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MAGNETIC OBSERVATORIES

VOLUME 47

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Australian Geomagnetism Report 1999 - Volume 47

Compiled by P.A. Hopgood

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AUSTRALIA

Magnetic results for 1999

Alice Springs

Canberra

Charters Towers

Gnangara

Kakadu

Learmonth

Macquarie Island

Mawson

Casey

Davis

Australian Repeat Station Network

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SUMMARY

During 1999 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 upgraded to magnetic observatory standard, including twice-weekly absolute observations. Davis magnetic station did not have sufficient absolute control to be considered observatory standard, so continued to be regarded as a variation station.

The magnetometers at the Canberra Magnetic Observatory are the Australian standards. The calibration of these instruments can be traced to International Standards. Absolute magnetometers at all the other Australian observatories are standardised to those at Canberra

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

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

A total of seven magnetic repeat stations were occupied in 1999.

The magnetic observatory at Tangerang, Indonesia was upgraded by GA's Geomagnetism group under an AusAID grant.

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 1999.

ACRONYMS and ABBREVIATIONS

AAD	Australian Antarctic Division
ACRES	Australian Centre for Remote Sensing
ACT	Australian Capital Territory
A to 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)
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
EDAS	Environmental Data Recording System
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
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)
PEM	Photo-Electronic Magnetometer
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 – Part 1

CONTINUED OVERLEAF . . .

CONTENTS – Part 2

This is the first volume of the *Australian Geomagnetism Report* to be distributed in electronic format.

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

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

ACTIVITIES & SERVICES 1999

Geomagnetic Observatories

The Geomagnetism Section of the Australian Geological Survey Organisation (now Geoscience Australia) operated eight permanent geomagnetic observatories in the Australian region during 1999. 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**, Antarctica

Antarctic Operations

Geoscience Australia continued its contribution to the Australian National Antarctic Research Expedition (ANARE) in 1999 by the operation of a magnetic observatory at Macquarie Island (Tasmania) in the sub-Antarctic and an observatory at Mawson in Antarctica. GA's operations at Macquarie Island and Mawson were supervised and managed from GA headquarters in Canberra, where the observers (as well as those stationed at Casey and 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 (all 1999) and Casey (until March). At Casey full absolute control began on 22 March, 1999, which included twice-weekly absolute observations. These observations were reduced and used by GA staff together with data supplied by the Antarctic Division from the variometers at these sites to produce monthly mean values of the magnetic field.

Magnetic repeat station network

GA maintains a network of repeat stations covering continental Australia, its offshore islands, Papua New Guinea, and some south-west Pacific Islands. In 1999 seven stations on mainland Australia at Tibooburra, Parafield, Eucla, Carnegie, Derby, Mt Isa and Maryborough were re-occupied.

Calibrations of instruments

GA continued to provide a compass calibration facility at cost recovery rates during 1999. This service was used throughout the year by agencies requiring the calibration of compasses and compass theodolites.

In collaboration with the Australian Department of Defence, the construction of a Magnetic Calibration Facility commenced. This began with the construction of a purpose designed building to the south-east of the Canberra Magnetic Observatory compound from September 1999.

Indonesian Observatories

Geoscience Australia received an AusAID grant to upgrade the existing magnetic observatory at Tangerang, Indonesia. This was carried out in February 1999 when an EDA FM105B 3-axis flugate variometer and an Elsec 820 PPM variometer was installed by GA staff. Data from these instruments was transferred by optic fibre to a new PC based acquisition system. One-minute data values from the Tangerang observatory have been transferred to Geoscience Australia on a daily basis since the upgrade took place. These data will compliment data gained during repeat station occupations to produce more accurate AGRF models in the future.

DATA DISTRIBUTION 1999

During 1999 data from GA's observatory network was routinely provided in support of international programs.

INTERMAGNET

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

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

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

Ørsted Satellite Support

Since October 1994, preliminary monthly mean values from Australian observatories have been provided to the Ørsted satellite project within about a fortnight after the end of each month. In support of the Ørsted satellite project, 1999 preliminary monthly mean values from most Australian observatories were provided by e-mail to IPGP, France.

Storms & Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 1999 were provided monthly to:

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

Indices of Magnetic Disturbance

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

Canberra is also one of twelve mid-latitude observatories (of which it is one of two in the southern hemisphere) used in the derivation of the planetary three-hour range index Kp. 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 1999, 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.

CNB K indices were also provided weekly to the Regional Warning Centre at Meudon Observatory (near Paris), and 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 1999 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 1999 as indicated.

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

Annual mean values for all the Australian magnetic observatories for 1995 were provided to the following world data centres by e-mail on 25 Mar. 1999:

- WDC-A for Solar-Terrestrial Physics - Boulder, USA
- WDC-C1 for Geomagnetism at BGS, Edinburgh, U.K.
- WDC-C2 for Geomagnetism, Kyoto, Japan
- IZMIRAN (Russian Academy of Sciences), Moscow.

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

Australian Geomagnetism Report series

Beginning publication monthly as the ***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 the Australian Geological Survey Organisation†,or in which the latter had significant involvement. Detailed information about the instrumentation and the observatories was included in the *AGRs 1993 and 1994*.

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, and on 8 November 2001 became simply Geoscience Australia (GA).

INSTRUMENTATION

During 1999 the basic system used 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 modem via either telephone lines or satellite.

Intervals of Recording and Mean Values

The standard recorded value was every 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 1999

Observatory	Variometer/Serial no. (operational period)	Resolution (nT)	Acquisition interval (sec.)	Components recorded
ASP	Narod ring-core fluxgate/9004-3 GSM-19 Overhauser Magnetometer / BMR#1	0.025 0.01	1, 60 10, 60	X, Y, Z‡ F
CNB	Narod ring-core fluxgate/9004-2 GEM Systems GSM-90 / 803810	0.025 0.01	1, 60 1, 60	NW, NE, Z† F
CTA	EDA FM105B fluxgate: 2887/3181* Elsec 820M3 PPM s/n 128	0.2 0.1	1, 60 10, 60	NW, NE, Z† F
GNA	DMI FGE (ver.D) S0160/E0167 Geometrics 856 No.50706	0.03 0.1	1, 60 10, 60	NW, NE, Z† F
KDU	EDA FM105B fluxgate 2884/5460* Geometrics 856 no.50707	0.2 0.1	1, 60 10, 60	NW, NE, Z† F
LRM	EDA FM105B fluxgate 146205/3181* (to 11 Feb. 1999) Geometrics 856 No.50708 Narod ring-core fluxgate No.9004-4 (from 12 Feb. 1999) Geometrics 856 No.50708	0.2 0.1 0.025 0.1	60 60 1, 60 10, 60	X, Y, Z‡ F NW, NE, Z F
MCQ	Narod ring-core fluxgate 9305-1 Elsec 820M3 PPM 140	0.025 0.1	1, 60 10, 60	A, B, C† F
MAW	Narod ring-core fluxgate 9004-1 Elsec 820M3 PPM 158	0.025 0.1	1, 60 10, 60	NW, NE, Z† F
DVS	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡
CSY	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡

* The serial numbers of the EDA fluxgates are in the sequence: control electronics/sensor head.
** The EDAs at Casey and Davis are 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 1999. The predominant magnetometer combination was a D,I-fluxgate magnetometer (or DIM) measuring the magnetic field direction, complimented by a PPM to measure the total field intensity. At some observatories, older classical QHMs were still available for use as backup should the primary instruments become unserviceable.

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

MNS2 Proton Precession Magnetometer

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

Declination & Inclination Magnetometer (DIM)

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

In 1999 both Elsec 810 and Bartington MAG-01H fluxgate sensors and electronics were used together with Zeiss-Jena 020B and 010B non-magnetic theodolites.

Ancillary equipment

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

Doric model 410A Trendicator digital indicators were used to monitor temperature at two observatories during 1999. These units comprise a small mains powered electronics module together with an external thermistor to sense temperature variations. Typical usage was to place the thermistor within the sensor head of an EDA FM105B fluxgate.

The Doric Trendicator had a digital display of the temperature in degrees Celsius as well as an analogue output of approximately 0.01 volts/°C. The analogue output was converted to a digital signal by an A to D converter for recording on an acquisition computer.

Absolute Magnetometers employed in 1999

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
ASP	DIM: Elsec 810/221; Zeiss 020B/313887* PPM: Elsec 770/193	D, I F	0.1' 1 nT
CNB	DIM: Elsec 810/200; Zeiss 020B/353756* PPM: MNS-2/no.3	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. 50713 (until 14 Sep. 1999) Geometrics 856 no. 50631 (from 13 Oct. 1999)	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; Zeiss 020B/311847* PPM: Austral /525 (primary); /524 (secondary) QHM Nos. 177, 178, 179 (secondary)	D, I F H, D	0.1' 1 nT 0.1 nT
MAW	DIM: Elsec 810/213; Zeiss 020B/352229* PPM: Elsec 770/199 Elsec 770/206 (secondary) QHM Nos. 300, 301, 302 (secondary)	D,I F F H	0.1' 1 nT 1 nT 0.1 nT
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 810/2506; Zeiss 020B/355939*† (until 22 Jul 1999) PPM: Geometrics 816/1025 QHM No. 492 (primary from 29 Jul 1999 to 19 Jan 2000)	D, I F H	0.1' 1 nT 0.1 nT

* DIM serial numbers are in the sequence DIM control module followed by Zeiss theodolite
† The DIMs at Casey and Davis are Antarctic Division instruments

MAGNETIC STANDARDS

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

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

This correction has been subtracted from 1999 Canberra F-baselines. Appropriate adjustments have also been made to the X, Y and Z baselines of the other observatories, to take account of the PPM MNS2 no. 3 correction, as the PPMs at these sites have been standardized for consistency with this instrument.

All absolute instruments were calibrated against Canberra DIM Elsec 810 no.200 with Zeiss020B theodolite no.353756 and PPM MNS2 no.3, although often through subsidiary travelling standards.

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

DATA ACQUISITION

During 1999 data acquisition at all the Australian observatories was computer-based. Throughout the year data were recorded every second and every minute at all observatories except at Learmonth. At Learmonth 1-minute data were recorded all year and 5-second data were recorded until 0635UT on 11 February, 1999. From 0511UT on 12 Feb. 1999 1-second data were recorded at Learmonth.

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

Analogue to digital PC cards, the A to D facility of EDAS-2 data loggers or external ADAM A to D converters were used to convert analogue data, produced by EDA FM105B and DMI FGE variometers, to digital values for recording on data acquisition PCs.

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

Digital data have been automatically retrieved from the observatories each day since March 1996. In 1999 the data from the observatories were either retrieved on demand by modems: via telephone lines within Australia; or ANARESAT satellite link from Antarctica, directly to the Geomagnetism Section at the GA headquarters in Canberra.

MAGNETIC OBSERVATORIES

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

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

On the pages that follow there is an operational report and data summary for each magnetic observatory in the Australian network that operated in 1999.

Australian Magnetic Observatories, 1999

Observatory	IAGA code	Year begun	Geographic Coordinates Latitude S	Longitude E	Geomagnetic† Lat.	Long.	Elev'n (m)	Observer in Charge
Kakadu	KDU	1995	12° 41' 11"	132° 28' 20"	-22.3°	205.3°	14	K. Stellmacher
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-28.2°	220.7°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.7°	186.1°	4	M. McMullan
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-33.1°	207.9°	557	W. Serone
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-42.1°	188.5°	60	E.P. Paull
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.8°	226.7°	859	P.A. Hopgood Liejun Wang

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Australian Magnetic Observatories (cont.)

Observatory	IAGA code	Year begun	Geographic Coordinates Latitude S	Longitude E	Geomagnetic† Lat.	Long.	Elev'n (m)	Observer in Charge
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-60.1°	244.3°	8	P. Roberts
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.2°	108.6°	12	R. Sutton
Casey	CSY		66° 17'	110° 32'	-76.8°	183.4°	40	S. Wallace
Variation Station								
Davis	DVS		68° 34' 38"	77° 58' 23"	-76.5°	126.6°	29	L. Symons

† Geomagnetic coordinates are based on the 1995.0 International Geomagnetic Reference Field (IGRF) model in which the geomagnetic north pole position is 79.365°N, 288.593°E

Crustal Anomalies:

Crustal anomalies for 1999.5 epoch have been calculated for each of the Australian observatories and are shown in the table below. The crustal anomaly for each element is the difference between the All Days Annual Mean of the element at the observatory and the IGRF 1995 value at the location of the observatory with the secular variation model applied out to epoch 1999.5.

Obs'ty	Epoch 1999.5	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (° ')	I (° ')
CNB	1999 Annual Mean	23140	5159	-53403	58429	23708	12° 34.1'	-66° 03.7'
	IGRF95 for 1999.5	23138	5120	-53456	58473	23697	12° 28.6'	-66° 05.5'
	Crustal Anomaly	**+2**	**+39**	**+53**	**-44**	**+11**	**+00° 05.5'**	**+00° 01.8'**
ASP	1999 Annual Mean	29934	2662	-44329	53555	30052	05° 04.9'	-55° 51.9'
	IGRF95 for 1999.5	29906	2663	-44360	53566	30024	05° 05.3'	-55° 54.5'
	Crustal Anomaly	**+28**	**-1**	**+31**	**-11**	**+28**	**-00° 00.4'**	**+00° 02.6'**
CTA	1999 Annual Mean	31525	4295	-37913	49494	31816	07° 45.5'	-49° 59.8'
	IGRF95 for 1999.5	31985	4405	-38119	49956	32287	07° 50.5'	-49° 44.1'
	Crustal Anomaly	**-460**	**-110**	**+206**	**-462**	**-471**	**-00° 05.0'**	**-00° 15.7'**
GNA	1999 Annual Mean	23207	-936	-53707	58514	23226	-02° 18.5'	-66° 36.8'
	IGRF95 for 1999.5	23246	-849	-53823	58634	23262	-02° 05.5'	-66° 37.6'
	Crustal Anomaly	**-39**	**-87**	**+116**	**-120**	**-36**	**-00° 13.0'**	**+00° 00.8'**
KDU	1999 Annual Mean	35357	2309	-30216	46566	35432	03° 44.2'	-40° 27.4'
	IGRF95 for 1999.5	35360	2328	-30235	46583	35437	03° 46.0'	-40° 28.3'
	Crustal Anomaly	**-3**	**-19**	**+19**	**-17**	**-5**	**-00° 01.8'**	**+00° 00.9'**
LRM	1999 Annual Mean	29696	80	-44292	53325	29696	+00° 09.2'	-56° 09.6'
	IGRF95 for 1999.5	29732	102	-44475	53498	29733	+00° 11.8'	-56° 14.2'
	Crustal Anomaly	**-36**	**-22**	**+183**	**-173**	**-37**	**-00° 02.6'**	**+00° 04.6'**
MAW	1999 Annual Mean	7653	-16910	-45618	49250	18561	-65° 39.0'	-67° 51.5'
	IGRF95 for 1999.5	7641	-16924	-45734	49360	18569	-65° 42.2'	-67° 54.2'
	Crustal Anomaly	**+12**	**+14**	**+116**	**-110**	**-8**	**+00° 03.2'**	**+00° 02.6'**
MCQ	1999 Annual Mean	10856	6367	-63295	64534	12586	30° 23.6'	-78° 45.2'
	IGRF95 for 1999.5	10628	6352	-63596	64790	12382	30° 51.8'	-78° 59.0'
	Crustal Anomaly	**+228**	**+15**	**+301**	**-256**	**+204**	**-00° 28.2'**	**+00° 13.8'**
CSY	1999 Annual Mean	-516	-9585	-63771	64489	9599	-93° 04.8'	-81° 26.4'
	IGRF95 for 1999.5	-1344	-9308	-62849	63548	9404	-98° 12.9'	-81° 29.4'
	Crustal Anomaly	**+828**	**-277**	**-922**	**+941**	**+195**	**+05° 08.1'**	**+00° 03.0'**
DVS	1999 Annual Mean	3299	-16430	-51685	54334	16758	-78° 38.8'	-72° 02.1'
	IGRF95 for 1999.5	3527	-16603	-51737	54450	16973	-78° 00.4'	-71° 50.2'
	Crustal Anomaly	**-228**	**+173**	**+52**	**-116**	**-215**	**-00° 38.4'**	**-00° 12.0'**

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 1277 mm above the concrete floor; two 300mm diameter azimuth pillars that were about 85m from the absolute shelter at approximate true bearings of 130° and 255°; and two small (1m cube) underground vaults located some 50m north and east of the control house in which the variometer sensors were housed.

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

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

- 3-character IAGA code: ASP
- Commenced operation: June 1992
- Geographic latitude: 23° 45' 39.6" S
- Geographic longitude: 133° 53' 00.0" E
- Geomagnetic† latitude: -33.1°
- Geomagnetic† longitude: 207.9°
- Elevation above mean sea level (top of pier): 557 metres
- Lower limit for K index of 9: 350 nT.
- Azimuth of principal reference pillar (B) from Pier G: 255° 00' 50"
- Distance to Pillar B: 85 metres
- Observer in Charge: W. Serone (ACRES)

† Based on the IGRF 1995 model.

Variometers

Variations in the X, Y and Z components of the magnetic field were recorded at Alice Springs in 1999 using a three-component Narod ring-core fluxgate (RCF) magnetometer and in the total magnetic field intensity (F) using a GEM system GSM-19 Overhauser-effect proton precession magnetometer (PPM). The six channels of variometer data, (three RCF channels, RCF head and electronics temperatures, and the PPM data), were recorded on an IBM compatible personal computer.

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

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

Absolute Instruments

The principal absolute instruments employed at Alice Springs during 1999 were a D,I fluxgate magnetometer (DIM) and a proton precession magnetometer (PPM). The DIM used was Elsec Type 810, no. 221 with fluxgate sensor mounted on Zeiss 020B non-magnetic theodolite, no. 313887. The PPM was Elsec model 770 no. 193.

Instrument corrections

No comparisons with the ASP absolute magnetometers were performed during 1999, so the corrections applied to these instruments for 1999 remained the same as for 1998 (see *AGRs 1996-1998*). The corrections adopted for the DIM Elsec 810 no. 221 with Zeiss 020B no. 313887 routinely used at Alice Springs were 0.0' and 0.0' in D and I respectively. The correction adopted for ASP PPM Elsec E770 no. 193 was -0.32nT: this comprised a +0.46nT raw difference from the Australian Standard PPM: MNS2 no.3, and a correction of -0.78nT to the latter.

At the 1999 mean field values at Alice Springs the above absolute instrument corrections translated to X, Y and Z baseline adjustments of 0nT, 0nT and 0nT when rounded to the nearest nanoTesla. These corrections have been applied in the computation of data in this report.

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 9-10.

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
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
1992.708	D	4	58.4	-56	8.1	29915	29803	2594	-44579	53686	XYZ
1993.5	D	4	58.9	-56	6.7	29928	29815	2599	-44556	53674	XYZ
1994.5	D	5	0.0	-56	5.1	29940	29826	2609	-44531	53660	XYZ
1995.5	D	5	1.1	-56	2.6	29965	29850	2621	-44497	53646	XYZ
1996.5	D	5	2.0	-55	59.5	29998	29883	2632	-44460	53634	XYZ
1997.5	D	5	2.8	-55	57.5	30011	29895	2640	-44423	53611	XYZ
1998.5	D	5	4	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	4.9	-55	53	30034	29916	2660	-44332	53548	XYZ

ASP - Operations

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

Daily files of both 1-minute and 1-second resolution data were automatically retrieved from Alice Springs to GA in Canberra by modems via a telephone line connection. System timing checks and PC hard-disk housekeeping tasks were also performed manually via the telemetry line. Accurate timing on the data acquisition computer was maintained with a one-second pulse from a Trimble Accutime GPS clock mounted outside the control hut.

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

Significant Events 1999

Feb 03 GSM-19 variometer failure - reason unknown.

Feb 05 GSM-19 variometer re-started.

Feb 17 Absolute PPM giving poor results.

Feb 24 PPM cable discovered to be broken. A replacement cable sent from GA, Canberra.

Mar 12 New PPM cable installed and tested satisfactorily.

May Replacement UPS sent to ASP observatory.

Jun 23 0629 (approx.): Replacement UPS installed.

Nov 24 0508: System re-booted (just before observations) – reason unknown

Significant Events (cont.)

Dec 02 ASP accepted as an INTERMAGNET Observatory.(IMO)

Dec 14 Commenced daily e-mail transmission of 1-minute data to the Edinburgh INTERMAGNET GIN.

ASP Data losses in 1999:

Feb 03 1158 to 05/0237 (1d 14h 40m) F-channel only: Reason unknown.

Jun 23 0627-0629 (3m) All channels: UPS replaced.

Nov 24 0508 (1m) All channels: System re-booted.

Distribution of ASP data during 1999

Preliminary Monthly Means for Project Ørsted

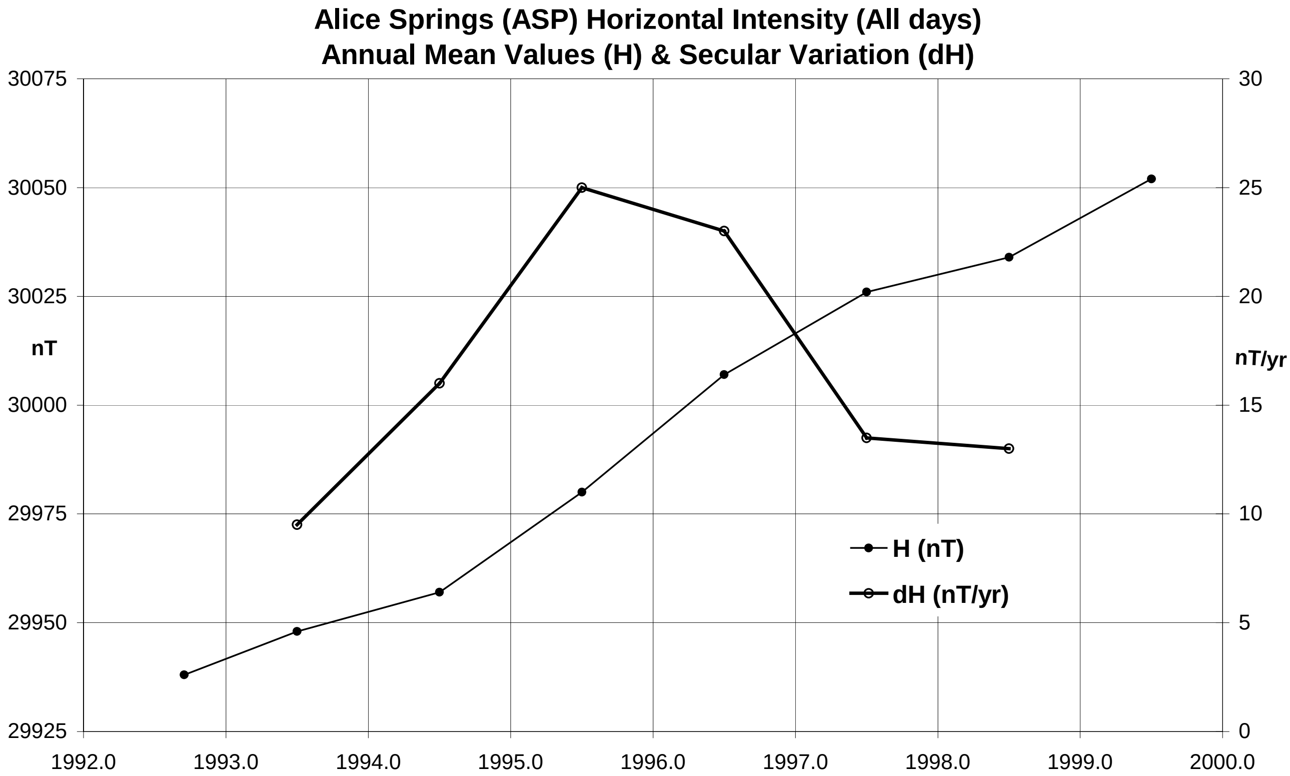
- IPGP monthly (by e-mail): Jan. 1999

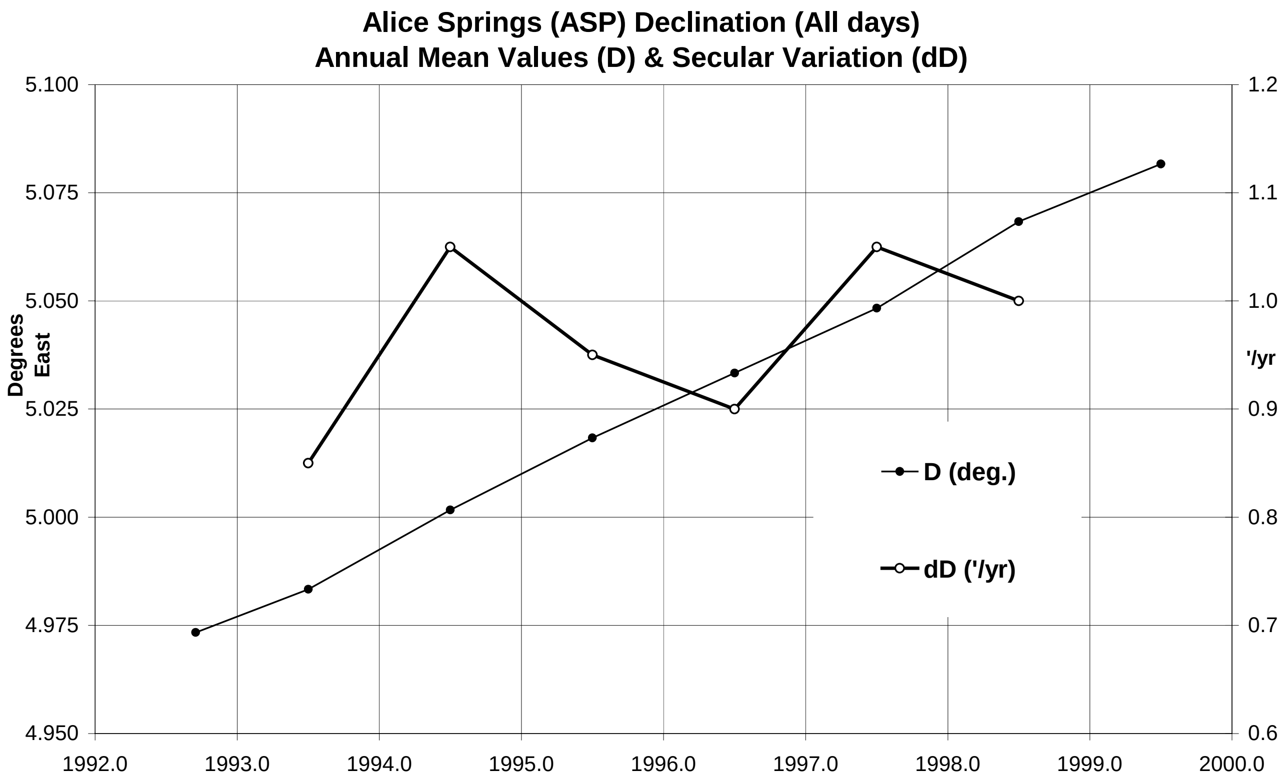
1-minute & Hourly Mean Values

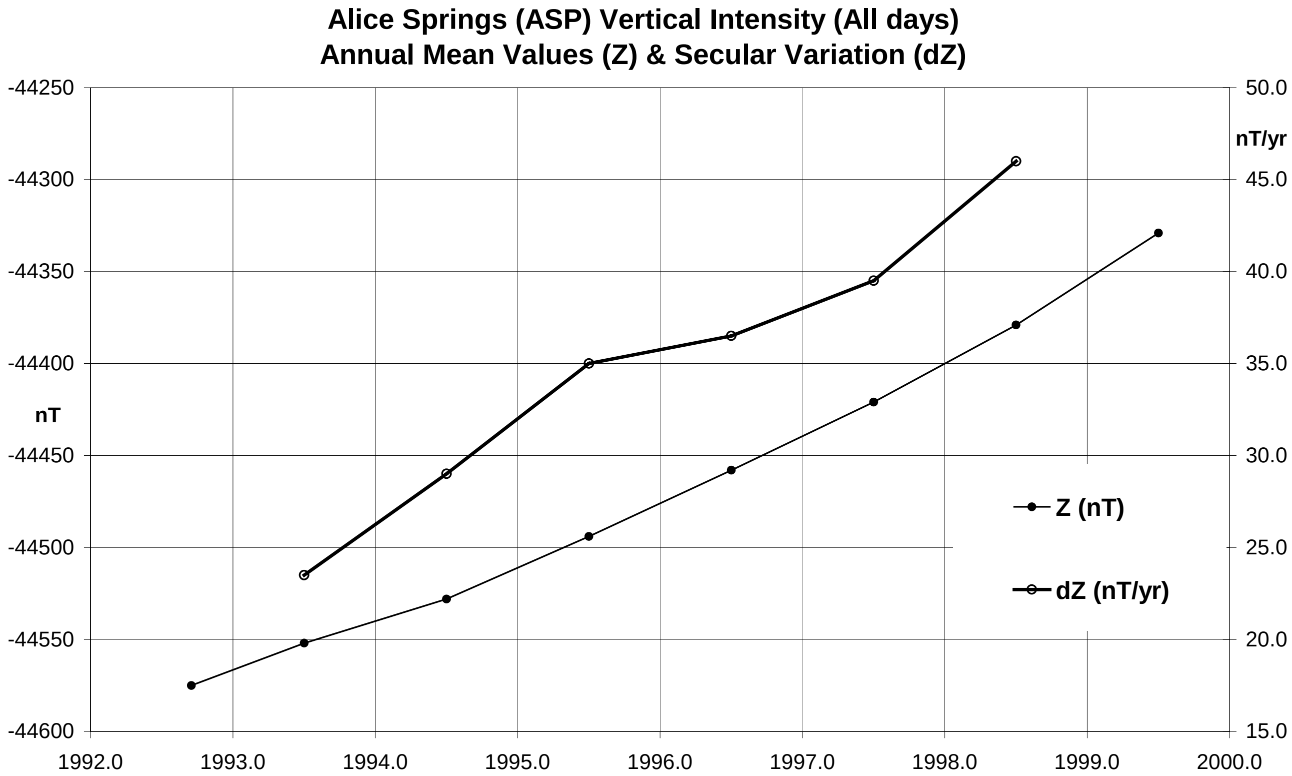
- 1998: WDC-A, Boulder, USA (01 Nov. 1999)

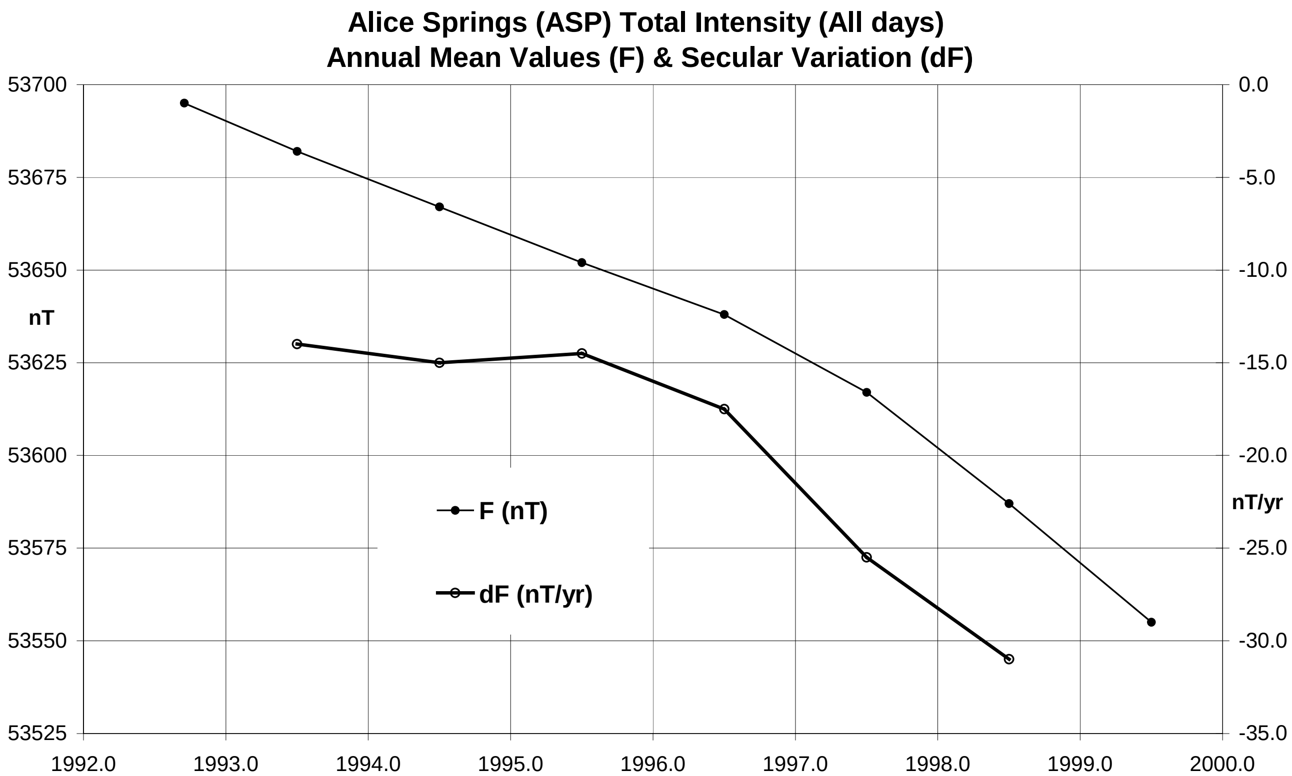
1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail commenced 14 December 1999.


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


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


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


Alice Springs (ASP) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53700
53675
53650
53625
53600
53575
53550
53525
nT
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
nT/yr
1992.0
1993.0
1994.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
F (nT)
dF (nT/yr)

Alice Springs 1999 Monthly & Annual Mean Values

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

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

ALICE SPRINGS	1999	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29929.6	2659.2	-44350.4	53570.6	30047.5	5° 04.6'	-55° 52.9'
	5xQ days	29935.7	2660.7	-44347.5	53571.7	30053.7	5° 04.7'	-55° 52.5'
	5xD days	29914.8	2654.4	-44355.2	53566.1	30032.4	5° 04.2'	-55° 53.9'
February	All days	29932.2	2658.6	-44344.9	53567.5	30050.1	5° 04.5'	-55° 52.6'
	5xQ days	29936.9	2659.5	-44344.4	53569.7	30054.8	5° 04.6'	-55° 52.3'
	5xD days	29907.1	2653.8	-44350.0	53557.5	30024.6	5° 04.2'	-55° 54.1'
March	All days	29926.2	2658.1	-44341.9	53561.7	30044.1	5° 04.5'	-55° 52.8'
	5xQ days	29939.1	2659.5	-44338.1	53565.7	30057.0	5° 04.6'	-55° 52.0'
	5xD days	29907.5	2656.5	-44347.9	53556.1	30025.2	5° 04.6'	-55° 54.0'
April	All days	29929.4	2661.0	-44337.9	53560.3	30047.5	5° 04.8'	-55° 52.5'
	5xQ days	29940.4	2662.6	-44336.8	53565.5	30058.6	5° 04.9'	-55° 51.9'
	5xD days	29910.0	2661.7	-44340.6	53551.7	30028.2	5° 05.1'	-55° 53.6'
May	All days	29939.1	2664.9	-44333.1	53561.9	30057.4	5° 05.2'	-55° 51.8'
	5xQ days	29946.6	2664.5	-44331.3	53564.5	30064.9	5° 05.1'	-55° 51.3'
	5xD days	29925.4	2664.3	-44336.5	53557.0	30043.8	5° 05.3'	-55° 52.6'
June	All days	29946.7	2664.8	-44324.9	53559.3	30065.0	5° 05.1'	-55° 51.1'
	5xQ days	29950.2	2664.5	-44324.0	53560.6	30068.5	5° 05.0'	-55° 50.9'
	5xD days	29939.9	2665.4	-44325.7	53556.2	30058.3	5° 05.2'	-55° 51.5'
July	All days	29940.5	2665.6	-44321.4	53553.0	30058.9	5° 05.3'	-55° 51.3'
	5xQ days	29950.9	2665.6	-44320.2	53557.8	30069.2	5° 05.2'	-55° 50.7'
	5xD days	29928.7	2667.6	-44321.6	53546.6	30047.3	5° 05.6'	-55° 51.9'
August	All days	29930.6	2662.6	-44321.4	53547.3	30048.8	5° 05.0'	-55° 51.8'
	5xQ days	29938.0	2663.3	-44320.6	53550.9	30056.3	5° 05.0'	-55° 51.4'
	5xD days	29907.3	2660.1	-44325.9	53537.9	30025.3	5° 05.0'	-55° 53.2'
September	All days	29924.1	2660.6	-44320.4	53542.7	30042.1	5° 04.9'	-55° 52.1'
	5xQ days	29932.9	2661.4	-44317.5	53545.4	30051.0	5° 04.9'	-55° 51.6'
	5xD days	29913.1	2661.1	-44322.4	53538.3	30031.3	5° 05.0'	-55° 52.8'
October	All days	29921.2	2661.2	-44320.2	53541.0	30039.3	5° 04.9'	-55° 52.3'
	5xQ days	29938.6	2663.6	-44316.2	53547.5	30056.8	5° 05.0'	-55° 51.2'
	5xD days	29889.0	2658.7	-44324.8	53526.7	30007.0	5° 05.0'	-55° 54.2'
November	All days	29936.2	2662.5	-44317.2	53547.0	30054.4	5° 05.0'	-55° 51.4'
	5xQ days	29948.5	2663.9	-44314.6	53551.8	30066.7	5° 05.0'	-55° 50.6'
	5xD days	29913.9	2659.1	-44319.4	53536.2	30031.8	5° 04.8'	-55° 52.7'
December	All days	29951.6	2664.0	-44309.1	53549.0	30069.8	5° 05.0'	-55° 50.3'
	5xQ days	29959.1	2664.5	-44305.4	53550.2	30077.3	5° 04.9'	-55° 49.7'
	5xD days	29931.0	2662.5	-44313.6	53541.1	30049.2	5° 05.0'	-55° 51.5'
Annual	All days	29933.9	2661.9	-44328.6	53555.1	30052.1	5° 04.9'	-55° 51.9'
Mean	5xQ days	29943.1	2662.8	-44326.4	53558.4	30061.2	5° 04.9'	-55° 51.3'
Values	5xD days	29915.6	2660.5	-44332.0	53547.6	30033.7	5° 04.9'	-55° 53.0'

(Calculated: 15:37 hrs., Fri. 01 Jun. 2001)

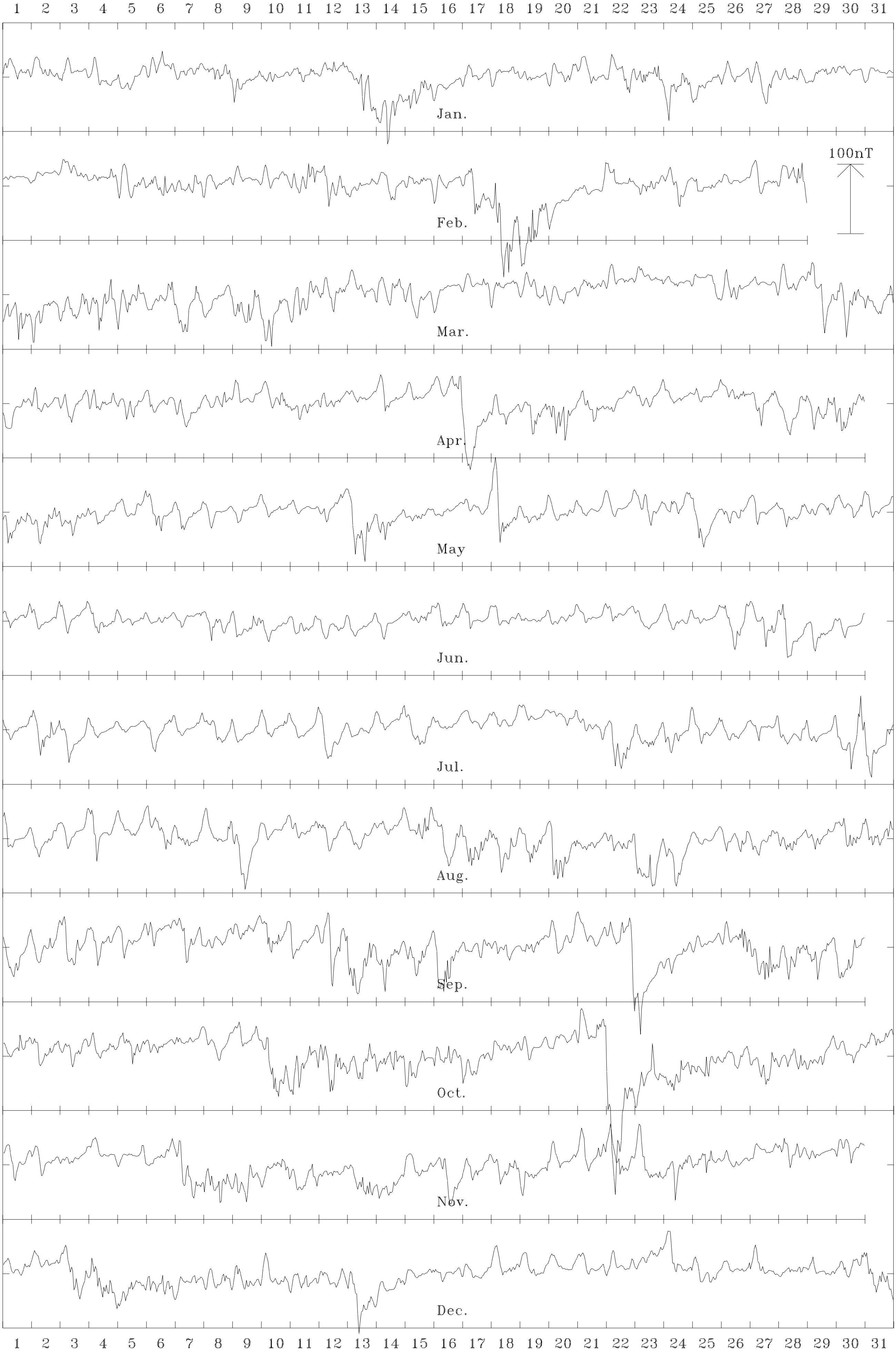
ASP Hourly Mean Values

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

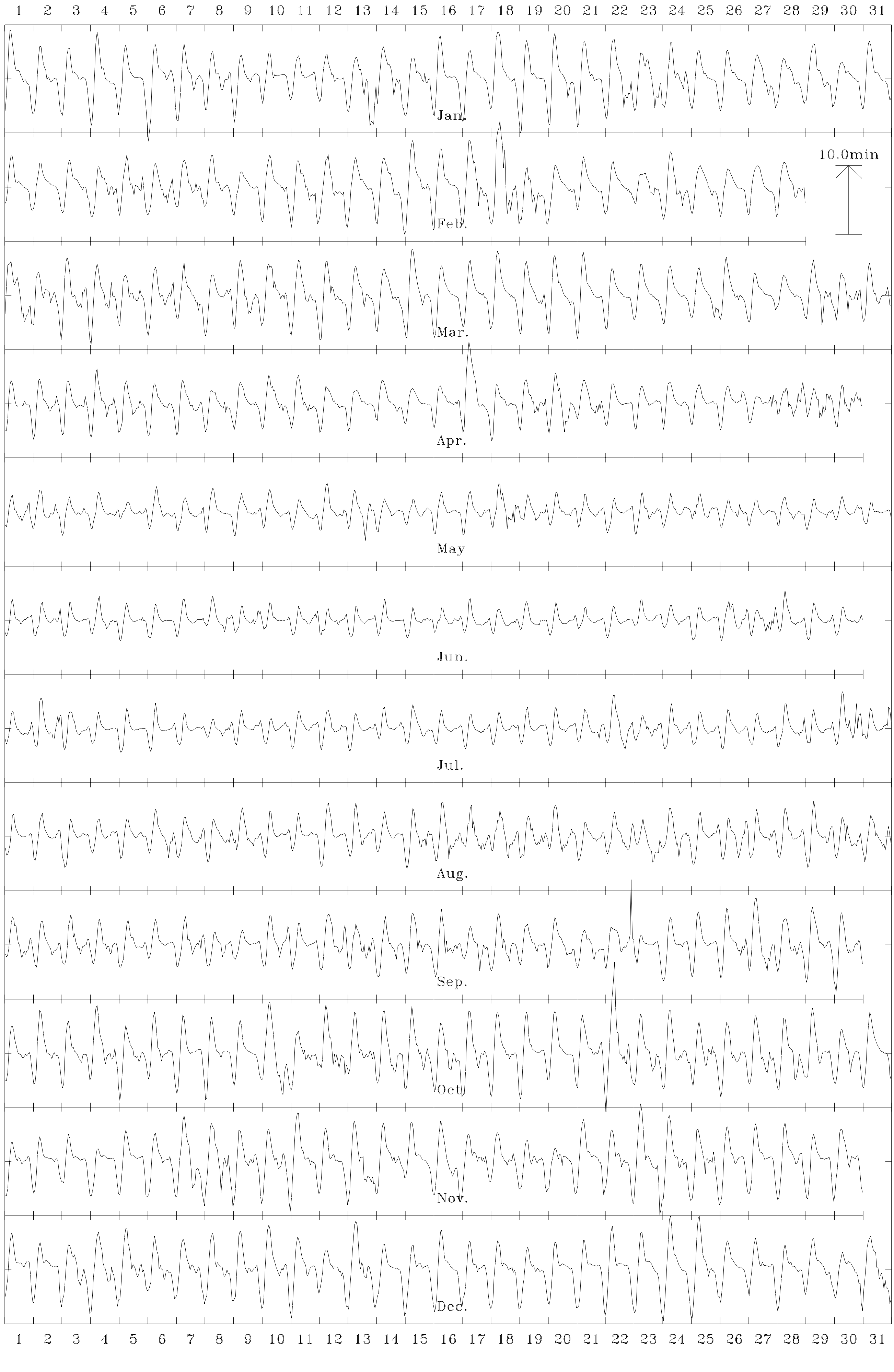
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

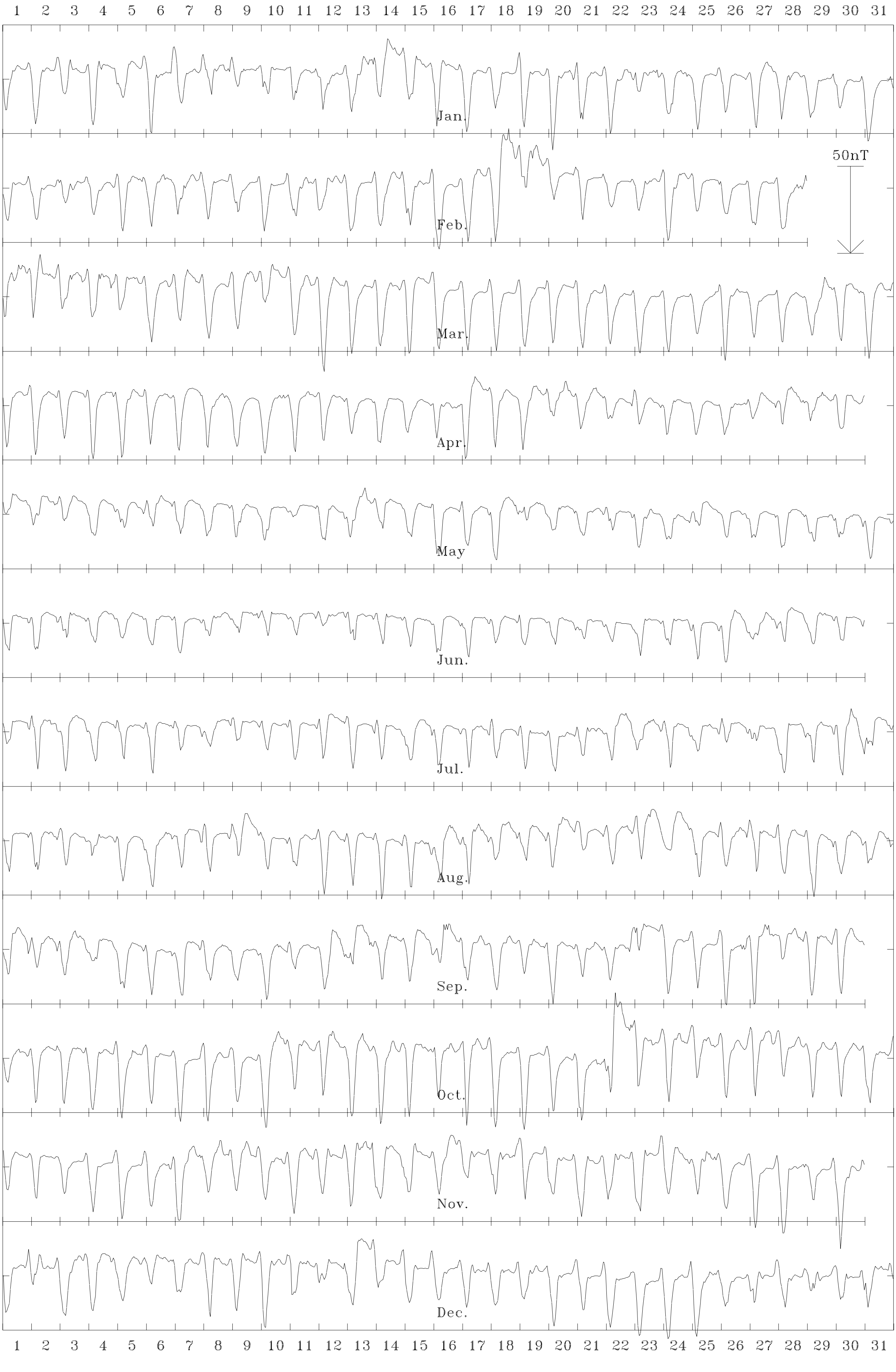
Alice Springs 1999 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 30052 nT



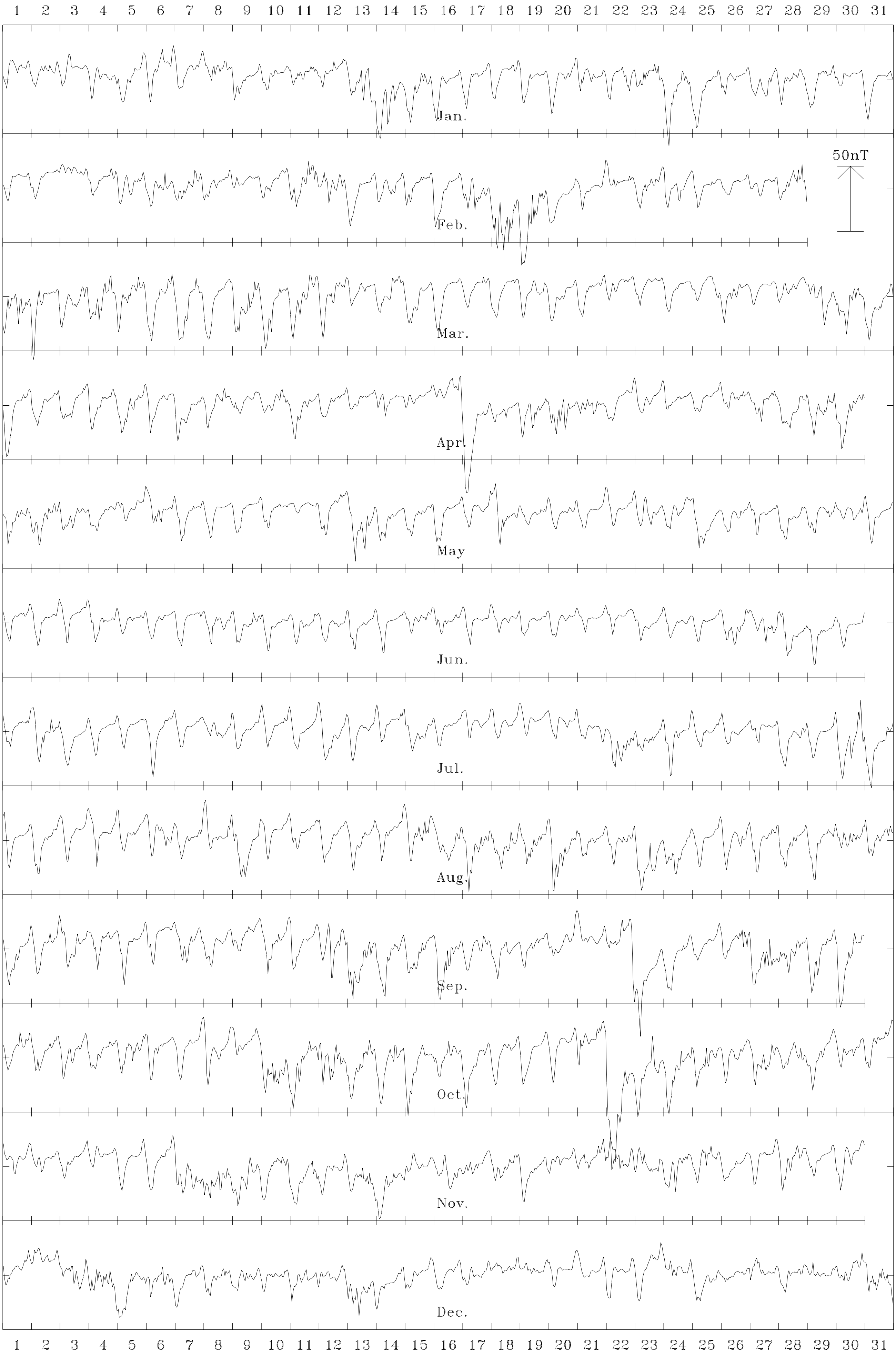
Alice Springs 1999 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.08 deg.



Alice Springs 1999 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -44329 nT



Alice Springs 1999 Total intensity (F). Scale: 4.0 nT/mm. Mean: 53555 nT



CANBERRA OBSERVATORY

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

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

The observatory comprises six buildings: a Recorder House; a Sensor House some 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 some 230m‡ north of the Recorder House. Other structures on the site include a sheltered external observation site, four azimuth pillars and a seismic vault. The latter houses seismometers operated by GA's earthquake seismology and nuclear monitoring group.

In September the construction of a building to house large coils for magnetometer calibrations was commenced.

‡ Distances recently re-determined by GPS survey.

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

- 3-character IAGA code: CNB
- Commenced operation 1978
- Geographic latitude: 35° 18' 52.6" S
- Geographic longitude: 149° 21' 45.4" E
- Geomagnetic† latitude: -42.8°
- Geomagnetic† longitude: 226.7°
- 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: P.A. Hopgood (GA)
Liejun Wang (GA)

† Based on the IGRF 1995 model.

Variometers

During 1999 (since November 1995) a Narod ring-core fluxgate (RCF) variometer operated as the principal variometer at the observatory. It measured variations in three orthogonal components of the magnetic field. It was aligned to measure the (magnetic) north-west; north-east and vertical field components.

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

Absolute Instruments

Throughout 1999 absolute observations were regularly performed at Canberra with a Declination & Inclination Magnetometer (DIM) and a Proton Precession Magnetometer (PPM).

Absolute Instruments (cont.)

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

The PPM used was MNS2 no. 3. This PPM had been in service at CNB for many years, principally within the Helmholtz coils of Proton Vector Magnetometer (PVM) serial A situated on pier AE in the Absolute House. Although the PVM was not routinely used in 1999, the sensor of the PPM remained in the coils on pier AE during absolute measurements of total intensity.

Pier differences

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

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

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

Instrument corrections

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

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

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

At the field intensities at Canberra, corrections of 0.0', 0.0' and -0.8nT in D, I and F respectively resulted in respective corrections to X, Y and Z of -0.3nT, -0.1nT and +0.7nT. These corrections have been applied to the results in this report.

Operations

Absolute observations were performed weekly (routinely on Tuesdays) by staff of the Geomagnetism Section on a roster. The rostered duties 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 GNA) to INTERMAGNET.

The RCF variometer was situated on pier (VE) in the 'Variometer House' that was maintained as nearly 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 were they were recorded on a PC.

A PPM variometer, the sensor of which was located in the (old AMO) Sensor House was controlled from the Recorder House where the data were recorded.

CNB 1999 Operations (cont.)

Shortly after 0000UT each day, digital data were retrieved semi-automatically via modems and telephone line from the observatory to GA in Canberra. Once the raw data were received at GA, processing was automatically scheduled, after which the processed data were provided to INTERMAGNET by e-mail.

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

Occasional intermittent contamination of RCF variometer channels were thought to be caused by a steel bell around the neck of a sheep on the observatory compound that roamed close to the 'RCF' house.

Significant Events 1999

1999 Tests were carried out intermittently all year in preparation for a UHF data-link between CNB observatory and GA Canberra.

Jan 20 1420 to 21/0212: RCF sensor temperature recording behaved erratically. Data were synthesised from reasonably well behaved electronics temperature data.

Apr 27 Lightning protection installed for Radio (UHF) equipment.

May 21 UPS was installed, and the isolation transformer and lightning protection device were removed.

May 24 02-03 hrs. UT: Heater fan was installed and the thermostat sensor shifted between in the RCF variometer room.

Aug 06 Altered the Absolute Pier Aw with a keeper for instruments.

Aug 10 The DIDD AMO function failed and was switched off. An incorrect test cable for the head temperature was installed.

Aug 11 A correct test cable was installed - head temperature is now another measure of the electronics temperature.

Aug 24 Earthworks began for the construction of the magnetic calibration facility at the observatory.

Aug 25 Fibre optic termination box installed in PPM hut causing F reading jump of +5nT.

Sept. Magnetic Calibration Facility under construction.

Sep 17 Slate top of principal absolute observation pier Aw was removed and re-affixed using resin. (Relocation estimated to result in change in azimuth to mark of less than 1 arc-second.)

Sep 24 New infra-red heater was tested then installed in RCF hut.

Oct 20 0530 (approximately): A fan to circulate the air throughout the RCF variometer room was installed.

Oct 26 0540: Heater was switched to winter setting (~15°C) and the locks removed from both internal doors of the RCF variometer hut, causing a baseline jump.

Oct 29 Vandals damaged Magnetic Calibration Facility building and other buildings on the observatory site.

Nov 02 0300 (approx.): Internal door lock in PPM-variometer house was removed, causing PPM reading to drop by about 3nT.

Nov 09 to 10th: Two periods of data were corrupted by the presence of equipment used to relocate the 240V supply to the seismic pit from the variometer hut to an electric distribution box N of the variometer hut.

CNB Significant Events 1999 (cont.)

Nov 16 The test head temperature sensor was replaced with the standard sensor in the Narod head again. It appears to be not reinstalled properly or completely unserviceable.

Nov 23 0605: Heater in RCF variometer hut switched to summer (~25°C) setting.

Dec 12 RCF signal was split between the acquisition PC and Magnetic Calibration Facility.

Distribution of data during 1999

K indices - weekly by e-mail

- IPS Radio & Space Services, Sydney.
- Regional Warning Centre, Meudon (via Paris)
- British Geological Survey, Edinburgh.
- International Service of Geomagnetic Indices, Paris.
- Royal Observatory of Belgium, Brussels (from 06 Dec. 1999)
- CLS, CNES (French Space Agency), Toulouse (from 06 Dec. 1999)

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

- IPGP (monthly by e-mail): Jan. – Feb. 1999

1-minute & Hourly Mean Values

- 1998: WDC-A, Boulder, USA (Mar. 26, 1999)

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh GIN by e-mail.
- Definitive 1998 data for CD-ROM sent to the INTERMAGNET GIN, Paris (26 Sep., 1999)

CNB Data losses in 1999

Mar 01 0141-0144 (4m) RCF channels:
0141-0143 (3m) F channel

May 18 0249-0253 (5m) RCF channels;
0249-0252 (4m) F-channel: Earth leakage protection tripped during unsuccessful attempt to install a new UPS.

May 21 0102 (1m) All channels: UPS installed.

Jun 22 0620 to 23/0356 (21h 37m) All channels: Leakage detector tripped.

Jul 02 0650 to 05/0201 (2d 19h 12m) All channels: Power outage.

Jul 29 1204-1302 (59m) F-channel.

Jul 30 1401-1735 (3h 35m); 1818-1822 (5m): F-channel

Aug 08 1754 to 10/0250 (1d 8h 57m): F-channel mostly missing. (Total of 1871 minutes lost.)

Aug 10 0548-0549 (2m) All channels

Aug 11 0343-0351 (9m) F-channel
0458-0502 (5m) RCF channels

Aug 16 0211-0249 (39m) F-channel

Aug 25 0137-0211 (35m); 0215 (1m): F-channel

Sep 07 2330-2339 (10m),
2348 to 08/0105 (1h 18m): F channel

CNB Data losses in 1999 (cont.)

Sep 08	0107 (1m); 0114 (1m); 0119-0124 (6m); 0127-1029 (3m): F-channel
Sep 13	0253-0301 (9m) F-channel: PPM tests.
Nov 11	0209-0211 (3m) F-channel
Nov 16	0510-0511 (2m) RCF channels
Dec 13	0924 to 14/0034 (15h 11m): RCF channels; 0924 to 14/0027 (15h 04m) F-channel: Interfacing Magnetic Calibration Facility.
Dec 14	0046-0111 (35m), 0122-0129 (8m), 0431-0441 (11m), 2344 (1m): RCF channels; 0033-0034 (2m), 0049-0106 (18m), 0125-0129 (5m), 0431-0438 (8m): F-channel
Dec 20	2357 to 21/0009 (13m) F-channel
Dec 21	0021 (1m), 0025 (1m), 0038-0039 (2m) F-channel
Dec 22	2133 (1m) F-channel.

Rapid Variation Phenomena 1999

Solar Flare Effects (sfe) - CNB 1999

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Apr. 04	0520	0524	0537	0	+10	-2	solar
Aug 02	2123	2126	2140	+6	0	+2	solar

Sudden Storm Commencements (ssc) - CNB 1999

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Jan 13	1054	ssc	C	+33	0	+8
Feb 17	0710	ssc*	C	+25 *	+5 *	+3
18	0246	ssc*	B	+55	+20 *	+14
Apr 16	1125	ssc*	C	+20 *	+3	+5
May 05	1543	ssc	C	+15	+3	+3
18	0056	ssc*	C	+19	-11 *	+10 *
Aug 04	0218	ssc	B	+18	-5	+4
15	1044	ssc	C	+18	0	+5
Sep 12	0359	ssc	B	+18	+12	+2
22	1222	ssc	A	+48	0	+11
Oct 21	0225	ssc*	A	+48 *	+6 *	+8
Dec 12	1552	ssc	C	+15	+5	+4

Principal Magnetic Storms: Canberra 1999

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. 18	02 46	ssc*	+2.9*	+55	+14	18(4,5)	6	29.4	185	75	19	18
Mar.		No		Principal		Magnetic			Storms			
Apr. 16	11 25	ssc*	+0.4	+20*	+5	17(2)	5	22.5	160	65	17	12
May		No		Principal		Magnetic			Storms			
Jun.		No		Principal		Magnetic			Storms			
Jul. 30	10 ..	...	..	..	..	30(5,7,8)	5	16.6	146	70	31	09
Aug.		No		Principal		Magnetic			Storms			
Sep. 22	12 22	ssc	0.0	+48	+11	22(7,8)	6	25.6	241	98	23	08
Oct. 21	02 25	ssc*	+0.9*	+48*	+8	22(1,3)	6	35.6	242	218	24	24
Nov.		No		Principal		Magnetic			Storms			
Dec.		No		Principal		Magnetic			Storms			

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 1999.

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 1999

Date	January	February	March	April	May	June	Date
01	1211 1121 10	Q 0000 0000 00	D 3433 5434 29	2311 0210 10	D 2333 3332 22	0110 1111 06	01
02	1213 3312 16	Q 0100 0010 02	4332 3322 22	1321 2130 13	D 2233 3131 18	2111 0003 08	02
03	Q 1210 2111 09	0111 2222 11	1213 2333 18	2223 2032 16	2112 2221 13	2221 1001 09	03
04	0122 2213 13	1122 3331 16	D 1344 3553 28	2222 3132 17	1211 1111 09	1121 3111 11	04
05	2221 1112 12	2111 4331 16	2333 2311 18	2233 3210 16	1012 1311 10	1001 0010 03	05
06	2122 4323 19	1222 3422 18	0103 2233 14	2221 3211 14	1233 2111 14	0101 1100 04	06
07	2222 3332 19	1233 2312 17	D 2244 0332 20	2223 3222 18	2222 1111 12	0000 1111 04	07
08	D 3333 3332 23	1121 1110 08	2211 1223 14	0012 2412 12	1112 1111 09	D 2333 2310 17	08
09	4232 2133 20	Q 1200 1110 06	2433 5331 24	2221 1211 12	1112 1111 09	D 4410 2432 20	09
10	2133 1011 12	0120 0222 09	D 3345 2222 23	2233 2333 21	1211 1200 08	2100 1100 05	10
11	1232 1132 15	D 3143 4433 25	2332 3321 19	1333 3310 17	Q 1100 0000 02	0011 1131 08	11
12	1123 3012 13	D 3354 3333 27	2323 2232 19	3212 2101 12	1111 2321 12	2100 1210 07	12
13	D 1114 4545 25	1222 1111 11	1011 3112 10	Q 1101 1101 06	D 2543 4532 28	2110 1011 07	13
14	D 1244 5433 26	1021 2322 13	1112 4223 16	2132 1211 13	2132 2100 11	Q 0010 0000 01	14
15	D 3323 3323 22	2332 3321 19	2432 2111 16	Q 1111 0011 06	1212 2121 12	0000 2211 06	15
16	1322 1111 12	2222 1011 11	Q 0101 0001 03	1113 3224 17	Q 1211 1100 07	0012 1110 06	16
17	2131 1111 11	D 1234 4221 19	1011 0211 07	D 3543 2221 22	Q 0101 0100 03	1121 1100 07	17
18	0111 2232 12	D 4556 6444 38	1122 1220 11	2201 2111 10	D 2333 4342 24	1211 1111 09	18
19	Q 0211 1011 07	D 2455 5322 28	1011 2230 10	1123 3333 19	2211 3212 14	1100 0100 03	19
20	0222 2431 16	Q 0100 1111 05	Q 0113 2120 10	D 3344 5421 26	1111 1111 08	Q 0000 0000 00	20
21	1213 1112 12	1200 0113 08	1012 2110 08	1223 4421 19	1200 1100 05	Q 0000 0000 00	21
22	1222 4434 22	1232 0022 12	Q 0000 1111 04	Q 2100 0110 05	Q 0010 1000 02	Q 00-- ---- --	22
23	D 2433 1443 24	2232 3311 17	1102 2122 11	Q 0111 2100 06	0013 3110 09	-101 0001 --	23
24	2433 2332 22	0124 3322 17	Q 0212 1000 06	1211 1110 08	1412 1122 14	0100 1010 03	24
25	2222 1222 15	1311 0210 09	0012 1232 11	Q 0010 1012 05	D 4343 2110 18	1000 0000 01	25
26	Q 1123 2012 12	Q 0110 1100 04	1223 3201 14	1012 2220 10	2110 2311 11	D 2323 4232 21	26
27	0223 3322 17	1032 1000 07	Q 0110 1001 04	1134 2233 19	2331 1002 12	D 2322 4334 23	27
28	1232 3222 17	0131 3445 21	1032 1111 10	D 1133 3433 21	1222 2122 14	D 2543 1111 18	28
29	1232 3312 17		D 2242 5332 23	D 2334 3324 24	1100 1210 06	0112 2221 11	29
30	Q 1122 0101 08		3245 4333 27	D 3444 4322 26	0001 2220 07	Q 1110 0000 03	30
31	Q 1111 1110 07		2122 3124 17		Q 0001 0000 01		31
Mean K-sum	**15.6**	**14.1**	**15.0**	**14.7**	**11.1**	**7.9**	

Date	July	August	September	October	November	December	Date
01	0111 0122 08	3421 0000 10	1344 4232 23	2212 3221 15	1123 2111 12	2111 1211 10	01
02	D 33-- ---- --	Q 0221 1221 11	1211 2310 11	3322 2321 18	1222 1121 12	1112 2122 12	02
03	---- ---- --	Q 2102 0011 07	1333 4211 18	1222 2322 16	1011 1012 07	2235 3332 23	03
04	Q ---- ---- --	3342 1201 16	1333 3222 19	1324 3333 22	Q 2111 1111 09	D 4354 3433 29	04
05	Q -000 0000 --	2112 2112 12	Q 2311 0011 09	2322 3323 20	0100 0022 05	D 3234 3322 22	05
06	1021 0221 09	2223 2323 19	Q 1111 1121 09	Q 1123 2111 12	1121 1221 11	D 2443 3332 24	06
07	1100 0011 04	3212 2132 16	1133 3132 17	Q 2101 1011 07	D 3353 4423 27	3233 2322 20	07
08	2212 3222 16	1012 2133 13	Q 2211 3312 15	1213 3011 12	D 2344 5343 28	2332 2333 21	08
09	1110 0110 05	3234 3300 18	1122 3121 13	0121 1222 11	D 3334 4443 28	1324 3232 20	09
10	0001 1021 05	Q 1010 1011 05	2343 4232 23	D 2444 4432 27	2223 3332 20	1222 2232 16	10
11	0100 1102 05	1211 1111 09	1211 1111 09	3343 3323 24	D 2333 3333 23	0112 3200 09	11
12	2334 1221 18	1233 1111 13	D 1324 2242 20	D 3335 5434 30	2122 2222 15	1211 1333 15	12
13	0111 1110 06	1224 4011 15	D 4444 4443 31	2243 4333 24	D 2223 5454 27	D 345- ---- --	13
14	0001 1021 05	Q 1222 1101 10	3343 2422 23	D 2333 4434 26	3232 3222 19	Q -220 0220 --	14
15	2223 2221 16	1213 4332 19	3345 3221 23	4333 3332 24	Q 2232 2121 15	0110 1123 09	15
16	Q 0000 1000 01	2234 4332 23	D 3445 4222 26	2322 4323 21	1234 3422 21	1331 1123 15	16
17	Q 1111 0101 06	D 2344 4331 24	2112 4532 20	2243 4321 21	2222 2332 18	1322 2111 13	17
18	0000 0100 01	D 2344 4322 24	2233 4411 20	1211 3211 12	2213 3333 20	1022 2222 13	18
19	Q 1100 1001 04	3334 3232 23	2223 4212 18	Q 2132 0011 10	1433 2223 20	1221 2110 10	19
20	1000 2211 07	D 3544 5323 29	1132 2322 16	Q 1122 2101 10	2223 0122 14	0111 0111 06	20
21	D 1022 1331 13	Q 1112 1111 09	2221 4223 18	4423 2334 25	0232 1323 16	Q 1111 0110 06	21
22	D 2344 3332 24	0111 3233 14	D 1223 4366 27	D 6565 5453 39	3223 3211 17	Q 0000 0100 01	22
23	2112 2332 16	D 3334 5333 27	3531 1112 17	D 3431 5533 27	2341 2133 19	Q 0000 2111 05	23
24	3201 1122 12	D 2344 5432 27	Q 1311 0202 10	3344 4323 26	2234 3322 21	2353 1123 20	24
25	2121 2112 12	2211 1123 13	Q 1101 2011 07	2234 4311 20	2235 4333 25	2331 3123 18	25
26	1112 1102 09	1301 4422 17	0011 2544 17	1222 2221 14	Q 1111 2010 07	Q 1110 1002 06	26
27	1121 1101 08	3231 1321 16	D 3344 5543 31	1223 3422 19	Q 0001 1001 03	3322 1110 13	27
28	0111 1233 12	2333 2222 19	2344 3323 24	2231 4432 21	2212 2213 15	1222 1122 13	28
29	3321 0100 10	2223 1332 18	3344 1332 23	2112 2122 13	Q 1111 1011 07	2331 0112 13	29
30	D 1234 5455 29	1244 3333 23	2334 4422 24	Q 1112 3101 10	2324 3112 18	0231 2354 20	30
31	D 4341 1234 22	2334 3344 26		1222 2223 16		D 4443 4353 30	31
Mean K-sum	**10.5**	**16.9**	**18.7**	**19.1**	**16.6**	**14.9**	

Occurrence distribution of K-indices

K-Index:	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**-**
January	13	81	80	55	16	3	0	0	0	0	0
February	44	64	54	37	16	7	2	0	0	0	0
March	35	67	69	54	16	7	0	0	0	0	0
April	28	73	70	51	16	2	0	0	0	0	0
May	49	103	58	29	7	2	0	0	0	0	0
June	94	86	30	15	7	1	0	0	0	0	7
July	63	82	47	22	8	3	0	0	0	0	23
August	19	66	66	65	28	4	0	0	0	0	0
September	9	63	65	55	39	7	2	0	0	0	0
October	8	51	79	69	31	8	2	0	0	0	0
November	17	58	82	60	18	5	0	0	0	0	0
December	31	69	68	55	13	6	0	0	0	0	6
ANNUAL TOTAL	**410**	**863**	**768**	**567**	**215**	**55**	**6**	**0**	**0**	**0**	**36**

Canberra 1999 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	1999	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23141.8	5154.9	-53421.7	58446.5	23709.0	12° 33.5'	-66° 04.1'
	5xQ days	23144.4	5157.2	-53419.5	58445.7	23712.1	12° 33.7'	-66° 03.9'
	5xD days	23129.9	5149.3	-53424.0	58443.4	23696.2	12° 33.1'	-66° 04.8'
February	All days	23139.7	5158.5	-53417.4	58442.0	23707.7	12° 34.0'	-66° 04.0'
	5xQ days	23144.8	5159.3	-53416.8	58443.6	23712.9	12° 34.0'	-66° 03.7'
	5xD days	23117.5	5154.1	-53423.5	58438.4	23685.1	12° 34.1'	-66° 05.4'
March	All days	23132.5	5157.0	-53414.9	58436.8	23700.3	12° 34.1'	-66° 04.4'
	5xQ days	23141.7	5159.8	-53409.8	58436.0	23709.9	12° 34.2'	-66° 03.7'
	5xD days	23118.4	5154.4	-53420.4	58436.0	23686.0	12° 34.1'	-66° 05.3'
April	All days	23134.1	5160.0	-53410.5	58433.6	23702.6	12° 34.4'	-66° 04.2'
	5xQ days	23144.8	5161.1	-53407.6	58435.3	23713.2	12° 34.2'	-66° 03.5'
	5xD days	23116.5	5158.0	-53414.2	58430.0	23685.0	12° 34.7'	-66° 05.2'
May	All days	23143.7	5160.2	-53405.3	58432.8	23712.0	12° 34.2'	-66° 03.5'
	5xQ days	23150.3	5160.6	-53402.7	58433.0	23718.5	12° 34.0'	-66° 03.1'
	5xD days	23131.4	5158.4	-53409.3	58431.3	23699.6	12° 34.3'	-66° 04.3'
June	All days	23149.1	5161.6	-53399.3	58429.5	23717.6	12° 34.2'	-66° 03.1'
	5xQ days	23151.2	5161.8	-53398.3	58429.5	23719.7	12° 34.1'	-66° 02.9'
	5xD days	23143.8	5160.2	-53401.2	58429.0	23712.1	12° 34.2'	-66° 03.4'
July	All days	23144.6	5161.7	-53396.7	58425.4	23713.2	12° 34.3'	-66° 03.3'
	5xQ days	23154.7	5164.0	-53393.0	58426.1	23723.5	12° 34.3'	-66° 02.6'
	5xD days	23132.8	5163.3	-53399.3	58423.2	23702.0	12° 34.9'	-66° 03.9'
August	All days	23135.8	5159.8	-53397.0	58422.0	23704.2	12° 34.3'	-66° 03.7'
	5xQ days	23142.3	5160.7	-53394.6	58422.4	23710.7	12° 34.3'	-66° 03.3'
	5xD days	23116.3	5154.7	-53403.5	58419.8	23684.1	12° 34.2'	-66° 05.0'
September	All days	23130.6	5158.7	-53397.6	58420.4	23698.9	12° 34.4'	-66° 04.0'
	5xQ days	23138.9	5161.4	-53395.5	58422.0	23707.6	12° 34.5'	-66° 03.5'
	5xD days	23119.6	5156.9	-53399.8	58417.9	23687.7	12° 34.5'	-66° 04.7'
October	All days	23130.4	5156.4	-53398.7	58421.1	23698.2	12° 34.0'	-66° 04.1'
	5xQ days	23144.6	5159.8	-53394.9	58423.5	23712.8	12° 34.1'	-66° 03.2'
	5xD days	23104.3	5151.1	-53407.4	58418.3	23671.6	12° 34.1'	-66° 05.7'
November	All days	23143.5	5155.3	-53392.9	58420.9	23710.8	12° 33.5'	-66° 03.3'
	5xQ days	23153.9	5157.0	-53390.7	58423.2	23721.3	12° 33.4'	-66° 02.7'
	5xD days	23122.1	5150.3	-53395.9	58414.7	23688.8	12° 33.4'	-66° 04.5'
December	All days	23158.2	5160.5	-53384.2	58419.2	23726.2	12° 33.7'	-66° 02.3'
	5xQ days	23162.6	5163.4	-53381.4	58418.7	23731.2	12° 34.0'	-66° 01.9'
	5xD days	23143.7	5158.4	-53388.6	58417.3	23711.6	12° 33.9'	-66° 03.1'
Annual	All days	23140.3	5158.7	-53403.0	58429.2	23708.4	12° 34.1'	-66° 03.7'
Mean	5xQ days	23147.9	5160.5	-53400.4	58429.9	23716.1	12° 34.1'	-66° 03.2'
Values	5xD days	23124.7	5155.8	-53407.3	58426.6	23692.5	12° 34.1'	-66° 04.6'

(Calculated:17:05 hrs., Thu. 29 Mar. 2001)

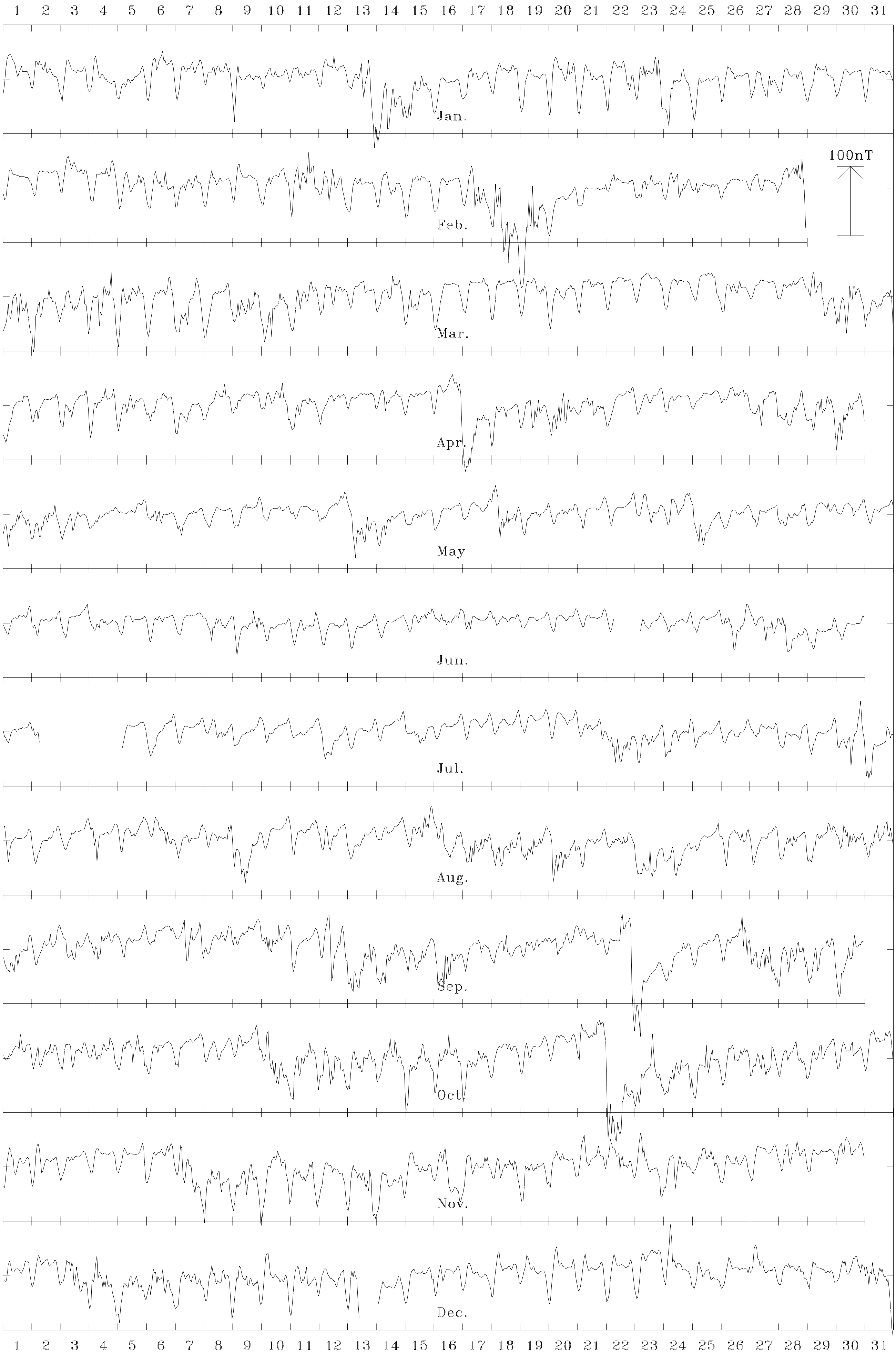
Hourly Mean Values

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

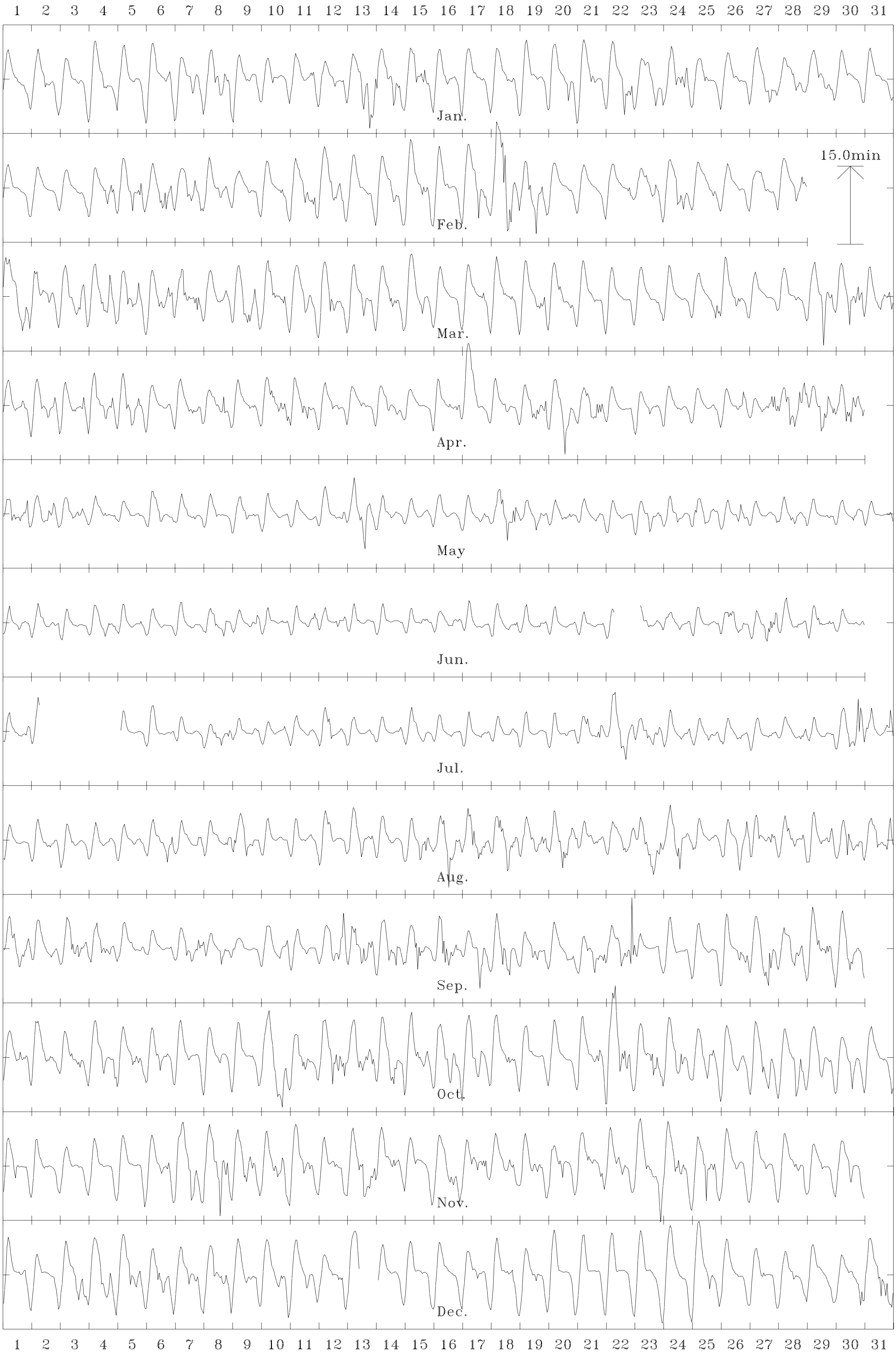
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

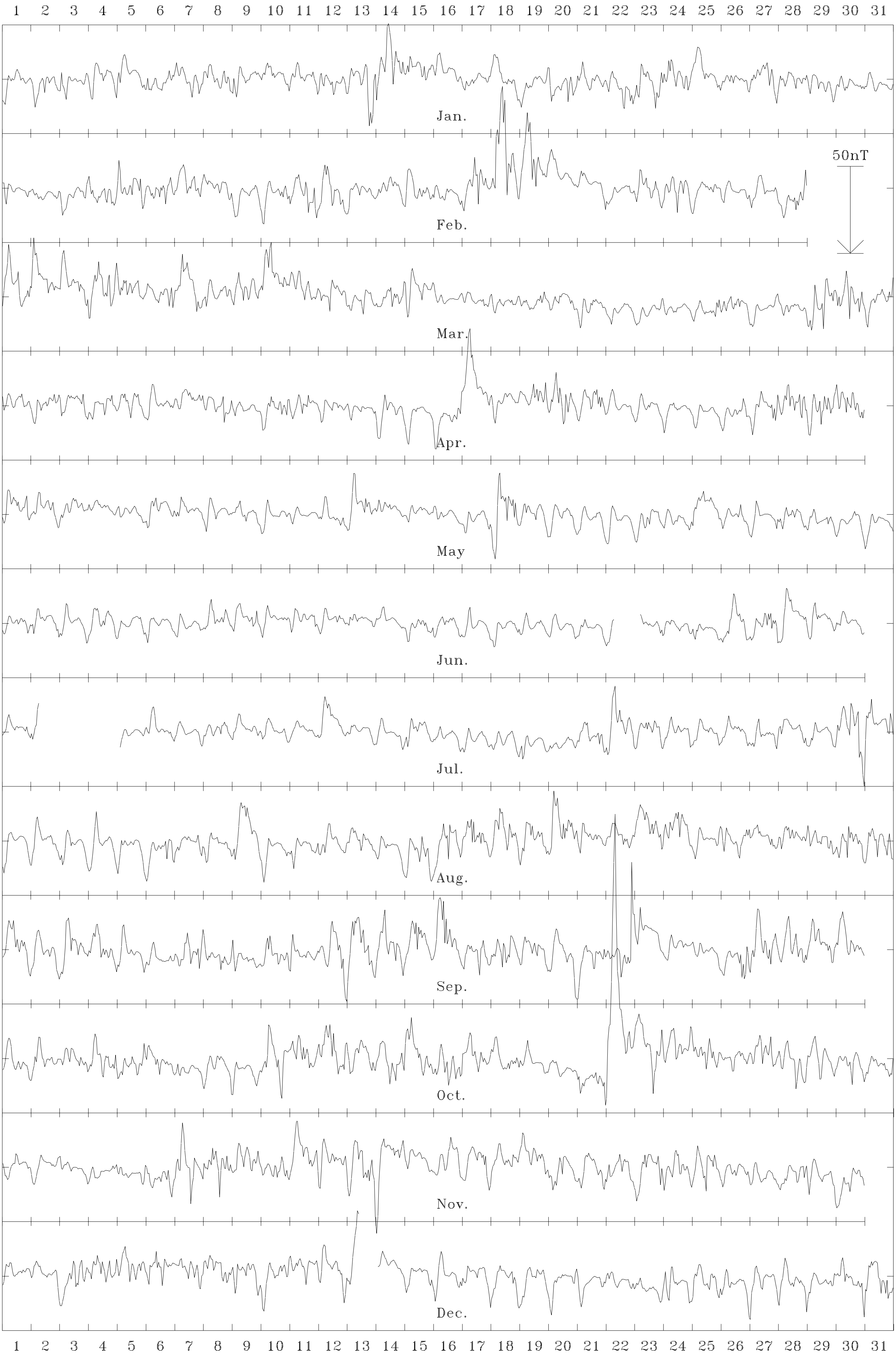
Canberra 1999 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23708 nT



Canberra 1999 Declination (east) (D). Scale: 1.00 min/mm. Mean: 12.57 deg.



Canberra 1999 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −53403 nT



Canberra 1999 Total intensity (F). Scale: 3.0 nT/mm. Mean: 58429 nT

Canberra Annual Mean Values

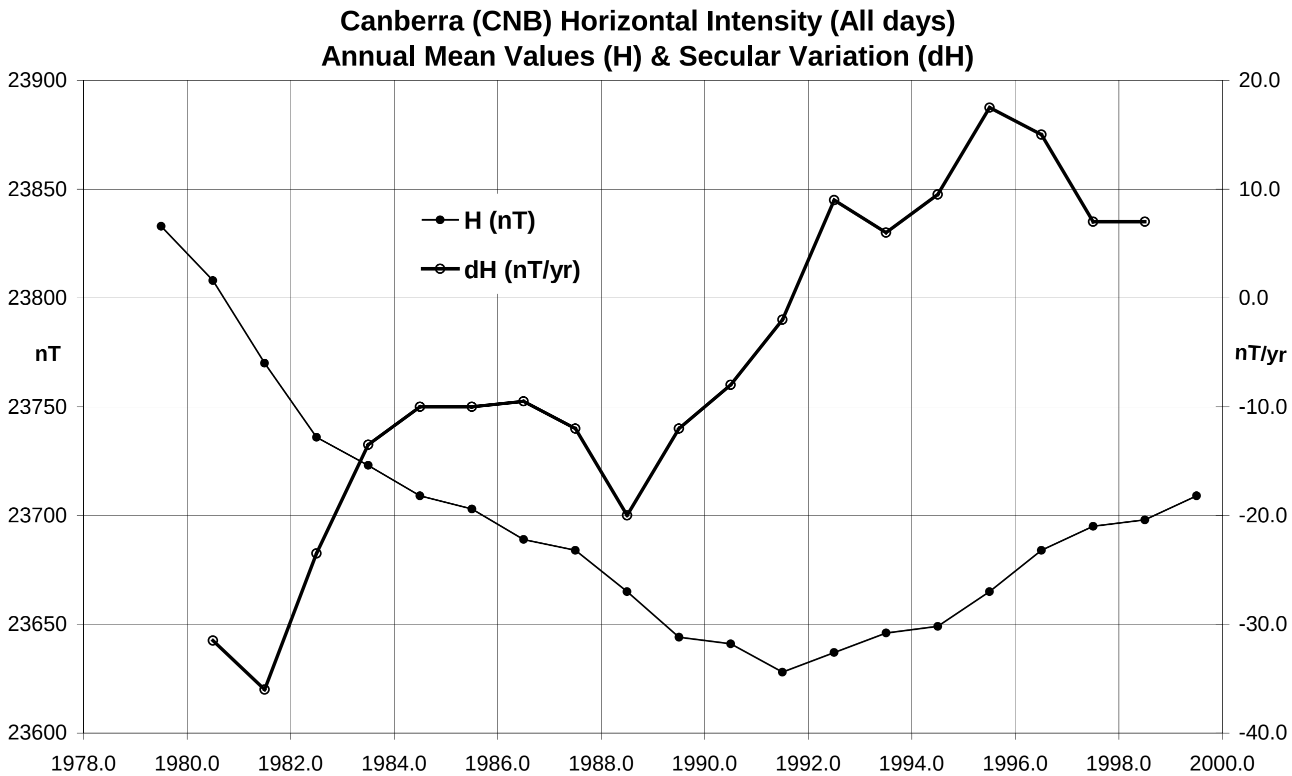
The table below gives annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z & F are on pages 26-27.

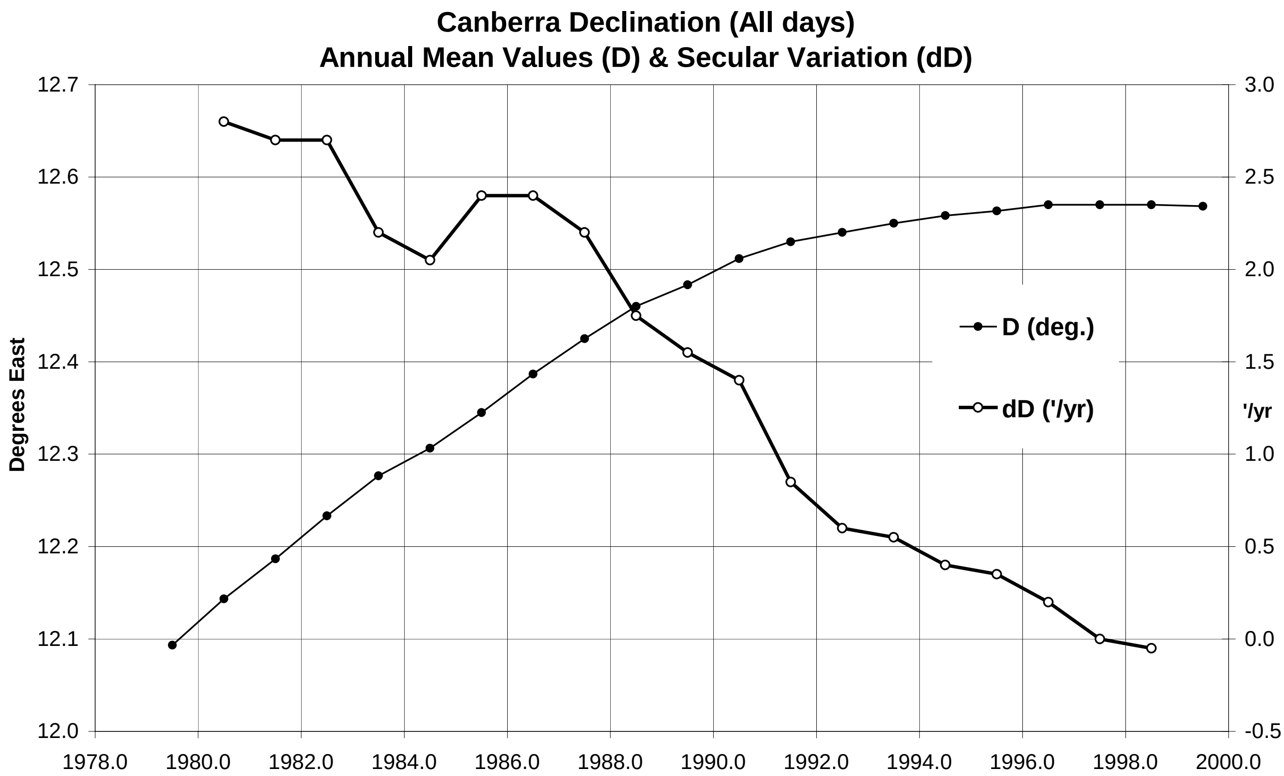
Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1979.5	A	12	5.6	-66	5.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	8.6	-66	6.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	9.1	23770	23234	5018	-53771	58791	DFI
1982.5	A	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	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
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
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

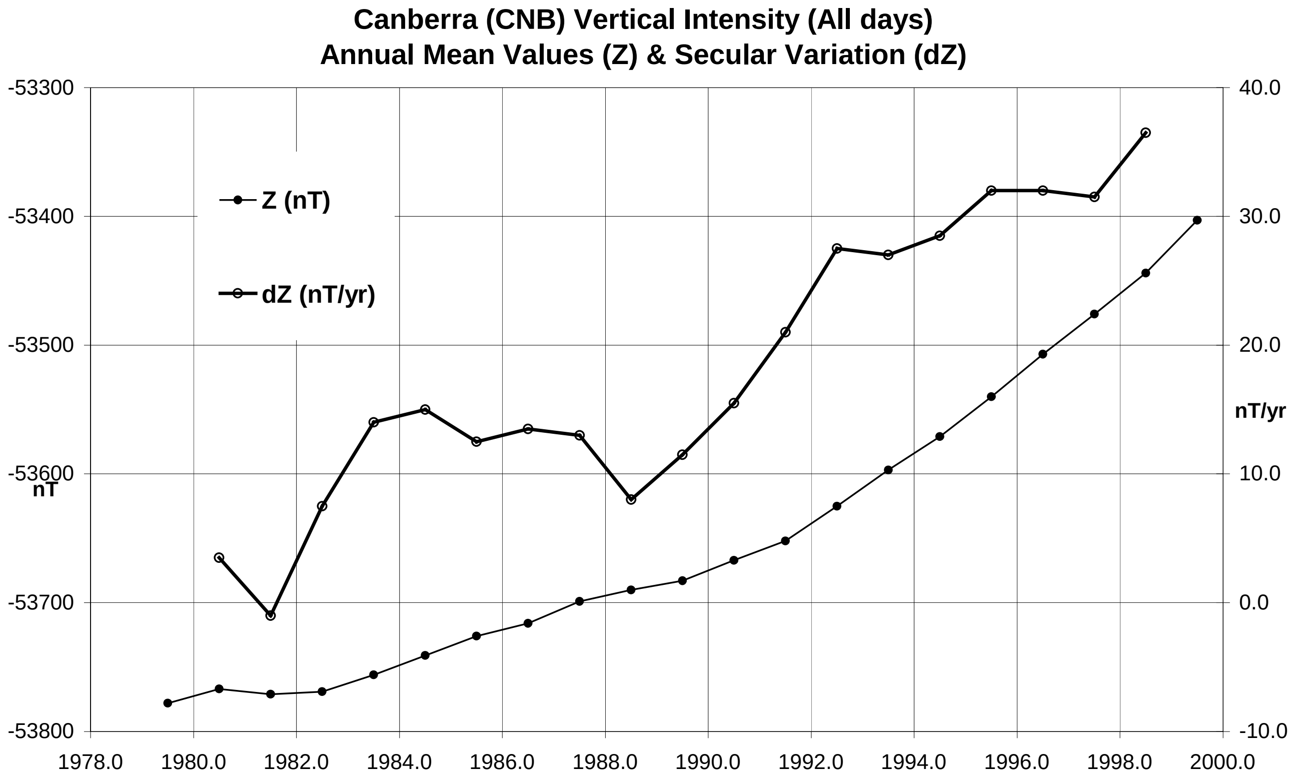
Canberra Annual Mean Values (cont.)

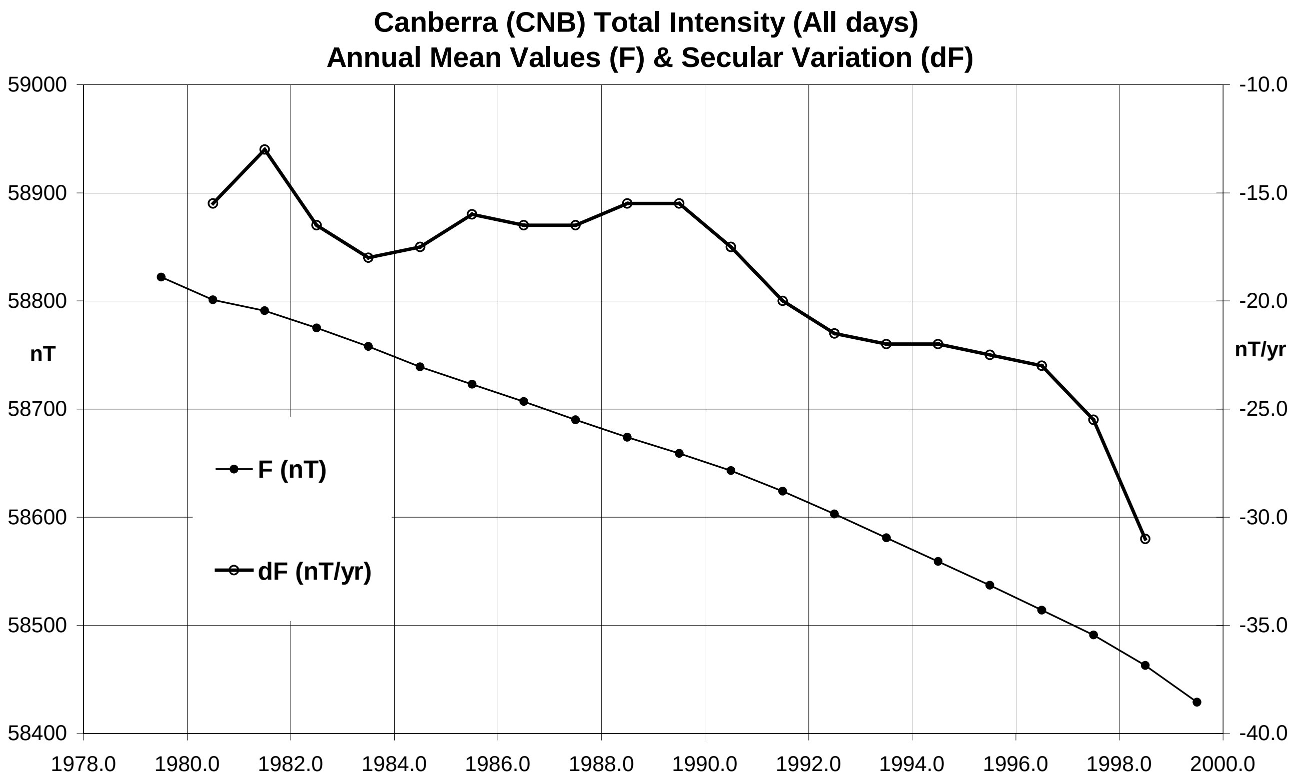
1996.5	D	12	34.2	-66	7.9	23676	23108	5152	-53508	58512	ABC
1997.5	D	12	34.1	-66	6.9	23683	23115	5154	-53479	58488	ABC
1998.5	D	12	34.2	-66	6.4	23678	23110	5153	-53450	58459	ABC
1999.5	D	12	34.1	-66	4.6	23692	23124	5156	-53407	58427	ABC

* Elements ABC indicates non-aligned variometer orientation






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


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
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
1978.0
1980.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0

CHARTERS TOWERS OBSERVATORY

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

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

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

Although not controlled, the temperature within the tunnel where the variometers were located, varied very little over the year: from about 27°C in winter to about 29°C in summer. There was no discernible diurnal temperature variation in the tunnel. The control electronics associated with the variometers were housed in an air-conditioned (for cooling) room in an adjacent arm of the tunnel.

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

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

- 3-character IAGA code: CTA
- Commenced operation: June 1983
- Geographic latitude: 20° 05' 25" S
- Geographic longitude: 146° 15' 51" E
- Geomagnetic† latitude: -28.2°
- Geomagnetic† longitude: 220.7°
- Elevation above mean sea level (top of pier): 370 metres
- Lower limit for K index of 9: 300 nT.
- Azimuth of principal reference PO spire from pier C: 34° 40' 45"
- Distance to PO Spire: 1.75km.
- Observer in Charge: J.M. Millican (Uni. of Qld)

† Based on the IGRF 1995 model.

Variometers

Since its commissioning in mid-1983 the principal variometers employed at the Charters Towers observatory were EDA model FM-105B 3-component fluxgate magnetometers, the sensor heads of which were located on concrete blocks in the mine tunnel. The unit that operated during 1999 was installed on 26 August 1998. Its sensors were aligned with two of them horizontal, aligned at an approximately equal angle on either side of the magnetic meridian (magnetically NW and NE), and the third sensor vertical. Temperature of both the EDA sensor and electronics were monitored with LM35C sensors.

There was also a cycling proton precession magnetometer monitoring variations in the magnetic total intensity, F. Elsec 820 no. 128 PPM was employed during 1999. 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 X, Y or Z variometer channels become unserviceable.

Data Recording

During 1999, mean data values over 1-second and 1-minute intervals were recorded in the variables A (NW), B (NE), C (Z), and EDA sensor & electronics temperatures. Analogue outputs from the EDA and LM35C temperature sensors were input to an ADAM 4017 A to D module mounted with the EDA electronics case. The digital output from the ADAM was recorded on an IBM compatible PC.

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

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

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

Absolute Instruments

Throughout 1999 the variometers at CTA were calibrated by the performance of weekly absolute observations on Pier C in the absolute shelter.

A Declination & Inclination Magnetometer (DIM) comprising an Elsec Type 810 (no. 215) fluxgate unit mounted on a Zeiss 020B theodolite (no. 313888) was used with with a Geometrics 816 PPM (no. 767) to perform sets of absolute observations.

Instrument Corrections

No absolute magnetometer intercomparisons were performed at Charters Towers magnetic observatory in 1999. In consideration of the small magnitude of the corrections relative to their uncertainties determined in 1998, no corrections have been applied to the CTA mean values in this report.

Operations

The officer in charge at CTA observatory performed most routine operations during 1999. Tasks included:

- weekly performance of a set of absolute observations
- weekly system check
- 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.

Significant Events 1999

Feb 04 0740-0820: Activity near sensors.

Feb 14 2330: UPS taken out of service.

Mar 18 New *PowerWare* Prestige UPS installed and found to interfere with PPM.

Mar 19 0211: Line conditioner installed to mitigate UPS interfering with PPM.

Oct 13 2311: UPS circuitry by-passed.

Oct 15 2338: New UPS installed.

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 35-36.

No instrument corrections have been applied to the baselines used in the calculation of the CTA annual mean values.

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

Distribution of CTA data during 1999

1-minute & Hourly Mean Values

- 1996: WDC-A, Boulder, USA (12 May 1999)
- 1997: WDC-A, Boulder, USA (13 May 1999)

Preliminary Monthly Means for Project Ørsted

IPGP monthly (by e-mail): None sent in 1999.

Charters Towers 1999 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	1999	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31524.4	4295.1	-37940.9	49515.1	31815.6	7° 45.5'	-50° 01.1'
	5xQ days	31529.6	4295.9	-37938.3	49516.5	31820.9	7° 45.5'	-50° 00.7'
	5xD days	31509.0	4290.1	-37945.1	49508.1	31799.7	7° 45.2'	-50° 02.1'
February	All days	31523.6	4295.8	-37934.0	49509.4	31815.0	7° 45.6'	-50° 00.8'
	5xQ days	31529.3	4297.1	-37934.6	49513.6	31820.8	7° 45.7'	-50° 00.5'
	5xD days	31497.7	4291.1	-37935.7	49493.9	31788.7	7° 45.5'	-50° 02.3'
March	All days	31518.0	4296.5	-37928.4	49501.6	31809.5	7° 45.8'	-50° 00.9'
	5xQ days	31532.2	4298.0	-37923.9	49507.4	31823.8	7° 45.7'	-49° 59.9'
	5xD days	31497.3	4293.4	-37934.3	49492.6	31788.5	7° 45.7'	-50° 02.2'
April	All days	31523.3	4298.9	-37923.1	49501.1	31815.1	7° 45.9'	-50° 00.3'
	5xQ days	31533.7	4300.8	-37921.2	49506.5	31825.7	7° 46.0'	-49° 59.7'
	5xD days	31501.2	4298.2	-37924.9	49488.4	31793.1	7° 46.2'	-50° 01.6'
May	All days	31529.7	4298.3	-37916.9	49500.3	31821.3	7° 45.8'	-49° 59.7'
	5xQ days	31536.9	4298.2	-37914.7	49503.2	31828.4	7° 45.7'	-49° 59.2'
	5xD days	31515.3	4297.2	-37919.8	49493.4	31806.9	7° 45.9'	-50° 00.6'
June	All days	31537.3	4299.3	-37911.0	49500.8	31829.0	7° 45.8'	-49° 59.0'
	5xQ days	31540.6	4298.5	-37910.2	49502.2	31832.2	7° 45.6'	-49° 58.8'
	5xD days	31530.0	4298.0	-37911.6	49496.5	31821.6	7° 45.7'	-49° 59.5'
July	All days	31531.6	4296.5	-37906.8	49493.7	31822.9	7° 45.6'	-49° 59.2'
	5xQ days	31542.1	4295.8	-37905.6	49499.5	31833.3	7° 45.3'	-49° 58.6'
	5xD days	31520.1	4299.8	-37907.2	49487.0	31812.0	7° 46.1'	-49° 59.8'
August	All days	31522.3	4294.5	-37905.0	49486.2	31813.4	7° 45.5'	-49° 59.6'
	5xQ days	31529.6	4296.0	-37904.6	49490.7	31820.9	7° 45.5'	-49° 59.2'
	5xD days	31497.6	4289.7	-37909.8	49473.7	31788.3	7° 45.3'	-50° 01.2'
September	All days	31513.7	4293.3	-37904.1	49480.0	31804.8	7° 45.5'	-50° 00.0'
	5xQ days	31523.4	4295.0	-37902.0	49484.7	31814.7	7° 45.5'	-49° 59.4'
	5xD days	31502.3	4293.2	-37906.0	49474.1	31793.5	7° 45.6'	-50° 00.7'
October	All days	31510.5	4289.8	-37901.6	49475.7	31801.1	7° 45.2'	-50° 00.1'
	5xQ days	31528.4	4292.6	-37897.8	49484.4	31819.3	7° 45.2'	-49° 59.0'
	5xD days	31477.8	4286.0	-37905.2	49457.4	31768.3	7° 45.2'	-50° 02.0'
November	All days	31523.3	4289.2	-37898.3	49481.3	31813.8	7° 44.9'	-49° 59.3'
	5xQ days	31535.3	4290.1	-37895.8	49487.1	31825.8	7° 44.8'	-49° 58.5'
	5xD days	31501.5	4286.8	-37900.3	49468.7	31791.8	7° 45.0'	-50° 00.5'
December	All days	31539.6	4290.6	-37890.0	49485.4	31830.1	7° 44.8'	-49° 58.1'
	5xQ days	31547.9	4291.2	-37885.9	49487.7	31838.4	7° 44.8'	-49° 57.4'
	5xD days	31518.7	4289.0	-37894.3	49475.3	31809.2	7° 44.9'	-49° 59.4'
Annual	All days	31524.8	4294.8	-37913.3	49494.2	31816.0	7° 45.5'	-49° 59.8'
Mean	5xQ days	31534.1	4295.8	-37911.2	49498.6	31825.4	7° 45.4'	-49° 59.3'
Values	5xD days	31505.7	4292.7	-37916.2	49484.1	31796.8	7° 45.5'	-50° 01.0'

(Calculated:15:57 hrs., Mon. 22 Jan. 2001)

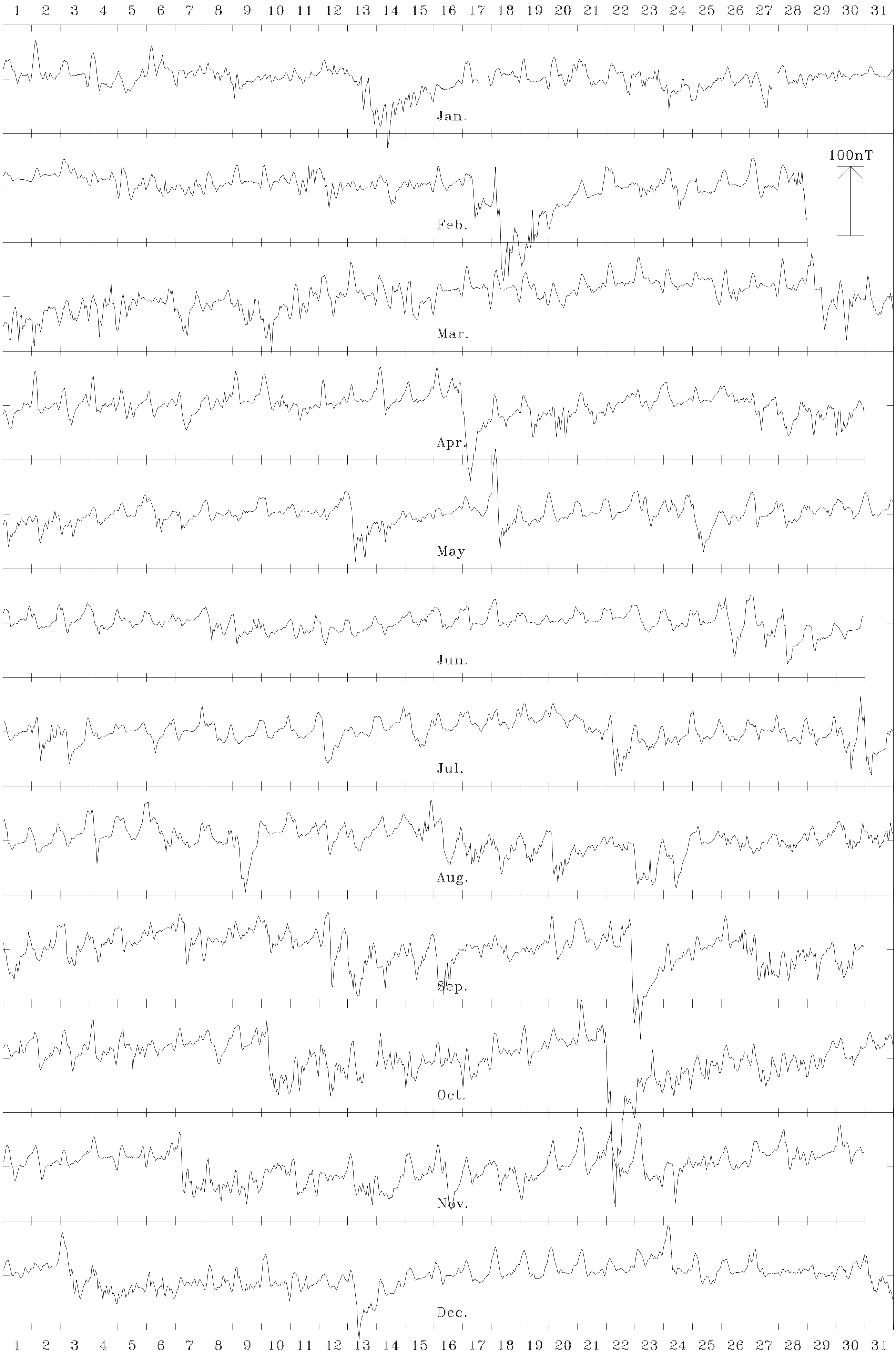
Hourly Mean Values

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

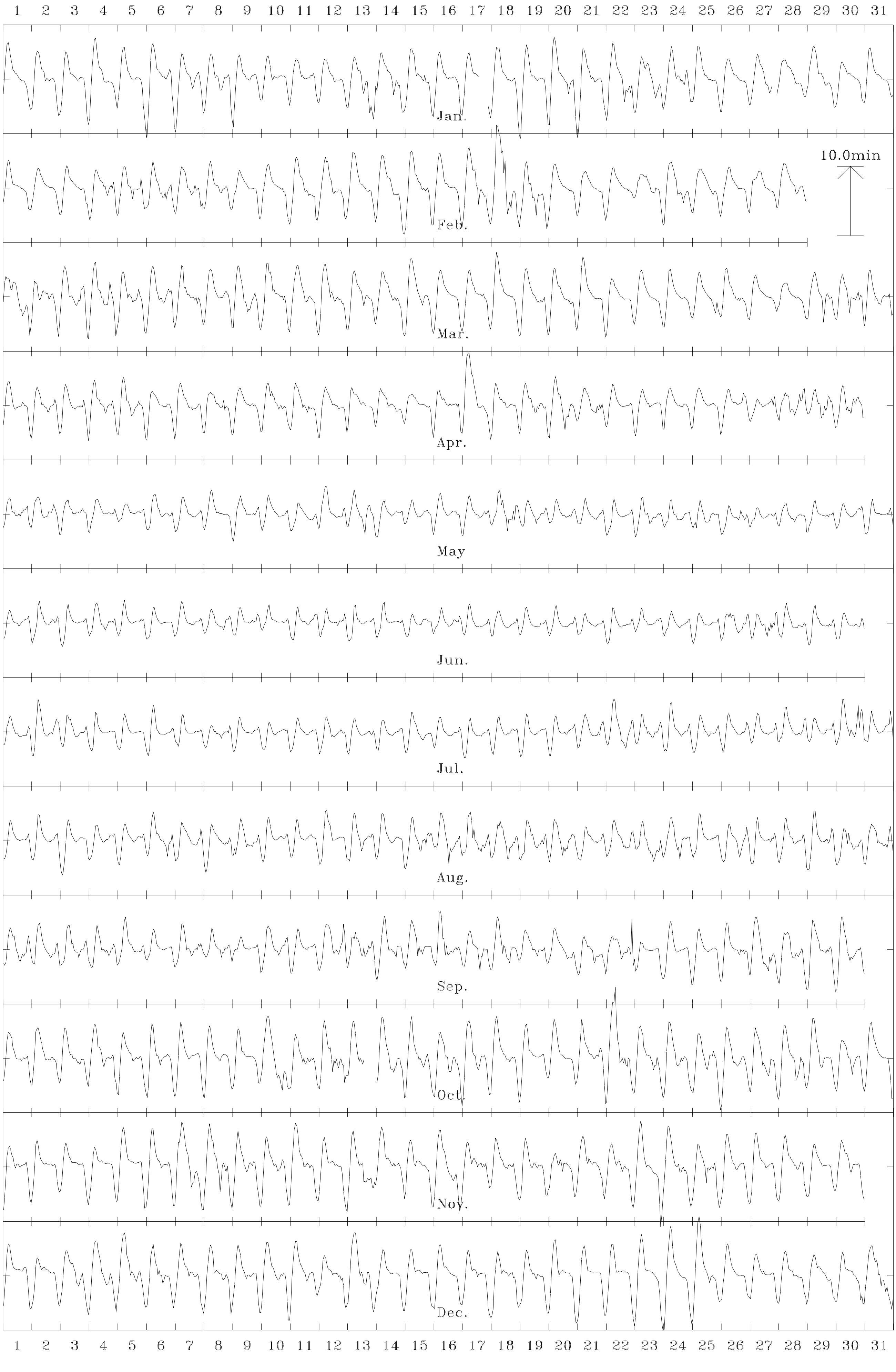
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

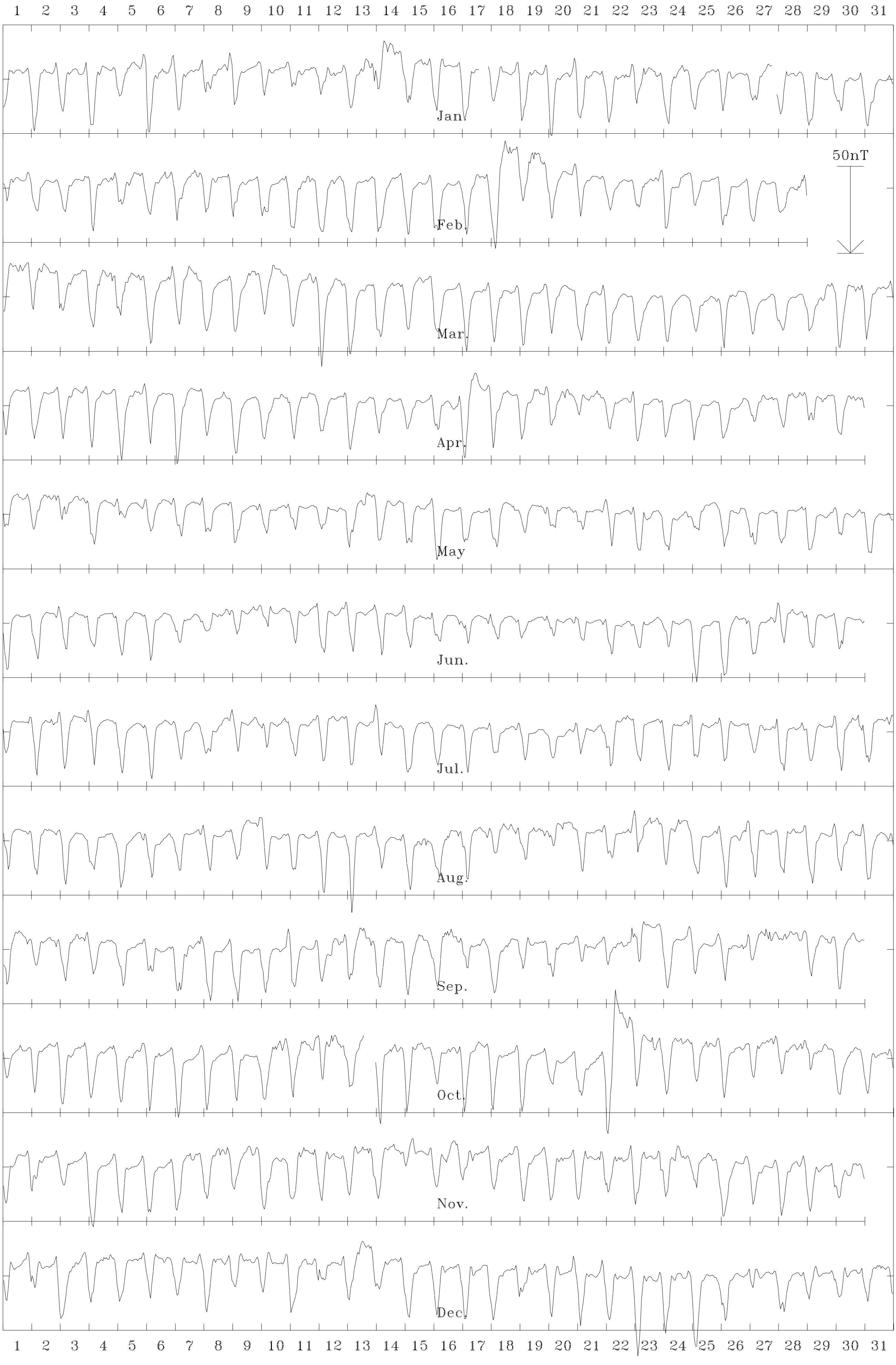
Charters Towers 1999 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 31816 nT



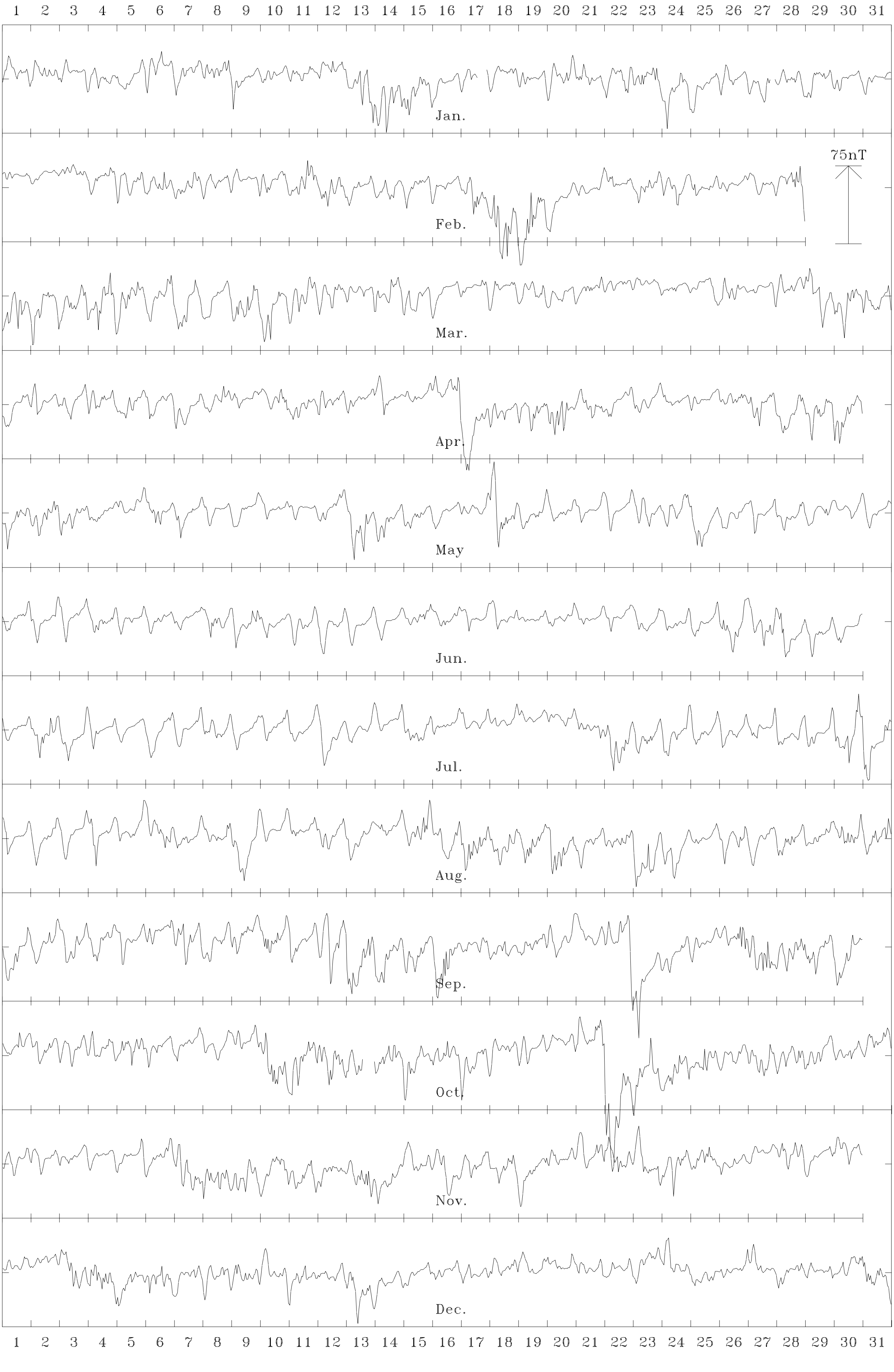
Charters Towers 1999 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.76 deg.

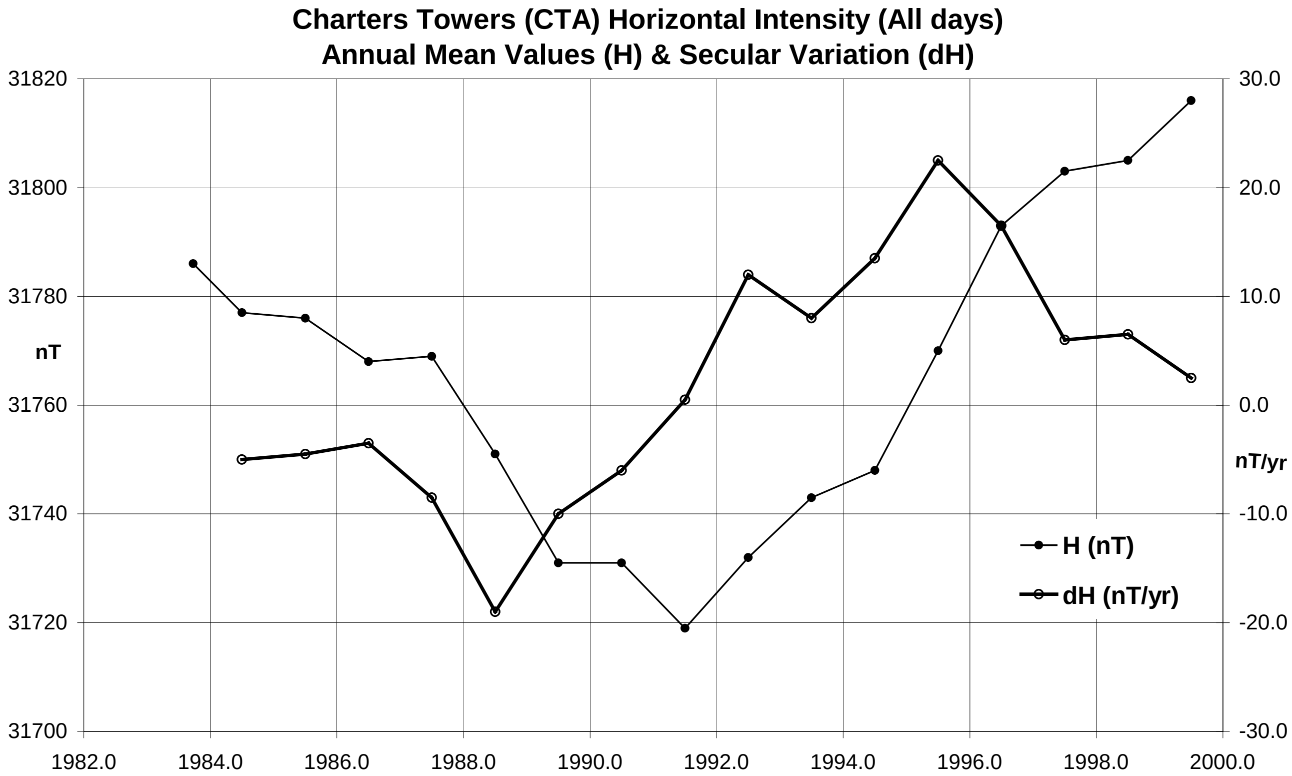


Charters Towers 1999 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −37913 nT

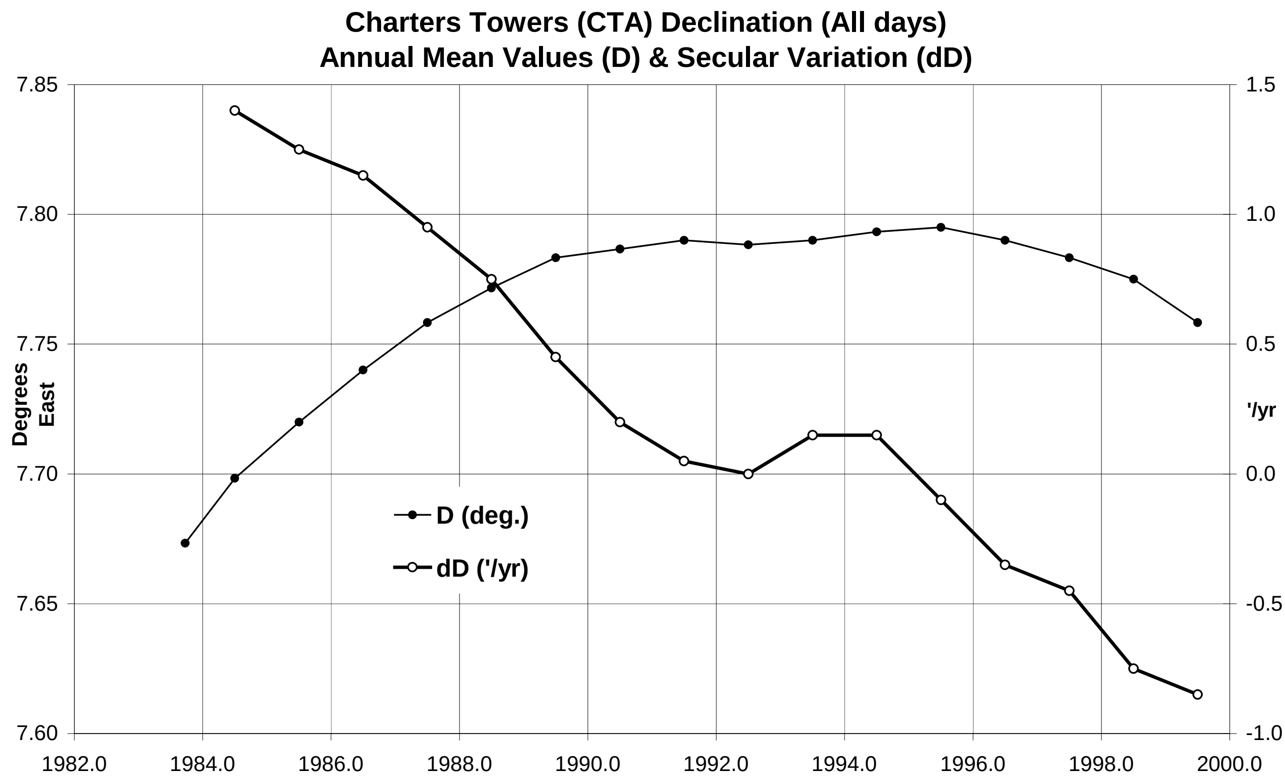


Charters Towers 1999 Total intensity (F). Scale: 5.0 nT/mm. Mean: 49494 nT

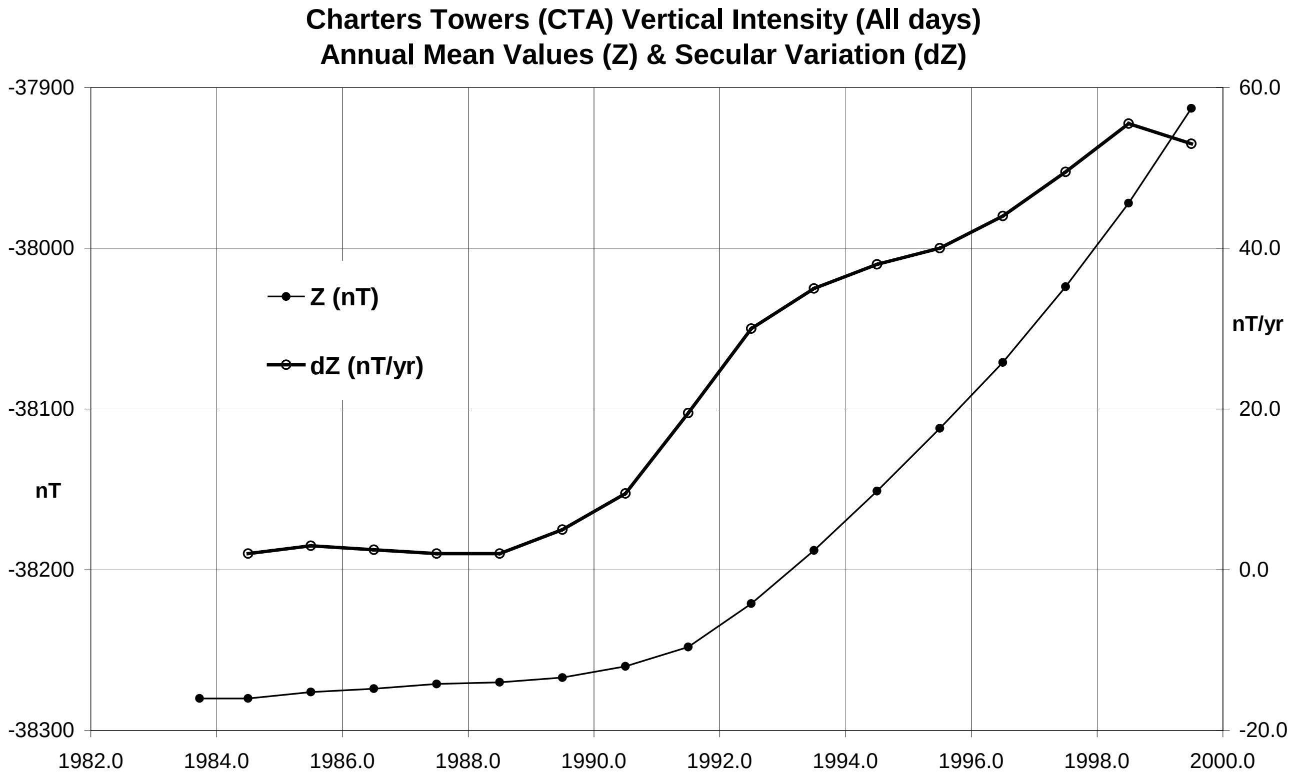




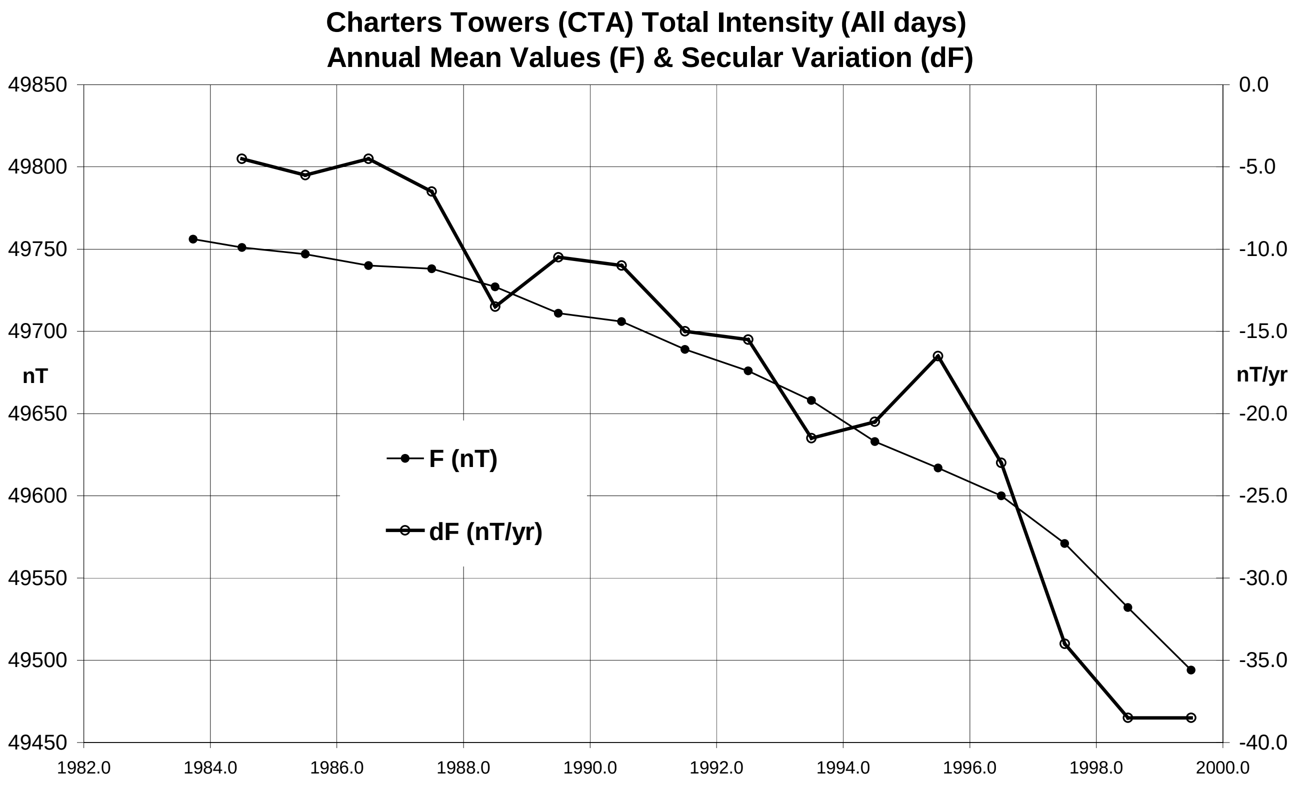
Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
31820
31800
31780
31760
31740
31720
31700
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0



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



Charters Towers (CTA) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-37900
-38000
-38100
-38200
-38300
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



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
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0

CTA Data losses in 1999

Jan 17 1407-2112 (7h 06m): Power failure - UPS not maintaining power.

Jan 27 1837-2157 (3h 21m) : Power failure

Feb 04 0740-0820 (40m): Data contaminated due to activity near variometer sensors.

Feb 14 2331 (1m):System rebooted

Mar 06 0631 (1m): System rebooted

Mar 18 2259 (1m); 2324 (1m); 2332 (1m): System reboots. 2306 (1m): PPM only.

Mar 19 0211 (1m) System rebooted

Oct 13 1312-2312 (10h 01m): Power failure
2314 (1m): System rebooted

Oct 15 1246-1256 (11m): Power failure

Oct 15 2338 (1m): System rebooted

GNANGARA OBSERVATORY

The Gnangara Magnetic Observatory is located within the Gnangara pine plantation, approximately 27km to the north-east of the city of Perth, Western Australia. The Gnangara magnetic observatory is the successor to the observatory at Watheroo (1919-1959) located 180km north of Perth in Western Australia. Magnetic recording began at Gnangara in 1957. A brief history of the observatory is in *AGR 1994*.

Situated on a 4 hectare site, the observatory comprised two principal buildings: a Recorder Vault; and an Absolute House 60m NE of the Recorder Vault. The Recorder Vault once housed an Eschenhagen analogue variometer. (An old Absolute House and a small non-magnetic storage hut were demolished in 1998).

There were also two small below-ground vaults on the observatory site. Each of these was approximately 20m from the Recorder Vault: one to its north-west and one to its south-west, and connected to the latter by underground conduits. As the sensor vaults were below the ground, the diurnal temperature changes of the variometers were kept to a minimum. The annual temperature range has been measured (in previous years) to drift from around 11°C in winter to 32°C in summer. The standard temperature was 20°C.

Other structures on the site include three azimuth reference pillars.

As there is a security problem at the observatory site, security measures were put in place during 1998. These are described in the *AGR 1998*.

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

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic latitude: 31° 46' 48" S
- Geographic longitude: 115° 56' 48" E
- Geomagnetic† latitude: -42.1°
- Geomagnetic† longitude: 188.5°
- 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: 65 metres
- Observer in Charge: E.P. Paull (MGO, GA)

† Based on the IGRF 1995 model.

Variometers

Throughout 1999 magnetic field variations were monitored with a Danish Meteorological Institute (DMI) suspended FGE (version D - serial S0160/E0167) 3-component fluxgate variometer that was located in the Recorder Vault. Two of its sensors were horizontal and aligned in the magnetic NW and NE directions, and the other one was vertical. The sensors were located at the east end of the vault, while the electronic equipment and acquisition PC were confined to the west end of the vault. The FGE variometer had in-built temperature sensors for both sensor and electronics. The seasonal temperature drift ranged between 15°C and 26°C. The analogue outputs of the FGE were input to a DT2805 A to D board, the digital output of which was recorded on the acquisition PC.

Variations in the total intensity were monitored with a Geometrics 856 PPM (serial 50706). The sensor of the recording PPM was located in one of the small below-ground vaults.

Throughout 1999 1-second values and 1-minute means of the magnetic components and temperature were recorded digitally on a PC.

Absolute Instruments

Throughout 1999, Declination and Inclination Magnetometer (DIM) Bartington Mag-010H/0725H with Zeiss020B/355937 was employed regularly to perform absolute observations in D & I. DIMs were used on Pier B in the Absolute House. Absolute observations in total intensity, in 1999, were performed with Geometrics 856/50713 PPM. The PPM sensor was located on the supplementary station (a wall bracket - pier C) in the same building as Pier B.

Baselines in X, Y & Z were calculated from the observations in D, I & F with the variometer ordinates in the magnetic NE, NW & vertical components.

Baselines

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

Corrections of 0.0′, 0.0′ in D and I, have been applied to the DIM Bartington Mag-010H/0725H with Zeiss020B/355937, used at GNA during 1999.

A correction of +1.17 nT has been applied to total intensity observations by G856/50713 PPM. (This comprises a +1.95nT difference from the Australian Standard PPM: MNS2 no.3, and a correction of -0.78nT to the latter.)

A Total Intensity difference of -5.6nT was applied to PPM observations performed at the supplementary station (pier C) to adjust them to Pier B. This value was determined on 15 June 1999 during the service visit by staff from GA, Canberra.

The aggregate adjustment to total intensity observations performed on pier C with G856/50713 PPM was -4.43nT. Together with the zero corrections to the DIM observations, resultant baseline adjustments were:

$$\Delta X = -1.75 \text{ nT}, \quad \Delta Y = +0.08 \text{ nT}, \quad \Delta Z = +4.07 \text{ nT}$$

GNA baselines (cont.)

From 13 October 1999 baselines were adopted using G856/50631 absolute PPM. A correction of +0.54nT has been applied to observations by this instrument, which, together with the pier difference resulted in a total correction to this instrument's observations performed on pier C of –5.06nT, and so with zero DIM corrections gave baseline adjustments of:

$\Delta X = -2.00$ nT, $\Delta Y = +0.09$ nT, $\Delta Z = +4.65$ nT

By application of a variometer model, values of X, Y and Z were computed from the recorded components. All reported magnetic values in 1999 refer to the standard Pier B.

Operations

The Gnangara magnetic observatory was operated by the staff at AGSO's Mundaring Geophysical Observatory, located 30km. east of Perth and 25km. from Gnangara.

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

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

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

The raw 1-minute and 1-second data were retrieved by modem directly from the observatory to GA, Canberra.

Significant Events 1999

Jun 15 to 17: Service visit to the observatory by staff from GA, Canberra, during which instrument comparisons were performed and pier differences determined.

Jul. 26 Round of angles performed by OIC.

Aug 16 PC clock 0.4second out. MGO will look at GPS clock on roof of vault this week.

Aug 18 GPS receiver found to have been knocked over and the 12v power was not working.

Sep 02 New GPS clock installed.

Sep 21 Geometrics 856 no. 50713 PPM failed during routine absolute observations. F computed from PPM variometer and pier difference.

Oct 06 Geometrics 856 no. 50631 PPM sent to replace faulty absolute unit. (It was compared at CNB on 05 Oct.). Battery box and charger also sent to eliminate the requirement for D-cells.

Oct 13 PPM G856_50631 installed in absolute hut. BMR 0019395, Battery and charger – 990204 Geometrics Head local ser# - 28079922 G816/826Model G-856Ax Serial 50631 Decane filling, 11.933 Ohm, 30.045 mH.

26.10.1999 Fencing contractor repaired fence and placed a large post (bollard) just inside the fence in front of the south mark. Hopefully this will deter vehicles from driving through the fence and knocking over the mark.

Distribution of data during 1999

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

- 1998: WDC-A, Boulder, USA (26 Sep. 1999)

Preliminary Monthly Means for Project Ørsted

- IPGP monthly (by e-mail): Jan. 1999

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh GIN daily by e-mail.
- Definitive 1998 data for the INTERMAGNET CD-ROM to the Paris INTERMAGNET GIN (23 Sep. 1999)

K indices

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

The table on the next page shows K indices for Gnangara for 1999. 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

Sudden Storm Commencements (ssc) - GNA 1999

Month	& date	U.T.	Type &	Quality	Chief movement (nT) H	D	Z
Jan.	13	1054	ssc*	B	+27 *	+6 *	+11
Feb.	17	0708	ssc*	C	+17 *	+15	+14
	18	0246	ssc*	A	+20 *	-55 *	-30 *
Apr.	16	1126	ssc	C	+18	+15	+15
May	05	1543	ssc	C	+11	+5	+5
	18	0056	ssc*	B	+10	-20 *	-10 *
Jun.	26	2017	ssc*	A	+25	+50 *	+23 *
Jul.	02	0100	ssc*	B	-10 *	-45 *	-25 *
Aug.	15	1043	ssc	C	+15	+5	+4
Sep.	15	0855	ssc	B	+14	+18	+12
	22	1222	ssc	A	+40	+10	+12
Oct.	21	0225	ssc*	B	+26	-28 *	+12 *
Dec.	12	1551	ssc	C	+15	+5	+6

The Principal Magnetic Storms and Solar Flare Effects scaled from Gnangara magnetograms for 1999 are on page 48.

K indices & Daily K sums at Gnangara (K=9 limit: 450 nT) for 1999

Date	January	February	March	April	May	June	Date
01	2111 2122 12	Q 0000 0000 00	D 4322 5444 28	3211 0320 12	D 4433 4442 28	0110 2112 08	01
02	1113 3312 15	Q 0000 0011 02	5331 3433 25	2221 2131 14	D 1132 3141 16	3112 0003 10	02
03	Q 2110 2101 08	1111 2313 13	2202 2543 20	2212 1042 14	2112 3231 15	3111 1011 09	03
04	1121 2214 14	1112 3332 16	D 2343 4543 28	2221 4143 19	1121 2111 10	1111 3213 13	04
05	3111 1213 13	3212 3352 21	3232 2411 18	2234 2310 17	1011 1311 09	1000 0021 04	05
06	3111 4442 20	2222 3433 21	1102 2255 18	3122 3322 18	2233 3111 16	1110 1100 05	06
07	2222 3323 19	2223 2422 19	D 3333 0431 20	2212 3232 17	2122 2212 14	1100 1122 08	07
08	D 4323 3333 24	2122 2231 15	2112 1234 16	0022 2422 14	2111 0011 07	D 2232 1412 17	08
09	4222 3223 20	Q 2101 1121 09	3223 5332 23	2111 1131 11	1111 0011 06	D 2210 2343 17	09
10	3122 1112 13	1120 0242 12	D 4434 2243 26	1133 3454 24	1211 1100 07	2110 1211 09	10
11	2223 2232 18	D 3233 4343 25	2233 3422 21	2133 3312 18	Q 0100 0000 01	1011 1233 12	11
12	2113 3122 15	D 4244 3342 26	2223 3233 20	3212 1211 13	0130 2332 14	2210 2312 13	12
13	D 1223 4656 29	2222 0111 11	1001 3122 10	Q 1111 1111 08	D 3443 5532 29	2110 1122 10	13
14	D 2243 5344 27	1122 3323 17	2113 3332 18	1232 1121 13	3232 2101 14	Q 1110 0000 03	14
15	D 3432 3433 25	4332 3332 23	3332 2111 16	Q 1111 0011 06	2222 2221 15	0000 2211 06	15
16	3112 1112 12	3122 1001 10	Q 1001 0101 04	1113 2224 16	Q 1111 1210 08	1112 1121 10	16
17	2121 2111 11	D 2134 5322 22	2111 1321 12	D 5544 2222 26	Q 0000 1210 04	2211 1211 11	17
18	1111 1232 12	D 4556 6564 41	1121 1221 11	2211 2111 11	D 3334 4352 27	1221 1012 10	18
19	Q 1212 0012 09	D 4335 5423 29	1011 3342 15	1113 4334 20	3222 3223 19	2110 0210 07	19
20	1212 2432 17	Q 1100 0122 07	Q 1102 2330 12	D 3333 5432 26	1222 1222 14	Q 0000 1000 01	20
21	2223 2011 13	1100 0123 08	0021 2120 08	1232 3541 21	1210 1110 07	Q 0000 0000 00	21
22	2112 3433 19	3231 1132 16	Q 1010 1110 05	Q 1000 0121 05	Q 0110 0001 03	Q 0000 0001 01	22
23	D 3323 1445 25	3132 3411 18	1101 1122 09	Q 1111 1211 09	2113 3121 14	0111 0002 05	23
24	3333 3343 25	1023 3321 15	Q 1112 0001 06	1111 1210 08	2322 1122 15	1111 1021 08	24
25	2212 2112 13	1211 0311 10	0112 1243 14	Q 0010 0112 05	D 3333 3221 20	2100 0011 05	25
26	Q 2213 1012 12	Q 0000 1000 01	2223 3211 16	1022 1130 10	2120 2311 12	D 2333 3242 22	26
27	--13 33-- --	1012 1021 08	Q 1100 1002 05	0023 2254 18	2330 1013 13	D 2223 3343 22	27
28	2223 3322 19	1121 3445 21	1121 1111 09	D 3223 3444 25	2011 2131 11	D 2543 1121 19	28
29	2121 2321 14		D 3242 5343 26	D 2115 4543 25	1000 0210 04	1113 3221 14	29
30	Q 2012 0111 08		3245 4444 30	D 4334 4442 28	0000 2221 07	Q 2110 0000 04	30
31	Q 2111 2100 08		2113 3244 20		Q 0100 1001 03		31
Mean K-sum	**16.3**	**15.6**	**16.4**	**15.7**	**12.3**	**9.4**	

Date	July	August	September	October	November	December	Date
01	1111 1132 11	3321 0000 09	2334 4343 26	2112 3231 15	2223 2222 17	2111 1222 12	01
02	D 4343 2445 29	Q 1311 2321 14	2221 3322 17	2322 2213 17	2221 1102 11	2111 2133 14	02
03	2333 1101 14	Q 2112 0011 08	1234 4221 19	2112 2312 14	1001 0011 04	3324 3343 25	03
04	Q 0000 0011 02	2432 1221 17	2233 3332 21	2222 3333 20	Q 3210 1112 11	D 4343 4533 29	04
05	Q 0000 0012 03	2221 2122 14	Q 2121 1122 12	3322 4324 23	1100 0023 07	D 3234 3443 26	05
06	1010 0222 08	3232 3433 23	Q 1121 1132 12	Q 0123 2221 13	3021 2242 16	D 2344 4333 26	06
07	2110 0010 05	2232 2233 19	2133 3142 19	Q 3111 1012 10	D 4343 6424 30	3223 3333 22	07
08	2123 3222 17	1121 2233 15	Q 2111 2312 13	3213 4001 14	D 3434 5544 32	3232 2232 19	08
09	1100 1221 08	4334 2300 19	2121 3121 13	2121 1222 13	D 4343 5443 30	2223 3232 19	09
10	0022 1131 10	Q 1000 0112 05	2332 4142 21	D 2225 3532 24	2123 3433 21	2122 2432 18	10
11	0011 1113 08	2101 0222 10	3221 1111 12	3343 4334 27	D 3433 3344 27	2111 3200 10	11
12	2322 1131 15	2222 1111 12	D 2225 2264 25	D 3335 5434 30	3322 2223 19	2102 1344 17	12
13	1100 0020 04	2223 3132 18	D 4434 4453 31	3243 4444 28	D 3222 5564 29	D 5344 4322 27	13
14	0000 0032 05	Q 1221 1111 10	3343 2323 23	D 3323 5544 29	4243 4332 25	Q 3210 0221 11	14
15	3332 2221 18	1103 4453 21	3145 3331 23	3533 5533 30	Q 3121 1111 11	2101 2024 12	15
16	Q 1110 1100 05	2134 4433 24	D 3335 5432 28	3323 4433 25	2133 3523 22	3231 1223 17	16
17	Q 0000 0200 02	D 3344 4342 27	3221 4432 21	2233 5322 22	3223 3343 23	2322 2212 16	17
18	1110 0221 08	D 3334 4423 26	2133 4311 18	2101 3221 12	3232 4343 24	2123 2333 19	18
19	Q 1100 0000 02	3334 3343 26	3113 4122 17	Q 2020 0011 06	3322 3234 22	1222 2212 14	19
20	1100 2211 08	D 2434 5333 27	1112 2232 14	Q 1002 2020 07	3233 0112 15	1111 0112 08	20
21	D 1011 1332 12	Q 1112 2210 10	2132 4233 20	4422 3345 27	2232 1333 19	Q 2110 0111 07	21
22	D 3333 4433 26	0111 3433 16	D 3222 4367 29	D 5665 5553 40	4213 3112 17	Q 1000 1110 04	22
23	1212 2332 16	D 4224 4533 27	5531 1122 20	D 3322 6435 28	2231 2133 17	Q 1001 1111 06	23
24	3311 1133 16	D 3334 5443 29	Q 2210 0202 09	3334 4334 27	2134 4332 22	3243 2223 21	24
25	2222 2122 15	2201 1124 13	Q 1100 1011 05	3234 5511 24	2134 4342 23	3322 3113 18	25
26	2232 1101 12	1201 4333 17	1001 3545 19	1122 2221 13	Q 2111 2001 08	Q 2110 0113 09	26
27	2231 0000 08	3332 1332 20	D 3233 5544 29	2114 2533 21	Q 1000 0002 03	3222 1121 14	27
28	1222 1334 18	3223 3332 21	3233 4333 24	3211 4442 21	3213 2223 18	1111 1112 09	28
29	3121 0001 08	1122 1343 17	3333 2434 25	2112 2132 14	Q 2101 1011 07	3221 0113 13	29
30	D 2123 4364 25	2245 3333 25	4323 4222 22	Q 2112 3211 13	2123 3222 17	1222 1345 20	30
31	D 4331 0234 20	2234 3344 25		2122 2323 17		D 5334 3344 29	31
Mean K-sum	**11.5**	**18.2**	**19.6**	**20.1**	**18.2**	**16.5**	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	10	75	82	55	17	3	2	0	0	0	4
February	37	56	56	46	18	8	3	0	0	0	0
March	27	69	62	53	28	9	0	0	0	0	0
April	21	81	65	40	25	8	0	0	0	0	0
May	48	85	64	38	10	3	0	0	0	0	0
June	70	92	50	22	5	1	0	0	0	0	0
July	67	73	55	40	11	1	1	0	0	0	0
August	19	51	65	74	34	5	0	0	0	0	0
September	8	52	68	67	31	11	2	1	0	0	0
October	13	42	75	66	29	20	3	0	0	0	0
November	22	44	68	67	31	6	2	0	0	0	0
December	19	66	75	61	23	4	0	0	0	0	0
ANNUAL TOTAL	**361**	**786**	**785**	**629**	**262**	**79**	**13**	**1**	**0**	**0**	**4**

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 46-47.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	XYZ
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	XYZ
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	XYZ
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	XYZ
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	XYZ
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	XYZ
1959.5	Q	-2	54.1	-65	52.4	23954	23923	-1213	-53482	58603	DHZ
1960.5	Q	-2	53.5	-65	52.1	23959	23928	-1209	-53480	58599	DHZ
1961.5	Q	-2	53.3	-65	52.7	23952	23922	-1207	-53491	58606	DHZ
1962.5	Q	-2	52.8	-65	53.0	23945	23915	-1203	-53490	58599	DHZ
1963.5	Q	-2	52.3	-65	54.0	23931	23901	-1199	-53497	58600	DHZ
1964.5	Q	-2	51.7	-65	54.9	23916	23886	-1194	-53501	58599	DHZ
1965.5	Q	-2	51.7	-65	55.3	23906	23876	-1194	-53497	58589	DHZ
1966.5	Q	-2	52.4	-65	56.3	23889	23859	-1198	-53499	58582	DHZ
1967.5	Q	-2	54.1	-65	57.4	23868	23837	-1208	-53499	58572	DHZ
1968.5	Q	-2	55.7	-65	58.6	23843	23812	-1218	-53494	58558	DHZ
1969.5	Q	-2	57.5	-65	59.7	23820	23788	-1229	-53488	58538	DHZ
1970.5	Q	-2	59.7	-66	1.2	23786	23754	-1243	-53475	58516	DHZ
1971.5	Q	-3	2.3	-66	2.2	23761	23728	-1259	-53461	58490	DHZ
1972.5	Q	-3	5.2	-66	3.9	23727	23693	-1278	-53454	58467	DHZ
1973.5	Q	-3	7.8	-66	6.2	23686	23651	-1293	-53460	58454	DHZ
1974.5	Q	-3	9.9	-66	9.0	23642	23606	-1305	-53477	58456	DHZ
1975.5	Q	-3	11.5	-66	11.3	23608	23571	-1314	-53496	58457	DHZ
1976.5	Q	-3	12.3	-66	14.2	23567	23530	-1318	-53528	58471	DHZ
1977.5	Q	-3	13.6	-66	17.0	23528	23491	-1324	-53557	58478	DHZ
1978.5	Q	-3	15.1	-66	20.5	23481	23443	-1332	-53596	58499	DHZ
1979.5	Q	-3	16.5	-66	23.1	23444	23406	-1339	-53624	58525	DHZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1346	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.9	-66	36.5	23258	23219	-1338	-53772	58587	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ
1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	8.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	6.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	2.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23165	-1173	-53757	58547	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	XYZ
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	XYZ
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	XYZ
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	XYZ
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	XYZ
1999.5	Q	-2	18.4	-66	36.3	23224	23215	-935	-53705	58515	XYZ
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	XYZ
1994	J		-1.6		1.1	8	7	-11	27	-22	XYZ
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	XYZ
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	XYZ
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	XYZ
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	XYZ
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	XYZ
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	XYZ

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

Gnangara 1999 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	1999	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23207.4	-955.9	-53720.6	58526.9	23227.1	-2° 21.5'	-66° 37.1'
	5xQ days	23211.8	-953.2	-53719.4	58527.5	23231.4	-2° 21.1'	-66° 36.8'
	5xD days	23195.2	-959.5	-53724.7	58526.0	23215.1	-2° 22.1'	-66° 37.8'
February	All days	23205.8	-951.4	-53717.3	58523.2	23225.3	-2° 20.9'	-66° 37.1'
	5xQ days	23211.0	-950.9	-53717.7	58525.6	23230.4	-2° 20.8'	-66° 36.8'
	5xD days	23184.9	-952.7	-53726.1	58523.0	23204.5	-2° 21.2'	-66° 38.4'
March	All days	23199.9	-947.1	-53714.1	58517.8	23219.2	-2° 20.3'	-66° 37.3'
	5xQ days	23210.3	-946.0	-53710.3	58518.5	23229.6	-2° 20.0'	-66° 36.7'
	5xD days	23184.5	-947.1	-53718.6	58515.8	23203.8	-2° 20.4'	-66° 38.3'
April	All days	23202.8	-942.1	-53710.3	58515.5	23222.0	-2° 19.5'	-66° 37.1'
	5xQ days	23213.1	-941.3	-53707.9	58517.3	23232.1	-2° 19.3'	-66° 36.5'
	5xD days	23185.9	-938.5	-53714.5	58512.5	23204.8	-2° 19.1'	-66° 38.1'
May	All days	23210.0	-936.7	-53706.2	58514.4	23228.8	-2° 18.7'	-66° 36.6'
	5xQ days	23217.2	-936.4	-53704.2	58515.4	23236.1	-2° 18.6'	-66° 36.2'
	5xD days	23197.0	-936.7	-53710.1	58512.8	23215.9	-2° 18.7'	-66° 37.4'
June	All days	23216.8	-935.1	-53702.0	58513.2	23235.6	-2° 18.4'	-66° 36.2'
	5xQ days	23220.9	-935.2	-53701.4	58514.3	23239.7	-2° 18.4'	-66° 35.9'
	5xD days	23211.0	-933.7	-53703.2	58512.0	23229.8	-2° 18.2'	-66° 36.5'
July	All days	23211.3	-931.6	-53700.7	58509.8	23230.0	-2° 17.9'	-66° 36.5'
	5xQ days	23219.4	-933.0	-53698.6	58511.1	23238.1	-2° 18.1'	-66° 36.0'
	5xD days	23201.0	-929.5	-53701.5	58506.4	23219.6	-2° 17.7'	-66° 37.0'
August	All days	23202.8	-930.0	-53702.9	58508.5	23221.4	-2° 17.7'	-66° 37.0'
	5xQ days	23209.7	-930.4	-53701.3	58509.7	23228.4	-2° 17.7'	-66° 36.6'
	5xD days	23181.0	-930.4	-53708.9	58505.3	23199.7	-2° 17.9'	-66° 38.3'
September	All days	23197.1	-927.3	-53702.6	58505.9	23215.6	-2° 17.4'	-66° 37.3'
	5xQ days	23204.9	-929.1	-53700.0	58506.6	23223.5	-2° 17.6'	-66° 36.8'
	5xD days	23187.0	-925.9	-53704.6	58503.7	23205.5	-2° 17.2'	-66° 37.9'
October	All days	23195.0	-926.0	-53704.9	58507.1	23213.5	-2° 17.2'	-66° 37.4'
	5xQ days	23210.3	-923.3	-53700.8	58509.4	23228.6	-2° 16.7'	-66° 36.5'
	5xD days	23166.0	-926.6	-53711.9	58502.0	23184.5	-2° 17.4'	-66° 39.2'
November	All days	23211.6	-923.4	-53704.3	58513.1	23230.0	-2° 16.7'	-66° 36.5'
	5xQ days	23222.7	-921.8	-53702.1	58515.5	23241.0	-2° 16.4'	-66° 35.9'
	5xD days	23190.0	-925.8	-53707.6	58507.6	23208.5	-2° 17.2'	-66° 37.8'
December	All days	23226.8	-920.7	-53698.7	58513.9	23245.0	-2° 16.2'	-66° 35.6'
	5xQ days	23232.6	-920.2	-53694.7	58512.6	23250.8	-2° 16.1'	-66° 35.2'
	5xD days	23208.9	-921.6	-53703.3	58511.1	23227.2	-2° 16.4'	-66° 36.7'
Annual	All days	23207.3	-935.6	-53707.1	58514.1	23226.1	-2° 18.5'	-66° 36.8'
Mean	5xQ days	23215.3	-935.1	-53704.9	58515.3	23234.1	-2° 18.4'	-66° 36.3'
Values	5xD days	23191.0	-935.7	-53711.2	58511.5	23209.9	-2° 18.6'	-66° 37.8'

(Calculated:10:16 hrs., Fri. 17 Nov. 2000)

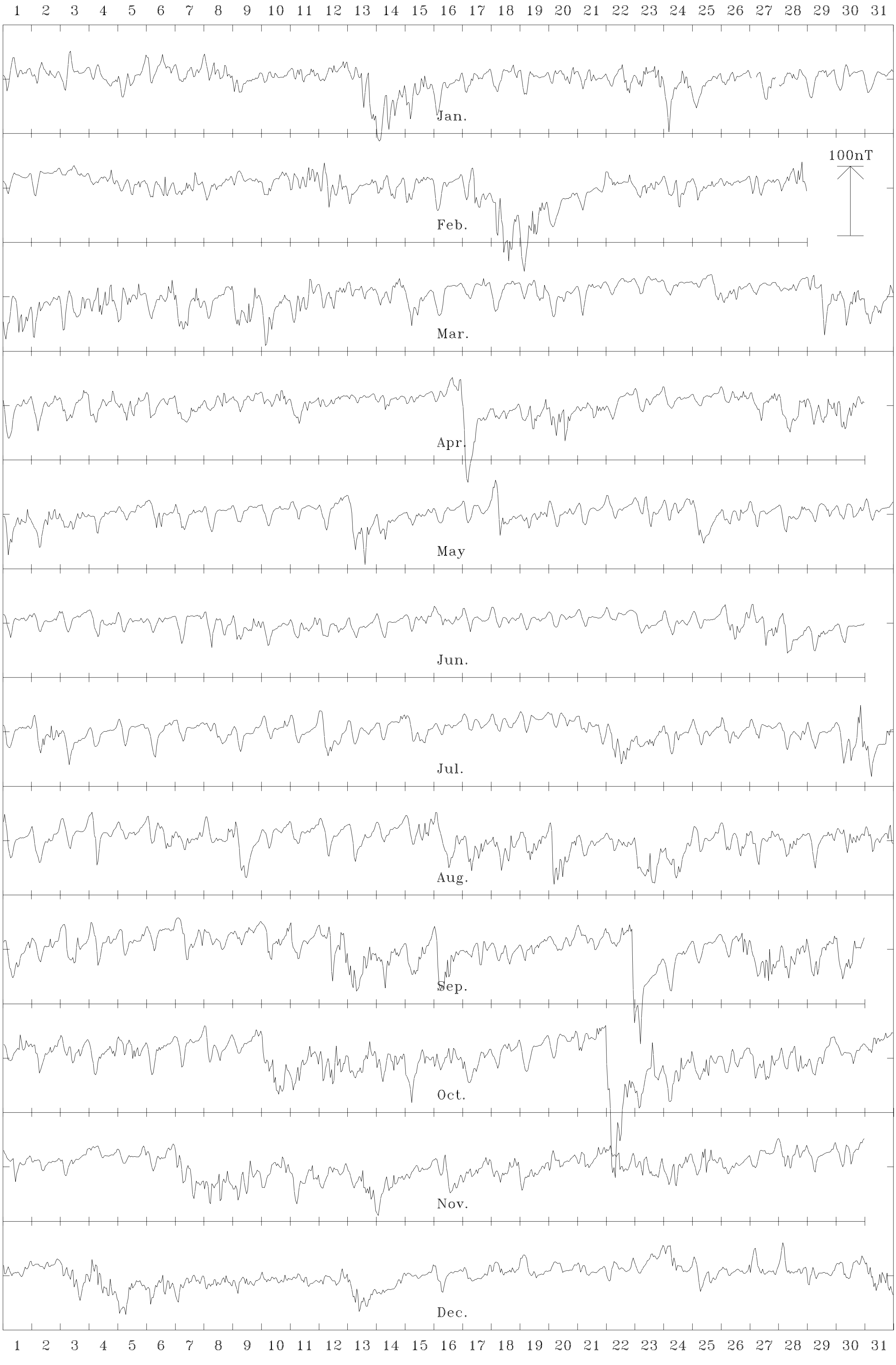
Hourly Mean Values

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.

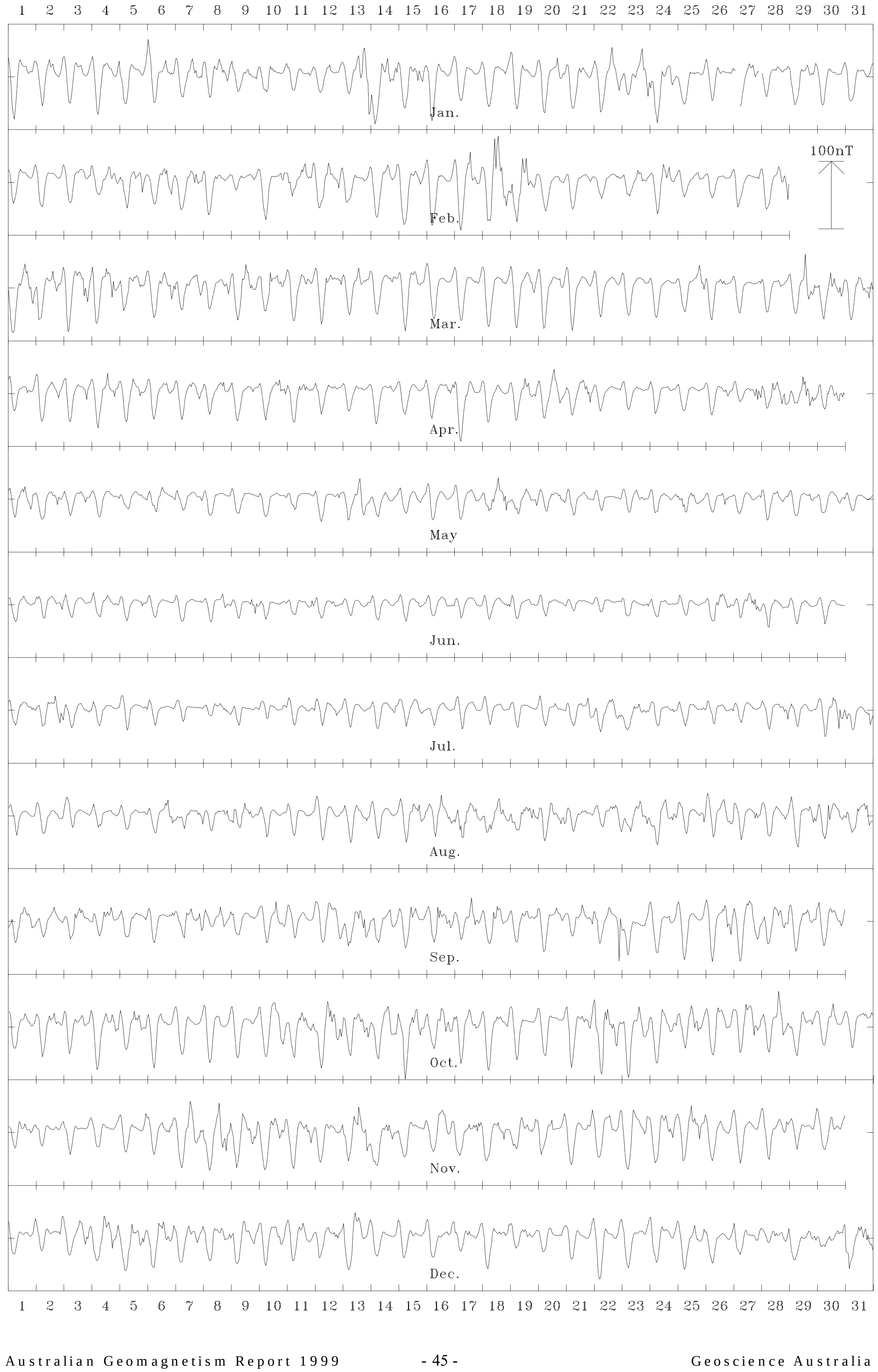
Gnangara 1999 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23226 nT

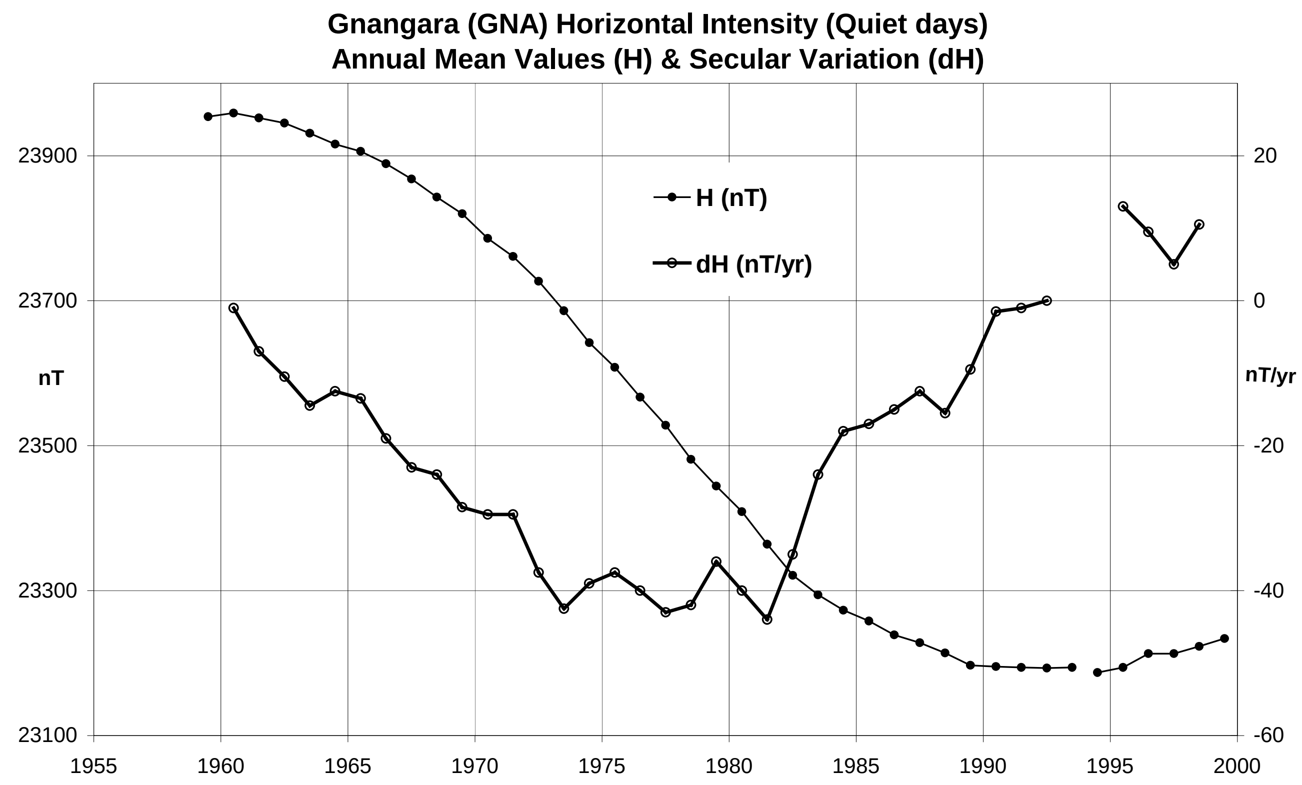


Gnangara 1999 Declination (east) (D). Scale: 1.00 min/mm. Mean: −2.31 deg.

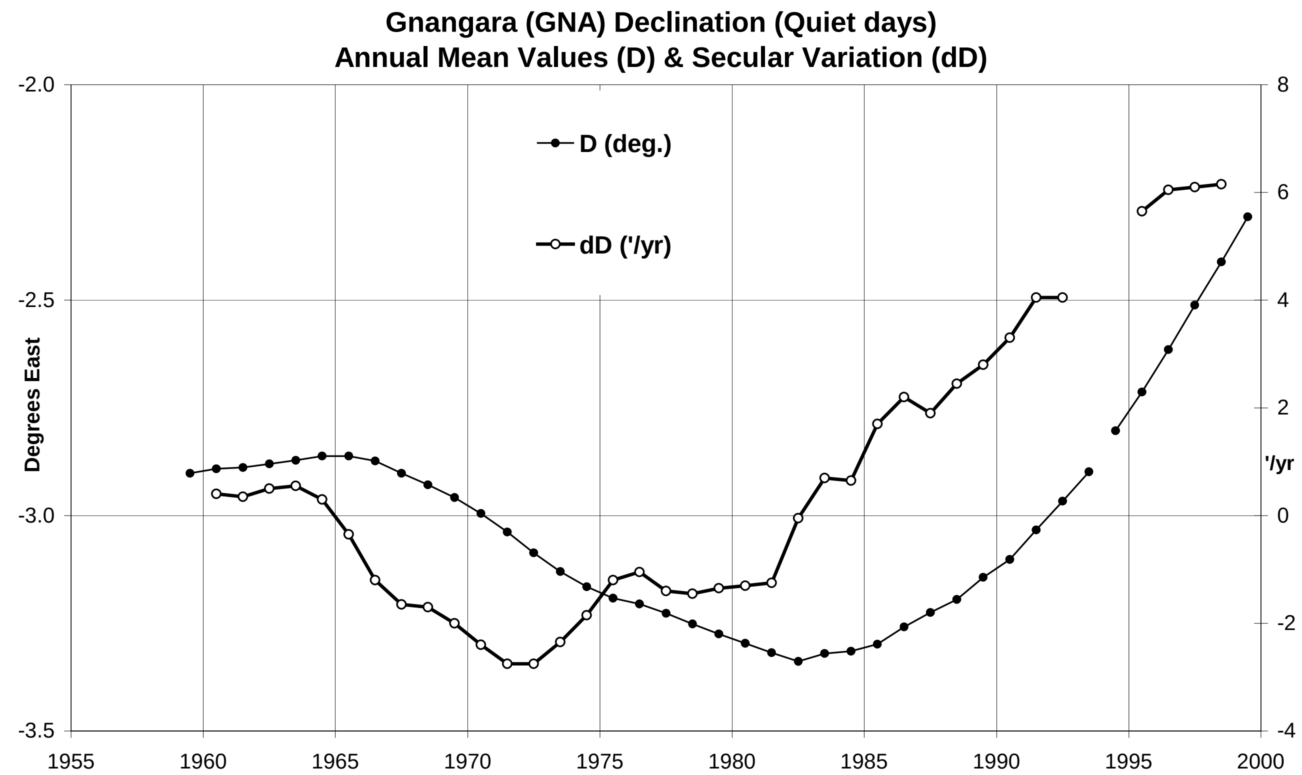
Gnangara 1999 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53707 nT

Gnangara 1999 Total intensity (F).   Scale: 7.5 nT/mm.   Mean: 58514 nT

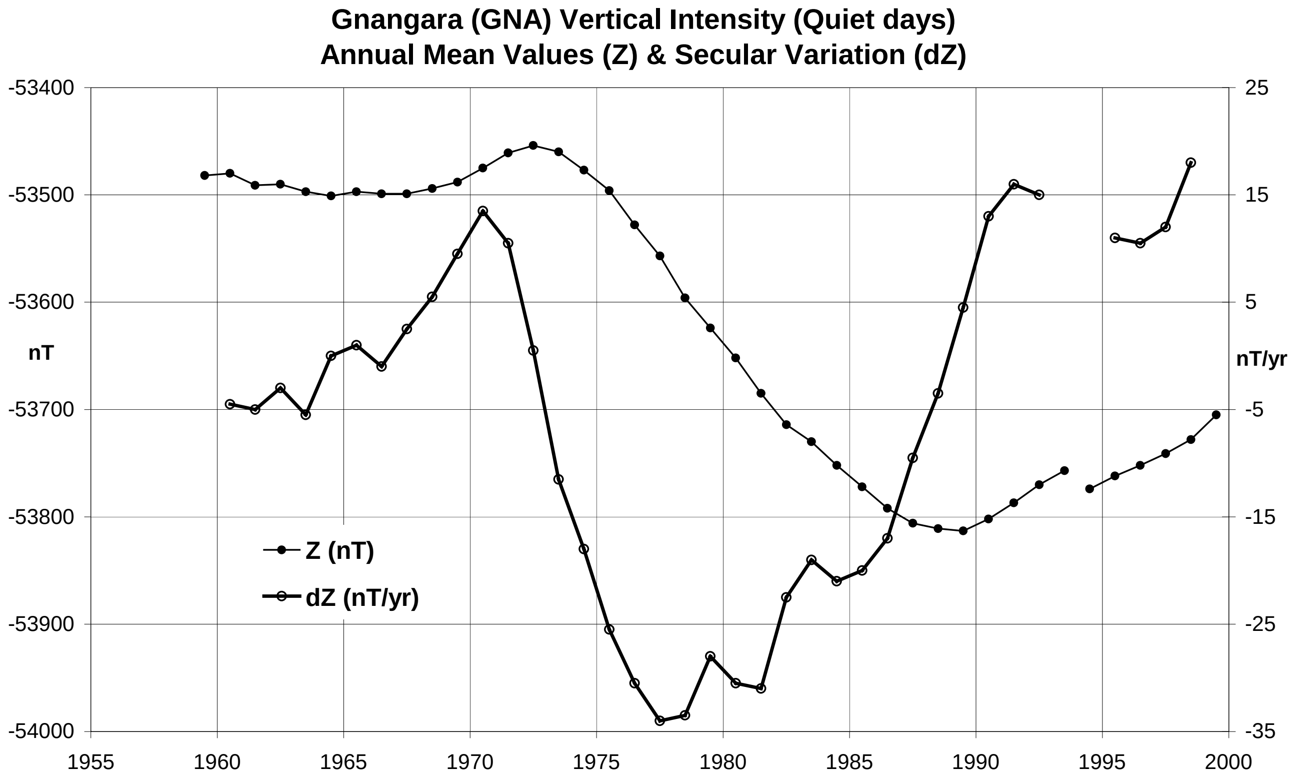


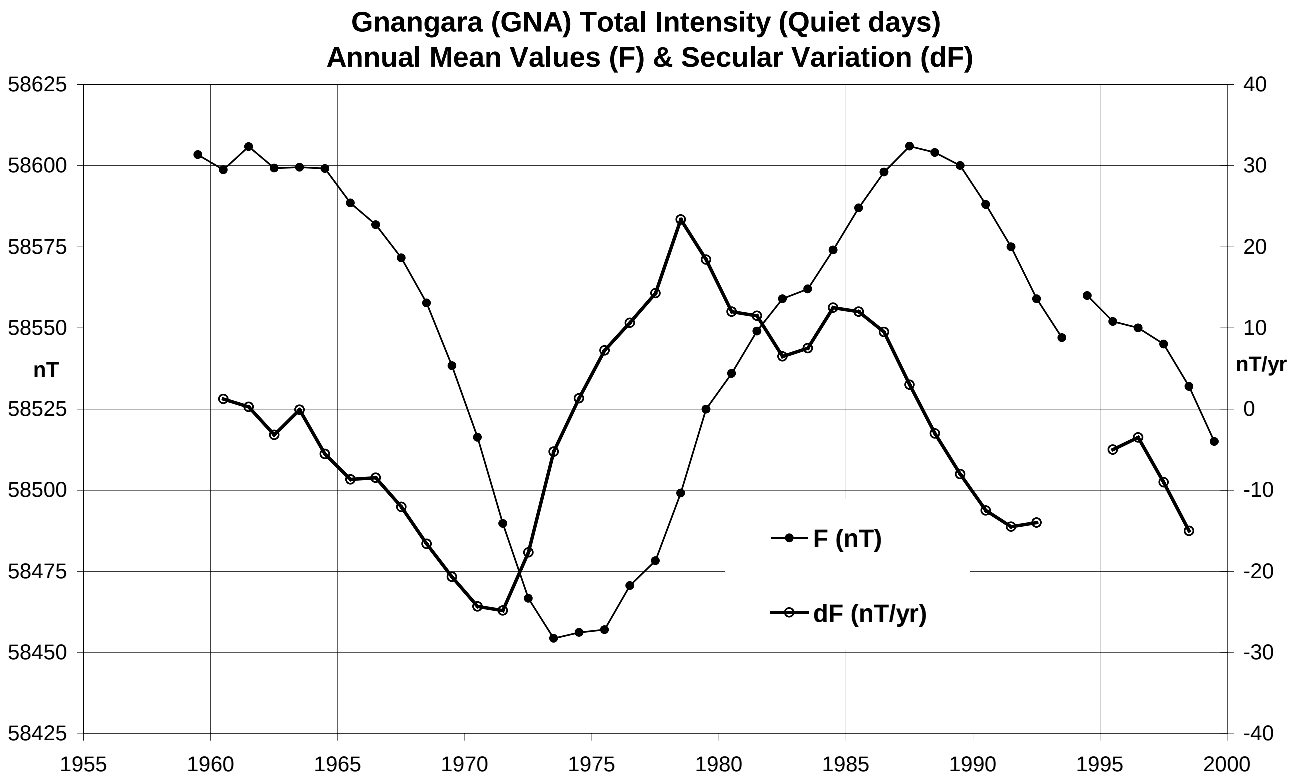


Gnangara (GNA) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT/yr
23900
23700
23500
23300
23100
20
0
-20
-40
-60
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000



Gnangara (GNA) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
D (deg.)
dD ('/yr)
Degrees East
'/yr
-2.0
-2.5
-3.0
-3.5
8
6
4
2
0
-2
-4
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000


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


Gnangara (GNA) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)
58625
58600
58575
58550
nT
58525
58500
58475
58450
58425
40
30
20
10
nT/yr
0
-10
-20
-30
-40
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
F (nT)
dF (nT/yr)

Principal Magnetic Storms - Gnangara, 1999

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. 13	10 54	ssc*	+0.9* +27* +11	13(6,8)	6	20.3 109 141	13 24
Feb. 18	02 46	ssc*	-8.2* +20* -30*	18(4,5,7)	6	30.6 137 203	19 24
Mar.		No	Principal	Magnetic		Storms	
Apr.		No	Principal	Magnetic		Storms	
May		No	Principal	Magnetic		Storms	
Jun.		No	Principal	Magnetic		Storms	
Jul. 29	23 ..	...	.. .. ..	30(7)	6	20.4 146 127	31 08
Aug.		No	Principal	Magnetic		Storms	
Sep. 22	12 22	ssc	+1.5 +40 +12	22(8)	7	47.4 227 212	23 06
Oct. 10	05 ..	...	.. .. ..	10(4,6), 12(4,5), 14(5,6), 15(2,5,6), 17(5)	5	24.1 117 138	17 18
Oct. 21	02 25	ssc*	-4.1* +26 +12*	22(2,3), 23(5)	6	46.1 278 193	24 24
Nov. 06	16 ..	...	.. .. ..	07(5)	6	26.5 101 164	10 04
13	12 ..	...	.. .. ..	13(7)	6	18.8 90 109	14 03
Dec. 30	19 ..	...	.. .. ..	30(8), 31(1)	5	19.9 105 116	*02* 03

Solar Flare Effects (sfe) - GNA 1999

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Apr. 04	0520	0525	0536	0	+8	+7	solar
Oct. 14	0858	0902	0907	-4	+10	+5	solar
Nov. 14	0756	0802	0806	+10	+9	+8	solar

GNA data loss in 1999:

Jan 27	0133-0518 (3h 46m); 2012-2115 (1h 04m); 2137-2351 (2h 15m): All data channels lost.
Jun 17	0522 to 21/0153 (3d 20h 32m) PPM only lost.
Jul 23	0053–0111 (19m) All channels lost
Jul 26	0048-0049 (2m) PPM only lost.
Nov 15	0650 (1m) All channels lost
Nov 24	0026-0027 (2m) PPM only lost

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 sensor vaults that house the variometer sensors, both located 50-60m from the control house, one to the SSW and one to the WSW. Cables between the sensor vaults and the control house passed through underground conduits.
- a concrete slab with tripod feet 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 Kakadu observatory are:

- 3-character IAGA code: KDU
- Commenced operation: 05 March 1995
- Geographic ‡ latitude: 12° 41' 10.9" S
- Geographic ‡ longitude: 132° 28' 20.5" E
- Geomagnetic† latitude: -22.3°
- Geomagnetic† longitude: 205.3°
- 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
- Observer in Charge: Kim Stellmacher

† Based on the IGRF 1995 model.
‡ Geodetic Datum of Australia 1994 (GDA 94)

Variometers

Variations in the magnetic NW, NE and vertical components of the magnetic field were monitored at Kakadu in 1999 using a three-component EDA FM105B fluxgate magnetometer (electronics no. 2884, and sensor no. 5460). The total intensity, F, was monitored using a Geometrics model 856 proton precession magnetometer (no. 50707). Analogue variometer data from the three EDA fluxgate channels, and the EDA head and electronics temperature channels, were converted to digital data with an ADAM 4017 A to D converter mounted inside the EDA electronics console. 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 EDA 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. The EDA fluxgate sensor temperature was not monitored due to a faulty temperature-sensor. (Typical temperature variations were described in the *AGR 1997*.) The EDA fluxgate sensor head was aligned with the orthogonal sensor elements as close as possible to magnetic NW, NE, and vertical.

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

On 1 October, additional lightning protection was installed. This was an ERICO System 3000 (Advanced Integrated Lightning Protection), consisting of Dynasphere Air Termination Unit, mast, and copper rod designed to protect an 80m radius area about the sphere. The copper rod was later discovered to be copper-coated steel. The rod was installed in a 24mx200mm bore hole, believed to be deep enough to reach the dry season water table, next to the control hut using 15 bags of Ground Enhancing Material. The mast was fastened to 3 steel star pickets (replaced by stainless steel pegs on a visit in 2000) and stainless steel wire. In addition, 48m of copper ribbon (50mm x 0.5mm) was buried in a shallow trench towards the Absolute Shelter, and 17m in the opposite direction. This is in addition to the aluminium power cables buried in shallow trenches from the control hut to and around both variometer sensor pits, and a conducting loop around the Control Hut. All of these lightning protection parts were connected together.

The variometer sensitivity and alignment model used in 1999 was determined from a campaign of absolute observations performed on 4 May 1998 during a magnetic storm (see *AGR 1998*). No temperature coefficients were applied to the data.

The adopted variometer baselines for 1999 have standard errors no greater than: 1nT in F, X, Y, & Z; and 0.1' in D & I. The adopted baselines (including drifts) resulted in F-check (the difference between the EDA and PPM variometers) varying in a 3nT range during the year, with 90% of the data falling within ±1nT of the mean.

Absolute Instruments

The principal absolute magnetometers used at Kakadu in 1999 were a DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on Zeiss 020B non-magnetic theodolite (no. 359142), and a proton precession magnetometer, PPM: Elsec model 770 (no. 189).

As described in the *AGR 1998*, the best way to use the DIM was to take all readings on the x10 scale, but switch to the x1 scale while rotating the theodolite, and rotate the theodolite so that the objective lens passes exclusively through positive field values (or alternatively exclusively through negative field values).

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

Instrument corrections

Instrument corrections that were applied to the absolute magnetometers used at Kakadu in 1999 were determined through a series of instrument comparisons performed in May 1998 and also in 1996 (see *AGR 1998*).

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

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

These instrument corrections have been applied to the 1999 data in this report.

Operations

Kakadu observatory has suffered damage from lightning a number of times since its installation in 1995. Some lightning protection measures were taken in December 1998 and additionally in October 1999.

The observatory survived damage from electrical storms during the wet seasons at the beginning and end of 1999, operating throughout 1999 with a few problems.

Data was lost on numerous occasions in February and March due to battery failure in the uninterruptible power supply. The EDA 3-axis variometer failed for several days in January due to loose connections, and on a few occasions in October due to loose electronics cards. The Geometrics PPM variometer failed in February due to problems restarting after power failures and faulty power supply leads.

KDU operations (cont.)

As in 1998, the EDA head temperature channel was probably not functioning.

The acquisition computer did not have an attached external clock. Its clock was checked and set remotely on week-days. The largest time-corrections performed remotely were less than 2 seconds (on 03 Aug. and 17 Dec.) required after system restarts. All other time corrections were less than 1 second, generally only a few tenths of a second. No time corrections were applied to the data.

The operation of the observatory was checked weekly by the local observer and when possible, absolute observations were performed by her. Completed absolute observation forms were sent weekly to GA in Canberra by post, and were reduced and used to calibrate the variometer data.

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

The control house containing the variometer electronics was maintained at a temperature of about 23°C. The temperature of the EDA electronics was 29°C ± 1°C varying with periods of 1-day and about 1-hour (air-conditioner cycling). The EDA electronics was partially shielded from direct air-conditioner airflow. The PPM variometer temperature would have fluctuated more than the EDA with the air-conditioner cycling.

Distribution of data during 1999

- No KDU data were distributed during 1999

Significant Events 1999

Feb 05 Variometer PPM failed to recover from power failure. PPM returned to Canberra on Feb 09, and reinstalled on Feb 21.

Feb 28 Variometer PPM failed again, apparently due to loose power supply leads.

Mar 13 UPS batteries replaced, PPM problems rectified.

Oct 01 ERICO System 3000 lightning protection installed.

Oct 27 Loose ADAM A/D card in EDA was fixed.

Dec 01 Observatory unattended until late Jan 2000.

Data losses in 1999:

Jan 20 1031 to 26/0745 (5d 21h 15m) EDA-channels: Loose EDA plugs.

Feb 05 0101-1125 (10h 25m) All channels: UPS fault.

Feb 05 0101 to 21/2356 (16d 22h 56m) F-channel lost: Firmware failure after power failure.

Feb 17 0509-0512 (4m) and 0524-0529 (6m) All channels: UPS fault.

Feb 18 0202-0203 (2m): All channels: UPS fault.

Feb 20 1606-1655 (50m) and 2052-2129 (38m) All channels: UPS fault.

Feb 21 0015-0029 (15m) and 0120-0200 (41m) All channels: UPS fault.

Feb 23 0015-0040 (26m) All channels: UPS fault.

Feb 24 2355 to 25/0237 (2h 43m) All channels: UPS fault.

Feb 25 0240 (1m) All channels: UPS fault.

Feb 27 0849-0941 (53m) All channels: UPS fault.

Feb 28 0115-0125 (11m) and 2307-2339 (33m) All channels: UPS fault.

Feb 28 0150 to Mar 13/0416 (13d 02h 27m) F-channel lost: Loose power supply leads.

Mar 02 0009-0038 (30m) All channels: UPS fault.

Mar 05 0045-0256 (2h 12m) All channels: UPS fault.

Mar 09 2335-2344 (10m) All channels: UPS fault.

Mar 13 0305-0359 (55m) All channels. UPS batteries replaced.

Sep 30 0135-0140 (6m) F-channel lost: Equipment adjustments.

Oct 23 2200 to 24/0400 (6h 01m) EDA channels lost: Loose EDA/ADAM card.

Oct 24 2000 to 25/0400 (8h 01m) EDA channels lost: Loose EDA/ADAM card.

Oct 26 2200 to 27/0100 (3h 01m) EDA channels lost. Loose EDA/ADAM card fixed.

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 56-57.

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
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
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

* Elements ABC indicates non-aligned variometer orientation

Kakadu 1999 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	1999	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35355.2	2305.1	-30247.4	46585.5	35430.3	3° 43.8'	-40° 29.3'
	5xQ days	35361.1	2307.2	-30246.3	46589.4	35436.3	3° 44.0'	-40° 28.9'
	5xD days	35331.8	2298.9	-30251.7	46570.2	35406.5	3° 43.4'	-40° 30.7'
February	All days	35355.5	2307.3	-30239.8	46580.9	35430.7	3° 44.0'	-40° 28.8'
	5xQ days	35362.2	2307.5	-30238.8	46585.3	35437.4	3° 44.0'	-40° 28.5'
	5xD days	35327.9	2303.4	-30241.8	46561.1	35402.9	3° 43.8'	-40° 30.3'
March	All days	35352.0	2307.3	-30232.7	46573.6	35427.2	3° 44.1'	-40° 28.6'
	5xQ days	35367.3	2308.6	-30228.6	46582.6	35442.5	3° 44.1'	-40° 27.6'
	5xD days	35329.7	2305.9	-30237.9	46560.0	35404.8	3° 44.1'	-40° 30.0'
April	All days	35354.1	2308.9	-30227.1	46571.7	35429.5	3° 44.2'	-40° 28.2'
	5xQ days	35364.2	2309.8	-30225.7	46578.5	35439.6	3° 44.2'	-40° 27.6'
	5xD days	35332.2	2308.7	-30227.2	46555.2	35407.6	3° 44.3'	-40° 29.2'
May	All days	35364.5	2310.8	-30219.7	46574.8	35439.9	3° 44.3'	-40° 27.3'
	5xQ days	35371.5	2310.5	-30219.3	46579.9	35446.9	3° 44.2'	-40° 26.9'
	5xD days	35349.3	2310.1	-30221.4	46564.4	35424.7	3° 44.3'	-40° 28.1'
June	All days	35370.5	2312.1	-30212.8	46575.0	35446.0	3° 44.4'	-40° 26.6'
	5xQ days	35374.0	2311.3	-30211.8	46577.0	35449.4	3° 44.3'	-40° 26.4'
	5xD days	35361.7	2312.8	-30213.0	46568.5	35437.2	3° 44.5'	-40° 27.0'
July	All days	35364.5	2312.3	-30208.2	46567.5	35440.0	3° 44.5'	-40° 26.6'
	5xQ days	35375.5	2312.2	-30208.7	46576.2	35451.0	3° 44.4'	-40° 26.1'
	5xD days	35352.8	2313.8	-30206.7	46557.8	35428.5	3° 44.7'	-40° 27.1'
August	All days	35354.5	2310.4	-30206.1	46558.4	35429.9	3° 44.3'	-40° 27.0'
	5xQ days	35361.5	2311.1	-30206.0	46563.7	35437.0	3° 44.4'	-40° 26.6'
	5xD days	35328.8	2308.0	-30209.6	46541.1	35404.1	3° 44.3'	-40° 28.4'
September	All days	35343.4	2310.1	-30203.4	46548.2	35418.8	3° 44.4'	-40° 27.4'
	5xQ days	35355.2	2310.1	-30201.0	46555.7	35430.6	3° 44.3'	-40° 26.7'
	5xD days	35329.6	2311.3	-30203.9	46538.1	35405.1	3° 44.6'	-40° 28.0'
October	All days	35341.6	2309.3	-30200.2	46544.8	35417.0	3° 44.3'	-40° 27.3'
	5xQ days	35362.0	2310.8	-30198.2	46559.0	35437.4	3° 44.3'	-40° 26.2'
	5xD days	35307.9	2307.5	-30201.0	46519.7	35383.3	3° 44.3'	-40° 28.9'
November	All days	35354.8	2307.1	-30199.4	46554.2	35430.0	3° 44.0'	-40° 26.6'
	5xQ days	35369.0	2306.7	-30198.6	46564.4	35444.2	3° 43.9'	-40° 25.9'
	5xD days	35331.1	2305.8	-30200.7	46536.9	35406.3	3° 44.0'	-40° 27.8'
December	All days	35368.1	2309.1	-30194.7	46561.3	35443.4	3° 44.1'	-40° 25.7'
	5xQ days	35377.1	2310.2	-30191.7	46566.3	35452.5	3° 44.2'	-40° 25.1'
	5xD days	35347.0	2307.1	-30196.6	46546.4	35422.2	3° 44.1'	-40° 26.8'
Annual	All days	35356.6	2309.1	-30216.0	46566.3	35431.9	3° 44.2'	-40° 27.4'
Mean	5xQ days	35366.7	2309.7	-30214.6	46573.2	35442.1	3° 44.2'	-40° 26.9'
Values	5xD days	35335.8	2307.8	-30217.6	46551.6	35411.1	3° 44.2'	-40° 28.5'

(Calculated:11:13 hrs., Fri. 14 Sep. 2001)

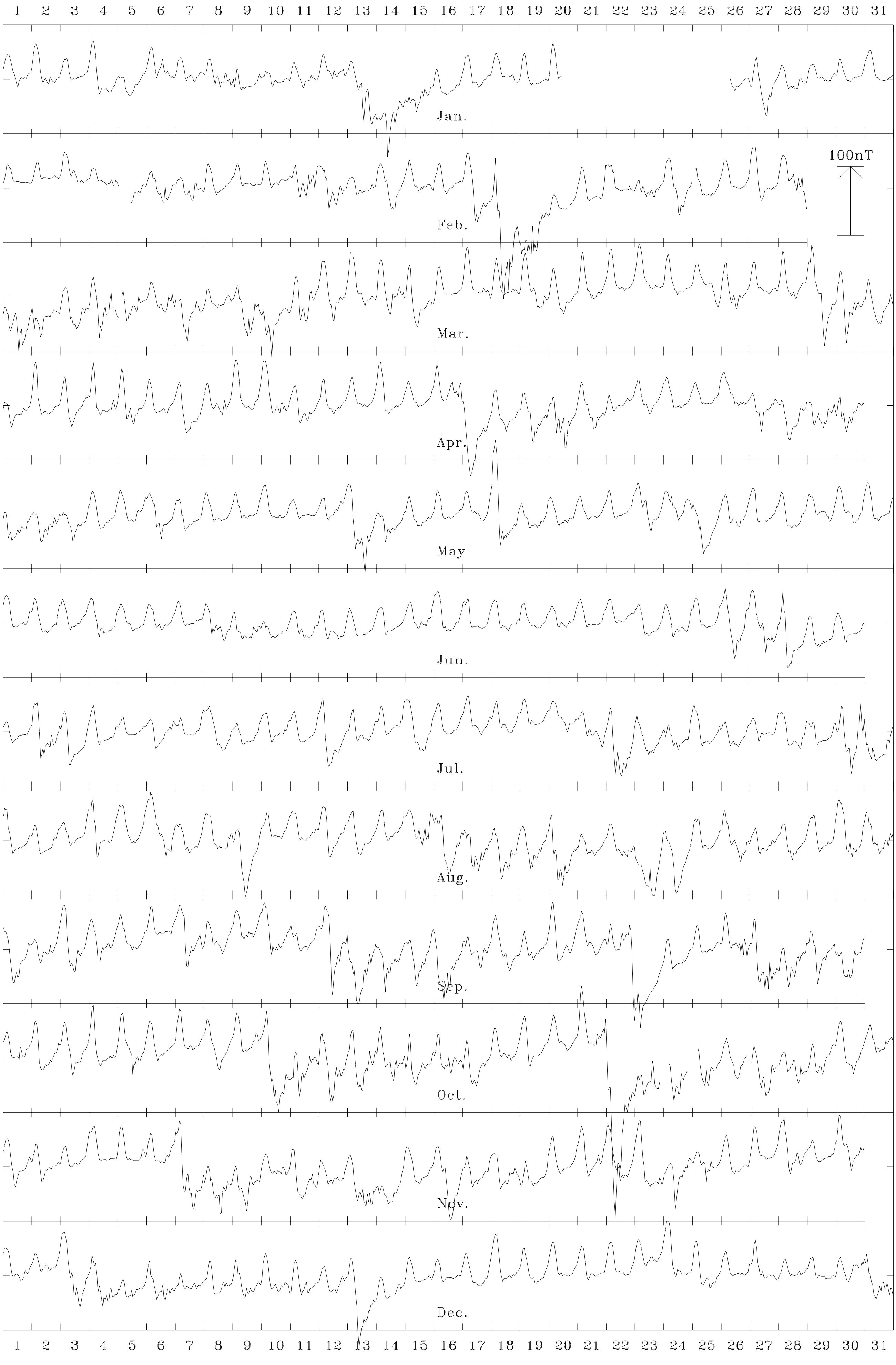
Hourly Mean Values

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

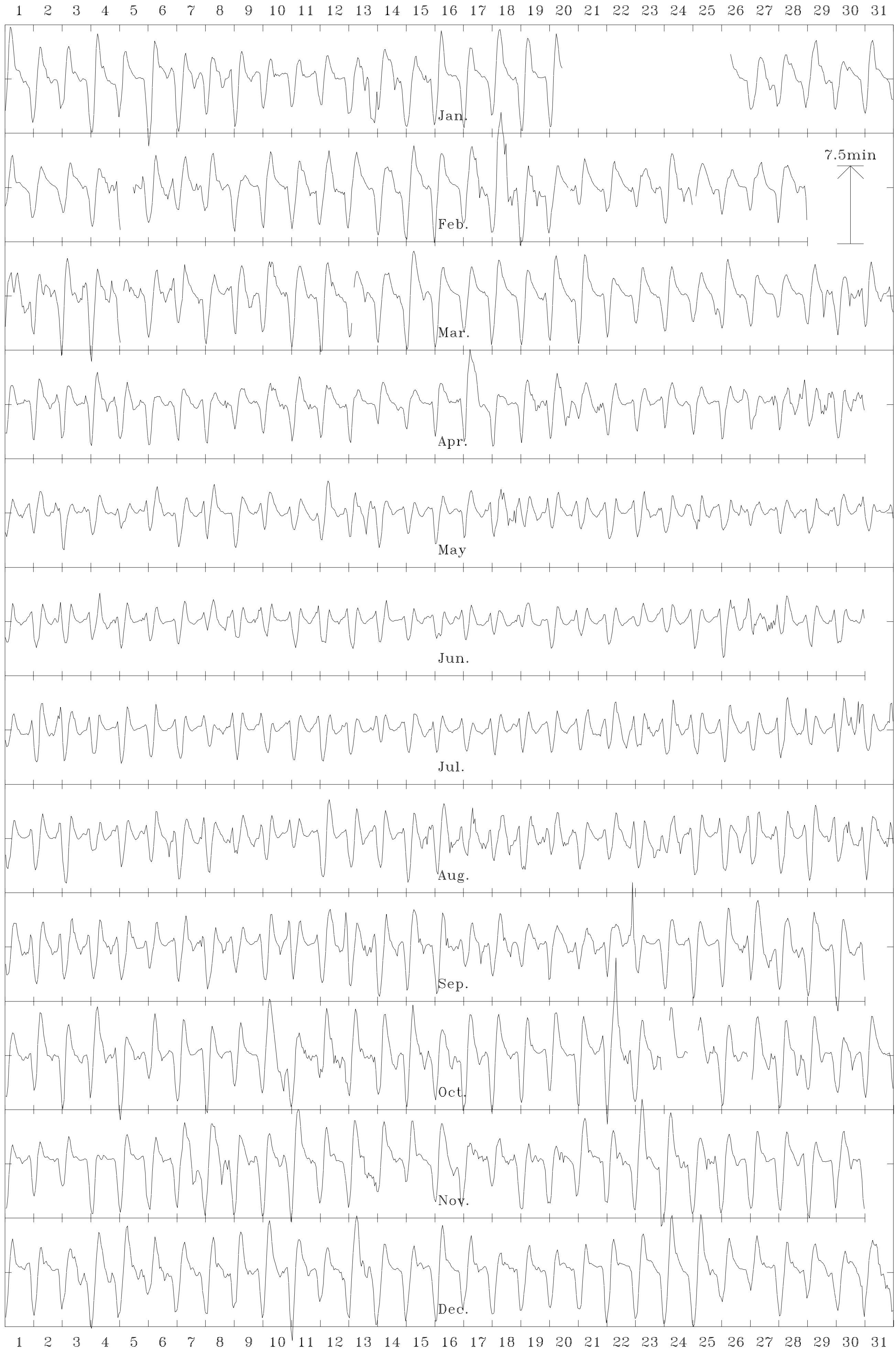
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

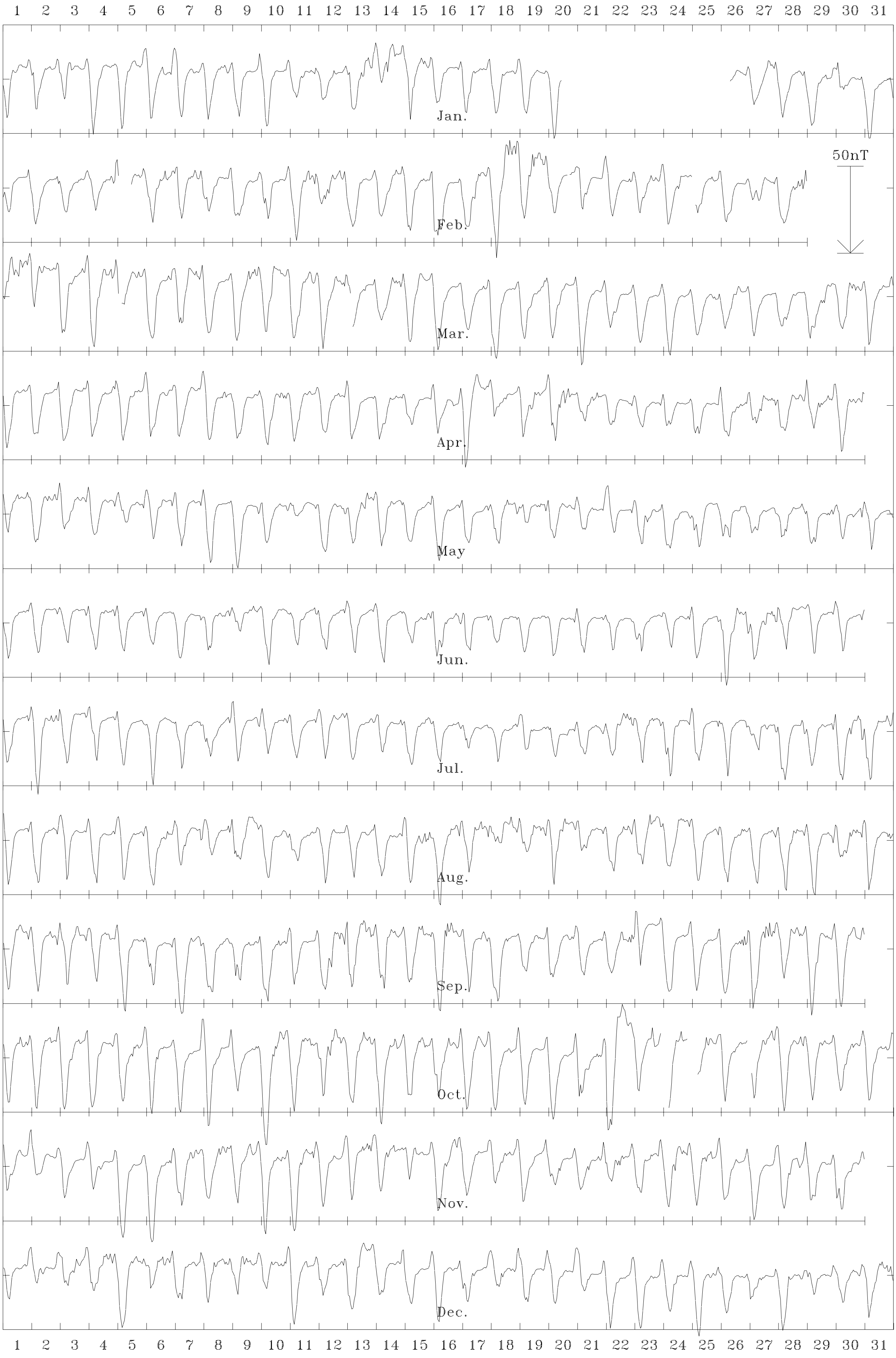
Kakadu, NT 1999 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 35432 nT



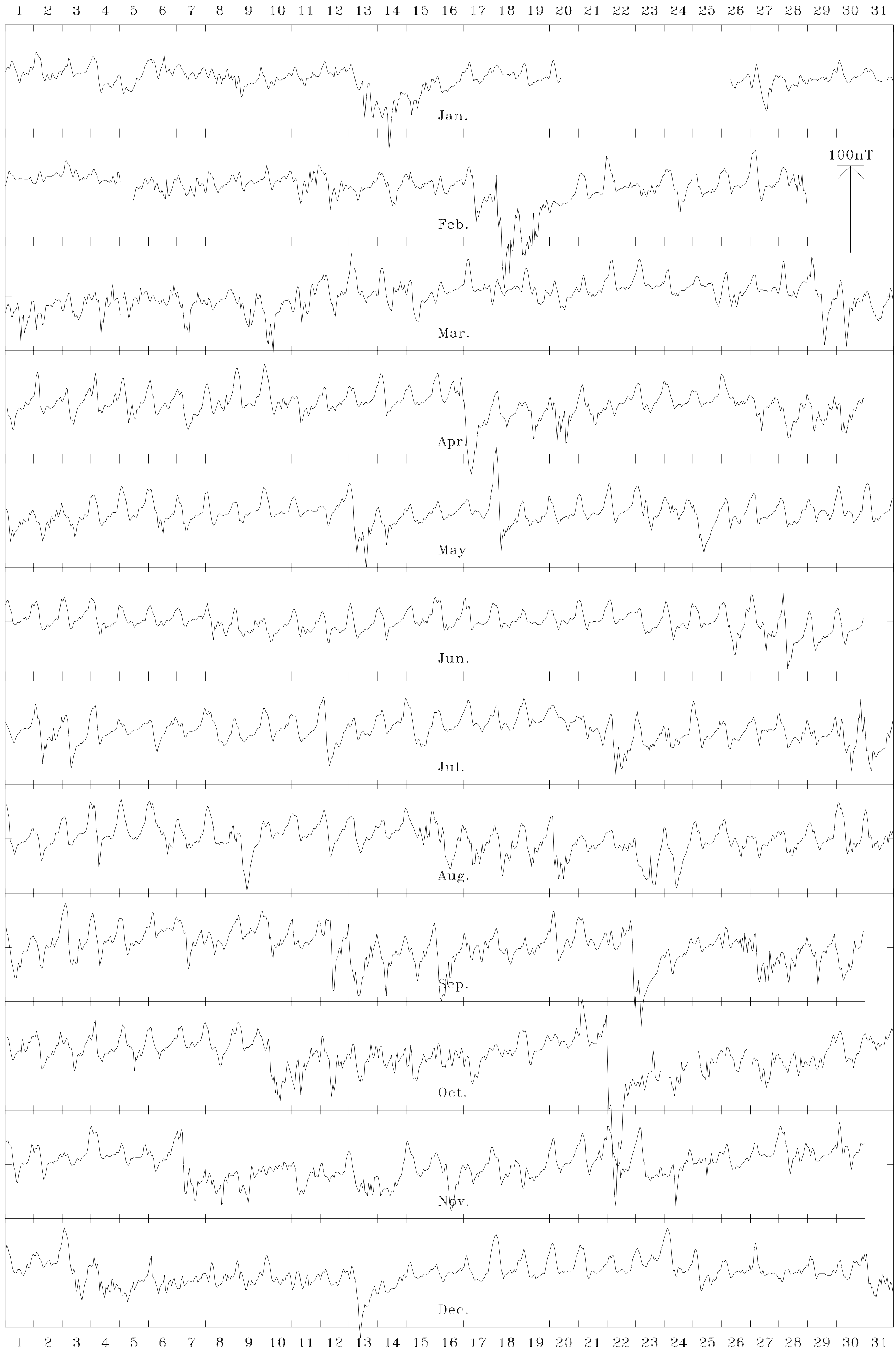
Kakadu, NT 1999 Declination (east) (D). Scale: 0.50 min/mm. Mean: 3.74 deg.

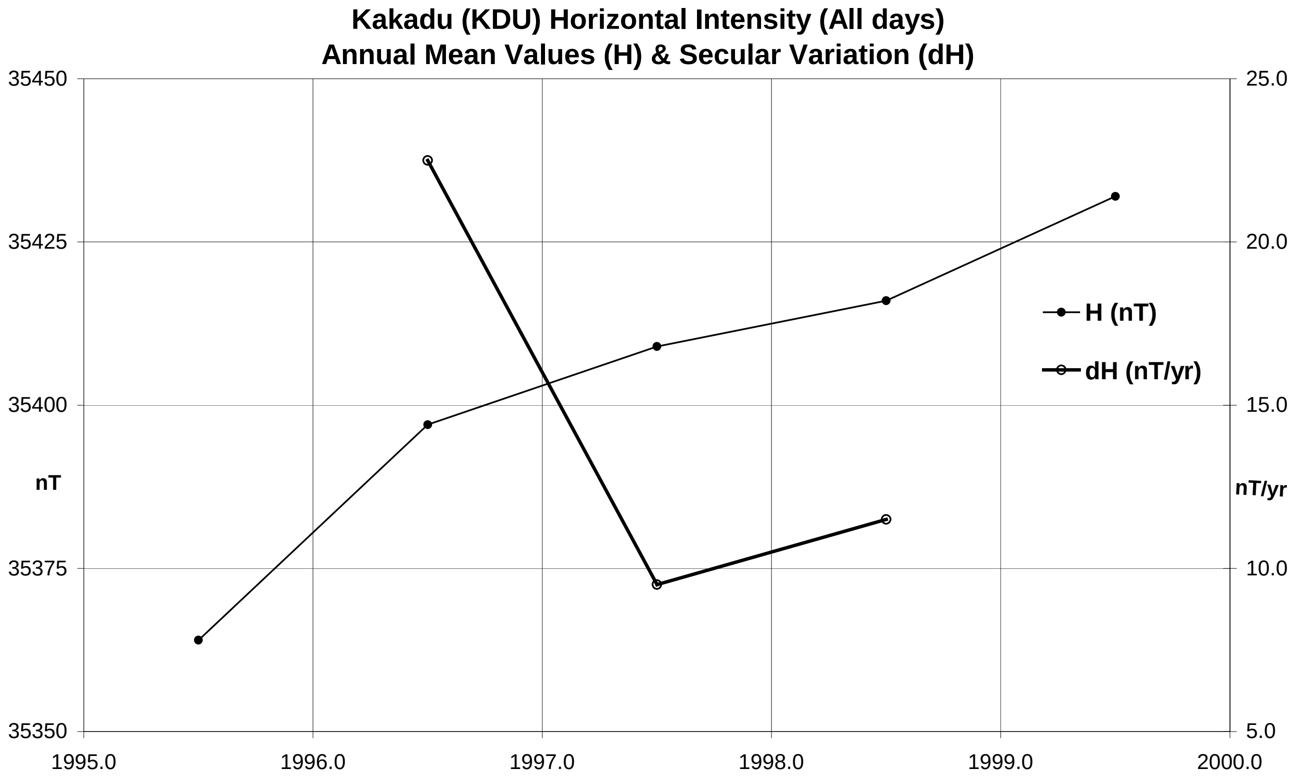


Kakadu, NT 1999 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: -30216 nT

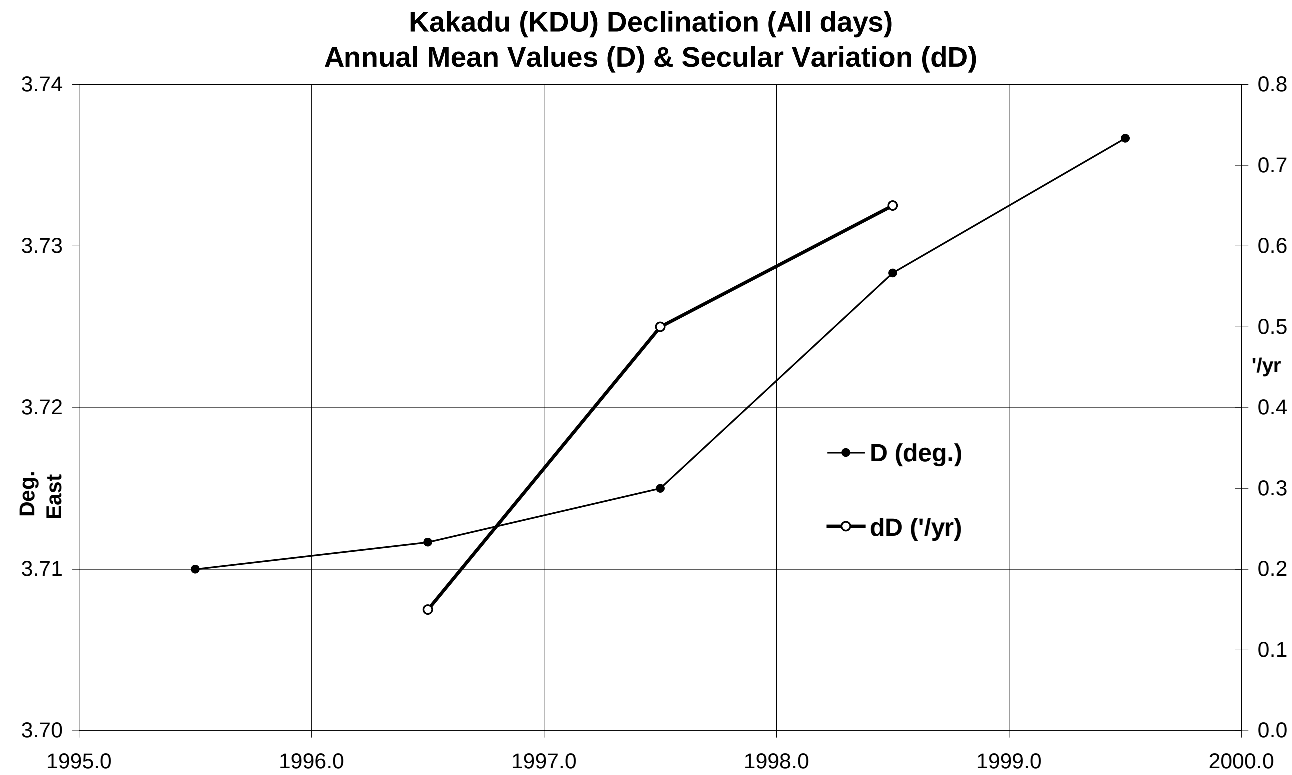


Kakadu, NT 1999 Total intensity (F). Scale: 6.0 nT/mm. Mean: 46566 nT

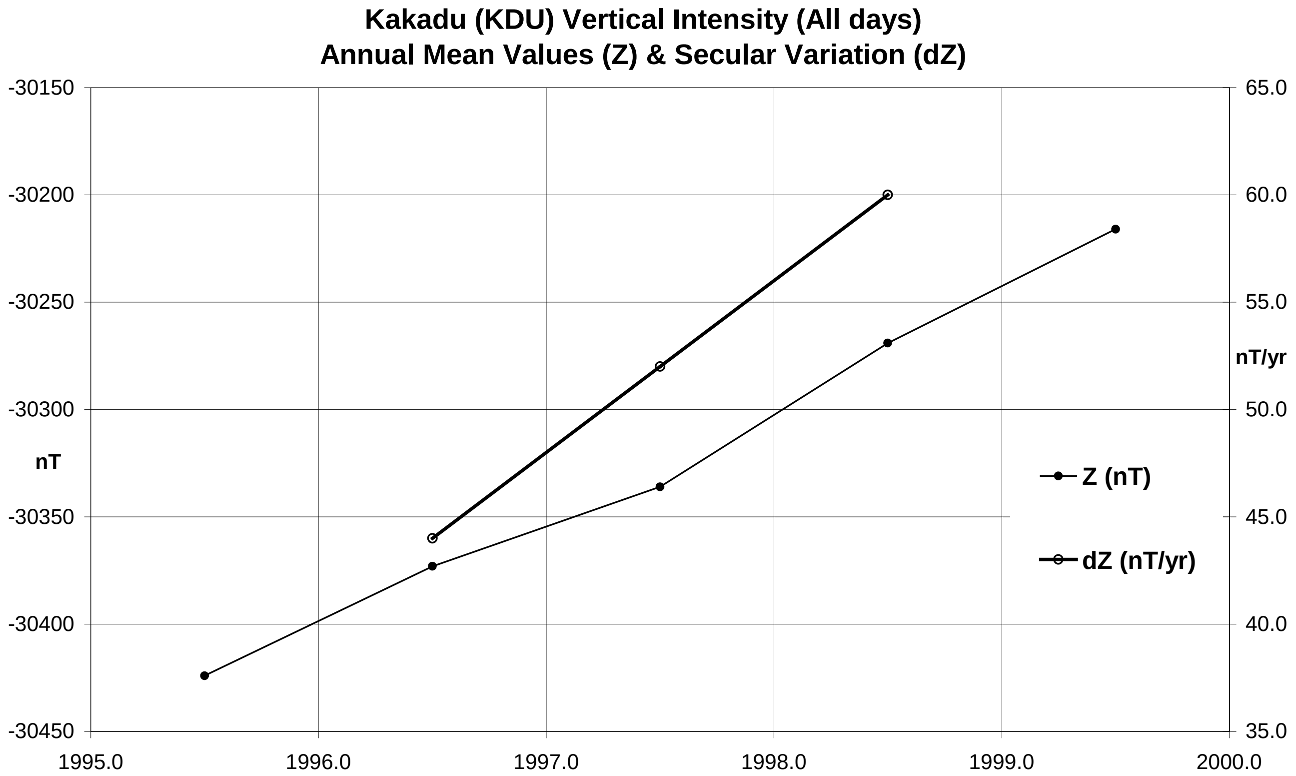


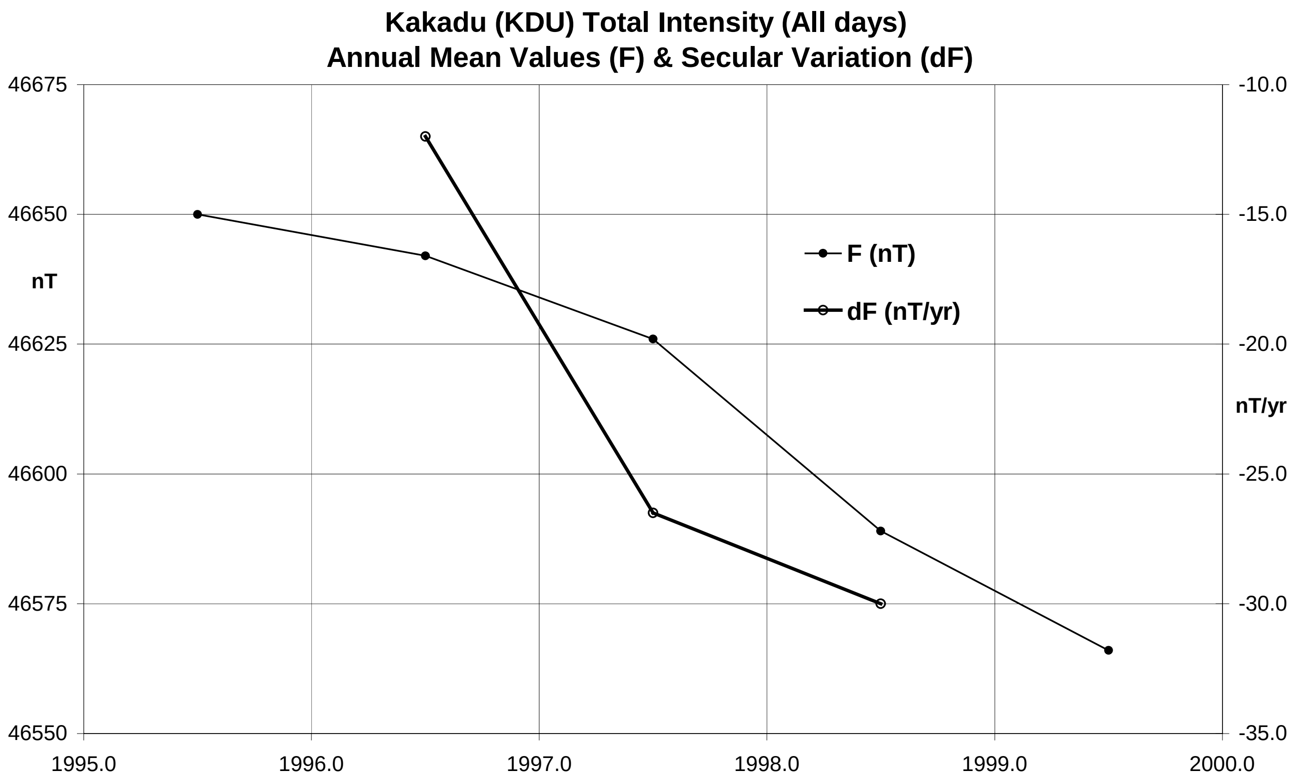


Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
35450
35425
35400
35375
35350
nT
25.0
20.0
15.0
10.0
5.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
H (nT)
dH (nT/yr)



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


Kakadu (KDU) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-30150
-30200
-30250
-30300
nT
-30350
-30400
-30450
65.0
60.0
55.0
nT/yr
50.0
45.0
40.0
35.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
Z (nT)
dZ (nT/yr)


Kakadu (KDU) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
46675
46650
nT
46625
46600
46575
46550
-10.0
-15.0
-20.0
nT/yr
-25.0
-30.0
-35.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
F (nT)
dF (nT/yr)