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MAGNETIC OBSERVATORIES

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Department Minister: The Hon. Ian Macfarlane MP
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Department Secretary: Mark Paterson

Geoscience Australia

Chief Executive Officer: Dr Neil Williams

Geospatial and Earth Monitoring Division

Chief of Division: Dr Chris Pigram

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G.P.O. Box 378
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Australian Government

Geoscience Australia

Magnetic results for 2005

Kakadu

Charters Towers

Learmonth

Alice Springs

Gnangara

Canberra

Macquarie Island

Casey

Mawson

– and –

Australian Repeat Station Network

Compiled and edited by P.A. Hopgood

with contributions by

A.M. Lewis, P.G. Crosthwaite, L. Wang

and N. Bartzis

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SUMMARY

During 2005 Geoscience Australia operated geomagnetic observatories at **Kakadu** and **Alice Springs** in the Northern Territory, **Charters Towers** in Queensland, **Learmonth** and **Gnangara** in Western Australia, **Canberra** in the Australian Capital Territory, **Macquarie Island**, Tasmania, in the sub-Antarctic, and **Casey** and **Mawson** in the Australian Antarctic Territory.

The operations at Macquarie Island, Casey and Mawson were the joint responsibility of the Australian Antarctic Division of the Commonwealth Department of the Environment and Heritage and GA.

The absolute magnetometers in routine service at the Canberra Magnetic Observatory also served as the Australian Reference. The calibration of these instruments can be traced to International Standards and reference instruments. Absolute magnetometers at all the other Australian observatories are referenced against those at Canberra

Magnetic mean value data at resolutions of 1-minute and 1-hour were provided to the World Data Centres for Geomagnetism at Boulder, USA (WDC-A) and at Copenhagen, Denmark (WDC-C1), as well as to the INTERMAGNET program. K indices, principal magnetic storms and rapid variations were scaled with computer assistance, for the Canberra and Gnangara observatories. The scaled data were provided regularly to the International Service of Geomagnetic Indices. K indices were digitally scaled for the Mawson observatory.

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

During a field survey in November 2005 the magnetic repeat station at Weipa in NE Australia and those at Norfolk Island and Lord Howe Island in the SW Pacific were re-occupied.

The Indonesian observatories at Tangerang and Tondano were most recently upgraded by GA's Geomagnetism personnel in 2001 under an AusAID grant that also included the purchase of instrumentation and the training of staff from Indonesia's national meteorological and geophysical organisation, Badan Meteorologi & Geofisika (BMG). To assist the geomagnetism program in Indonesia, data were routinely received from the Tondano observatory for processing. (No usable data were received from Tangerang in 2005.)

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 2005.

ACRONYMS and ABBREVIATIONS

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

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CONTENTS (continued)

Part 2

End of Part 2

The *Australian Geomagnetism Report* has been published in electronic format since Volume 47 for calendar year 1999.

These volumes are available on Geoscience Australia's web site: http://www.ga.gov.au/

The final volume that was produced in printed format was the *Australian Geomagnetism Report 1998,* Volume 46.

Part 1

ACTIVITIES and SERVICES

Geomagnetic Observatories

The Geomagnetism Project of Geoscience Australia (GA) operated nine permanent geomagnetic observatories in the Australian region during 2005. The observatories were, in order of latitude, located at:

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

Antarctic Operations

Geoscience Australia continued its contribution to the Australian National Antarctic Research Expedition (ANARE) in 2005 by the operation of a magnetic observatory at Macquarie Island (Tasmania) in the sub-Antarctic and observatories at Casey and Mawson in Antarctica. GA's operations at these three observatories were supervised and managed from GA headquarters in Canberra, where the observers were trained. Logistic support was provided by the Australian Antarctic Division, Department of the Environment and Heritage.

Magnetic repeat station network

GA maintains a network of magnetic repeat stations throughout continental Australia, its offshore islands, Papua New Guinea and some islands in the south-west Pacific Ocean. The repeat stations have occupied at intervals of between one and two years to determine the secular variation of the magnetic field. In recent times this interval has increased to between two and four years.

During a field survey in November 2005 repeat stations at Weipa in northern Queensland and at Norfolk and Lord Howe Islands in the SW Pacific were re-occupied.

Calibration of compasses

During 2005 GA continued to provide a service for the calibration and testing of direction finding (and other) instrumentation at cost recovery rates. The service was used throughout the year by agencies requiring the calibration of compasses and compass theodolites as well as the determination of magnetic signatures of other equipment.

National Magnetometer Calibration Facility

In collaboration with the Australian Department of Defence a purpose-designed NATIONAL MAGNETOMETER CALIBRATION FACILITY building was constructed in the south-east of the Canberra Magnetic Observatory compound in 1999. The construction, installation and initial calibration of a Finnish/Ukrainian designed large 3-axis coil system was completed in December of that year.

The facility is routinely used for the calibration of observatory variometers as well as for clients' instrumentation on a cost recovery basis.

Indonesian Observatories

Funded by AusAID, between 1998 and 2001 Geoscience Australia undertook work to assist in the upgrade of the Indonesian geomagnetic observatories at Tangerang (TNG) near Jakarta on Java and Tondano (TND) near Manado on Sulawesi. The AusAID grant also included the cost of instrumentation (that was purchased in 2000) and the training at GA of staff from Indonesia's BMG.

As a result of this project it is now possible to transmit absolute observation and variometer data to GA from these Indonesian observatories for routine processing. This continued in 2005, enabling assistance to be provided to the Indonesian geomagnetism program. Due to equipment failures and insufficient resources no data were received from TNG in 2005.

The Indonesian data will also complement data gained during repeat station occupations to enhance AGRF models.

DATA DISTRIBUTION

During 2005 data from GA's observatory network were routinely provided in support of international programs.

Data from all the observatories were automatically retrieved to GA in Canberra daily or more frequently, where they were processed and made available on the GA web site.

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, preliminary 2005 monthly mean values from all Australian observatories were provided by e-mail to IPGP, France.

Storms and Rapid Variations

Details of storms and rapid variations at Canberra and Gnangara during 2005 were provided monthly to:

- National Oceanic and Atmospheric Administration, USA.
- WDC C2, Kyoto, Japan
- Ebro Observatory, Spain

Indices of Magnetic Disturbance

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

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

During 2005, K indices for CNB were provided semi-monthly to the GeoForschungsZentrum (Potsdam, Germany) for the derivation of global geomagnetic activity indicators such as the 'planetary' Kp index.

K indices for CNB were also provided to:

- CLS, CNES (French Space Agency), Toulouse, France.
- Royal Observatory of Belgium, Brussels.
- Geomagnetism Research Group of the British Geological Survey (BGS).
- University of Newcastle, Australia.

K indices for CNB and GNA were provided to:

- The International Service of Geomagnetic Indices (ISGI), France, for the compilation of the 'antipodal' aa index and the world-wide 'mondial' am index.
- IPS Radio and Space Services, Sydney, from where they were further distributed to recipients of their bulletins and reports.

Throughout 2005 all routine K index information was sent by e-mail.

Until the end of November 2002 K indices for Canberra and Gnangara were derived by the hand scaling of H and D traces on magnetograms (with a scale of 3nT/mm and 20mm/hr.) produced from the digital data, using the method described by Mayaud (1967).

From 01 December 2002 for Canberra and Gnangara, and from 2005 for Mawson, the K indices were derived using a computer assisted method developed at GA. The method uses the linear-phase, robust, non-linear (LRNS) smoothing algorithm (Hattingh et al. 1989) to produce an estimate of the quiet or 'non-K' daily variation. This initial curve is then manipulated on a computer screen using a spline fitting technique that allows the observer to create what is considered a better estimate of the non-K variations. The estimate of the non-K variation curve for the day is automatically subtracted from the magnetic variations which are then scaled for K indices.

Distribution of mean magnetic values

During 2005 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 all observatories operated by GA in **2004** were provided (including via the other WDCs) to WDC-A, Boulder USA; WDC-C1, Copenhagen, and the Paris INTERMAGNET GIN.

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.

INTERMAGNET

Data from INTERMAGNET observatories were routinely e-mailed to the Edinburgh GIN as shown in the following table.

Data from Australian magnetic observatories have been contributed to the INTERMAGNET project (see Trigg and Coles, 1994) since the first CDROM of definitive data was produced. The following table summarises Australian data that have been distributed on INTERMAGNET CDROMs. This reflects the continuing incorporation of Australian observatories into the INTERMAGNET project. The commencement of regular transmission (by e-mail) of preliminary near real-time 1-minute data to an INTERMAGNET GIN (Edinburgh), and the frequency of data transmission is also shown in the table.

Magnetic Observatory	Data on CDROM	Transmission began	Transmission periodicity
Kakadu	from 2000	Aug. 2001	Daily to 22 Sep., 2005 then real-time
Charters Towers	from 2000	Aug. 2001	Daily to 01 Sep., 2005 then real-time
Learmonth	from 2005	23 Aug. 2005	Daily to 20 June, 2005 then real-time
Alice Springs	from 1999	Dec. 1999	Daily
Gnangara	from 1994	early 1995	Daily
Canberra	from 1991	Oct. 1994	Daily to 01 Sep., 2005 then real-time
Macquarie Is.	from 2001	Jun. 2002	Daily to 02 June, 2005 then real-time
Mawson	from 2005	24 Nov. 2005	Daily to 15 Dec., 2005 then real-time

Australian Geomagnetism Report series

Beginning publication as the monthly ***Observatory Report*** in September 1952, the series was renamed the ***Geophysical Observatory Report*** in January 1953 (Vol.1 No. 1). Continuing as a monthly report, in January 1990 (Vol. 38 No. 1) the series was renamed the ***Australian Geomagnetism Report***. With the same title the monthly series was replaced by the annual report in 1993 (Vol. 41). Details of other reports containing Australian geomagnetic data are in the *AGRs 1995* and *1996*.

The current annual series includes data from the magnetic observatories, variation stations and repeat stations operated by Geoscience Australia†, or in which the latter had significant involvement. Detailed information about the instrumentation and the observatories was included in the *AGRs 1993* and *1994*.

The last report that was produced and distributed in printed format was *AGR 1998*. Beginning with *AGR 1999*, the report has only been available on GA's web site, from where it may be viewed and downloaded.

World Wide Web

Australian Geomagnetic information is available via the Internet through Geoscience Australia's web site:

http://www.ga.gov.au

Regularly updated data and indices from Australian observatories and the current AGRF model, together with information about the Earth's magnetic field, are available on the Geomagnetism Project web pages.

† On 13 August 1992, the Bureau of Mineral Resources, Geology and Geophysics (BMR) was renamed the Australian Geological Survey Organisation (AGSO). References to BMR relate to the period before the name change, and references to AGSO relate to the period after the name change. On 7 August 2001 the Australian Geological Survey Organisation was renamed AGSO−Geoscience Australia, which, when amalgamated with the Australian Surveying and Land Information Group (AUSLIG) on 8 November 2001, became simply Geoscience Australia (GA).

During 2005 the basic system used at Australian observatories to monitor magnetic fluctuations comprised an orthogonal three component variometer, in combination with a Proton Precession Magnetometer (PPM) or Overhauser Magnetometer that measured the magnetic total 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 intensity readings and those derived from the 3-component variometer. In the event of one channel of the three-component variometer becoming unserviceable, the other two channels with the total intensity can be used to synthesize the missing data.

Data produced at observatories were recorded digitally with the capability of remote data recovery to GA, Canberra, by dial-up telephone lines or network connections.

Intervals of Recording and Mean Values

The standard recording time interval was 1-second for 3-component variometer data and 10-seconds for total intensity data. 1-minute values were derived by averaging all 1-second samples from the 3-component variometer, and all 10-second samples from the PPM, that fell within the 1-minute intervals. The 1-second, 10-second and 1-minute values were all recorded, the higher frequency data being valuable in the computation of baselines and other variometer parameters.

The 1-minute means were centred on the UT minute, eg. the first value *within* an hour, labelled 01^m, was the mean over the interval from 00^m30^s to 01^m30^s, in accordance with IAGA resolution 12 adopted at the Canberra Assembly in December 1979. Hourly mean values were computed from minutes 00^m to 59^m, eg. the hourly mean value labelled 01^h, was the mean of the 1-minute means from 01^h00^m to 01^h59^m inclusive. Daily means were the average of hourly mean values 00^h to 23^h.when all hour means in the day existed.

The INTERMAGNET filter was applied to the 1-second 2005 KDU, CTA, CNB and MAW data to generate the 1-minute values. A box-filter was applied to the 2005 1-second data from the other observatories to generate 1-minute values.

Monthly means were computed for the 5 International Quiet Days, the 5 International Disturbed Days and all days in the month over as many days in each of the sub-sets that existed.

Annual means were computed from the monthly means for a Quiet Day mean, a Disturbed Day mean and an all day mean, over as many months for which Quiet, Disturbed or all days means existed.

Magnetic Variometers

Variometers that were employed at each of the magnetic observatories during the year are summarised in the following table. Descriptions of these instruments that were given in *Australian Geomagnetism Reports* are shown below:

Narod 3-axis ringcore fluxgate magnetometer:	*AGRs 1993-96*
DMI 3-axis fluxgate magnetometer:	*AGRs 2004-05*
EDA FM105B fluxgate magnetometer:	*AGRs 1993-96*
Elsec 820 PPM:	*AGRs 1993-96*
Geometrics 856 PPM:	*AGRs 1993-96*
GEM GSM90 Overhauser-effect magnetometer:	*AGRs 2004-05*

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 when a total field instrument is also recording variations in F (Crosthwaite, 1992, 1994). The 'non-aligned' configuration has typically been two orthogonal horizontal components each aligned at 45 degrees to the magnetic meridian (i.e. magnetic NW and NE) and a vertical component, although there was a variation† to this at Macquarie Island.

The F-check test (that calculates the difference between F observed and F derived from the three orthogonal components) provides better quality control when the magnitude of the components are similar.

† See the *Variometers* section, under *MACQUARIE ISLAND* in this report.

Data Reduction

By the use of regular absolute observations, parameters were gained to enable the calculation of the geographic X, Y and Z (and so H, D, I and F) components of the magnetic field through an equation of the form:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} S_{XA} & S_{XB} & S_{XC} \\ S_{YA} & S_{YB} & S_{YC} \\ S_{ZA} & S_{ZB} & S_{ZC} \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix} + \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix} + \begin{pmatrix} Q_X \\ Q_Y \\ Q_Z \end{pmatrix} (T - T_S) + \begin{pmatrix} q_X \\ q_Y \\ q_Z \end{pmatrix} (t - t_S) + \begin{pmatrix} D_X \\ D_Y \\ D_Z \end{pmatrix} (\tau - \tau_0)$$

where:
- A, B and C are the near-orthogonal, arbitrarily orientated variometer ordinates;
- matrix [S] combines scale-values and orientation parameters;
- vector [B] contains baseline values;
- vectors [Q] and [q] contain temperature-coefficients for sensors and electronics;
- T and t are the temperatures of the sensors and electronics, while Ts and ts are their standard temperatures;
- vector [D] contains drift-rates with a time origin at τ_0, where τ is the time.

The parameters in [S], [Q] and [q] were determined using the calibration coils at the NATIONAL MAGNETOMETER CALIBRATION FACILITY (see page 1 above) at the Canberra Observatory, while those in [B] and [D] that best fit the absolute observations were determined by multiple linear regressions. (If this technique failed, nominal values were adopted.)

By calculating the total field intensity, F, using the model parameters adopted above, and comparing the result with the recording PPM's readings, a continuous monitor of the validity of the model parameters is available. This is the so-called 'F-check' that is monitored continuously at all observatories with a redundant PPM channel.

Variometers in service at Australian Observatories in 2005

Observatory	Variometer/Serial no. (operational period)	Resolution (nT)	Acquisition interval (sec.)	Components recorded
KDU	DMI FGE fluxgate E0198/S0183	0.1	1, 60	NW, NE, Z†
	GEM Systems GSM90 No. 4071413 / 42185	0.01	10, 60	F
CTA	DMI FGE (ver.G) S0210/E0227	0.1	1, 60	NW, NE, Z†
	Elsec 820 PPM no.139 (At start of year to 02 June 2005)	0.1	10, 60	F
	GEM GSM90 PPM no. 4081420, with sensor 42178 (03 June 2005 to end of year)	0.01	10, 60	F
LRM	DMI s/n E0271/S0237	0.03	1, 60	NW, NE, Z
	Geometrics 856 no. 50708	0.1	10, 60	F
ASP	Narod ring-core fluxgate/9004-3 (until 14 September 2005)	0.025	1, 60	X, Y, Z‡
	DMI suspended fluxgate E306/S261 (from 14 September 2005)	0.032	1, 60	NW, NE, Z
	GEM GSM90 Overhauser total field magnetometer s/n 708729, with sensor 3112370 (until 23 March 2005)	0.01	10, 60	F
	GEM GSM90 Overhauser total field magnetometer s/n 4081419, with sensor 42177 (from 23 May 2005)	0.01	10, 60	F
GNA	EDA FM105B sensor 2887 / electronics 2877	0.2	1, 60	NW, NE, Z†
	Geometrics 856 No.50706 PPM	0.1	10, 60	F
CNB	Narod ring-core fluxgate/9004-2 [Secondary variometer: LEMI 3-axis fluxgate magnetometer]	0.025	1, 60	NW, NE, Z†
	GEM Systems GSM90 / 803810 / sensor 81225	0.01	1, 60	F
MCQ	Narod ring-core fluxgate 9305-1	0.025	1, 60	A, B, C†
	DMI suspended fluxgate FGE no. E290/S250 (secondary)	0.3	1, 60	NW, NE, Z
	Elsec 820M3 PPM no. 140 (primary to 01 June 2005 then secondary instrument)	0.1	10, 60	F
	GEM Systems GSM90 / no.4081418 / sensor no.42176 (primary from 02 June 2005)	0.01	10, 60	F
CSY	EDA FM105B fluxgate**	0.2	10	X, Y, Z‡
MAW	Narod ring-core fluxgate 9004-1	0.025	1, 60	NW, NE, Z†
	Elsec 820M3 PPM 158 (to 15 December 2005)	0.1	10, 60	F
	GEM GSM90 4081417 / 42175 (from 15 December 2005)	0.01	10, 60	F

* The serial numbers of the EDA fluxgates are in the sequence: control electronics/sensor head.
** The EDAs at Casey (and Davis) were Australian Antarctic Division instruments.
‡ Installed before 1993.
† Recorded components A, B & C or (magnetic) NW, NE & Z indicate non-aligned orientation.

Absolute magnetometers

The principal absolute magnetometer combination used to calibrate the variometers at the Australian magnetic observatories during 2005 was a D,I-fluxgate magnetometer (or Declination and Inclination Magnetometer – DIM) that measured the magnetic field direction, complemented by a PPM to measure the total field intensity. At some observatories, older classical QHMs were still available as backup should the primary instruments have become unserviceable.

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

In 2005 Elsec 810, Bartington MAG-01H and DMI fluxgate Model G sensors and electronics were used together with Zeiss-Jena 020B and 010B non-magnetic theodolites.

Absolute magnetometers that were employed at each of the magnetic observatories during the year are summarised in the table on the next page. Descriptions of these instruments that were given in *Australian Geomagnetism Reports* are:

Declination & Inclination magnetometer:	*AGRs 1994-2000*
Geometrics 816 Proton Precession Mag.:	*AGRs 1994-96*
Elsec 770 Proton Precession Mag.:	*AGRs 1994-96*
Elsec 820 PPM:	*AGRs 1993-96*
Austral PPM:	*AGRs 1995-96*

Offset Method

The *offset method* of performing DIM observations was used at some observatories during 2005. This involved setting the theodolite to a whole number of minutes, resulting in a non-zero fluxgate output, followed by a series of eight fluxgate vs. time readings being recorded without moving the theodolite.

Absolute Magnetometers employed in 2005

Observatory	Magnetometer Type: Model/Serial no.	Elements	Resolution
KDU	DIM: Bartington MAG010H/B0622H; Zeiss 020B/359142* PPM: GEM Systems GSM90 No.4081421/42186	D, I F	0.1' 0.01 nT
CTA	DIM: DMI DI0036; Zeiss 020B/394050* PPM: GSM90 3091318; sensor 91472	D, I F	0.1' 1 nT
LRM	DIM: Bartington 0702H; Zeiss 020B/312714* PPM: GEM GSM90_3091316 sensor 761100 (from 25 June 2004)	D, I F	0.1' 0.01 nT
ASP	DIM: DMI DI0052; Zeiss 020B/313887* (from 28 January 2005) Overhauser total field magnetometer: GEM GSM-90 s/n 2101216, sensor 306403	D, I F	0.1' 0.01 nT
GNA	DIM: DMI DI0037; Zeiss 020B/390444* PPM: GEM GSM90 no. 3091317, sensor 91457	D, I F	0.1' 0.01 nT
CNB	DIM: Elsec 810/215; Zeiss 020B/353756* (to 10 Feb. 2005) (Aust. Ref.) DMI DI0048; Zeiss 020B/353756* (from 10 Feb. 2005) (Aust. Ref.) PPM: GSM-90 no.905926, sensor 21867 (Australian Reference)	D, I F	0.1' 0.1 nT
MCQ	DIM: Elsec 810/214; Zeiss 020B/311847* DMI DI0045; Zeiss 020B/393911* (secondary) PPM: GSM90 no. 3091319, sensor 01504 Austral no. 525 (secondary) QHM Nos. 177‡, 178, 179 (secondary)	D, I " F " H, D	0.1' " 0.01 nT 1 nT 0.1 nT
CSY	DIM: Elsec 810/2591; Zeiss 020B/356514*† (to 13 Jan. 2005) DMI DI0051; Zeiss 020B/313888* (from 14 Jan. 2005) PPM: Geometrics 816/766 (to 13 Jan. 2005) GEM GSM90_4081416 sensor 42172 (from 14 Jan 2005)	D, I " F "	0.1' " 1 nT 0.01 nT
MAW	DIM: DMI D26035; Zeiss 020B/311542* (primary, used weekly) DMI DI0022; Zeiss 020B/353758* (backup, used monthly) PPM: GEM GSM90_3091315/91378 (primary, used weekly) Elsec 770_210 (backup, used weekly)	D,I " F "	0.1' " 0.01 nT 1 nT

* DIM serial numbers are in the sequence DIM control module followed by Zeiss theodolite
† The DIM at Casey is an Antarctic Division instrument.
‡ QHM 177 was not sighted during a service visit to MCQ in March 2003.

Reference Magnetometers

BMR/AGSO/GA has always maintained reference magnetometers for Declination and Total Magnetic Intensity. Since the late 1970s these absolute magnetometers have been held at the Canberra Magnetic Observatory where they were in routine service for the calibration of variometers there. During 1993 a Declination and Inclination magnetometer (DIM) replaced classical magnetometers as the primary Declination and Inclination reference for Australia. (Details of the magnetometers that served this purpose prior to 1993 are in *AGR*s *1993-1997*.) The adoption of a DIM as the Inclination reference has eliminated the requirement for frequent QHM calibrations, at the Rude Skov magnetic observatory in Denmark, to maintain an accurate Horizontal Intensity, H, reference. This has enabled the more rapid adoption of final instrument corrections.

Proton precession magnetometer MNS2 no.3 served as the Total Intensity (F) reference from the late 1970s until 2000. In January 1995 its crystal oscillator frequency was found to be 13.4ppm below the (CODATA 1986) value recommended by IAGA for use from 1992. This resulted in F readings at Canberra that were theoretically 0.78nT too high.

This correction was subsequently taken into account when referencing total field absolute instruments deployed at all Australian observatories. The instrument was described in *AGR*s *1994-2000*.

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

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

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

All absolute instruments in use within the Australian observatory network are periodically compared with the Canberra observatory reference magnetometers, although often through subsidiary travelling reference absolute instruments.

An *IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing* takes place at an observatory in the global network approximately every two years. Since the 1994 workshop a delegate from the GA Geomagnetism group has attended these workshops with a set of travelling absolute magnetometers. Magnetometer intercomparisons performed at the IAGA workshops have enabled the Australian Magnetic Reference magnetometers, and so all magnetometers used in the Australian observatory network, to be corrected to international 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 international standards via the Australian Magnetic Reference magnetometers held at Canberra observatory

Data Acquisition

During 2005 data acquisition at all the Australian observatories was computer-based. At the beginning of the year all observatories except CSY (that used AAD's ADAS acquisition system) were using DOS based data acquisition. Data were recorded every second throughout the year at all observatories. One minute means were also recorded at observatories until the new Gdap acquisition system (that does not record 1-minute values) was installed. This system was installed at all observatories except ASP and GNA and CSY in 2005.

The timing of the data acquisition was controlled by the software/operating system clock in the acquisition PCs. As it was possible that the drift rate of a PC's software 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 remotely by instructions from GA, Canberra. At most observatories the PC clocks were kept corrected by synchronizing them with 1-second GPS clock pulses.

ADAM A/D converters were used to convert analogue data, produced by GA's DMI FGE variometers, to digital values for recording on data acquisition PCs.

The Australian Antarctic Division's EDA FM105B variometer at Casey acquired data via their Analogue Data Acquisition System (ADAS).

The Narod ringcore fluxgate magnetometers have in-built A/D converters that provided digital data direct to the acquisition PCs.

Digital data have been retrieved automatically from the observatories each day since March 1996. In 2005 the data from the observatories were retrieved on demand by modems: via: telephone lines within Australia; ANARESAT satellite link from Antarctica, directly to GA headquarters in Canberra; or TCP/IP network connections.

Ancillary Equipment

Uninterruptible Power Supplies (UPS) and lightning surge filters were installed at most observatories during 2005.

MAGNETIC OBSERVATORIES

The locations of the observatories are shown on the cover page of this *Australian Geomagnetism Report* (the figure in the *REPEAT STATION NETWORK* section of this *AGR* also shows the mainland observatories) 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 calendar year 2005.

Australian Magnetic Observatories: 2005

Observatory	IAGA code	Year begun	Geographic Coordinates Latitude S	Geographic Coordinates Longitude E	Geomagnetic† Lat.	Geomagnetic† Long.	Elev'n (m)	Observer in Charge
Kakadu	KDU	1995	12° 41' 11"	132° 28' 20"	-21.89°	205.62°	15	R. Lynch
Charters Towers	CTA	1983	20° 05' 25"	146° 15' 51"	-27.87°	220.96°	370	J.M. Millican
Learmonth	LRM	1986	22° 13' 19"	114° 06' 03"	-32.26°	186.47°	4	G.A. Steward O.D. Giersch
Alice Springs	ASP	1992	23° 45' 40"	133° 53' 00"	-32.75°	208.18°	557	W. Serone S. Evans
Gnangara	GNA	1957	31° 46' 48"	115° 56' 48"	-41.74°	188.85°	60	O. McConnel H. VanReeken
Canberra	CNB	1978	35° 18' 53"	149° 21' 45"	-42.51°	226.91°	859	L. Wang
Macquarie Is.	MCQ	1952	54° 30'	158° 57'	-59.87°	244.15°	8	S. Redfern B. Copley
Casey	CSY	1999*	66° 17'	110° 32'	-76.36°	184.01°	40	C. Clarke T. Taylor
Mawson	MAW	1955	67° 36' 14"	62° 52' 45"	-73.11°	110.35°	12	G. Roser M. Leayr D. Taylor

† Geomagnetic coordinates are based on the 2005.0 International Geomagnetic Reference Field (IGRF) model updated to 2005.5 with magnetic north pole position of 79.765°N, 288.197°E.

* From 1988 to 1999 absolute calibrations of the variometers at Casey were considered insufficient for observatory standard. From 1975 to 1987 no magnetic variometers operated at Casey: only monthly absolute observations were performed. (Further details in the Casey section of this report)

KAKADU OBSERVATORY

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

The observatory comprises:

- a 3m x 3m air-conditioned concrete-brick CONTROL HOUSE, with concrete ceiling and aluminium cladding and roof, where all recording instrumentation and control equipment is housed;
- a 3m x 3m roofed ABSOLUTE SHELTER, 50m NW of the CONTROL HOUSE, that houses a 380mm square fibre-mesh-concrete observation pier (Pier A), the top of which is 1200mm from its concrete floor;
- two 300mm diameter azimuth pillars that are both about 100m from Pier A at approximate true bearings of 27° and 238°;
- two 600mm square underground vaults that house the variometer sensors, both located 50-60m from the CONTROL HOUSE, one to its SSW and one to its WSW. Cables between the sensor vaults and the CONTROL HOUSE are routed via underground conduits.
- a concrete slab, with tripod foot placements and a 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 Kakadu Observatory:

- 3-character IAGA code: KDU
- Commenced operation: 05 March 1995
- Geographic‡ latitude: 12° 41' 10.9" S
- Geographic‡ longitude: 132° 28' 20.5" E
- Geomagnetic† : Lat. -21.89°; Long. 205.62°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier A
- Elevation of top of Pier A: 14.6 metres AMSL
- Azimuth of principal reference (Pillar AW from Pier A): 237° 52.8'
- Distance to Pillar AW: 99.6 metres
- Observer in Charge: Rory Lynch

‡ Geodetic Datum of Australia 1994 (GDA 94)
† Based on the IGRF 2005.0 model updated to 2005.5

Variometers

Variations in the magnetic-NW, magnetic-NE and vertical components of the magnetic field were monitored at Kakadu in 2005 using a suspended 3-axis linear-fluxgate DMI FGE magnetometer (no. E0198 with sensor no. S0183).

The magnetic field total intensity, F, was monitored using a GEM Systems GSM90 Overhauser-effect magnetometer (no. 4071413, sensor no. 42185).

A DOS data acquisition system was used at KDU until 22 September 2005. Timing on the DOS computer was corrected for drift using the 1 pulse per second output of a Trimble Acutime GPS clock. Absolute timing was checked by telephone daily.

On 22 September 2005, shared IP communications with the GA seismic data acquisition system became available and magnetic data acquisition was changed to a Posix-compliant QNX OS system. Timing on the QNX computer was continuously corrected using both the 1 PPS output and the absolute time code output of the same clock.

Analogue variometer outputs from the three fluxgate channels, together with the fluxgate sensor and electronics temperature channels, were converted to digital data with an ADAM 4017 analogue-to-digital converter mounted inside the fluxgate electronics module. These digital data together with the digital PPM data were recorded on the data acquisition computer. The recording equipment was located in the CONTROL HOUSE.

The magnetic sensors were located in the concrete underground vaults: the fluxgate sensor in the northern vault (the one nearest the ABSOLUTE SHELTER); and the PPM sensor in the southern vault. Both vaults were completely buried in soil to minimise sensor-temperature fluctuations.

The GSM90 variometer electronics was located in the covered vault with its sensor – both DC power and data cables ran between the GSM90 vault and the CONTROL HOUSE.

The fluxgate electronics console was placed in its own partially insulated plastic box, resting on the concrete floor in the CONTROL HUT (not in the vault as mistakenly described in previous reports), with some bricks for heat-sinks to minimise temperature fluctuations. This proved to be effective in reducing the amplitude of temperature fluctuations with periods of the order of hours.

The equipment was protected from power blackouts, surges and lightning strikes by a mains filter, an uninterruptible power supply and a surge absorber. The data connections between the acquisition computer and both the ADAM A/D and the PPM variometer were via fibre-optic modems and several metres of fibre-optic cable to isolate any damage from lightning entering the system through any one piece of equipment.

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

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

Absolute Instruments and Corrections

The principal absolute magnetometers used at Kakadu in 2005 were a declination-inclination magnetometer, DIM: Bartington type MAG010H fluxgate sensor (no. B0622H) mounted on a Zeiss 020B non-magnetic theodolite (no. 359142) and a GEM Systems GSM90 (no. 4081421, with sensor no. 42186) total-intensity magnetometer.

Absolute Instruments and Corrections (cont.)

As described in the *AGR1998*, the best way to use this DIM was to take all readings on the x10 scale, but to switch to the x1 scale while rotating the theodolite. Additionally, the theodolite should be rotated so that the objective lens passes exclusively through positive field values (or alternatively exclusively through negative field values). This method was used at KDU throughout 2005.

DIM observations at KDU were performed using the *offset method* (see *Absolute Magnetometers*, this report) during 2005. All DIM and PPM measurements were made on Pier A at the standard height.

Corrections were applied to the absolute magnetometers used at Kakadu to align them with the Australian reference instruments held in Canberra. The D and I corrections that were applied in 2005 were determined through instrument comparisons performed during a regular maintenance and calibration visit in November 2004, and can be traced through comparisons to B0806H/100846, B0610H/160459, and comparisons at the 2004 IAGA Workshop at Kakioka. The F correction was measured by instrument comparisons and frequency comparisons at Canberra before the instrument was deployed.

The corrections adopted for 2005 for the Kakadu absolute magnetometers were:

B0622H/359142: +0.05′ in D; -0.05′ in I

GSM90_4081421: 0.0nT in F.

These corrections were applied during the determination of baselines. (In previous years, such corrections were applied as a final adjustment to the data, rather than when baselines were determined.)

At the mean magnetic field values at Kakadu these D, I, and F corrections translate to corrections of:

$\Delta X = -0.5nT$ $\Delta Y = +0.5nT$ $\Delta Z = -0.5nT$

These instrument corrections have been applied to the 2005 data in this report.

Baselines

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

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

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

0.4nT in F; 03" in D; 04" in I)

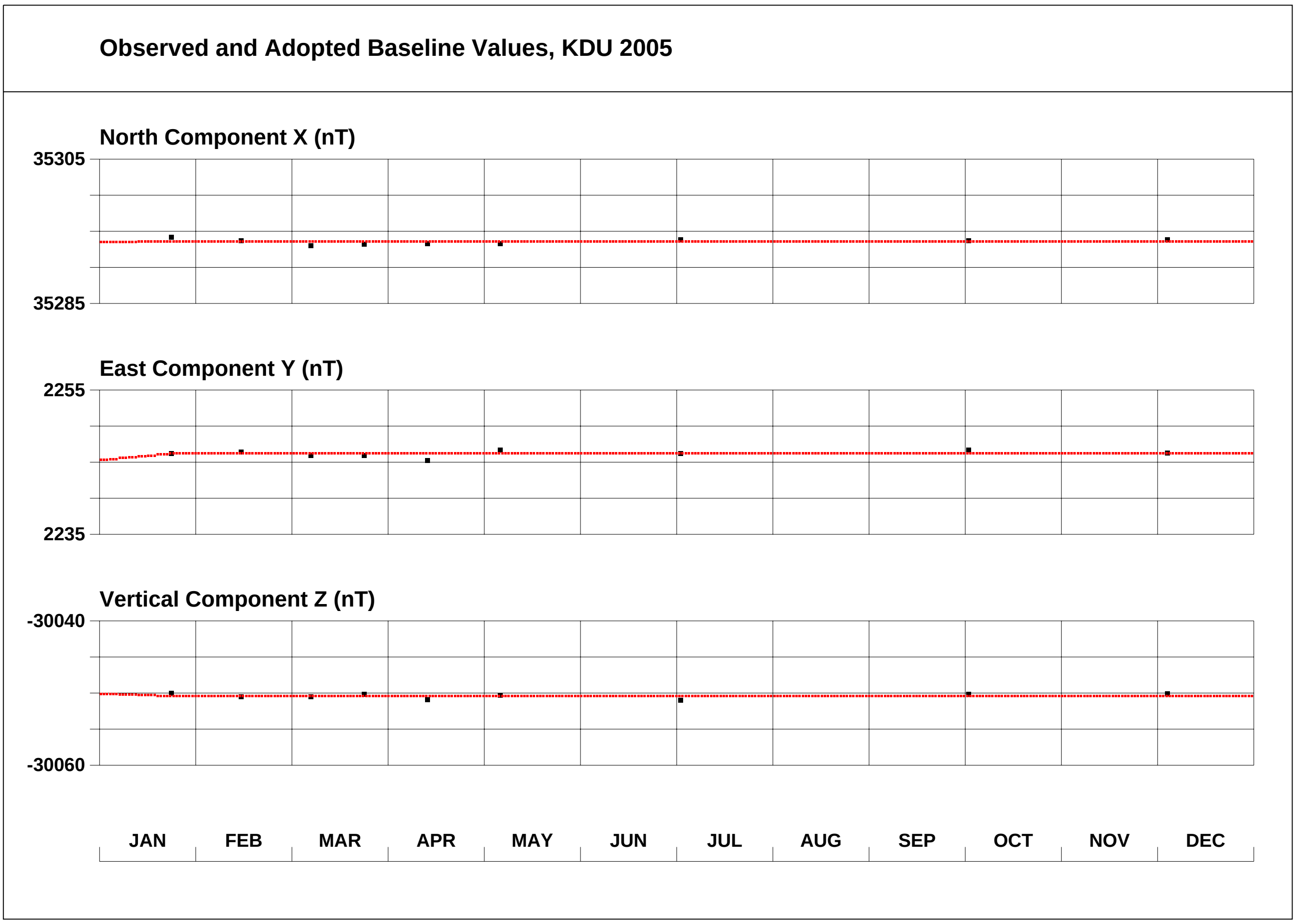
Drifts were applied to 2005 baselines to align 2004 data with the first absolute observation on 23 January 2005 (with the updated adopted instrument corrections applied). The maximum drift was 0.9nT in Y over the interval 01-23 January. No drifts were applied after 23 January 2005.

There were only nine pairs of DIF observations performed during 2005. Two observations were rejected for the purposes of baseline determination.

Throughout the year there was about a ±0.5nT variation in the difference between F determined with the DMI fluxgate (final data model with drifts applied) and the variometer PPM. However this variation was about two metastable states which differed by 1nT. Any daily variation was swamped by the transition between the two states. The variation appeared to be caused by a slow onset change in the DMI FGE magnetometer, taking a few minutes to start and end, and therefore difficult to identify. The change in any vector component appeared to be no more than 1nT.

From May 2005 to February 2006 the difference between the KDU absolute GSM90 proton magnetometer and variometer GSM90 proton magnetometer was consistent to within ±0.3nT. No seasonal variation was noticeable during that period.

Observed and adopted baseline values in X, Y and Z for 2005 are shown in the following (INTERMAGNET format) chart.



Operations

The 2005 local observer (RL) was trained in geomagnetic observations in late 2003, and began observations in January 2004. Due to other commitments, he was unable to make as many observations as is customary at geomagnetic observatories. Fortunately the DMI FGE magnetometer baselines appeared to be exceptionally stable throughout 2005 and the fewer than normal number of observations did not seem to affect the quality of the final data.

The variometer GSM90 PPM failed on 01 March 2005. During a service visit over 11-16 April 2005 a serial line driver was replaced and data flow resumed. Not surprisingly there was a change in the variometer PPM baseline (about 2nT) noticed after the repair.

During a service visit by GA staff (CB & DP) on 22 September 2005 the seismic X25 communications were changed to IP. The DOS magnetic data acquisition system was decommissioned and a QNX magnetic data acquisition system was installed and shared the IP communications link to GA.

1-second and 1-minute mean magnetic data were acquired at the Kakadu observatory during 2005 while the DOS system was in use. 1-second vector and 10-second scalar data were acquired while the QNX system was in use.

DOS system data timing was controlled by the acquisition computer clock, the rate of which was kept accurate with the 1 PPS (not the actual data stream) from a GPS clock. On weekdays the time was checked, and corrected if necessary, via modem from GA. The GPS clock kept the acquisition computer clock within 0.1s of the nearest UTC second; i.e. an error of a whole number of seconds would not be corrected. The clock was 3s fast from 2005-04-12 23:08 to 2005-04-13 02:23, and 1s fast from 2006-04-16 to 2005-04-25 23:33.

QNX system data timing was also controlled by the acquisition computer clock which was maintained using both the 1 PPS and data stream output of a GPS clock. There was a small error around computer resets which was corrected within a few minutes.

Although some lightning protection measures were incorporated in the original construction of the observatory, Kakadu has suffered frequent damage from lightning since its installation in 1995. Further lightning protection measures were taken in December 1998 and again in October 1999. Since then, although power and communications have frequently been interrupted, the observatory has survived *serious* damage from electrical storms.

When possible, absolute observations were performed weekly by the local observer. On these occasions the operation of the observatory was also checked by the observer. Completed absolute observation forms were sent to GA in Canberra by post, where they were reduced and used to calibrate the variometer data.

Data were retrieved from the DOS data acquisition system (until 22 September 2005) daily by standard telephone-line modem connection, usually at 9600 to 14400 baud. Data were retrieved from the QNX data acquisition system (after 22 September) every 10 minutes using *rsync over ssh* in near-real-time using the network connection.

The CONTROL HOUSE containing the variometer electronics was maintained at a temperature of about 23°C. The temperature control unit combined both heating and cooling. The DMI FGE magnetometer electronics temperature was 27.5 ± 0.8 °C during 2005, except during October/November when it rose as high as 33.8°C. The DMI fluxgate electronics temperatures varied with a typical daily variation of less than 0.25°C in January when temperature control was at its best, and 1.5°C in October/November when temperature control was at its worst.

The DMI sensor, although buried underground, varied between 26.7°C and 33.8°C during 2005, in accordance with the seasons in long periods, and probably with the barometric pressure in short periods. Daily variations may have been about 0.25°C.

The DMI FGE magnetometer maintained exceedingly stable baselines throughout 2005 (except for the frequent transitions between the two metastable states).

Late in 2004 and during 2005 and beyond, the DMI FGE variometer showed frequent shifts amounting to 1nT in F, sometimes several times per day. The shift always had the same character: a slow onset and decay of about 5 minutes; always of the same magnitude and sign, and was stable in either the shifted or un-shifted state. The occasional sets of absolute observations in early 2005 that straddled a shift seemed to indicate that no component was shifted by more than 1nT, indicating that the problem was not serious. The shifts began when the GSM90 variometer and new computer were installed during the November 2004 maintenance visit. Although the pre-GSM90 data (Geometrics 856) was much noisier and such shifts not so obvious, no similar shifts were apparent before the visit. The source of this problem was not resolved in 2005.

Significant Events in 2005

Mar 01 ~1000: GSM90 variometer stopped. Possibly affected by lightning occurring around at the time.

Mar 07 Local observer unable to perform absolute observations due to bad weather.

Mar 29 Local observer apparently power cycled the GSM90 variometer over the Easter weekend (25-28 March) but still no valid F data. System restarted at 0543 (29^{th}) to try and resurrect F, but still no valid F data.

Apr 11 Officers from GA's Canberra Network group (TS and JW) tested variometer PPM and COM2 on the acquisition PC.

Apr 12 The executables MACQ, MACQMON, MACQCMD on the PC104 system were replaced and several reboots took place. A backup desktop PC was installed, appropriate executables uploaded; KDU.INI, KDU.BAT were updated. The problem with PPM data remained. The PC104 computer was replaced. Two hours of data lost when the backup computer was installed.

Absolute PPM into ACQ system worked. Tried swapping fibre-modems. Left PC104 PC running but still there were no useful PPM variometer data.

Apr 13 GSM90_4081419 (not sensor 42177) sent to replace GSM90_4071413 in the vault. Fibre modems and B+B 232/422 converter were also sent.

Apr 15 & 16 GA officers (TS and JW) opened PPM vault and replaced electronics. Replacing the B+B 232/422 converter box in the RECORDER HOUSE fixed the problem. The **original variometer PPM was re-installed** followed by several reboots.

May 07 Local observer performed routine (FDI) observations before and after a flip in FCheck at 0237: very little change in DI, 1nT change in F.

Sep 22 Officers from GA's Canberra Network group (CB and DP) installed a router to share x25 seismic and IP geomagnetic data. The DOS system was replaced with QNX6.3 and the monitor replaced. Data now automatically sent to INTERMAGNET in real time. The same TSIP Trimble Acutime clock in use through an interface box.

Nov 27 Data line stopped working.

Dec 02 ~0515: Data line temporarily working again. Confirmation was received that the telephone line was damaged.

Data losses in 2005

Mar 01 1000 to Apr 16/0200 (45d 16h 00m) F channel: Serial line driver damaged during electrical storm.

Apr 11 0639-0802 (1h 24m), 2204-2211 (8m) XYZ channels: Tests being carried out.

Apr 12 0435-0536 (1h 02m), 0538-0606 (29m), 0611 (1m), 0622 (1m) XYZ channels: Maintenance.

Apr 16 0028, 0053, 0133 (3 mins) XYZ channels: Maintenance.

Sep 22 0049–0130 (42m), 0259 (1m) F channel: Maintenance

Box filtered data to fill in missing INTERMAGNET-filtered data in the following periods:

Mar 29 0542–0544

Apr 12 0248–0250, 0610, 0612–0613, 0621, 0623

Apr 16 0027, 0029, 0052, 0054, 0132, 0134

Sep 22 0258–0259

Distribution of KDU data

Preliminary Monthly Means for Project Ørsted

- IPGP monthly (by e-mail)

1-minute and Hourly Mean Values to WDCs

- 2005 data: WDC-A, Boulder, USA (sent in 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh IM GIN by e-mail: daily until 22 Sep. 2005, then in real-time from that date.

2005 Definitive data: to IM Paris GIN (sent in 2006)

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 16 & 17.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts*
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABC
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABC
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABC
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABC
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABC
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABC
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABC
2002.5	A	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	ABC
2003.5	A	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	ABC
2004.5	A	3	43.3	-40	15.7	35429	35354	2299	-30005	46428	ABC
2005.5	A	3	42.2	-40	13.4	35424	35350	2288	-29960	46395	ABC
1995.583	Q	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	ABC
1996.728	Q	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	ABC
1997.455	Q	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	ABC
1998.5	Q	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	ABC
1999.5	Q	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	ABC
2000.5	Q	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	ABC
2001.5	Q	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	ABC
2002.5	Q	3	44.5	-40	18.4	35454	35378	2313	-30074	46491	ABC
2003.5	Q	3	44.2	-40	17.4	35439	35363	2309	-30043	46459	ABC
2004.5	Q	3	43.3	-40	15.0	35441	35366	2301	-30003	46435	ABC
2005.5	Q	3	42.3	-40	12.7	35436	35362	2290	-29959	46403	ABC
1995.583	D	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	ABC
1996.728	D	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	ABC
1997.455	D	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	ABC
1998.5	D	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	ABC
1999.5	D	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	ABC
2000.5	D	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	ABC
2001.5	D	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	ABC
2002.5	D	3	44.5	-40	20.4	35416	35341	2311	-30077	46464	ABC
2003.5	D	3	44.0	-40	19.8	35396	35321	2305	-30050	46431	ABC
2004.5	D	3	43.2	-40	16.9	35407	35332	2297	-30008	46412	ABC
2005.5	D	3	42.2	-40	14.5	35404	35330	2286	-29963	46381	ABC

* Elements ABC indicates non-aligned variometer orientation

Monthly and 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	2005	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	35344.1	2291.0	-29987.0	46407.7	35418.3	3° 42.5'	-40° 15.2'
	5xQ days	35356.3	2293.6	-29985.5	46416.2	35430.7	3° 42.7'	-40° 14.5'
	5xD days	35325.2	2284.5	-29991.6	46396.0	35399.0	3° 42.0'	-40° 16.4'
February	All days	35356.8	2293.7	-29978.9	46412.3	35431.1	3° 42.7'	-40° 14.1'
	5xQ days	35368.1	2295.8	-29977.3	46419.9	35442.5	3° 42.8'	-40° 13.5'
	5xD days	35339.2	2290.5	-29980.5	46399.8	35413.4	3° 42.5'	-40° 15.0'
March	All days	35357.6	2294.2	-29971.9	46408.4	35432.0	3° 42.7'	-40° 13.7'
	5xQ days	35364.9	2294.6	-29971.6	46413.8	35439.2	3° 42.7'	-40° 13.3'
	5xD days	35342.1	2292.4	-29975.4	46398.8	35416.4	3° 42.7'	-40° 14.6'
April	All days	35356.4	2293.2	-29967.0	46404.3	35430.7	3° 42.7'	-40° 13.5'
	5xQ days	35364.3	2293.1	-29964.5	46408.7	35438.6	3° 42.6'	-40° 12.9'
	5xD days	35340.1	2291.5	-29969.8	46393.5	35414.3	3° 42.6'	-40° 14.4'
May	All days	35330.1	2290.0	-29966.9	46384.0	35404.2	3° 42.5'	-40° 14.7'
	5xQ days	35359.5	2291.7	-29963.6	46404.4	35433.7	3° 42.5'	-40° 13.1'
	5xD days	35281.5	2287.6	-29970.8	46349.5	35355.6	3° 42.6'	-40° 17.3'
June	All days	35346.7	2290.8	-29962.1	46393.6	35420.9	3° 42.5'	-40° 13.6'
	5xQ days	35360.5	2290.8	-29959.9	46402.7	35434.6	3° 42.4'	-40° 12.9'
	5xD days	35332.2	2291.6	-29962.9	46383.1	35406.5	3° 42.7'	-40° 14.4'
July	All days	35349.2	2288.7	-29957.7	46392.5	35423.2	3° 42.3'	-40° 13.3'
	5xQ days	35365.7	2290.1	-29955.0	46403.4	35439.8	3° 42.3'	-40° 12.3'
	5xD days	35325.3	2286.8	-29960.5	46376.1	35399.3	3° 42.2'	-40° 14.6'
August	All days	35347.5	2286.6	-29952.9	46388.0	35421.4	3° 42.1'	-40° 13.1'
	5xQ days	35354.7	2287.8	-29951.7	46392.8	35428.7	3° 42.1'	-40° 12.7'
	5xD days	35317.9	2282.4	-29954.3	46366.2	35391.5	3° 41.9'	-40° 14.6'
September	All days	35332.2	2284.2	-29951.5	46375.3	35405.9	3° 41.9'	-40° 13.8'
	5xQ days	35349.8	2286.4	-29949.0	46387.3	35423.7	3° 42.0'	-40° 12.8'
	5xD days	35300.9	2283.4	-29956.1	46354.5	35374.7	3° 42.1'	-40° 15.5'
October	All days	35358.1	2284.8	-29945.6	46391.3	35431.8	3° 41.8'	-40° 12.2'
	5xQ days	35367.3	2286.1	-29944.0	46397.3	35441.1	3° 41.9'	-40° 11.7'
	5xD days	35344.2	2283.5	-29946.7	46381.4	35417.9	3° 41.8'	-40° 12.9'
November	All days	35358.4	2281.9	-29943.7	46390.1	35431.9	3° 41.6'	-40° 12.1'
	5xQ days	35366.1	2283.4	-29941.9	46395.0	35439.8	3° 41.6'	-40° 11.6'
	5xD days	35350.7	2281.3	-29945.3	46385.3	35424.2	3° 41.5'	-40° 12.5'
December	All days	35363.9	2281.5	-29939.6	46391.7	35437.4	3° 41.5'	-40° 11.6'
	5xQ days	35369.4	2281.6	-29939.9	46396.2	35443.0	3° 41.5'	-40° 11.3'
	5xD days	35358.5	2281.3	-29941.0	46388.5	35432.1	3° 41.5'	-40° 11.9'
Annual	All days	35350.1	2288.4	-29960.4	46394.9	35424.1	3° 42.2'	-40° 13.4'
Mean	5xQ days	35362.2	2289.6	-29958.7	46403.1	35436.3	3° 42.3'	-40° 12.7'
Values	5xD days	35329.8	2286.4	-29962.9	46381.0	35403.7	3° 42.2'	-40° 14.5'

(Calculated: 11:32 hrs., Wed. 15 Nov. 2006)

Hourly Mean Values

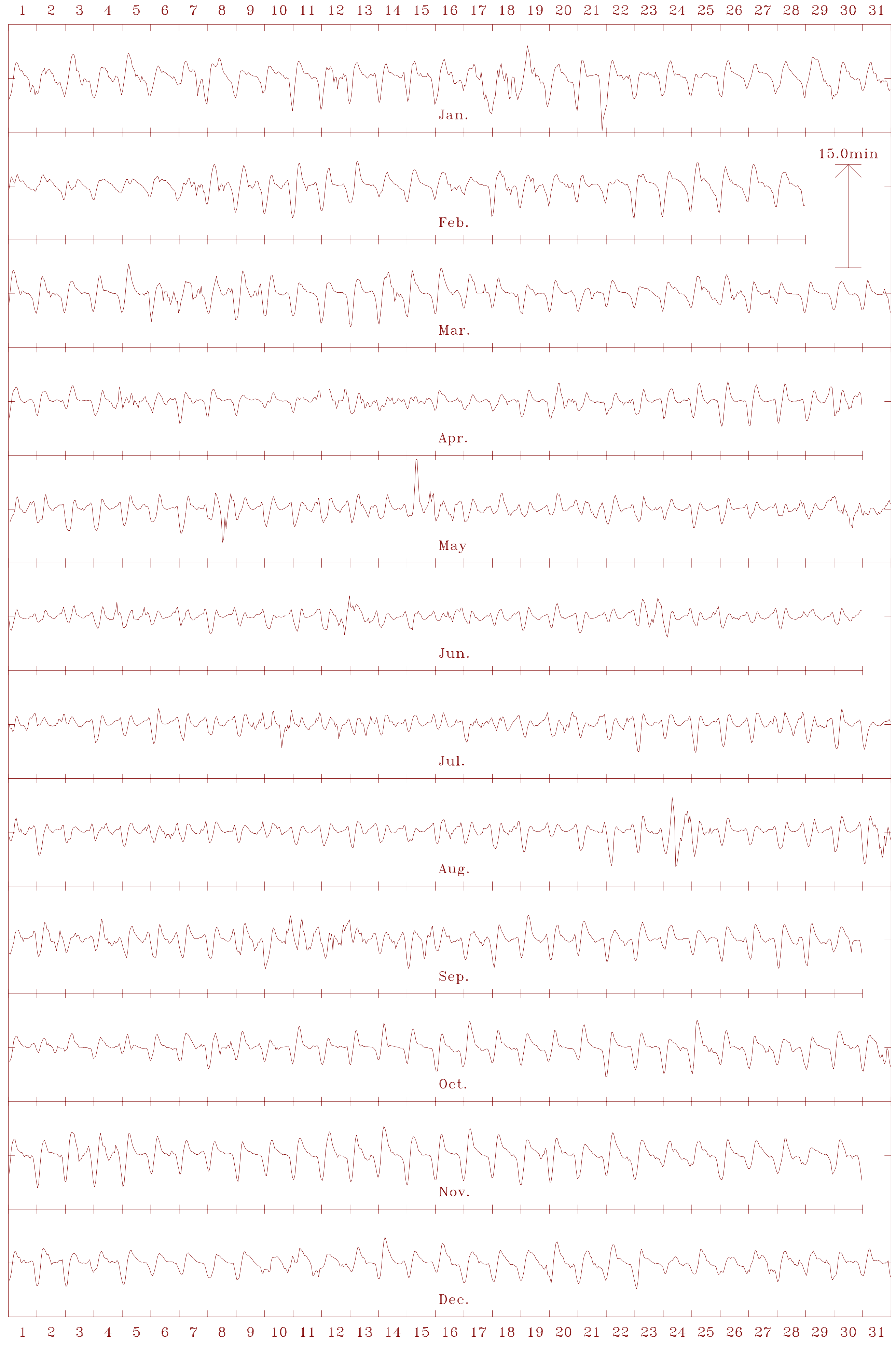
The charts on the following pages are plots of hourly mean values.

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.

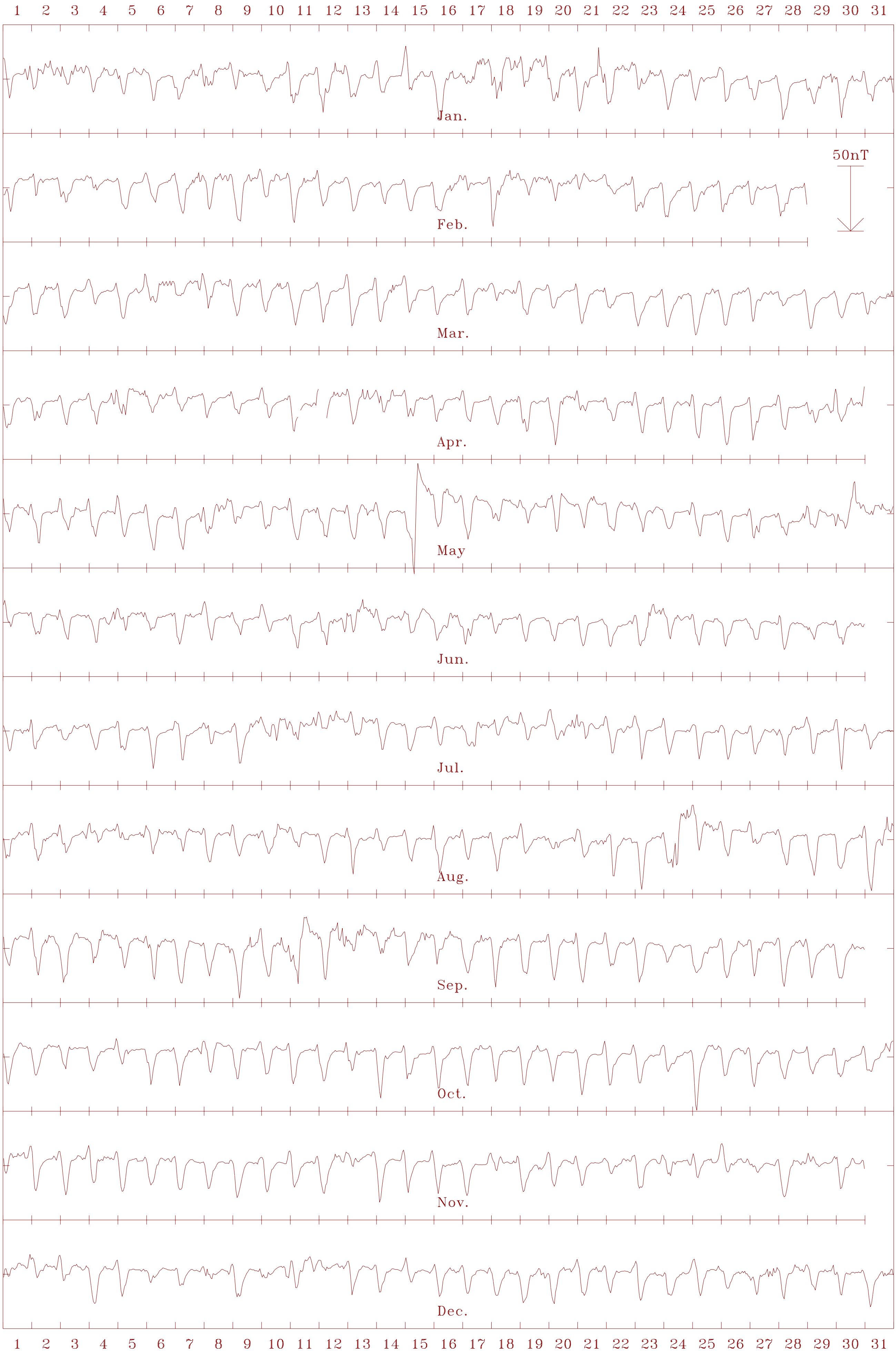
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Kakadu, NT 2005 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 35424 nT

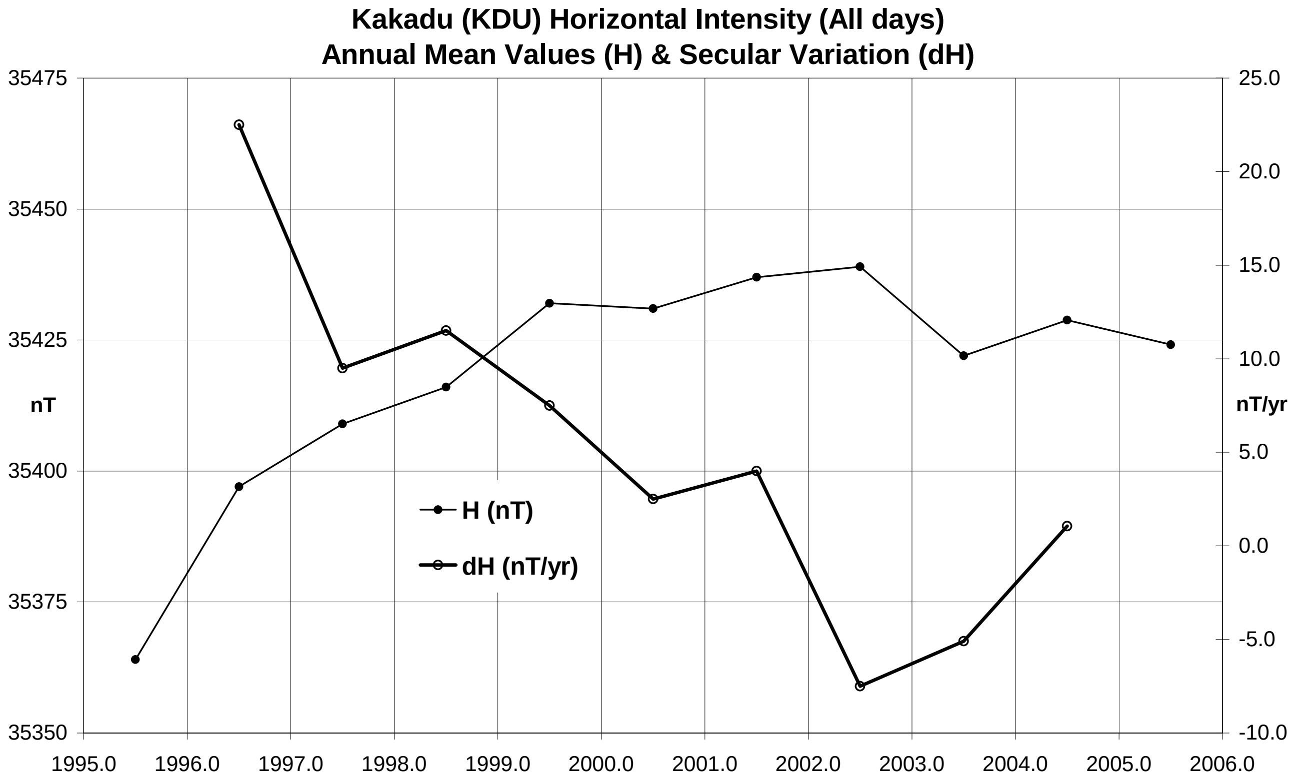
Kakadu, NT 2005 Declination (east) (D). Scale: 0.75 min/mm. Mean: 3.70 deg.

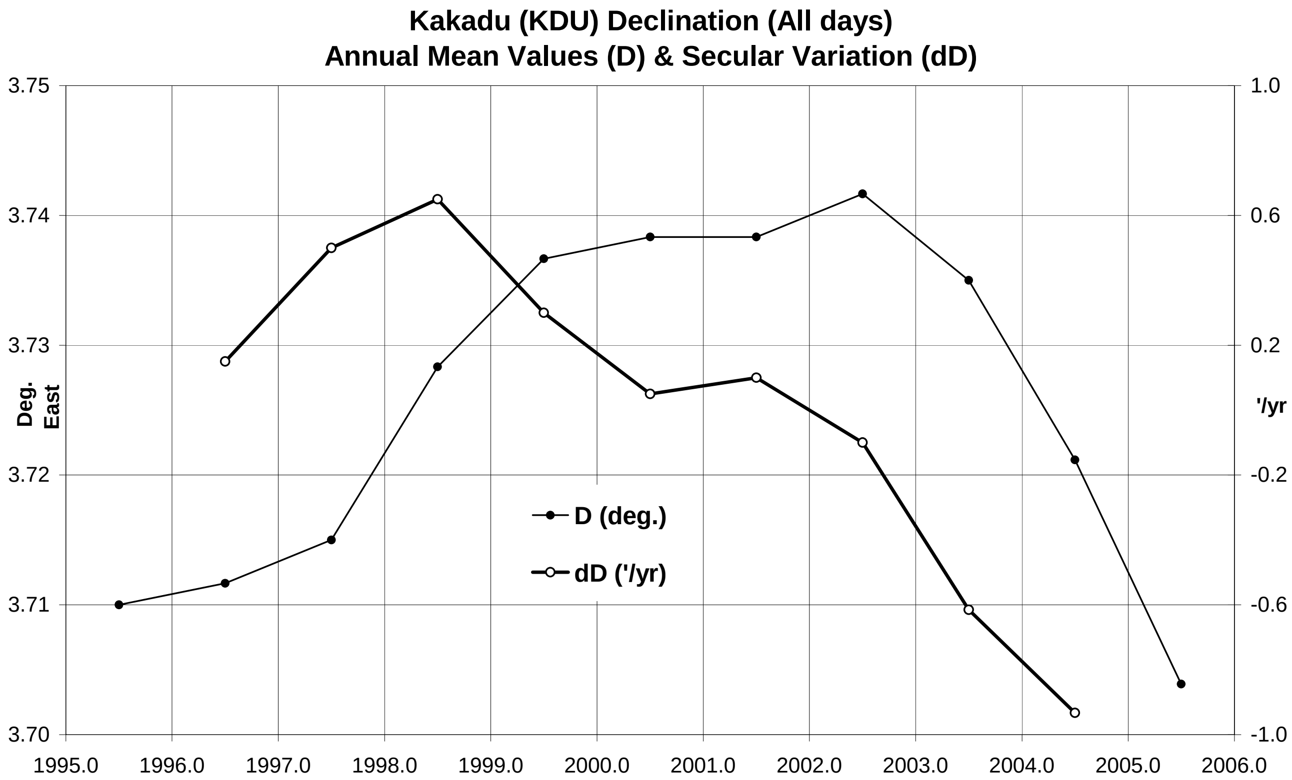


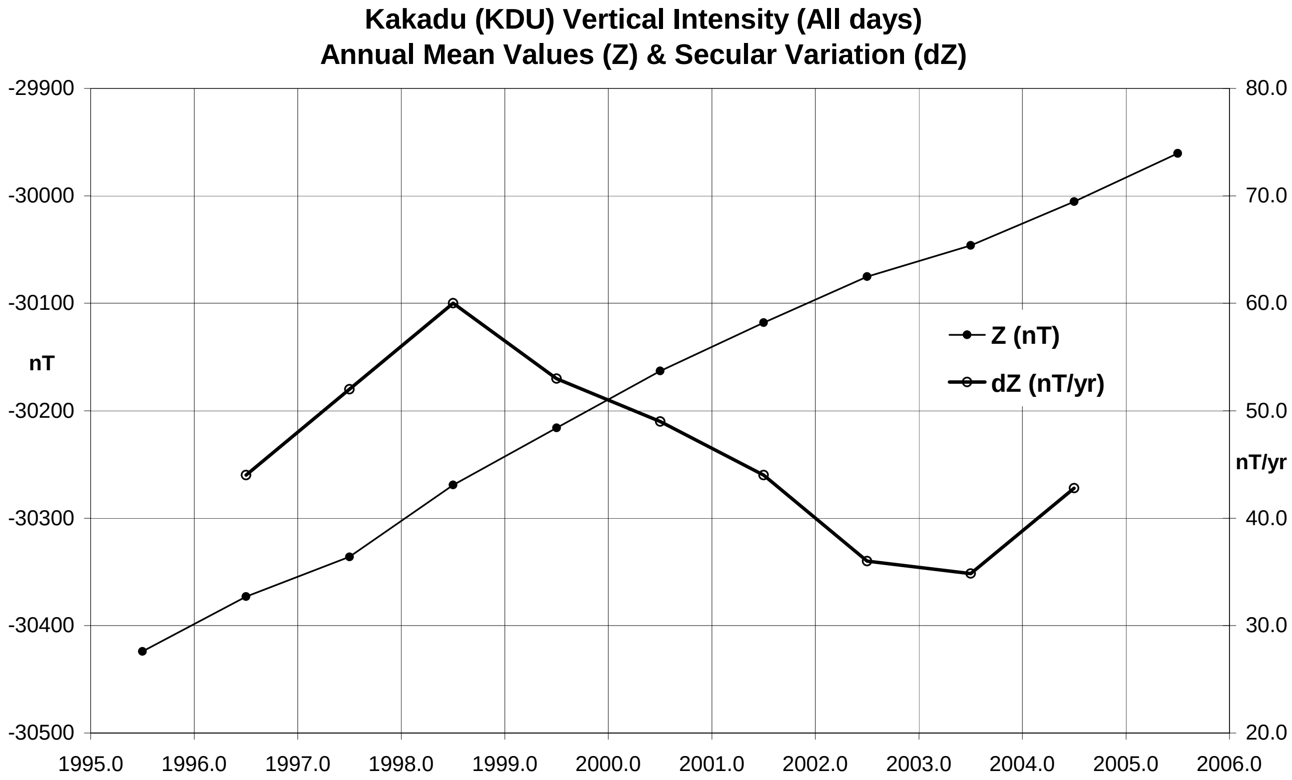
Kakadu, NT 2005 Vertical intensity (Z). Scale: 4.0 nT/mm. Mean: −29960 nT

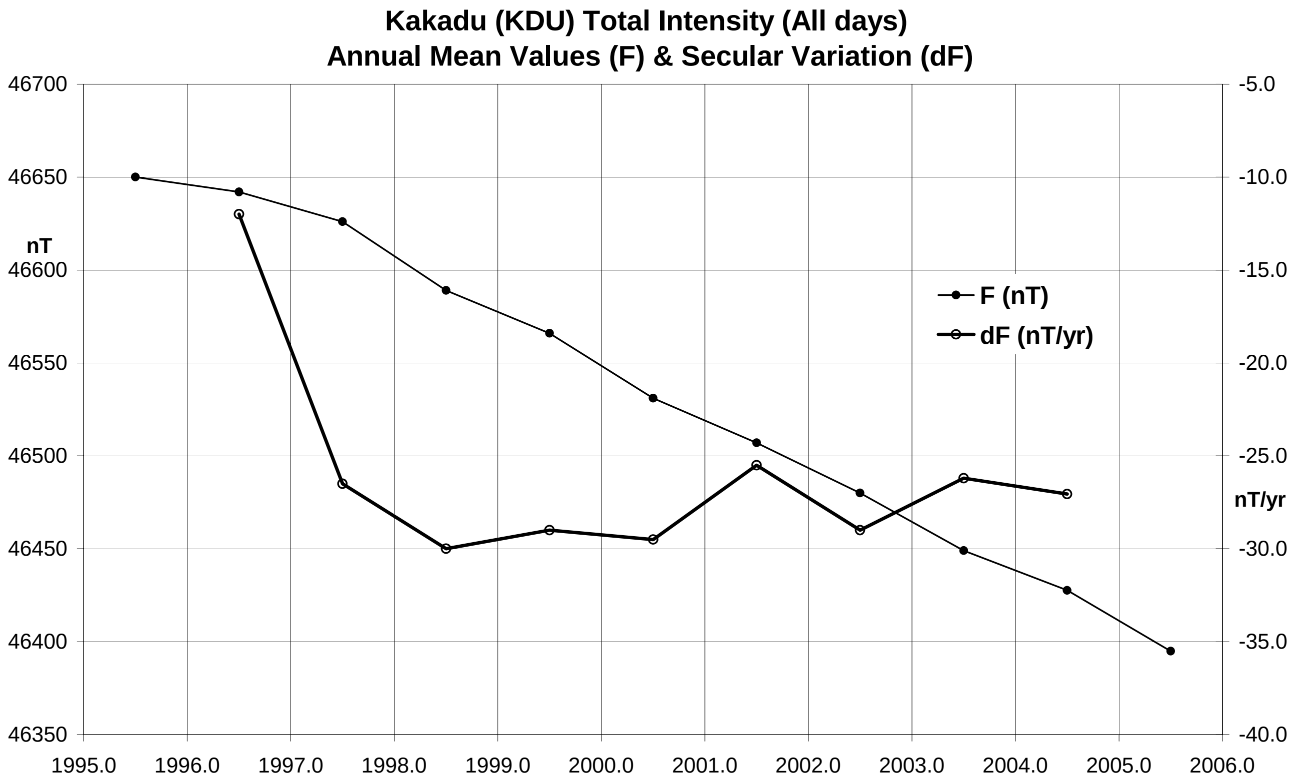


Kakadu, NT 2005 Total intensity (F). Scale: 10.0 nT/mm. Mean: 46395 nT


Kakadu (KDU) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
35475
35450
35425
35400
35375
35350
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0


Kakadu (KDU) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Deg. East
'/yr
D (deg.)
dD ('/yr)
3.75
3.74
3.73
3.72
3.71
3.70
1.0
0.6
0.2
-0.2
-0.6
-1.0
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0


Kakadu (KDU) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-29900
-30000
-30100
-30200
-30300
-30400
-30500
nT
80.0
70.0
60.0
50.0
40.0
30.0
20.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
Z (nT)
dZ (nT/yr)


Kakadu (KDU) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
46700
46650
46600
46550
46500
46450
46400
46350
nT
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
nT/yr
1995.0
1996.0
1997.0
1998.0
1999.0
2000.0
2001.0
2002.0
2003.0
2004.0
2005.0
2006.0
F (nT)
dF (nT/yr)

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

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

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

Although not controlled, the temperature within the tunnel where the variometers were located varied very little over the year: from about 26°C in winter to about 29°C in summer. There was no discernible diurnal temperature variation in the tunnel. The control electronics associated with the variometers (with the exception of the DMI fluxgate magnetometer electronics) were housed in an air-conditioned (for cooling) room in an adjacent arm of the tunnel.

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

Key data for Charters Towers Observatory:

- 3-character IAGA code: CTA
- Commenced operation: June 1983
- Geographic latitude: 20° 05' 25" S
- Geographic longitude: 146° 15' 51" E
- Geomagnetic† : Lat. -27.87°; Long. 220.96°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier C
- Elevation of top of Pier C: 370 metres AMSL
- Azimuth of principal reference (PO spire from Pier C): 34° 40' 45"
- Distance to PO spire: 1.75 km
- Observer in Charge: J.M. Millican

† Based on the IGRF 2005.0 model updated to 2005.5

In 2002 the Towers Hill area was declared to be of Queensland heritage value, and handed over to the Charters Towers City Council. In 2004 the council and Geoscience Australia reached an agreement that the site of the observatory be leased to Geoscience Australia for operating the observatory. This has ensured Geoscience Australia can continue to operate the observatory without the threat of magnetic contamination to the site.

Variometers

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

From 28 August 2000 a DMI FGE non-suspended 3-component fluxgate magnetometer was employed as the principal variometer at CTA observatory. DMI sensor unit S0210 with electronics E0227 operated throughout 2005. The sensor assembly of the instrument was located on the same concrete blocks in the mine tunnel previously used for the EDA FM-105B sensors. Two of its sensors were aligned horizontally at an approximately equal angle on either side of the magnetic meridian (magnetically NW and NE), and the third sensor was aligned vertically. Temperature variation of electronics and sensor was less than 2deg.C, which indicates the field variations due to temperature were no more than 1nT over the year.

Prior to its installation at Charters Towers, the DMI FGE magnetometer's scale-values, relative sensor alignments and temperature sensitivities were determined at the NATIONAL MAGNETOMETER CALIBRATION FACILITY at Canberra Observatory. The results were summarised in the *AGR 2000*.

Throughout 2005 there was also a cycling proton precession magnetometer monitoring variations in the magnetic total intensity, F. The PPM sensor was suspended from the ceiling of the tunnel. During 2005 two PPM variometers were employed: Elsec 820_139 operating until 02 June 2005 and GSM90_4081420/42178 operating after that date. The continuously recording PPM served as both an F-check, and a backup, should any one of the channels of the 3-axis variometer become unserviceable.

Absolute Instruments and Corrections

The variometers at CTA were calibrated weekly by the performance of absolute observations. Throughout 2005 a declination & inclination magnetometer (DIM) comprising DMI fluxgate unit DI0036 mounted on Zeiss 020B theodolite no. 394050 was used with GSM90_3091318/91472 PPM to perform sets of absolute observations. Both absolute PPM and DIM observations were performed on Pier C in the absolute shelter so no pier difference adjustments were necessary.

By regular inter-comparisons of 'travelling' reference absolute magnetometers at Canberra and at Charters Towers, corrections to the abovementioned absolute magnetometers used at CTA were determined to align them with the Australian Magnetic Reference. The corrections adopted for 2005, determined through a series of instrument comparisons made during a routine maintenance visit during 25-29 August 2005, were all zero.

Baselines

At the mean 2005 magnetic field values at Charters Towers of:

$$X = 31507\text{nT}, \quad Y = 4265\text{nT}, \quad Z = -37670\text{nT},$$

the above instrument corrections translate to baseline corrections of:

$$\Delta X = 0.0\text{nT}, \quad \Delta Y = 0.0\text{nT}, \quad \Delta Z = 0.0\text{nT}.$$

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

The DMI E0227/S0210 variometer performed well in 2005 with baseline drifts in the X, Y and Z components within a 6nT range. The drifts were examined from an F-check plot. (F-check is the difference between F calculated from the variometer components and F measured by variometer PPMs.) With reference to PPM variometer E820_139 between 01 January and 02 June 2005 F-check variation was 2.8nT. It was less than 1nT with reference to the PPM variometer GSM90_4081420/42178 between 03 June and 31 December 2005. The variations were mainly associated with the variometer E0227/S0210 baseline drifts.

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

$$\Delta X = 0.0 \pm 0.8\text{nT}; \quad \Delta Y = 0.0 \pm 1.8\text{nT}; \quad \Delta Z = 0.0 \pm 0.7\text{nT}$$

With drift corrections applied F-check varied within a 2nT envelope. This is not unreasonably high as the baseline was calibrated against the absolute PPM and DIM, where the absolute PPM may have had 2nT variations throughout 2005 (as the difference between absolute PPM and variometer PPM varied within about 2nT).

Observed and adopted baseline values in X, Y and Z for 2005 are shown in the following (INTERMAGNET format) chart.

Operations

The officer in charge at CTA observatory performed most routine operations during 2005. Tasks included:

- weekly performance of a set of absolute observations;
- weekly temperature measurement in tunnel;
- mailing the observation-sheet and log-sheet to GA, Canberra, each week.

Analogue outputs from the DMI FGE 3-channel fluxgate, as well as the fluxgate sensor and electronics temperature channels, were digitized with an ADAM 4017 A/D converter mounted inside the electronics console. Throughout 2005 mean values data over 1-second and 1-minute intervals were recorded in the components A (NW), B (NE), C (Z), as well as the DMI variometer sensor and electronics temperatures. These digital data were recorded on an acquisition computer.

The digital readings from the PPM variometers, that cycled every 10 seconds, were input directly to the acquisition computer on which they were recorded.

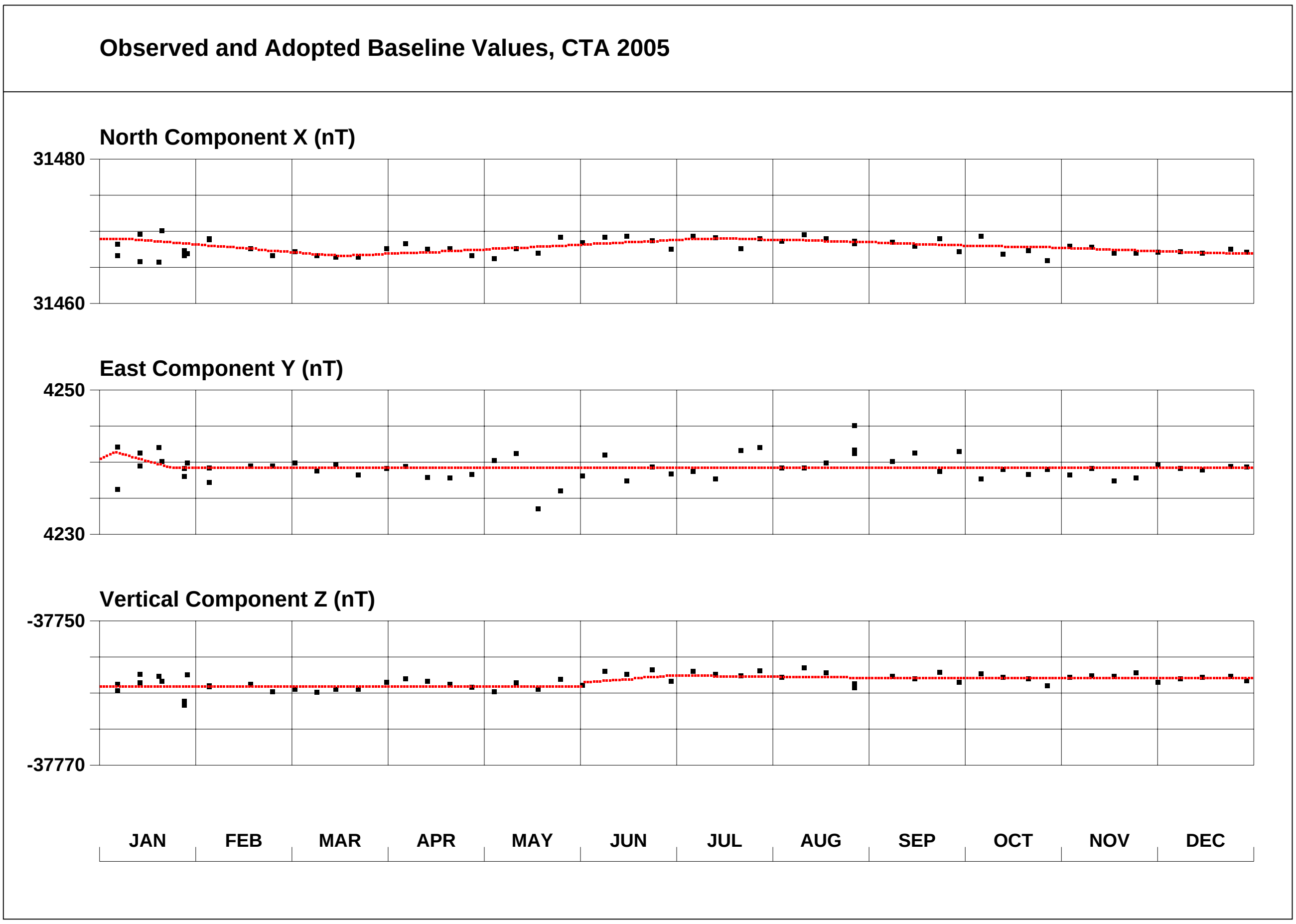
Time was taken from the acquisition computer system clock. The computer did not have an attached external GPS clock. On weekdays the PC clock was checked and set remotely from GA in Canberra.

Data files were telemetered daily from CTA to Geoscience Australia in Canberra via modems and standard telephone lines. From 01 September 2005 real-time data transfer from CTA observatory to GA, Canberra, was started through a network. The data transfer delay time was 10 minutes.

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

Significant Events in 2005

24 Jan	UPS power supply failed. Variometer PPM E820_139 stopped.
26 Jan	Problem with variometer PPM E820_139 was fixed.
27 Jan	A portion of CTA tunnel near entrance collapsed.
03 Feb	New UPS is installed.
04 Feb	No communication between acquisition computer and DMI variometer due to ADAM problem. No data were recorded.
11 Feb	A new ADAM A/D was installed.
17 Feb	Network PC (DNX6.3/Gdap) was installed.
21 Feb	Collapsed tunnel was repaired.
12 Apr	PPM connected to the network computer. Baud rate of GdapE820 changed to 300 (37.5 x 8). The computer was rebooted at 0133UT.
14 Apr	0120: Connected PPM to the network computer again. All flow control was switched off. PPM was now working.
18 Apr	Sent opto-isolator to CTA to be used between the PPM and computer.
03 Jun	GSM90 PPM installed to replace the Elsec820. DMI connected to the network computer and started transferring real-time data.
21–29 Aug.	Maintenance visit during which absolute instrument comparisons were performed.
01 Sep	Real-time time delivery of data to the INTERMAGNET GIN commenced.
20 Oct	Telemetry stopped due to electrical storms.



Data losses in 2005

24 Jan 0139-0425 (2h 47m), 0503-0505 (3m) XYZ channels

24 Jan 0140 to 25/0911 (1d 07h 32m) F channel

26 Jan 0045-0046 (2m) F channel

31 Jan 0427-0431 (5m) XYZ channels

02 Feb 0653-0944 (2h 52m) F channel

04 Feb 0538 to 11/0332 (6d 21h 55m) XYZ channels

04 Feb 0539-0540 (2m), 0548-0604 (17m), 0616-0627 (12m), 0630-0631 (2m) F channel

07 Feb 0057 (1m) F channel

08 Feb 0358 (1m), 0402-0417 (16m), 0420-0421 (2m) F channel

11 Feb 0323 (1m), 0331 (1m) F channel

11 Apr 0057-0104 (8m), 0106 (1m), 0411-0422 (12m) F channel

14 Apr 0034 to 20/0501 (6d 04h 28m) F channel

18 May 2326-2330 (5m) XYZ channels

18 May 2327-2328 (2m), 2344-2353 (10m) F channel

03 Jun 0000-0202 (2h 03m) F channel

03 Jun 0007-0033 (27m), 0123-0131 (9m), 0148-0155 (8m) XYZ channels

04 Jun 0401-0430 (30m) XYZ channels

04 Jun 0416-0426 (11m) F channel

28 Aug 2317-2319 (3m) XYZ channels

10 Oct 0615-0616 (2m) XYZ channels

19 Oct 0442 to 20/0721 (1d 02h 40m) XYZ channels

19 Oct 0443 to 20/2348 (1d 19h 06m) F channel

20 Oct 2343-2346 (4m) XYZ channels

Distribution of CTA data

1-minute and Hourly Mean Values to WDCs

- 2005 data to WDC-A, Boulder USA (sent in 2006)

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2005

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh IM GIN by e-mail: daily until 01 Sep. 2005, then in real-time from that date.
- 2005 Definitive data to WDC-C1, Copenhagen (sent in 2006)

Notes and Errata (cumulative since *AGR1993*)

In the *AGRs 2000-2004* it was incorrectly reported that the principal variometer installed on 28 August 2000 was DMI FGE suspended 3-component fluxgate magnetometer. It had a non-suspended sensor assembly.

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 26 & 27.

Zero 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
2000.5	A	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	ABC
2001.5	A	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	ABC
2002.5	A	7	44.5	-49	54.0	31815	31525	4285	-37781	49392	ABC
2003.5	A	7	44.1	-49	53.7	31796	31506	4279	-37751	49357	ABC
2004.5	A	7	43.6	-49	51.6	31800	31511	4275	-37710	49328	ABC
2005.5	A	7	42.5	-49	50.1	31795	31507	4265	-37670	49294	ABC
1983.729	Q	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	XYZ
1984.5	Q	7	41.9	-50	17.5	31788	31502	4258	-38278	49756	XYZ
1985.5	Q	7	43.2	-50	17.4	31787	31499	4270	-38274	49752	XYZ
1986.5	Q	7	44.4	-50	17.8	31778	31489	4280	-38272	49745	XYZ
1987.5	Q	7	45.5	-50	17.7	31776	31486	4289	-38269	49742	XYZ
1988.5	Q	7	46.4	-50	18.3	31764	31472	4296	-38268	49733	XYZ
1989.5	Q	7	47.0	-50	19.1	31746	31454	4299	-38265	49719	XYZ
1990.5	Q	7	47.3	-50	18.8	31746	31454	4302	-38257	49714	XYZ
1991.5	Q	7	47.3	-50	18.6	31739	31446	4301	-38244	49698	XYZ
1992.5	Q	7	47.4	-50	17.1	31746	31453	4303	-38218	49683	XYZ
1993.5	Q	7	47.4	-50	15.3	31754	31461	4304	-38185	49663	XYZ

continued on page 28 …

Monthly and 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	2005	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	31503.9	4265.2	-37691.3	49308.4	31791.3	7° 42.6'	-49° 51.2'
	5xQ days	31514.4	4268.4	-37690.0	49314.4	31802.2	7° 42.8'	-49° 50.6'
	5xD days	31487.6	4258.1	-37695.6	49300.7	31774.3	7° 42.1'	-49° 52.3'
February	All days	31516.5	4269.6	-37683.2	49310.7	31804.4	7° 42.9'	-49° 50.2'
	5xQ days	31527.3	4274.6	-37679.5	49315.2	31815.8	7° 43.3'	-49° 49.4'
	5xD days	31481.7	4259.8	-37686.2	49289.9	31768.6	7° 42.4'	-49° 52.2'
March	All days	31513.0	4270.1	-37678.1	49304.6	31801.0	7° 43.0'	-49° 50.1'
	5xQ days	31520.1	4270.3	-37676.9	49308.2	31808.0	7° 42.9'	-49° 49.7'
	5xD days	31497.1	4267.2	-37680.6	49296.1	31784.8	7° 42.9'	-49° 51.1'
April	All days	31512.2	4270.5	-37675.0	49301.7	31800.2	7° 43.1'	-49° 50.0'
	5xQ days	31520.0	4270.8	-37671.9	49304.4	31808.0	7° 43.0'	-49° 49.5'
	5xD days	31496.2	4268.2	-37676.9	49292.8	31784.1	7° 43.0'	-49° 51.0'
May	All days	31487.4	4265.9	-37677.9	49287.8	31775.1	7° 42.9'	-49° 51.5'
	5xQ days	31514.1	4270.1	-37674.0	49302.2	31802.1	7° 43.0'	-49° 49.9'
	5xD days	31442.8	4259.4	-37683.7	49263.1	31730.0	7° 42.9'	-49° 54.1'
June	All days	31503.1	4267.1	-37673.0	49294.1	31790.8	7° 42.8'	-49° 50.4'
	5xQ days	31516.9	4268.1	-37669.6	49300.4	31804.5	7° 42.7'	-49° 49.5'
	5xD days	31488.5	4267.6	-37674.3	49285.8	31776.3	7° 43.1'	-49° 51.2'
July	All days	31505.2	4264.8	-37668.5	49291.8	31792.6	7° 42.6'	-49° 50.1'
	5xQ days	31520.9	4267.2	-37665.8	49300.0	31808.4	7° 42.6'	-49° 49.2'
	5xD days	31484.3	4260.5	-37672.2	49281.0	31771.3	7° 42.4'	-49° 51.4'
August	All days	31503.2	4263.4	-37665.3	49288.0	31790.4	7° 42.4'	-49° 50.1'
	5xQ days	31510.8	4265.3	-37664.9	49292.7	31798.1	7° 42.5'	-49° 49.7'
	5xD days	31476.5	4259.4	-37668.0	49272.6	31763.3	7° 42.4'	-49° 51.7'
September	All days	31489.5	4260.3	-37666.7	49280.0	31776.4	7° 42.3'	-49° 50.9'
	5xQ days	31506.3	4263.2	-37664.5	49289.4	31793.5	7° 42.4'	-49° 49.9'
	5xD days	31460.2	4256.3	-37672.0	49265.0	31746.8	7° 42.3'	-49° 52.7'
October	All days	31515.3	4263.1	-37658.3	49290.4	31802.4	7° 42.2'	-49° 49.1'
	5xQ days	31523.1	4264.4	-37657.5	49294.8	31810.2	7° 42.2'	-49° 48.7'
	5xD days	31503.4	4260.3	-37658.9	49282.9	31790.1	7° 42.1'	-49° 49.8'
November	All days	31517.0	4260.6	-37653.8	49287.8	31803.7	7° 41.9'	-49° 48.9'
	5xQ days	31523.8	4262.1	-37652.4	49291.2	31810.6	7° 42.0'	-49° 48.4'
	5xD days	31510.0	4259.9	-37655.2	49284.3	31796.6	7° 42.0'	-49° 49.3'
December	All days	31521.8	4259.5	-37649.5	49287.4	31808.3	7° 41.7'	-49° 48.4'
	5xQ days	31527.0	4260.8	-37649.1	49290.6	31813.6	7° 41.8'	-49° 48.1'
	5xD days	31517.3	4257.9	-37649.9	49284.7	31803.6	7° 41.6'	-49° 48.7'
Annual	All days	31507.3	4265.0	-37670.1	49294.4	31794.7	7° 42.5'	-49° 50.1'
Mean	5xQ days	31518.7	4267.1	-37668.0	49300.3	31806.3	7° 42.6'	-49° 49.4'
Values	5xD days	31487.1	4261.2	-37672.8	49283.2	31774.2	7° 42.4'	-49° 51.3'

(Calculated: 11:40 hrs., Mon. 18 Dec. 2006)

Hourly Mean Values

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

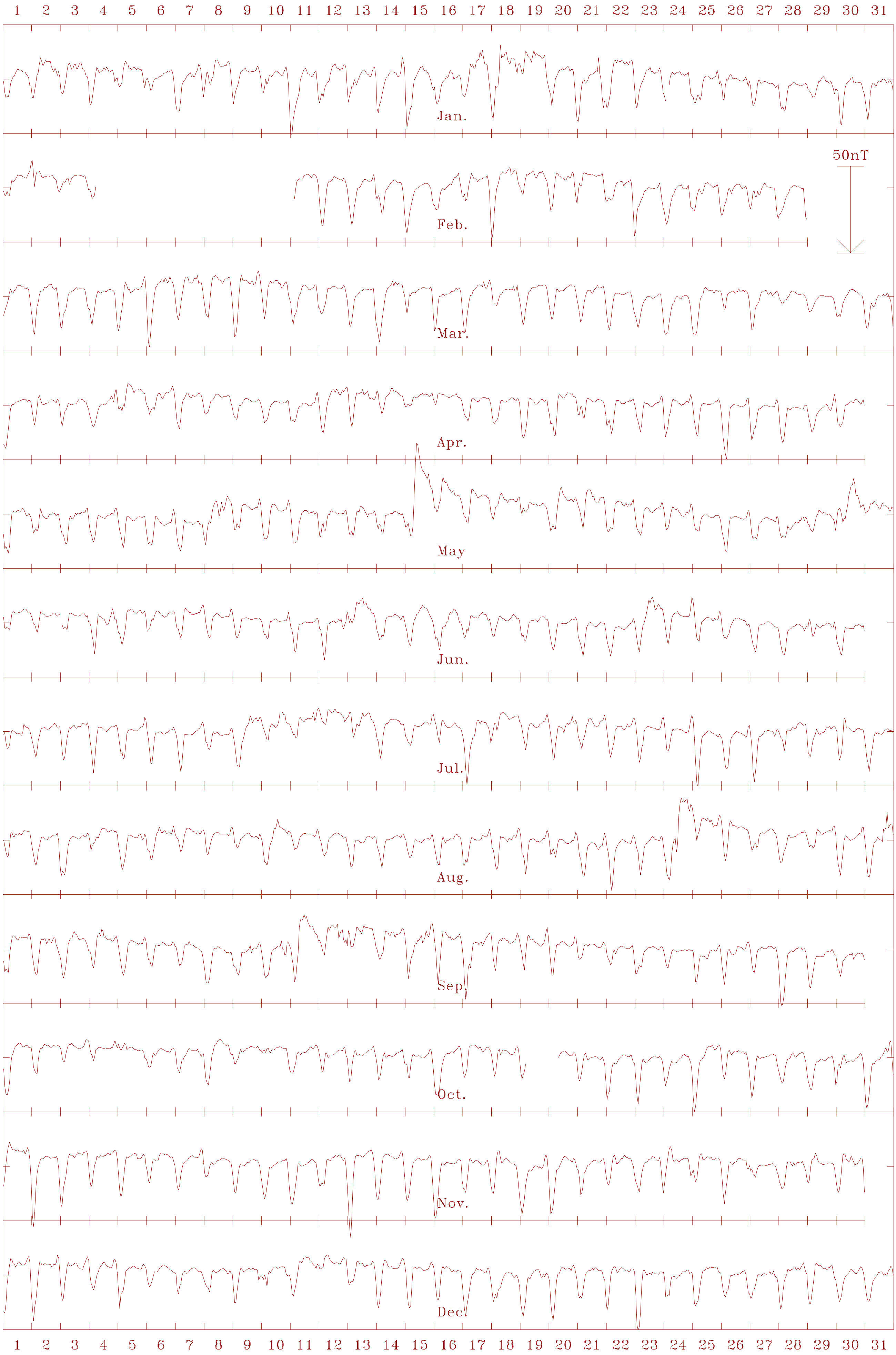
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

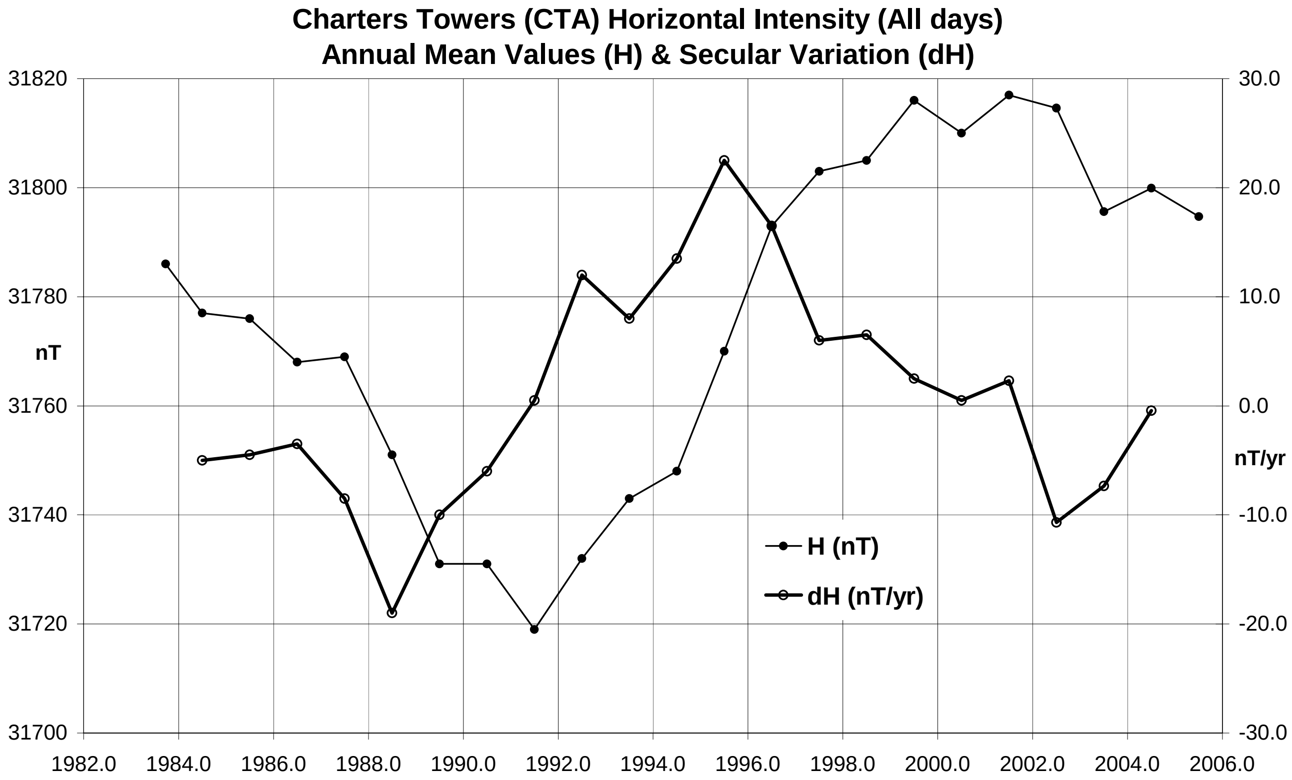
Charters Towers 2005 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 31795 nT

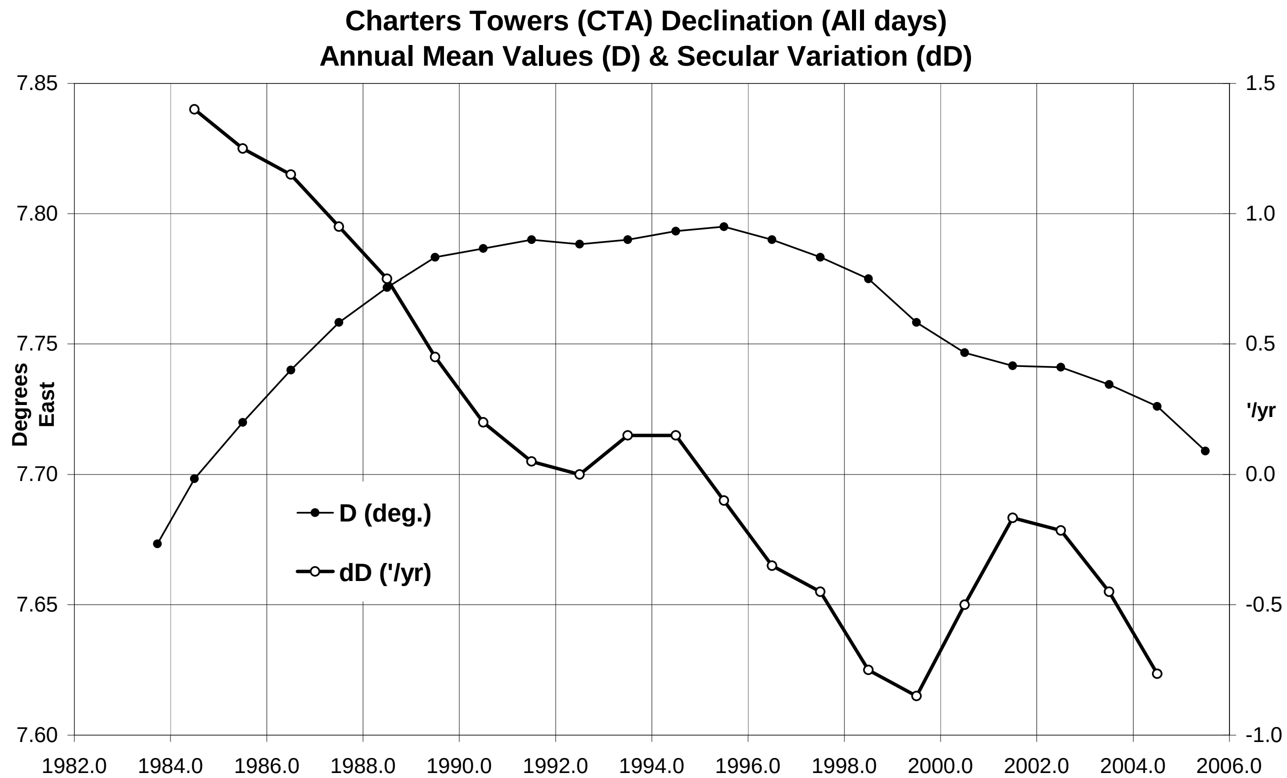
Charters Towers 2005 Declination (east) (D). Scale: 0.75 min/mm. Mean: 7.71 deg.

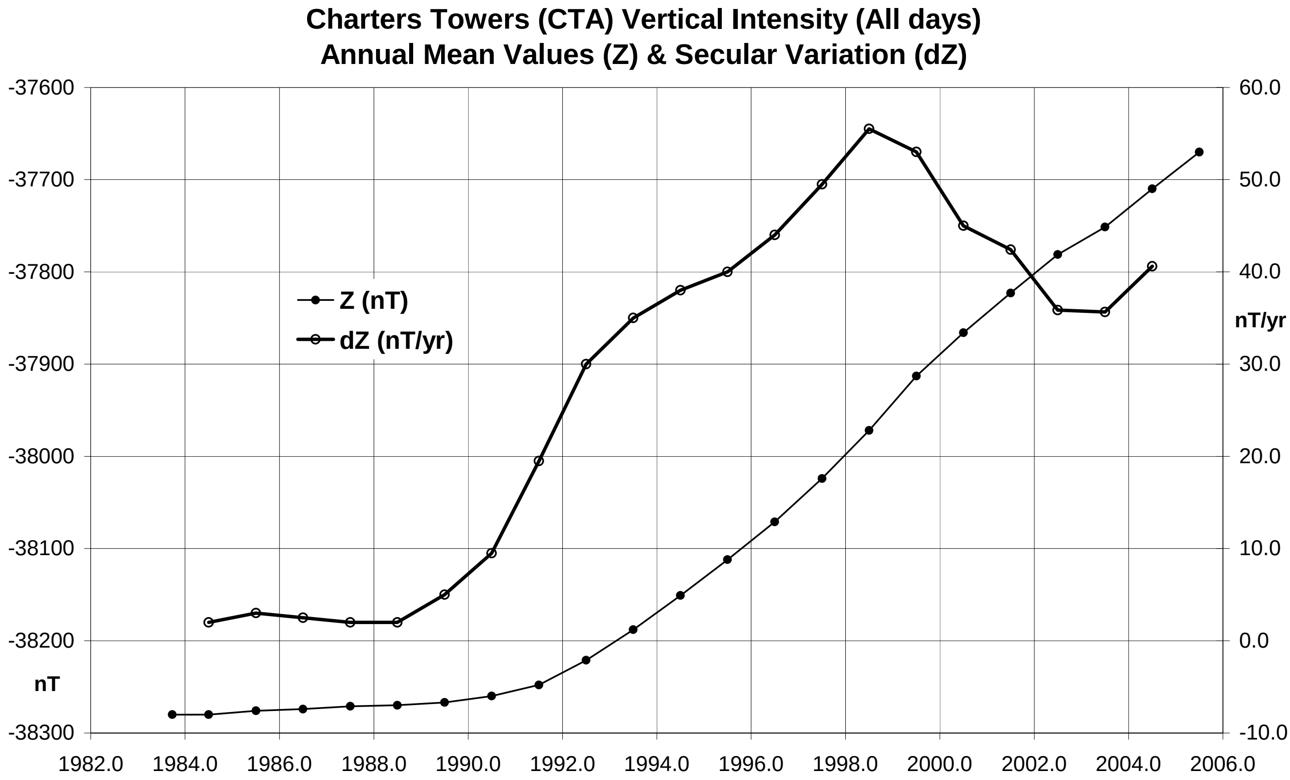
Charters Towers 2005 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −37670 nT

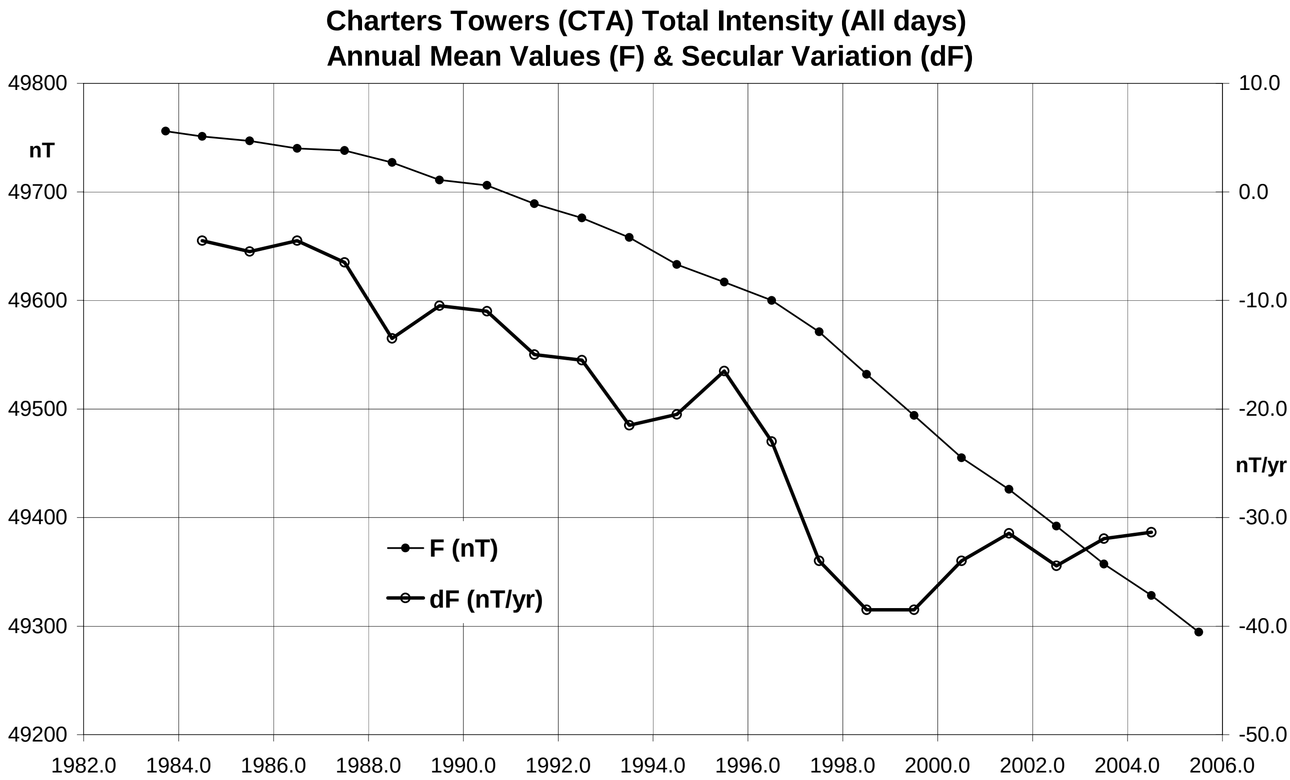



Charters Towers 2005 Total intensity (F). Scale: 5.0 nT/mm. Mean: 49294 nT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Jan.
Feb.
100nT
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31


Charters Towers (CTA) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
31820
31800
31780
31760
31740
31720
31700
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Degrees East
'/yr
D (deg.)
dD ('/yr)
7.85
7.80
7.75
7.70
7.65
7.60
1.5
1.0
0.5
0.0
-0.5
-1.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
Z (nT)
dZ (nT/yr)
nT
nT/yr
-37600
-37700
-37800
-37900
-38000
-38100
-38200
-38300
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Charters Towers (CTA) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
F (nT)
dF (nT/yr)
nT
nT/yr
49800
49700
49600
49500
49400
49300
49200
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
1982.0
1984.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0

CTA – Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1994.5	Q	7	47.6	-50	13.2	31762	31469	4307	-38148	49640	XYZ
1995.5	Q	7	47.7	-50	10.4	31781	31488	4310	-38109	49622	XYZ
1996.5	Q	7	47.4	-50	7.7	31799	31506	4310	-38070	49603	XYZ
1997.5	Q	7	46.9	-50	4.9	31812	31519	4308	-38023	49576	XYZ
1998.5	Q	7	46.4	-50	2.5	31815	31522	4303	-37971	49537	XYZ
1999.5	Q	7	45.5	-49	59.3	31825	31534	4296	-37911	49499	XYZ
2000.5	Q	7	44.8	-49	57.2	31823	31533	4290	-37864	49461	ABC
2001.5	Q	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	ABC
2002.5	Q	7	44.5	-49	53.2	31828	31538	4287	-37780	49400	ABC
2003.5	Q	7	44.2	-49	52.7	31811	31521	4282	-37749	49365	ABC
2004.5	Q	7	43.6	-49	50.9	31810	31522	4277	-37708	49334	ABC
2005.5	Q	7	42.6	-49	49.4	31806	31519	4267	-37668	49300	ABC
1983.729	D	7	39.9	-50	18.7	31769	31485	4237	-38281	49746	XYZ
1984.5	D	7	41.8	-50	19.4	31756	31470	4253	-38283	49740	XYZ
1985.5	D	7	43.1	-50	18.9	31761	31474	4266	-38277	49739	XYZ
1986.5	D	7	44.4	-50	19.3	31752	31463	4276	-38276	49732	XYZ
1987.5	D	7	45.4	-50	18.9	31757	31467	4286	-38272	49732	XYZ
1988.5	D	7	46.3	-50	20.4	31731	31439	4291	-38274	49716	XYZ
1989.5	D	7	46.9	-50	22.2	31696	31404	4292	-38272	49693	XYZ
1990.5	D	7	47.1	-50	21.1	31707	31415	4295	-38263	49693	XYZ
1991.5	D	7	47.4	-50	21.8	31687	31394	4295	-38253	49672	XYZ
1992.5	D	7	47.3	-50	19.5	31706	31414	4297	-38225	49663	XYZ
1993.5	D	7	47.4	-50	17.2	31723	31430	4299	-38191	49648	XYZ
1994.5	D	7	47.6	-50	15.1	31730	31437	4302	-38154	49624	XYZ
1995.5	D	7	47.7	-50	12.0	31755	31462	4307	-38114	49609	XYZ
1996.5	D	7	47.4	-50	8.6	31784	31491	4308	-38072	49595	XYZ
1997.5	D	7	47.0	-50	6.4	31788	31495	4305	-38026	49563	XYZ
1998.5	D	7	46.5	-50	4.4	31782	31490	4299	-37976	49520	XYZ
1999.5	D	7	45.5	-50	1.0	31797	31506	4293	-37916	49484	XYZ
2000.5	D	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	ABC
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABC
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABC
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABC
2004.5	D	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	ABC
2005.5	D	7	42.4	-49	51.3	31774	31487	4261	-37673	49283	ABC

LEARMONTH OBSERVATORY

Learmonth, Western Australia, is situated on Australia's North West Cape overlooking Exmouth Gulf to the east and Cape Range to the west. Learmonth is approximately 1100km north of the city of Perth. The nearest town is Exmouth, approximately 35km to the north. The Learmonth Geomagnetic Observatory is situated at the Learmonth Solar Observatory, which is jointly staffed by IPS Radio and Space Services, Department of Industry, Tourism and Resources and the U.S. Air Force. The magnetic observatory was established in late November 1986 from when it has operated continuously. Further details of the observatory's history are in *AGR 1994*.

The observatory comprised:

- Three small underground vaults, two that housed the variometer sensors and one that housed the fluxgate electronics, all located within the perimeter of the solar observatory compound, at approximately 40m to the east of the solar observatory Radio Solar Telescope Network (RSTN) building.

  The principal (fluxgate sensor) vault was 0.6m x 0.6m of concrete construction with a 25mm plastic lid and was set into the ground by about two-thirds of its 1m depth. A smaller plastic subsidiary vault at a distance of approximately 3m from the principal vault housed the fluxgate electronics. A 50mm diameter PVC conduit carrying control and power cables ran underground from the subsidiary vault to the electronics console and data acquisition computer in the RSTN building.

  The PPM sensor was housed in a plastic vault, cylindrical in shape of 600mm diameter with its 1m depth completely buried in the ground. This vault was approximately 10m north of the principal vault. A PVC conduit carried the PPM sensor head signal cable to the electronics console in the RSTN building.

  The fluxgate magnetometer vault was lined with polystyrene foam and all three vaults were buried beneath local sand or limestone aggregate to minimize diurnal temperature fluctuations

- A concrete absolute observation pier within a roofed shelter with brick walls on two sides to the same height as the pier. This was about 200 metres south of the solar observatory and situated on Royal Australian Air Force property. There was a safety tie down bar on the absolute pier to ensure that the absolute instruments could not be accidentally dislodged from the pier during observations.

- The acquisition computer, PPM control electronics, GPS, modem and back-up power were located within the RSTN building.

Key data for Learmonth Observatory:

- 3-character IAGA code: LRM
- Commenced operation: November 1986
- Geographic latitude: 22 13' 19" S
- Geographic longitude: 114° 06' 03" E
- Geomagnetic† : Lat. -32.26°; Long. 186.47°
- Lower limit for K index of 9: 300 nT
- Principal pier identification: Pier A
- Elevation of top of Pier A: 4 metres AMSL
- Azimuth of principal reference (West windsock from Pier A): 283° 02' 18"
- Distance to West windsock: not recorded
- Observers in Charge: G.A. Steward (to 01 Jul. 2005) O.D. Giersch (from 02 Jul. 2005), both of IPS, Radio & Space Services.

† Based on the IGRF 2005.0 model updated to 2005.5

Variometers

Variations in the magnetic NW, NE and vertical components of the magnetic field were recorded at Learmonth in 2005 using a Danish Meteorological Institute FGE suspended three-axis fluxgate magnetometer.

The analogue data from the DMI instrument, including sensor and electronics temperatures were digitized with an ADAM 4017 8-channel 16-bit converter in +/-5V mode and recorded at 1-second intervals on the acquisition computer.

The data from the fluxgate instrument were also recorded independently by IPS, Radio & Space Services for its use.

During 2005 a Geometrics model 856 (no. 50708) PPM measured variations in the total intensity of the magnetic field, F. This served both as a backup, should any one of the X, Y or Z variometer channels become unserviceable, and as an F-check on the quality of the variometer data and model. The digital data from the variometer PPM were recorded at 10-second intervals.

From January to June 2005 the data from both the DMI fluxgate and variometer PPM were recorded on a computer running MS-DOS based data acquisition, control and display software. Timing was generated by the software (DOS) clock of the computer that was synchronized to 1-second pulses from a Trimble *Accutime* GPS clock.

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

In June 2005 the data acquisition system was upgraded to the Geophysical Data Acquisition Platform (GDAP) comprising a PC-104 industrial computer running the QNX operating system. The uninterruptible power supply was replaced with a DC battery box trickle charged from a 12V power supply. This system powered the computer, DMI variometer and G856 PPM.

The GDAP system was connected to the IPS computer network and so near real-time (every 10 minutes) data downloads from the observatory to GA in Canberra commenced on 20 June 2005. Data from Learmonth were sent via the IPS dedicated data line to the IPS office in Sydney and from Sydney to GA in Canberra via the Internet.

Absolute Instruments and Corrections

The principal absolute instruments used to calibrate the magnetic variometer at the Learmonth observatory in 2005 were a declination and inclination fluxgate magnetometer (DIM) and a PPM. The DIM was a Bartington, model number MAG01H, serial number B0702H with a fluxgate element mounted on a Ziess 020B theodolite, serial number 312714. The absolute total field magnetometer used was a GEM GSM90 PPM, serial number 3091316, with sensor 761100.

Instrument comparisons between the LRM observatory absolute instruments (GSM90_3091316/761100 PPM and B0702H / Zeiss 020B 312714 DIM) and the travelling reference instruments (GSM90_003985/11690 total field magnetometer and B0610H / Zeiss 010B 160459 DIM) were performed at Learmonth Observatory on 21/22 June 2005.

The results of the comparisons were:

Travelling Reference		LRM instrument		Inst. difference
GSM90_003985	–	GSM90_3091316	=	0.3nT (F)
B0610H/160459	–	B0702H/312714	=	0.0' (D)
B0610H/160459	–	B0702H/312714	=	–0.1' (I)

The adopted differences between the abovementioned Travelling Reference Instruments (B0610H/160459, GSM90_003985) and the International Average derived from the 2004 IAGA workshop at Kakioka, Japan (IAGA, 2004) were:

International Avrg.		Travelling Ref.		Inst. Corr'n
various inst's	–	GSM90_003985	=	0.0nT (F)
various inst's	–	B0610H/160459	=	0.0' (D)
various inst's	–	B0610H/160459	=	-0.05' (I)

The corrections to the LRM instruments adopted to align them with the International Average were:

International Avrg.		LRM instrument		Inst. correction
various inst's	–	GSM90_3091316	=	0.0nT (F)
various inst's	–	B0702H/312714	=	0.0' (D)
various inst's	–	B0702H/312714	=	-0.2' (I)

Baselines

At the mean 2005 magnetic field values at LRM of X = 29775nT, Y = 245nT and Z = -44080nT, the instrument corrections adopted for the absolute magnetometers used at LRM during 2005 converted to the baseline corrections:

$\Delta X = -2.6$ nT $\Delta Y = 0.0$ nT $\Delta Z = -1.7$ nT

These corrections have been applied to all LRM 2005 final data.

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

0.9nT in X;   1.9nT in Y;   0.8nT in Z

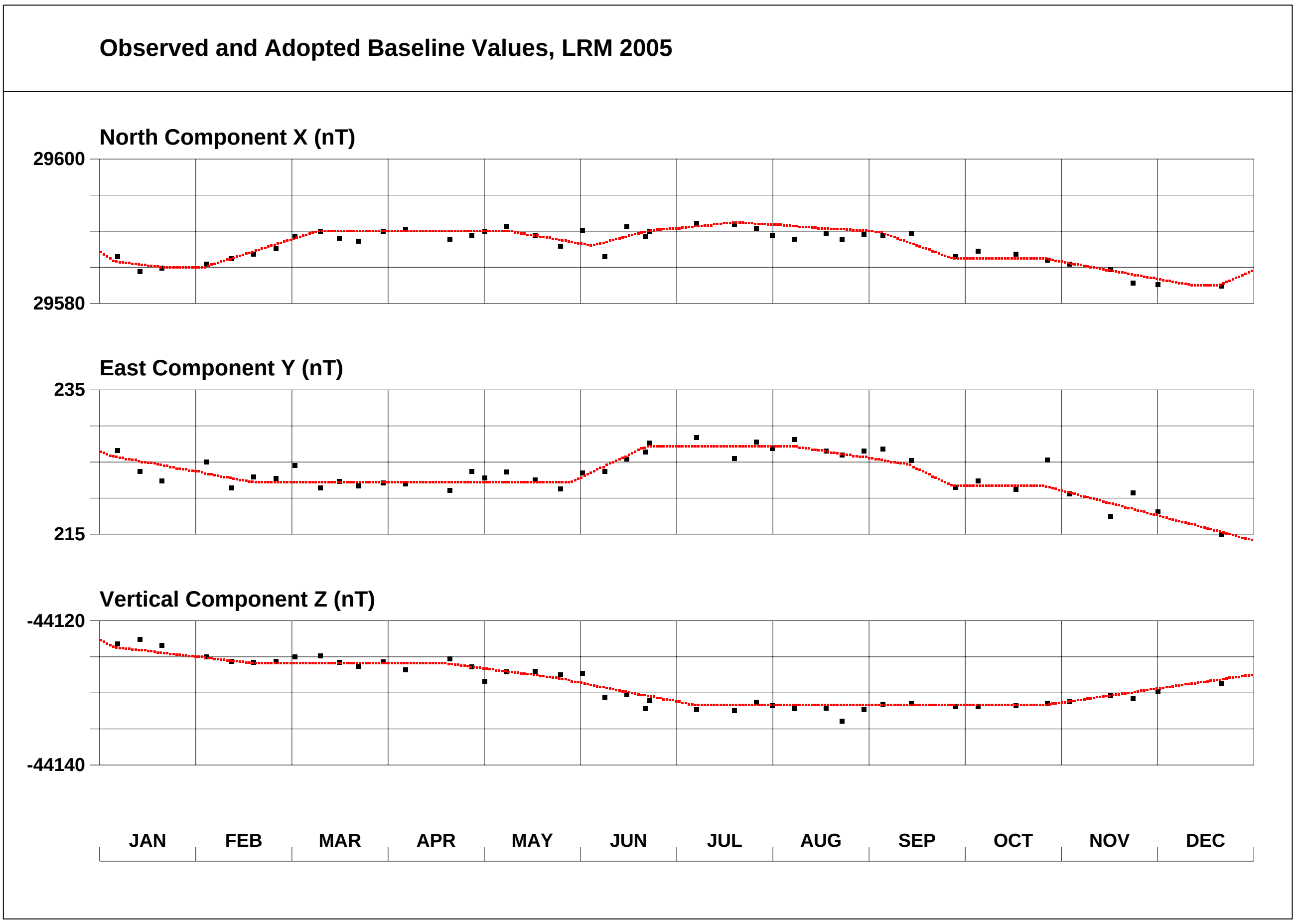
(In terms of the absolute observed components, they were:

0.7nT in F;   14" in D;   04" in I)

The drifts applied to the X, Y, and Z baselines amounted to no more than 15nT in any of the X, Y and Z components throughout the year, with each component having approximately the same amount of drift.

There was about 4nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM.

Observed and adopted baseline values in X, Y and Z for 2005 are shown in the following (INTERMAGNET format) chart.



Operations

The local observers at LRM magnetic observatory were staff members of IPS, Radio & Space Services at the Learmonth Solar Observatory. There was a change of observer (GS to OG) on 01 July 2005. During 2005 the observer performed routine tasks at the magnetic observatory that included:

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

Throughout 2005 absolute observations were performed on the pier (A) in the absolute shelter. The DIM absolute observations were routinely performed using the *offset* method (see *Absolute Magnetometers*, this report) throughout 2005.

Until 20 June 2005, 1-second values and 1-minute mean value data were transferred daily through modems via telephone lines to GA in Canberra. The clocks on the acquisition PC were also checked each weekday and corrected if necessary via the telephone link to GA. After 20 June data were transferred every 10 minutes via a TCP/IP network connection.

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

Significant Events in 2005

19 Jan	0110 and 0210: Step in fluxgate Z-channel, probably caused by a vehicle parked about 17m from its sensor during electrical maintenance.
28 Jan	Routine absolute observation missed.
04 Feb	Modem was re-set as it was not answering.
10 Feb	Modem was re-set as it gave a busy signal.
12 Feb	2335: System rebooted.
14 Feb	Modem was re-set as it gave a busy signal. An 8-port QNX6.3 12V + 4-port KVM sent to LRM.
18 Feb	QNX computer connected to IPS network – pinged O.K. from local IPS PC. Firewall not yet altered at IPS.
07 Mar	Secure-shell (ssh) connection via computer "jupiter" to QNX machine working, i.e. networking was established from GA to LRM.
08 Mar	Cranes working on IPS equipment for the rest of the week (until 11 March)
09 Mar	0600 to 10/ 0300 data contaminated by cranes operating nearby.
12 Apr	Routine absolute observation missed.
16 Apr	~2030: Unscheduled system reboots. PPM failed to restart.
18 Apr	A request to reset the PPM was sent: it started working again at 0222 on 20 Apr. 2005.
19 Apr.	0629 and 0705: System reboots after power failure.
20 Apr	~0215: Variometer PPM reset.
19-24 June	Maintenance visit by staff (AML and BJS) from GA, Canberra.: The PPM vault was excavated and opened in an endeavour to replace the G856 variometer with a GSM90. This proved infeasible as the GSM90 was found to interfere with the IPS solar spectrometer. Gdap system and QNX PC104 were installed. The UPS was replaced with a 12V DC battery power supply. Instrument tests and comparisons were also carried out during the maintenance visit.
20 Jun	Communication of real-time data commenced.

continued on page 39 ...

Learmonth Annual Mean Values

The table below gives annual mean values calculated using the monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in H, D, Z & F are on pages 37 & 38.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ (1)
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441	53342	DHZ
1991.5	A	-0	26.3	-56	24.5	29507	29506	-226	-44426	53333	DHZ
1992.5	A	-0	23.4	-56	22.6	29531	29530	-201	-44407	53330	DHZ
1993.5	A	-0	18.9	-56	21.2	29550	29549	-162	-44396	53331	DHZ
1994.5	A	-0	15.0	-56	20.5	29555	29555	-129	-44386	53326	DHZ
1995.5	A	-0	10.8	-56	18.2	29588	29588	-93	-44373	53333	DHZ
1996.5	A	-0	06.2	-56	15.5	29630	29630	-54	-44358	53344	DHZ
1997.5	A	-0	01.3	-56	13.3	29658	29658	-11	-44338	53343	DHZ
1998.5	A	0	04.2	-56	11.6	29676	29676	36	-44320	53338	DHZ
1999.5	A	0	09.2	-56	09.6	29696	29696	80	-44292	53325	ABZ (2)
2000.5	A	0	13.5	-56	07.9	29707	29706	116	-44260	53305	ABZ
2001.5	A	0	17.7	-56	05.7	29724	29724	153	-44227	53287	ABZ
2002.5	A	0	20.8	-56	04.2	29734	29733	180	-44197	53268	ABZ
2003.5	A	0	23.8	-56	03.1	29737	29736	206	-44174	53250	ABZ
2004.5	A	0	26.3	-56	00.4	29759	29758	228	-44132	53229	ABZ
2005.5	A	0	28.3	-55	57.8	29773	29772	245	-44079	53192	ABZ
1987.5	Q	-0	34.8	-56	26.3	29486	29484	-299	-44445	53336	DHZ (1)
1988.5	Q	-0	33.5	-56	26.3	29494	29492	-288	-44455	53349	DHZ
1989.5	Q	-0	34.3	-56	26.2	29481	29479	-294	-44433	53324	DHZ
1990.5	Q	-0	28.7	-56	24.5	29516	29515	-246	-44439	53348	DHZ
1991.5	Q	-0	26.2	-56	23.4	29527	29526	-225	-44423	53341	DHZ
1992.5	Q	-0	23.3	-56	21.7	29545	29544	-200	-44405	53336	DHZ
1993.5	Q	-0	18.8	-56	20.5	29561	29560	-162	-44394	53336	DHZ
1994.5	Q	-0	15.0	-56	19.7	29569	29569	-129	-44384	53332	DHZ
1995.5	Q	-0	10.8	-56	17.5	29600	29600	-93	-44371	53338	DHZ
1996.5	Q	-0	06.3	-56	15.2	29636	29635	-54	-44357	53346	DHZ
1997.5	Q	-0	01.3	-56	12.8	29667	29667	-11	-44338	53348	DHZ
1998.5	Q	0	04.1	-56	11.1	29686	29686	35	-44318	53342	DHZ
1999.5	Q	0	09.2	-56	09.0	29705	29705	80	-44290	53329	ABZ (2)
2000.5	Q	0	13.5	-56	07.1	29719	29719	117	-44258	53311	ABZ
2001.5	Q	0	17.8	-56	05.0	29736	29736	154	-44225	53293	ABZ
2002.5	Q	0	20.8	-56	03.3	29748	29747	180	-44195	53274	ABZ
2003.5	Q	0	23.8	-56	02.2	29752	29751	206	-44171	53256	ABZ
2004.5	Q	0	26.3	-55	59.8	29770	29769	228	-44130	53233	ABZ
2005.5	Q	0	28.3	-55	57.2	29784	29783	245	-44078	53197	ABZ
1987.5	D	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	DHZ (1)
1988.5	D	-0	33.6	-56	28.2	29461	29459	-288	-44460	53335	DHZ
1989.5	D	-0	34.4	-56	29.0	29433	29431	-295	-44441	53303	DHZ
1990.5	D	-0	29.0	-56	26.7	29478	29477	-249	-44445	53332	DHZ
1991.5	D	-0	26.5	-56	26.5	29473	29472	-227	-44431	53318	DHZ
1992.5	D	-0	23.5	-56	24.1	29506	29505	-201	-44412	53320	DHZ
1993.5	D	-0	18.9	-56	22.3	29530	29529	-163	-44398	53322	DHZ
1994.5	D	-0	14.9	-56	21.6	29537	29537	-128	-44389	53318	DHZ
1995.5	D	-0	10.9	-56	19.1	29574	29574	-94	-44374	53326	DHZ
1996.5	D	-0	06.2	-56	16.0	29622	29622	-53	-44359	53340	DHZ
1997.5	D	-0	01.3	-56	14.2	29643	29643	-11	-44340	53336	DHZ
1998.5	D	0	04.2	-56	13.0	29652	29652	36	-44322	53326	DHZ
1999.5	D	0	09.3	-56	10.7	29677	29677	81	-44295	53317	ABZ (2)
2000.5	D	0	13.4	-56	09.5	29679	29679	116	-44264	53294	ABZ
2001.5	D	0	17.6	-56	07.2	29699	29699	152	-44230	53276	ABZ
2002.5	D	0	20.8	-56	05.4	29712	29712	179	-44200	53259	ABZ
2003.5	D	0	23.8	-56	04.5	29713	29713	206	-44177	53240	ABZ
2004.5	D	0	26.3	-56	01.6	29739	29738	227	-44135	53219	ABZ
2005.5	D	0	28.3	-55	58.9	29754	29753	245	-44082	53184	ABZ

Note (1): At the near zero magnetic declination at LRM the DHZ sensor orientation closely approximated an XYZ orientation.

Note (2): ABZ indicates sensor alignments in the magnetic NW, NE and vertical directions.

Monthly and Annual Mean Values

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

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

Learmonth	2005	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29761.3	237.1	-44111.9	53213.3	29762.2	+0° 27.4'	-55° 59.6'
	5xQ days	29771.6	239.0	-44108.1	53215.9	29772.6	+0° 27.6'	-55° 58.9'
	5xD days	29749.1	233.0	-44119.9	53213.1	29750.0	+0° 26.9'	-56° 00.5'
February	All days	29771.3	238.7	-44101.8	53210.5	29772.3	+0° 27.6'	-55° 58.6'
	5xQ days	29780.4	237.9	-44100.3	53214.3	29781.3	+0° 27.5'	-55° 58.1'
	5xD days	29754.9	236.4	-44105.7	53204.6	29755.9	+0° 27.3'	-55° 59.7'
March	All days	29772.2	240.8	-44093.1	53203.8	29773.2	+0° 27.8'	-55° 58.3'
	5xQ days	29777.8	240.5	-44093.2	53207.0	29778.7	+0° 27.8'	-55° 58.0'
	5xD days	29758.0	242.0	-44094.9	53197.3	29759.0	+0° 28.0'	-55° 59.1'
April	All days	29772.6	243.3	-44087.3	53199.2	29773.6	+0° 28.1'	-55° 58.1'
	5xQ days	29779.6	243.7	-44085.6	53201.7	29780.6	+0° 28.1'	-55° 57.6'
	5xD days	29758.4	242.6	-44088.8	53192.6	29759.4	+0° 28.0'	-55° 58.9'
May	All days	29749.6	243.2	-44090.3	53188.8	29750.6	+0° 28.1'	-55° 59.4'
	5xQ days	29777.8	242.0	-44085.9	53201.0	29778.8	+0° 27.9'	-55° 57.7'
	5xD days	29703.0	244.3	-44094.9	53166.7	29704.0	+0° 28.3'	-56° 02.1'
June	All days	29765.4	247.4	-44083.0	53191.7	29766.4	+0° 28.6'	-55° 58.3'
	5xQ days	29778.3	246.2	-44080.3	53196.6	29779.3	+0° 28.4'	-55° 57.5'
	5xD days	29751.8	249.5	-44083.7	53184.6	29752.8	+0° 28.8'	-55° 59.0'
July	All days	29770.9	248.9	-44076.3	53189.2	29772.0	+0° 28.7'	-55° 57.7'
	5xQ days	29786.0	248.5	-44074.4	53196.0	29787.0	+0° 28.7'	-55° 56.9'
	5xD days	29749.2	249.7	-44079.4	53179.6	29750.2	+0° 28.9'	-55° 59.0'
August	All days	29771.2	248.9	-44070.9	53184.9	29772.3	+0° 28.7'	-55° 57.5'
	5xQ days	29778.5	248.8	-44070.5	53188.6	29779.5	+0° 28.7'	-55° 57.1'
	5xD days	29743.5	245.8	-44075.1	53172.9	29744.5	+0° 28.4'	-55° 59.2'
September	All days	29758.1	248.1	-44071.7	53178.2	29759.2	+0° 28.7'	-55° 58.3'
	5xQ days	29774.4	249.1	-44068.6	53184.8	29775.5	+0° 28.8'	-55° 57.3'
	5xD days	29728.4	248.9	-44076.4	53165.5	29729.4	+0° 28.8'	-56° 00.0'
October	All days	29783.8	249.4	-44060.5	53183.3	29784.9	+0° 28.8'	-55° 56.5'
	5xQ days	29792.0	249.3	-44057.7	53185.6	29793.0	+0° 28.8'	-55° 55.9'
	5xD days	29770.9	249.7	-44062.6	53177.8	29771.9	+0° 28.8'	-55° 57.2'
November	All days	29788.4	249.1	-44056.0	53182.2	29789.5	+0° 28.8'	-55° 56.1'
	5xQ days	29793.7	248.3	-44054.5	53183.9	29794.8	+0° 28.7'	-55° 55.7'
	5xD days	29781.9	249.6	-44057.7	53180.0	29782.9	+0° 28.8'	-55° 56.5'
December	All days	29794.9	248.1	-44049.9	53180.7	29795.9	+0° 28.6'	-55° 55.5'
	5xQ days	29800.9	249.1	-44050.4	53184.5	29801.9	+0° 28.7'	-55° 55.2'
	5xD days	29789.8	248.4	-44050.0	53177.9	29790.8	+0° 28.7'	-55° 55.8'
Annual	All days	29771.7	245.3	-44079.4	53192.2	29772.7	+0° 28.3'	-55° 57.8'
Mean	5xQ days	29782.6	245.2	-44077.5	53196.7	29783.6	+0° 28.3'	-55° 57.2'
Values	5xD days	29753.2	245.0	-44082.4	53184.4	29754.3	+0° 28.3'	-55° 58.9'

(Calculated: 13:18 hrs., Thu., 29 Jun., 2006)

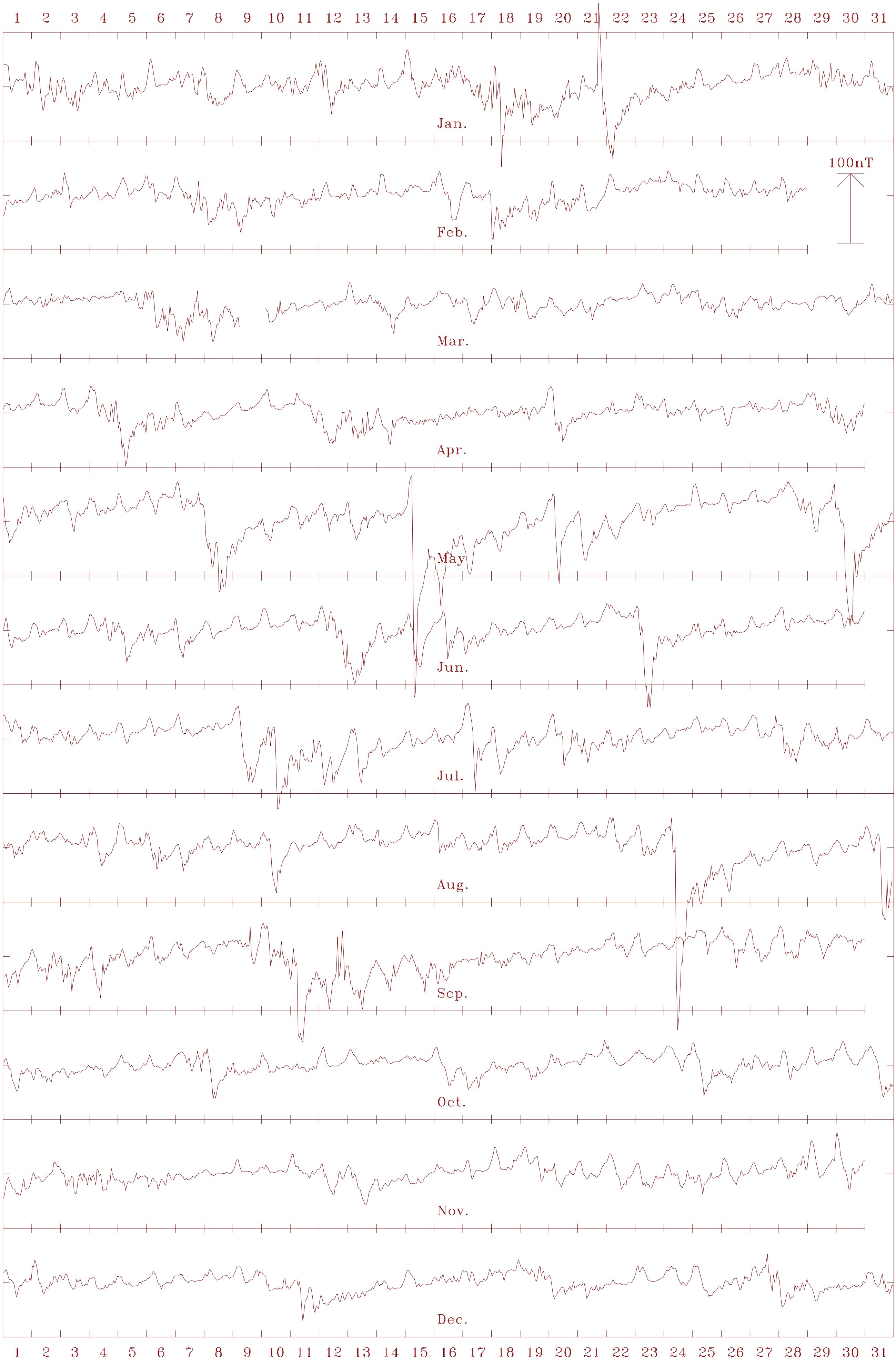
Hourly Mean Values

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

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

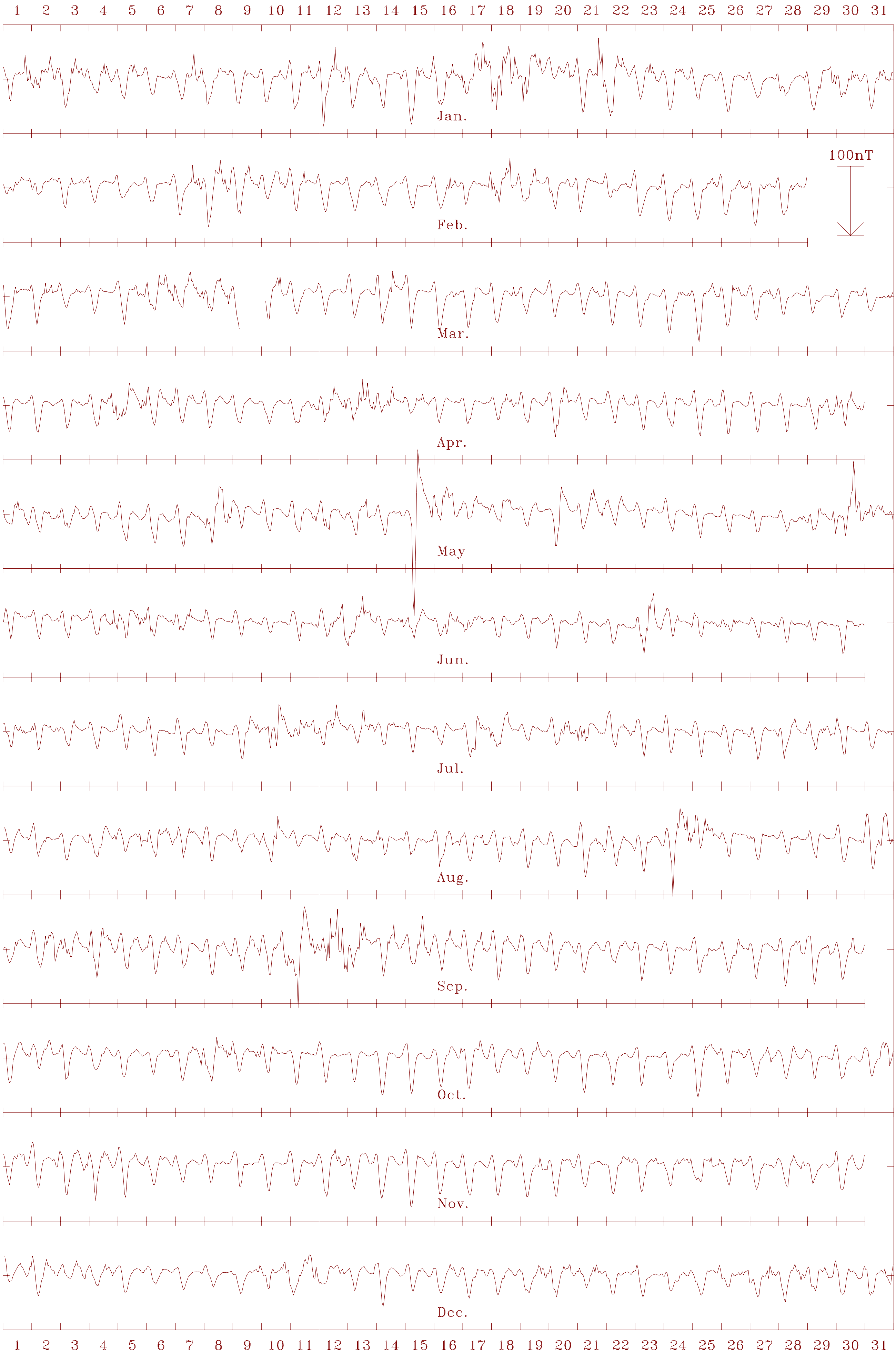
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

Learmonth 2005 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 29773 nT

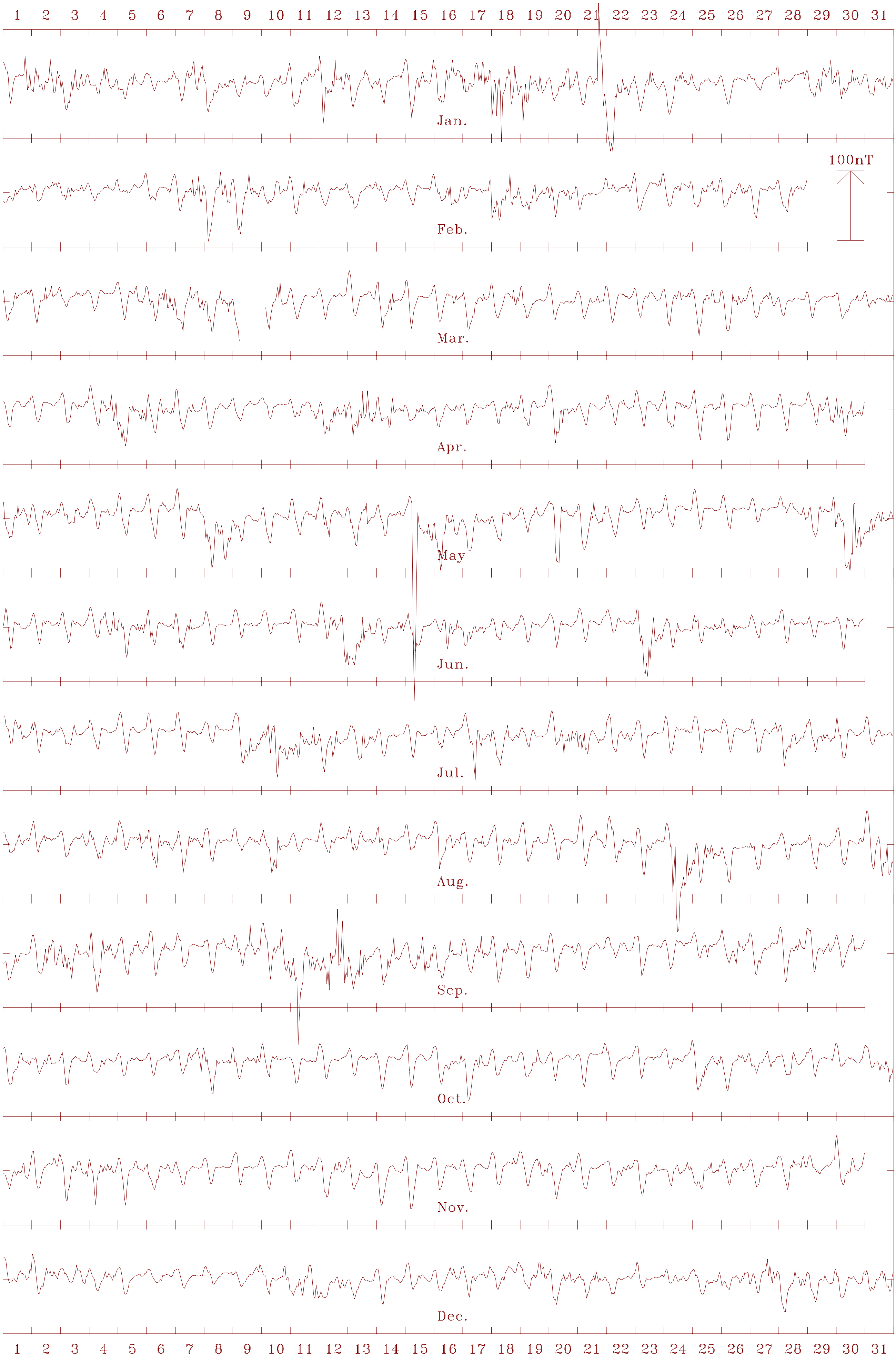


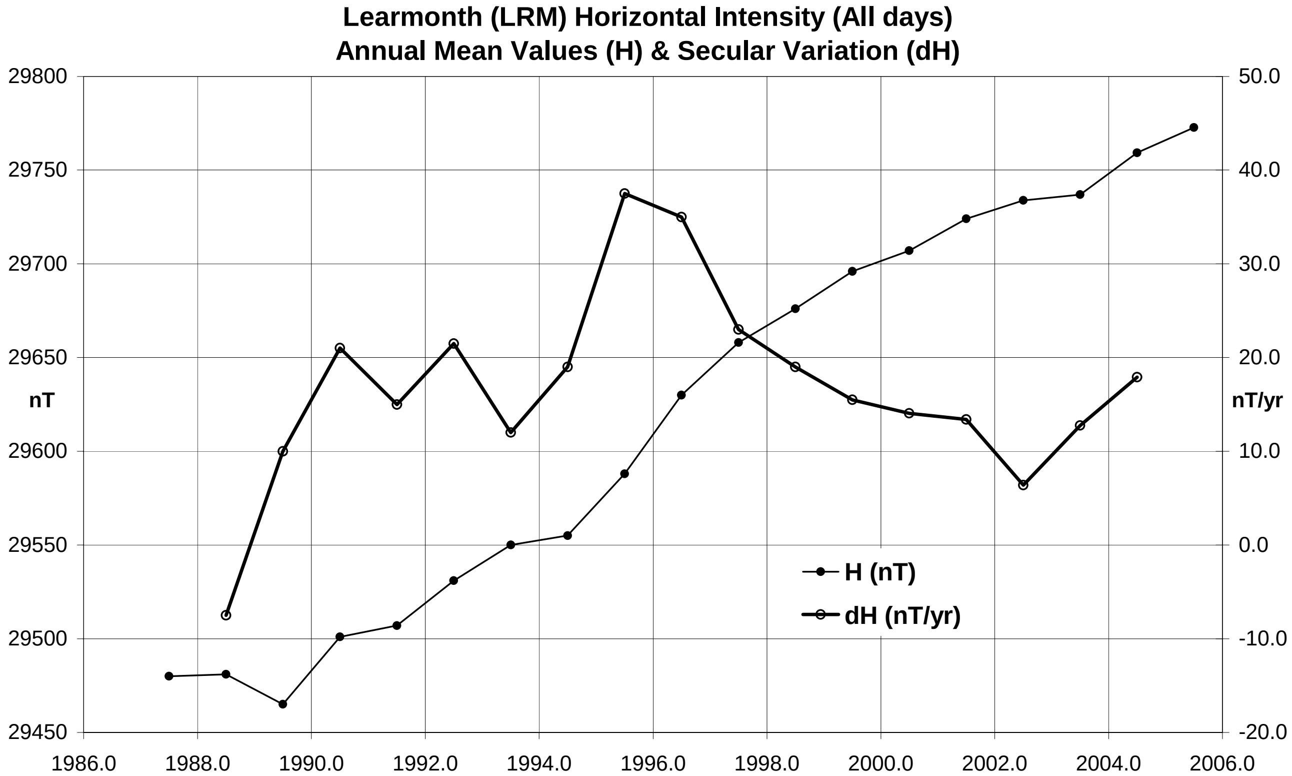
Learmonth 2005 Declination (east) (D). Scale: 0.75 min/mm. Mean: 0.47 deg.

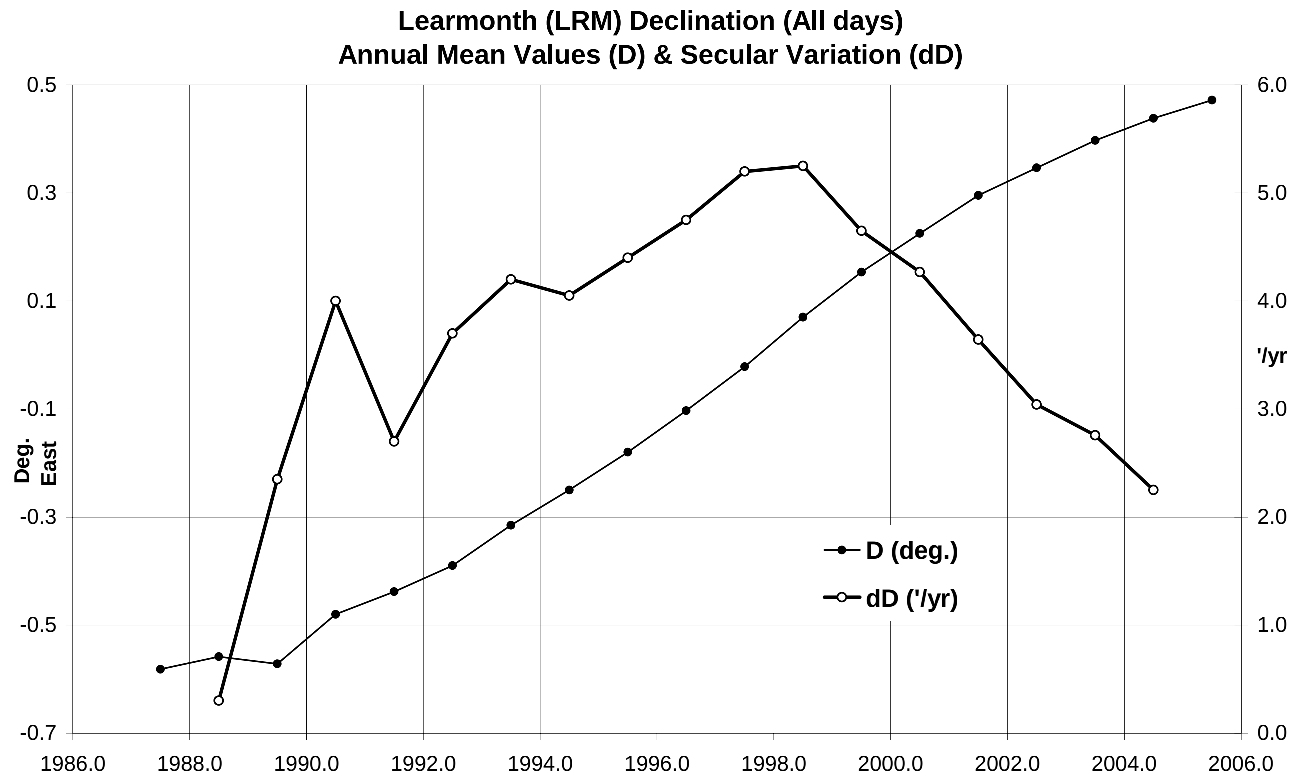
Learmonth 2005 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −44079 nT



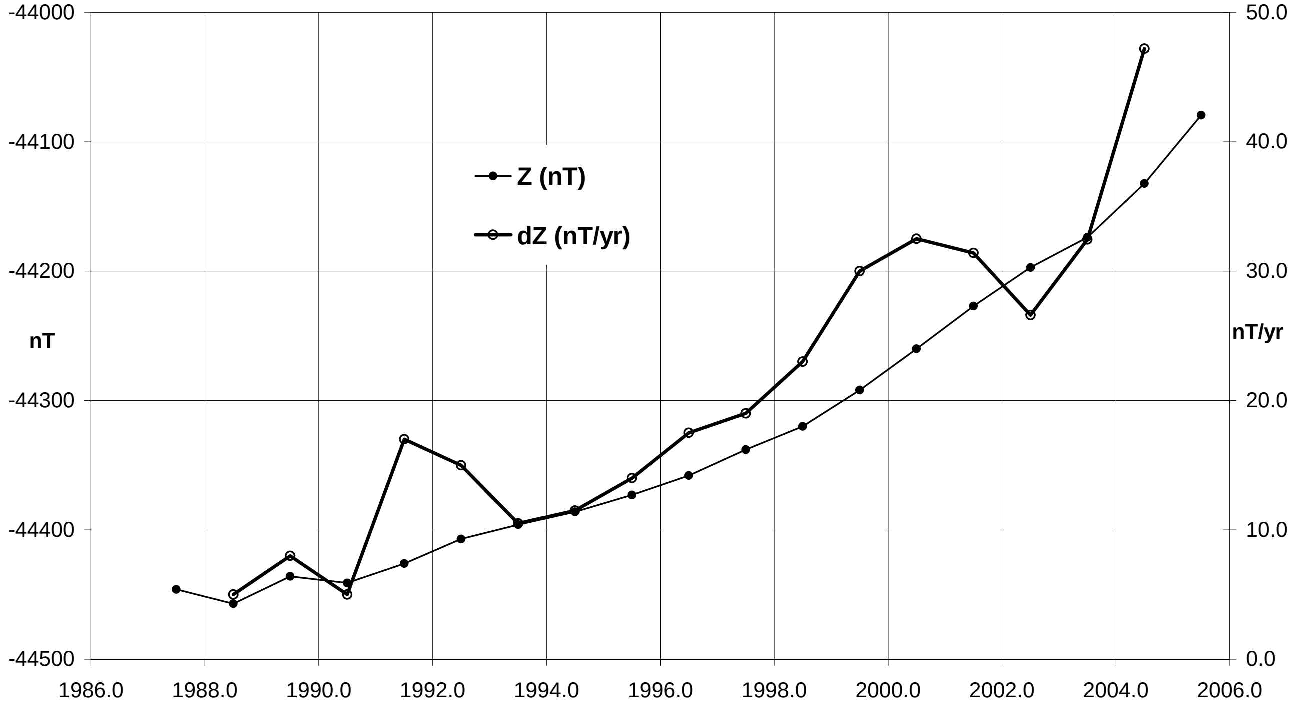
Learmonth 2005 Total intensity (F). Scale: 7.5 nT/mm. Mean: 53192 nT



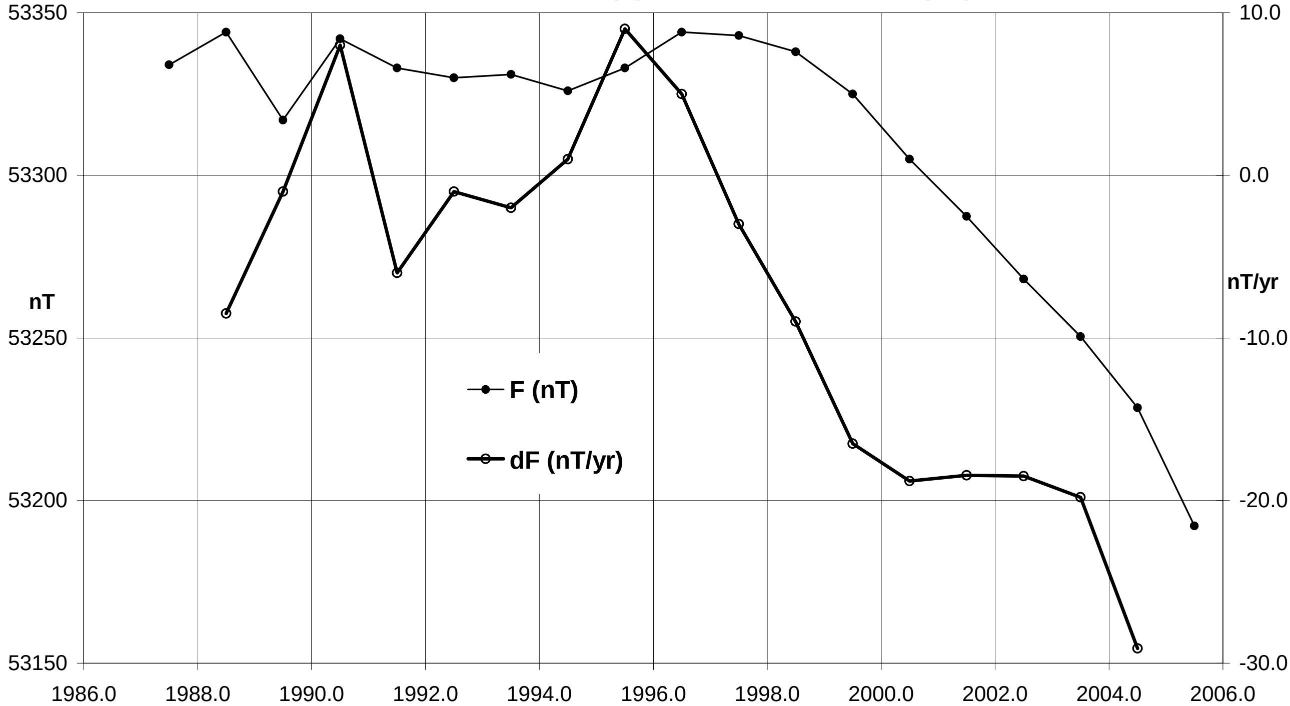

Learmonth (LRM) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
nT
nT/yr
H (nT)
dH (nT/yr)
29800
29750
29700
29650
29600
29550
29500
29450
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Learmonth (LRM) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
Deg. East
'/yr
D (deg.)
dD ('/yr)
0.5
0.3
0.1
-0.1
-0.3
-0.5
-0.7
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1986.0
1988.0
1990.0
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0

Learmonth (LRM) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)



Learmonth (LRM) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)



Significant Events in 2005 (cont.)

08 Jul	New observer (OG) performed first absolute observation.
23 Aug	2340: Delivery of data to the Edinburgh INTERMAGNET GIN commenced (in real-time), following its admission to the INTERMAGNET network.
28 Nov	Firebreak was cut around the observatory perimeter.
07 Nov	19" flat screen monitor installed on acquisition system to replace the 17" CRT monitor.

Distribution of LRM data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2005.

1-minute and Hourly Mean Values to WDCs

- 2005: WDC-A, Boulder, USA (16 Aug. 2006)

1-minute Values for Project INTERMAGNET

- Preliminary data to the Edinburgh IM GIN by e-mail: (in real-time) from 23 August 2005.
- 2005 Definitive data sent to IM GIN, Paris (16 Aug 2006)

Data losses in 2005

07 Jan	2232-2233 (2m), 2238-2238 (1 m), 2252-2253 (2m), 2321-2322 (2m) X,Y,Z channels: System reboots
	2232 to 08/0020 (1h 49m) F-channel only: Reboots.
19 Jan	0112-0209 (58m) All channels: Data contaminated
12 Feb	2333-2335 (3m) All channels
02 Mar	2333-2335 (3m) X,Y,Z channels
02 Mar	1650 to 03/0140 (8h 51m) F-channel only
03 Mar	2024-2025 (2 min.), 2059 (1m) X,Y,Z channels
03 Mar	to 05/2304 (2d 02h 41m) F-channel only.
09 Mar	to 10/0300 (21h 02m) All channels: Processing of contaminated data inhibited.
17 Mar	0203 (1m) All channels
18 Mar	0714-0716 (3m), 0732 (1m) X,Y,Z channels
	0714-0907 (1h 54m) F-channel only
16 Apr	2031-2032 (2m), 2100 (1m) X,Y,Z channels
16 Apr	2031 to 20/0221 (3d 05h 51m) F-channel only
19 Apr	0628-0629 (2m), 0704 (1m) X,Y,Z channels
24 May	1154-1155 (2m), 1250-1251 (2m) X,Y,Z channels
24 May	1154to 25/0128 (13h 35m) F-channel only
19 Jun	0218 to 20/0739 (1d 05h 22m) F-channel only: System Upgrades
20 Jun	0254-0255 (2m), 0551-0607 17m), 0637-0738 (1h 02m) X,Y,Z channels: System Upgrades
06 Jul	1050 (1m) Spike in F-channel data only removed.
08 Jul	0437 (1m) Spike in F-channel data only removed
31 Jul	0039 (1m) Spike in F-channel data only removed
02 Oct	1017 (1m) Spike in F-channel data only removed
17 Nov	0310-0317 (8m) F-channel only
22 Nov	0232-0233 (2m) F-channel only

Notes and Errata (cumulative since *AGR1993*)

The adjustment applied to the absolute PPM used at Learmonth in 1994 was given as -1nT on in the *AGR1994* (p. 44). This correction was in addition to a -1nT correction to the reference PPM (MNS2 no.3) and so should have been shown as -2nT. This results in baseline adjustments in X, Y and Z of -1.1nT, 0.0nT and +1.7nT respectively. No changes in the data presented are required as the correct adjustments were applied in their calculation.

The distributed LRM 2003 data contained an error in the instrument corrections applied. These data were corrected and redistributed on 23 May 2006. The LRM 2003 data reported in *AGR2003* was based upon the application of the correct instrument corrections.

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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), Sustainable Ecosystems Centre for Arid Zone Research. The observatory is situated on an alluvial plain over tertiary sediments, overlying late Proterozoic carbonates and quartzites.

Continuous recording of magnetic data commenced at the Alice Springs Magnetic Observatory on 01 June 1992. A detailed history of the observatory was given in the *AGR 1994*.

The observatory comprised: a 3m x 3m air-conditioned concrete-brick CONTROL HOUSE where all recording instrumentation and control equipment was housed; a 3m x 3m roofed absolute shelter, 80m SE of the CONTROL HOUSE, which enclosed a concrete observation pier (Pier G), the top of which was 1277mm above the concrete floor; two 300mm diameter azimuth pillars that were about 85m from the absolute shelter at approximate true bearings of 130° and 255°; and two small (1m cube) underground vaults located approximately 50m north and 50m east of the CONTROL HOUSE in which the variometer sensors were housed.

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

Key data for Alice Springs Observatory:

- 3-character IAGA code: ASP
- Commenced operation: June 1992
- Geographic latitude: 23° 45' 39.6" S
- Geographic longitude: 133° 53' 00.0" E
- Geomagnetic†: Lat. -32.75°; Long. 208.18°
- Lower limit for K index of 9: 350 nT
- Principal pier identification: Pier G
- Elevation of top of Pier G: 557 metres AMSL
- 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 2005.0 model updated to 2005.5

Variometers

At the beginning of 2005 variations in the magnetic field were recorded at Alice Springs using a three-component Narod ring-core fluxgate (RCF) magnetometer with its sensor aligned so that the sensor elements were as close as possible to geographic north, geographic east and vertical (X, Y and Z). The total magnetic field intensity (F) was monitored using a GEM Systems GSM-90 Overhauser-effect proton precession magnetometer (PPM).

Variometers (cont.)

The GSM-90 variometer failed on 23 March 2005 and was replaced with a similar instrument on 23 May 2005 which was still operating at the end of 2005. The east-aligned channel of the Narod RCF variometer failed on 09 August 2005. As there was a total intensity magnetometer running at the time, it was possible to synthesize the faulty channel from the total intensity and the two functional RCF magnetometer channels. In this way it was possible to continue acquiring three-component variometer data until the RCF magnetometer was replaced. Unfortunately the total intensity magnetometer exhibited periods when the data acquired were somewhat scattered. This had the effect of causing the synthesized channel to be scattered also: indeed it was extremely scattered as the missing channel was highly sensitive (19:1) to variations in total intensity. Notwithstanding the filtering of outlying total intensity values during these periods, the synthesized (Y) channel appeared excessively noisy. These periods were from 0000 on 11 August to 0030 on 16 August and from 0000 on 17 August to approximately 0415 on 18 August 2005. The filtering process also had the effect of disabling all of the X, Y and Z channels on the filtered minutes.

On 14 September 2005 the Narod RCF 3-component magnetometer was replaced with a DMI suspended 3-component fluxgate magnetometer. This was installed with its sensors aligned in the magnetic-NW, magnetic-NE (45 deg. either side of the magnetic meridian) and vertical directions.

The variometer sensor heads were housed in underground concrete vaults: the RCF and DMI sensors were in turn located in the eastern vault; the PPMs in the northern vault. The electronic equipment for RCF variometer control and data recording was housed in the temperature-controlled, thermally insulated CONTROL HOUSE. The electronics for the variometer PPMs and for the DMI fluxgate variometer were housed in the respective vaults with their sensors. The eastern vault was insulated with foam beads and both vaults were completely concealed beneath local soil to minimise temperature fluctuations. The cables from each of the sensor vaults to the CONTROL HOUSE passed through underground conduits.

Six channels of variometer data (three fluxgate variometer channels, fluxgate variometer sensor and electronics temperatures, and the PPM data) were recorded on a PC.

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

Absolute Instruments and Corrections

The principal absolute instruments employed at Alice Springs during 2005 were a D,I fluxgate magnetometer (DIM) and an Overhauser effect proton precession magnetometer (PPM). The DIM used was DMI single-axis fluxgate magnetometer no. DI0052 with its sensor mounted on Zeiss 020B non-magnetic theodolite no. 313887, and the PPM used was a GEM model GSM90, no 2101216 with sensor 306403. A Hewlett Packard H4300 Personal Data Assistant handheld computer was used to communicate via the serial data port of the GSM90 PPM.

No absolute observations were performed at ASP between early December 2004 and late January 2005. During that period the DIM absolute magnetometer was returned to GA in Canberra to replaced the single axis (Elsec model 810 no. 221) fluxgate sensor with DMI no. DI0052.

Comparisons between the ASP absolute instruments: DIM DI0052/318887 and GSM90_2101216/306403 that were in use at the observatory at the time, and the travelling reference absolute instruments B0610H/160459 and GSM90_003985/11690, were performed at Alice Springs in late May 2005 during a service visit (when the variometer PPM was replaced). The instrument differences adopted from the comparisons were:

DIM: B0610H/160459 = DI0052/318887 + 0.11' (±0.09) in D
B0610H/160459 = DI0052/318887 - 0.02' (±0.02) in I
GSM90: 003985/11690 = 2101216/306403 + 0.4nT (±0.1) in F

The travelling reference instruments were routinely compared with the Australian reference instruments held at Canberra Observatory (DIM DI0048/353756 and PPM GSM90_905926/21867) The average differences of the DIM comparisons between 10 February and 24 May 2005 were:

DIM: DI0048/353756 = B0610H/160459+ 0.00' (±0.15) in D
DI0048/353756 = B0610H/160459 + 0.07' (±0.02) in I

The average differences of the PPM comparisons performed on 11 and 30 May 2005 were:

GSM90: 905926/21867 = 003985/11690 + 0.0nT (±0.07) in F

Taking into account the uncertainties of the measurements the corrections to the absolute magnetometers used at the ASP observatory during 2005 to align them with the Australian reference magnetometers at Canberra were:

DIM DI0052/318887: ΔD = 0.0' and ΔI = 0.0'
PPM GSM90_2101216/306403: ΔF = +0.4 nT

At the average magnetic field values at Alice Springs these instrument corrections convert to baseline corrections of:

ΔX = +0.22nT, ΔY = +0.02nT, ΔZ = –0.33nT

These corrections have been applied to all final ASP 2005 data.

Baselines

The standard deviations in the 2005 weekly absolute observations from the final adopted variometer model and data were:

1.6 nT in X; 2.6 nT in Y; 1.6 nT in Z

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

0.35 nT in F; 16" in D; 09" in I)

The drifts applied to the X, Y, and Z baselines amounted to less than 20nT in any of those components throughout the year.

There was about 7nT variation in the difference between F measured with the fluxgate (final data model with drifts applied) and the variometer PPM for the period when PPM data were available.

Observed and adopted baseline values in X, Y and Z for 2005 are shown in the following (INTERMAGNET format) chart.

Operations

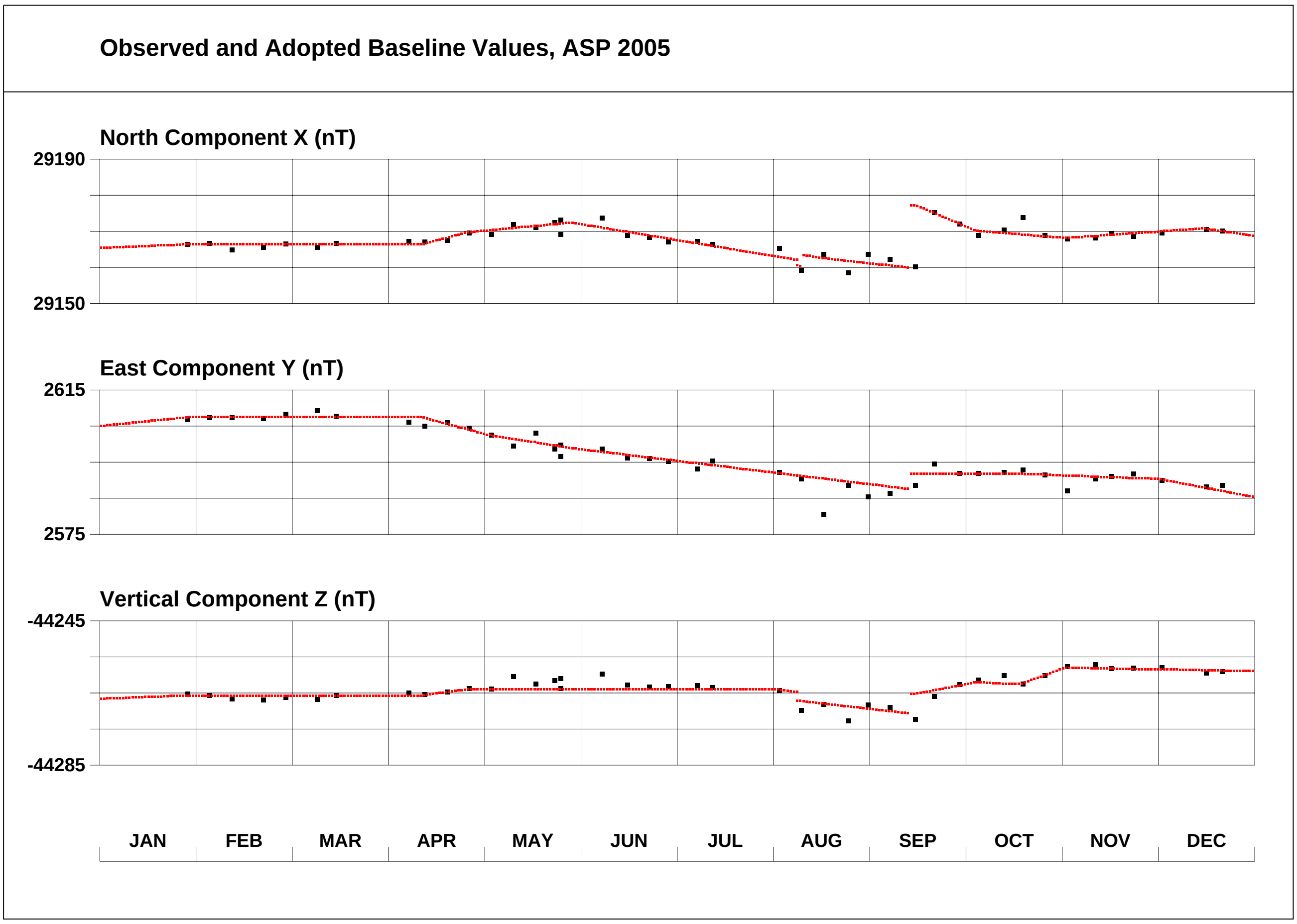
During 2005 absolute observations were performed weekly (often on a Wednesday afternoon) by the local Observers in Charge, who were officers at the nearby Australian Centre for Remote Sensing (ACRES; that became a part of Geoscience Australia when AusLIG merged with ASGO to form GA) installation. DIM and PPM observations were routinely performed on absolute pier G, using pillar B as azimuth reference. The operation of the observatory was checked twice weekly (usually on Mondays and Fridays) by an observer. The absolute observation data were sent weekly by post to GA in Canberra, where they were processed and used to calibrate the variometer data.

Daily files of both 1-minute and 1-second resolution data were automatically retrieved from Alice Springs to GA in Canberra by modems via a telephone line connection. After preliminary processing the data were then automatically e-mailed to the INTERMAGNET GIN at Edinburgh as well as being made available on the GA website. System timing checks and PC hard-disk housekeeping tasks were also performed semi-automatically via the telemetry line. Accurate timing on the data acquisition computer was maintained with a one-second pulse from a Trimble Accutime GPS clock mounted outside the CONTROL HUT.

Operations (cont.)

Two maintenance visits by personnel from GA, Canberra were made to the ASP observatory during 2005. The first visit (by AML) was over the period 23-27 May 2005, during which a faulty GEM GSM90 PPM variometer (electronics and sensor) was replaced. In addition, instrument checks and comparisons were performed, pier gradients measured, azimuth mark angles checked and pier differences to the remote reference stations at the airport (E and F) were measured.

The second maintenance visit to the ASP observatory in 2005 was made (by AML and BS) over the period 13-16 September. During this visit the 3-component Narod variometer, the Y-channel of which had failed on 09 August, was replaced with a DMI 3-axis suspended fluxgate variometer. A series of absolute observations were performed after the new variometer was installed to establish baseline values etc. for the new system.



Significant Events in 2005

10 Dec. 2005	Local observer (WFS) on extended leave resulting in no absolute observations until late January 2005. DIM at GA for comparison and to have the Elsec sensor replaced with a DMI sensor.
08 Jan	1330-1500: PPM variometer noisy.
19 Jan	Radio modem equipment sent for noise testing at ACRES.
28 Jan	First absolute observations performed with the new DMI DI0052/313887 DIM.
09 Feb	to 11th: Tested WiFi link from absolute hut to ACRES.
17 Feb	WiFi antenna removed from control hut. Local observer (WFS) away until 04 April.
18 Mar	1015: Variometer PPM began recording a constant value until Mar 23 at 0635, after which it failed completely.
30 Mar	Local observer (SDE) investigated PPM problems.
01 Apr	0221: System rebooted in an unsuccessful attempt to fix PPM.
04 Apr	Local observer (WFS) in hut to test acquisition PC's com2 with hand-held PC (PDA) used to log absolute PPM readings. All O.K.
23-27 May	Service visit to ASP by officer (AML) from GA, Canberra. Variometer PPM GSM90_708729/3112370 was replaced with GSM90_4081419/42177; comparisons, pier differences, tests, training new observer (SDE) carried out.
01 Jul	Both local observers (WFS & SDE) became GA employees (having previously been contracted from another business) and commenced sharing the weekly absolute observing duties.
13 Jul	First absolute observation by SDE.
09 Aug	1253: Baseline step in X, Y & Z variometer channels and Y channel suddenly became erratic.
10 Aug	2359: System remote rebooted. PPM became noisy.
11 Aug	0037: Local observer (WFS) powered Narod off/on at the hut. Airconditioner reported to be malfunctioning.
12 Aug	0548: System rebooted remotely in unsuccessful attempt to get PPM working better.
15 Aug	0035: PPM retuned (from T54 to T53), polarise set to "b" and autotune set to "y"
18 Aug	Attempts to reset automatic PPM tuning etc. Several reboots.

Significant Events (cont.)

13-16 Sep. Service visit to ASP by officers (AML, BS) from GA, Canberra to install a new (DMI E0306/S0261) 3-component variometer.

14 Sep 0401: Narod 3-axis RCF variometer switched off.

15 Sep 0030: First usable data from new (DMI) variometer.

17 Nov New airconditioner installed in control hut.

13 Dec 19 inch flat screen monitor sent to ASP for use with the acquisition PC.

Data losses in 2005

Jan 06 (intermittent 3m) Data filtered: F channel.

Jan 08 1352-1354 (3m), 1356 (1m), 1359-1407 (9m) 1411 (1m), 1413-1420 (8m), 1423-1425 (3m), 1427-1428 (2m), 1430-1435 (6m): Data not recorded: F channel.

1436-1443 (8m) Data not processed: F channel.

1444-1449 (6m) 1451-1452 (2m) 1458-1519 (22m) Data not recorded: F channel.

Days when intermittent F-channel data were filtered-out: Jan 26 (2m), Jan 27 (4m), Feb 01 (2m), Feb 06 (3m), Feb 14 (1m), Feb 17 (1m), Feb 18 (8m), Feb 24 (1m), Mar 01 (2m), Mar 03 (3m), Mar 05 (1m), Mar 07 (4m), Mar 10 (1m), Mar 14 (4m)

Mar 18 1016 to 23/0635 (4d 20h 20m) Data invalid: F-channel

Mar 23 0636 to 30 Apr/2359 (38d 17h 24m) Data not recorded: F-channel

Apr 01 0222-0223 (2m) Data not recorded: XYZ channels

May 01 0000 to 23/0658 (22d 06h 59m) Data not recorded: F-channel

May 23 0659-0714 (16m) Data not processed: F-channel

May 23 (intermittent 3m) Data filtered: F-channel

May 25 0434-0506 (33m), 0508-0556 (49m) Data not recorded: F-channel

May 26 0320-0327 (8m), 0349-0351 (3m) Data not recorded: F-channel

May 26 (intermittent 10m) Data filtered: F-channel.

Aug 11 0005 (1m) Data not recorded: X,Y,Z & F channels

Aug 12 0548 (1m) Data not recorded: X,Y,Z & F channels

Days when intermittent F-channel data were filtered-out during the period when the faulty Y-channel of the 3-component Narod RCF variometer was being synthesized from the recording PPM and the two serviceable Narod data channels. As a consequence, those minutes of PPM data that were rejected by the filtering process were also lost in the X, Y & Z channels:

Aug 11 (479m), Aug 12 (517m), Aug 13 (536m), Aug 14 (500m), Aug 15 (515m), Aug 16 (29m), Aug 17 (549m), Aug 18 (106m), Aug 22 (2m)

Aug 15 0400 (1m) Data not recorded: F-channel only

Aug 16 0033-0038 (6m) Data not recorded: F-channel only

Aug 18 0353 (1m) Data not recorded: X,Y,Z & F-channels

Aug 18 0414 (1m) Data not recorded: X,Y,Z & F-channels

Aug 18 0320-0321 (2m) Data not recorded: F-channel only

Aug 18 0333 (1m) Data not recorded: F-channel only

Sep 14 0402-0751 (3h 50m) Data not recorded: F-channel.

Sep 14 0402-0822 (4h 21m) Data not recorded: X,Y,Z only.

Sep 14 0752-0754 (3m) Data not processed: F-channel only

Sep 14 0755-0806 (12m) Data not recorded: F-channel only

Sep 14 0807-0821 (15m) Data not processed: F-channel only

Sep 14 0822 (1m) Data not recorded: F-channel only

Sep 14 0823-0854 (32m) Data not processed: X,Y,Z & F.

Sep 14 2245-2344 (1h 00m) Data not processed: X,Y,Z & F

Sep 15 0010 (1m) Data not recorded: X,Y,Z & F channels.

Days when intermittent F-channel data were filtered-out: Oct 05 (1m), Oct 13 (4m), Oct 29 (3m), Nov 09 (3m), Nov 12 (2m), Dec 07 (1m), Dec 16 (5m)

Data loss summary	XYZ(mins)	F(mins)
Data not recorded	268	88,277
Data invalid	6,980	
Processing inhibited	92	133
Rejected by filtering	3,233	3,305
Total data unavailable	3,593	98,963
As a percentage of year	0.68%	18.83%

Distribution of ASP data

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2005

1-minute and Hourly Mean Values to WDCs

- 2005 data sent in 2006.

1-minute Values for Project INTERMAGNET

- Preliminary data daily to the Edinburgh IM GIN by e-mail.
- 2005 Definitive data to Paris IM GIN (29 Sep. 2006)

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 48 & 49.

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

continued on page 50 …

Monthly and 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	2005	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	29951.1	2675.6	-44116.0	53389.6	30070.4	5° 06.3'	-55° 43.3'
	5xQ days	29961.3	2679.5	-44113.8	53393.8	30080.9	5° 06.6'	-55° 42.6'
	5xD days	29936.6	2669.4	-44121.2	53385.5	30055.4	5° 05.7'	-55° 44.2'
February	All days	29961.0	2679.3	-44107.1	53388.0	30080.6	5° 06.6'	-55° 42.4'
	5xQ days	29970.4	2681.0	-44103.9	53390.7	30090.1	5° 06.7'	-55° 41.8'
	5xD days	29945.5	2675.1	-44110.4	53381.8	30064.8	5° 06.3'	-55° 43.3'
March	All days	29959.8	2681.1	-44099.9	53381.5	30079.6	5° 06.8'	-55° 42.2'
	5xQ days	29966.5	2681.1	-44098.9	53384.4	30086.2	5° 06.8'	-55° 41.8'
	5xD days	29944.9	2679.6	-44104.1	53376.5	30064.5	5° 06.8'	-55° 43.1'
April	All days	29959.6	2681.4	-44095.9	53378.1	30079.4	5° 06.9'	-55° 42.0'
	5xQ days	29967.4	2680.3	-44093.6	53380.5	30087.1	5° 06.7'	-55° 41.6'
	5xD days	29944.5	2680.4	-44098.1	53371.4	30064.2	5° 06.9'	-55° 42.9'
May	All days	29936.6	2677.0	-44100.6	53368.9	30056.1	5° 06.6'	-55° 43.5'
	5xQ days	29962.0	2679.6	-44096.8	53380.1	30081.6	5° 06.6'	-55° 42.0'
	5xD days	29892.2	2672.9	-44107.1	53349.2	30011.5	5° 06.6'	-55° 46.1'
June	All days	29951.1	2678.8	-44095.3	53372.7	30070.7	5° 06.7'	-55° 42.5'
	5xQ days	29964.0	2678.2	-44091.7	53376.9	30083.5	5° 06.4'	-55° 41.7'
	5xD days	29936.9	2680.0	-44096.8	53366.0	30056.6	5° 06.9'	-55° 43.3'
July	All days	29955.0	2677.2	-44087.0	53367.9	30074.4	5° 06.4'	-55° 42.0'
	5xQ days	29969.2	2678.4	-44085.5	53374.7	30088.7	5° 06.4'	-55° 41.2'
	5xD days	29934.9	2674.3	-44091.4	53360.1	30054.1	5° 06.3'	-55° 43.2'
August	All days	29953.4	2675.8	-44081.8	53362.6	30072.7	5° 06.3'	-55° 41.9'
	5xQ days	29960.6	2677.4	-44080.5	53365.7	30080.0	5° 06.4'	-55° 41.5'
	5xD days	29926.9	2669.9	-44084.9	53350.1	30045.8	5° 05.9'	-55° 43.4'
September	All days	29941.1	2673.7	-44084.0	53357.5	30060.2	5° 06.2'	-55° 42.6'
	5xQ days	29957.4	2675.5	-44081.3	53364.5	30076.7	5° 06.2'	-55° 41.7'
	5xD days	29911.9	2671.9	-44089.5	53345.5	30031.0	5° 06.3'	-55° 44.4'
October	All days	29965.5	2675.7	-44075.5	53364.3	30084.7	5° 06.2'	-55° 41.0'
	5xQ days	29971.3	2676.8	-44073.0	53365.5	30090.6	5° 06.2'	-55° 40.6'
	5xD days	29954.1	2673.3	-44077.9	53359.7	30073.2	5° 06.0'	-55° 41.7'
November	All days	29970.4	2673.5	-44070.8	53363.0	30089.4	5° 05.9'	-55° 40.6'
	5xQ days	29975.9	2674.6	-44069.0	53364.6	30095.0	5° 05.9'	-55° 40.2'
	5xD days	29963.6	2673.2	-44072.2	53360.3	30082.6	5° 05.9'	-55° 41.0'
December	All days	29975.9	2671.9	-44065.5	53361.6	30094.7	5° 05.6'	-55° 40.1'
	5xQ days	29982.1	2672.9	-44065.5	53365.2	30101.1	5° 05.7'	-55° 39.8'
	5xD days	29972.0	2670.9	-44066.4	53360.1	30090.8	5° 05.5'	-55° 40.4'
Annual	All days	29956.7	2676.7	-44090.0	53371.3	30076.1	5° 06.4'	-55° 42.0'
Mean	5xQ days	29967.4	2677.9	-44087.8	53375.5	30086.8	5° 06.4'	-55° 41.4'
Values	5xD days	29938.7	2674.2	-44093.3	53363.8	30057.9	5° 06.3'	-55° 43.1'

(Calculated: 10:18 hrs., Thu., 02 Nov. 2006)

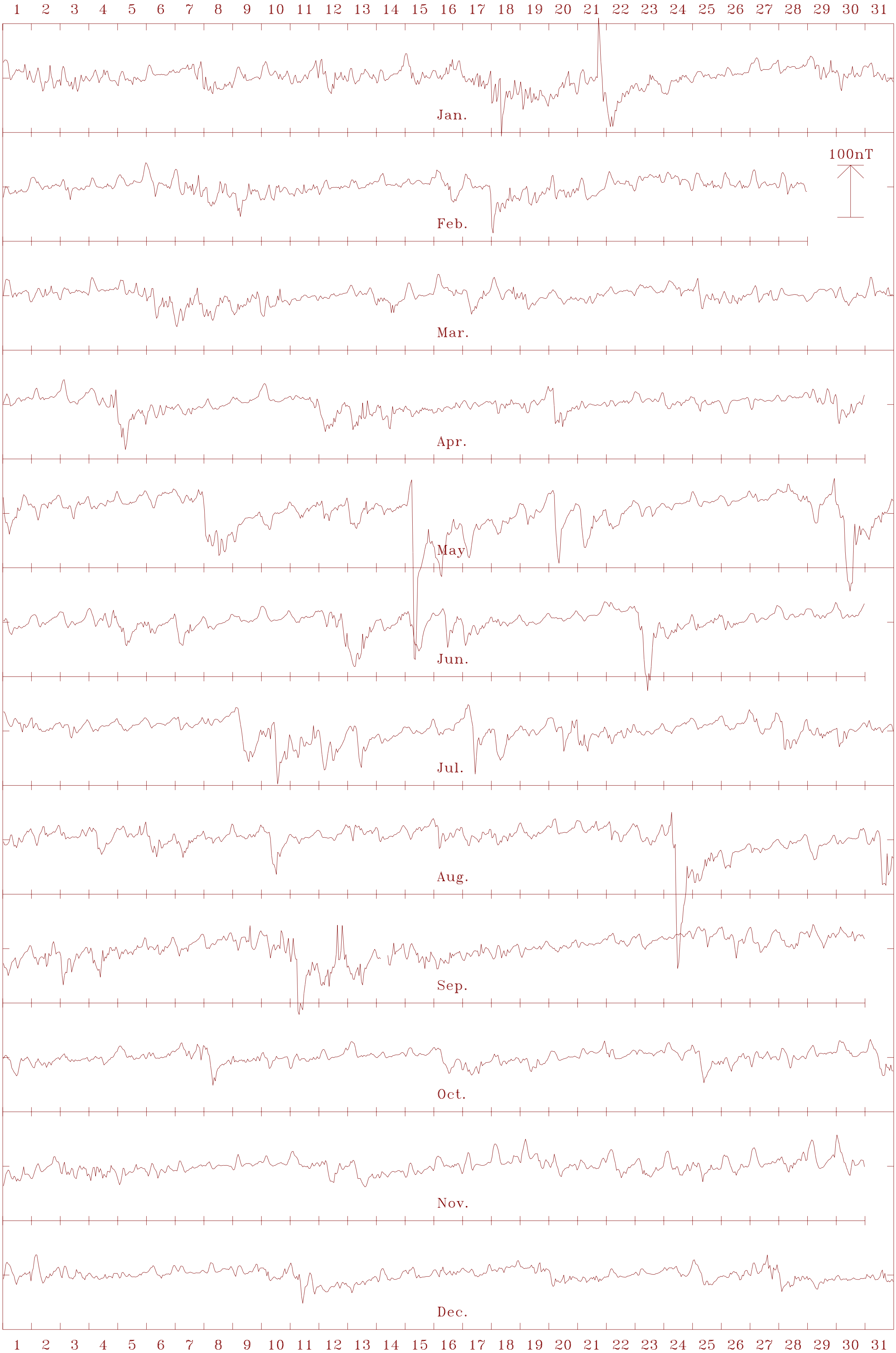
Hourly Mean Values

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

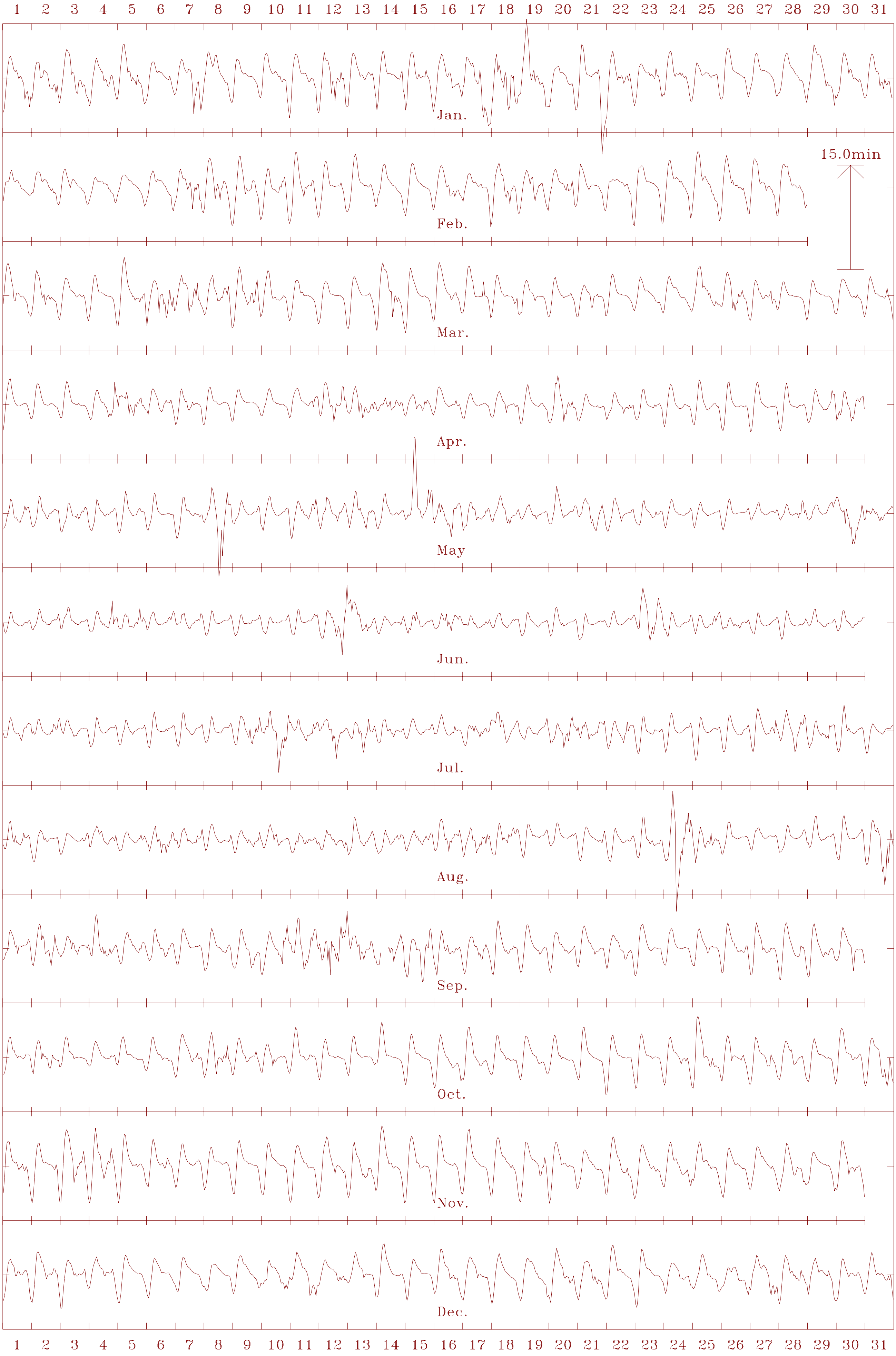
The reference levels indicated with marks on the vertical axes refer to the *all-days* mean value for the respective months. All elements in the plots are shown increasing (algebraically) towards the top of the page, with the exception of Z, which is in the opposite sense.

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

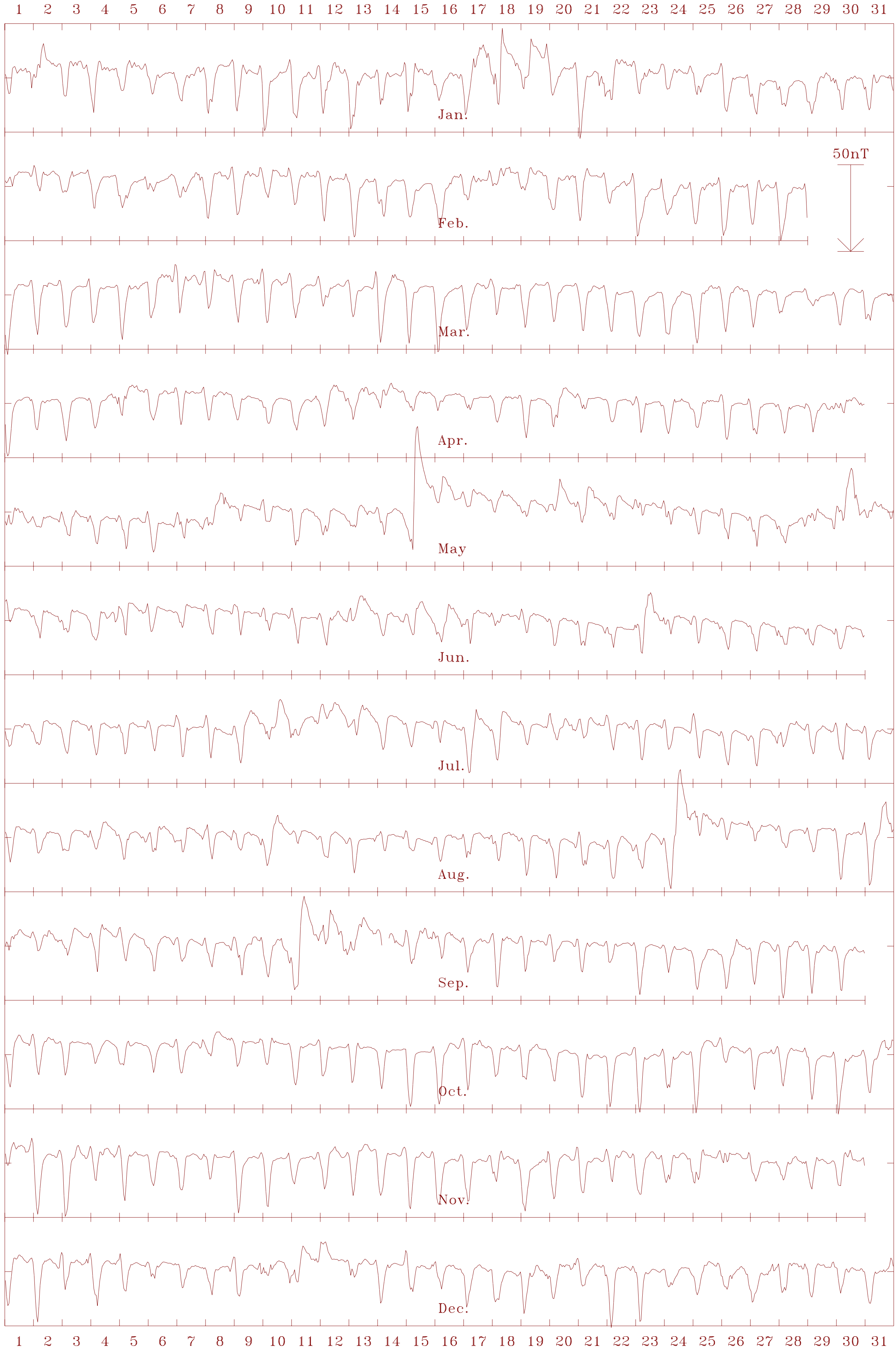
Alice Springs 2005 Horizontal intensity (H). Scale: 10.0 nT/mm. Mean: 30076 nT



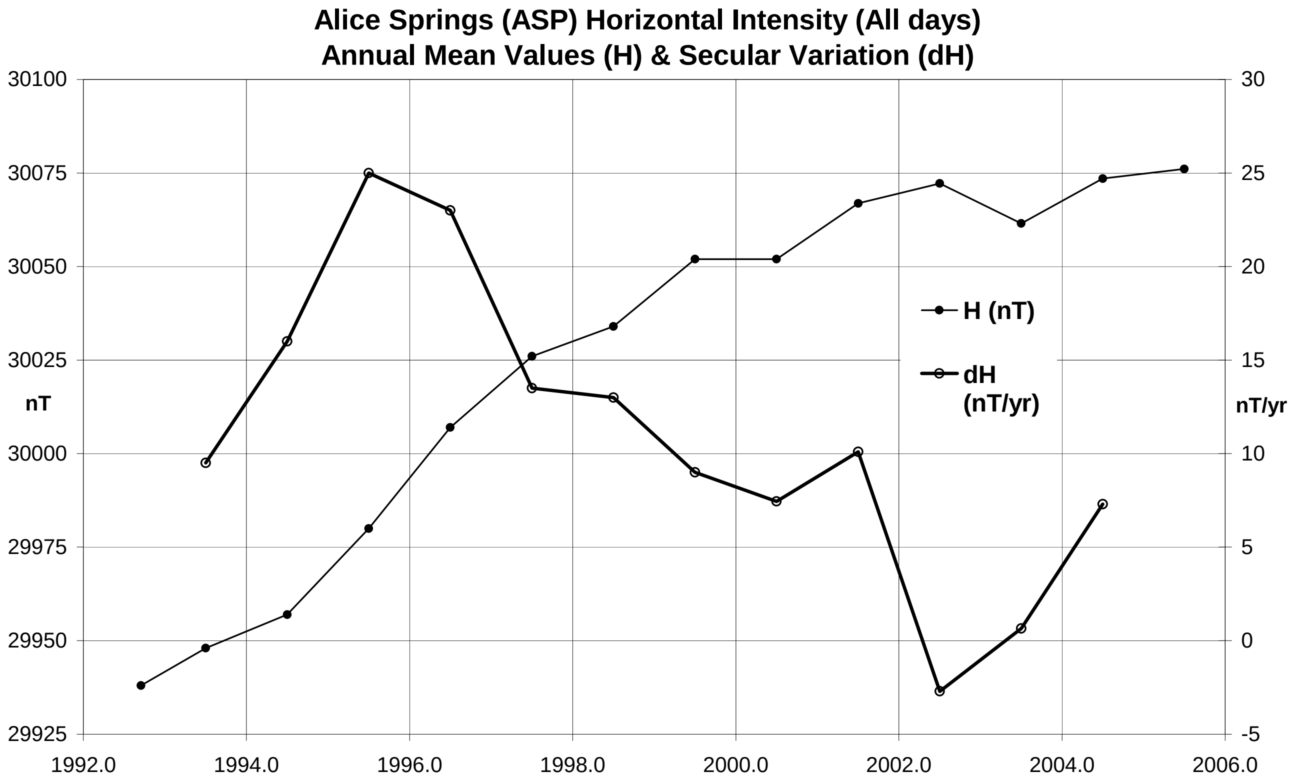
Alice Springs 2005 Declination (east) (D). Scale: 0.75 min/mm. Mean: 5.11 deg.

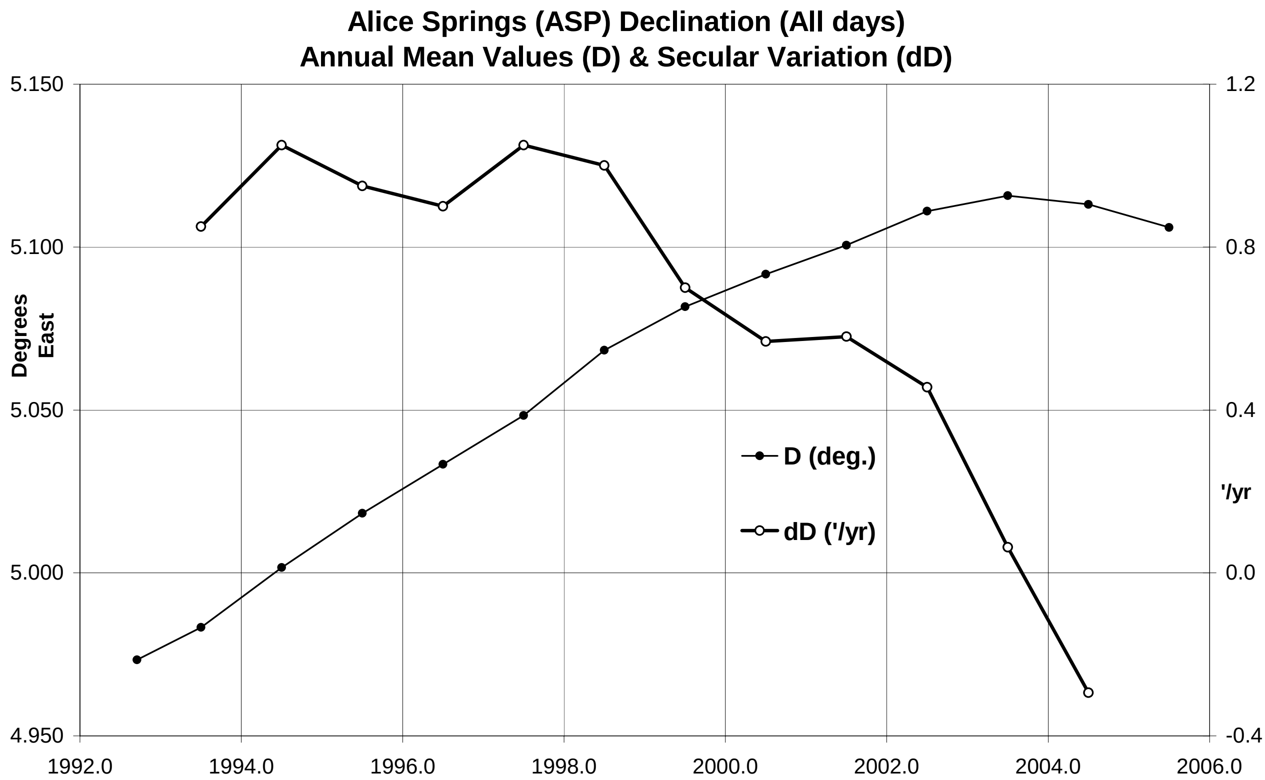


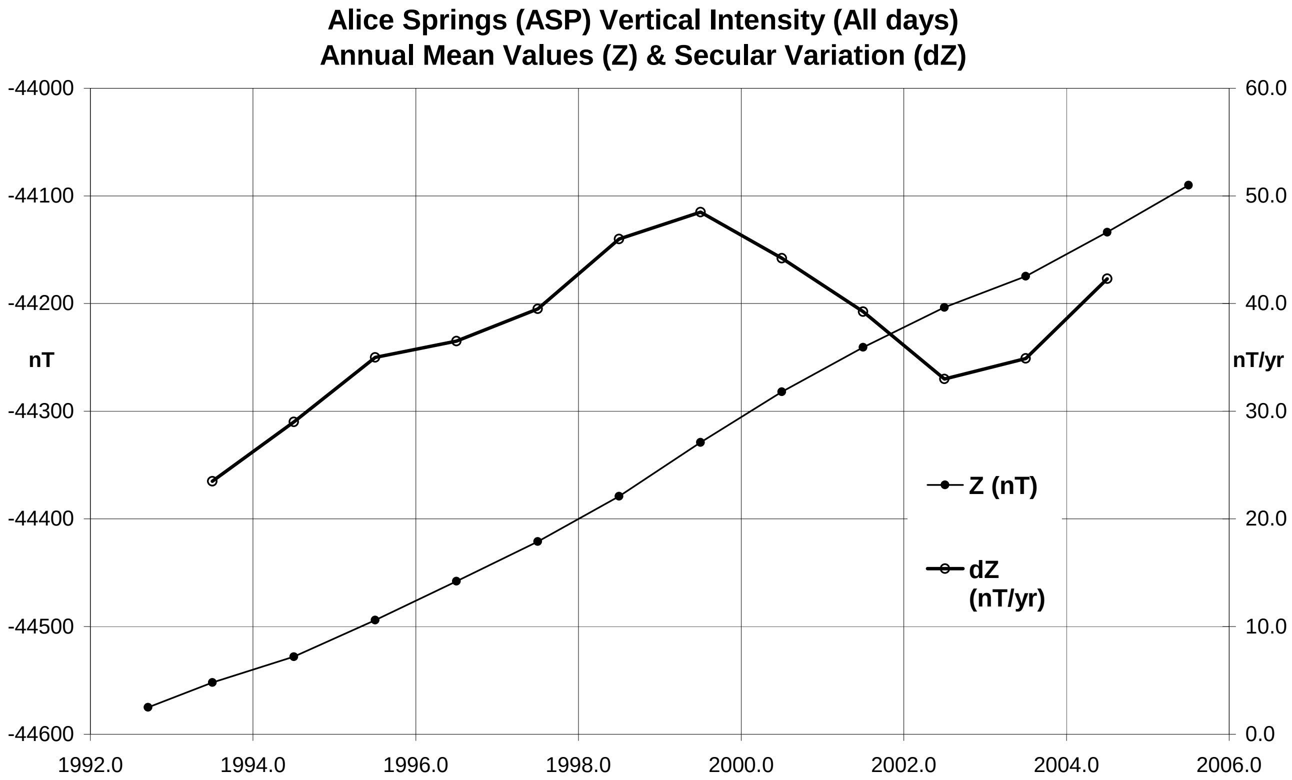
Alice Springs 2005 Vertical intensity (Z). Scale: 3.0 nT/mm. Mean: −44090 nT

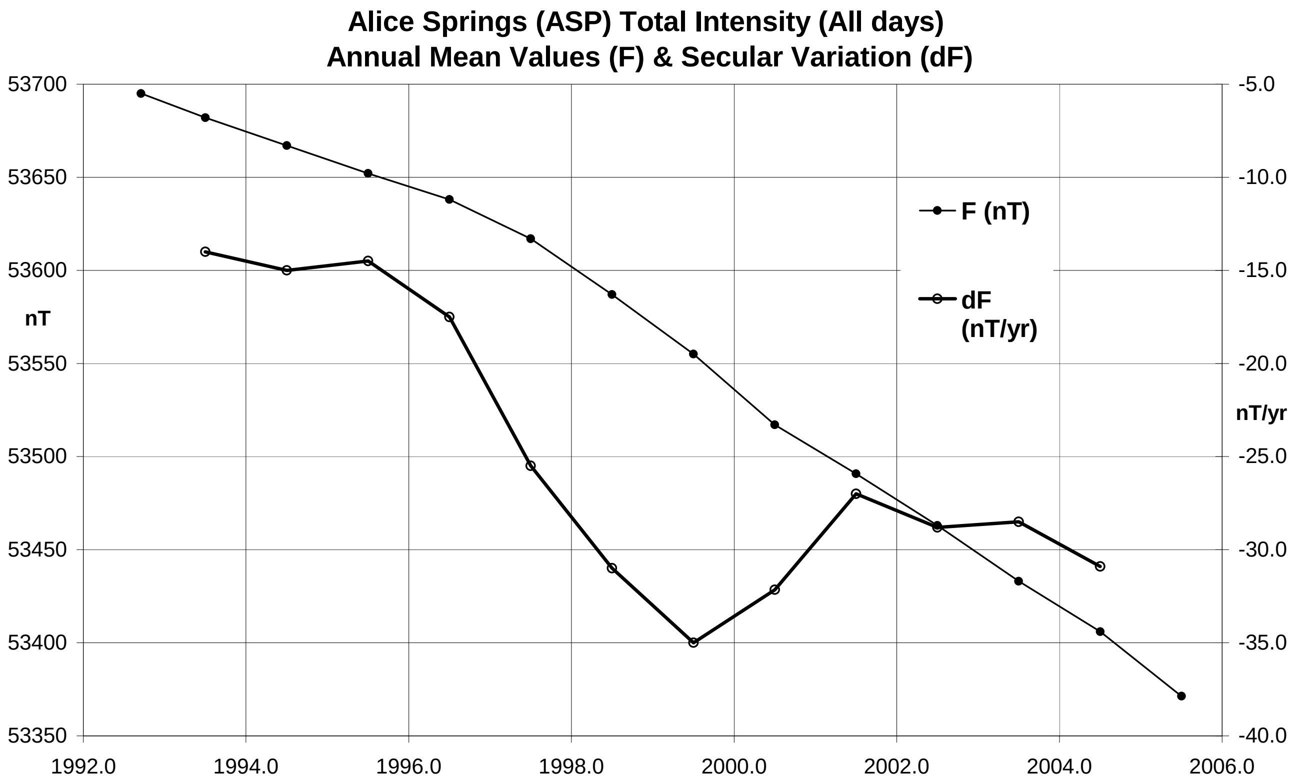


Alice Springs 2005 Total intensity (F). Scale: 5.0 nT/mm. Mean: 53371 nT


Alice Springs (ASP) Horizontal Intensity (All days)
Annual Mean Values (H) & Secular Variation (dH)
30100
30075
30050
30025
30000
29975
29950
29925
nT
30
25
20
15
10
5
0
-5
nT/yr
H (nT)
dH (nT/yr)
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Alice Springs (ASP) Declination (All days)
Annual Mean Values (D) & Secular Variation (dD)
5.150
5.100
5.050
5.000
4.950
Degrees East
1.2
0.8
0.4
0.0
-0.4
'/yr
D (deg.)
dD ('/yr)
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0


Alice Springs (ASP) Vertical Intensity (All days)
Annual Mean Values (Z) & Secular Variation (dZ)
-44000
-44100
-44200
-44300
-44400
-44500
-44600
nT
60.0
50.0
40.0
30.0
20.0
10.0
0.0
nT/yr
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
Z (nT)
dZ (nT/yr)


Alice Springs (ASP) Total Intensity (All days)
Annual Mean Values (F) & Secular Variation (dF)
53700
53650
53600
53550
53500
53450
53400
53350
nT
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
nT/yr
1992.0
1994.0
1996.0
1998.0
2000.0
2002.0
2004.0
2006.0
F (nT)
dF (nT/yr)

Alice Springs Annual Mean Values (cont.)

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
2004.5	A	5	06.6	-55	44.9	30073	29954	2680	-44134	53406	XYZ
2005.5	A	5	06.4	-55	42.0	30076	29957	2677	-44090	53371	ABZ
1992.708	Q	4	58.4	-56	06.0	29950	29838	2596	-44572	53700	XYZ
1993.5	Q	4	59.0	-56	04.8	29959	29845	2603	-44550	53686	XYZ
1994.5	Q	5	00.2	-56	03.3	29971	29857	2614	-44524	53672	XYZ
1995.5	Q	5	01.1	-56	01.0	29991	29876	2623	-44492	53656	XYZ
1996.5	Q	5	02.0	-55	58.6	30013	29897	2633	-44458	53640	XYZ
1997.5	Q	5	02.9	-55	56.0	30035	29919	2643	-44419	53621	XYZ
1998.5	Q	5	04.1	-55	54.1	30043	29926	2654	-44377	53590	XYZ
1999.5	Q	5	04.9	-55	51.3	30061	29943	2663	-44326	53558	XYZ
2000.5	Q	5	05.6	-55	49.5	30065	29946	2669	-44279	53521	XYZ
2001.5	Q	5	06.1	-55	47.3	30078	29959	2675	-44239	53495	XYZ
2002.5	Q	5	06.7	-55	45.5	30086	29966	2680	-44201	53469	XYZ
2003.5	Q	5	07.0	-55	45.0	30076	29956	2682	-44171	53439	XYZ
2004.5	Q	5	06.9	-55	43.1	30084	29964	2682	-44131	53410	XYZ
2005.5	Q	5	06.4	-55	41.4	30087	29967	2678	-44088	53376	ABZ
1992.708	D	4	58.4	-56	08.1	29915	29803	2594	-44579	53686	XYZ
1993.5	D	4	58.9	-56	06.7	29928	29815	2599	-44556	53674	XYZ
1994.5	D	5	00.0	-56	05.1	29940	29826	2609	-44531	53660	XYZ
1995.5	D	5	01.1	-56	02.6	29965	29850	2621	-44497	53646	XYZ
1996.5	D	5	02.0	-55	59.5	29998	29883	2632	-44460	53634	XYZ
1997.5	D	5	02.8	-55	57.5	30011	29895	2640	-44423	53611	XYZ
1998.5	D	5	04.0	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	04.9	-55	53.0	30034	29916	2660	-44332	53548	XYZ
2000.5	D	5	05.5	-55	51.8	30026	29908	2664	-44287	53506	XYZ
2001.5	D	5	05.8	-55	49.4	30043	29924	2669	-44245	53480	XYZ
2002.5	D	5	06.6	-55	47.6	30051	29931	2677	-44207	53454	XYZ
2003.5	D	5	06.8	-55	47.2	30038	29919	2677	-44178	53423	XYZ
2004.5	D	5	06.6	-55	44.9	30054	29934	2677	-44137	53398	XYZ
2005.5	D	5	06.3	-55	43.1	30058	29939	2674	-44093	53364	ABZ

GNANGARA OBSERVATORY

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

The observatory was built on the north-eastern part of an approximately 260m x 140m (3.6 hectare) site. In 2005 the observatory comprised a VARIOMETER/RECORDER VAULT and an ABSOLUTE HOUSE approximately 70m north-east of the former. The site is on well drained sand with low natural magnetic gradients of less than 1nT/m, although numerous artificial features have introduced higher gradients.

The VARIOMETER VAULT is partially underground, and partially buried beneath sand. It is approximately 10m x 5m and provided a secure, temperature-stable and physically stable environment. This vault housed the recording equipment, fluxgate variometer sensor and electronics, total field variometer electronics, GPS clock, backup power supply, telephone, and alarm system.

A small vault, approximately 20m north-west of the VARIOMETER VAULT and connected by an underground conduit, housed the total field variometer sensor. As the sensor vaults were below the ground, the diurnal temperature changes of the variometers were kept to a minimum.

There were also four azimuth reference marks on the site.

Key data for Gnangara Observatory:

- 3-character IAGA code: GNA
- Commenced operation: 1957
- Geographic‡ latitude: 31° 46' 48" S
- Geographic‡ longitude: 115° 56' 48" E
- Geomagnetic† : Lat. -41.74°; Long. 188.85°
- Lower limit for K index of 9: 450 nT
- Principal pier identification: Pier B
- Elevation of top of Pier B: 60 metres AMSL
- Azimuth of principal reference (Pillar N from Pier B): 315° 21' 42"
- Distance to Pillar N: 70 metres
- Observers in Charge: O. McConnel (GA) and G. van Reeken

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

† Based on the IGRF 2005.0 model updated to 2005.5

Variometers

An EDA model FM105B 3-component fluxgate magnetometer (electronics no. 2877 and sensor no. 2887) monitored magnetic field variations throughout 2005. (For security reasons during March/April 2004 this instrument replaced a Danish Meteorological Institute suspended 3-component FGE fluxgate variometer that had been in service at the observatory since August 1998.) The EDA instrument was located in the VARIOMETER VAULT and was deployed with two of its sensors horizontal and both aligned at 45° to the magnetic meridian to monitor the magnetic NW and NE components. The other sensor was vertical. The sensors were located at the eastern end of the vault, while the electronic equipment and acquisition PC were confined to the western end. The EDA variometer had in-built sensors to monitor both sensor and electronics temperatures. It used an internally installed ADAM A to D converter for magnetic and temperature data.

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

The standard temperature for the observatory was 20°C. The temperatures of both the fluxgate sensors and electronics (within the VARIOMETER VAULT) range annually from around 15°C in winter to 28°C in summer and have a maximum rate of change of < 0.1°C/day. The F variometer PPM sensor would have been subjected to temperature changes greater than this as the vault in which it was housed was not as well insulated as the VARIOMETER VAULT.

Throughout 2005, the fluxgate magnetic channels and sensor and electronics temperatures were sampled and recorded on a PC every 1-second, and the PPM every 10-seconds. 1-minute means of the magnetic components and temperatures were also recorded.

The acquisition computer was accessible via a modem for remote control and data retrieval. The telephone and equipment were protected from lightning and powered through a UPS.

Timing was derived from a GPS receiver with antenna at the west of the VARIOMETER VAULT. The acquisition computer clock was synchronised to the 1-second pulse from the GPS clock, but the time code from the GPS was not used. Timing errors were normally less than 0.1s.

Absolute Instruments and Corrections

The Declination and Inclination Magnetometer (DIM) that was employed at GNA throughout 2005 was a Danish Meteorological Institute model G (no.DI0037) electronics unit with sensor mounted on Zeiss020B/390444 non-magnetic theodolite. (It was brought into service at GNA on 06 April 2004 after the absolute instruments at the observatory were stolen three weeks earlier.) It was operated on Pier B in the ABSOLUTE HOUSE.

GEM model GSM90 PPM no. 3091317 (also brought into service on 06 April 2004) was employed to perform absolute observations in total intensity, F, throughout 2005. These were performed with the sensor on Pier B in the ABSOLUTE HOUSE. A Personal Data Assistant (PDA) was used to control the GSM90 during the observations.

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

The DIM was compared with the Australian Reference at CNB on 26 Feb 2004 and has corrections of: 0.0' in D and 0.0' in I. These corrections were confirmed during a service visit 16-21 May 2005 via a travelling reference magnetometer.

The GEM GSM90 absolute PPM was compared at the Canberra Magnetic Observatory on 06 May 2003 and has a zero instrument correction.

Due to the zero differences between the Australian Reference at Canberra Magnetic Observatory and the GNA observatory magnetometers, corrections of 0.0nT in X, 0.0nT in Y and 0.0nT in Z were applied to the GNA 2005 baseline values.

During a maintenance visit to GNA in May 2005 it was discovered that the magnetic, metal, DIM instrument case was being placed at a distance of about 2 metres from the absolute pier during some of the routine absolute observations that had been performed at GNA between April 2004 and May 2005. To determine the magnetic effect of the DIM case at pier B, observations were performed both with the case near pier B and with the case removed (to 10m from Pier B), with the following results at Pier B:

F (without DIM box) - F (with DIM box) = -8.0nT

D (without DIM box) - F (with DIM box) = +1.6'

I (without DIM box) - I (with DIM box) = -0.3'

i.e.

the difference (without DIM box) - Pier B (with DIM box) is

3.18nT in X, -0.11nT in Y and -7.34nT in Z

However it was also discovered that the location of the DIM case was not consistent at each observation: its placement differed by up to 1m between observations. This affected the total field intensity at the pier between -4nT and -8nT. During some observations the DIM case was over 6m from the pier and so had little effect. A method was devised to correct for the contamination at the pier that was based on the difference between the absolute PPM and the variometer PPM (FP). If the difference between the two PPMs was between -4 nT and -8 nT for observations between 30 April and 31 December 2004, the following pier corrections were applied:

FP	D correction	I correction	Pier name
-4 nT	1.2'	-0.2'	B4
-5 nT	1.3'	-0.2'	B5
-6 nT	1.4'	-0.2'	B6
-7 nT	1.5'	-0.3'	B7
-8 nT	1.6'	-0.3'	B8

If the difference was between -2nT and -3nT or greater than -8 nT the observation was not included in the final baseline calculations.

The corrections to the 2005 observations were as follows:

2005	Obs'n	Pier	2005	Obs'n	Pier
06 Jan.	1	B4	22 Mar.	1	not used
06 Jan.	2	B5	22 Mar.	2	not used
18 Jan.	1	B7	05 Apr.	1	B4
18 Jan.	2	not used	05 Apr.	2	B5
15 Feb.	1	B6	19 Apr.	1	B5
15 Feb.	2	B6	19 Apr.	2	B5
01 Mar.	1	B5	03 May	1	B5
01 Mar.	2	B6	03 May	2	not used

After the application of the above corrections the results showed a significant improvement in consistency and a more uniform difference between total field values calculated from the corrected fluxgate variometer data and the PPM variometer data.

Corrections to contaminated 2004 observations were shown in the *AGR 2004*.

Baselines

The scale values and orientations of the variometer sensors were determined from a sequence of absolute observations performed in June 1999.

By observing an annual cycle in baselines similar to that in temperature, temperature coefficients (Q) for the X, Y and Z variometer channels were estimated at:

Q_X = 1.2nT/deg.C Q_Y = -0.5nT/deg.C Q_Z = -1.0nT/deg.C.

Any inaccuracies in the temperature coefficients were accounted for through the regular absolute observations. Variometer temperature changes between absolute observations averaged less than 0.5°C, and the expected effect on baselines was less than 0.1nT.

The mean values and standard deviations of the differences between the absolute measurements in 2005 and the derived values from the variometer data and model were:

−0.51 ± 1.67 nT in X

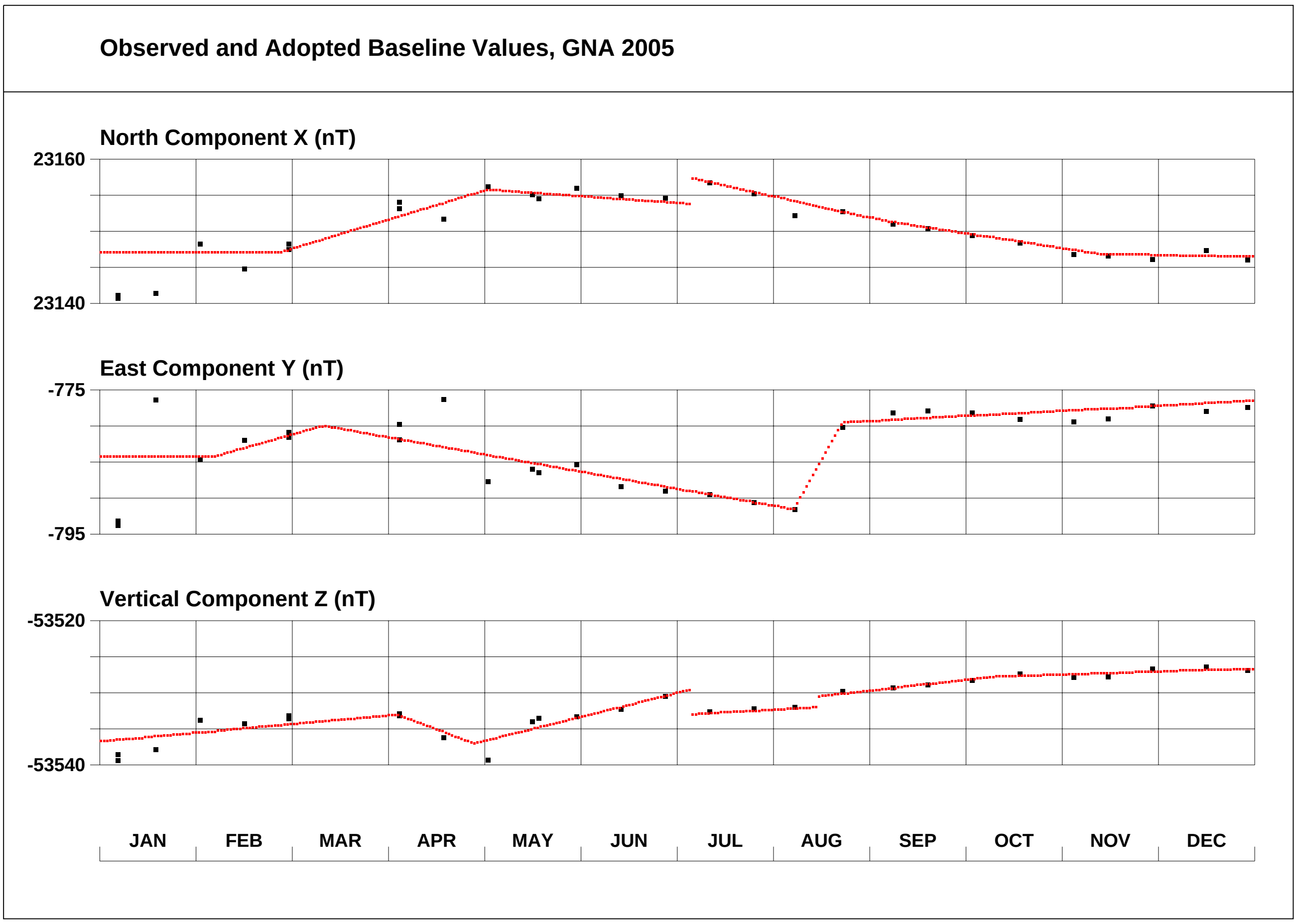
−0.25 ± 2.71 nT in Y

−0.02 ± 0.99 nT in Z

In 2005 the daily average of the difference between F derived from the fluxgate data and F measured by the variometer PPM (apart from a few wild values) varied from −1.3nT to +1.4nT.

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

Observed and adopted baseline values in X, Y and Z for 2005 are shown in the following (INTERMAGNET format) chart.



Operations

The Gnangara magnetic observatory was maintained by an out-posted GA staff member (ODM). Absolute observations were performed by a contract observer (GVR).

1-second and 1-minute mean variometer data in the magnetic NE, NW, vertical and total intensity magnetic components, with sensor and electronics temperatures, were acquired on a PC at the observatory. These raw data were retrieved by modem directly from the observatory to GA, Canberra, shortly after 00hrs UT each day.

The routine processing of absolute observations; the scaling of principal magnetic storms, rapid variations and K indices; and the distribution of data, was performed by staff at GA in Canberra.

Absolute observations were performed fortnightly. The stainless steel security door was left open in the same position during observations.

The area in the vicinity of the Gnangara observatory is being developed for residential use. Although this currently poses no threat to the observatory in a technical sense, there has been an increasing problem with security breaches at the site.

Although not the case in 2005, as well as vandalism, break-ins and theft from the observatory, considerable data have been lost in recent years due to power outages and data contamination caused by these events. Since late in 2000 the observers have no longer felt safe at the site and a security firm was engaged to be in attendance during routine absolute observations to ensure their safety. This continued throughout 2005. The search for an alternative observatory site also continued in 2005.

K indices

K indices from the Gnangara Magnetic Observatory contribute to the global am-index, and its derivatives.
The table on page 55 shows K indices for Gnangara for 2005.
Throughout 2005 K indices for Gnangara were derived using a computer assisted method developed at GA. The method, based on the IAGA accepted LRNS algorithm, is described in the *Data Distribution* section near the beginning of this report.

Significant Events in 2005

Jan 12 Modem (possibly halted by an electrical storm on Jan 09) was re-started.

Jan 18 The difference between the absolute and variometer PPMs from about 18-22 January and March was unusually scattered. F-check exhibited minimal drift until 03 May.

January A hole in the ABSOLUTE HOUSE wall, caused during break-enter on 21 March 2004, was repaired.

Mar 11 Acquisition PC did not respond to remote access and was found to have failed. Returned to GA, Canberra for repair and found to have faulty CPU board. A replacement unit was returned on 16 March.

Mar 17 0458: Replacement acquisition computer installed. As there was not a suitable port on the computer (an oversight when it was configured) the GPS could not be connected. This resulted in reduced accuracy as the configured clock rate adjustment did not match the new CPU board. This was to be determined and set remotely.

Mar 18 PC rebooted but PPM failed to restart. The PPM was restarted on the 24 March.

Apr 07 2058: Acquisition PC failed and was returned to GA, Canberra.

Apr 13 ~0230: The repaired PC was installed, the connection checked and timing corrected.

May 2005: It was discovered that the fortnightly absolute observations had been contaminated by the steel DIM case being left near the observation pier. A scheme to correct the observations was devised based on the concept of virtual piers B4, B5 etc. (see *Absolute Instruments and Corrections*, this report and *AGR04*.)

May 16 to 21: Service visit by project officer from GA, Canberra, during which instrument comparisons, tests and calibrations were performed, pier differences and gradients determined and azimuths measured.

Jun 29 0408: The acquisition PC failed.

Jul 04 ~2330: The failed acquisition PC spontaneously started working again. This may be explained by a brief local power outage and restoration at that time. The PPM did not restart.

Jul 05 0610: The halted PPM was manually restarted.

Jul 07 ~0600: A Maitec UPS was installed.

Jul 30 0700: System failed after a power outage from 0651-1020. The UPS was clearly not serviceable.

Aug 01 Local technical officer discovered the PPM cycling and the UPS off. The PC was started and the UPS switched on.

Aug 16 0652: Local technical officer tested if the EDA variometer would run on +/-12V. This resulted in BLV shifts.

Oct 16 A number of PC reboots occurred for reasons unknown.

Oct 16 1737: The acquisition PC failed

Oct 18 0145: Acquisition PC rebooted and unsuccessful attempt to install battery-box, so UPS re-installed.

Dec 29 Last set of absolute observations for the year scheduled for this day were missed.

Data losses in 2005

Feb 21 0610-0614 (5m) Spike removed: XYZF

Mar 10 0726 to 16/0412 (5d 20h 47m) Acquisition PC failure: XYZ

Mar 10 0726 to 17/0500 (6d 21h 35m) Acquisition PC failure: F

Mar 16 0414-0422 (9m); 0430 to 17/0457 (24h 28m) Acquisition PC failure: XYZ

Mar 16 0413 (1m); 0423-0429 (7m) Data contaminated due to PC failure and subsequent replacement: XYZF

Mar 17 0532 (1m) Data contaminated when PC failed and subsequently replaced: XYZF

Mar 18 0732-0749 (18m) PC reboot: XYZ

Mar 18 0732 to 24/0323 (5d 19h 52m) PPM failed to start on reboot: F

Apr 07 2058 to 13/0229 (5d 05h 32m) Acquisition PC failure: XYZ

Apr 07 2058 to 13/0231 (5d 05h 34m) Acquisition PC failure: F

Apr 13 0230-0243 (14m) Data contaminated due to PC failure and subsequent replacement: XYZF

May 15 2217-2238 (22m): XYZ

May 15 2217 to 16/0649 (8h 33m): F

Jun 29 0408 to Jul 04/2323 (5d 19h 16m) Acquisition PC failure: XYZ

Jun 29 0408 to Jul 05/0609 (6d 02h 02m) Acquisition PC failure: F

Jul 04 2326-2327 (2m): XYZ

Jul 07 0551-0610 (20m) Data contaminated when UPS installed: XYZF

Jul 30 0700 to Aug 01/0318 (1d 20h 19m) Power outage: XYZ

Jul 30 0700 to Aug 01/0323 (1d 20h 24m) Power outage: F

Aug 01 0325-0327 (3m): XYZF

Aug 16 0628-0638 (11m): XYZ

Aug 16 0559-0602 (4m); 0606-0616 (11m); 0624 (1m): F

Sep 30 1601-1604 (4m): XYZF

Oct 10 2341-2344 (4m): XYZF

Oct 11 0028-0031 (4m): XYZF

Oct 16 0558-0601 (4m); 0656-0659 (4m); 0735-0738 (4m); 0745-0748 (4m); 1204-1207 (4m); 1237-1240 (4m); 1417-1420 (4m); 1423-1426 (4m); 1608-1611 (4m); 1635-1638 (4m) PC reboots: XYZF

Oct 16 1737 to 18/0144 (1d 08h 08m) Acquisition PC problems: XYZF

Oct 18 0158 (1m); 0216-0219 (4m): F

Oct 18 0223-0227 (5m): XYZF

Oct 18 0145-0222 (38m); 0228-0329 (62m) Data contaminated due to acquisition PC problems: XYZF

Oct 18 0229-0233 (5m): F

Oct 18 0348-0358 (11m): XYZ

Oct 18 0348-0359 (12m): F

Annual totals data lost: XYZ channels: 30,671 min. or 5.84%
F channel : 39,974 min or 7.61%

Distribution of GNA data

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 and Hourly Mean Values to WDCs

- 2005 data sent in 2006.

Preliminary Monthly Means for Project Ørsted

- Sent monthly by email to IPGP throughout 2005

1-minute values for Project INTERMAGNET

- Preliminary data to the Edinburgh IM GIN daily by e-mail.
- 2005 Definitive data: to Paris IM GIN (31 Aug 2006)

Notes and Errata (cumulative since *AGR1993*)

The *AGR1999* (p.40) and *AGR2000* (p.42) both show the same incorrect value in the table entitled *Gnangara Annual Mean Values*. The H component value given for the International Quiet Day mean for 1999.5 incorrectly shown as 23224 (in nT) should read **23234** (nT).

Principal Magnetic Storms: Gnangara, 2005

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. 07	09 ··	···	··	··	··	07(8), 08(1)	6	25	131	143	08	15
11	15 ··	···	··	··	··	12(5)	6	24	90	163	13	18
16	06 ··	···	··	··	··	18(1,3)	7	36	187	184	19	18
21	16 58	ssc	9.3	125	85	21(7,8)	7	44	286	200	24	03
Feb. 07	09 ··	···	··	··	··	07(5,7,8), 08(6)	5	20	12	121	09	06
Mar. 05	21 ··	···	··	··	··	06(1,4,6), 07(4,6,7)	5	21	108	132	08	03
09	12 ··	···	··	··	··	09(6,7)	5	14	69	78	10	03
18	18 ··	···	··	··	··	18(7,8)	5	12	43	55	19	06
Apr. 04	15 ··	···	··	··	··	04(7,8), 05(1)	5	15	138	98	06	03
May 07	19 15	ssc	2.1	11	12	08(5)	7	37	163	246	09	00
15	02 34	ssc	10.1	41	55	15(3)	8	37	311	190	18	02
29	09 ··	···	··	··	··	30(5)	7	34	211	183	31	14
Jun. 12	06 ··	···	··	··	··	12(8)	6	28	132	165	13	21
Jul. 09	09 ··	···	··	··	··	10(5)	6	24	153	173	12	21
13	02 ··	···	··	··	··	13(5,6)	5	18	84	82	14	01
Aug. 10	06 ··	···	··	··	··	10(4)	6	17	79	97	10	18
24	06 12	ssc	1.3	28	13	24(4)	8	66	295	408	26	03
31	09 ··	···	··	··	··	31(5,6)	6	25	137	186	**01**	**14**
Sep. 02	09 ··	···	··	··	··	02(6,7), 04(4)	5	19	101	108	04	18
09	14 01	ssc	2.1	48	19	11(3,5)	7	40	268	231	13	18
15	09 ··	···	··	··	··	15(5,6)	6	32	93	153	16	21

There were no Principle Magnetic Storms reported for GNA in Oct., Nov. and Dec., 2005

Rapid Variation Phenomena

Sudden Storm Commencements (ssc) - GNA 2005

Month & date	U.T.	Type & Quality		Chief movement (nT) H	D	Z
Jan. 21	1658	ssc	A	+125	+63	+85
May 06	1307	ssc	A	+8	+2	+3
07	1915	ssc	B	+11	+14	+12
15	0234	ssc	C	+41	+68	+55
Jun. 14	1835	ssc	A	+19	+22	+18
Aug. 24	0612	ssc	A	+28	+9	+13
Sep. 09	1401	ssc	A	+48	+15	+19

No ***ssc*** reported at GNA in Feb., Mar., Apr., Jul., Oct., Nov. and Dec. 2005

Solar Flare Effects (sfe) - GNA 2005

Month & date	U.T. of movement Start	Max.	End	Amplitude(nT) H	D	Z	Confir-mation
Jan. 01	0025	0032	0107	+10	+2	+5	solar

No ***sfe*** reported at GNA in Feb. - Dec., 2005.

K indices and Daily K sums at Gnangara (K=9 limit: 450 nT) for 2005

Date	January	February	March	April	May	June	Date
01	3233 3445 27	2011 1211 09	3123 1223 17	2220 1121 11	D 3333 4442 26	3111 2211 12	01
02	D 4343 3435 29	1011 2331 12	3223 3312 19	1001 1101 05	2211 4222 16	1101 1112 08	02
03	4224 4432 25	2231 1221 14	3100 2221 11	1110 1112 08	2123 3333 20	2221 1111 11	03
04	3232 4343 24	Q 1012 2211 10	Q 2001 0011 05	D 1121 2455 21	1100 1221 08	D 1111 3353 18	04
05	3233 3412 21	Q 1000 1001 03	1221 3334 19	D 5444 4343 31	Q 1111 1220 09	3333 2443 25	05
06	Q 1111 1131 10	1231 1243 17	D 5335 4544 33	3112 2332 17	0000 2111 05	2210 2022 11	06
07	1103 5546 25	D 3323 5455 30	D 4335 4554 33	1113 320- --	2111 2133 14	2324 4222 21	07
08	6443 3232 27	D 3323 4544 28	D 4333 3343 26	---- ---- --	D 5324 7654 36	0111 0010 04	08
09	Q 2114 0012 11	D 3333 4443 27	D 3323 3553 27	---- ---- --	2111 0223 12	0000 2221 07	09
10	2111 2323 15	D 3332 4342 24	32-- ---- --	Q ---- ---- --	2121 1122 12	Q 0000 1020 03	10
11	3221 2324 19	3214 2232 19	---- ---- --	---- ---- --	1023 2354 20	0010 0122 06	11
12	3435 6454 34	2100 1332 12	Q ---- ---- --	D ---- ---- --	2332 1433 21	D 0133 3456 25	12
13	3222 3433 22	Q 2100 0221 08	---- ---- --	D 2344 4434 28	3333 4422 24	D 5443 5331 28	13
14	3121 1144 17	1121 1123 12	---- ---- --	3323 4333 24	1122 1121 11	1111 1043 12	14
15	4333 3423 25	Q 2121 0002 08	---- ---- --	2222 3332 19	D 5586 3245 38	3333 3211 19	15
16	2123 3433 21	3212 4332 20	---- ---- --	2101 1122 10	D 3444 4532 29	D 1224 4443 24	16
17	D 3345 5646 36	2101 1314 13	--22 1422 --	0110 1022 07	3323 2433 23	2312 2322 17	17
18	D 7575 5555 44	D 4433 4522 27	1111 1255 17	2111 3322 15	2013 3311 14	1211 2121 11	18
19	D 5444 6423 32	1124 4332 20	4312 2002 14	0121 2212 11	2222 3121 15	1111 1111 08	19
20	2223 3422 20	3121 2442 19	Q 1101 1021 07	2334 4332 24	2443 3313 23	Q 2011 0000 04	20
21	D 2222 2677 30	2111 2111 10	0023 4213 15	Q 1110 0110 05	2223 4442 23	Q 0000 0000 00	21
22	5333 4443 29	2000 1322 10	Q 1110 1111 07	1110 3132 12	2222 3111 14	1111 0023 09	22
23	3222 4532 23	Q 1121 1022 10	Q 1001 1221 08	1120 1332 13	0011 3311 10	D 3354 4543 31	23
24	3112 3431 18	1121 3112 12	1001 3133 12	3212 2121 14	Q 0000 1012 04	3313 2211 16	24
25	Q 1012 2221 11	2122 2433 19	D 3232 3433 23	1221 2121 12	Q 2111 0100 06	2312 1443 20	25
26	Q 1101 2020 07	3123 3332 20	1234 3432 22	Q 1000 0022 05	Q 0000 0000 00	2212 3221 15	26
27	Q 1000 0023 06	1211 3122 13	3222 3432 21	Q 0100 1110 04	Q 0100 1000 02	Q 1000 1021 05	27
28	3011 1222 12	2222 2323 18	2110 0021 07	Q 0000 1121 05	0211 1353 16	Q 1111 1111 08	28
29	2223 3344 23		1110 0112 07	0111 3344 17	2223 2234 20	---- ---- --	29
30	3223 3223 20		2111 1311 11	D 4323 4444 28	D 3354 7544 35	---- ---- --	30
31	3223 4432 23		1220 1442 16		3222 4122 18		31
Mean K-sum	**22.1**	**15.9**	**16.4**	**14.4**	**16.9**	**13.5**	

Date	July	August	September	October	November	December	Date
01	---- ---- --	-123 2412 --	2212 4012 14	2222 3332 19	2112 2431 16	D 4223 2234 22	01
02	---- ---- --	2213 2121 14	D 2124 4554 27	D 2233 3412 20	1110 1143 12	3232 3233 21	02
03	---- ---- --	2220 1332 15	3334 4213 23	2112 1112 11	D 3323 3352 24	3212 3342 20	03
04	0000 0002 02	2112 2222 14	2345 4322 25	1001 1110 05	D 2323 3442 23	2111 3132 14	04
05	Q 0101 2011 06	1111 2332 14	2112 2232 15	0001 1111 05	3232 2313 19	2001 0011 05	05
06	Q 0011 1212 08	D 2345 4443 29	2112 3321 15	0000 2220 06	D 3212 2422 18	Q 0112 2111 09	06
07	1111 1212 10	4223 2233 21	1112 1001 07	1012 3344 18	2121 2222 14	Q 0010 0001 02	07
08	Q 1110 0101 05	1111 2213 12	Q 0111 1231 10	D 4344 3353 29	Q 2011 0122 09	Q 0000 0021 03	08
09	D 2123 5434 24	2111 2222 13	2201 4433 19	2212 2233 17	1001 1111 06	2011 1124 12	09
10	D 2345 6555 35	2136 5210 20	2233 3565 29	2124 2112 15	Q 0021 0023 08	3321 2333 20	10
11	2233 4241 21	Q 0011 2100 05	D 6676 7455 46	3101 2221 12	1212 1222 13	D 2233 3453 25	11
12	D 3334 5321 24	Q 0100 2122 08	D 4366 6656 42	Q 0000 1002 03	2112 4322 17	3211 2322 16	12
13	D 2333 5533 27	D 1223 2232 17	D 5246 5243 31	1101 1231 10	D 1223 3334 21	2010 3121 10	13
14	1122 3100 10	2221 2122 14	2133 5332 22	Q 2101 0001 05	2213 2112 14	1121 1012 09	14
15	0110 1121 07	1001 1113 08	D 2124 6654 30	Q 1010 1000 03	1112 2112 11	Q 2111 1001 07	15
16	2211 0321 12	3323 4324 24	2235 4322 23	1112 23-- --	Q 1110 0212 08	2212 2332 17	16
17	2124 3234 21	2222 2432 19	0123 3333 18	D ---- ---- --	Q 1010 0000 02	1001 2111 07	17
18	3343 4133 24	3122 3433 21	1123 3222 16	--10 2322 --	0000 1321 07	2111 1112 10	18
19	1211 2123 13	1112 2221 12	1011 1221 09	2111 3221 13	2100 2443 16	2112 2333 17	19
20	2223 4452 24	Q 1000 0110 03	Q 1001 1220 07	Q 1011 0100 04	1233 1221 15	D 3222 3332 20	20
21	3323 1343 22	1011 1433 14	Q 1011 2111 08	0000 0003 03	2111 2110 09	2122 4312 17	21
22	2311 3432 19	1212 2112 12	2111 2321 13	4110 1021 10	1011 2323 13	3111 0011 08	22
23	1111 1301 09	2112 3222 15	0110 1110 05	Q 1101 1210 07	1121 2212 12	Q 2010 0001 04	23
24	Q 1100 1131 08	D 3358 6565 41	Q 1000 1110 04	2001 2322 12	1112 2223 14	0012 3221 11	24
25	Q 1100 0011 04	D 4223 5532 26	Q 1002 3112 10	D 3334 2423 24	2221 1211 12	3122 2111 13	25
26	0011 0201 05	2111 0011 07	3223 3233 21	2121 2331 15	1113 2211 12	1011 2233 13	26
27	1121 1334 16	2121 1110 09	2223 2322 18	2002 3531 16	Q 1111 0122 09	D 3112 3454 23	27
28	D 3322 5334 25	Q 1001 0122 07	1212 3422 17	0001 3221 09	2022 4232 17	D 3222 3343 22	28
29	2224 2323 20	2110 0100 05	1112 2311 12	1000 0221 06	1110 0224 11	3323 2322 20	29
30	22-- ---- --	Q 1000 0021 04	0122 4322 16	0101 2132 10	D 4223 3333 23	1212 1322 14	30
31	---- ---- --	D 1123 6655 29		D 1123 4553 24		2111 3334 18	31
Mean K-sum	**15.4**	**15.1**	**18.4**	**11.8**	**13.5**	**13.8**	

Occurrence distribution of K indices

K-Index:	0	1	2	3	4	5	6	7	8	9	-
January	13	35	62	68	42	17	7	4	0	0	0
February	21	65	66	46	21	5	0	0	0	0	0
March	23	54	42	45	18	10	0	0	0	0	56
April	30	65	47	33	21	3	0	0	0	0	41
May	35	58	64	50	26	10	2	2	1	0	0
June	42	77	46	35	17	6	1	0	0	0	16
July	31	64	44	43	17	10	1	0	0	0	38
August	32	73	82	33	12	9	5	0	1	0	1
September	21	63	68	42	19	13	12	2	0	0	0
October	58	72	58	33	11	4	0	0	0	0	12
November	29	80	82	36	12	1	0	0	0	0	0
December	35	76	72	53	10	2	0	0	0	0	0
ANNUAL TOTAL	**370**	**782**	**733**	**517**	**226**	**90**	**28**	**8**	**2**	**0**	**164**

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 62 & 63. See also *Notes and Errata* section for this observatory.

Year	Days	D (Deg	Min)	I (Deg	Min)	H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elts
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	ABC
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	ABC
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	ABC
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	ABC
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	ABC
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	ABC
2000.5	A	-2	13.6	-66	36	23230	23212	-903	-53682	58493	ABC
2001.5	A	-2	9.0	-66	34.7	23241	23225	-872	-53651	58468	ABC
2002.5	A	-2	4.7	-66	33.8	23245	23230	-843	-53622	58444	ABC
2003.5	A	-2	1.1	-66	33.4	23243	23229	-819	-53601	58424	ABC
2004.5	A	-1	57.3	-66	31.6	23260	23247	-794	-53562	58395	ABC
2005.5	A	-1	54.6	-66	29.7	23274	23262	-776	-53516	58358	ABC
1959.5	Q	-2	54.1	-65	52.4	23954	23923	-1213	-53482	58603	DHZ
1960.5	Q	-2	53.5	-65	52.1	23959	23928	-1209	-53480	58599	DHZ
1961.5	Q	-2	53.3	-65	52.7	23952	23922	-1207	-53491	58606	DHZ
1962.5	Q	-2	52.8	-65	53.0	23945	23915	-1203	-53490	58599	DHZ
1963.5	Q	-2	52.3	-65	54.0	23931	23901	-1199	-53497	58600	DHZ
1964.5	Q	-2	51.7	-65	54.9	23916	23886	-1194	-53501	58599	DHZ
1965.5	Q	-2	51.7	-65	55.3	23906	23876	-1194	-53497	58589	DHZ
1966.5	Q	-2	52.4	-65	56.3	23889	23859	-1198	-53499	58582	DHZ
1967.5	Q	-2	54.1	-65	57.4	23868	23837	-1208	-53499	58572	DHZ
1968.5	Q	-2	55.7	-65	58.6	23843	23812	-1218	-53494	58558	DHZ
1969.5	Q	-2	57.5	-65	59.7	23820	23788	-1229	-53488	58538	DHZ
1970.5	Q	-2	59.7	-66	1.2	23786	23754	-1243	-53475	58516	DHZ
1971.5	Q	-3	2.3	-66	2.2	23761	23728	-1259	-53461	58490	DHZ
1972.5	Q	-3	5.2	-66	3.9	23727	23693	-1278	-53454	58467	DHZ
1973.5	Q	-3	7.8	-66	6.2	23686	23651	-1293	-53460	58454	DHZ
1974.5	Q	-3	9.9	-66	9.0	23642	23606	-1305	-53477	58456	DHZ
1975.5	Q	-3	11.5	-66	11.3	23608	23571	-1314	-53496	58457	DHZ
1976.5	Q	-3	12.3	-66	14.2	23567	23530	-1318	-53528	58471	DHZ
1977.5	Q	-3	13.6	-66	17.0	23528	23491	-1324	-53557	58478	DHZ
1978.5	Q	-3	15.1	-66	20.5	23481	23443	-1332	-53596	58499	DHZ
1979.5	Q	-3	16.5	-66	23.1	23444	23406	-1339	-53624	58525	DHZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1346	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.9	-66	36.5	23258	23219	-1338	-53772	58587	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ
1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	8.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	6.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	2.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23165	-1173	-53757	58547	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	ABC
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	ABC
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	ABC
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	ABC
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	ABC
1999.5	Q	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	ABC
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	ABC
2001.5	Q	-2	08.8	-66	34.1	23252	23235	-871	-53648	58470	ABC
2002.5	Q	-2	04.5	-66	33.1	23257	23242	-842	-53619	58446	ABC
2003.5	Q	-2	01.1	-66	32.7	23255	23241	-819	-53599	58426	ABC
2004.5	Q	-1	57.2	-66	31.0	23269	23256	-793	-53559	58396	ABC
2005.5	Q	-1	54.5	-66	29.1	23284	23271	-775	-53513	58360	ABC

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

continued on page 64 ...

Monthly and 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	2005	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	23250.5	-784.4	-53542.8	58378.4	23263.7	-1° 55.9'	-66° 30.9'
	5xQ days	23258.8	-781.9	-53538.9	58378.1	23272.0	-1° 55.5'	-66° 30.4'
	5xD days	23242.1	-787.8	-53549.5	58381.2	23255.5	-1° 56.5'	-66° 31.5'
February	All days	23259.3	-780.1	-53534.2	58373.9	23272.3	-1° 55.3'	-66° 30.3'
	5xQ days	23267.5	-780.7	-53532.8	58375.9	23280.6	-1° 55.3'	-66° 29.8'
	5xD days	23245.1	-783.1	-53538.2	58372.0	23258.3	-1° 55.8'	-66° 31.1'
March	All days	23259.2	-774.4	-53525.7	58366.0	23272.1	-1° 54.4'	-66° 30.1'
	5xQ days	23265.3	-775.5	-53524.6	58367.4	23278.2	-1° 54.5'	-66° 29.7'
	5xD days	23247.0	-772.0	-53529.5	58364.6	23259.8	-1° 54.1'	-66° 30.8'
April	All days	23259.0	-774.5	-53521.3	58361.8	23271.9	-1° 54.4'	-66° 30.0'
	5xQ days	23265.4	-775.1	-53521.8	58364.9	23278.3	-1° 54.5'	-66° 29.7'
	5xD days	23247.6	-773.7	-53521.0	58357.0	23260.4	-1° 54.4'	-66° 30.6'
May	All days	23241.6	-775.9	-53528.4	58361.5	23254.5	-1° 54.7'	-66° 31.1'
	5xQ days	23265.2	-776.3	-53522.7	58365.6	23278.2	-1° 54.7'	-66° 29.7'
	5xD days	23199.0	-776.4	-53538.4	58353.8	23212.1	-1° 55.0'	-66° 33.6'
June	All days	23255.3	-774.3	-53520.6	58359.8	23268.2	-1° 54.4'	-66° 30.2'
	5xQ days	23267.5	-775.3	-53517.3	58361.6	23280.4	-1° 54.5'	-66° 29.4'
	5xD days	23243.3	-772.1	-53521.8	58356.1	23256.1	-1° 54.2'	-66° 30.9'
July	All days	23258.9	-774.3	-53514.4	58355.5	23271.7	-1° 54.4'	-66° 29.8'
	5xQ days	23274.4	-775.0	-53511.0	58358.6	23287.3	-1° 54.4'	-66° 28.9'
	5xD days	23241.2	-774.0	-53519.3	58352.9	23254.0	-1° 54.4'	-66° 30.9'
August	All days	23261.5	-775.4	-53510.2	58352.7	23274.4	-1° 54.6'	-66° 29.6'
	5xQ days	23268.4	-774.5	-53508.0	58353.5	23281.3	-1° 54.4'	-66° 29.2'
	5xD days	23237.0	-779.4	-53517.6	58349.8	23250.1	-1° 55.3'	-66° 31.1'
September	All days	23250.8	-775.1	-53510.8	58349.0	23263.7	-1° 54.6'	-66° 30.2'
	5xQ days	23266.4	-774.2	-53508.4	58353.1	23279.3	-1° 54.3'	-66° 29.3'
	5xD days	23223.2	-774.9	-53516.1	58342.9	23236.2	-1° 54.7'	-66° 31.8'
October	All days	23275.5	-771.8	-53498.2	58347.3	23288.3	-1° 53.9'	-66° 28.6'
	5xQ days	23280.1	-771.5	-53495.7	58346.8	23292.9	-1° 53.9'	-66° 28.3'
	5xD days	23265.5	-773.2	-53502.0	58346.8	23278.4	-1° 54.2'	-66° 29.2'
November	All days	23279.7	-773.3	-53493.6	58344.8	23292.5	-1° 54.1'	-66° 28.2'
	5xQ days	23283.8	-772.8	-53492.1	58345.0	23296.7	-1° 54.1'	-66° 28.0'
	5xD days	23272.4	-773.3	-53495.7	58343.8	23285.3	-1° 54.2'	-66° 28.7'
December	All days	23287.7	-772.6	-53487.9	58342.7	23300.6	-1° 54.0'	-66° 27.7'
	5xQ days	23292.5	-771.2	-53487.8	58344.5	23305.2	-1° 53.8'	-66° 27.4'
	5xD days	23284.4	-773.6	-53488.4	58341.9	23297.3	-1° 54.2'	-66° 27.8'
Annual	All days	23261.6	-775.5	-53515.7	58357.8	23274.5	-1° 54.6'	-66° 29.7'
Mean	5xQ days	23271.3	-775.3	-53513.4	58359.6	23284.2	-1° 54.5'	-66° 29.1'
Values	5xD days	23245.7	-776.1	-53519.8	58355.2	23258.6	-1° 54.7'	-66° 30.7'

(Calculated: 16:14 hrs., Fri., 27 Oct. 2006)

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.

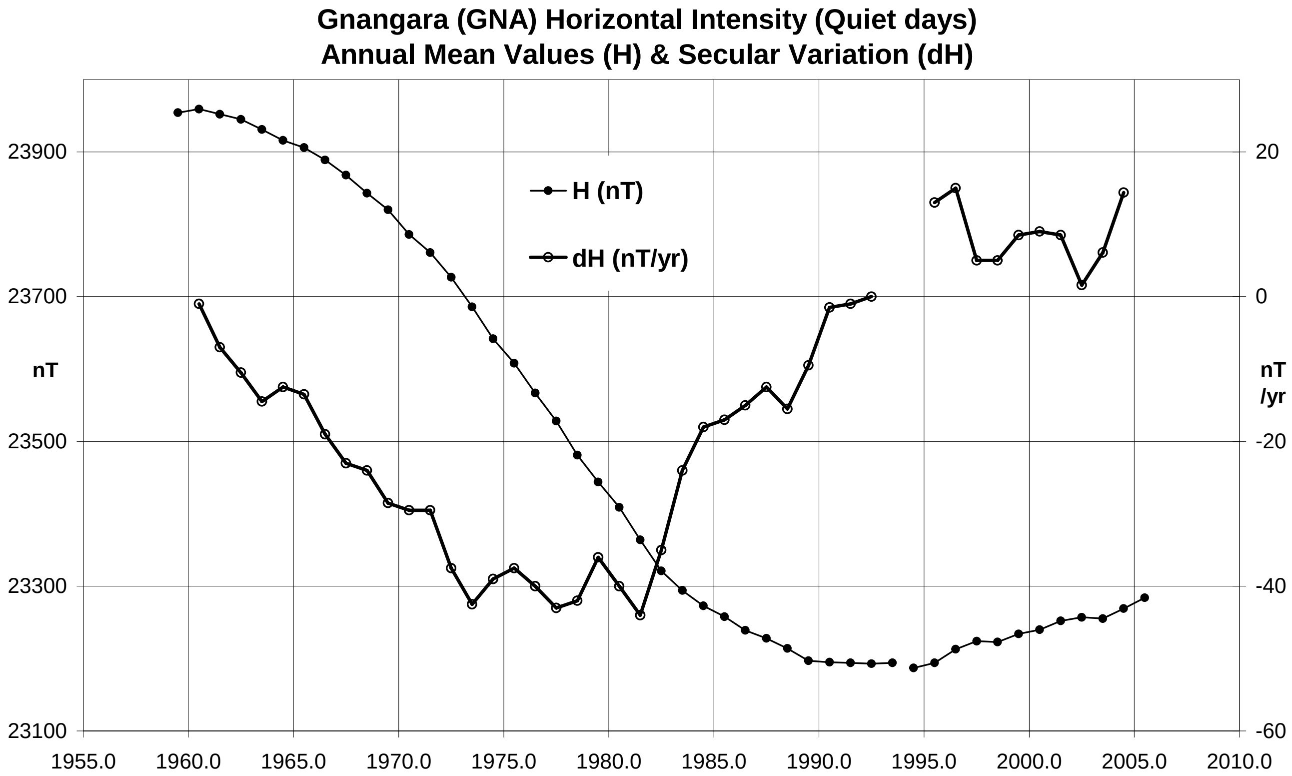
The mean value given at the top of each plot is the *all-days* annual mean value of the element.

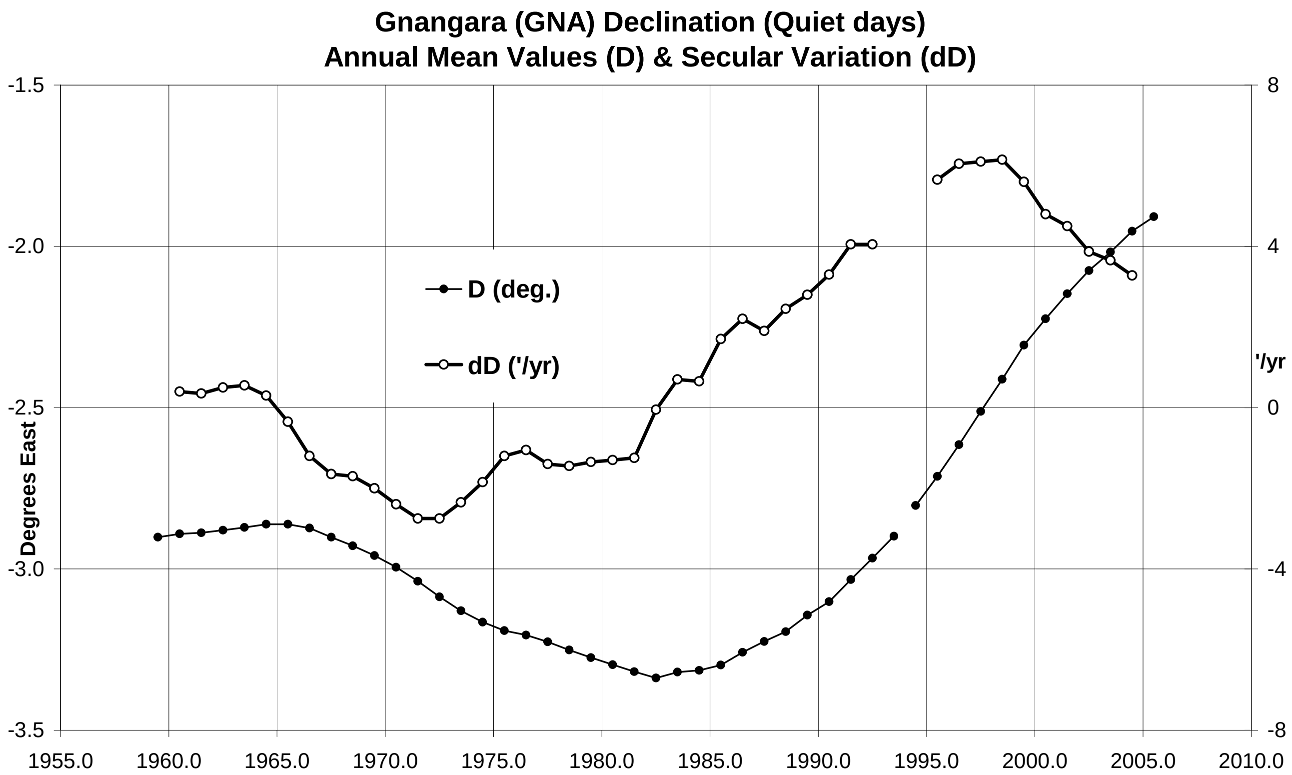
Gnangara 2005 Horizontal intensity (H). Scale: 7.5 nT/mm. Mean: 23275 nT

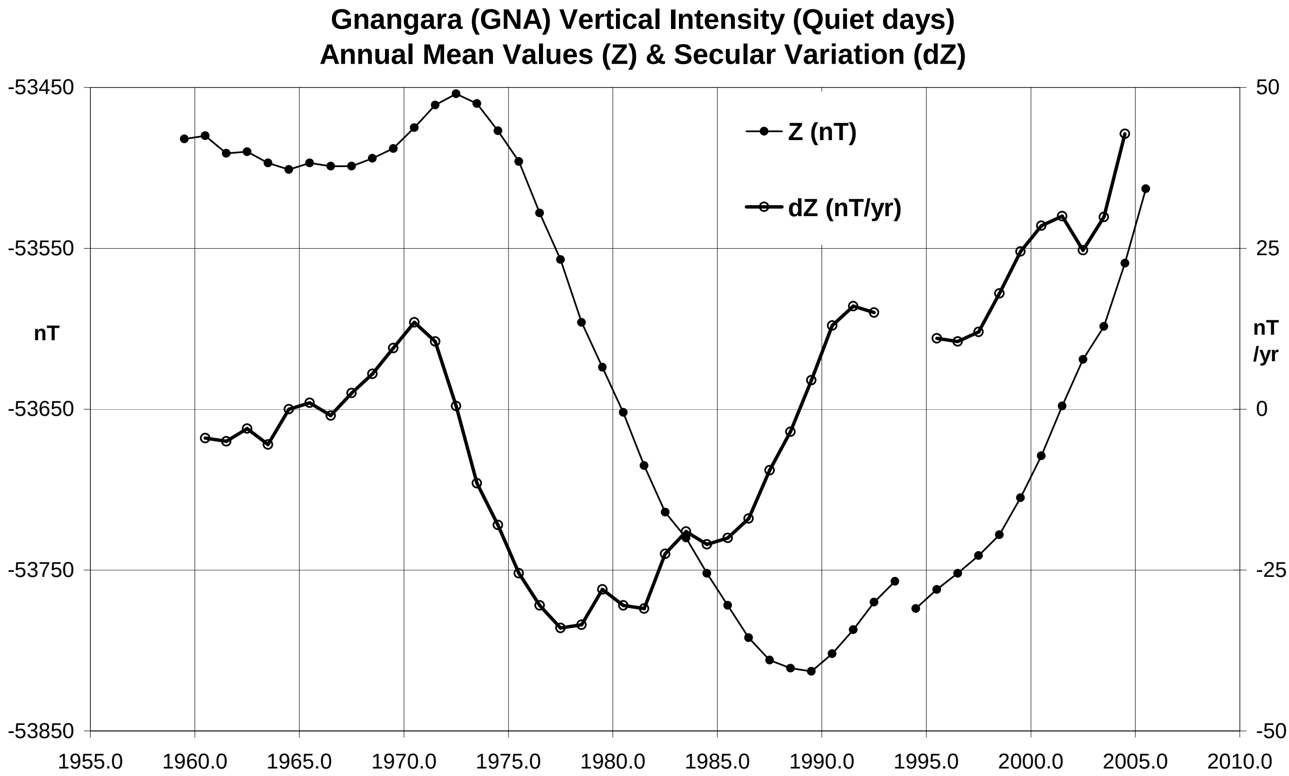
Gnangara 2005 Declination (east) (D). Scale: 1.00 min/mm. Mean: −1.91 deg.

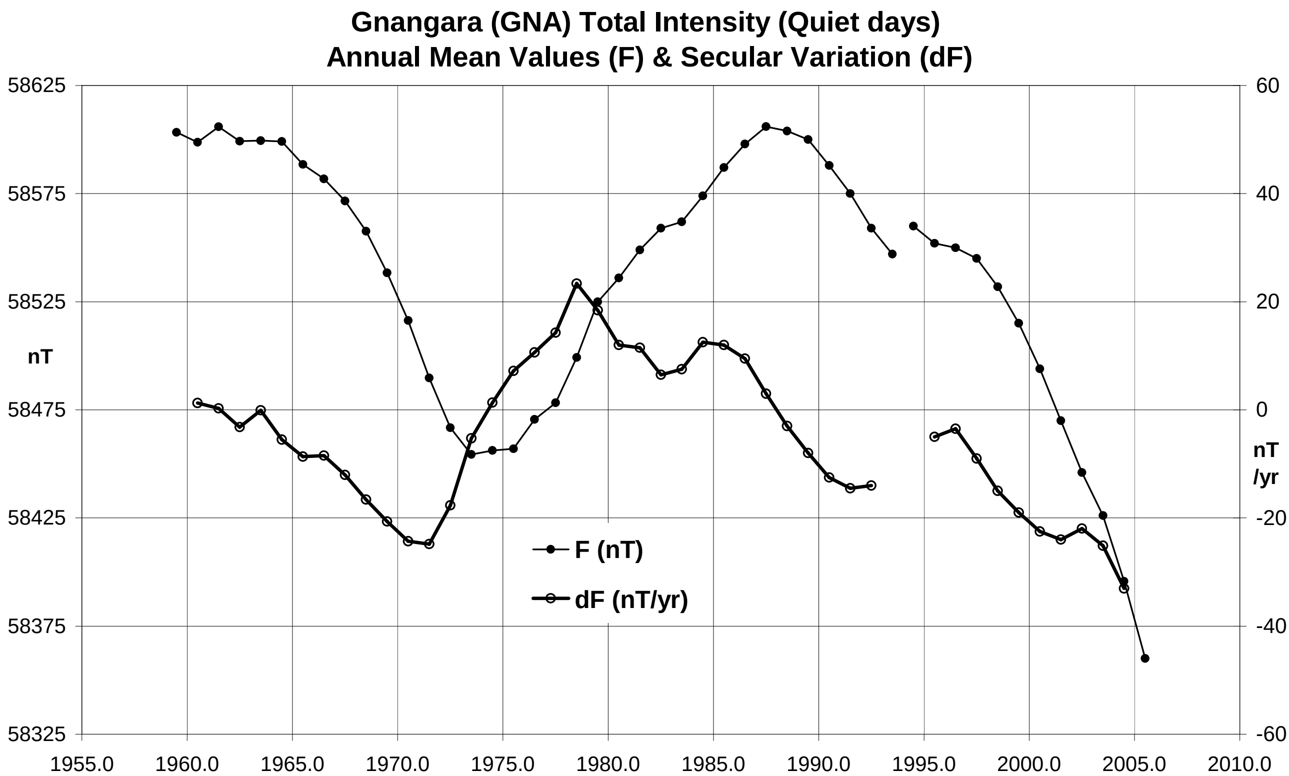
Gnangara 2005 Vertical intensity (Z). Scale: 7.5 nT/mm. Mean: −53516 nT

Gnangara 2005 Total intensity (F). Scale: 7.5 nT/mm. Mean: 58358 nT


Gnangara (GNA) Horizontal Intensity (Quiet days)
Annual Mean Values (H) & Secular Variation (dH)
H (nT)
dH (nT/yr)
nT
nT
/yr
23900
23700
23500
23300
23100
20
0
-20
-40
-60
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0


Gnangara (GNA) Declination (Quiet days)
Annual Mean Values (D) & Secular Variation (dD)
D (deg.)
dD ('/yr)
Degrees East
'/yr
-1.5
-2.0
-2.5
-3.0
-3.5
8
4
0
-4
-8
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0


Gnangara (GNA) Vertical Intensity (Quiet days)
Annual Mean Values (Z) & Secular Variation (dZ)
-53450
-53550
-53650
-53750
-53850
nT
50
25
0
-25
-50
nT
/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
Z (nT)
dZ (nT/yr)


Gnangara (GNA) Total Intensity (Quiet days)
Annual Mean Values (F) & Secular Variation (dF)
58625
58575
58525
58475
58425
58375
58325
nT
60
40
20
0
-20
-40
-60
nT
/yr
1955.0
1960.0
1965.0
1970.0
1975.0
1980.0
1985.0
1990.0
1995.0
2000.0
2005.0
2010.0
F (nT)
dF (nT/yr)

Annual Mean Values – GNA (cont.)

Year	Days	D		I		H	X	Y	Z	F	Elts
		(Deg	Min)	(Deg	Min)	(nT)	(nT)	(nT)	(nT)	(nT)	
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	ABC
1994	J		-1.6		1.1	8	7	-11	27	-22	ABC
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	ABC
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	ABC
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	ABC
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	ABC
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	ABC
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	ABC
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	ABC
2001.5	D	-2	09.6	-66	36.0	23219	23203	-875	-53656	58465	ABC
2002.5	D	-2	04.9	-66	34.9	23227	23211	-844	-53627	58441	ABC
2003.5	D	-2	01.3	-66	34.5	23225	23210	-819	-53605	58420	ABC
2004.5	D	-1	57.6	-66	32.7	23242	23228	-795	-53566	58391	ABC
2005.5	D	-1	54.7	-66	30.7	23259	23246	-776	-53520	58355	ABC

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

End of Part 1