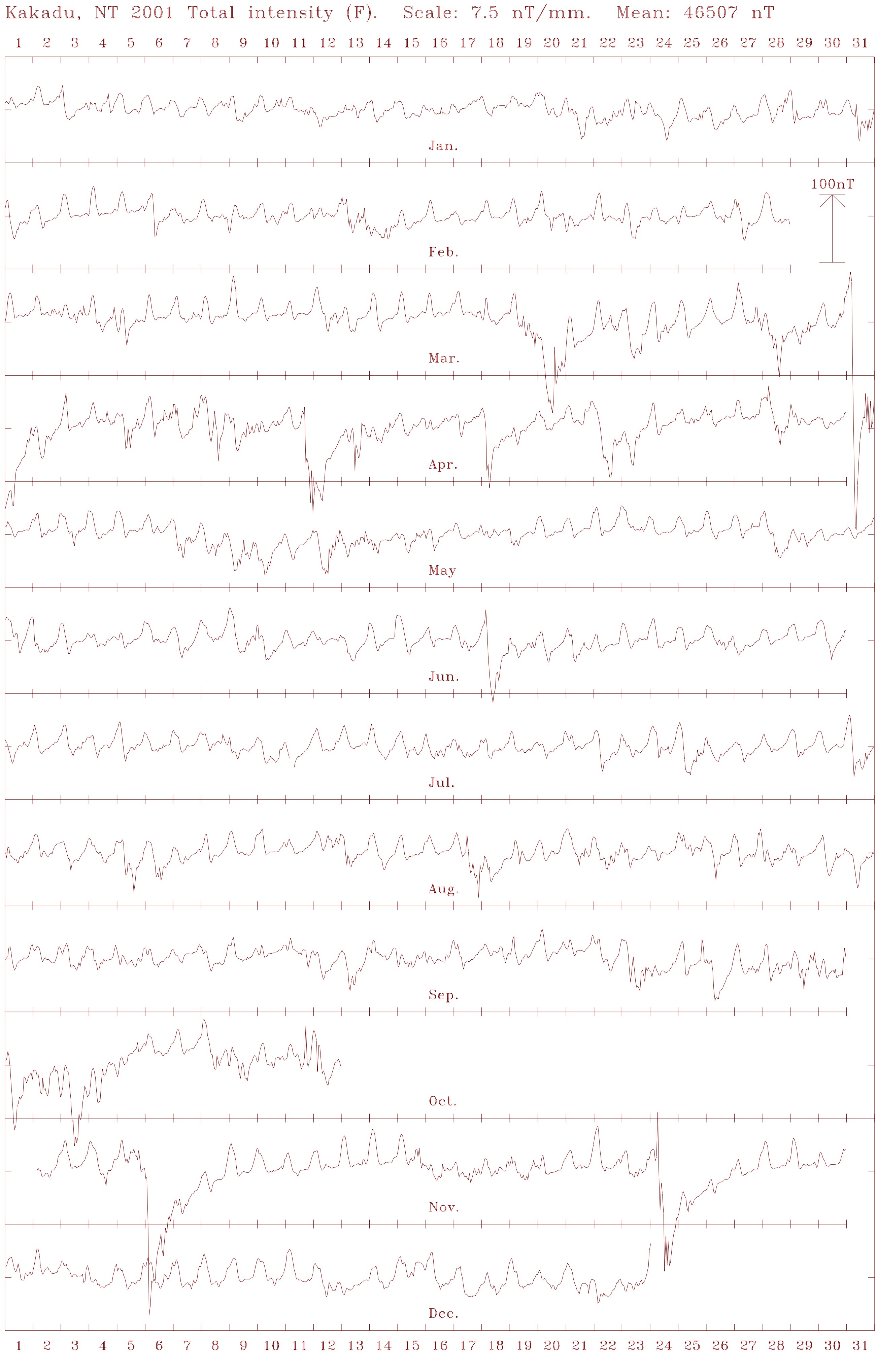


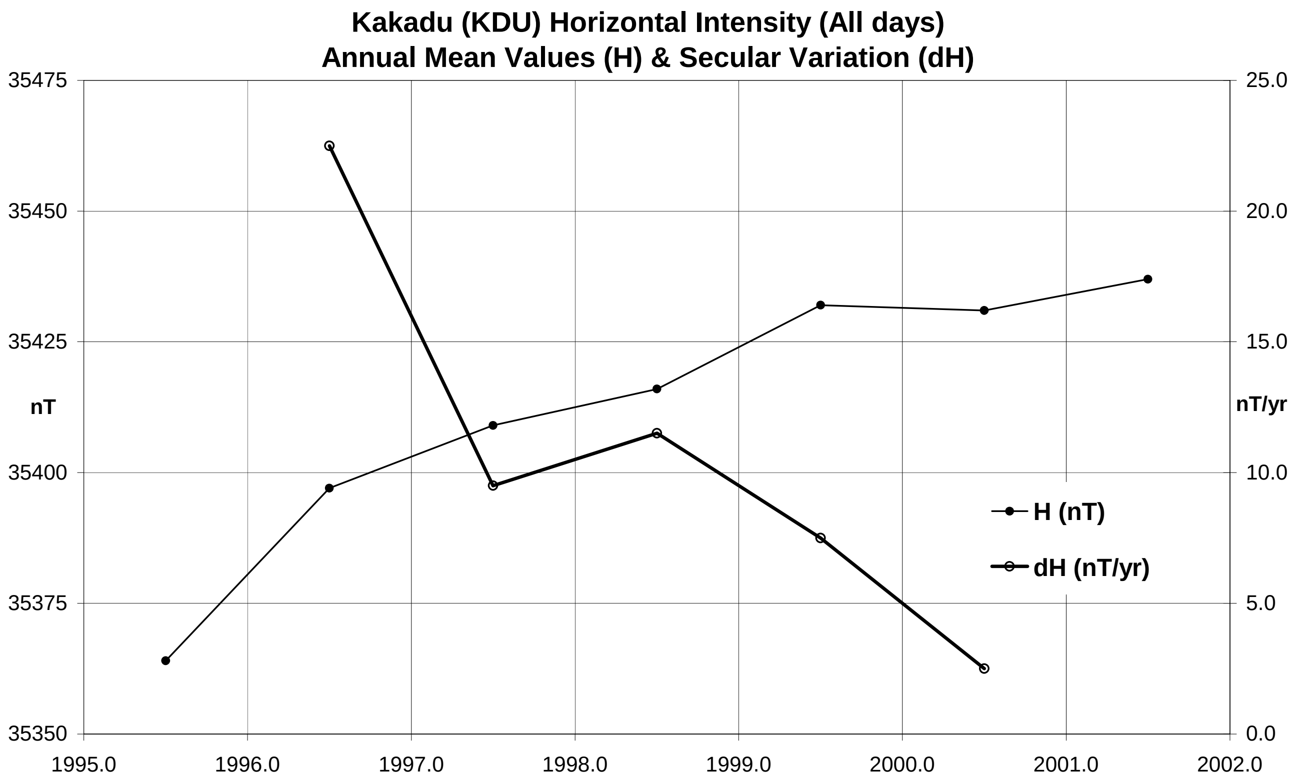
Kakadu, NT 2001 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.74 deg.

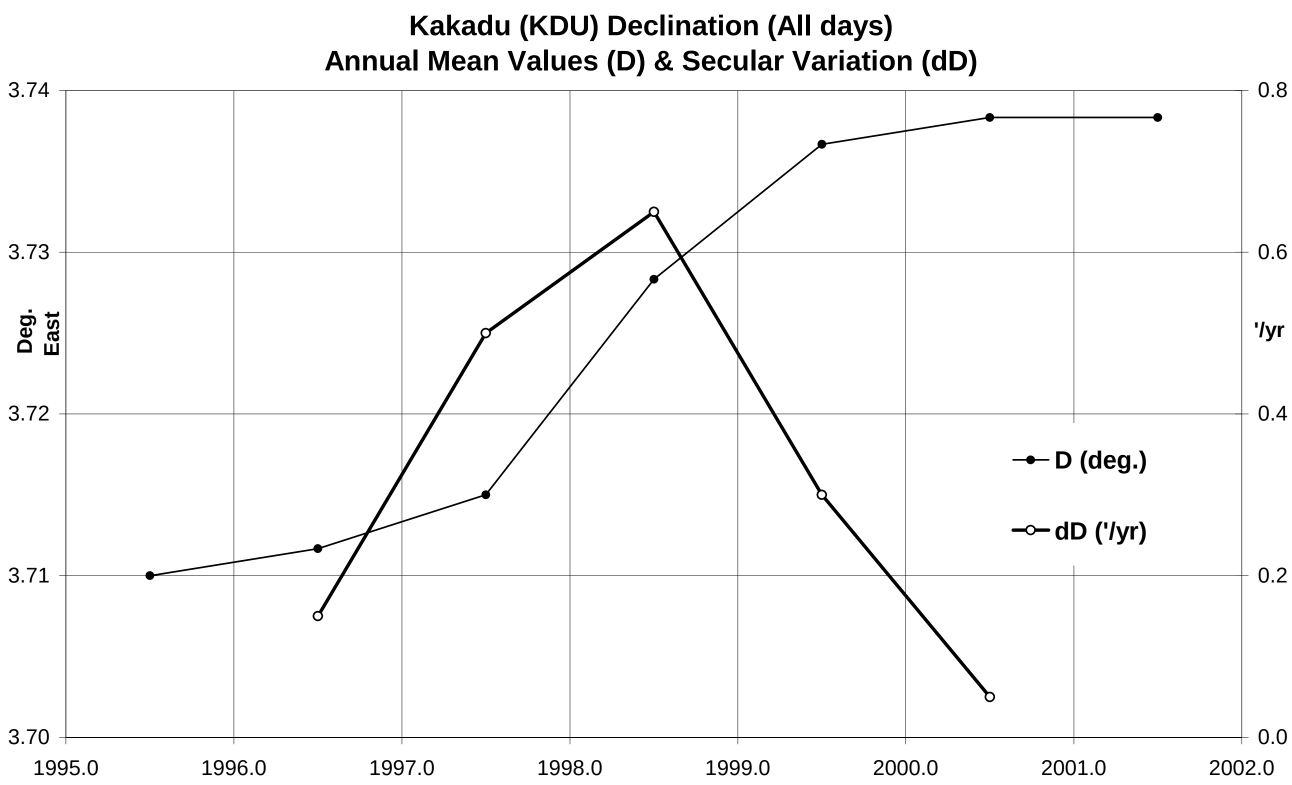


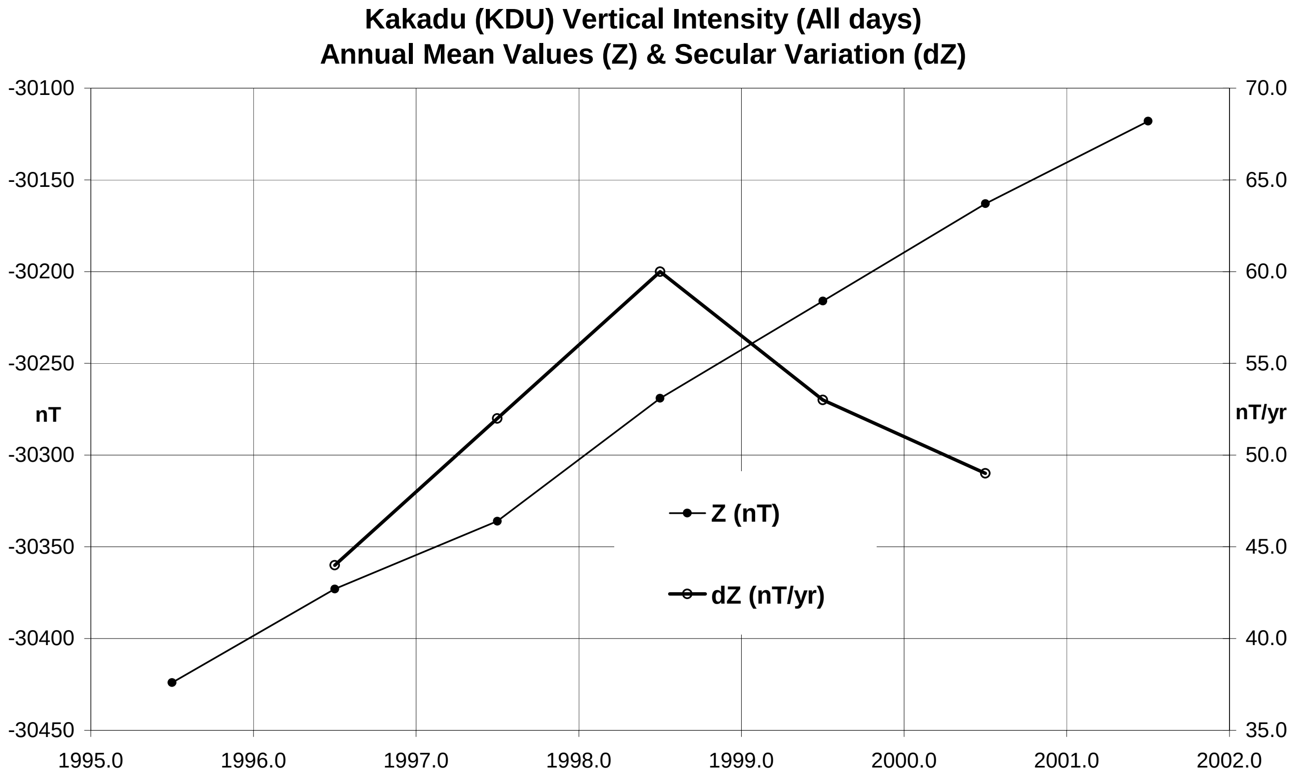
Kakadu, NT 2001 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: -30118 nT

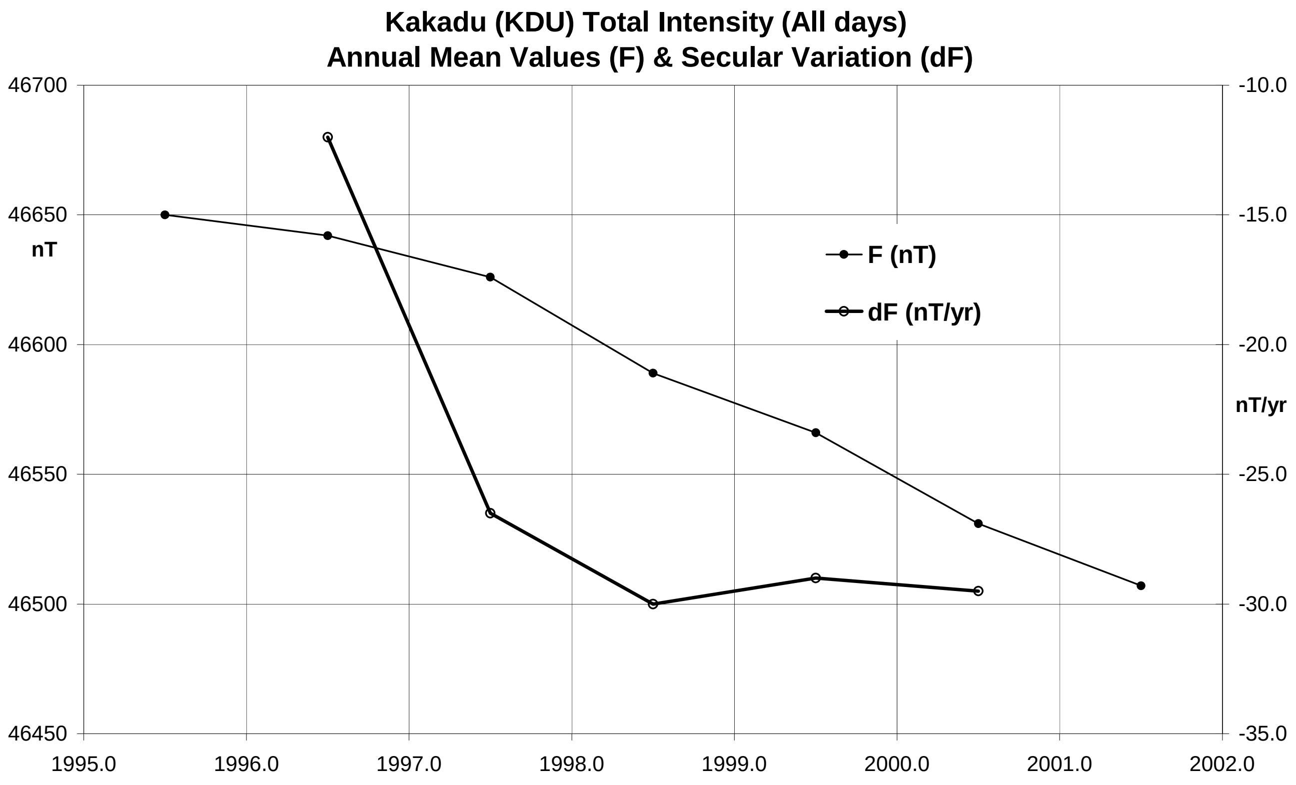



Kakadu, NT 2001 Total intensity (F). Scale: 7.5 nT/mm. Mean: 46507 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
100nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
35475
35450
35425
35400
35375
35350
nT
25.0
20.0
15.0
10.0
5.0
0.0
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
0.6
0.4
0.2
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)
-30100
-30150
-30200
-30250
-30300
-30350
-30400
-30450
nT
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
Z (nT)
dZ (nT/yr)


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

KDU Data losses in 2001:

Apr 04 0100 – 0120 (21 min) Maintenance.

Jul 11 0350 – 0705 (3h 16m) Maintenance.

Aug 09 0215 – 0340 (1h 26m) Power failure.

Sep 30 0342 – 0353 (12 min) UPS replaced.

Oct 13 0000 to Nov 02 / 0331 (20d 03h 32m) Lightning damage.

Nov 15 0049 – 0051 (3 min) Operational error.

Dec 24 0024 to 31 / 2359 (7d 23h 36m) Data degraded below observatory quality. Processing inhibited.

Loss of redundant F channel data

May to Jul 11 PPM variometer data very noisy most of the period.

Jun 06 0023, 0026-0038 (14 min) Maintenance.

Jul 11 0350 – 0705 (3h 16m) Maintenance.

Aug 09 0215 to 15 / 0600 (6d 03h 46m)

Aug 15 2200 to 23 / 0038 (7d 02h 39m)

Aug 23 1638 to 29 / 0024 (5d 07h 47m)

Sep 30 0342 - 0352, 0406 - 0407, 0409 (14 min) UPS replaced.

Oct 13 0000 to Nov 02 / 0334; Nov 02 0338, 2131 - 2133 (20d 03h 39m) Lightning damage.

Nov 15 0049 – 0051 (3 min) Operational error.

Dec 31 0752 – 0810 (19 min) Unknown cause.

Distribution of KDU data during 2001

Preliminary Monthly Means for Project Ørsted

- IPGP monthly (by e-mail)

1-minute & Hourly Mean Values

- 1999: WDC-A, Boulder, USA (08 Jan.2001)
- 2000: WDC-A, Boulder, USA (01 Feb.2001)

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail from 12 Aug 2001.
- Definitive 1995-2000 data in the INTERMAGNET binary CD-ROM format to DMI (sent during March 2001).

LEARMONTH OBSERVATORY

Learmonth, Western Australia, is situated on Australia's North West Cape overlooking the Exmouth Gulf to the east and Cape Range to the west. Learmonth is approximately 1100km north of the city of Perth. The nearest town is Exmouth, approximately 35km to the north. The Learmonth Geomagnetic Observatory is situated at the Learmonth Solar Observatory, jointly staffed by IPS Radio and Space Services, Department of Industry, Tourism & Resources and the U.S. Air Force. The magnetic observatory was established 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 observatory comprises:

- Two small underground vaults that house the variometer sensors located within the perimeter of the solar observatory compound, both at approximately 40m to the east of the RSTN building. The principal (fluxgate sensor) vault is 0.6m x 0.6m concrete construction with a 25mm plastic lid and is set into the ground by about two-thirds of its 1m depth. The internal walls and top of this vault is lined with 50mm polystyrene foam sheets for thermal insulation and the vault is covered with a pile of sand and gravel. A 50mm diameter PVC conduit carrying control and power cables runs underground from the vault to the electronics console and data acquisition computer in the solar observatory Radio Solar Telescope Network (RSTN) building. A second (wooden) PPM sensor vault is approximately 10m north of the principal vault. It is completely buried beneath local sand. A PVC conduit carries the PPM sensor head signal cable to the electronics console in the RSTN building.
- A concrete absolute observation pier within a roofed shelter with brick walls on two sides to the same height as the pier. This was about 200 metres south of the solar observatory, situated on Royal Australian Air Force property.
- The control electronics and acquisition PC were located within the central or Radio Solar Telescope Network building of the solar observatory

Key data for the observation pier of the observatory are:

- 3-character IAGA code: LRM
- Commenced operation: November 1986
- Geographic latitude: 22 13' 19" S
- Geographic longitude: 114° 06' 03" E
- Geomagnetic† : Lat. -32.36°; Long. 186.28°
- 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: G.A. Steward (IPS Radio & Space Services)

† Based on the IGRF 2000.0 model updated to 2001.5

Variometers

A Narod 3-axis Ring Core fluxgate (RCF) variometer (s/n 9004-04), initially installed on 12 Feb. 1999 and aligned to monitor magnetic variations in the magnetic NW, NE and vertical directions was still in service at the beginning of 2001 and continued until 12 August that year. The RCF contained its own temperature sensors. From 14 August 2001 until 12 December a Bartington MAG03MSL70 (s/n 504) three-axis fluxgate was used. The Bartington instrument was also aligned to monitor the NW, NE and vertical components of the magnetic field. From 12 December 2001 a Danish Meteorological Institute FGE suspended three axis fluxgate (s/n E0254, S0227) was used to monitor the NW, NE and vertical components of the magnetic field.

The Narod RCF instrument was replaced because the A (X) channel was faulty throughout 2001, producing noisy data that drifted rapidly and ultimately became very unstable. Upon replacement it was discovered that water damage had occurred to it. The Narod RCF was replaced with a Bartington variometer as a temporary measure only as it was not an observatory quality instrument, having poor baseline stability. It remained in service until an observatory quality instrument could be acquired.

Throughout 2001 the five channels of digital data output from the various fluxgate instruments (three orthogonal magnetic channels, sensor temperature and electronics (or A/D card) temperature) were recorded at 1-second intervals. The RCF produced digital data, the analogue output from the Bartington was digitized with a PAR24B 8 channel 24 bit converter. The analogue data from the DMI instrument was digitized with an ADAM 4017 8 channel 16 bit converter.

The data from the fluxgate instruments were also recorded by IPS on a separate system.

During 2001 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. The digital data from the variometer PPM was recorded at 10-second intervals.

The data from both fluxgate and PPM 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 synchronized to 1-second pulses from a GPS clock.

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

Absolute Instruments & Corrections

Throughout 2001 the local observer performed regular (approximately weekly) sets of absolute observations on the pier (A) in the absolute shelter using the DIM comprising Bartington 010H no. 0702H fluxgate unit with Zeiss 020B theodolite no. 312714 together with Geometrics 856 no. 50471 PPM.

DIM absolute observations were performed using the *offset* method (see *Kakadu Observatory – Absolute Instruments & Corrections*, this report) throughout 2001.

On 14 December 2001 a new stand for the absolute PPM sensor was introduced into the absolute routine and a safety tie down bar was installed on the absolute pier to ensure that that the absolute instruments could not be knocked from the pier during observations.

The corrections adopted for the absolute magnetometers used at LRM during 2001 are: 0.0′, 0.0′ and -1.5 nT in D I, and F respectively. These values convert to corrections:

$\Delta X = -0.84$ nT $\Delta Y = 0$ nT $\Delta Z = 1.24$ nT.

at the mean 2001 field values at LRM of 29725nT, 155nT and -44230nT in X, Y and Z respectively. These instrument corrections have been applied to all data in this report.

The corrections were derived from a series of PPM instrument comparisons at the Canberra Observatory and the Learmonth Observatory. A travelling standard PPM, GEM GSM90_810881 was compared to the Australian standard PPM (GEM GSM90_905026) at the Canberra Observatory on 15 November 2001. The travelling standard instrument was then taken to LRM and compared with the LRM absolute PPM (G856_50471) on 14 December 2001.

No DIM comparisons were made during 2001, the LRM DIM was last compared in 1999.

Operations

The local observer at LRM magnetic observatory was a staff member of IPS at the Learmonth Solar Observatory. During 2001 the observer performed routine tasks at the magnetic observatory that included:

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

1-second values and 1-minute mean value data were transferred daily through modems via telephone lines to GA in Canberra. The clocks on the acquisition PC were 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 2001. Any temperature dependence of the RCF sensors and electronics contributed to baseline drifts over the year which were taken into account in the data processing. The Bartington and DMI variometers had accurately determined temperature coefficients.

The A channel (commonly called the X channel or channel 0) of the Narod RCF developed a fault from 17:00:40 UT on 01 February 2000 that remained until 14 August 2001. This meant that all calibrated 1-minute value data from the Narod instrument during that period had to be derived through recovering the A channel from the two remaining operational RCF magnetic channels and the variometer PPM. As the variometer PPM was recorded at 10-second intervals only one-minute mean data could be recovered in this way. **This also means that calibrated one-second data from Learmonth are not available from 01 February 2000 until 14 August 2001.**

The Narod instrument was replaced in the short term by the Bartington fluxgate on 14 August 2001. Baseline stability problems were well known with the Bartington instrument, but no other variometer was available at the time. In December 2001 the Bartington variometer was replaced with a Danish Meteorological Institute suspended fluxgate variometer. To enable the installation of the suspended DMI sensors and electronics the vault had to be modified. This was carried out during the service visit by staff from GA, Canberra.

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

Distribution of LRM data during 2001

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2001
- 2000 data: IPGP by e-mail (Jun. 2001)

1-minute & Hourly Mean Values

- 1999: WDC-C1, Copenhagen, Denmark (30 May 2001)
- 2000: WDC-C1, Copenhagen, Denmark (30 May 2001)
- 2000: WDC-A, Boulder, USA (30 May, 2001)

LRM - Significant Events 2001

1 Jan	Narod A (X) channel has been unusable since 01 February 2000. Data recovered using PPM until Narod was replaced with Bartington (on 14 August 2001).
14 Jun	Routine absolute observations missed.
30 Jun	Data acquisition system failure.
02 Jul	System re-booted.
26 Jul	Routine absolute observation missed.
01 Aug	Test cable inserted into NAROD to confirm source of problems with Narod data. This caused data loss 0348-0435. Modem problems also in evidence.
06 Aug	New system based on Bartington MAG03MSL70 s/n 504 PAR24b/2 and 486 PC sent to observatory
10 Aug	Modem problems still being experienced.
12 Aug	System upgraded, resulting in data loss from 0645 until 0636 on 14 August.
14 Aug	Technical officer from Perth office (OM) replaced NAROD with Bartington 504 and PAR24/2 Bartington data acquired from 0636 14 August. Bartington performed very poorly until the instrument settled down after a few days.
08 Nov	Crane working on IPS radio telescope.Data corrupted ~00:30 - 05:30 UT.
09 Nov	Data corrupted ~00-06hrs UT
10 Nov	Data corrupted ~00-05hrs UT
17 Nov	No routine absolute observations for six weeks as local observer absent on extended leave.

continued …

Significant Events (cont.)

10 Dec to 17 Dec — Service visit by staff (AML, BS) from GA, Canberra. DMI suspended variometer and safety bar on absolute pier were installed; PPM comparisons, azimuth checks, pier survey; alternate site for magnetometers with PPM and GPS were all performed.

LRM significant data loss in 2001

30 Jun — 0256 to 02 Jul / 0309 (2d 00h 14m) All channels: System stalled.

01 Aug — 0348-0435 (48min) All channels: System tests

12 Aug — 0648 to 14 / 0900 (2d 02h 13m) All channels: System upgrades

16 Aug — 1600 to 17 / 0100 (9h 01m) All channels: Fluxgate failure

08 Nov — 0015 - 0715 (7h 01m) All channels: Corrupted data not processed.

09 Nov — 0000 – 0615 (6h 16m); 2345 to 10 / 0515 (5h 31m): All channels: Corrupted data not processed.

11 Dec — 2347 - 2349 (3 min) All channels: Corrupted data not processed.

12 Dec — 0100 – 0905 (8h 06m); 2300 to 13 / 0100 (2h 01m): All Channels: System upgrades.

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 (1)
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441	53342	DHZ
1991.5	A	-0	26.3	-56	24.5	29507	29506	-226	-44426	53333	DHZ
1992.5	A	-0	23.4	-56	22.6	29531	29530	-201	-44407	53330	DHZ
1993.5	A	-0	18.9	-56	21.2	29550	29549	-162	-44396	53331	DHZ
1994.5	A	-0	15.0	-56	20.5	29555	29555	-129	-44386	53326	DHZ
1995.5	A	-0	10.8	-56	18.2	29588	29588	-93	-44373	53333	DHZ
1996.5	A	-0	06.2	-56	15.5	29630	29630	-54	-44358	53344	DHZ
1997.5	A	-0	01.3	-56	13.3	29658	29658	-11	-44338	53343	DHZ
1998.5	A	0	04.2	-56	11.6	29676	29676	36	-44320	53338	DHZ
1999.5	A	0	09.2	-56	09.6	29696	29696	80	-44292	53325	ABZ (2)
2000.5	A	0	13.5	-56	7.9	29707	29706	116	-44260	53305	ABZ
2001.5	A	0	17.7	-56	5.7	29724	29724	153	-44227	53287	ABZ
1987.5	Q	-0	34.8	-56	26.3	29486	29484	-299	-44445	53336	DHZ (1)
1988.5	Q	-0	33.5	-56	26.3	29494	29492	-288	-44455	53349	DHZ
1989.5	Q	-0	34.3	-56	26.2	29481	29479	-294	-44433	53324	DHZ
1990.5	Q	-0	28.7	-56	24.5	29516	29515	-246	-44439	53348	DHZ
1991.5	Q	-0	26.2	-56	23.4	29527	29526	-225	-44423	53341	DHZ
1992.5	Q	-0	23.3	-56	21.7	29545	29544	-200	-44405	53336	DHZ
1993.5	Q	-0	18.8	-56	20.5	29561	29560	-162	-44394	53336	DHZ
1994.5	Q	-0	15.0	-56	19.7	29569	29569	-129	-44384	53332	DHZ
1995.5	Q	-0	10.8	-56	17.5	29600	29600	-93	-44371	53338	DHZ
1996.5	Q	-0	06.3	-56	15.2	29636	29635	-54	-44357	53346	DHZ
1997.5	Q	-0	01.3	-56	12.8	29667	29667	-11	-44338	53348	DHZ
1998.5	Q	0	04.1	-56	11.1	29686	29686	35	-44318	53342	DHZ
1999.5	Q	0	09.2	-56	09.0	29705	29705	80	-44290	53329	ABZ (2)
2000.5	Q	0	13.5	-56	7.1	29719	29719	117	-44258	53311	ABZ
2001.5	Q	0	17.8	-56	5.0	29736	29736	154	-44225	53293	ABZ
1987.5	D	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	DHZ (1)
1988.5	D	-0	33.6	-56	28.2	29461	29459	-288	-44460	53335	DHZ
1989.5	D	-0	34.4	-56	29.0	29433	29431	-295	-44441	53303	DHZ
1990.5	D	-0	29.0	-56	26.7	29478	29477	-249	-44445	53332	DHZ
1991.5	D	-0	26.5	-56	26.5	29473	29472	-227	-44431	53318	DHZ
1992.5	D	-0	23.5	-56	24.1	29506	29505	-201	-44412	53320	DHZ
1993.5	D	-0	18.9	-56	22.3	29530	29529	-163	-44398	53322	DHZ
1994.5	D	-0	14.9	-56	21.6	29537	29537	-128	-44389	53318	DHZ
1995.5	D	-0	10.9	-56	19.1	29574	29574	-94	-44374	53326	DHZ
1996.5	D	-0	06.2	-56	16.0	29622	29622	-53	-44359	53340	DHZ
1997.5	D	-0	01.3	-56	14.2	29643	29643	-11	-44340	53336	DHZ
1998.5	D	0	04.2	-56	13.0	29652	29652	36	-44322	53326	DHZ
1999.5	D	0	09.3	-56	10.7	29677	29677	81	-44295	53317	ABZ (2)
2000.5	D	0	13.4	-56	9.5	29679	29679	116	-44264	53294	ABZ
2001.5	D	0	17.6	-56	7.2	29699	29699	152	-44230	53276	ABZ

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 2001 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	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29737.4	133.4	-44239.6	53305.5	29737.7	+0° 15.4'	-56° 05.5'
	5xQ days	29746.7	139.5	-44237.8	53309.2	29747.1	+0° 16.1'	-56° 04.9'
	5xD days	29725.6	129.1	-44240.3	53299.5	29725.9	+0° 14.9'	-56° 06.1'
February	All days	29737.0	139.5	-44233.9	53300.5	29737.4	+0° 16.1'	-56° 05.3'
	5xQ days	29742.7	140.3	-44233.2	53303.2	29743.0	+0° 16.2'	-56° 05.0'
	5xD days	29726.7	138.3	-44235.2	53295.9	29727.1	+0° 16.0'	-56° 05.9'
March	All days	29711.4	152.5	-44234.7	53287.0	29711.8	+0° 17.6'	-56° 06.7'
	5xQ days	29733.7	155.5	-44230.8	53296.1	29734.1	+0° 18.0'	-56° 05.3'
	5xD days	29651.1	148.5	-44242.0	53259.4	29651.5	+0° 17.2'	-56° 10.2'
April	All days	29701.2	138.1	-44236.3	53282.6	29701.5	+0° 16.0'	-56° 07.3'
	5xQ days	29718.4	139.4	-44233.8	53290.1	29718.7	+0° 16.1'	-56° 06.3'
	5xD days	29673.2	135.5	-44240.4	53270.4	29673.5	+0° 15.7'	-56° 08.9'
May	All days	29723.9	154.2	-44229.4	53289.5	29724.3	+0° 17.8'	-56° 05.8'
	5xQ days	29733.9	150.2	-44226.3	53292.6	29734.3	+0° 17.4'	-56° 05.2'
	5xD days	29695.5	156.5	-44234.8	53278.2	29695.9	+0° 18.1'	-56° 07.5'
June	All days	29729.1	147.1	-44224.5	53288.4	29729.5	+0° 17.0'	-56° 05.4'
	5xQ days	29734.0	147.5	-44224.1	53290.7	29734.3	+0° 17.1'	-56° 05.1'
	5xD days	29716.5	147.3	-44224.9	53281.7	29716.9	+0° 17.0'	-56° 06.1'
July	All days	29733.3	153.3	-44220.6	53287.5	29733.7	+0° 17.7'	-56° 05.0'
	5xQ days	29739.4	151.9	-44219.2	53289.7	29739.8	+0° 17.6'	-56° 04.6'
	5xD days	29728.3	154.0	-44220.9	53284.9	29728.7	+0° 17.8'	-56° 05.3'
August	All days	29727.2	164.9	-44221.8	53285.1	29727.7	+0° 19.1'	-56° 05.4'
	5xQ days	29731.4	165.7	-44220.7	53286.5	29731.8	+0° 19.2'	-56° 05.1'
	5xD days	29716.4	162.2	-44224.6	53281.4	29716.9	+0° 18.8'	-56° 06.0'
September	All days	29726.3	167.1	-44218.4	53281.8	29726.8	+0° 19.3'	-56° 05.3'
	5xQ days	29737.8	169.1	-44217.6	53287.6	29738.3	+0° 19.5'	-56° 04.6'
	5xD days	29710.2	164.8	-44220.0	53274.1	29710.7	+0° 19.1'	-56° 06.2'
October	All days	29703.2	156.1	-44226.8	53275.9	29703.7	+0° 18.1'	-56° 06.8'
	5xQ days	29729.9	157.8	-44223.0	53287.5	29730.3	+0° 18.2'	-56° 05.3'
	5xD days	29653.7	153.9	-44233.4	53253.7	29654.1	+0° 17.8'	-56° 09.7'
November	All days	29712.6	168.8	-44222.6	53277.6	29713.1	+0° 19.5'	-56° 06.2'
	5xQ days	29735.9	167.3	-44220.3	53288.7	29736.4	+0° 19.3'	-56° 04.8'
	5xD days	29655.0	166.0	-44231.1	53252.6	29655.5	+0° 19.2'	-56° 09.6'
December	All days	29741.3	165.2	-44215.7	53287.9	29741.7	+0° 19.1'	-56° 04.4'
	5xQ days	29743.9	166.0	-44216.2	53289.7	29744.3	+0° 19.2'	-56° 04.3'
	5xD days	29729.4	166.5	-44216.7	53282.1	29729.8	+0° 19.3'	-56° 05.1'
Annual	All days	29723.7	153.4	-44227.0	53287.4	29724.1	+0° 17.7'	-56° 05.7'
Mean	5xQ days	29735.6	154.2	-44225.2	53292.6	29736.0	+0° 17.8'	-56° 05.0'
Values	5xD days	29698.5	151.9	-44230.4	53276.2	29698.9	+0° 17.6'	-56° 07.2'

(Calculated:13:12 hrs., Tue. 11 Dec. 2003)

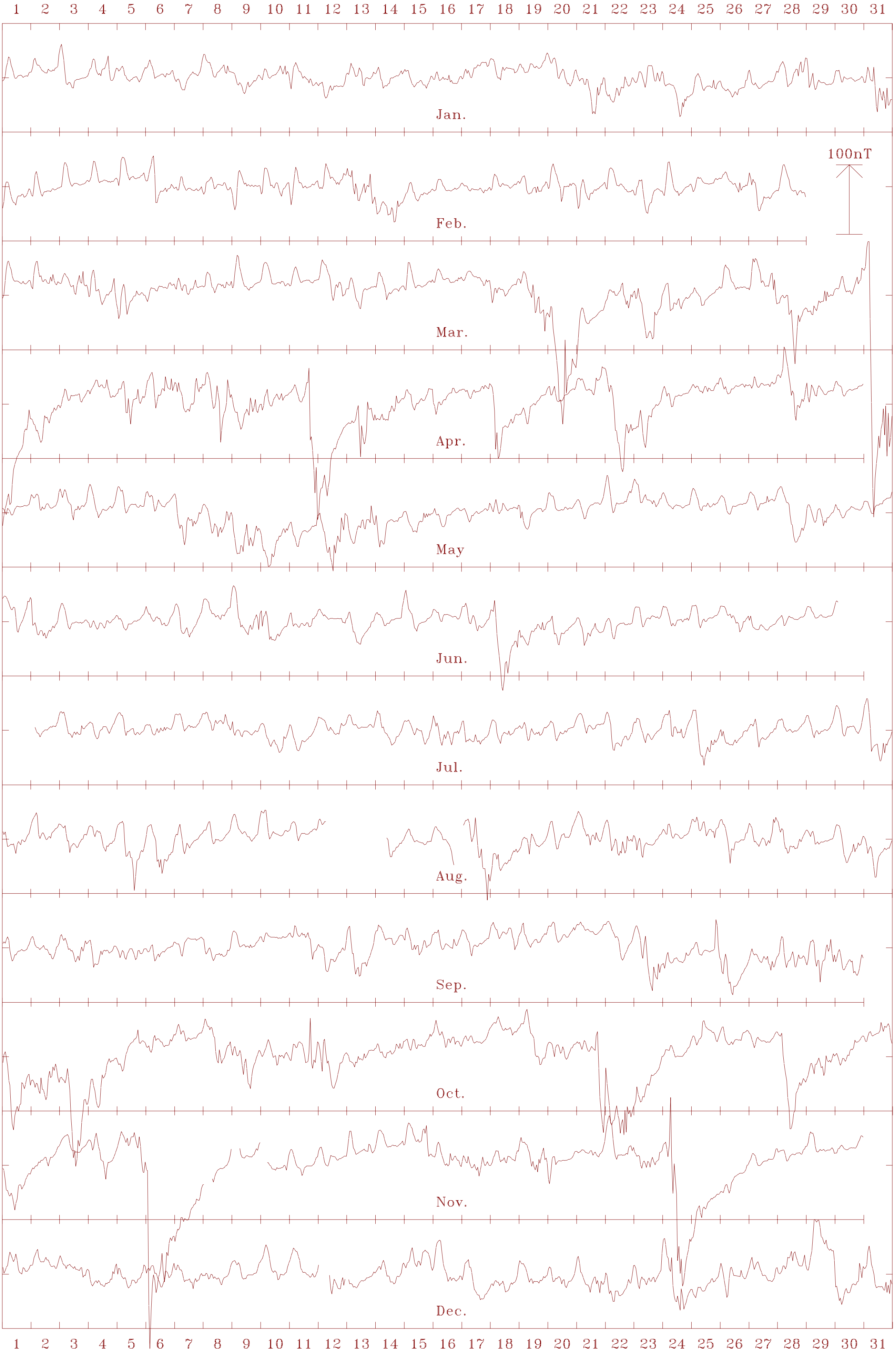
Hourly Mean Values

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.

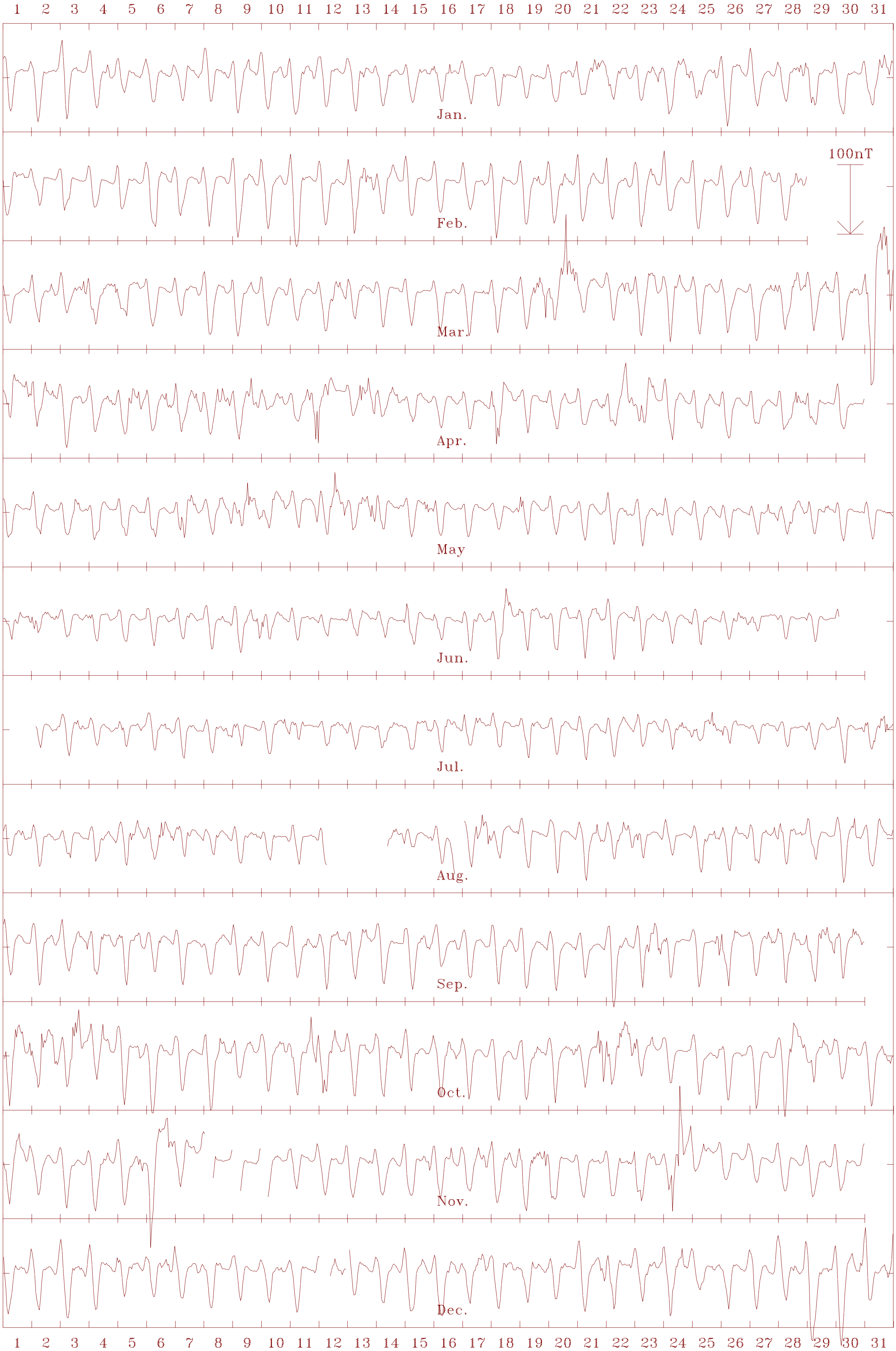
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Learmonth 2001 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29724 nT

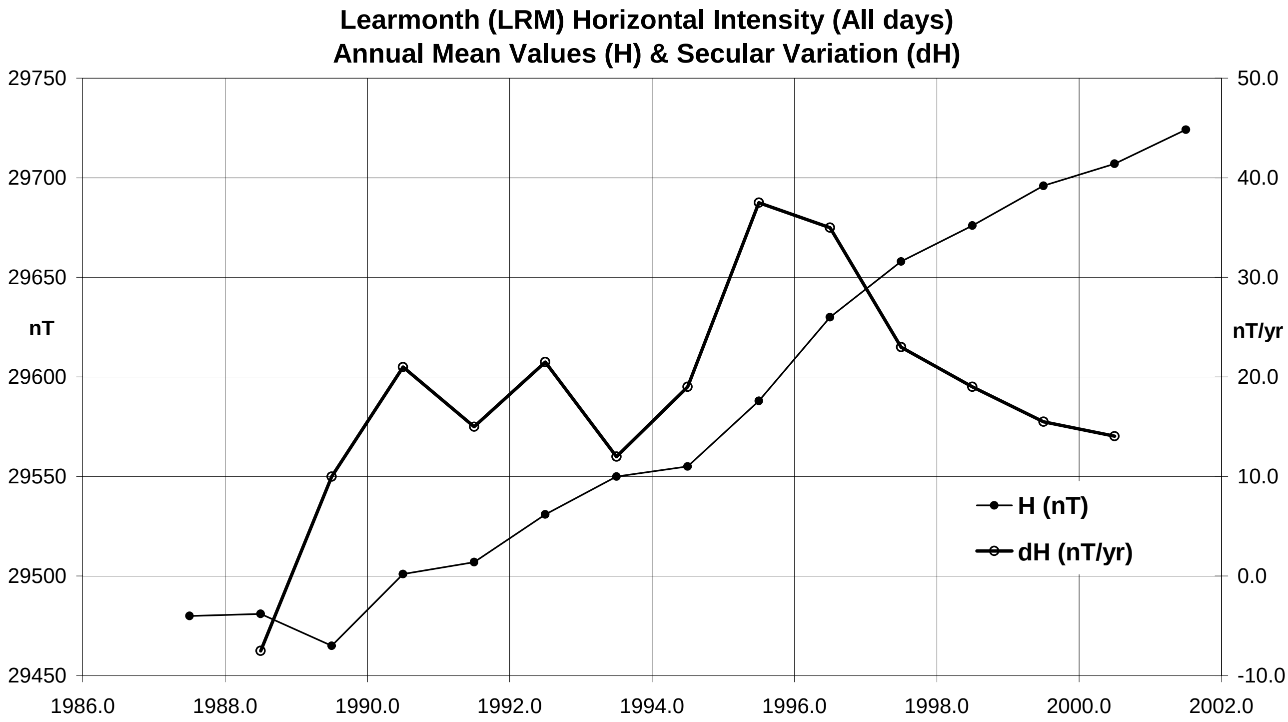


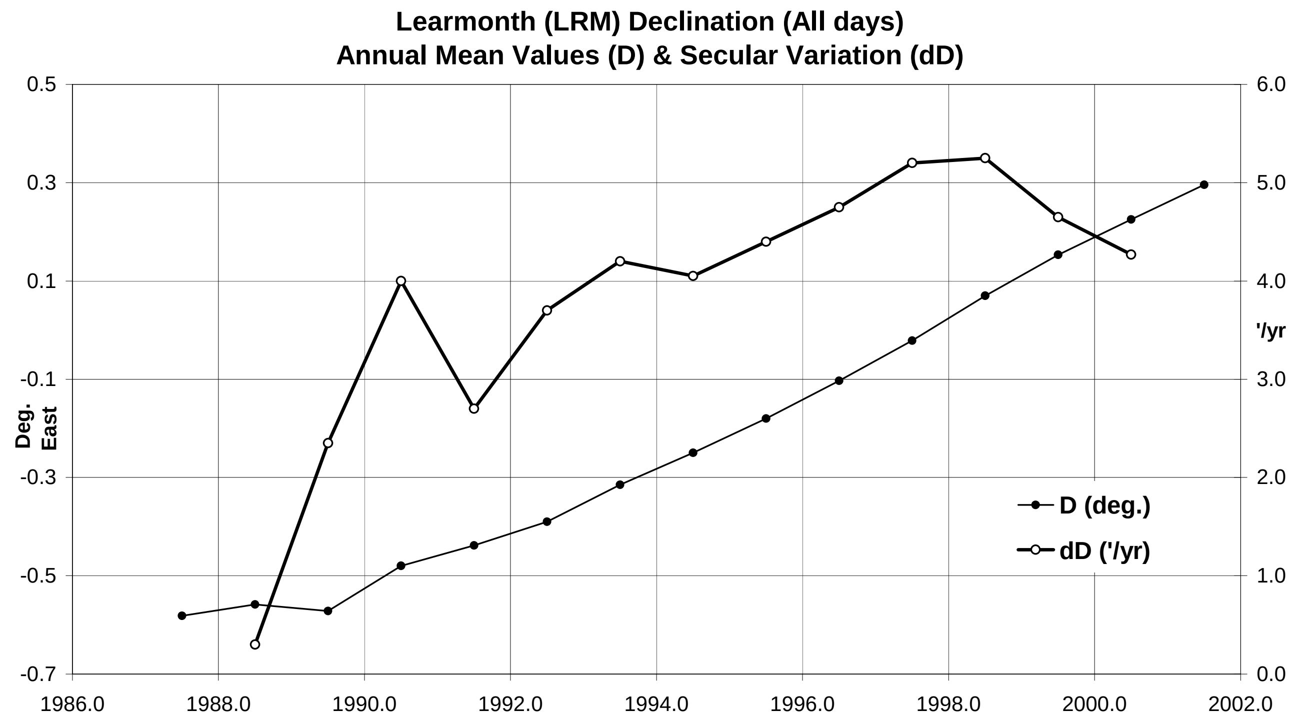
Learmonth 2001 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.30 deg.

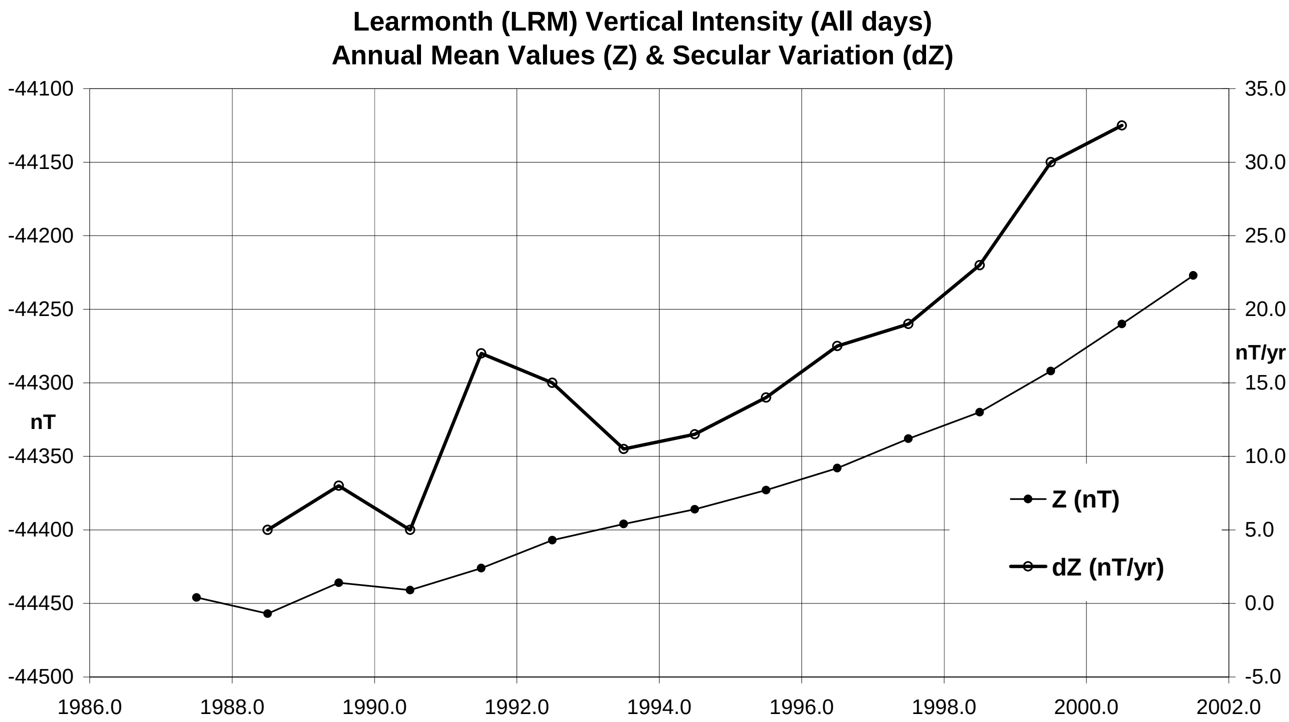
Learmonth 2001 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: -44227 nT



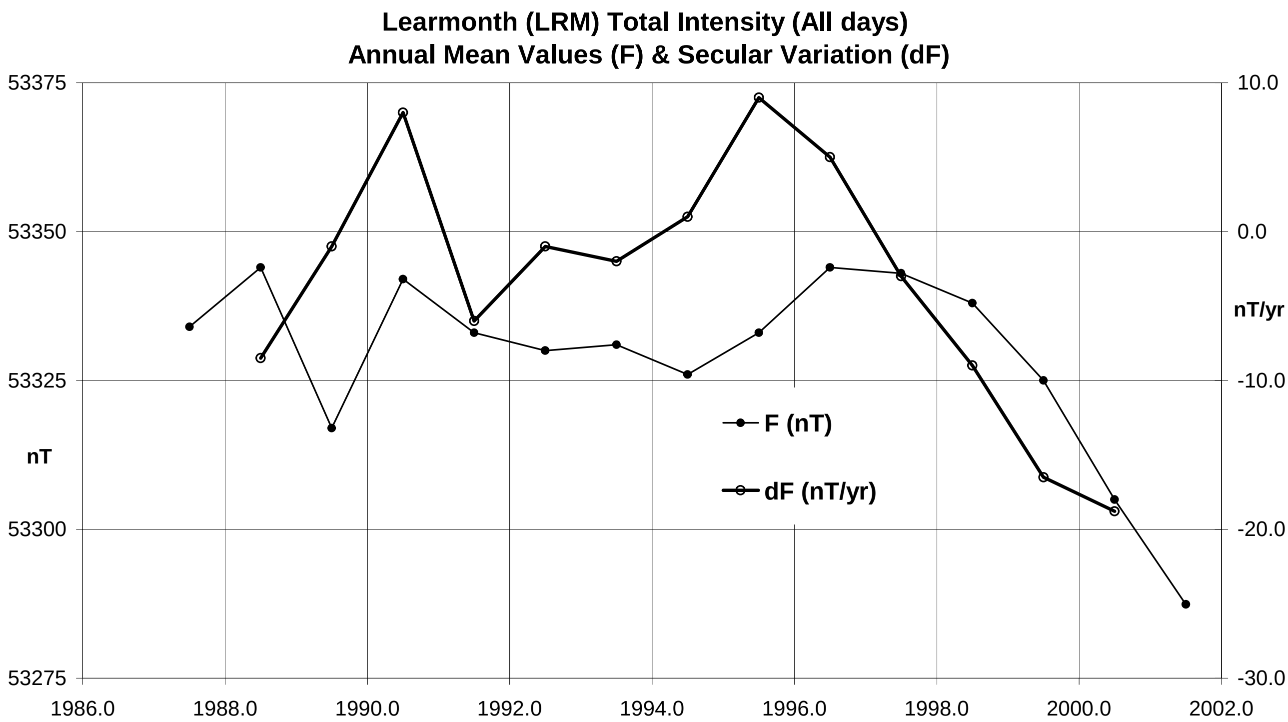
Learmonth 2001 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53287 nT


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


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



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



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

Macquarie Island (Tas.) is approximately 1,350 km. SSE of Hobart, that locates it about half way between Tasmania and Antarctica. Magnetic recording at Macquarie Island has been continuous since 1952, becoming digital in October 1984. Details of the observatory's history are in *AGR 1994*.

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

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

- 3-character IAGA code: MCQ
- Commenced operation: 1952
- Geographic latitude: 54° 30' S
- Geographic longitude: 158° 57' E
- Geomagnetic† : Lat. -59.94°; Long. 244.09°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of pier): 8 metres
- Lower limit for K index of 9: 1500 nT.
- Azimuth of principal reference pillar (NMI) from pier AE: 353° 44' 13"
- Distance to Pillar NMI: ~200 metres
- Observers in Charge: Dave Gilles (2000/01)
  Mick Eccles (2001)

Variometers

The equipment employed to monitor magnetic variations at MCQ in 2001 included an Elsec 820M3 PPM for measuring the magnetic total intensity and a Narod 3-axis ringcore fluxgate (RCF) magnetometer. The RCF sensors, mounted on a marble '*tombstone'* base, were not aligned with either the standard field elements or cardinal points, but were oriented in such a way that the three mutually orthogonal components recorded were of approximately equal magnitudes. Details of the *'tombstone'* RCF sensor base and the orientation of the sensors were given in the section on *Variometer Alignment* in *AGRs 1993-1996*. The RCF sensors were located in the Variometer House, and the backup power supply and the acquisition computer situated in the office. The electronic console of the RCF magnetometer was situated in a small room within the Variometer House. The Variometer House temperature was controlled with a heating system. The Elsec 820 PPM sensor was located on the pier in the PPM House.

MCQ - Absolute Instruments and Corrections

Magnetic absolute measurements were performed in the Absolute House, on Pier AW with an Austral PPM (serial 525) and on Pier AE with an Elsec 810 DIM (serial 201 from the beginning of 2001 and serial 214 from late March) with Zeiss020B (serial 311847) theodolite. Replacement magnetometer electronics, serial 214, arrived in late March 2001 to replace serial 201 which had malfunctioned in early January 2001.

The classical QHMs (serial 177, 178, 179 on Askania circle 640616) were available as backup for use on pier AE. QHMs 178 and 179 where relied upon during February and March 2001 until the replacement DIM electronics arrived.

Baselines

For consistency with the Australian Magnetic Standard held at Canberra, a correction of +1.0nT was applied to the PPM readings, while zero corrections were applied to the DIM readings. This resulted in baseline corrections of:

$\Delta X = +0.17$ nT $\Delta Y = +0.10$ nT $\Delta Z = -0.98$ nT.

Operations

The magnetic observers-in-charge at Macquarie Island in 2001 were supported jointly by the Australian Antarctic Division (AAD) in the Department of The Environment and Heritage and GA. They were members of the Australian National Antarctic Research Expedition (ANARE).

The duties of the magnetic observer included maintaining the equipment, performing absolute observations to calibrate the variometers and providing regular data reports to GA headquarters in Canberra.

Dave Gillies arrived at MCQ on 8 December 2000 and took over the absolute observations from Jean Osanz on 17 December 2000. Mick Eccles arrived on 31 March 2001 and took over from Dave Gillies on 5 April 2001.

Twice weekly absolute calibrations were performed on the observation piers in the Absolute House.

The RCF variometer produced 8 samples per second that were averaged and output as 1-second data. The PPM variometer produced 10-second samples. The 1-second RCF data and 10-second PPM data as well as 1-minute means of both were recorded on an acquisition PC.

All data were automatically transmitted daily, via a network connection, to GA where they were processed. Timing was provided by the Antarctic Division's GPS clock (which was also used with Atmospheric and Space Physics experiments).

Macquarie Island Annual Mean Values

The table below gives annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z & F are on pages 77-78.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1993.5	A	29	57.2	-78	48.1	12558	10880	6270	-63428	64659	ABC
1994.5	A	30	02.2	-78	48.3	12549	10863	6281	-63404	64634	ABC
1995.5	A	30	06.6	-78	47.5	12559	10864	6300	-63376	64608	ABC
1996.5	A	30	11.0	-78	46.4	12574	10870	6322	-63353	64589	ABC
1997.5	A	30	15.4	-78	45.9	12580	10866	6339	-63336	64573	ABC
1998.5	A	30	20.0	-78	45.8	12579	10857	6353	-63320	64557	ABC
1999.5	A	30	23.6	-78	45.2	12586	10856	6367	-63294	64534	ABC
2000.5	A	30	28.4	-78	45.0	12585	10847	6382	-63268	64507	ABC

continued …

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
2001.5	A	30	33.5	-78	44.1	12595	10846	6404	-63231	64473	ABC
1951.5		23	50.8	-78	17.6	13383	12241	5411	-64589	65961	HDZ
1952.5		24	04.2	-78	17.8	13371	12208	5453	-64550	65920	HDZ
1953.5		24	14.6	-78	18.2	13360	12182	5486	-64533	65901	HDZ
1954.5		24	28.4	-78	18.4	13356	12156	5533	-64535	65903	HDZ
1955.5		24	42.0	-78	18.6	13350	12129	5579	-64520	65887	HDZ
1956.5		24	53.2	-78	19.3	13333	12095	5611	-64506	65870	HDZ
1957.5		25	05.7	-78	19.8	13319	12062	5649	-64482	65843	HDZ
1958.5		25	16.6	-78	20.1	13307	12033	5682	-64456	65815	HDZ
1959.5		25	26.3	-78	20.9	13288	12000	5708	-64436	65792	HDZ
1960.5		25	32.0	-78	22.0	13262	11967	5716	-64414	65765	HDZ
1961.5		25	50.0	-78	22.5	13240	11917	5769	-64359	65707	HDZ
1962.5		26	05.8	-78	23.3	13216	11869	5814	-64321	65665	HDZ
1963.5		26	08.5	-78	24.2	13193	11843	5813	-64294	65634	HDZ
1964.5		26	17.0	-78	24.7	13174	11812	5834	-64249	65586	HDZ
1965.5		26	28.6	-78	25.5	13152	11773	5864	-64214	65547	HDZ
1966.5		26	37.6	-78	26.7	13121	11729	5881	-64175	65503	HDZ
1967.5		26	46.5	-78	28.5	13084	11681	5894	-64166	65486	HDZ
1968.5		26	54.7	-78	29.7	13053	11639	5908	-64132	65447	HDZ
1969.5		27	02.3	-78	30.8	13026	11602	5921	-64099	65409	HDZ
1970.5		27	09.6	-78	32.1	12996	11563	5932	-64078	65383	HDZ
1971.5		27	13.3	-78	33.3	12963	11527	5930	-64032	65331	HDZ
1972.5		27	22.1	-78	34.4	12937	11489	5947	-64008	65302	HDZ
1973.5		27	27.6	-78	35.8	12905	11451	5951	-63985	65273	HDZ
1974.5		27	34.3	-78	37.6	12865	11404	5955	-63956	65237	HDZ
1975.5		27	43.2	-78	38.2	12847	11373	5976	-63926	65204	HDZ
1976.5		27	51.6	-78	39.1	12822	11336	5992	-63891	65165	HDZ
1977.5		27	59.8	-78	39.9	12802	11304	6010	-63861	65132	HDZ
1978.5		28	11.3	-78	41.1	12773	11258	6034	-63838	65103	HDZ
1979.5		28	19.6	-78	42.3	12745	11219	6047	-63807	65067	HDZ
1980.5		28	28.8	-78	43.0	12723	11183	6067	-63768	65025	HDZ
1981.5		28	37.5	-78	44.5	12687	11136	6078	-63735	64985	HDZ
1982.5		28	49.5	-78	45.4	12666	11097	6107	-63711	64958	HDZ
1983.5		28	54.9	-78	45.7	12652	11075	6117	-63674	64919	HDZ
1984.5		29	03.7	-78	46.1	12640	11049	6140	-63650	64893	HDZ
1985.5		29	12.0	-78	47.4	12608	11006	6151	-63619	64856	XYZ
1986.5		29	19.0	-78	47.5	12600	10986	6169	-63590	64826	XYZ
1987.5		29	26.8	-78	47.8	12593	10966	6191	-63584	64819	XYZ
1988.5		29	32.2	-78	47.8	12590	10954	6207	-63560	64795	XYZ
1989.5		29	37.8	-78	47.8	12587	10941	6223	-63552	64786	XYZ
1990.5		29	42.8	-78	48.0	12577	10923	6234	-63519	64752	XYZ
1991.5		29	47.6	-78	47.6	12578	10915	6250	-63487	64721	XYZ
1992.5		29	53.0	-78	47.5	12573	10901	6264	-63447	64681	XYZ
1993.5	Q	29	56.9	-78	47.2	12575	10896	6277	-63427	64661	ABC
1994.5	Q	30	01.5	-78	47.0	12574	10887	6292	-63403	64637	ABC
1995.5	Q	30	06.2	-78	46.5	12577	10881	6308	-63377	64613	ABC
1996.5	Q	30	10.5	-78	45.9	12585	10879	6326	-63356	64594	ABC
1997.5	Q	30	15.2	-78	45.4	12591	10876	6344	-63336	64576	ABC
1998.5	Q	30	19.7	-78	45.1	12593	10870	6359	-63321	64562	ABC
1999.5	Q	30	23.5	-78	44.6	12598	10867	6373	-63293	64535	ABC
2000.5	Q	30	28.3	-78	44.3	12598	10858	6389	-63266	64509	ABC
2001.5	Q	30	33.3	-78	43.4	12608	10857	6409	-63229	64474	ABC
1993.5	D	29	58.5	-78	50.0	12521	10846	6256	-63429	64654	ABC
1994.5	D	30	03.3	-78	50.2	12514	10831	6267	-63408	64632	ABC
1995.5	D	30	07.8	-78	49.4	12522	10830	6285	-63376	64601	ABC
1996.5	D	30	11.9	-78	47.4	12556	10852	6316	-63350	64583	ABC
1997.5	D	30	16.0	-78	47.3	12555	10843	6328	-63334	64566	ABC
1998.5	D	30	21.0	-78	47.7	12543	10824	6338	-63320	64550	ABC
1999.5	D	30	24.3	-78	46.4	12564	10836	6358	-63297	64532	ABC
2000.5	D	30	29.0	-78	46.7	12554	10819	6368	-63273	64507	ABC
2001.5	D	30	34.6	-78	46.0	12560	10813	6389	-63238	64473	ABC

* Elements ABC indicates non-aligned variometer orientation

Macquarie Island 2001Monthly & Annual Mean Values

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

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

Macquarie Island	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	10858.0	6391.3	-63234.8	64477.9	12599.4	30° 28.9'	-78° 43.9'
	5xQ days	10871.3	6399.5	-63235.1	64481.1	12615.1	30° 29.0'	-78° 43.1'
	5xD days	10811.9	6370.8	-63238.3	64471.6	12549.3	30° 30.5'	-78° 46.6'
February	All days	10858.6	6397.4	-63234.5	64478.2	12603.0	30° 30.3'	-78° 43.7'
	5xQ days	10862.5	6400.7	-63234.6	64479.3	12608.0	30° 30.5'	-78° 43.4'
	5xD days	10846.5	6390.3	-63235.5	64476.6	12589.0	30° 30.3'	-78° 44.4'
March	All days	10830.6	6391.0	-63247.4	64485.7	12575.7	30° 32.7'	-78° 45.3'
	5xQ days	10855.2	6401.4	-63234.2	64477.7	12602.1	30° 31.7'	-78° 43.7'
	5xD days	10726.3	6351.7	-63301.4	64517.9	12466.3	30° 38.0'	-78° 51.5'
April	All days	10824.7	6393.8	-63253.0	64490.4	12572.1	30° 34.2'	-78° 45.5'
	5xQ days	10846.6	6406.4	-63250.9	64493.1	12597.2	30° 34.1'	-78° 44.2'
	5xD days	10781.6	6370.8	-63261.1	64489.1	12523.3	30° 34.8'	-78° 48.1'
May	All days	10845.2	6403.9	-63236.4	64478.4	12594.7	30° 33.7'	-78° 44.2'
	5xQ days	10853.7	6408.3	-63237.0	64480.9	12604.3	30° 33.5'	-78° 43.7'
	5xD days	10810.6	6386.8	-63229.1	64464.0	12556.4	30° 34.5'	-78° 46.1'
June	All days	10853.8	6408.6	-63230.1	64474.2	12604.6	30° 33.6'	-78° 43.6'
	5xQ days	10856.7	6410.6	-63230.1	64474.9	12608.1	30° 33.6'	-78° 43.4'
	5xD days	10844.1	6407.7	-63222.5	64465.1	12595.8	30° 34.8'	-78° 44.0'
July	All days	10855.6	6409.8	-63224.0	64468.6	12606.7	30° 33.6'	-78° 43.4'
	5xQ days	10858.1	6410.5	-63224.0	64469.2	12609.3	30° 33.4'	-78° 43.3'
	5xD days	10851.1	6408.2	-63223.4	64467.2	12602.1	30° 33.9'	-78° 43.6'
August	All days	10846.5	6408.0	-63219.2	64462.2	12598.0	30° 34.5'	-78° 43.8'
	5xQ days	10854.7	6411.6	-63221.6	64466.3	12606.9	30° 34.2'	-78° 43.4'
	5xD days	10822.1	6394.9	-63211.0	64448.8	12570.4	30° 34.8'	-78° 45.2'
September	All days	10844.1	6408.6	-63221.5	64464.2	12596.2	30° 34.9'	-78° 43.9'
	5xQ days	10856.6	6414.7	-63221.8	64467.1	12610.1	30° 34.6'	-78° 43.2'
	5xD days	10814.4	6393.1	-63228.3	64464.5	12562.9	30° 35.5'	-78° 45.7'
October	All days	10826.2	6402.0	-63236.5	64475.4	12577.5	30° 35.9'	-78° 45.1'
	5xQ days	10849.1	6415.1	-63227.4	64471.4	12603.9	30° 35.7'	-78° 43.6'
	5xD days	10758.6	6368.0	-63270.9	64494.9	12502.3	30° 37.4'	-78° 49.4'
November	All days	10847.4	6413.1	-63227.7	64471.4	12601.5	30° 35.5'	-78° 43.7'
	5xQ days	10856.4	6416.5	-63225.7	64471.1	12610.8	30° 35.1'	-78° 43.2'
	5xD days	10834.3	6409.8	-63229.1	64470.6	12588.8	30° 36.6'	-78° 44.4'
December	All days	10860.7	6414.6	-63206.3	64452.6	12613.6	30° 34.0'	-78° 42.9'
	5xQ days	10863.0	6415.9	-63208.9	64455.7	12616.2	30° 34.0'	-78° 42.7'
	5xD days	10844.0	6405.7	-63196.1	64439.0	12594.7	30° 34.3'	-78° 43.7'
Annual	All days	10846.0	6403.5	-63231.0	64473.3	12595.3	30° 33.5'	-78° 44.1'
Mean	5xQ days	10857.0	6409.3	-63229.3	64474.0	12607.7	30° 33.3'	-78° 43.4'
Values	5xD days	10812.1	6388.2	-63237.2	64472.4	12558.4	30° 34.6'	-78° 46.1'

(Calculated:12:28 hrs., Tue. 16 Dec. 2003)

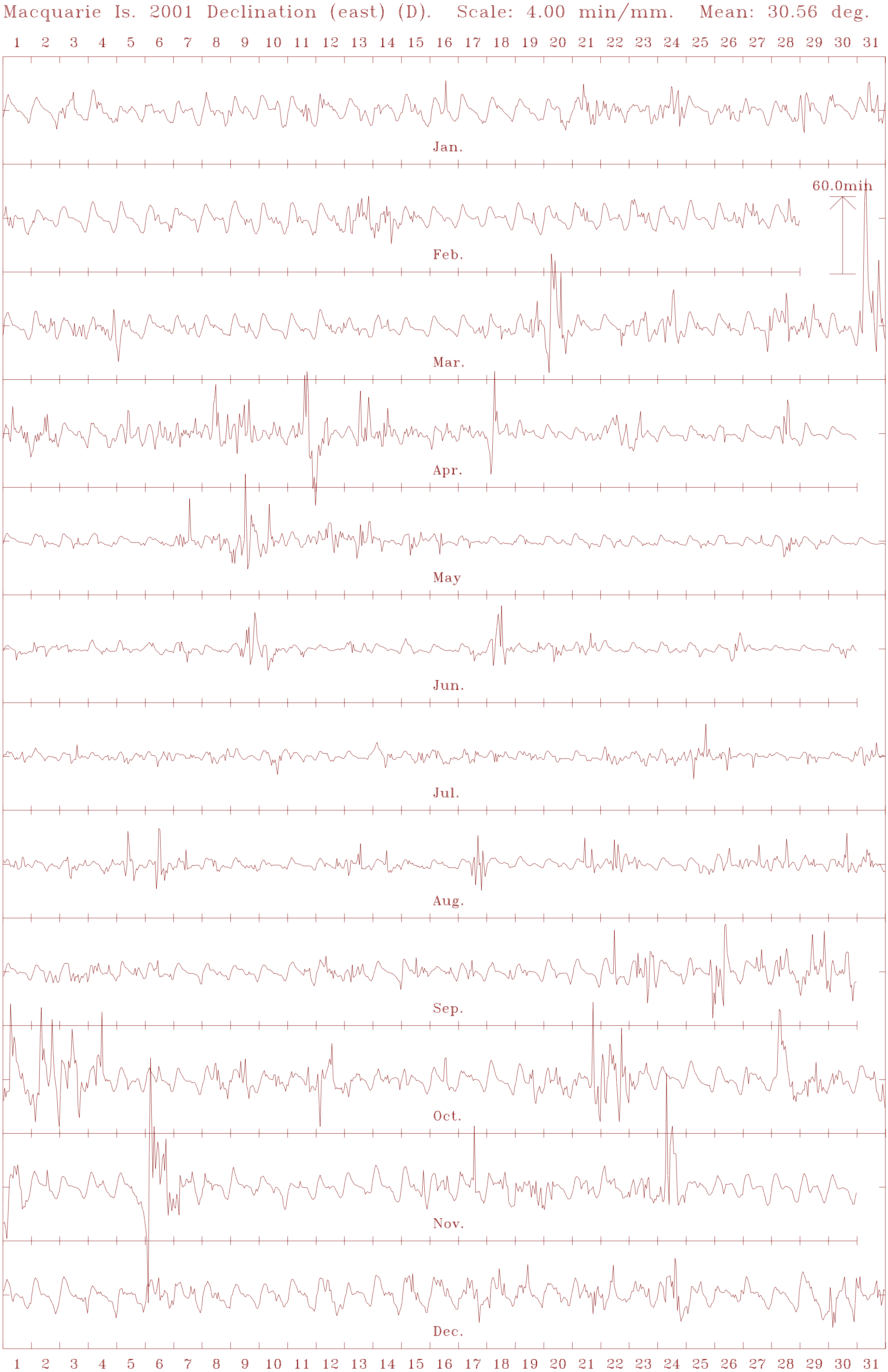
Hourly Mean Values

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

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

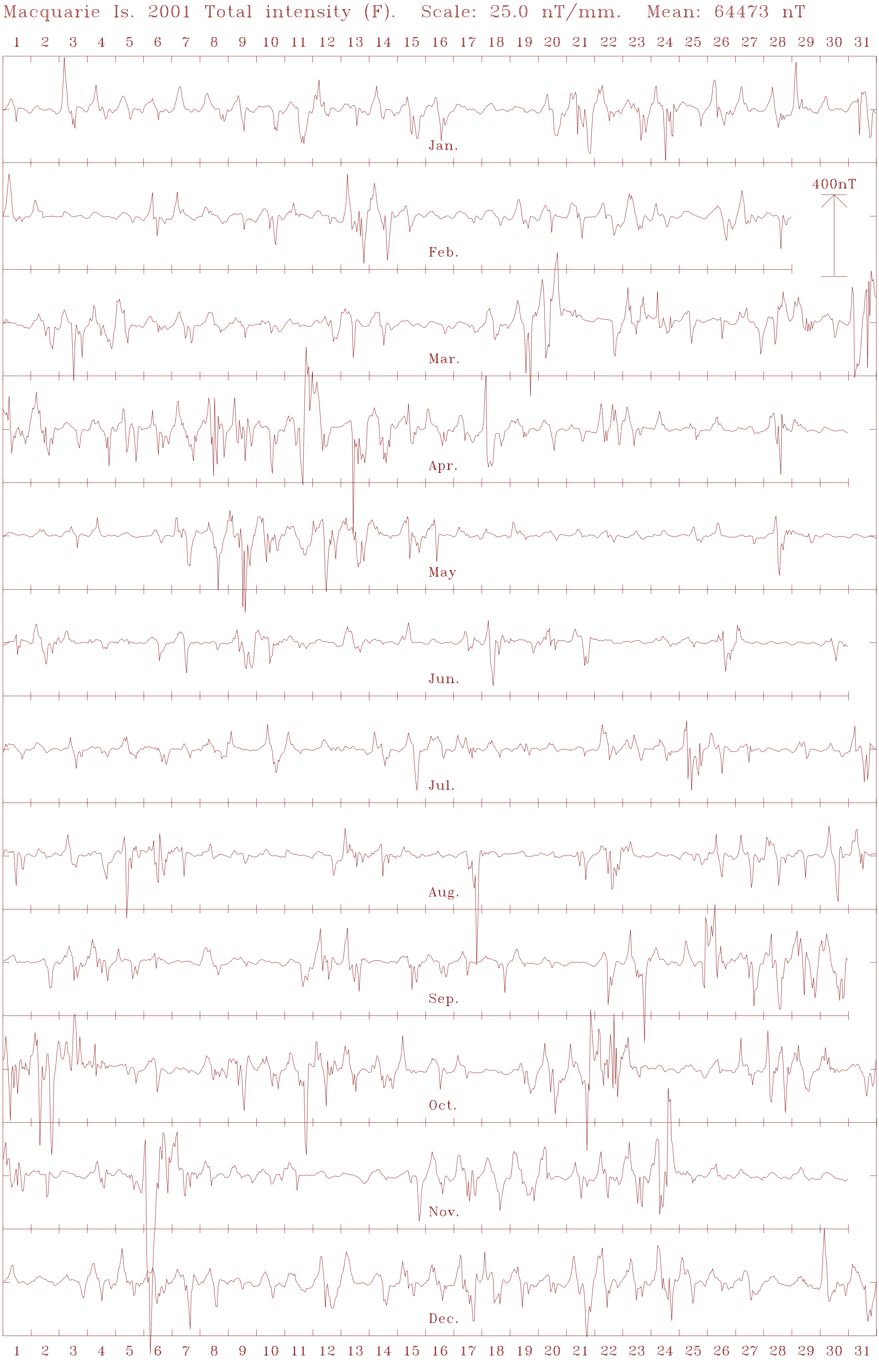
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

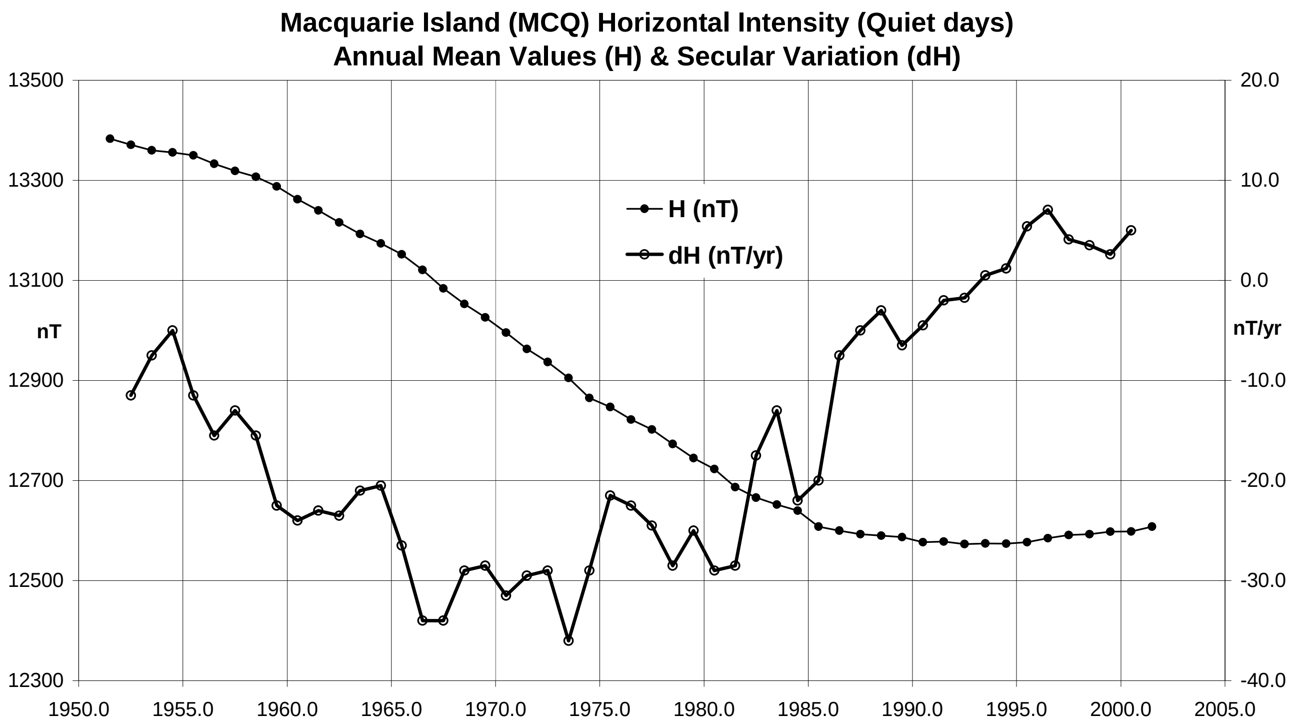
Macquarie Is. 2001 Horizontal intensity (H). Scale: 40.0 nT/mm. Mean: 12595 nT

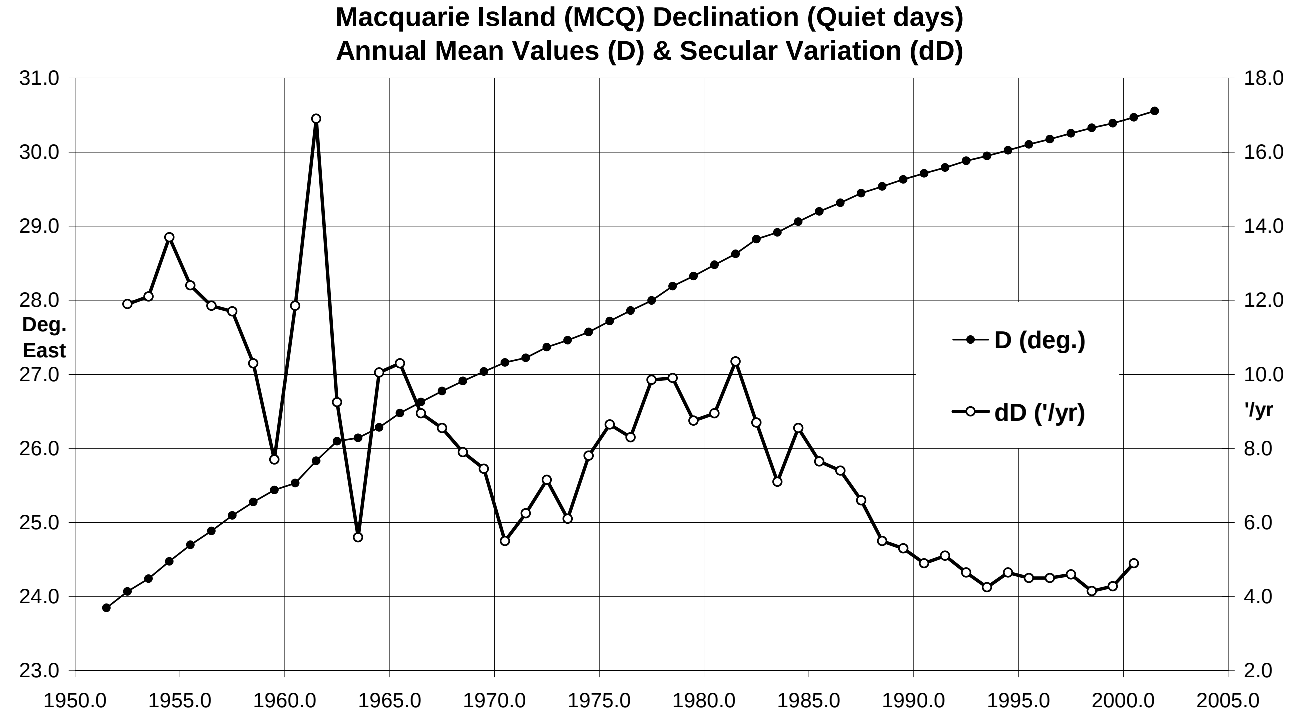


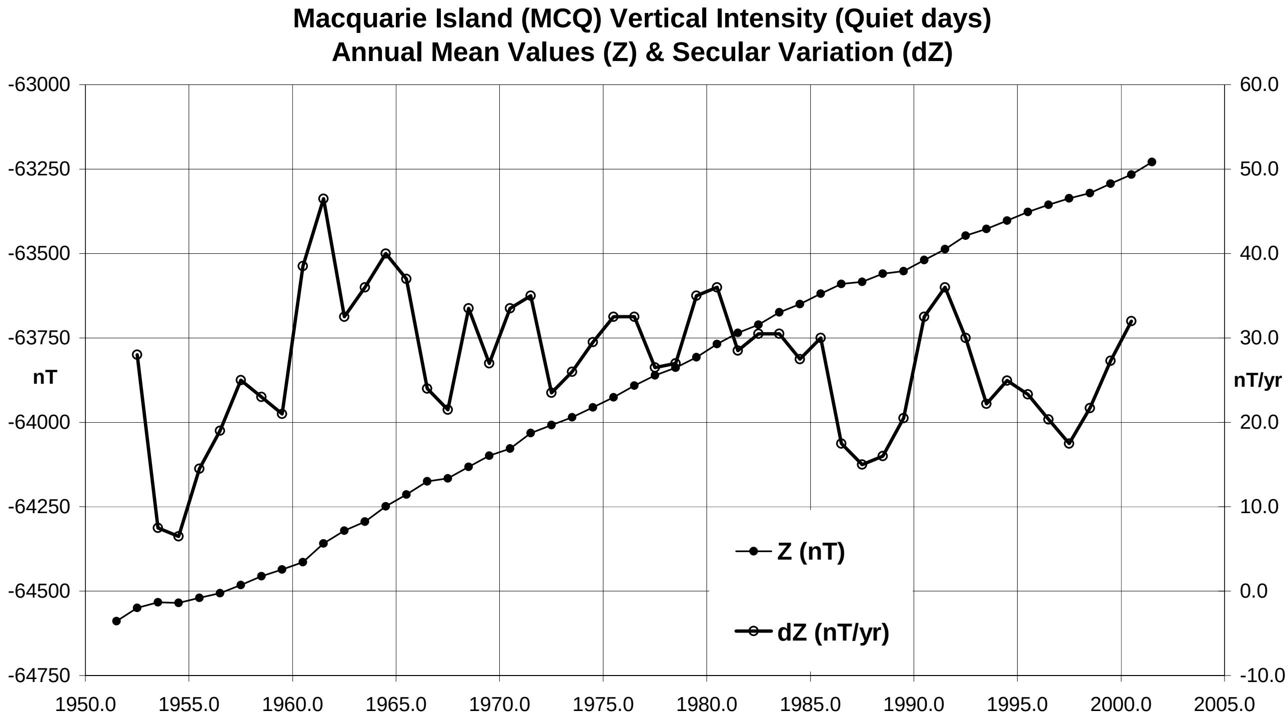
Macquarie Is. 2001 Declination (east) (D). Scale: 4.00 min/mm. Mean: 30.56 deg.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
60.0min
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

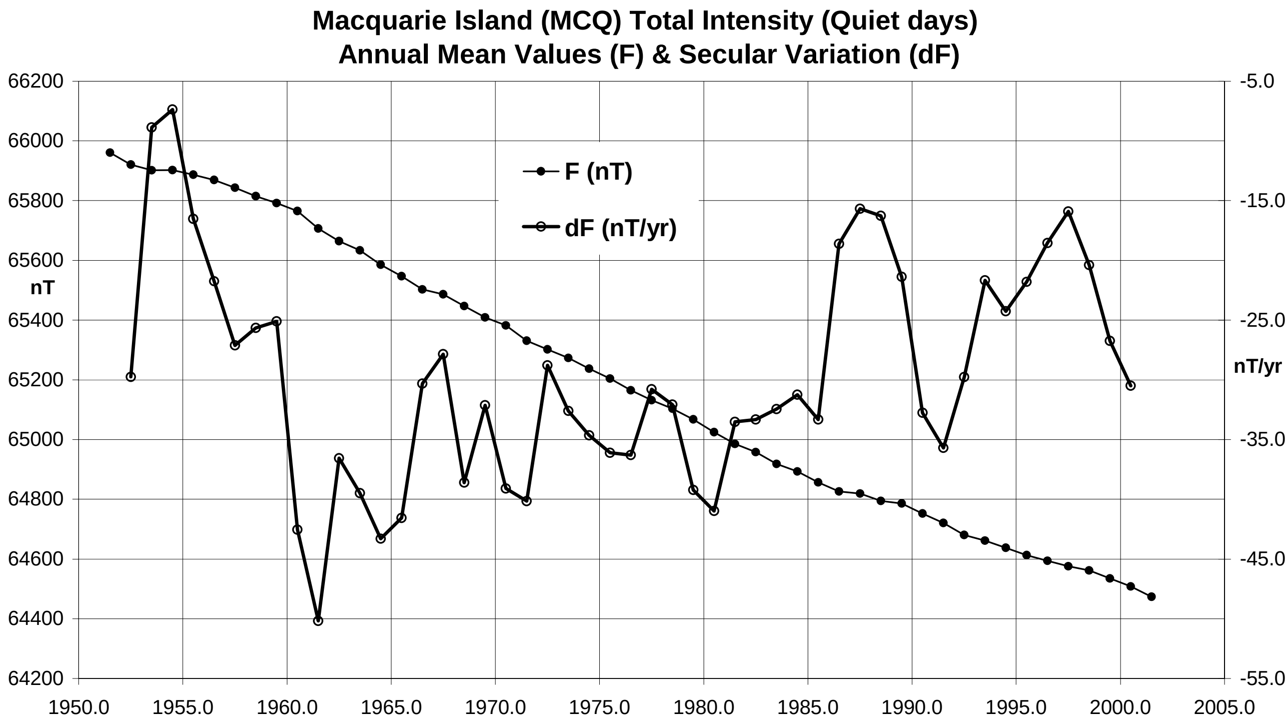
Macquarie Is. 2001 Vertical intensity (Z). Scale: 25.0 nT/mm. Mean: −63231 nT


Macquarie Is. 2001 Total intensity (F). Scale: 25.0 nT/mm. Mean: 64473 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
400nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


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


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


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


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

Significant Events: MCQ, 2001

All 2001 The variometers ran smoothly throughout the year.

Jan 15 A combination of QHMs 178 and 179 were used for this period due to unserviceable DIM electronics.

Apr 05 DIM E810_214 replaced the secondary instruments in the performance of absolute observations.

Aug 03 At approximately 0042 the door between variometer sensor and its electronics was opened to improve temperature stability.

Distribution of MCQ data during 2001

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP from July 2001
- 1998, 1999, 2000, Jan-Jun 2001 data to IPGP by email (sent Jul. 2001)

1-minute & Hourly Mean Values

- 1998: WDC-A, Boulder, USA (sent 13 Jun., 2001)
- 1999: WDC-A, Boulder, USA (sent 15 Jun., 2001)
- 2000: WDC-A, Boulder, USA (sent 27 Jun., 2001)

Data Distribution (cont.)

1-minute Values for Project INTERMAGNET

- Definitive data (not for CD-ROM) sent to the INTERMAGNET GIN, Paris:
  1998 (sent 14 Jun, 2001); 1999 (sent 26 Jun, 2001);
  2000 (sent 20 Jul., 2001)

Data losses: MCQ, 2001

There was no period in 2001 when data acquisition was interrupted.

Errors in MCQ 2001 Data

Mar 30 9 backward time jumps occurred on this day due to an adjustment of the clock. It should be noted that there are errors of about 3 secs for this day.

Apr 09 60 backwards time jumps occurred on this day due to an adjustment of the clock. It should be noted that there are errors of about 20 sec for this day.

Oct 13 36 backwards time jumps occurred on this day due to an adjustment of the clock. It should be noted that there are errors of about 12 sec for this day.

MAWSON OBSERVATORY

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

The magnetic observatory buildings comprising the Variometer House and the Absolute House, are situated on the south-east and inland side of the Mawson base, at the end of East Bay.

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

Additional details of the observatory's history were given in the *AGR 1994*.

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

- 3-character IAGA code: MAW
- Geographic latitude: 67° 36' 14" S
- Geographic longitude: 62° 52' 45" E
- Geomagnetic†: Lat. -73.11°; Long. 109.84°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of pier A): 12 metres
- Lower limit for K index of 9: 1500 nT.
- Azimuth of principal reference mark (89/2) from pier A: 19° 14.0'
- Distance to azimuth mark 89/2: 105 metres
- Observers in Charge: Peter Johnson (2000, GA/BoM)
  Martin Purvins (2001, GA/BoM)
  Andrew Jenner (2002, GA/BoM)

Variometers

A 3-axis Narod ringcore fluxgate (RCF) magnetometer and an Elsec 820M3 PPM monitored magnetic variations at Mawson throughout 2001. The sensors of both these instruments were located within the sensor room of the MAW Variometer House. This building also housed a global positioning system (GPS) clock, a data acquisition PC, a network PC, and an Aironet ethernet radio link and a standby power supply. In addition, an EDA 3-component magnetometer and its associated data acquisition PC that were installed in September 2000 were available as a standby variometer to replace the principal system should it fail.

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

The RCF produced 8 samples per second that were averaged and output as 1-second data. The PPM variometer produced 10-second samples. The temperatures of the sensors and the electronics of the RCF system were monitored by its in-built dual temperature system. Temperature within the sensor room was kept close to 10°C by a fast-cycle heater.

Absolute Instruments and Corrections

Several absolute magnetometers were stored and used in the Absolute House, including the primary instruments: an Elsec model 770 PPM (serial 199) and a fluxgate theodolite magnetometer. Bartington B0766H mounted on a Zeiss 020B (serial 313792) theodolite had been in service since January 2000, until it was replaced in late February 2001 with Danish DMI fluxgate magnetometer DIM (D26035) mounted on a Zeiss020B theodolite (serial 311542)

Secondary instruments were an Askania declinometer (Serial 630332), three horizontal magnetometers (QHM Serial 300, 301, and 302), and an Elsec 770 PPM (Serial 206). The declinometer and QMHs were used on Askania circle 611665.

All observations were performed on Pier A.

For standardization with the Australian Magnetic Standard held at Canberra, a correction of +1.6nT has been applied to the PPM readings. Corrections of zero have been applied to the DIM readings. These resulted in baseline corrections of:

$\Delta X = +0.25$ nT $\Delta Y = -0.54$ nT $\Delta Z = -1.48$ nT.

Operations

The 2001 observer in charge of magnetic (and seismological) observatory operations was employed jointly by GA and the Bureau of Meteorology and was a member of the Australian National Antarctic Research Expedition (ANARE).

The 2001 observer (MP) arrived and took over absolute observations from the 2000 observer (PJ) on 04 December 2000, who departed the station on 7 December 2000. The 2001 observer departed the station on 12 February 2002, after the 2002 observer (AJ) had arrived and taken charge of the observatory on 3 January 2002.

In 2001, twice-weekly absolute observations were performed by the observer in charge of the observatory on the observation pier A in the Absolute House. The absolute observations were sent to GA where they were reduced.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance as required.

The 1-second RCF data and 10-second PPM data as well as 1-minute means of both were recorded on an acquisition PC. A PC running QNX, also in the variometer house, automatically copied files from the acquisition PC. The QNX PC was connected to the station's radio network. The files on this PC were subsequently automatically retrieved at GA, Canberra, by ftp via the ANARE satellite communications system. A GPS clock provided system timing. Using a PC in the Science Building the data acquisition system was routinely interrogated to ensure correct operation and to check timing.

The final data for the year were reduced and analysed by GA staff.

MAW 2001 Data Loss

Sep 26 1751-1752 (2 min) All channels: PC re-booted.

Sep 28 0826-0832 (7 min) All channels: Power failure on station.

Oct 12 1201-1205 (5 min): All channels. Power failure on station.

Data Loss (cont.) *Errors in Data:*

Oct 8 9 backwards time jumps occurred on this day due to an adjustment of the clock. It should be noted that there are errors of about 3 secs for this day.

Oct 16 3 backwards time jumps occurred on this day due to an adjustment of the clock. It should be noted that there are errors of about 1 sec for this day.

MAW Significant Events 2001

All 2001 Numerous temperature adjustments of the order of +/- 1°C were made to the Variometer Hut throughout the year to maintain it at 10°C.

Jan 25 Aurora Australis day trippers came ashore and two of them were found to be in the 'magnetic quiet zone'.

Feb 19 DIM D26035/311542 arrived to replace the B0766H/313792.

Mar 3 DIM B0766H/313792 was forwarded to Davis aboard Voyage 7.

Apr 16 Heater was left on in Absolute Hut.

Jul 11 Foam insulation was placed over variometer.

Aug 26 Several 'E-boxes' (shipping containers) were found in the 'magnetic quiet zone', they were removed.

Sep 14 Removal of battery charger from Absolute Hut.

Sep 28 UPS was found to have low battery. Station power failure from 1026 to 1031.

Oct 5 Acquisition PC clock was adjusted by -2 secs.

Oct 8 Acquisition PC clock was adjusted by -90 ticks at 0908.

Oct 9 Acquisition PC clock was found to be 3 secs slow therefore it was adjusted by +55 ticks at 0817.

Oct 12 Station power failure from 1200 to 1205. As a result the acquisition PC was re-booted at 1206.

Oct 16 Acquisition PC clock was found to be 1 sec fast therefore it was adjusted by +50 ticks.

Dec 10 Magnetic absolute observations were contaminated due to observer wearing metallic belt and jeans.

Mawson, Antarctica Annual Mean Values

The table below gives annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month as indicated. Plots of these data with secular variation in H, D, Z & F are on pages 88-89.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1955.5		-58	38.1	-69	33.3	18272	9854	-15387	-49012	52307	DHZ
1956.5		-58	53.2	-69	32.5	18282	9927	-15352	-49006	52305	DHZ
1957.5		-59	8.7	-69	31.1	18292	9461	-15655	-48974	52279	DHZ
1958.5		-59	25.6	-69	30.3	18293	9538	-15610	-48940	52247	DHZ
1959.5		-59	42.6	-69	28.5	18293	9615	-15562	-48860	52172	DHZ
1960.5		-59	59.6	-69	25.2	18323	9708	-15540	-48800	52127	DHZ
1961.5		-60	14.6	-69	23.1	18322	9228	-15828	-48707	52039	DHZ
1962.5		-60	30.1	-69	21.1	18333	9305	-15796	-48650	51990	DHZ
1963.5		-60	45.2	-69	17.6	18356	9386	-15775	-48562	51915	DHZ
1964.5		-60	59.2	-69	15.4	18353	9449	-15734	-48460	51819	DHZ
1965.5		-61	12.6	-69	13.1	18356	8958	-16022	-48368	51734	DHZ
1966.5		-61	24.0	-69	9.6	18362	9014	-15997	-48235	51612	DHZ
1967.5		-61	34.4	-69	7.2	18374	9068	-15980	-48168	51553	DHZ
1968.5		-61	43.8	-69	5.2	18365	9107	-15948	-48060	51449	DHZ
1969.5		-61	53.0	-69	3.4	18353	9144	-15913	-47954	51346	DHZ
1970.5		-62	0.5	-69	0.4	18358	8621	-16208	-47840	51241	DHZ
1971.5		-62	5.3	-68	56.4	18375	8652	-16211	-47719	51135	DHZ
1972.5		-62	11.4	-68	53.1	18381	8683	-16201	-47600	51026	DHZ
1973.5		-62	17.6	-68	49.7	18391	8717	-16194	-47486	50923	DHZ
1974.5		-62	24.8	-68	47.2	18390	8750	-16175	-47380	50824	DHZ
1975.5		-62	31.4	-68	44.0	18397	8785	-16164	-47269	50723	DHZ
1976.5		-62	37.3	-68	40.0	18418	8823	-16167	-47157	50626	DHZ
1977.5		-62	43.9	-68	36.9	18425	8857	-16157	-47051	50530	DHZ

continued …

MAW - Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1978.5		-62	51.9	-68	35.5	18421	8893	-16132	-46986	50468	DHZ
1979.5		-62	57.9	-68	32.9	18425	8923	-16120	-46890	50380	DHZ
1980.5		-63	5.8	-68	29.8	18432	8396	-16409	-46784	50284	DHZ
1981.5		-63	14.6	-68	27.1	18443	8443	-16397	-46705	50215	DHZ
1982.5		-63	21.2	-68	25.5	18433	8470	-16372	-46616	50128	DHZ
1983.5		-63	26.6	-68	22.3	18439	8498	-16364	-46503	50025	DHZ
1984.5		-63	33.1	-68	19.3	18446	8532	-16354	-46404	49936	DHZ
1985.5		-63	40.2	-68	17.0	18457	8571	-16346	-46342	49882	DHZ
1986.5		-63	48.7	-68	15.1	18460	8613	-16328	-46276	49822	XYZ
1987.5		-63	56.6	-68	12.5	18470	8655	-16317	-46198	49753	XYZ
1988.5		-64	4.4	-68	10.7	18475	8120	-16595	-46142	49703	XYZ
1989.5		-64	12.8	-68	9.7	18474	8160	-16574	-46099	49663	XYZ
1990.5		-64	21.1	-68	6.4	18492	8208	-16570	-46015	49592	XYZ
1991.5		-64	28.8	-68	4.2	18502	8250	-16561	-45957	49542	XYZ
1992.5	Q	-64	36.5	-68	-1.7	18513	7938	-16724	-45885	49479	XYZ
1993.5	Q	-64	43.6	-67	-59.4	18522	7908	-16749	-45819	49422	ABC
1994.5	Q	-64	51.8	-67	-57.4	18537	7874	-16781	-45779	49389	ABC
1995.5	Q	-65	0.4	-67	55.3	18550	7838	-16813	-45731	49350	ABC
1996.5	Q	-65	9.2	-67	53.5	18561	7799	-16843	-45692	49318	ABC
1997.5	Q	-65	18.9	-67	52.0	18572	7757	-16875	-45663	49295	ABC
1998.5	Q	-65	28.6	-67	51.3	18575	7710	-16900	-45642	49277	ABC
1999.5	Q	-65	38.5	-67	50.2	18579	7663	-16925	-45611	49250	ABC
2000.5	Q	-65	48.0	-67	49.6	18579	7616	-16946	-45585	49225	ABC
2001.5	Q	-65	56.3	-67	48.9	18577	7574	-16963	-45555	49198	ABC
1992.5	A	-64	36.9	-68	-2.8	18499	7930	-16712	-45894	49482	XYZ
1993.5	A	-64	44.2	-68	-0.7	18506	7898	-16736	-45830	49426	ABC
1994.5	A	-64	52.9	-67	-59.4	18511	7858	-16760	-45794	49394	ABC
1995.5	A	-65	0.9	-67	56.7	18532	7828	-16798	-45741	49352	ABC
1996.5	A	-65	9.8	-67	54.5	18548	7791	-16833	-45698	49319	ABC
1997.5	A	-65	19.4	-67	53.0	18560	7749	-16865	-45670	49297	ABC
1998.5	A	-65	29.1	-67	52.4	18561	7702	-16887	-45648	49278	ABC
1999.5	A	-65	39.0	-67	51.5	18561	7653	-16910	-45618	49250	ABC
2000.5	A	-65	48.2	-67	50.6	18566	7610	-16935	-45594	49230	ABC
2001.5	A	-65	56.2	-67	49.8	18567	7571	-16953	-45565	49203	ABC
1992.5	D	-64	39.6	-68	-5.2	18466	7904	-16689	-45907	49482	XYZ
1993.5	D	-64	45.9	-68	-3.0	18476	7877	-16713	-45847	49430	ABC
1994.5	D	-64	55.3	-68	-1.9	18476	7831	-16734	-45804	49390	ABC
1995.5	D	-65	1.7	-67	58.8	18504	7812	-16774	-45752	49353	ABC
1996.5	D	-65	11.1	-67	56.2	18525	7775	-16814	-45707	49318	ABC
1997.5	D	-65	20.4	-67	55.0	18534	7733	-16844	-45682	49299	ABC
1998.5	D	-65	30.9	-67	54.8	18530	7680	-16864	-45665	49282	ABC
1999.5	D	-65	41.0	-67	53.9	18528	7630	-16884	-45626	49245	ABC
2000.5	D	-65	49.7	-67	52.6	18543	7593	-16917	-45614	49239	ABC
2001.5	D	-65	56.4	-67	51.6	18547	7561	-16935	-45583	49212	ABC

* Elements ABC indicates non-aligned variometer orientation

Distribution of MAW data during 2001

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP from July 2001
- 1998 data to IPGP by email (sent 18 May 2001)
- 1999, 2000, Jan-Jun 2001 data to IPGP by email (sent 30 Jul. 2001)

1-minute & Hourly Mean Values (WDC format)

- 1998: WDC-A, Boulder, USA (sent 13 Jun., 2001)
- 1999: WDC-A, Boulder, USA (sent 15 Jun., 2001)
- 2000: WDC-A, Boulder, USA (sent 27 Jun., 2001)

1-minute Values (INTERMAGNET format)

- 1998: WDC-C1, Copenhagen, Denmark (sent 14 Jun., 2001)
- 1999: WDC-C1, Copenhagen, Denmark (sent 26 Jun., 2001)
- 2000: WDC-C1, Copenhagen, Denmark (sent 20 Jul., 2001)

K indices

The table on the next page shows Mawson K indices for 2001. Using the digital data, these have been derived by a computer algorithm that calculates a simple range in the X and Y magnetic components over each 3-hour UT period. The K indices were calculated from the maximum of the X and Y ranges in the usual manner. This was suitable for Mawson as the diurnal variation is small.

K indices & Daily K sums at Mawson Antarctica (K=9 limit: 1500 nT) for 2001

Date	January	February	March	April	May	June	Date
01	Q 4332 2223 21	3663 3244 31	5331 1233 21	4573 3466 38	Q 1211 1112 10	1101 3223 13	01
02	Q 4321 2224 20	5532 2224 25	4432 2456 30	6665 3675 44	1231 2223 16	D 7543 3346 35	02
03	3773 4223 31	Q 3121 0111 10	5333 4344 29	4332 2333 23	4223 3235 24	2552 2144 25	03
04	5343 5434 31	Q 2232 2221 16	4554 4476 39	5442 5562 33	2333 1054 21	6342 2215 25	04
05	4433 2345 28	2322 2225 20	6554 2323 30	3465 3535 34	Q 1221 0134 14	5431 1144 23	05
06	Q 4432 2313 22	D 5454 2355 33	3332 2255 25	4243 2256 28	0121 1114 11	4342 2235 25	06
07	4553 2325 29	4452 2234 26	4442 3433 27	5654 4654 39	5634 3362 32	5543 2221 24	07
08	4443 3355 31	3442 1346 27	3333 2255 26	D 4345 5487 40	3224 3477 32	2222 1116 17	08
09	4333 4354 29	4233 3345 27	3332 3312 20	4565 3654 38	D 6744 5565 42	D 3544 4377 37	09
10	3321 3343 22	3332 3432 23	3432 1242 21	6333 3436 31	D 6643 3364 35	D 6664 3355 38	10
11	4322 4654 30	4342 2225 24	Q 3522 1133 20	D 6433 6767 42	5332 2346 28	3432 3343 25	11
12	5553 3322 28	4322 3345 26	2123 3354 23	D 7765 3323 36	D 5465 5676 44	Q 3331 1144 20	12
13	2334 4213 22	D 5564 5676 44	5534 3245 31	D 3347 5666 40	D 5454 3587 41	5543 3264 32	13
14	4543 2254 29	D 5553 4585 40	5433 2343 27	6654 3445 37	7442 2252 28	5211 1125 18	14
15	3233 3536 28	4333 2224 23	Q 3221 1133 16	5533 2355 31	3544 3366 34	5534 2122 24	15
16	4223 4333 24	3322 2215 20	Q 1221 1235 17	7433 3346 33	6443 2204 25	2321 0133 15	16
17	5431 3334 26	Q 4421 2343 23	Q 1222 2252 18	5542 2355 31	5432 2235 26	2222 3334 21	17
18	3233 2123 19	Q 4321 2224 20	5652 2326 31	D 9763 3336 40	5532 1116 24	D 4645 3335 33	18
19	Q 3322 2244 22	3443 2242 24	D 5443 4556 36	Q 5431 2115 22	6432 2153 26	4321 1266 25	19
20	4343 4445 31	3543 3124 25	D 7545 4666 43	5532 2234 26	2333 3113 19	5556 4325 35	20
21	D 4435 4665 37	4543 3225 28	6433 2112 22	3321 2344 22	Q 3222 1121 14	D 3564 3366 36	21
22	6554 4335 35	3332 2354 25	2222 3336 23	3664 4764 40	2331 2234 20	Q 4412 2234 22	22
23	D 4434 5475 36	D 4654 3344 33	D 7654 5364 40	6655 2124 31	3321 1244 20	Q 3311 2232 17	23
24	D 4545 5584 40	3332 4313 22	3562 3453 31	Q 2543 1013 19	4321 1145 21	5333 3244 27	24
25	4422 1343 23	Q 2221 1143 16	3334 3244 26	Q 2222 2334 20	3122 3342 20	4542 3222 24	25
26	4453 4334 30	4322 3555 29	Q 2222 2243 19	2442 1134 21	2433 1102 16	2223 3555 27	26
27	5442 2332 25	D 5653 2232 28	6534 2357 35	Q 3322 1333 20	1110 2344 16	6542 1112 22	27
28	3443 3444 29	3223 3342 22	D 3356 5646 38	4654 6555 40	D 4324 3557 33	Q 2110 0001 05	28
29	D 6543 2235 30		5664 3445 37	5443 3210 22	6312 2322 21	Q 1011 1044 12	29
30	Q 3432 2211 18		2433 3333 24	Q 1111 0011 06	Q 0000 1021 04	1312 3153 19	30
31	D 2245 5655 34		D 8786 5676 53		Q 2001 0102 06		31
Mean K-sum	27.7	25.4	28.3	30.9	23.3	24.0	

Date	July	August	September	October	November	December	Date
01	6321 2235 24	6533 3343 30	Q 4422 1232 20	D 7776 4566 48	D 4654 5442 34	3333 3223 22	01
02	Q 4531 1033 20	2333 2322 20	1112 2334 17	D 5655 3677 44	3331 4212 19	3232 3224 21	02
03	2322 3343 22	5464 2235 31	4334 3455 31	D 5577 6644 44	Q 3321 2111 14	3333 4355 29	03
04	4322 1333 21	3322 3454 26	5653 2445 34	6455 3455 37	3334 3332 24	5544 4344 33	04
05	4443 3365 32	D 5354 4354 33	6422 2442 26	2323 2331 19	2222 4456 27	4653 4454 35	05
06	3333 3232 22	D 2444 4456 33	5222 2256 26	2434 2153 24	D 7875 6665 50	5435 4445 34	06
07	Q 2222 3223 18	4533 3233 26	Q 1111 1115 12	Q 2132 2014 15	D 6654 4445 38	4433 5533 30	07
08	D 4443 2266 31	4433 3222 23	6542 2343 29	3434 4547 34	4443 1225 25	5433 5433 30	08
09	7531 2225 27	1421 2344 21	Q 2222 2101 12	6444 5422 31	3432 2354 26	Q 3233 1034 19	09
10	2434 3475 32	3332 1264 24	Q 1211 1244 16	4333 3443 27	3423 3345 27	Q 3332 4214 22	10
11	5541 1121 20	Q 6310 0116 18	4221 2343 21	4343 3665 34	4434 1223 23	Q 4333 3234 25	11
12	1233 2233 19	3433 1345 26	4553 2356 33	5745 -655 --	3422 3213 20	4445 3453 32	12
13	3321 1155 21	D 6733 2356 35	3763 2322 28	5543 3444 32	3421 2334 22	Q 5552 2311 24	13
14	5432 3322 24	3433 3545 30	2322 1113 15	3444 3455 32	Q 3331 2142 19	3334 4444 29	14
15	2333 3556 30	Q 5432 2265 29	D 6433 2475 34	5553 2403 27	3222 2463 24	4443 4224 27	15
16	D 6543 3336 33	Q 2211 1134 15	6322 2566 32	3333 3234 24	5455 3423 31	4554 3335 32	16
17	D 6644 3445 36	D 4313 5666 34	2333 3116 22	Q 5432 3133 24	4645 5446 38	D 4674 5643 39	17
18	3553 3233 27	4441 3322 23	2421 1252 19	Q 3121 2251 17	4545 3335 32	5445 4324 31	18
19	3242 3344 25	1343 1110 14	4442 2024 22	2223 3553 25	D 6544 4455 37	5444 3344 31	19
20	Q 4432 3215 24	1222 2201 12	2122 1115 15	3654 3444 33	5452 1112 21	Q 4224 4324 25	20
21	Q 3321 2125 19	2332 3335 24	Q 4221 0115 16	D 4533 4768 40	3333 4422 24	D 3465 5554 37	21
22	5453 2346 32	D 3553 4566 37	4233 3421 22	D 7556 6775 48	4445 3355 33	3655 4333 32	22
23	6424 3333 28	6543 3155 32	D 2564 4874 40	5553 3224 29	4445 5466 38	4443 3423 27	23
24	5533 4355 33	Q 2211 1100 08	5332 2233 23	Q 4322 0102 14	D 57-9 8734 --	D 3676 5535 40	24
25	D 3664 3442 32	2311 2234 18	2442 2278 31	3333 2255 26	4543 4324 29	4544 3335 31	25
26	6543 2145 30	3443 1245 26	D 7676 4-54 --	Q 4343 3225 26	4343 3122 22	4433 2443 27	26
27	2343 2325 24	4642 3276 34	4423 4575 34	5623 4333 29	Q 4321 1323 19	4433 4343 28	27
28	Q 4311 1003 13	6443 1231 24	54-3 3565 --	5875 4545 43	Q 3221 2234 19	4332 3212 20	28
29	3442 3221 21	Q 2332 2213 18	D 6556 3567 43	4553 4546 36	4332 2112 18	3443 4434 29	29
30	2121 1264 19	2544 3443 29	D 6553 3856 41	4534 3234 28	Q 3322 1222 17	D 6873 3346 40	30
31	D 6443 4746 38	5655 3325 34		3222 4346 26		D 5553 4665 39	31
Mean K-sum	25.7	25.4	25.5	30.5	26.6	29.7	

Occurrence distribution of K-indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	0	9	46	77	68	37	7	3	1	0	0
February	1	15	65	60	43	30	8	1	1	0	0
March	0	16	52	71	41	37	23	6	2	0	0
April	4	17	30	58	42	42	34	11	1	1	0
May	15	43	55	52	35	23	17	7	1	0	0
June	8	40	52	53	38	31	15	3	0	0	0
July	3	24	52	78	43	28	17	3	0	0	0
August	6	30	47	70	45	29	19	2	0	0	0
September	3	33	63	38	39	31	20	8	3	0	2
October	4	9	33	63	54	49	19	14	2	0	1
November	0	22	50	58	59	30	13	4	2	1	1
December	1	5	23	82	82	40	11	3	1	0	0
ANNUAL TOTAL	**45**	**263**	**568**	**760**	**589**	**407**	**203**	**65**	**14**	**2**	**4**

Mawson, Antarctica 2001 Monthly & Annual Mean Values

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

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

Mawson Antarctica 2001		X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	7611.2	-16959.7	-45561.8	49208.2	18589.4	-65° 49.8'	-67° 48.3'
	5xQ days	7601.3	-16956.6	-45566.4	49209.8	18582.4	-65° 51.3'	-67° 48.8'
	5xD days	7622.7	-16955.3	-45531.2	49180.3	18590.2	-65° 47.5'	-67° 47.4'
February	All days	7592.0	-16950.2	-45568.7	49208.3	18572.8	-65° 52.4'	-67° 49.5'
	5xQ days	7594.4	-16957.7	-45560.8	49203.9	18580.6	-65° 52.5'	-67° 48.8'
	5xD days	7589.3	-16937.7	-45587.7	49221.3	18560.4	-65° 51.9'	-67° 50.8'
March	All days	7573.3	-16941.7	-45579.5	49212.6	18557.5	-65° 54.9'	-67° 50.8'
	5xQ days	7584.3	-16958.1	-45555.6	49197.7	18576.8	-65° 54.2'	-67° 48.9'
	5xD days	7549.4	-16910.2	-45629.3	49244.5	18519.1	-65° 56.5'	-67° 54.6'
April	All days	7556.5	-16933.1	-45603.6	49229.4	18542.7	-65° 57.1'	-67° 52.4'
	5xQ days	7571.7	-16955.2	-45572.6	49210.5	18569.1	-65° 56.2'	-67° 49.9'
	5xD days	7542.5	-16915.9	-45637.7	49253.3	18521.6	-65° 58.2'	-67° 54.6'
May	All days	7566.9	-16944.0	-45568.1	49201.9	18556.9	-65° 56.1'	-67° 50.5'
	5xQ days	7581.2	-16962.3	-45553.3	49196.5	18579.5	-65° 55.1'	-67° 48.7'
	5xD days	7534.2	-16901.5	-45601.4	49213.2	18504.9	-65° 58.5'	-67° 54.8'
June	All days	7567.1	-16949.3	-45556.1	49192.5	18561.8	-65° 56.5'	-67° 49.9'
	5xQ days	7577.8	-16961.7	-45549.9	49192.7	18577.5	-65° 55.6'	-67° 48.7'
	5xD days	7548.8	-16933.0	-45564.1	49191.6	18539.5	-65° 58.4'	-67° 51.5'
July	All days	7563.7	-16952.8	-45549.7	49187.3	18563.7	-65° 57.3'	-67° 49.6'
	5xQ days	7570.5	-16960.3	-45549.0	49190.3	18573.2	-65° 56.7'	-67° 49.0'
	5xD days	7554.3	-16948.2	-45554.7	49188.9	18555.7	-65° 58.6'	-67° 50.3'
August	All days	7561.9	-16951.3	-45549.1	49185.9	18561.5	-65° 57.5'	-67° 49.7'
	5xQ days	7564.1	-16960.0	-45546.4	49186.7	18570.4	-65° 57.8'	-67° 49.1'
	5xD days	7550.9	-16926.7	-45530.3	49158.4	18534.6	-65° 57.5'	-67° 51.0'
September	All days	7558.4	-16949.8	-45560.2	49195.2	18558.8	-65° 58.0'	-67° 50.2'
	5xQ days	7564.6	-16966.1	-45548.4	49190.8	18576.1	-65° 58.2'	-67° 48.8'
	5xD days	7544.9	-16921.7	-45595.7	49216.5	18527.8	-65° 58.2'	-67° 53.1'
October	All days	7552.9	-16955.7	-45576.9	49211.9	18562.0	-65° 59.4'	-67° 50.4'
	5xQ days	7554.0	-16963.9	-45564.6	49203.4	18569.8	-65° 59.8'	-67° 49.6'
	5xD days	7541.3	-16924.9	-45625.1	49244.5	18529.4	-65° 59.0'	-67° 53.8'
November	All days	7564.3	-16972.8	-45571.6	49214.7	18582.3	-65° 58.7'	-67° 49.0'
	5xQ days	7561.8	-16976.6	-45564.2	49208.6	18584.5	-65° 59.4'	-67° 48.6'
	5xD days	7572.6	-16976.4	-45611.0	49254.1	18589.4	-65° 57.6'	-67° 49.6'
December	All days	7582.4	-16986.1	-45550.4	49202.4	18601.8	-65° 56.7'	-67° 47.2'
	5xQ days	7567.9	-16980.6	-45552.0	49199.6	18590.7	-65° 58.7'	-67° 47.9'
	5xD days	7588.2	-16978.3	-45542.3	49193.2	18597.3	-65° 55.2'	-67° 47.2'
Annual	All days	7570.9	-16953.9	-45566.3	49204.2	18567.6	-65° 56.2'	-67° 49.8'
Mean	5xQ days	7574.5	-16963.3	-45556.9	49199.2	18577.6	-65° 56.3'	-67° 48.9'
Values	5xD days	7561.6	-16935.8	-45584.2	49213.3	18547.5	-65° 56.4'	-67° 51.6'

(Calculated:11:22 hrs., Wed. 17 Dec. 2003)

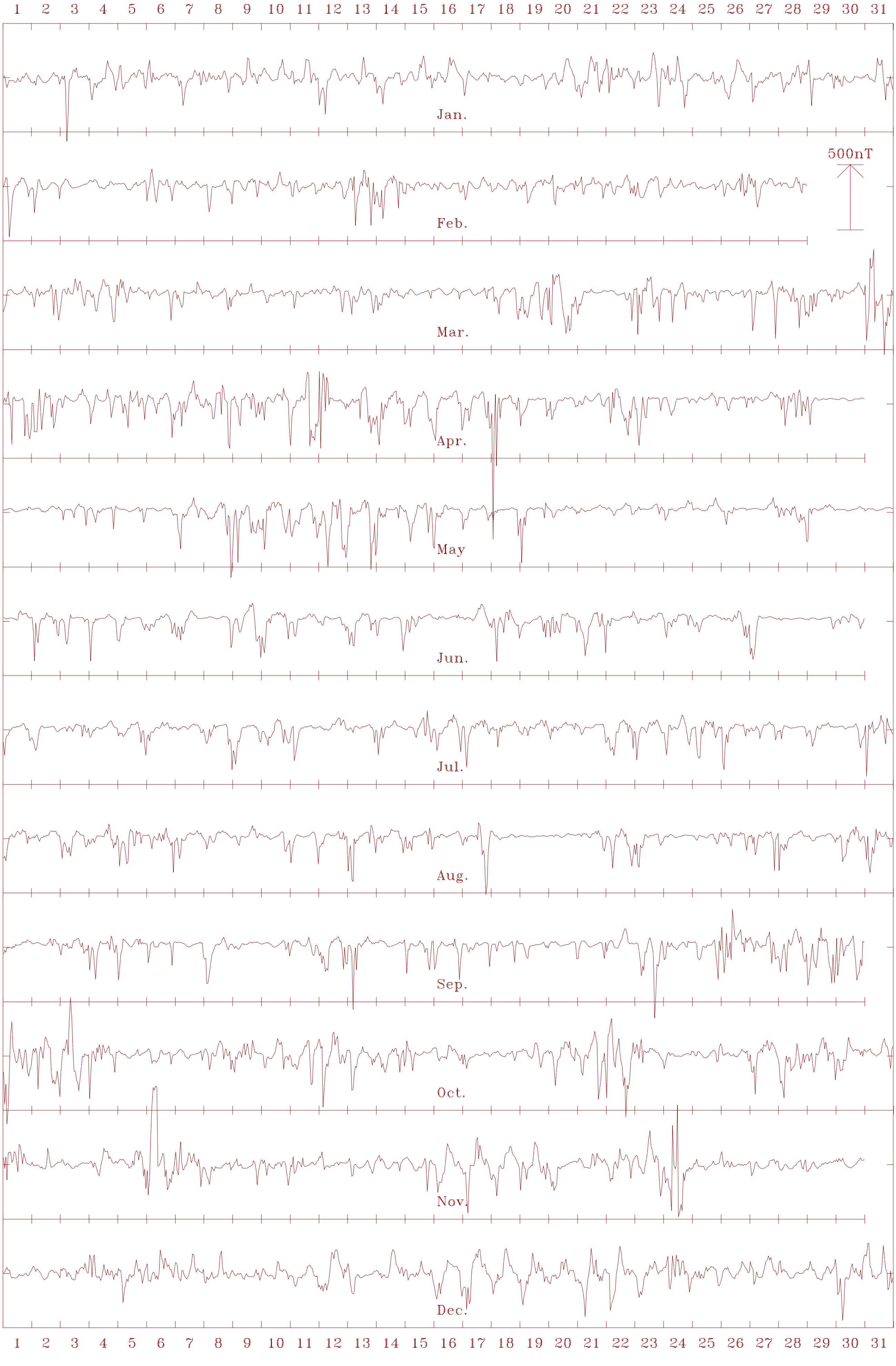
Hourly Mean Values

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

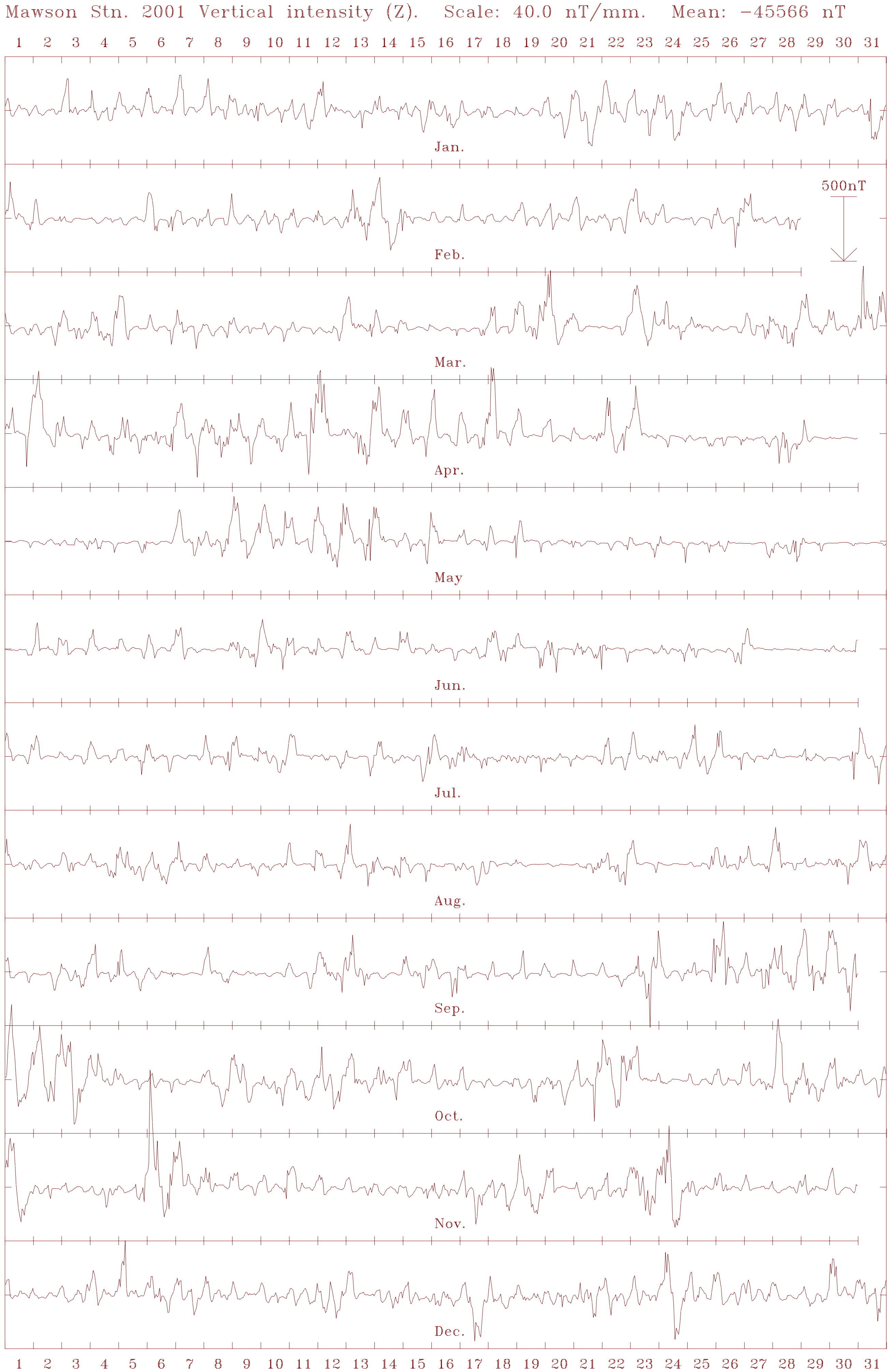
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

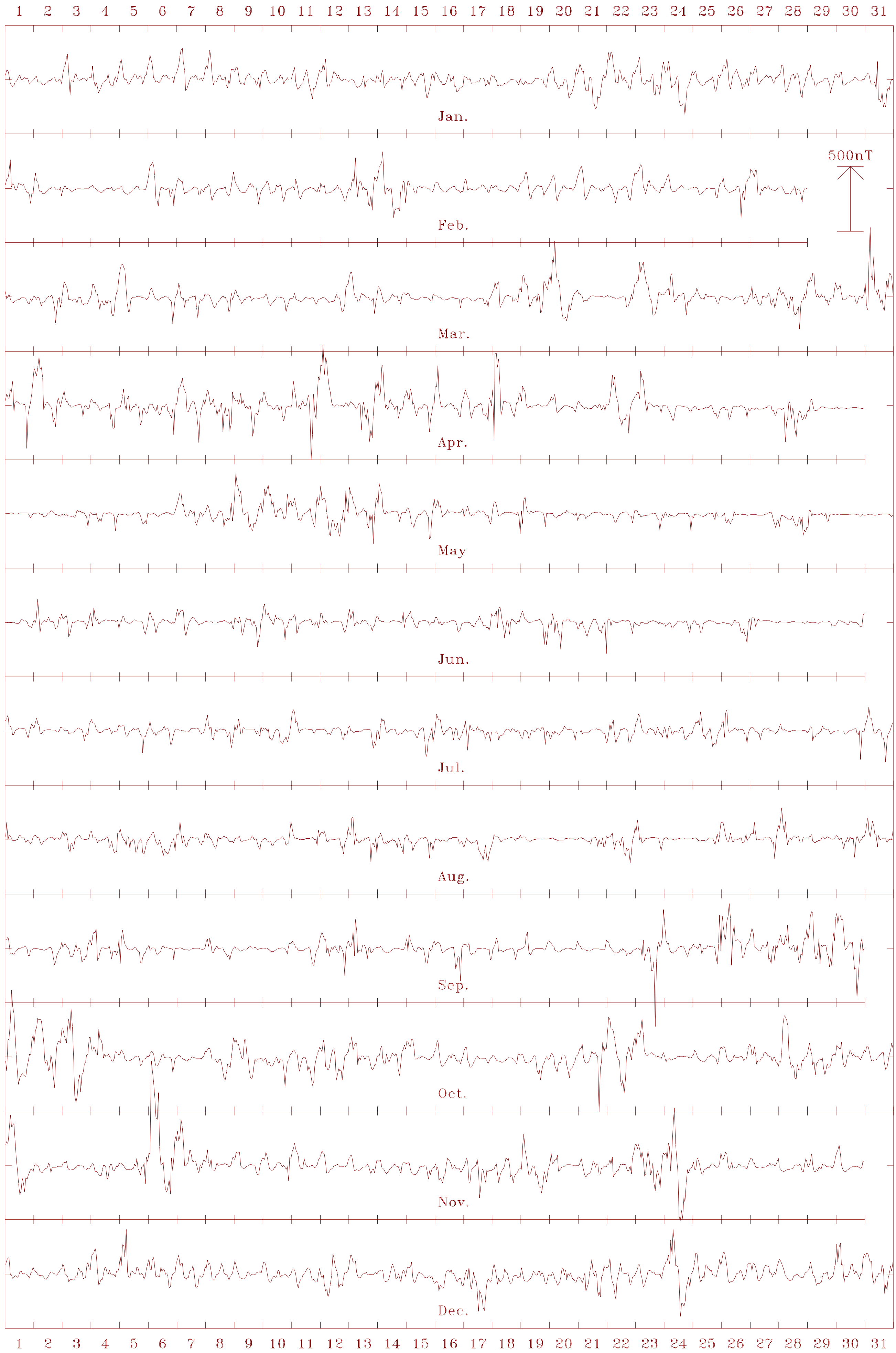
Mawson Stn. 2001 Horizontal intensity (H). Scale: 40.0 nT/mm. Mean: 18568 nT

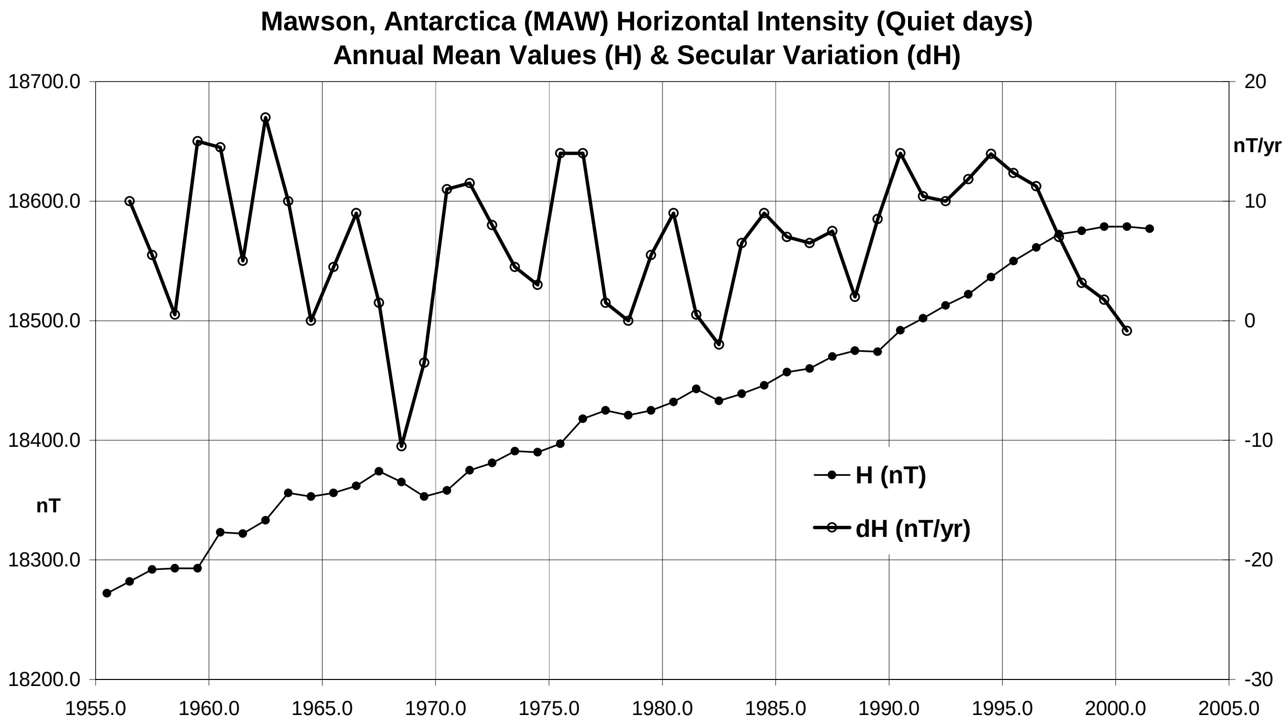


Mawson Stn. 2001 Declination (east) (D). Scale: 5.00 min/mm. Mean: −65.94 deg.

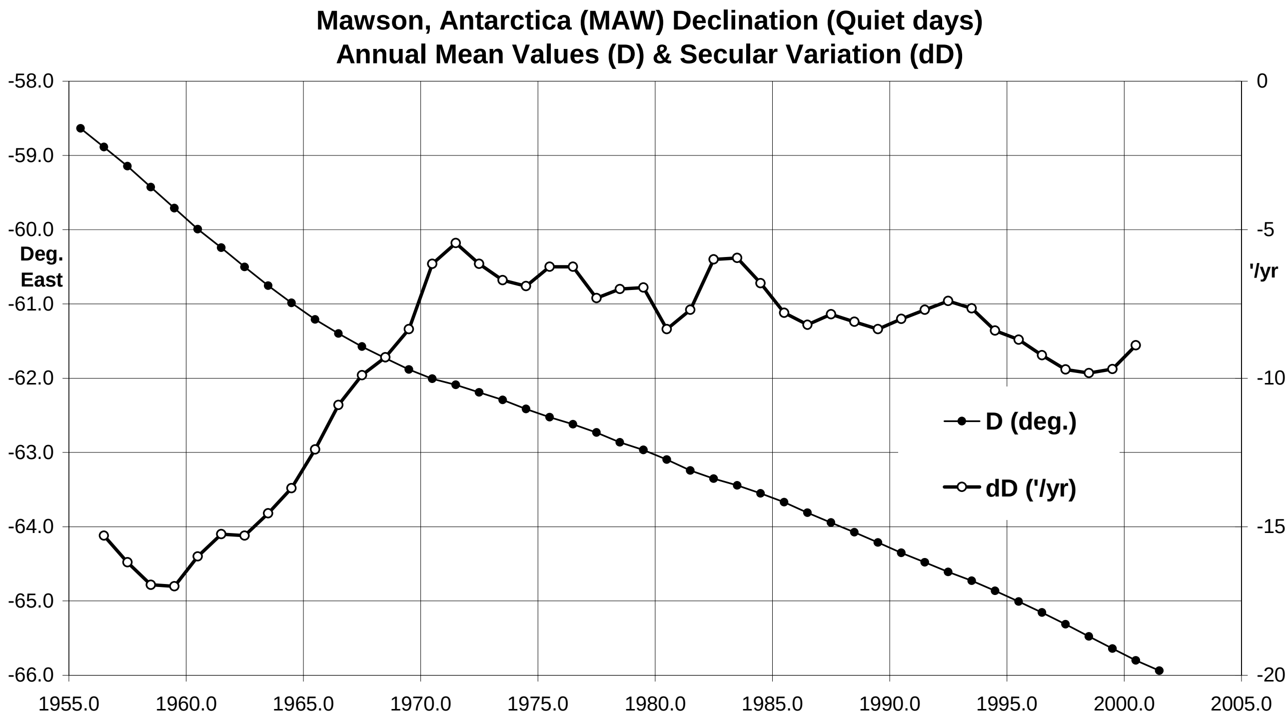

Mawson Stn. 2001 Vertical intensity (Z). Scale: 40.0 nT/mm. Mean: -45566 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
500nT
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Mawson Stn. 2001 Total intensity (F). Scale: 40.0 nT/mm. Mean: 49204 nT

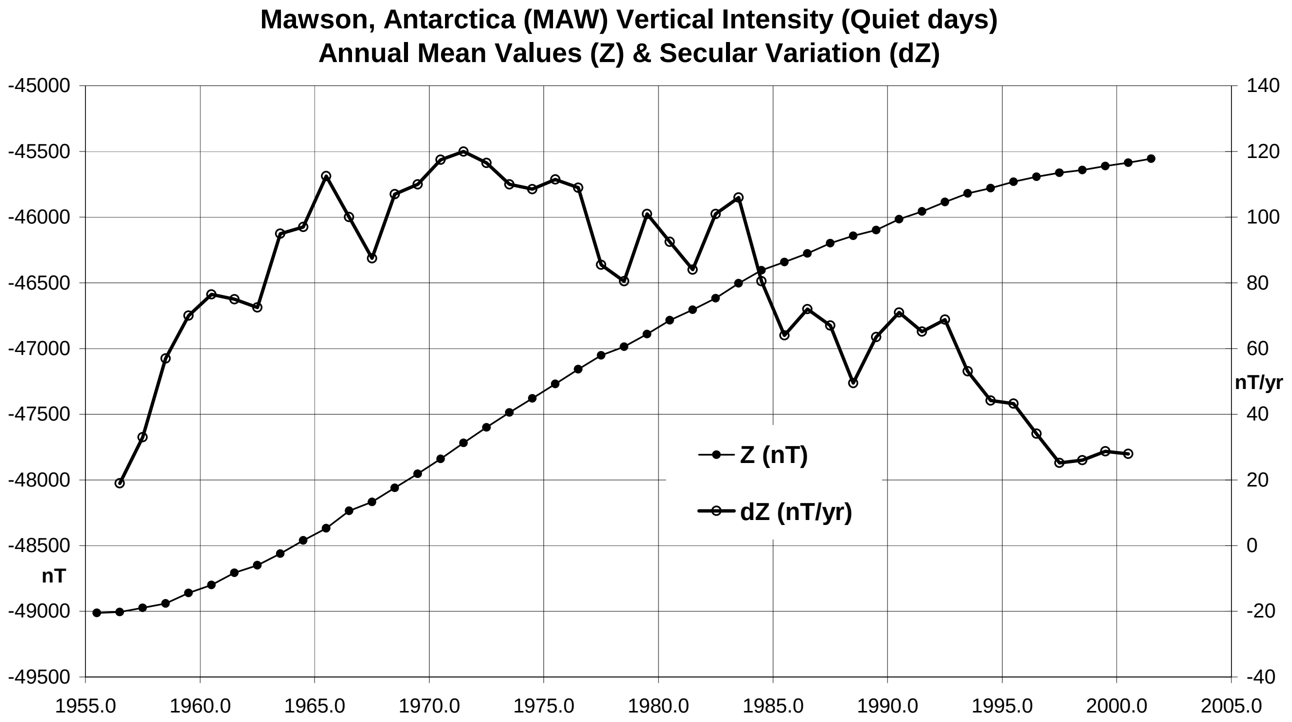


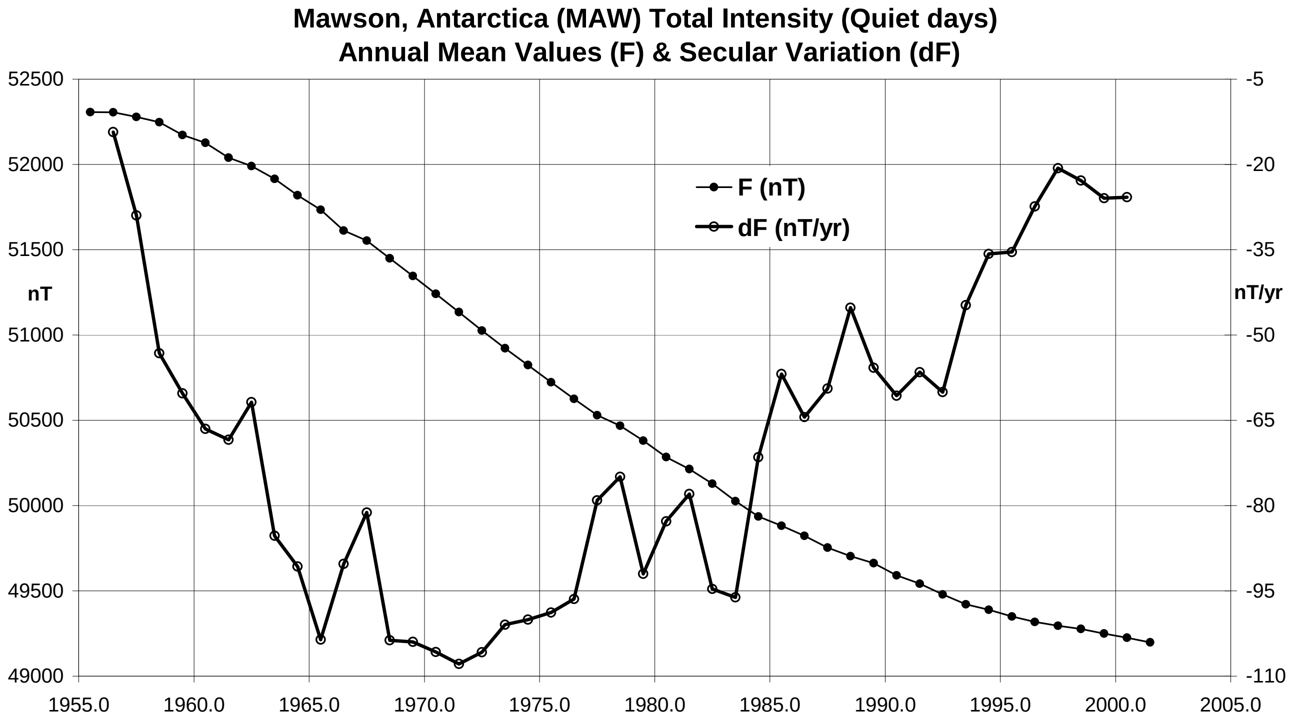


Mawson, Antarctica (MAW) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
18700.0
18600.0
18500.0
18400.0
18300.0
18200.0
nT
20
10
0
-10
-20
-30
nT/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
H (nT)
dH (nT/yr)



Mawson, Antarctica (MAW) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
-58.0
-59.0
-60.0
-61.0
-62.0
-63.0
-64.0
-65.0
-66.0
Deg.
East
0
-5
-10
-15
-20
'/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
D (deg.)
dD ('/yr)


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


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

Casey is the Australian Antarctic station nearest to Australia, situated 3880km south of Perth. The magnetic absolute hut is about 120 metres south of the tank house, the structure of the modern station nearest to it. The old Casey station, in use until the late 1980s, lies about 1km to the north-east of the present Casey.

The crystalline rocks of Casey have unusually high concentrations of magnetic minerals producing high magnetic gradients in and around the magnetic absolute hut.

The original station in the vicinity was Wilkes, established under the US Antarctic Research Program for the 1957-58 IGY, after which it was operated by ANARE. Wilkes was abandoned in 1968, having been replaced by (the old) Casey station which lies 3km across Newcomb Bay to its south west.

Key data for the principal observation pier of the Casey Station are:

- 3-character IAGA code: CSY
- Geographic latitude: 66° 17' S
- Geographic longitude: 110° 32' E
- Geomagnetic† : Lat. -76.46°; Long. 183.72°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of observation pier) 40 metres
- Azimuth of reference pillar (G11) from observation pier 307° 41' 02"
- Observer in Charge: Anthony Breed (AAD)
  Henry Banon (AAD)

History

A magnetic observatory was established at Wilkes (a few kilometres from where Casey now stands) by the US Antarctic Research Program for the 1957-58 IGY. It was subsequently operated by BMR and ANARE (McGregor, 2000) until the instrumentation was returned to the USA in 1968.

To provide information on the magnetic secular variation in Antarctica, BMR/ASGO/GA and the Australian Antarctic Division have jointly carried out regular absolute measurements of the magnetic field at Casey since 1975. The observations have been performed by Antarctic Division personnel, who were trained in the use of the instrumentation at GA in Canberra.

Until the Australian Antarctic Division installed an EDA FM105B fluxgate variometer in January 1988 to support their Atmospheric and Space Physics research program at Casey, monthly means were calculated from absolute observations without correction for daily field variations. These data, although exhibiting scatter, enabled the estimation of the secular variation trend from year to year at the station.

From 1991 to 1998 the digital variometer data and monthly absolute observations were made available to the GA observer at Mawson, who derived baselines and produced monthly mean values of the magnetic field (De Deuge, 1992) for Casey (and Davis). These monthly mean values, based on the five quietest days of the month (at Mawson), were provided to WDC-A. Although during this period the variometers at Casey (and Davis) were not operated to observatory standards, the monthly means derived from the variometer data were a significant improvement on those derived from the previous absolute observations only. Since 1998 the calculation of monthly means has been carried out at GA using International Quiet Days.

Until March 1999 two absolute observations were performed at Casey each month. On 22 March 1999 full absolute control began that included the performance of twice-weekly absolute observations and from when the operation was upgraded to full observatory status.

Variometers

An Antarctic Division EDA FM105B fluxgate variometer, with the data acquired by PC, operated at Casey throughout 2001. The fluxgate sensors were housed on the hill about 300m west of the Casey Science building. Their sensors were aligned close to true north, east and vertical. The temperatures were maintained at 20°C. Further description can be found in Crosthwaite (1999).

Absolute Instruments and Corrections

Magnetometers used to calibrate the recording variometers were Elsec 810 DIM no. 002591 with Zeiss020B theodolite no.356514 owned by the Antarctic Division, and Geometrics 816 no.1024 PPM, owned by GA. A QHM and QHM circles were available as a backup in the event that one of the primary instruments became unserviceable.

For standardization with the Australian Magnetic Standard held at Canberra, a correction of +2.2nT was been applied to the absolute PPM readings. Corrections of zero were applied to the DIM readings. These resulted in baseline corrections of:

ΔX = -0.03 nT ΔY = -0.33 nT ΔZ = -2.17 nT.

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

ΔD = +15.1′ ΔI = +0.2′ ΔF = +45nT

The combined corrections applied in X, Y and Z were:

ΔX = +42nT ΔX = -11.9nT ΔX = -47nT

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

Casey Operations

The magnetic observer-in-charge at Casey in 2001 was an officer of the Australian Antarctic Division, of the Department of The Environment and Heritage. He was a member of the Australian National Antarctic Research Expedition (ANARE). GA partially funded the position to enable the operation of the magnetic observatory to continue.

The magnetic observer performed twice-weekly absolute observations on the observation piers in the Absolute House to calibrate the variometers and provided regular reports to GA headquarters in Canberra.

The EDA variometer produced 1-second samples that were recorded on an AAD computer via their Analogue Data Acquisition System (ADAS). These were sent to GA where they were converted into GA 1-second format from which calibrated minute, monthly and annual means were computed. There was no PPM variometer operating at Casey in 2001.

Significant Events: CSY, 2001

No significant events were recorded for Casey in 2001.

Distribution of CSY data during 2001

Preliminary Monthly Means for Project Ørsted

- None sent in 2001

1-minute Values

- 1999: WDC-C1, Copenhagen, Denmark (sent 23 Oct 2001)
- 2000: WDC-C1, Copenhagen, Denmark (sent 23 Oct 2001)

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

Casey Annual Mean Values

The table below gives annual mean values for Casey station. Until 1990 these were calculated using the monthly average values of regular absolute observations, denoted by AB. From 1991 they were gained using data from the AAD's fluxgate variometer that was calibrated through regular absolute observations. Until 1997 the means were calculated over the five quietest days at Mawson station, denoted QM. From 1998 monthly means were calculated over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month, denoted A, Q and D respectively.

Plots of these data with secular variation in H, D, Z & F are on the pages 97-98.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1977.96	AB	-88	29.6	-81	38.7	9495	250	-9492	-64650	65344	DHZ
1978.5	AB	-89	4.3	-81	36.2	9518	154	-9516	-64488	65187	DHZ
1979.5	AB	-89	21.6	-81	35.7	9525	106	-9524	-64469	65169	DHZ
1980.5	AB	-89	31.5	-81	33.9	9568	79	-9568	-64528	65233	DHZ
1981.5	AB	-88	2.1	-81	32.0	9540	327	-9534	-64083	64789	DHZ
1982.5	AB	-90	10.0	-81	28.4	9650	-28	-9650	-64400	65120	DHZ
1983.5	AB	-90	32.0	-81	31.5	9585	-89	-9585	-64326	65037	DHZ
1984.5	AB	-90	50.0			9640	-140	-9639			DHZ
1985.5	AB	-90	50.0	-81	25.9	9650	-140	-9649	-64067	64790	DHZ
1986.5	AB	-90	52.9	-81	27.2	9634	-148	-9633	-64101	64821	DHZ
1987.5	AB	-91	18.6	-81	29.1	9596	-219	-9593	-64097	64811	DHZ
1988.5	AB	-91	28.4	-81	27.2	9630	-248	-9627	-64086	64805	DHZ
1989.5	AB	-90	45.5	-81	23.5	9672	-128	-9671	-63887	64615	DHZ
1990.5	AB	-91	55.0	-81	27.4	9601	-321	-9596	-63920	64637	DHZ
1991.5	QM	-92	1.2	-81	25.0	9642	-340	-9636	-63881	64605	XYZ
1992.5	QM	-92	10.0	-81	25.0	9637	-364	-9630	-63848	64571	XYZ
1993.5	QM	-92	7.3	-81	25.0	9638	-357	-9631	-63852	64576	XYZ
1994.5	QM	-92	17.1	-81	25.3	9629	-384	-9621	-63824	64547	XYZ
1995.5	QM	-92	27.5	-81	25.6	9620	-413	-9611	-63807	64528	XYZ
1996.5	QM	-92	35.4	-81	25.3	9625	-435	-9615	-63804	64526	XYZ
1997.5	QM	-92	42.1	-81	25.2	9623	-454	-9612	-63774	64496	XYZ
1998.5	Q	-92	55.4	-81	25.7	9614	-490	-9601	-63777	64497	XYZ
1999.5	Q	-93	4.9	-81	26.5	9595	-516	-9581	-63762	64480	XYZ
2000.5	Q	-93	12.9	-81	27.0	9584	-537	-9568	-63749	64465	XYZ
2001.5	Q	-93	21.6	-81	27.9	9564	-561	-9548	-63729	64443	XYZ
1998.5	A	-92	55.4	-81	25.7	9615	-490	-9602	-63785	64505	XYZ
1999.5	A	-93	4.8	-81	26.4	9599	-516	-9585	-63772	64490	XYZ
2000.5	A	-93	13.2	-81	27.0	9587	-538	-9571	-63759	64476	XYZ
2001.5	A	-93	21.6	-81	27.9	9566	-561	-9549	-63733	64447	XYZ
1998.5	D	-92	58.2	-81	25.8	9615	-498	-9601	-63805	64526	XYZ
1999.5	D	-93	10.7	-81	26.6	9599	-532	-9583	-63796	64514	XYZ
2000.5	D	-93	13.6	-81	27.0	9588	-539	-9572	-63771	64487	XYZ
2001.5	D	-93	19.4	-81	27.8	9570	-555	-9553	-63746	64460	XYZ

Data losses: CSY, 2001

Some calibration activities for Antarctic Division caused contamination of short intervals of data, as did the daily sets of calibration pulses.

Jan 23 0128-0144 (17 min) All channels

Mar 21 0001-0937 (9 hr 37 min) All channels: Change to the ADAS 2000 logging system; logging system calibration

Mar 26 0001-0613 (6hr 13m) All channels: Logging system calibration.

Mar 29 0001-0048 (48m) All channels: Logging system calibration.

Mar 31 0001-0241 (2h 41m) All channels.

Apr 01 00001-0105 (1h 5m) All channels.

Apr 11 0808-0928 (1h 21m) All channels.

Apr 13 0230-0301 (32m); 0346-0350 (5m); 0402-0413 (12m); 0416-0440 (25m); 0744-0904 (1h 21m) All channels: Logging system calibrations.

Apr 19 0921-0931 (11m) All channels.

May 05 0135-0144 (10m); 0147 (1m) All channels.

May 15 0012-0055 (44m) All channels.

May 22 0227 (1m) All channels.

May 23 0221-0222 (2m) All channels

… continued on page 99

Casey, Antarctica 2001 Monthly & Annual Mean Values

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

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

Casey Station	2001	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	-532.1	-9562.4	-63708.4	64424.4	9577.8	-93° 11.2'	-81° 27.0'
	5xQ days	-537.7	-9565.3	-63717.5	64433.8	9580.8	-93° 13.1'	-81° 26.9'
	5xD days	-548.2	-9536.2	-63725.1	64437.2	9552.9	-93° 17.6'	-81° 28.5'
February	All days	-545.5	-9564.4	-63724.8	64441.0	9580.3	-93° 15.9'	-81° 27.0'
	5xQ days	-534.9	-9562.8	-63723.4	64439.2	9577.9	-93° 12.1'	-81° 27.1'
	5xD days	-533.3	-9579.8	-63720.2	64438.7	9595.2	-93° 11.3'	-81° 26.2'
March	All days	-561.9	-9552.7	-63741.2	64455.6	9569.5	-93° 22.0'	-81° 27.7'
	5xQ days	-554.3	-9550.2	-63731.3	64445.2	9566.3	-93° 19.3'	-81° 27.8'
	5xD days	-552.3	-9547.6	-63738.8	64452.5	9564.0	-93° 18.7'	-81° 28.0'
April	All days	-575.6	-9544.0	-63764.8	64477.7	9561.6	-93° 27.1'	-81° 28.3'
	5xQ days	-582.1	-9543.4	-63762.3	64475.2	9561.3	-93° 29.4'	-81° 28.3'
	5xD days	-584.9	-9547.7	-63818.3	64531.5	9566.2	-93° 30.5'	-81° 28.5'
May	All days	-573.5	-9548.4	-63752.1	64465.7	9565.7	-93° 26.2'	-81° 28.0'
	5xQ days	-571.6	-9541.6	-63739.1	64451.9	9558.8	-93° 25.7'	-81° 28.3'
	5xD days	-577.5	-9551.4	-63786.7	64500.5	9569.0	-93° 27.6'	-81° 28.1'
June	All days	-574.0	-9539.8	-63742.6	64455.1	9557.1	-93° 26.6'	-81° 28.4'
	5xQ days	-570.4	-9536.0	-63737.9	64449.8	9553.0	-93° 25.4'	-81° 28.6'
	5xD days	-582.6	-9541.3	-63752.7	64465.4	9559.2	-93° 29.7'	-81° 28.4'
July	All days	-573.6	-9541.8	-63740.7	64453.5	9559.1	-93° 26.4'	-81° 28.3'
	5xQ days	-573.1	-9542.0	-63735.1	64448.0	9559.2	-93° 26.2'	-81° 28.2'
	5xD days	-577.7	-9539.5	-63746.7	64459.2	9557.0	-93° 27.9'	-81° 28.4'
August	All days	-570.5	-9540.4	-63733.4	64446.1	9557.5	-93° 25.4'	-81° 28.3'
	5xQ days	-575.6	-9541.2	-63737.2	64450.0	9558.6	-93° 27.1'	-81° 28.3'
	5xD days	-575.4	-9531.0	-63750.2	64461.4	9548.5	-93° 27.3'	-81° 28.9'
September	All days	-560.6	-9548.5	-63732.7	64446.5	9565.3	-93° 21.6'	-81° 27.9'
	5xQ days	-574.8	-9541.8	-63726.2	64439.1	9559.2	-93° 26.9'	-81° 28.1'
	5xD days	-536.1	-9563.2	-63738.7	64454.6	9578.9	-93° 12.5'	-81° 27.2'
October	All days	-568.7	-9550.5	-63740.8	64455.0	9568.0	-93° 24.5'	-81° 27.8'
	5xQ days	-556.0	-9557.4	-63728.9	64444.0	9573.7	-93° 19.8'	-81° 27.4'
	5xD days	-545.5	-9559.6	-63739.4	64455.0	9576.2	-93° 16.1'	-81° 27.3'
November	All days	-546.7	-9548.8	-63723.6	64437.7	9565.6	-93° 16.6'	-81° 27.8'
	5xQ days	-525.0	-9554.1	-63716.4	64430.9	9568.7	-93° 08.8'	-81° 27.6'
	5xD days	-522.7	-9569.9	-63731.4	64449.1	9587.4	-93° 07.2'	-81° 26.7'
December	All days	-542.7	-9543.4	-63694.6	64408.1	9560.1	-93° 15.4'	-81° 27.8'
	5xQ days	-570.8	-9538.2	-63690.0	64402.9	9555.9	-93° 25.6'	-81° 28.0'
	5xD days	-518.6	-9562.9	-63701.6	64417.9	9578.9	-93° 06.4'	-81° 26.9'
Annual	All days	-560.5	-9548.8	-63733.3	64447.2	9565.6	-93° 21.6'	-81° 27.9'
Mean	5xQ days	-560.5	-9547.8	-63728.8	64442.5	9564.4	-93° 21.6'	-81° 27.9'
Values	5xD days	-554.6	-9552.5	-63745.8	64460.3	9569.5	-93° 19.4'	-81° 27.8'

(Calculated: 13:25 hrs., Fri. 19 Dec. 2003)

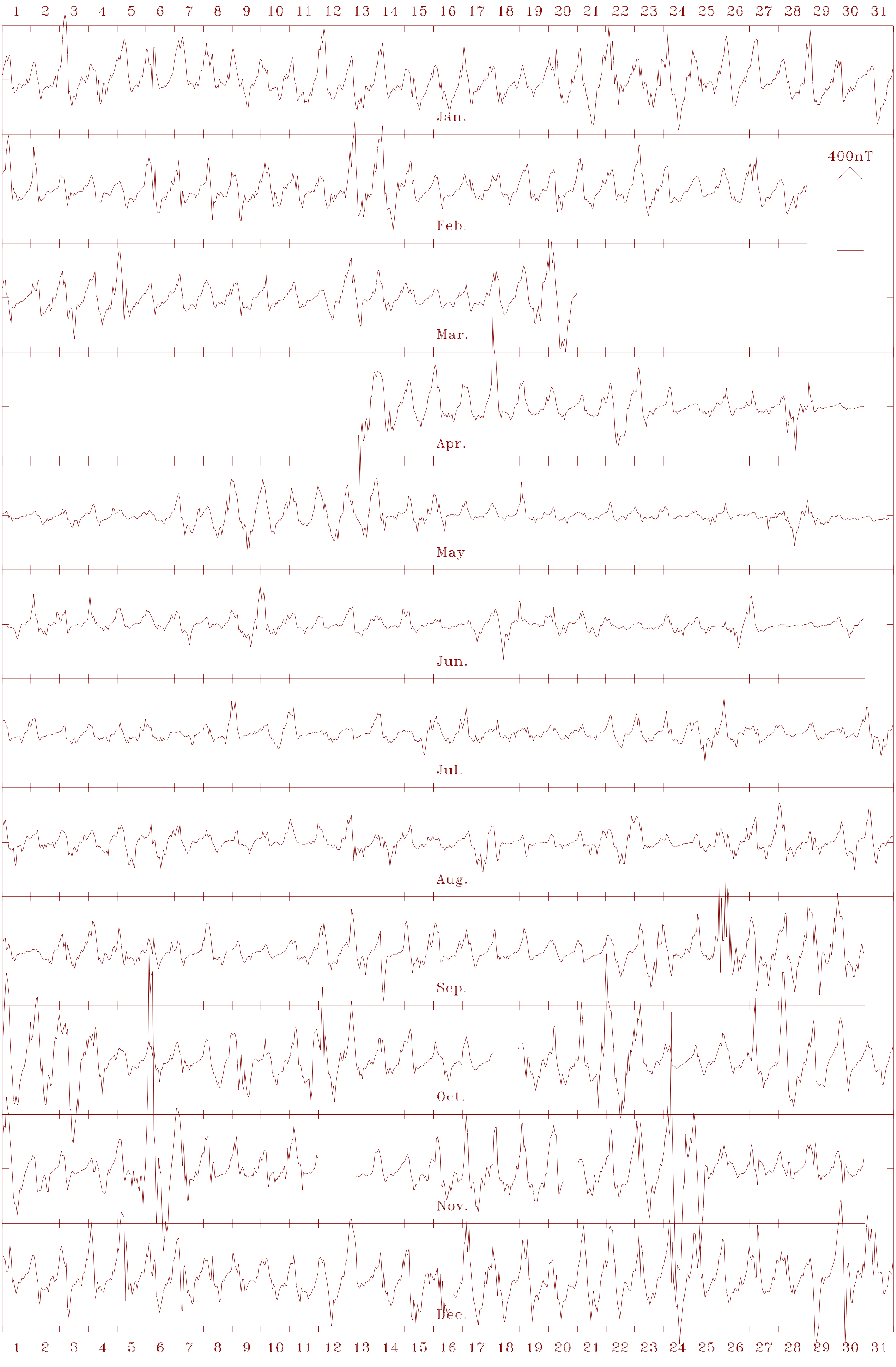
Hourly Mean Values

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

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

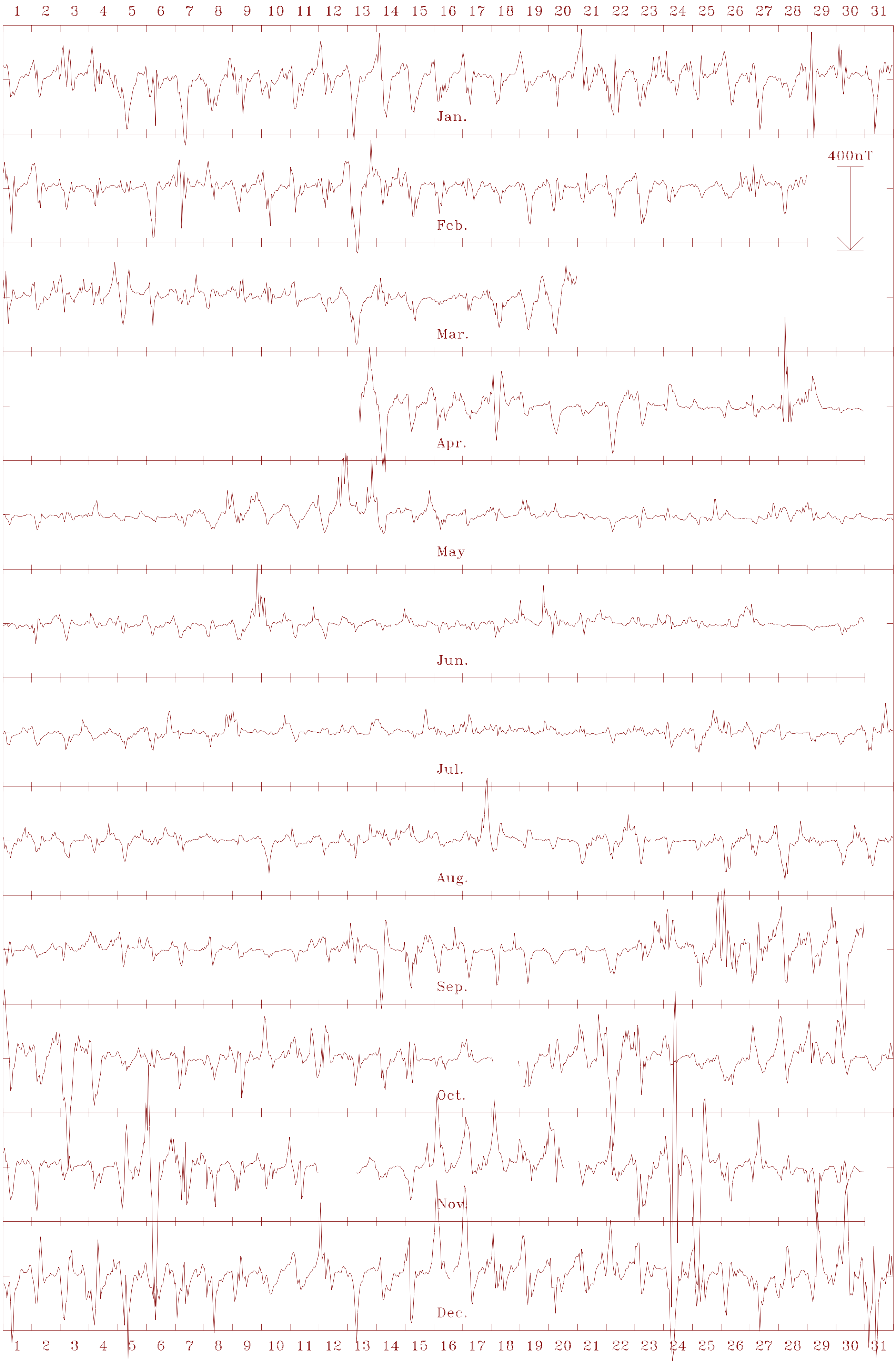
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Casey Stn. 2001 Horizontal intensity (H). Scale: 25.0 nT/mm. Mean: 9566 nT

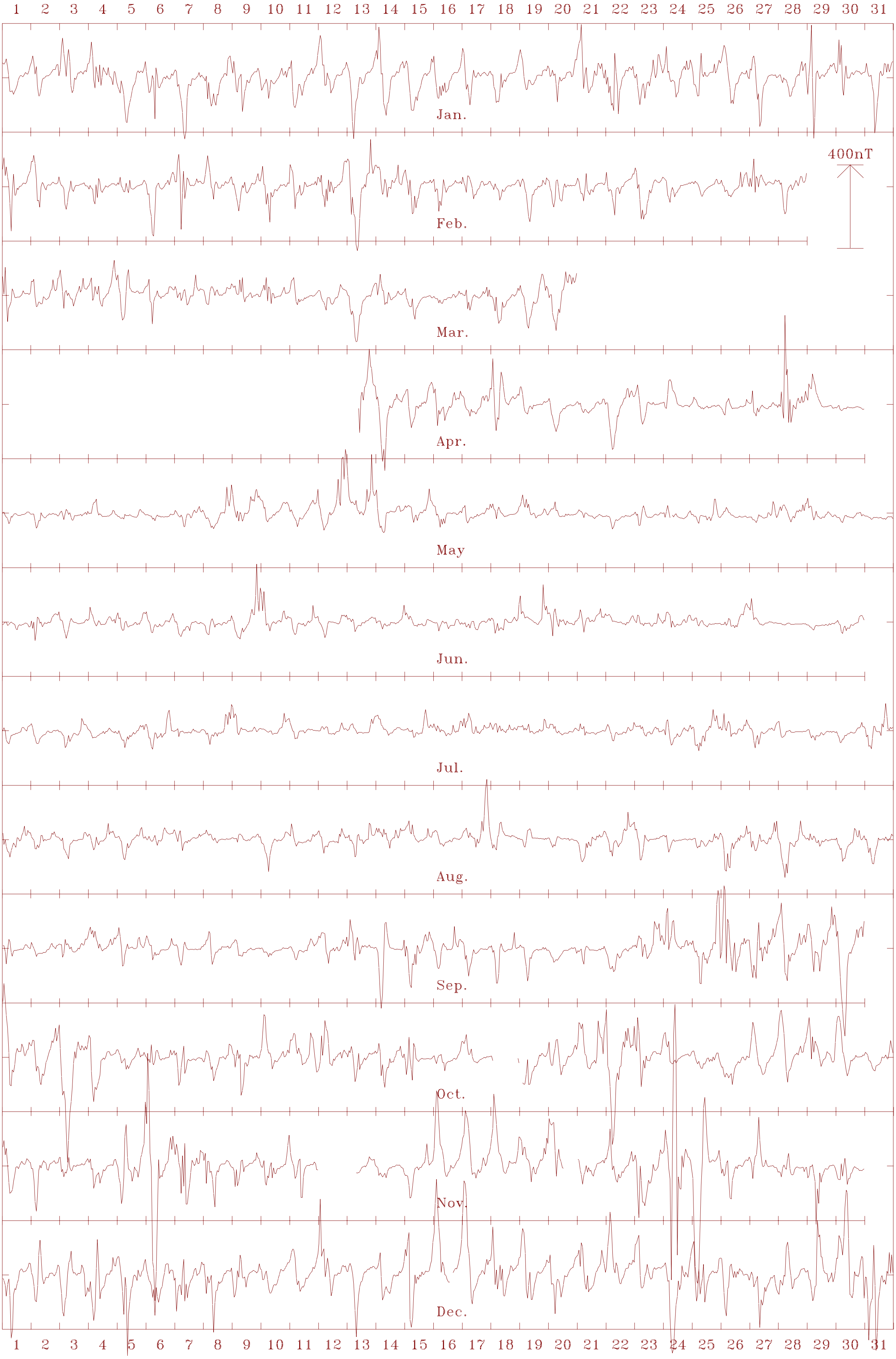


Casey Stn. 2001 Declination (east) (D). Scale: 10.0 min/mm. Mean: −93.36 deg.

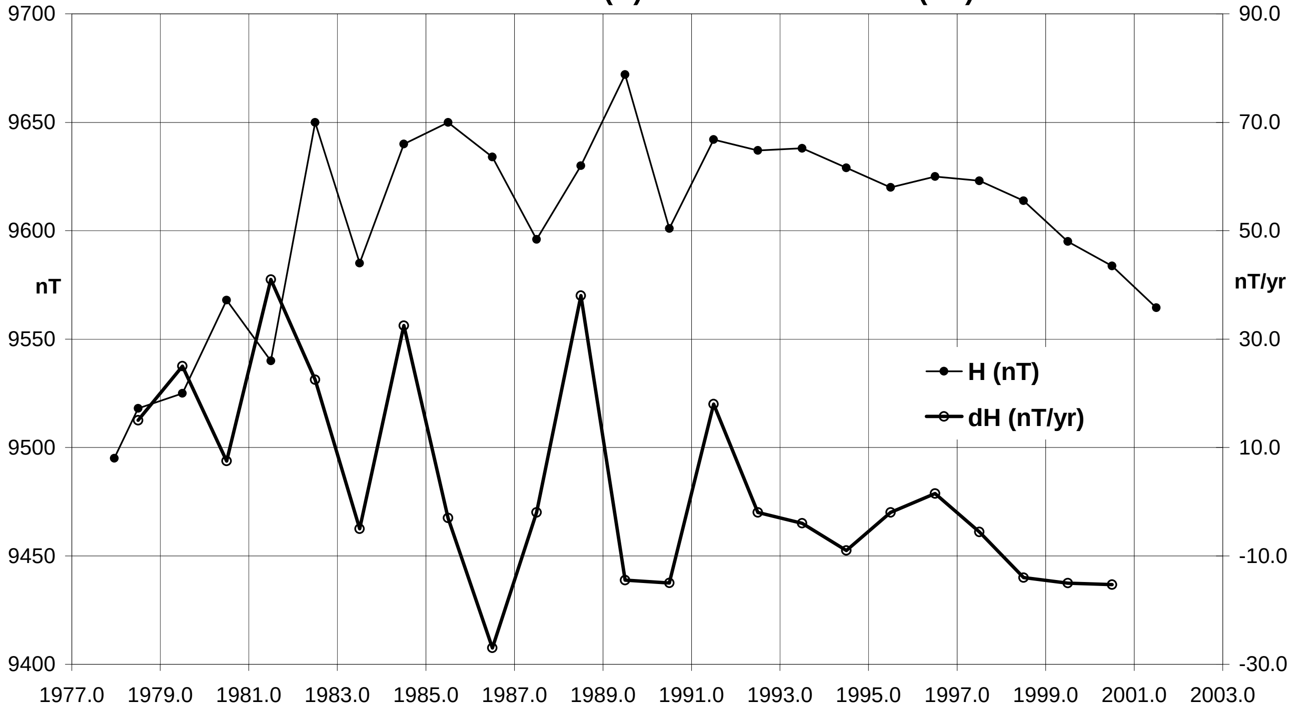
Casey Stn. 2001 Vertical intensity (Z). Scale: 25.0 nT/mm. Mean: -63733 nT



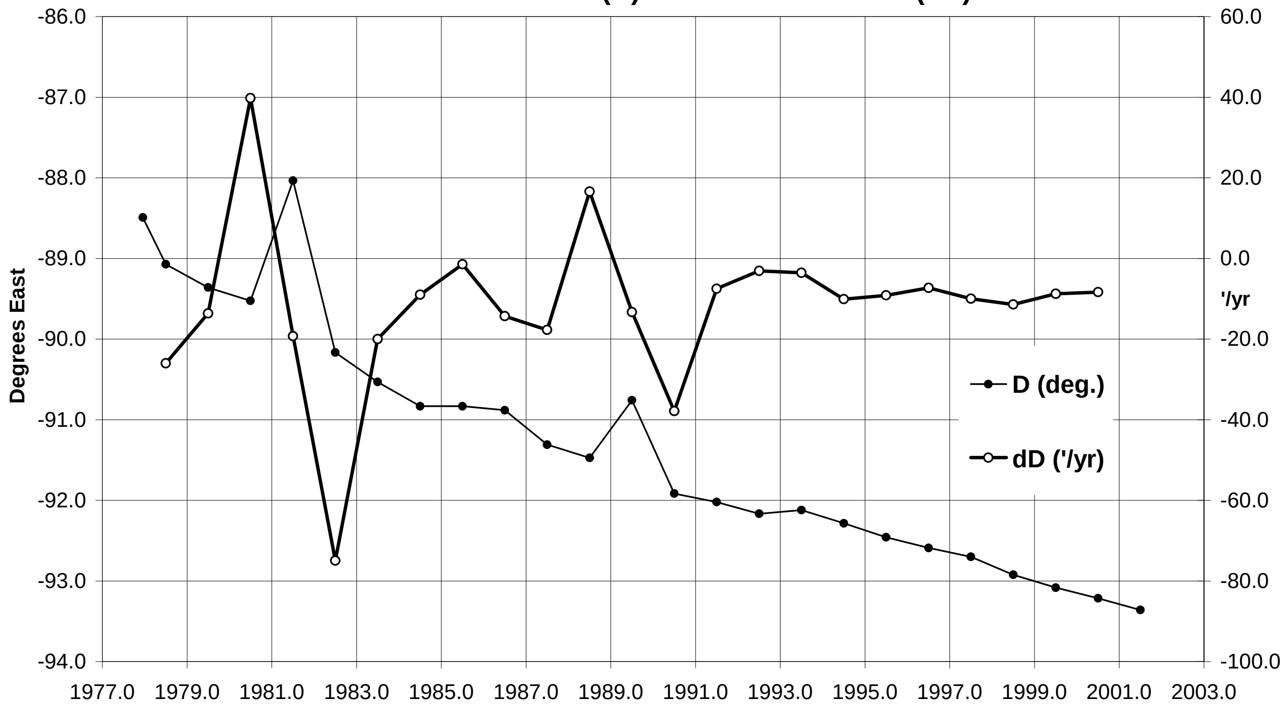
Casey Stn. 2001 Total intensity (F). Scale: 25.0 nT/mm. Mean: 64447 nT

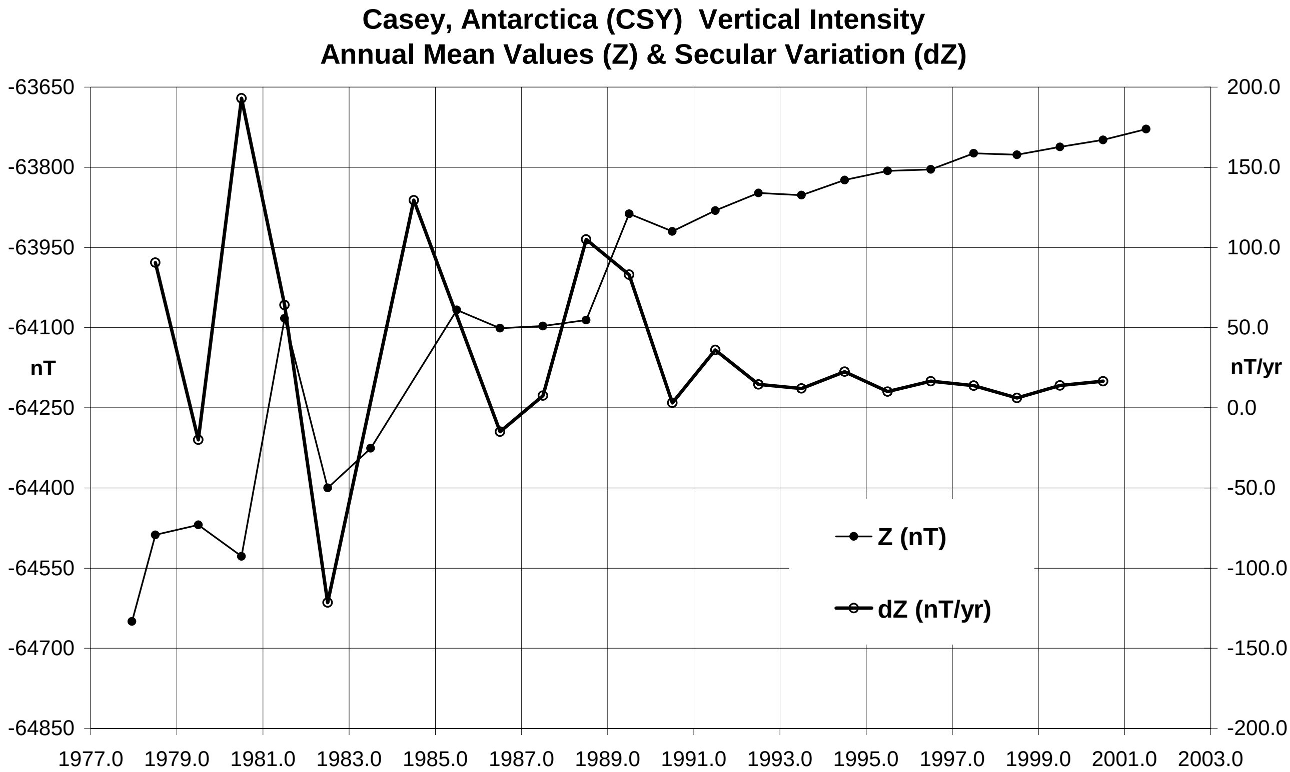


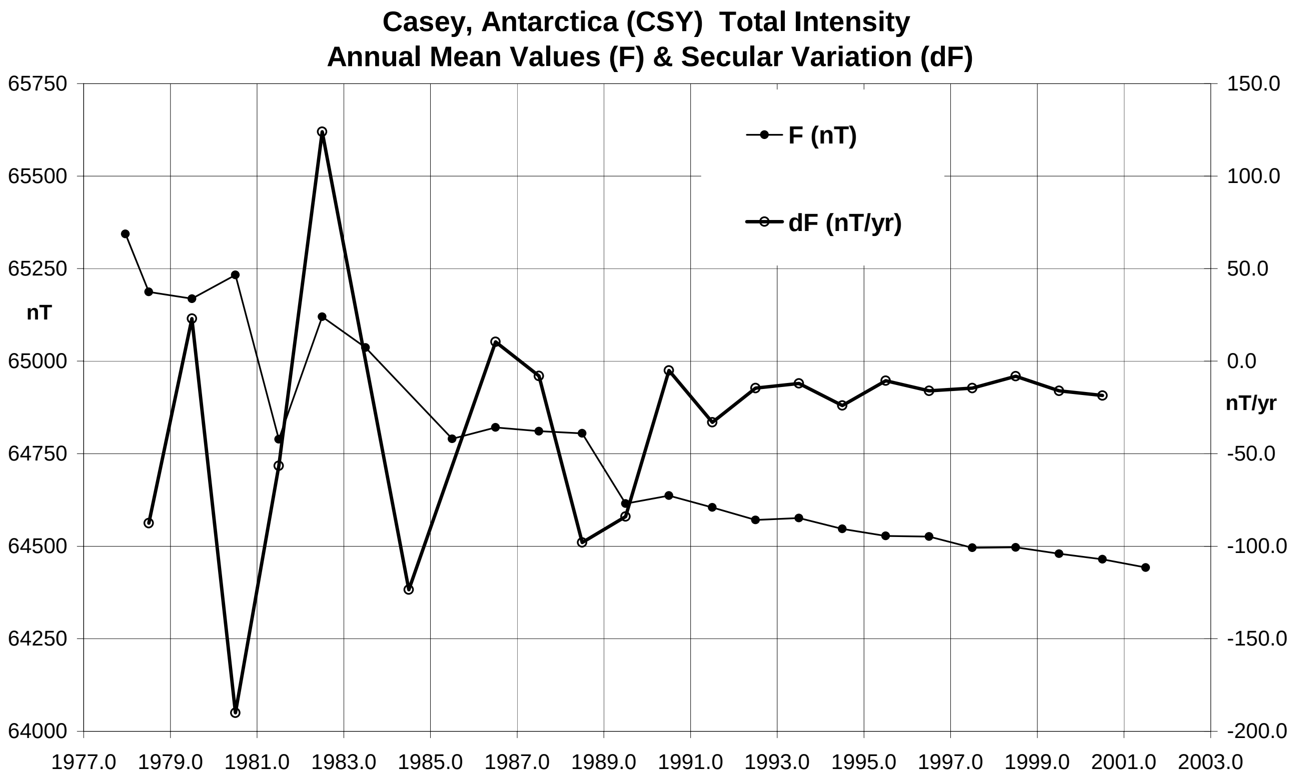
Casey, Antarctica (CSY) Horizontal Intensity
Annual Mean Values (H) & Secular Variation (dH)



Casey, Antarctica (CSY) Declination
Annual Mean Values (D) & Secular Variation (dD)




Casey, Antarctica (CSY) Vertical Intensity
Annual Mean Values (Z) & Secular Variation (dZ)
-63650
-63800
-63950
-64100
nT
-64250
-64400
-64550
-64700
-64850
200.0
150.0
100.0
50.0
nT/yr
0.0
-50.0
-100.0
-150.0
-200.0
1977.0
1979.0
1981.0
1983.0
1985.0
1987.0
1989.0
1991.0
1993.0
1995.0
1997.0
1999.0
2001.0
2003.0
Z (nT)
dZ (nT/yr)


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

Data losses: CSY, 2001 (cont.)

May 24 0601-0708 (1h 8m); 0727-0731 (5m) All channels.

May 29 0101-0113 (13m); 0718-0744 (27m) All channels.

May 30 0856-0859 (4m) All channels.

May 31 0001 (1m); 0724-0727 (4m); 0833-0835 (3m) All channels.

Jun 18 0819-0828 (10m) All channels.

Aug 10 0536-0548 (13m) All channels.

Sep 19 0414-0416 (3m) All channels.

Sep 21 0115 (1m) All channels.

Oct 02 0212-0232 (21m) All channels.

Oct 10 1236-1238 (3m); 1434-1459 (26m) All channels: Logging system calibration.

Oct 14 0936-0937 (2m): All channels.

Oct 16 0101-0127 (27m): All channels.

Oct 18 0136-2245 (21 hr 10m); 2359 to 19 / 0204 (2h 06m) All channels.

Oct 19 0211-0217 (7m) All channels.

Nov 06 0310-0310 (1m) All channels.

Nov 12 0001 to 13 / 0702 (1d 07h 02m) All channels: Power and communications failure.

Nov 20 1226-2359 (11h 34m) All channels.

Dec 16 1402-1405 (4m); 1411-1607 (1h 57m) All channels.

DAVIS Variation Station

BMR/AGSO/GA and the Australian Antarctic Division have jointly carried out regular absolute measurements of the magnetic field at Davis since 1973 to provide information on the magnetic secular variation in Antarctica. The observations have been performed by Antarctic Division personnel, who were trained in the use of the instruments at GA in Canberra.

Until the Australian Antarctic Division installed EDA FM105B fluxgate variometers at Davis in January 1986 to support their Atmospheric and Space Physics research program, monthly means were calculated from absolute observations without correction for daily field variations. These data, although exhibiting scatter, enabled the estimation of the secular variation trend from year to year.

From 1991 to 1998 the digital variometer data and monthly absolute observations were made available to the GA observer at Mawson, who derived baselines and produced monthly mean values of the magnetic field (De Deuge, 1992) for Davis (and Casey). These monthly mean values, based on the five quietest days of the month (at Mawson), were provided to WDC-A. Although during this period the variometers at Davis (and Casey) were not operated to observatory standards, the monthly means derived from the variometer data were a significant improvement on those derived from the previous absolute observations only.

Since 1998 the calculation of monthly means has been carried out at GA using International Quiet Days.

During calendar year 2001 diminishing resources from the Geomagnetism program at GA resulted in the withdrawal of support in the processing of geomagnetic data acquired at the Davis Station. The Atmospheric & Space Physics group of AAD continued the acquisition of magnetic data at the station.

Future *AGR* volumes will not contain a section on Davis.

Key data for the principal observation pier of the Davis Station are:

- 3-character IAGA code: DVS
- Geographic latitude: 68° 34' 38" S
- Geographic longitude: 77° 58' 23" E
- Geomagnetic† : Lat. -76.36°; Long. 127.94°
  † Based on the IGRF 2000.0 model updated to 2001.5
- Elevation above mean sea level (top of observation pier) 29 metres
- Azimuth of reference mark (PP) from observation pier 312° 00.8'
- Distance to azimuth mark PP: 80 metres
- Observer in Charge: Michael Terkildsen (AAD)

† Based on the IGRF 2000 model.

Magnetometers

An EDA FM105B fluxgate variometer, with the data acquired by PC, operated at Davis. Together with the DIMs used for absolute observations, the instruments were owned by the Australian Antarctic Division. The PPMs used for absolutes and the QHMs provided for backup were GA instruments.

Operations

The observers at Davis were officers of the Australian Antarctic Division, of the Australian Department of the Environment and Heritage, and were members of the Australian National Antarctic Research Expedition (ANARE).

Two sets of absolute observations were performed on one day each month.

Distribution of DVS data during 2001

Inquiries for variation data from Davis should be directed to the Atmospheric and Space Physics Section of the Australian Antarctic Division, Channel Highway, Kingston, Tasmania.

Preliminary Monthly Means for Project Ørsted

- None sent in 2001

1-minute Values

- 1999: WDC-C1, Copenhagen, Denmark (sent 23 Oct 2001)
- 2000: WDC-C1, Copenhagen, Denmark (sent 23 Oct 2001)

Summary of data loss in the Australian observatories in 2001

The table below summarizes the 2001 monthly digital data acquisition losses, in minutes per month, at the Australian observatories. The first figure refers to the principal 3-component variometers and the second figure (in parentheses) to the recording total intensity instruments. A single figure indicates the same data loss in a month for both instruments. Annual totals and percentage losses are also shown. The figures do not include data that have been excluded from processing such as contaminated data.

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

2001	ASP	CNB	CTA	GNA	KDU	LRM	MAW	MCQ	CSY
Jan	1 (8514)	1 (8)	0	0	0	0	0	0	173
Feb	6 (16)	0 (277)	5 (0)	0	0	0	0	0	140
Mar	0	0 (5637)	0	0	0	0	0	0	1314
Apr	0	0	0	0	21	0	0	0	852
May	0	0	731 (800)	0	0	0	0	0	338
Jun	0	0	0	0	0	1274	0	0	160
Jul	0	0	0	0	196	1630	0	0	155
Aug	0 (835)	0	0	8092	86	3554	0	0	168
Sep	0 (12,599)	0	0	0	12	0	7	0	154
Oct	174 (34,708)	0	0	0	27,360	0	5	0	1633
Nov	2,749 (31,517)	1494	1576 (2278)	0	1655	1128	0	0	2701
Dec	0 (24,651)	4	180 (1917)	0	11,496	610	0	0	276
3-axis variom.	2,930 (0.56%)	1499 (0.29%)	2,492 (0.47%)	8,092 (1.54%)	40,826 (7.77%)	8,196 (1.56%)	12 (0.002%)	0 (0.00%)	8,064 (1.53%)
Total field	112,840 (21.5%)	7420 (1.41%)	4,995 (0.95%)	8,092 (1.54%)	159,504 (30.3%)	8,196 (1.56%)	12 (0.002%)	0 (0.00%)	no PPM

International Quiet & Disturbed Days

2001	Quietest days 1 - 5					Quietest days 6 - 10					Most Disturbed days 1 - 5				
January	1	30	6	2	19	18	27	7	5K	9	24	21*	31*	23*	29*
February	3	4	18	25	17	16	5	24	19	9	13	6*	14*	27*	23*
March	15	16	26	11	17	10	1K	25	9	8K	31	20	28	19	23
April	30	27	24	19	25	26	17	20K	3	21A	11	8	13	12	18
May	31	5	30	21	1	2	26	6	24	20	9	12	13	10	28*
June	28	29	12	23	22	16	5	25	27K	3	18	9	2	10	21*
July	28	21	2	20	7	29	13	3	4	27	31	25	17*	8*	16*
August	16	24	15	11	29	2	8	20K	4	10	17	13	5	22*	6*
September	10	7	9	21	1	20	6	2	17	8K	23	29	30	26	15
October	24	18	7	17	26	27	25A	30A	10A	5A	22	3	2	21	1
November	3	27	30	28	14	12	29	13	21	9	6	24	1	7*	19
December	9	10	11	13	20	2	28	14	26	7	24	30	17*	31*	21*

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

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

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

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Geomagnetism Staff List 2001

Name	Classification	Responsibility
Charles E. Barton	Research Group Leader	Section Head
Peter A. Hopgood	Senior Professional Officer	Project Leader
Peter G. Crosthwaite	Senior Information Technology Officer	Digital acquisition, system and software development and maintenance; Kakadu & Gnangara observatories
Stewart D. Dennis	Professional Officer (until May 2001)	Antarctic Observatories
Andrew M. Lewis	Professional Officer	Project Leader, Repeat Station Survey, Alice Springs & Learmonth observatories
Liejun Wang	Professional Officer	Data-base development; Canberra & Charters Towers observatories
Adrian D. Costar	Professional Officer (from April 2001)	Antarctic Observatories
Peter Johnson	Technical Officer 2 (on contract) (shared by GA & BoM)	Mawson (2000 observer)
Martin Purvins	Technical Officer 2 (on contract) (shared by GA & BoM)	Mawson (2001 observer)
Andrew Jenner	Technical Officer 2 (on contract) (shared by GA & BoM)	Mawson (2002 observer)
Jean Osanz	Technical Officer 2 (on contract) (shared by AAD, IPS & GA)	Macquarie Island (2000 observer)
Dave Gillies	Technical Officer 2 (shared by AAD, IPS & GA)	Macquarie Island (2000/01 observer)
Mick Eccles	Technical Officers 2 (shared by AAD, IPS & GA)	Macquarie Island (2001 observer)
Bruce Sibson	Technical Officer 3	Technical support
Owen D. McConnel	Technical Officer 4	Technical support, Western Australia*

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

Non-GA Observers/OICs

Warren Serone	ACRES (contracted by GA)	Alice Springs
Jack M. Millican	Contracted by Queensland University	Charters Towers
Graham Steward	Learmonth Solar Observatory, IPS	Learmonth
Kim Stellmacher	Contracted by GA	Kakadu
Gerard (Hans) Van Reeken	Contracted by GA	Gnangara
Anthony Breed	AAD	Casey, 2001
Michael Terkildsen	AAD	Davis, 2001

End of Part 2