AGSO

MAWSON GEOPHYSICAL OBSERVATORY, 1993

ANNUAL REPORT AND DATA SUMMARY

BY A. RADA

RECORD 1994/28

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

AGSO Record 94/28.

Mawson Geophysical Observatory

1993

Annual Report & Data Summary.

by
Anton Rada

Geomagnetism Section
Geophysical Observatories and Mapping Program

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Minister for Resources: Hon. David Beddall, MP
Secretary: Greg Taylor

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Executive Director: Harvey Jacka

ISSN: 1039-0073
ISBN: 0 642 20414 4

TABLE OF CONTENTS:

APPENDICES:

LIST OF TABLES

LIST OF FIGURES

SUMMARY:

This report describes the operation of the Mawson geophysical observatory from December 1992 to December 1993. It includes a summary of final Mawson geomagnetic data from 1 January 1993 to 30 December 1993. Monthly averages of the quiet field for Davis and Casey stations have also been produced from data provided by the Auroral and Space Physics section (ASP) of the Antarctic Division.

Geomagnetic activity was continuously monitored at the Mawson observatory using two variometers:

1- A Photo-Electronic Magnetometer (PEM)

2- A Narod Ringcore Variometer (RCF)

The two variometers measured the geographic north, east and vertical components of the field, and an Elsec E820 proton precession magnetometer (PPM) measured the total field strength. The data for each variometer were recorded digitally on separate IBM-AT-compatible personal computers, and the PEM data was also recorded as analogue traces on a W&W chart recorder. The digital data were stored on disk, but could also be accessed from the AGSO office in Canberra via satellite telemetry (PEM System Only). The variometer data were calibrated through regular (3-4 times/week) magnetic absolute observations. Preliminary geomagnetic data (K indices and mean quiet field values) were forwarded monthly to the Geomagnetism Section of AGSO for publication in monthly observatory reports.

Seismic activity was monitored by two independent systems. One consisted of three Guralp wide band seismometers aligned geographic north, east and vertical. Digital data from this system were telemetered to the Nuclear Monitoring Section of the Australian Seismological Centre (ASC) in Canberra and recorded on a Sun/Unix computer network. The second system consisted of a short period vertical Benioff seismometer and a long period vertical Press-Ewing seismometer; the data were recorded locally on hot-pen helicorders. These charts were scaled and reported approximately weekly to AGSO and the National Earthquake Information Service (Boulder, Colorado) via email.

CHAPTER 1. INTRODUCTION:

The Geophysical Observatories and Mapping Division of the Australian Geological Survey Organisation (AGSO) operates geomagnetic and seismological observatories at Mawson and Macquarie Island, a seismological observatory at Casey and assists in the operation and calibration of the Antarctic Division geomagnetic monitoring programs at Casey and Davis, as its contribution to the Australian National Antarctic Research Expeditions (ANARE). Logistic support is provided by the Australian Antarctic Division, Department of The Enviroment, Sport and Territories. This report describes the Mawson Geophysical Observatory and gives a summary of the geomagnetic data and results for 1993. Station details are listed in Table 1 and a map of Mawson showing the location of the geophysical buildings and cable paths appears in previous reports (Kelsey, 1987).

Table 1. Station Data for Mawson, 1993

Magnetic Absolute Hut - Pier A (instrument level) (Hutchinson, 1989)

Geographic Coordinates	67° 36' 14.1" S 62° 52' 45.2" E
Geomagnetic Coordinates	73.194° S 107.5466° E (IGRF 1990.0)
Elevation	12 m
Foundation	Mawson Charnockite

Magnetic Variometer Building - Mark N1 (Crosthwaite, 1986)

Geographic Coordinates	67° 36' 11.4" S 62° 52' 44.5" E
Elevation	9 m
Foundation	Concrete on Mawson Charnockite

Cosray Vault - Seismometer Platform (Crosthwaite, 1986)

Geographic Coordinates	67° 36' 16.6" S 62° 52' 16.6" E
Elevation	17 m
Foundation	Concrete on Mawson Charnockite

The observatory commenced operation in 1955 with the installation of a three component La Cour magnetograph from Heard Island. The first seismological data were collected in 1956. The history of instrumentation changes at the observatory from 1955 until 1993 are listed in appendix A.

The author arrived at the Mawson ice-edge aboard the M.V. Aurora Australis on 11th December 1992, flew by helicopter into Mawson and assumed responsibility for the observatory. The previous observer, John Jamieson performed instrument comparisons before departing on 14 December 1992 (Jamieson, 1992). The following summer, the replacement observer for 1994, Adrian Giffen, arrived aboard the Aurora Australis on 11 December 1993. I carried out instrument comparisons before departing Mawson aboard the M.V. Aurora Australis on 15 December 1993.

CHAPTER 2. MAWSON GEOMAGNETIC OBSERVATORY:

2.1 Absolute Observations and Reductions

Absolute observations of the geomagnetic field were carried out regularly on Pier A of the Mawson Absolute Hut to calibrate the magnetic variometers. An average of 20 observations of F, D, I and H were carried out every month using the primary instruments (described below). Absolute observations were made in both quiet and disturbed field conditions. The routine absolute observations were reduced using software programs developed by Peter Crosthwaite (Crosthwaite, 1991). The first absolute observation by the author was carried out on 12/12/92 and the last on 14/12/93.

The monthly observation schedule from February to June comprised of:

8 X - PPM, DIM, DIM, PPM

On June 3rd (day 154) the DIM developed a fault in the cable and QHM 300 was used as the primary instrument until the DIM was repaired on July 2nd (day 183). It was found that the DIM was producing larger than normal baseline scatter and I was advised from Head Office to adopt the following schedule, using QHM 300 as the primary instrument. The monthly observation schedule after June comprised of:

6 X - DEC 332, QHM 300, DIM, PPM, PPM

2 X - DEC 332, QHM 300, QHM 301, PPM, PPM

2 X - DEC 332, QHM 300, QHM 302, PPM, PPM

1 X - Round of angles.

All QHM observations followed the standard 9 minute QHM observing schedule and a sighting on the azimuth mark was taken before and after, so both H and D were determined from the QHM observations. All QHMs were used as 2π instruments at Mawson. The PPM observations were made with the PPM sensor head in the standard bolts down orientation. The declinometer was left on the pier for the weight to hang between sets of absolute observations.

In addition, secondary instruments were included in the observation schedule about 2 times per month to ensure they remained calibrated with the primary instruments. Two secondary QHMs were used following the standard routine for determining H and D; the DIM fluxgate magnetometer was used mainly for "half sheet" observations to determine D and I. All D measurements were referenced to the azimuth mark BMR89/2. A flood light was used to illuminate the mark over winter. The light was powered from the external mains socket on the Variometer Building and was left in place all year. The mark became obscured from view and in some cases completely buried by snow and was dug clear by hand after each blizzard.

Temperature calibrations were performed at the start of the absolute observation. This was done by recording the temperature of the variometer as displayed on the Doric Trendicator, together with the digital temperature counts. PEM scale value calibrations were not performed in 1993.

2.2 Absolute Instruments

The primary absolute instruments used at Mawson in 1993 were:

Before June:

DIM Elsec 810/208, Theodolite 312714	for D and I
PPM Elsec 770/199 in bolts down orientation	for F

After June:

QHM 300, Thermometer 1650,	Askania glass circle 611665	for H
Declinometer 630332,	Askania glass circle 611665	for D
PPM Elsec 770/199 in bolts down orientation		for F

The secondary instruments were:

QHM 300, Thermometer 1650, Askania glass circle 611665	for D
QHM 301, Thermometer 1416, Askania glass circle 611665	for H and D
QHM 302, Thermometer 1401, Askania glass circle 611665	for H and D
PPM Elsec 770/206 in bolts down orientation	for F
DIM Elsec 810/208, Theodolite 312714	for D and I

QHM constants and thermometer correction factors are given in Table 2 and instrument parameters (QHM α angles corrected to H=18500nT and declinometer erect-inverted angles) are given in Table 3.
NOTE: There is a special correction for this year owing to the presence of a steel DIM case on the shelf of the Absolute Hut. See Section 2.3 for further details.
The instrument corrections for the pre June DIM period are not certain due to variable contamination from the DIM electronics box. SEE Section 2.3 for further details.

Table 2. Absolute Instrument Constants and Thermometer Corrections, 1993

2.1 QHM Constants

QHM	K nT	k1 $10^{-5}\,°C^{-1}$	k2 $10^{-10}\,nT^{-1}$	α.H $10^{5}\,'.nT$	Odd π mis-alignment	Collimation
300	7828.0	39.4	69.0	2.22	0.0'	22.5'
301	8230.5	39.7	90.0	0.00	0.0'	72.5'
302	7690.1	42.0	90.0	0.00	0.0'	27.0'
172	7938.5	39.1	46.1	0.00	0.0'	0.0'
704	6025.8	26.0	0.0	0.00	0.0'	27.0'

2.2 QHM reduction formula:

$$H = \frac{Kn}{(1-k_1T)(1+k_2H\cos\phi)\sin\phi\cos(\frac{1}{2}(\phi_+ - \phi_-)+\alpha)}$$

Where:

Where:	H	= magnitude of horizontal component of the magnetic field;
	K	= main constant of the QHM;
	n	= rotational torsion applied during QHM measurement (multiple of π);
	k_1	= QHM temperature coefficient;
	T	= ambient temperature of QHM;
	k_2	= QHM induction coefficient;
	ϕ	= $\frac{1}{2}(\phi_+ + \phi_-)$ = mean deflection angle;
	ϕ_+	= positive torsion deflection angle;
	ϕ_-	= negative torsion deflection angle;
and	α	= residual torsion in QHM fibre.

Note: Collimation is the angle between the normal of the magnet's mirror and its magnetic axis. In some expressions for calculating H from QHM observations the value of n is taken as the number of multiples of 2p. Whereas the software used to calculate H throughout 1993 used values of n as the multiples of p. Consequently the value of K in this table is half the value of K that is often quoted for the instruments.

2.3 Thermometer Correction Factors, 1993

Thermometer	-10°C	0°C	+10°C	+20°C	+30°C	+40°C
1650	-0.1	0.00	+0.05	+0.20	+0.1	+0.15
1401	+0.1	+0.10	+0.05	0.00	-0.5	
1416	-0.1	-0.10	-0.10	-0.05	-0.1	-0.10
619		-0.05	0.00	-0.05	-0.1	-0.10
704	0.0					0.00

Table 3. Mawson Absolute Instrument Parameters 1993

3.1 QHM a Angles

Instrument	Mean a Angle	Samples	1992 Average
QHM 300	12.68' +/- 0.29	66	12.9' +/- 0.6
QHM 301	-11.81' +/- 0.65	14	-11.4' +/- 0.5
QHM 302	-0.13' +/- 0.62	6	-0.7' +/- 0.3

3.2 Declinometer Erect-Inverted Angles

Instrument	Mean Erect-Inverted Angle	Samples	1992 Average
Declinometer 630332 Circle 611665	1.16' +/- 0.41	67	1.3' +/- 0.4

The secondary instruments were included in the observation routine and comparison with the standard instruments produced the instrument differences listed in Table 4.

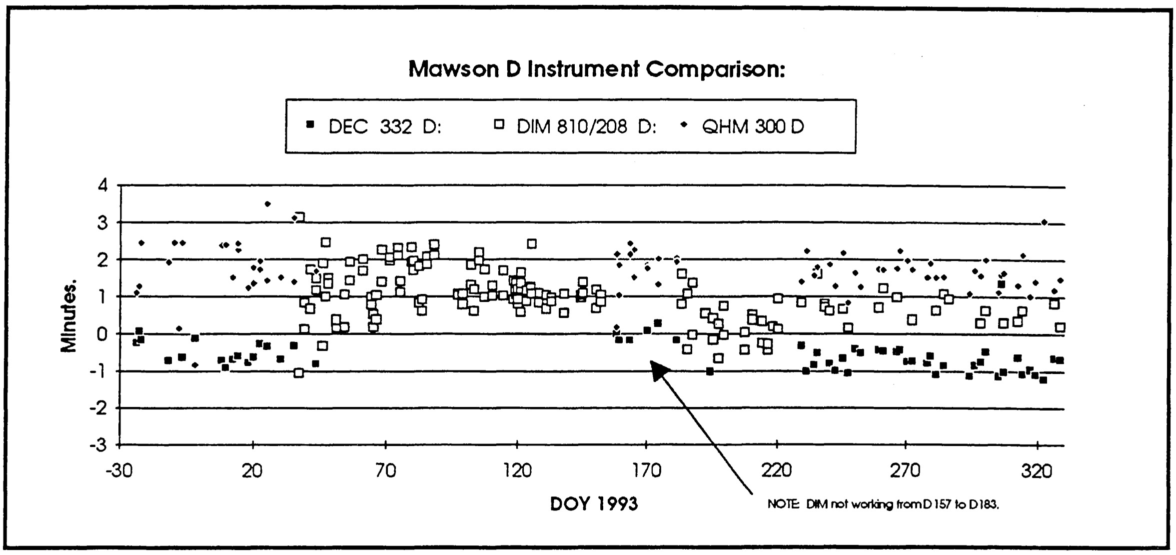
Table 4. Secondary Instrument Differences Through Baselines:

Primary instr. A	Secondary instr. B	Field Component	Instr.Difference A-B	Samples
Decl 630332	QHM 300	D	-2.1' +/- 0.84	30 [1]
Decl 630332	QHM 300	D	-2.3' +/- 0.61	33 [2]
Decl 630332	QHM 301	D	0.20' +/-1.01	14
Decl 630332	QHM 302	D	0.36' +/-0.88	7
Decl 630332	DIM 208	D	-1.39' +/- 0.57	33 [3]
QHM 300, PPM 199	DIM 810/208	I	-0.18' +/- 0.58	28 [3]
QHM 300	QHM 301	H	6.6 nT +/- 0.85	7 [3]
QHM 300	QHM 302	H	-0.9 nT +/- 1.29	7 [3]
QHM 300	DIM 208 PPM 199 Day 0 to 183	H	5.57 nT +/- 3.42	35 [4]
QHM 300	DIM 208 PPM 199 Day 183 to 330	H	1.99nT +/- 4.10	32 [4]

[1] Average of Day 220 to 320.
[2] Average of Day 335 in 1992 to Day 40 1993.
[3] Samples from when instruments were used together from Day 229 to 328
[4] Instruments not used together. Values averaged from Figure 2

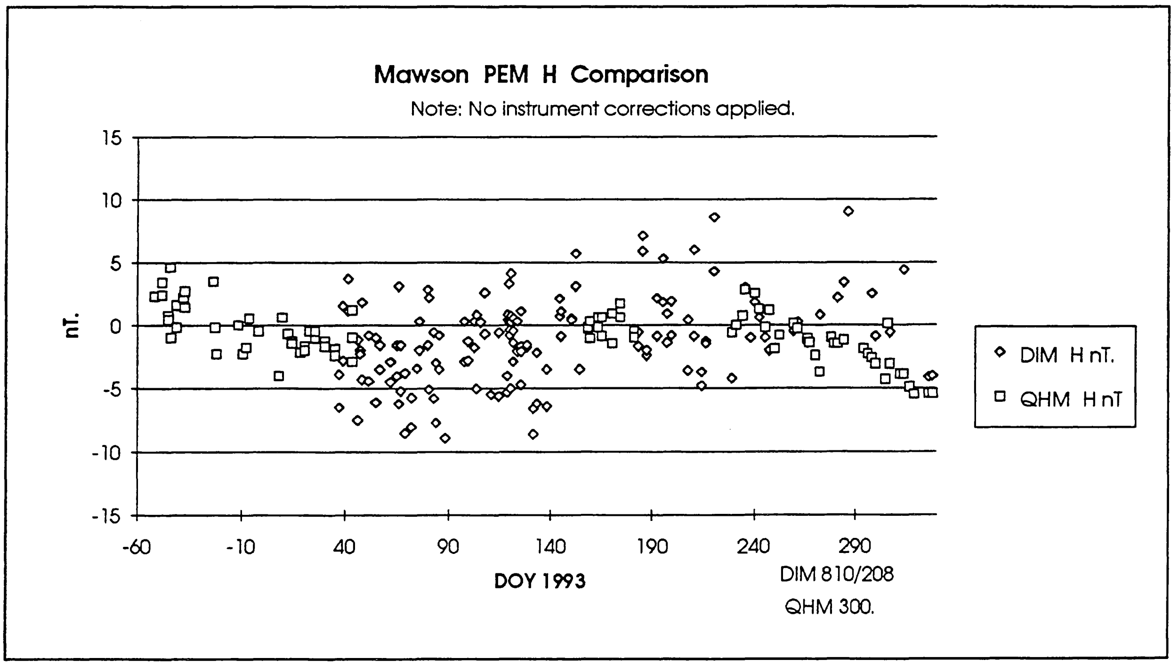
The DIM failed twice through the year , on the first occasion the cause was found to be a broken solder connection to the sensor head. This had also occurred in early 1992, see Jamieson 1992. A new cold tolerant cable was installed on day 138 and the sensor and optical axes aligned. It was noted that the new cable did not meet the specification of individually shielded wires however this did not appear to affect the function of the instrument. The second failure of the DIM occurred on day 154; part way through the observation the display could no longer be zeroed. The ASP engineer found IC1 to be faulty and replaced it with a similar compatible component. As a result of the repairs, the instruments display; which had previously changed slowly; became much quicker to respond. More high frequency magnetic fluctuations were displayed making the instrument harder to zero.

Figure 1. Declination Instrument difference through PEM Variometer.



Note: This graph shows the difference between absolute instrument declination and the PEM variometer (abs D- var D) using constants in force at 1/1/93. Instrument and baseline corrections have not been applied to produce this graph. Unlike 1992, Figure 1 shows no obvious change throughout the year between D measured by Declinometer 630332 and D measured by QHM 300.

Figure 2. Standard Instrument H Comparison.



Note: This graph shows the difference between absolute instrument and variometer results using constants in force at 1/1/93. Instrument and baseline corrections have not been applied.

2.3 Standard Instrument Comparisons and Corrections

Pre-Mawson simultaneous comparisons were performed by Adrian Giffen and Stewart Dennis on piers CE and AW. The summary of results for both pre Mawson and Post Mawson are given in Table 6.

Comparisons were made between the travelling standard instruments and the Mawson standards during the change over in December 1993. The travelling standards were:

QHM 172, thermometer 619	on Askania glass circle 611665	for H
HTM 704, thermometer 704	on Askania glass circle 611665	for H
Declinometer 640505	on Askania metal circle 508813	for D
PPM Elsec 770/188	in bolts down orientation	for F

The comparison observation schedule was as follows:
2 X QHM 300, HTM 704, HTM 704, QHM 300
2 X QHM 300, QHM 172, QHM 172, QHM 300
2 X DEC 332, DEC 505, DEC 505, DEC 332
1 X PPM E770/210, DEC 505, HTM 704, DIM, DIM, HTM 704, DEC 505, PPM E770/210
1 X Comparison of PPM E770/199, PPM E770/210 Total of 13 one minute obs.

The QHM and thermometer constants are listed in Table 2. All observations were performed on pier A in the absolute hut, and were reduced through baselines using both the PEM and RCF variometers.
A summary of the comparison results are given in Tables 5.1 to 5.3 .

Table 5. Absolute Instrument Comparisons at Mawson

5 .1 Horizontal Field Comparisons

Date	Primary Instrument A	Secondary Instrument B	RCF A-B H	PEM A-B H
11/12/93	QHM 172 Circle 611665	QHM 300 Circle 611665	44.8 nT ± 1.15	45.3 nT ± 4.8
11/12/93	HTM 704 Circle 611665	QHM 300 Circle 611665	-0.7 nT ± 0.8	0.2 nT ±2.7

5.2 Declination Comparisons

Date	Primary Instrument A	Secondary Instrument B	RCF A-B D	PEM A-B D
13/12/93	Decl 640505 Circle 508813	Decl 630332 Circle 611665	1.61' ± 0.39'	1.56' ± 0.67'
11/12/93	QHM 172 Circle 611665	QHM 300 Circle 611665	-47.20' ± 0.75'	-46.82' ± 1.14'
13/12/93	HTM 704 Circle 611665	QHM 300 Circle 611665	-43.73' ± 0.55'	-44.82' ± 2.95'

NOTE: QHM 172 and HTM 704 Versus QHM 300 for D are included because they were available; they are not usually compared.

5.3 Total Field Comparisons

Date	Primary Instrument A	Secondary Instrument B	RCF A-B	PEM A-B
10/12/93	PPM Elsec E770/210	PPM Elsec E770/199	2.6 nT ± 0.6	2.5 nT ± 1.0

The results from the comparisons using the RCF variometer show consistently smaller standard deviations than the results from the PEM variometer. For this reason the instrument differences derived using the RCF have been used.

The results of the comparison performed between the Mawson combination : DIM 810/208, PPM E770/210 and the travelling standards : PPM E770/210, DEC 505, HTM 704 ; show high scatter for both the RCF and

PEM. The scatter is attributed to the DIM observation as they have consistently produced a high scatter throughout the year. A longer set of comparisons between the Mawson combination and the Antarctic standards combination would produce better results.

On return to Australia the travelling standards were compared for H, D and F to the Australian standards by simultaneous comparisons on piers CE and AW by Anton Rada and Stewart Dennis at the Canberra Magnetic Observatory, CMO. Results are given in table 6.

Table 6. Instrument Comparisons of travelling standards at the CMO

6 .1 Horizontal Field Comparisons (Simultaneous comparisons on Pier CE and AW)

Primary Instrument A	**Secondary Instrument B**	**Pre Mawson A-B nT 29/10/93**	**Post Mawson A-B nT 24/3/94**
QHM 460	QHM 172	-57.2 +/- 0.03	-59.3 +/- 0.1
QHM 461	QHM 172	-56.7 +/- 0.8	-58.0 +/- 0.9
QHM 462	QHM 172	-59.4 +/- 0.5	-59.6 +/- 1.3
QHM 460	HTM 704	5.7 +/- 1.0	5.2 +/- 0.7
QHM 461	HTM 704	7.7 +/- 0.0	4.9 +/- 0.1
QHM 462	HTM 704	4.6 +/- 0.1	4.3 +/- 1.8

6.2 Declination Comparisons (on pier AW)

Primary Instrument A	**Secondary Instrument B**	**Pre Mawson A-B 10/11/93**	**Post Mawson A-B 11/4/94**
Ruska 4813/Lge	Decl 640505 Circle 508813	-0.9' +/- 1.0	0.03' +/- 0.4

6.3 Total Field Comparisons (on pier AW)

Primary Instrument A	**Secondary Instrument B**	**Pre Mawson A-B 8/11/93**	**Post Mawson A-B 31/3/94**
MNS2.3X	E770/210	0.5 nT +/- 0.4	0.13 nT +/- 0.5

The corrections adopted for 1993 to bring the Mawson standard instrument combination of: (QHM 300, Dec 332, PPM E770/199) into line with Australian and international standards are:

H: -3.5 nT, D: 1.4' +/- 0.5' , F: +1.0 nT +/- 0.7 nT

In terms of X,Y,Z and I this corresponds to: X: 5.3 nT, Y: 6.3 nT, Z: -2.5 nT, I: -0.23'

NOTE : Further corrections have been determined to compensate for contamination of the Absolute Hut. See below.

The instrument corrections have been applied to mean field values in this report.
From the adopted corrections above, and the results quoted in table 4, the corrections for DIM 208 / 312914 after day 229 are D: 0.0' +/- about 0.6' and I: -0.4'. The DIM I correction was derived from the instrument differences between the QHM and DIM combinations for I, shown in table 4 which has a standard deviation of 0.58'. For this reason an I correction of 0.0' for the DIM has been adopted.

Contamination of The Absolute Hut:
Absolute observations were contaminated by the presence of the magnetic DIM case in the Absolute hut. The DIM case was in the absolute hut on the lower shelf in the south east corner when the author arrived in December 1992, and remained there all year except for the period from day 155 to 180 when the DIM was being repaired. A series of observations were performed by A. Giffen in April 94, results are shown in Appendix J.

The results determine the effect of the magnetic case to be approximately -3 nT in X, -4 nT in Y, and +2nT in Z. As there is considerable uncertainity in these results and no obvious jump of this size shown in the baseline residuals, the more conservative corrections of:

+2 nT in X, +2 nT in Y, and -1nT in Z have been adopted.

For absolute observations made with QHM300, Dec332, PPM 199 on pier A in 1993 the corrections are:

For 1st Jan to 6th Jun & 3rd Jul to 31st Dec:

Component:	X (nT):	Y(nT):	Z(nT):
Instrument Correction:	5.3	6.3	-2.5
DIM Case Correction:	2	2	-1
Total Correction:	**7.3**	**8.3**	**-3.5**

For 6th Jun to 3rd Jul:

Instrument Correction:	5.3	6.3	-2.5
Total Correction:	**5.3**	**6.3**	**-2.5**

These corrections have been applied to derived mean field values in this report. The opportunity was taken within the Geomagnetism Section to compare these comparisons against previous years and adopt instrument corrections that are the best available at this time and are considered to be final.

2.4 Variometers and Recording Equipment

During 1993 a new Ring Core Fluxgate Variometer was installed and run in parallel with the PEM variometer. Both variometer systems were housed in the sensor room of the Magnetic Variometer Building, on the eastern outskirts of the station about 80 metres from the Absolute Hut.

PEM:

The three-component Photo-Electronic magnetometer (PEM) measured the X (positive north), Y (positive east) and Z (positive down) elements of the field. At Mawson X is positive, Y and Z are negative. An Elsec 820 proton precession magnetometer (PPM) measured the total field strength, F. Temperature in the variometer room was monitored by a Doric Trendicator with the sensor on the Y pier. Temperature in the variometer room was kept at the standard 10°C (±1°C) by a fast-cycle heater. This temperature only strayed significantly below 10°C during power failures.

The X and Y PEMs were set with a sensitivity of ±2000 nT and the Z PEM with a sensitivity of ±1000 nT. The X PEM uses QHM 291 as the sensing instrument, the Y PEM uses QHM 292; the Z PEM uses a LaCour type sensor.

The PEM variometer system functioned without problems during 1993 and was not modified in any way. The Elsec 820 PPM showed intermittent spikes on the analogue charts, and in the digital data. This problem had been present since 1991 (see deDeuge 1991, Jamieson 1992) and had been attributed to interruptions to power when the PPM was powered via a DC supply by the SPS1000 backup power supply. On the 22nd of Febuary the SPS was found to be cutting in and out rapidly (at a rate of 1Hz or faster) due to low voltage conditions at the variometer building. These conditions arose because the building was near the end of the station's mains supply line so that power demands along the line caused significant voltage drops at the variometer building. When the voltage level was borderline, the SPS cut in and out rapidly and caused spikes in the data. This problem has only occurred in the past over the summer period when power demands are high. As a result the DC supply for the Elsec 820 PPM was blown and was replaced. The data from the Elsec 820 PPM showed progressively more spikes until on the 27th of September it was removed as all data values were being rejected. A new Elsec 820 PPM arrived on Voyage 2 and was connected to the RCF system on the 11th of December.

PEM Recording System

The PEM variometer outputs are recorded by two separate systems, one analogue and one digital. The output from the PEM and Doric Trendicator are in analogue form. Output from the PPM was configured to be both digital and analogue.

The five channels of analogue data (X, Y, Z, F and temperature) were transmitted from the variometer building over a long shielded data cable (325m), and recorded in the Mawson Science Building on a six channel W+W chart recorder at a rate of 2 cm/hr. Hourly time marks were produced on the charts from the GED master clock. The charts were used as a visual indication of the state of the field and as a final backup for the digital data. The chart-recorded data were not fully calibrated.

The analogue X,Y,Z and temperature data were digitised with a Data Translation DT2895/5716a A/D board and recorded with the digital output from the PPM on an NEC IBM-AT compatible PowerMate 1 Personal Computer located in the recorder room of the Variometer Building. The five channels of digital data were recorded as minute values onto hard disk. The digital data could also be accessed (and telemetered to Australia) from the AGSO office in Canberra using the ANARESAT communications system to the Science building and then via the long cable to the variometer building. The recording system could be interrogated from the Science Building with a Teletype TTY43 printer terminal to check timing and correct operation.

The timing for the digital recording system was taken from the computer DOS clock, which was synchronised to the GED clock in the Science Building using minute pulses. The GED drifted by only 3-4ms per day during 1993 and was maintained to well within 50ms of UTC. The real time CMOS clock in the acquisition PC has a drift rate of approximately 1 second per day and was synchronised to the DOS clock approximately monthly.

The PEM recording system functioned without problems in 1993.

RCF:

Installation:

The RCF system was installed for testing in the Variometer Building on December 11th 1992. The wiring was ducted through to the logging room and the excess cable from the sensor to the electronics box was rapped in blankets as the cable was thought to have a temperature dependence. An NEC 286 IBM compatible PC was installed along side the PEM PC for data logging. The RCF electronics box was installed in the wooden instrument rack. The RCF sensor was placed temporarily on the floor equi-distant from each of the PEM X,Y,Z components and approx 70cm from the wall heater in the Instrument room. It was approximately aligned to the brass north-south marks in the floor of the Variometer building.

The total field strength, F was not logged by the RCF system until the 11th of December 1993 when an Elsec 820 proton precession magnetometer (PPM) was installed.
Fiducial buttons were connected to the system on the 15th of February and calibrations of X,Y,Z range differences done on the 24th of Feburary. See Appendix C.
Fiducials were recorded for absolute observations done on the 25th of Feburary and these; along with the range difference calibrations; were used to calculate the parameters for the RCF constants file.
See Appendix D.

RCF Recording System

The Narod Ring Core Fluxgate (RCF) measured the three-components X (positive north), Y (positive east) and Z (positive down) of the field. The total field strength, F can also be logged by connecting an Elsec 820 proton precession magnetometer (PPM).

The temperature of both the sensor housing (T1) and the electronics (T2) are monitored by sensors inside the perspex RCF sensor cover, and the electronics box. Temperature in the variometer room was kept at the standard 10°C (±1°C) by a fast-cycle heater. This temperature only strayed significantly below 10°C during power failures.

The digital X, Y, Z, T1, T2 and PPM data are recorded digitally on an NEC IBM-AT compatible Powermate 1 Personal Computer located in the recorder room of the Variometer Building. The five channels of digital data are recorded as minute averaged values onto hard disk.

The timing for the digital recording system was taken from the computer DOS clock, which has a drift rate of approximately 3 second per day. This drift was improved in early 1994 by applying a correction factor in the acqusition software. Although the minute pulses from the GED clock in the Science Building are wired to the variometer building, they were not successfully wired to the RCF PC. The DOS clock was maintained to within 1 min of UTC and was synchronised to UTC manually before observations. The real time CMOS clock in the acquisition PC has a drift rate of approximately 1 second per day and was synchronised to the DOS clock approximately monthly.

2.5 Variometer Calibrations and Parameters

Baseline Calibrations

The variometer model applied in this report is that described by Crosthwaite (1991). The magnetic field can be derived from the variometer output by applying the following matrix equation,

$$T = \begin{pmatrix} b_x \\ b_y \\ b_z \end{pmatrix} + \begin{pmatrix} d_x \\ d_y \\ d_z \end{pmatrix} * \left(\text{Time-Time}_0\right) + \begin{pmatrix} s_{xx} & s_{xy} & s_{xz} \\ s_{yx} & s_{yy} & s_{yz} \\ s_{zx} & s_{zy} & s_{zz} \end{pmatrix} * \begin{pmatrix} x\text{-}x_0 \\ y\text{-}y_0 \\ z\text{-}z_0 \end{pmatrix} + \begin{pmatrix} q_x \\ q_y \\ q_z \end{pmatrix} * \left(\text{Temp-Temp}_s\right)$$

where X, Y and Z are the magnitudes of the geomagnetic elements in nanotelsa
b_x, b_y, b_z are baselines for each of the components at standard temperature and reference time
d_x, d_y, d_z are baseline drift rates for each of the elements
Time_0 is a reference time
s_{ij} is the scale value matrix
x, y, z are the digital ordinates from the variometer
x_0, y_0, z_0 are digital offsets, ie. the digital output when the PEM output is 0V *
q_x, q_y, q_z are temperature coefficients
Temp is the variometer temperature in degrees celcius
Temp_s is the standard temperature for the variometer.

* x_0, y_0, z_0 are zero for the PC system, as the small offset of 2 or 3 counts is automatically compensated.

The variometer temperature is derived using the equation:

$$\text{Temp} = B_t + S_t*(t-t_0)$$

where Temp is the variometer temperature in degrees Celsius
B_t is the temperature baseline at the digital temperature reference level (t_0)
S_t is the temperature scale value
t is the digital temperature ordinate from the variometer
t_0 is the digital offset, ie. the digital output when the output from the Doric is 0V

The variometer parameters used in the model matrix equation were derived through multi-linear regression of the year's absolute measurements of the field (X,Y,Z) with time and the corresponding digital variometer and temperature data, using an Excel spreadsheet package. The resulting parameters were used to calculate values of the field from the variometer digital data, which were compared with field values obtained from the absolutes. The residuals from the two sets of values were minimised by iterating the regression/comparison process.

The temperature model was derived through linear regression performed on the year's temperature calibration data. The Doric readings (averages of 6 x 10s samples over an UTC minute) were used as the dependent variable, and the variometer temperature counts (also averages of 6 x 10s samples) were treated as the independent variable.
125 temperature calibrations were used in the regression; covering the period 12/12/92 to 14/12/93. The resulting temperature model is :

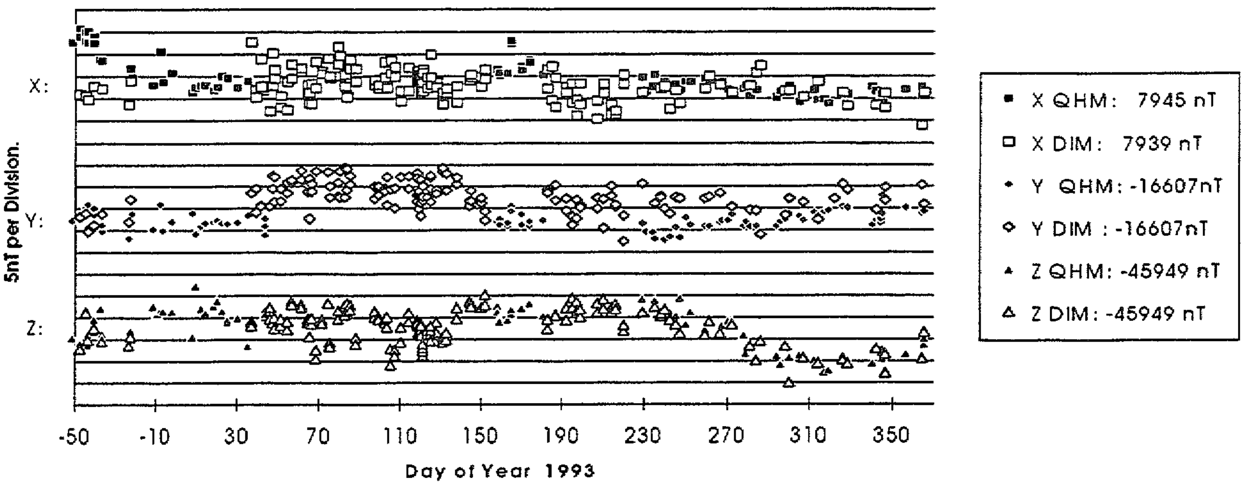
Temp=(**0.342** +/- 0.038) + (**0.003016** +/- 0.0000134)(t-0)

This compares well with the 1992 parameters of 0.342 +/- 0.11 and 0.003017 +/- 0.000033 for the counts intercept and slope respectively.

The installation of the Ring Core Fluxgate on day 346 1992 had no noticable effect on the X, Y, Z baseline. The DIM was used as the primary instrument from day 35 to day 155 and again from day 180 to day 220. During these times the instrument was repaired twice with the first repair resulting in an 'apparent' baseline shift. The first repair was on day 140 when the cable was replaced and lengthened to allow the electronics box to be placed on the bench instead of on the floor during observations. The electronics box contains 8 D-size Energiser batteries which are considerably magnetic. For the DIM observations performed prior to day 140 the electronics box was on the floor approximately 1.5 meters from the DIM sensor, and after day 140 on the bench approximately 4 meters from the sensor. From the step in baselines, the effect of the electronics box on the floor was approximately -2 nT in X, +4 nT in Y, and -4nT in Z. The DIM has been considered as the secondary instrument and this step has not been incorporated into the main variometer model used to produce mean field values in this report.

Plots of the residuals determined using fixed baselines are shown below.
Note: - DIM cable replaced on day 138.
- DIM electronics fault from day 155 to 180. Magnetic DIM case absent from Absolute hut.

Figure 3 Plot of DIM and QHM300 residuals (Determined using fixed PEM baselines.)



Note: This graph shows the difference between absolute instrument and variometer results using constants in force at 1/1/93. Instrument and baseline corrections have not been applied.

From results of linear regression analysis of several periods over the year, one scale value parameter matrix was adopted for the entire period for the three channels. The analysis used a total of 244 absolute observations on Pier A using the standard instruments. The model is presented in Appendix E. Regression analysis results are presented in Appendix H.

The results indicate that the variometer parameters for the Y channel remained apparently constant over the period covered by this report. The results for the X channel show a small linear baseline drift for the

second half of the year, which is similar to that found in 1992. The Z channel shows a change in drift from day 240 which is similar to that found by Lewis in 1990.
As the X and Y channels showed negligible statistical dependence upon the Z channel, no dependence was assumed (s_{XZ},s_{YZ} =0).

Shown below are plots of residuals determined using the adjusted baselines and new variometer parameters. The contamination corrections of -2 nT in X, -2 nT in Y, and +1nT in Z, due to the DIM case, have been added to the period from day155 to day 180 for consistency.

Figure 4.a Plot of X residuals determined using final variometer parameters.

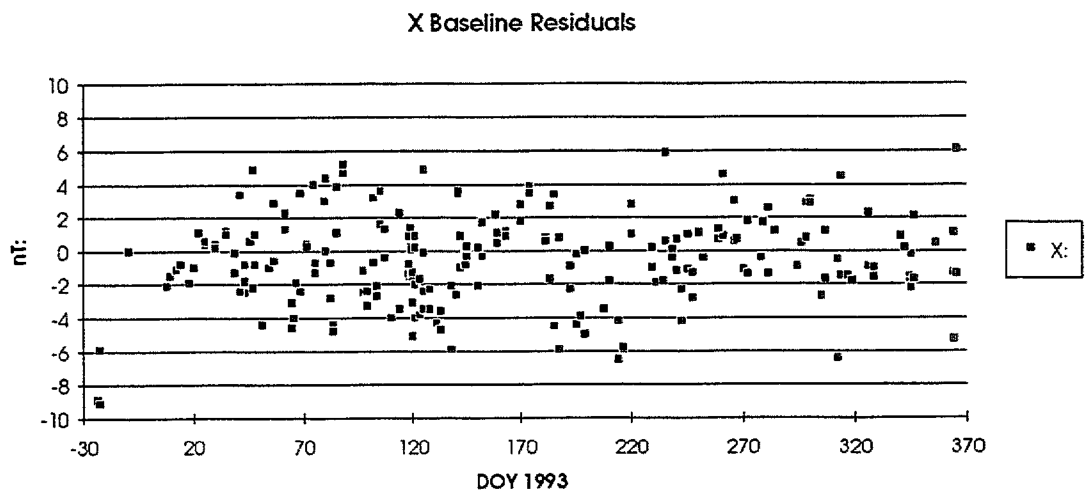


Figure 4.b Plot of Y residuals determined using final variometer parameters.

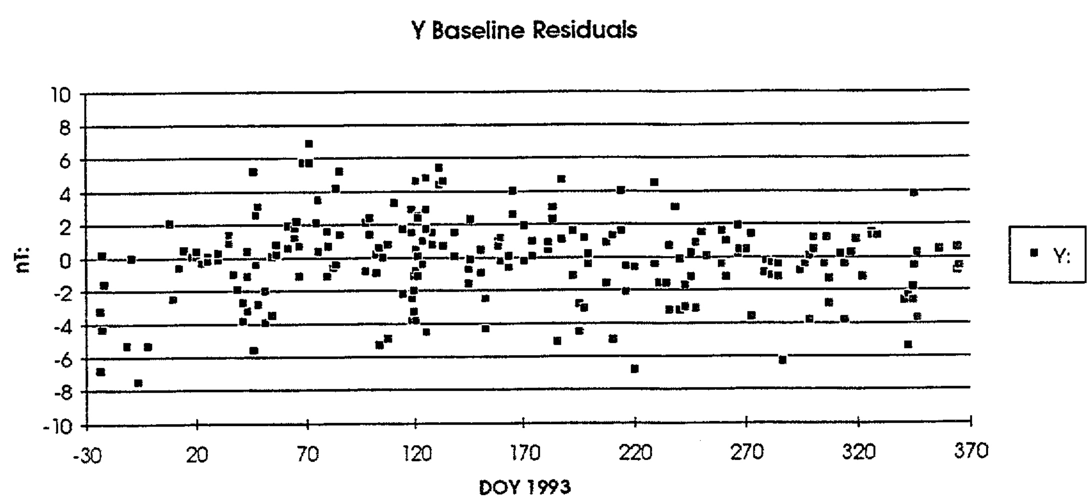
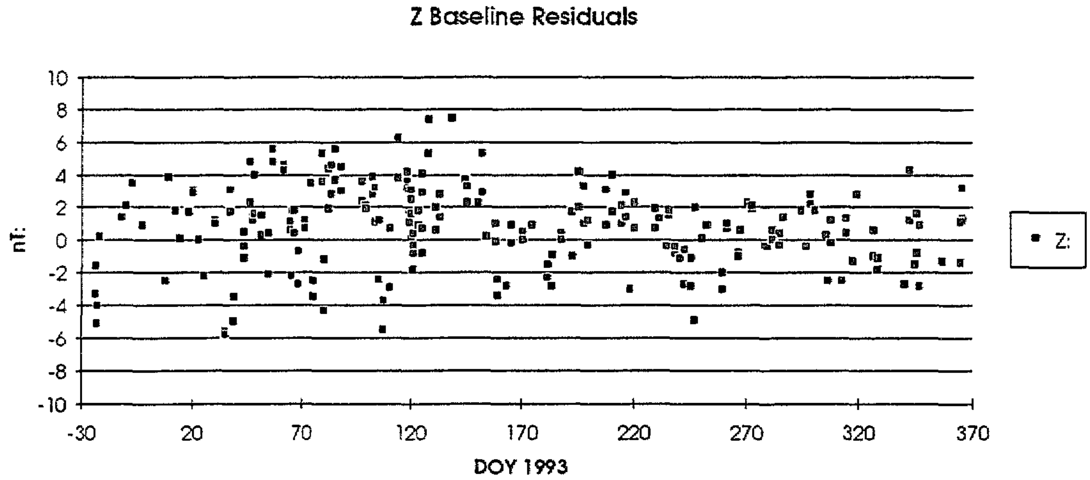


Figure 4.c Plot of Z residuals determined using final variometer parameters.



DIM Baseline Calibrations

The same model was used to determine variometer parameters using the DIM/PPM observations as the standard rather than the primary QHM/Dec/PPM observations. They are not the adopted values but are presented for comparison with the adopted parameters from the primary instruments. DIM observations were started in early February and continued through the year except for a period from day 155 to day 181 when the instrument was not working due to an electronics fault. See previous section for further details.
The variometer parameters are presented in Appendix F and are referenced to DIM 810/208 on theodolite 312714 and PPM 770/199, from 150 observations with no instrument corrections:

Orientation Calibrations

No calibrations using the orientation coils were carried out on the variometer system but the orientation of the X,Y, and Z PEMs can be determined from the system parameters. The matrix equation describing the system model can be written algebraically:

$$\mathbf{F} = \mathbf{b} + \mathbf{d}\Delta t + \mathbf{s}.(\mathbf{v}-\mathbf{v}_0) + \mathbf{q}\Delta T$$

where:
- **F** is the geomagnetic vector field
- **v** is the variometer output vector
- **b, d, q** are the baseline, drift rate and temperature coefficient vectors in the variometer coordinate system
- **s** is the scale value matrix in the variometer coordinate system
- **T** is the deviation from the standard temperature, 10 Deg C

These vectors/matrix parameters refer to the reference system defined by the axes of the PEM variometers which may not be orthogonal. The parameters referring to the geographic north/east/nadir reference system may be determined by inverting the system in the following way. The inverted scale value matrix, $\mathbf{s}^{-1}$, can be written as the product of a magnitude matrix and a normalised unit matrix, ie.

$$\mathbf{s}^{-1} = \mathbf{M}.\mathbf{U}$$

where **M** is a diagonal matrix with elements equal to the magnitude of the rows of $\mathbf{s}^{-1}$
U is a normalised unit matrix in which the row vectors, $\mathbf{u}_1$, $\mathbf{u}_2$, $\mathbf{u}_3$, have unit magnitude

It later turns out that M is a scale value matrix, so it will be called $\mathbf{S}^{-1}$; in this form

$$s^{-1} = S^{-1}.U \qquad \text{where } S = \begin{pmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & S_z \end{pmatrix} \text{ and } \mathbf{U} = \begin{pmatrix} \mathbf{u_1} \\ \mathbf{u_2} \\ \mathbf{u_3} \end{pmatrix} = \begin{pmatrix} u_{11} & u_{12} & u_{13} \\ u_{21} & u_{22} & u_{23} \\ u_{31} & u_{32} & u_{33} \end{pmatrix}$$

This implies $s = \mathbf{U}^{-1}.S$ and $\mathbf{U}.s = \mathbf{S}$. Multiplying through by $\mathbf{U}$, the model equation becomes

$$\mathbf{U.F = U.b + U.d\Delta t + S.(v\text{-}v_0) + U.q\Delta T}$$

Taking the x component of this vector equation gives

$$\mathbf{u_1.F} = \mathbf{u_1.b} + \mathbf{u_1.d}\Delta t + S_x(x\text{-}x_0) + \mathbf{u_1.q}\Delta T$$

In this form, the LHS is a projection of the total field **F** in the direction of the unit vector $\mathbf{u_1}$, which on the RHS is only dependent on the x-component of the variometer. Therefore $\mathbf{u_1}$ gives the orientation of the X PEM in the north/east/nadir reference frame, ie. **U** is the orientation matrix and **U.b, U.d, U.q** and S are the true baseline, drift, temperature parameters and scale value matrix of the instrument.

From the variometer parameters deduced from the standard instruments the orientation and true scale value matrices are obtained by inverting s and resolving into magnitude and normalised matrices, and hence a scale value matrix are:

$$\mathbf{U} = \begin{pmatrix} 0.9999949 & -0.00343 & 0 \\ 0.004014 & 0.999992 & 0 \\ -0.01838 & 0.004513 & 0.999821 \end{pmatrix} \qquad \mathbf{S} = \begin{pmatrix} 0.059794 & 0 & 0 \\ 0 & 0.060669 & 0 \\ 0 & 0 & 0.030229 \end{pmatrix}$$

The true scale values are not significantly different from the diagonal elements of the variometer scale value matrix. The orientation angles of the variometer can be derived from **U**,

ie. the deviation of the X PEM from north is arctan u_{12}/u_{11},
the deviation of the Y PEM from east is arctan u_{21}/u_{22},
the deviation of the Z PEM from north is arctan u_{32}/u_{31},
the deviation of the Z PEM from vertical is arctan $[\mathrm{sqrt}\,(u_{31}^2 + u_{32}^2) / u_{33}]$

The derived orientations of the PEMs are:

The X PEM is aligned 0.19° west of north, with no deviation from the horizontal plane
The Y PEM is aligned 0.23° south of east, with no deviation from the horizontal plane.
The Z PEM is aligned 13.79° west of north, and 1.08° off vertical.

Data loss

Mawson PEM data loss for 1993 is summarised below:

Table 6A Mawson PEM data loss .

Date:	*Channel:*	*From:*	*To:*	*Duration (min):*	*Cause:*
22/2/93	All	11:14:00	12:28:00	75	Power failure & System Re-booted.
22/2/93	F	12:08:00	12:21:00	14	PPM power supply Blown.
11/3/93	X	15:06:00	15:11:00	6	Large storm- off scale.
11/3/93	Z	15:09:00	15:12:00	4	Large storm- off scale.
16/3/93	All	8:44:00	8:46:00	3	System Re-booted.
4/4/93	X	23:02:00	23:04:00	3	Large storm- off scale.
11/7/93	F	9:35:00	Not Restored		E820 PPM Removed as it was faulty.
16/8/93	Z	18:18:00	18:29:00	12	Large storm- off scale.
11/10/93	All	1:02:00	5:00:00	239	Memory parity interupt on computer. System re-booted.

Data Continuity

Field values determined from the variometer data show good consistency across the change in observers in December 1992, as indicated by a comparison daily averages. The average daily values for the comparison were calculated using (1) the variometer parameters derived by Jamieson for his period 2, and (2) the parameters derived for period 1 of this report. These values are compared in table 7. The values for X and Y are consistent to 2 nT or less; the Z values differ by up to 3.0nT but this is acceptable given the standard deviations calculated for the baseline residuals. Because the two sets of parameters produce results which are so close, the choice of merging points for the two data sets is not important. It is convenient to choose the period from 25th of December 1992 to the 5th of January 1993 as the merging period, as the two models join on the 1st of January 1993. A linear interpolation can be used to merge the data sets, for example the X data during this period may be calculated as follows:

$$X(t) = X_{92}(t) + [\,X_{93}(360) - X_{92}(360)\,] * \frac{t-359}{360-359}$$

where t is the time in day of year 1992, and X_{92} and X_{93} are data values calculated using the 1992 parameters of Jamieson and the 93 parameters of this report, respectively.

Table 7. Comparison of data during changeover period.

Day	1992 Model			1993 Model			Differences:		
	X:	Y:	Z:	X:	Y:	Z:	dX	dY	dZ
27/12/92	7948.9	-16741.7	-45844.4	7935.4	-16747.6	-45841.2	0.2	1.6	2.2
28/12/92	7968.5	-16705.4	-45781.3	7954.7	-16711.1	-45777.4	-0.1	1.9	2.9
29/12/92	7897.7	-16693.6	-45879.8	7883.9	-16699.2	-45877.4	-0.2	1.9	1.4
30/12/92	7926.7	-16755.7	-45844.4	7913.0	-16762.0	-45840.9	0.0	1.2	2.5
31/12/92	7957.6	-16758.2	-45809.2	7943.8	-16764.5	-45805.2	-0.1	1.1	3.0
1/1/93	7948.5	-16748.2	-45844.9	7934.5	-16754.4	-45841.7	-0.3	1.3	2.2
2/1/93	7984.7	-16759.0	-45863.5	7970.6	-16765.3	-45861.0	-0.3	1.2	1.5
3/1/93	7909.4	-16704.3	-45928.7	7895.3	-16710.1	-45927.2	-0.4	1.7	0.5
4/1/93	7935.4	-16704.7	-45888.8	7921.1	-16710.7	-45886.6	-0.5	1.5	1.2
5/1/93	7941.5	-16736.1	-45878.4	7927.3	-16742.4	-45875.9	-0.6	1.2	1.5

2.6 Final Data

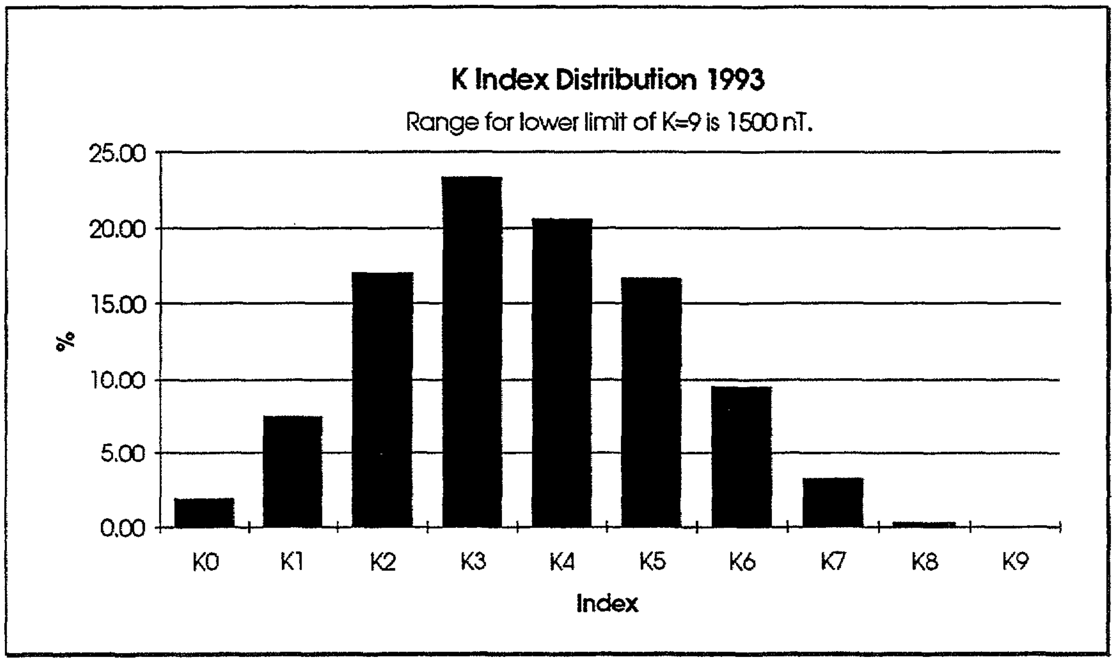
K Indices

Preliminary magnetic data reports were sent monthly to the Geomagnetism section in Canberra, normally for publication in the Australian Geomagnetism Report, however the Australian Geomagnetism report became an annual publication in 1993, so the final monthly means listed in this report will be used. Preliminary data included K indices and mean monthly quiet field values. Preliminary K indices were derived as range indices from the digital data using software written by Crosthwaite (1991). The five days of lowest K index sum per month were used to derive the mean monthly quiet field values. A summary of the final monthly K index distribution is given in Table 8 and summarised as the yearly K index distribution in Figure 5. Full final K indices and daily sums are presented in Appendix G.

Table 8. Mawson Monthly average K index and K index distribution for 1993.

	Month Mean	K0%	K1%	K2%	K3%	K4%	K5%	K6%	K7%	K8%	K9%
Jan	7.24	0.0	0.4	7.3	24.6	22.6	29.0	12.9	3.2	0.0	0.0
Feb	3.86	0.4	3.0	13.8	28.9	21.1	15.9	12.9	3.9	0.0	0.0
Mar	4.38	0.0	1.6	8.1	21.8	22.6	20.2	17.7	7.3	0.8	0.0
Apr	3.70	0.8	9.2	17.5	20.4	16.3	19.6	12.1	3.8	0.4	0.0
May	3.06	4.0	16.1	24.6	20.6	11.7	12.1	6.0	3.6	1.2	0.0
Jun	3.21	5.6	10.5	19.0	19.4	26.6	10.1	4.8	4.0	0.0	0.0
Jul	3.00	3.5	14.5	21.5	23.0	21.1	11.7	3.1	1.2	0.4	0.0
Aug	3.06	6.0	13.7	19.8	21.4	18.5	11.7	6.0	2.8	0.0	0.0
Sep	3.40	1.3	7.9	20.8	27.5	15.8	17.1	7.9	1.7	0.0	0.0
Oct	3.58	0.4	7.3	19.8	23.0	21.8	14.1	11.3	2.0	0.4	0.0
Nov	3.75	0.0	2.5	17.9	25.8	23.8	17.9	9.6	2.5	0.0	0.0
Dec	3.89	0.8	2.7	13.7	23.8	25.0	20.3	10.2	3.5	0.0	0.0
	3.84	**1.90**	**7.45**	**16.98**	**23.35**	**20.58**	**16.64**	**9.54**	**3.29**	**0.27**	**0.00**

Figure 5. Mawson K index distribution for 1993



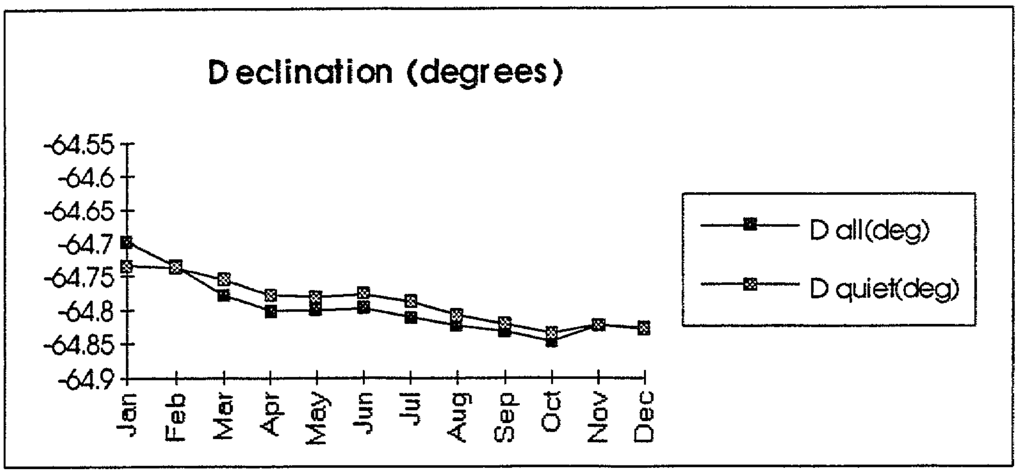
2.7 Final Monthly mean field values :

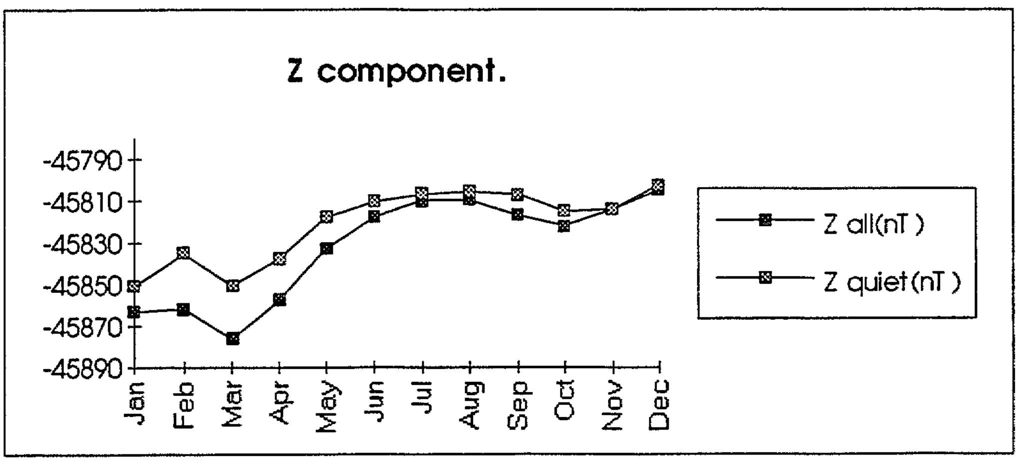
Monthly mean values were calculated for Jan 93 to Dec 93 using variometer counts and the variometer parameters presented in section 2.5 (baseline calibrations). For each month mean field values were derived for all days of the month, 5 international quiet days, 5 international disturbed days and the results are presented below in Table 9 and Figure 6. Final corrections given in Section 2.3 have been applied (Hourly values are summarised in Appendix K).

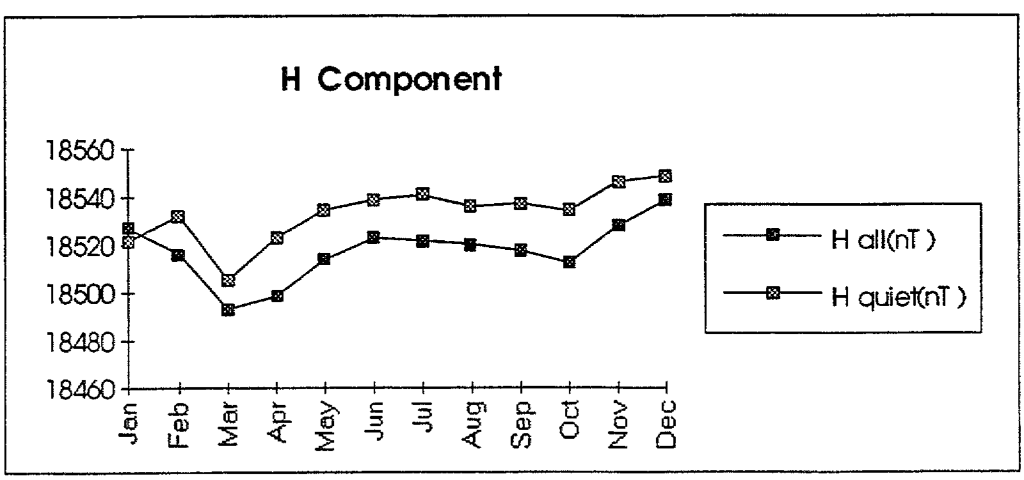
Table 9. Mawson Final Monthly Mean Values 1993:

Month	days	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (East)	I
January	All days	7932.0	-16732.4	-45862.4	49459.7	18517.4	-64° 38.2'	-68° 0.8'
	5xQ days	7918.9	-16731.7	-45850.1	49445.9	18511.1	-64° 40.4'	-68° 0.9'
	5xD days	7928.6	-16717.0	-45908.6	49497.1	18502.2	-64° 37.6'	-68° 3.0'
February	All days	7915.7	-16725.8	-45860.4	49453.0	18504.4	-64° 40.4'	-68° 1.6'
	5xQ days	7922.3	-16741.2	-45834.0	49434.7	18521.1	-64° 40.5'	-67° 59.8'
	5xD days	7907.5	-16702.3	-45872.5	49455.1	18479.8	-64° 40.0'	-68° 3.5"
March	All days	7893.8	-16711.2	-45875.4	49458.5	18481.9	-64° 43.0'	-68° 3.4'
	5xQ days	7905.9	-16719.1	-45849.7	49439.2	18494.1	-64° 41.5'	-68° 2.0'
	5xD days	7875.3	-16696.2	-45902.3	49475.7	18460.5	-64° 44.9'	-68° 5.5'
April	All days	7889.6	-16719.5	-45856.6	49443.2	18487.6	-64° 44.3'	-68° 2.6'
	5xQ days	7906.7	-16738.5	-45836.7	49433.8	18511.9	-64° 42.9'	-68° 0.5'
	5xD days	7860.4	-16687.9	-45877.5	49447.4	18446.7	-64° 46.7'	-68° 5.7'
May	All days	7896.3	-16733.1	-45831.8	49425.8	18502.7	-64° 44.3'	-68° 0.9'
	5xQ days	7910.8	-16749.3	-45817.2	49419.9	18523.5	-64° 43.1'	-67° 59.2'
	5xD days	7857.9	-16697.8	-45872.3	49445.7	18454.6	-64° 48.0'	-68° 5.1'
June	All days	7899.3	-16742.5	-45816.2	49415.0	18512.5	-64° 44.5'	-67° 59.9'
	5xQ days	7912.1	-16754.2	-45808.9	49414.2	18528.5	-64° 43.3'	-67° 58.7'
	5xD days	7883.4	-16727.1	-45831.0	49421.1	18491.9	-64° 46.0'	-68° 1.6'
July	All days	7896.4	-16741.9	-45808.8	49407.5	18510.8	-64° 44.9'	-67° 59.8'
	5xQ days	7911.1	-16755.9	-45805.9	49411.8	18529.6	-64° 43.6'	-67° 58.5'
	5xD days	7868.1	-16722.4	-45830.7	49416.8	18481.1	-64° 48.2'	-68° 2.3'
August	All days	7892.2	-16741.9	-45808.7	49406.8	18509.0	-64° 45.7'	-67° 59.9'
	5xQ days	7903.6	-16754.3	-45804.8	49409.1	18524.9	-64° 44.7'	-67° 58.8'
	5xD days	7869.0	-16721.3	-45812.4	49399.6	18480.5	-64° 48.0'	-68° 1.9'
September	All days	7888.7	-16740.9	-45815.9	49412.5	18506.5	-64° 46.2'	-68° 0.3'
	5xQ days	7900.0	-16757.4	-45805.7	49410.4	18526.2	-64° 45.5'	-67° 58.7'
	5xD days	7859.3	-16709.3	-45828.1	49408.6	18465.6	-64° 48.6'	-68° 3.2'
October	All days	7881.9	-16737.8	-45820.0	49414.2	18500.9	-64° 47.1'	-68° 0.7'
	5xQ days	7894.7	-16756.2	-45813.2	49416.1	18522.9	-64° 46.4'	-67° 59.2'
	5xD days	7855.8	-16704.5	-45823.8	49402.5	18459.7	-64° 48.9'	-68° 3.5'
November	All days	7895.5	-16748.0	-45809.5	49410.1	18515.9	-64° 45.6'	-67° 59.5'
	5xQ days	7903.5	-16764.4	-45809.4	49416.7	18534.1	-64° 45.5'	-67° 58.3'
	5xD days	7874.4	-16722.7	-45804.1	49393.3	18484.2	-64° 47.1'	-68° 1.4'
December	All days	7899.2	-16758.1	-45799.4	49404.8	18526.6	-64° 45.8'	-67° 58.5'
	5xQ days	7902.6	-16767.6	-45796.7	49405.9	18536.6	-64° 45.9'	-67° 57.8'
	5xD days	7886.0	-16743.9	-45802.3	49400.7	18508.3	-64° 46.9'	-67° 59.8'
Annual	All days	7898.4	-16736.1	-45830.4	49425.9	18506.3	-64° 44.2'	-68° 0.7'
Mean	5xQ days	7907.7	-16749.1	-45819.4	49421.5	18522.0	-64° 43.6'	-67° 59.4'
Values	5xD days	7877.1	-16712.7	-45847.1	49430.3	18476.3	-64° 45.9'	-68° 3.0'

Figure 6. Mawson final mean monthly values of H,D and Z for Jan93 to Dec93







CHAPTER 3. MAWSON SEISMOLOGICAL OBSERVATORY:

Seismic activity is monitored and continuously recorded by two separate systems at the Mawson observatory. One consists of short and long period analogue seismometers recording to local helicorders; the second consists of wide band Guralp seismometers whose data is telemetered in real time to the Australian Seismological Centre in Canberra. Seismometers for both systems were located in the Cosmic Ray Vault, at the bottom of a 13 metre deep shaft beneath the Cosray Building.

3.1 Analogue System

The locally recorded analogue system consists of a Benioff short period vertical (SPZ) seismometer and a Press-Ewing long period vertical (LPZ) seismometer. The output from both these instruments is preamplified and frequency filtered by TAM5 amplifier units and then transmitted via a long 10 pair data cable running between the Cosray Vault and the Science Building. These analogue signals are recorded on Helicorder hot pen drum recorders in the Science Building, the short period record at a chart rate of 60 mm/minute (four revolutions per hour) and the long period record at a rate of 15 mm/minute (one revolution per hour). The system parameters are set out in Table 10 below.

Table 10. Mawson Seismic System Parameters

Component	SP-Z	LP-Z
Seismometer	Benioff	Press-Ewing
Serial No.	55	11
Free Period (secs)	0.95	12.16
Mass (kg)	(107.5)	(6.9)
Coil Resist. (Ω)	(1000)	(500)
Damping Resist.(Ω)	(387)	(5120)
Preamplifier	TAM5 s/n -	TAM5 s/n 24
Gain (dB)	96	96
Attenuation (dB)	12	24
Bandpass Filter(Hz)	1.0 - 5.0	0.01 - 0.2
Power Supply	PP2	PP2
Recorder Amplifier	Geotech AR320	Geotech AR320
Recorder	Geotech RV301	Geotech RV301B
Chart Rate (mm/min)	60	15
Polarity	Up-Up	Up-Up
Motor Const G(N/A)	1.555	0.194
Cal. Coil Resist (Ω)	(247)	(3300)

() bracketed values taken from previous reports.

The local system was checked monthly for TAM5 offset voltages, AR320 amplifier balance and mechanical/electrical pen centre position on the helicorders. The LPZ seismometer mass was recentred when required, but the constant vault temperature of 10°C provided by the electric heater and fast cycle AGSO heater controller ensured that conditions were stable in the vault. The helicorders were cleaned and lubricated and the helicorder hot pens were changed in January.

Both SPZ and LPZ records were intermittently affected over the summer period by high frequency "grassy" interference lasting several minutes. After inquires around the station and testing in conjunction with radio VLV it was attributed to noise from radio transmissions, particularly HF field party and helicopter skeds (around 5 MHz) transmitted from aerials close to Cosray. Seismic noise from ocean waves during windy days in February and March made it necessary to increase AR320 amplifier attenuations on those days. No problems with blizz static were observed.

P phase arrival times with period and amplitude, and other phases where possible were scaled from the local helicorder records and emailed approximately weekly to the ASC. These data were relayed to the National Earthquake Information Service via the Global Telecommunications System. Quick Epicentre

Determination files (QEDs) were available on the ASC Sun via the terminal line. Ice movements were common on records throughout the year but increased with the onset of the summer melt in November and decreased with the freeze in April.

Notification of nuclear explosions recorded by the Australian nuclear monitoring network were received via email and fax. There was only one explosion recorded by the SPZ system at Mawson on 5th of October which had originated from Lopnor China at 0200 UT.

There were several short periods of data loss from the locally recorded system due to malfunctions and repairs. Data loss, other than daily loss during chart changes, are reported in table 11.

Table 11. Mawson Seismic System Data Loss

From:	To:	Comments
Jan 30th 15:23	Jan 31st 05:21	SPZ, LPZ
Apr 30th 12:24	May 01st 04:25	SPZ Pen Heat
Jun 11th 14:40	Jun 12th 05:00	Forgot to change charts.
Aug 15th 06:02	Aug 15th 17:50	SPZ Pen Heat
Oct 7th 05:00	Oct 7th 08:00	LPZ, SPZ annual calibrations
Oct 7th 13:00	Oct 8th 04:59	SPZ Pen Heat
Oct 21st 08:00	Oct 22nd 02:12	SPZ Pen Heat

Calibration

Calibration pulses were applied daily at the beginning and end of each locally recorded seismogram to monitor the operation and continuity of the system. Full calibrations were performed in September. Weight lift and current pulse tests were performed to determine the value of the seismometer motor constant, G, given by

$$G = g \cdot \frac{X_p}{I_p} \cdot \frac{m}{X_w}$$

Where g is the acceleration due to gravity, (9.81 ms^{-2})
X_p is the pen deflection amplitude (mm) for applied current I_p
I_p is the current pulse amplitude (mA)
m is the mass of the test weight (g)
X_w is the pen deflection amplitude (mm) for weight lift test

Frequency response tests were performed using a BWD Minilab as a function generator for the calibrations. Since the frequency selection dial on the instrument was inaccurate, input function periods were measured directly from the seismograms. Input currents were monitored by measuring the voltage across a 1004Ω resistor with a Fluke-77 digital multimeter, and the input wave forms were monitored with an oscilloscope. From the results, the seismometer amplification for sinusoidal input functions of various frequencies is calculated using the equation:

$$\text{Mag.} = \frac{A \cdot (2\pi f)^2 \cdot M}{G \cdot I_s}$$

where Mag is the seismometer magnification
A is the peak to peak pen deflection amplitude (mm)
f is the frequency of the input sinusoidal signal (Hz)
I_s is peak to peak current through the coil of the input signal (mA)
M is the seismometer mass (kg)

SPZ Seismometer Calibrations

The following equipment settings were used during the calibrations:
TAM5 Gain = 96 dB
Attenuation = 12 dB
Bandpass = 1 to 5 Hz
AR320 Attenuation = 24 dB
Weight lift tests were done using weights of masses 111.5, 202.2, 301.5 and 357.4 mg.
Pulse tests were done with currents of 0797, 1.793 , 3.187 and 3.984 mA

The results gave a mean value of G = 1.555 N/A
The measured free period was T = 0.95s

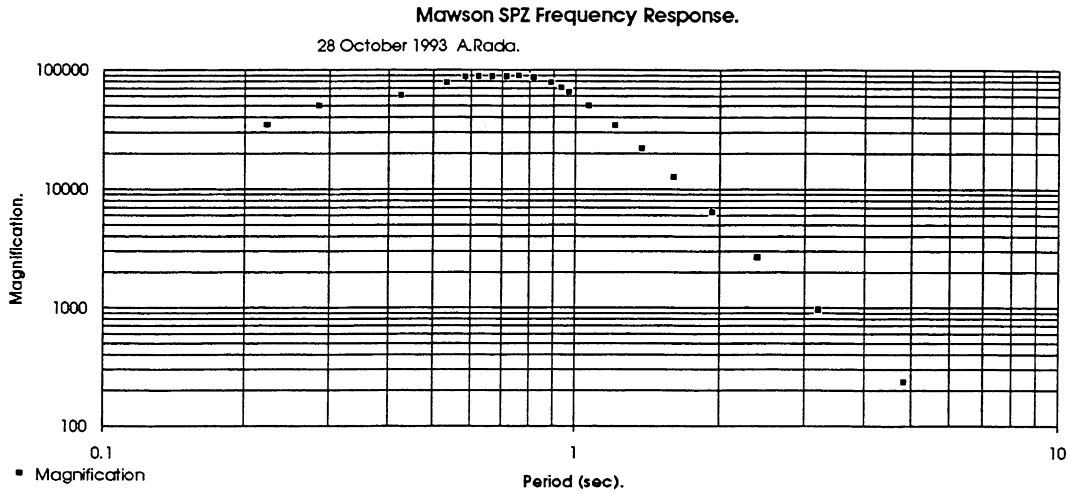
The results of the frequency response tests are given below in Table 12. Note that the nominal frequency is that read from the BWD function generator dial and the true frequency is that calculated from the chart trace.

Table 12. Frequency response of the SPZ seismometer

Nom Freq.	True Freq.	Period (s)	Is (pp)	Magnification
0.10	0.11	9.43	1.594	25
0.20	0.21	4.83	1.594	235
0.30	0.31	3.21	1.594	962
0.40	0.42	2.40	1.594	2676
0.50	0.52	1.93	1.594	6392
0.60	0.63	1.60	1.594	12646
0.70	0.73	1.38	1.594	22015
0.80	0.83	1.21	1.594	34021
0.90	0.94	1.07	1.594	49936
1.00	1.03	0.97	1.594	65275
1.10	1.07	0.93	1.594	70763
1.20	1.13	0.89	1.594	78042
1.30	1.22	0.82	1.594	86549
1.40	1.32	0.76	1.594	89835
1.50	1.40	0.72	1.594	88258
1.60	1.50	0.67	1.594	87869
1.70	1.61	0.62	1.594	88339
1.80	1.71	0.58	1.594	87083
2.00	1.88	0.53	1.594	78283
2.50	2.34	0.43	1.594	61085
3.50	3.50	0.29	1.594	50358
4.50	4.50	0.22	1.594	34685

The frequency response is graphed logarithmically below in Figure 7.

Figure 7. Frequency response of the SPZ seismometer



LPZ Seismometer Calibrations

The following equipment settings were used during the calibrations:
TAM5 Gain = 96 dB
Attenuation = 24 dB
Bandpass = 0.01 to 0.20 Hz
AR320 Attenuation = 24 dB
Weight lift tests were done using weights of masses 29.6 , 35.5 and 60.1 mg.
Pulse tests were done with currents of 0797, 1.793 and 3.187 mA

The results gave a mean value of G = 0.194 N/A
The measured free period was T = 12.16 s

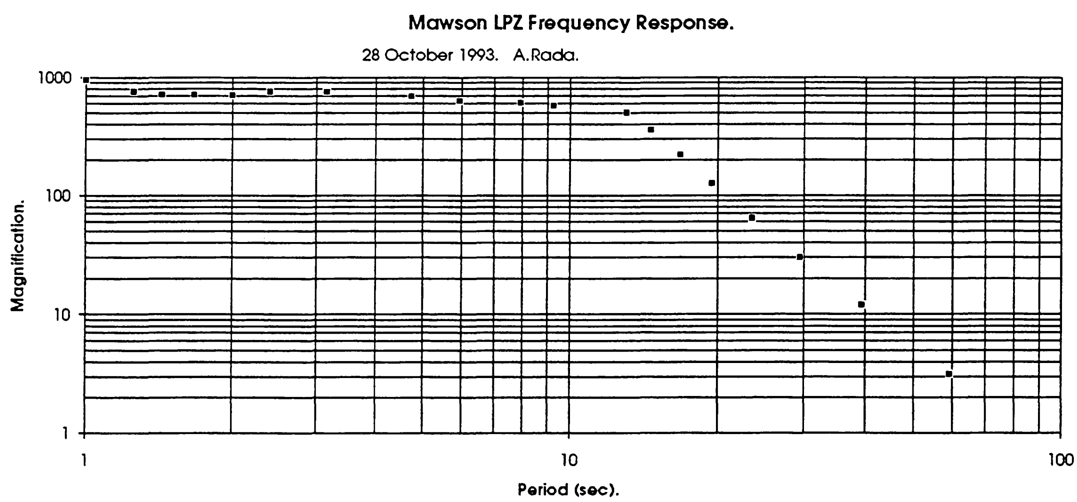
The results of the frequency response tests are given in Table 13.

Table 13. Frequency response of the LPZ seismometer :

Nom Freq.	True Freq.	Period (sec)	I (p-p)	Magnification.
1.00	1.000	1.00	2.988	942
0.80	0.800	1.25	2.988	754
0.70	0.700	1.43	2.988	716
0.60	0.600	1.67	2.988	712
0.50	0.500	2.00	2.988	707
0.40	0.417	2.40	2.988	752
0.30	0.317	3.16	2.988	747
0.20	0.211	4.73	2.988	690
0.16	0.168	5.94	2.988	630
0.12	0.126	7.93	2.988	610
0.10	0.108	9.27	2.988	570
0.09	0.077	13.04	1.594	503
0.08	0.068	14.64	1.594	358
0.07	0.060	16.80	1.594	220
0.06	0.051	19.47	1.594	126
0.05	0.042	23.60	1.594	64
0.04	0.034	29.50	1.594	30
0.03	0.025	39.33	1.594	12
0.02	0.017	59.30	1.594	3

The frequency response is graphed logarithmically below in Figure 8.

Figure 8. Frequency response of the LPZ seismometer



The responses are similar to the results from previous calibrations (Jamieson, 1992; deDeuge 1991). The LPZ response curve remains atypical of that of a standard long period seismometer. There are no electronic filters in the LPZ system apart from the 0.01 to 0.2 Hz bandpass filter in the standard TAM5 preamplifier unit. Recent seismometer parameters are presented in table 14.

Table 14. SPZ and LPZ Seismometer parameters 1984 -1993

Year	LPZ G	LPZ Free Period	SPZ G	SPZ Free Period
1993	0.194	12.16	1.55	0.95
1992	0.23	12.8	1.50	0.95
1991	0.210	13.2	1.52	0.946
1990	0.24, 0.19	13.7, 12.6	1.55	0.947
1989	0.17	16.2	1.48	0.948
1988	0.203	12.8	1.54, 1.45	0.98
1987	---	---	---	---
1986	---	---	1.45	0.98
1985	0.17	12.8	1.38	0.98
1984	0.21	12.0	1.50	0.96

3.2 Time Keeping

Observatory timing was provided by the master GED clock in the Science Building. Timing for the Guralp system was taken from the internal clock of the PDP11/23 computer which was synchronised to 12V minute pulses of 2 second duration from the GED clock via the long data cable to the Cosray Building. The clock also provided minute pulses to the AR320 seismic amplifiers in the seismic instrument rack in the Science Building to produce minute marks on the charts of the analogue system. The clock was kept running to an accuracy of within ±30 ms of UTC. Further information see section 4.1 TIME KEEPING.

3.3 Guralp System

The remotely recorded system consisted of three (nominally north, east and vertical) Guralp CMG-3 wide band seismometers. The analogue output from these instruments was preamplified and filtered before being digitised by a PDP11/23 computer in the Cosray Building and transmitted to the ANARESAT module via a pair of SUMMIT SADCM-3N asynchronous modem line drivers. The digital data were then telemetered via the ANARESAT system in real time to the ASC. The data files on the ASC computers were routinely checked to ensure that the seismic data were reaching their destination and the system functioning normally. The ANARESAT link to Australia frequently dropped out usually for only short periods. On such occasions the link would re establish automatically, however data from the down period was lost.

Routine maintenance for the remotely recorded system involved ensuring that the computer acquisition system was running and receiving time marks. The telemetry data circuit was occasionally interrupted by other problems with the communications system and required resetting. The PDP11 required rebooting only once during the year. The Guralp seismometer masses required occasional re-centring.

Calibration of the Guralp wide band seismometers was done on the 28th of July; results were calculated by Graeme Small at ASC and are given in Table 15.

Table 15. 1 Guralp seismometer Calibration values.

Channel:	Cal Const: (A/m/s*s)	Cal Current : (P-P) (*E-06 Amps)
V311 (Z)	0.472	19.15
H313 (N/S)	0.537	19.15
H314 (E/W)	0.582	19.15

From values in Table 15.1 the formula: Ground displacement= Accln./ (4*pi*pi*f*f) is used.

Table 15. 2 Guralp seismometer Vertical Channel Calibration results.

Vertical channel:			
T (sec) :	Disp(nm):	P-P counts:	Counts/nm:
0.1	10.3	188	18.3
0.15	23.1	368	15.9
0.26	69.5	952	13.7
1.05	1133	4128	3.64
2.07	4405	8128	1.85
5.2	27797	20608	0.74
10.8	119906	41984	0.35
15.5	246977	54016	0.22
27.2	760556	55296	0.073
57.5	3398825	31232	0.0042
127.2	16659038	15104	0.00041

Table 15. 3 Guralp seismometer East- West Channel Calibration results.

East - West channel:			
T (sec) :	Disp(nm):	P-P counts:	Counts/nm:
0.1	8.33	172	20.6
0.15	18.7	380	20.3
0.26	56.3	928	16.5
1.07	954	4160	4.36
2.04	3467	8000	2.31
5.2	22524	20992	0.93
11.1	102634	43520	0.42
15.5	200128	54784	0.27
27.2	616287	55296	0.089
58	2803312	30464	0.011
126.4	13308808	14976	0.00113

Table 15. 4 Guralp seismometer North- South Channel Calibration results.

North- South channel : l:			
T (sec) :	Disp(nm):	P-P counts:	Counts/nm:
0.1	9.03	172	19
0.15	20.3	384	18.9
0.26	61	888	14.6
1.06	1015	4128	4.07
2.06	3832	8128	2.12
5.2	24417	20736	0.85
11	109263	42240	0.39
15.1	205893	53504	0.26
27.3	672997	54528	0.018
56.8	2913294	30720	0.011
127.2	14610396	14720	0.001

CHAPTER 4. CONTROL EQUIPMENT:

4.1 Power Supplies

Station power was supplied by four diesel alternators as 240V, 50 Hz. The station powerhouse was reliable but numerous short periods of power loss were experienced throughout the year. However minimal data loss occurred during these power failures because of the backup power supplies.

Science Building

Backup power was supplied to the Science building by an Invertech UPS-100-FF-P rated at 100VA /50Hz and a Precision Power Standby Power System model SPS1000 rated at 1000VA. The equipment was distributed as follows:

Invertech UPS: SPZ, LPZ helicorders
Secondary GED clock
SPS1000: AR320 seismic amplifiers
Primary GED clock (also uses battery backup)
W&W chart recorder
9V DC adaptor for RS232/485 converter

The office PC was run from the mains supply through a surge protector. The backups were tested for 20 mins each month to cycle the batteries.

Variometer Building

All equipment in the Variometer building apart from the heating and the PC monitor was backed up by a Precision Power SPS1000:

2 X NEC acquisition computers
PEM control unit
RCF controller unit.
9V DC adaptor for RS232/485 converter
Doric trendicator
Statronics 53/3B power supply for E820 PPM
Statronics 53/3B power supply for fiducial latch, time mark, receiver latch and analogue buffers

Problems encountered with this backup system on day 53 were described in section 2.4.

Cosray Building

The Guralp system and PDP rack were backed by a General Systems UPS model GPS-1K245RV4. The analogue system seismic rack in the vault was powered by 12V from the Cosray building supply and converted to ±8V by a PP2 low power converter.

4.2 Timing

Two master clocks, GED crystal oven type 105, were available at the observatory. Both clocks were kept running to within ±50 msecs of UTC throughout the year. Observatory timing was taken from only one of these clocks, known as the primary clock, which provided all timing control for the geomagnetic and seismic equipment via a time mark relay driver. The primary clock was kept running to an accuracy of ±30 msecs of UTC. One-second pulses from the primary GED clock were transmitted to the secondary clock, so a continuous comparison between the two clock times was available to monitor sudden drift rate alterations and clock accuracy. The primary GED maintained a drift rate of approximately 2ms/day; the secondary GED maintained a drift rate of around 10ms/day.

The primary clock was compared regularly with radio time pips using a two channel oscilloscope. Time signals from radio station WWVH were received on 10 MHz using a Sony ICF2001D portable world band receiver connected to the unused east mast of the Ionospheric Prediction Service antenna. During the year the signal from a larger receiver in the Main Mawson Radio Office was wired to Wombat and used to synchronise the GED clock. A radio signal propagation delay time of 45 msecs for WWVH was assumed. ("Antarctic Station Timing Information": A.R. Klekociuk & D.J. Barrett, ASP 1991). The clocks were retarded by 1 second on the 2nd of July to account for a leap second.

CHAPTER 5. BUILDINGS AND MAINTENANCE

Five buildings were either in use for the operation of the Mawson geophysical observatories during 1993 or remnants from previous years. Those buildings were; Science Building (known as Wombat), new Variometer Building, Absolute Hut, Cosray Building and the old Variometer Building.

The Science Building was in a good state of repair and provided more than adequate room for observatory operation. During the 1993 winter the building was used for both AGSO, IPS (Ionospheric Prediction Service) and as an office for the winter biology program. Due to the increased pressure for office space over summer, the workroom was used by Glaciology and the IPS room was used as an office for the Australian Construction Service (ACS) maintenance group.
Other Items:
-The water supply to the Science building was frozen twice during 1993.
-The office was painted in late 1992.
- New shelving, display boards and white board were installed in January 1993.
- The oil fired standby boiler was un serviceable throughout 1993.
- Two broken windows were replaced in March 1993.
- The building is scheduled to be re sealed to prevent sub floor drift build up.
- Waste water is scheduled to be connected to site services as part of the grey water policy.

The Absolute Hut was just adequate for the purpose of doing absolutes, The absolute pier was unstable in strong winds due to minor coupling between the pier and the hut. Minor drift entered the building in various places during blizzes and the heater was inadequate to maintain a reasonable temperature during long periods of high wind.
A new 300 X 300mm oregon pier was installed in the south western corner of the hut on day 114. The oregon pier was lying against the southern wall in the Absolute hut, and was previously used as a seat while doing PPM obs. It was erected in the pre existing hole in the floor in the south west corner of the hut and set in Verti-Patch (Similar to concrete). The verti-patch was checked using the DIM in a quiet field by adjusting the DIM to the horizontal null and repeatedly moving the bags of verti-patch to within 2cm of the Flux Gate Sensor. There was found to be an effect of 3 nT at 2cm. There was found to be no effect at distances greater than 30cm. Two extra absolute observations were taken just prior to any work, and a series of absolute observations were taken upon completion. These observations were compared to both the RCF and PEM variometers and did not produced any noticeable BLV changes.

The new variometer Building was in excellent condition and provided adequate, temperature stable housing for the variometers. Small amounts of drift occasionally iced up the cold porch door during blizzards. No maintenance, apart from routine light bulb changes, was required. The sign declaring a magnetic quiet zone around the Variometer and Absolute huts was in very poor condition. A new professionally painted sign would be a valuable asset for the observatory in the near future.

The old Variometer Building was used only as a junction box for mains power to the light on azimuth mark SOH and to the Absolute Hut until a break in the power cable occurred in the quarry. Instead of repairing the old cable the electrician ran a new cable from the Variometer building to the Absolute hut for power. The old Variometer Building was then back fed from the Absolute hut.

A small area of the Cosray office was used to house the Guralp controller and PDP11 rack. One side of the Cosray vault housed the analogue equipment rack and analogue and Guralp seismometers. The vault provided a stable, isolated environment for the seismometers. Maintenance as required by the OH&S officer was done on the vault ladders and landing areas in October. The seismic room door at the bottom of the vault was replaced by the carpenter in September.

CHAPTER 6. CASEY & DAVIS MAGNETIC RESULTS:

The geomagnetic program at Davis and Casey is conducted in association with the Auroral and Space Physics (ASP) section of the Australian Antarctic Division. Regular observations of the magnetic field were initiated in the early 70's to determine long-term secular variations. Until 1993 observations were carried out 1-2 times per week on average. Monthly values of the magnetic field were derived from these and published in the Australian Geomagnetism Report. These were at best, only rough estimates considering the activity of the field at high latitudes and the often limited number of observations per month.

Table 16 below gives the quiet day averages for Davis and Casey for 1993, determined from the variometer data using the adopted baseline values given in Geomagnetic Report For Davis And Casey 1993 (Rada), and the scale value and temperature parameters given in the Casey Magnetometer 93 Report (Symons), and Davis 93 Magnetometer Report (Parcell).

The quiet day averages for Davis and Casey are derived for the 5 days which have been determined as quiet days from the Mawson data using the technique documented by deDeuge 1991. This assumes that the level of magnetic activity varies in the same way at all three stations, which may not always be true, but it is considered the best approximation to be made.

Table 16.1 Casey 1993 Monthly 5 Quiet Day Averages:

	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (deg)	I (deg)
Jan	-331	-9620	-63849	64571	9626	91.971	-81.427
Feb	-372	-9639	-63865	64589	9647	92.211	-81.411
Mar	-355	-9651	-63881	64607	9658	92.107	-81.403
Apr	-360	-9637	-63865	64589	9643	92.139	-81.413
May	-371	-9611	-63862	64582	9618	92.210	-81.435
Jun	-364	-9617	-63858	64579	9623	92.170	-81.430
Jul	-360	-9626	-63852	64575	9633	92.144	-81.421
Aug	-364	-9624	-63843	64565	9631	92.169	-81.421
Sep	-363	-9630	-63851	64574	9637	92.160	-81.417
Oct	-347	-9635	-63844	64567	9641	92.065	-81.413
Nov	-349	-9641	-63839	64564	9648	92.071	-81.406
Dec	-344	-9646	-63819	64545	9652	92.041	-81.399

Table 16.2 Davis 1993 Monthly 5 Quiet Day Averages:

	X (nT)	Y (nT)	Z (nT)	F (nT)	H (nT)	D (deg)	I (deg)
Jan	3575	-16342	-51804	54438	16728	-77.660	-72.104
Feb	3557	-16325	-51808	54435	16708	-77.707	-72.126
Mar	3551	-16318	-51865	54488	16700	-77.723	-72.152
Apr	3564	-16319	-51824	54450	16704	-77.682	-72.135
May	3552	-16326	-51802	54430	16708	-77.726	-72.124
Jun	3551	-16324	-51794	54422	16706	-77.726	-72.123
Jul	3556	-16326	-51790	54419	16709	-77.712	-72.119
Aug	3555	-16327	-51786	54415	16710	-77.716	-72.116
Sep	3554	-16340	-51803	54435	16722	-77.730	-72.110
Oct	3558	-16358	-51813	54450	16740	-77.729	-72.095
Nov	3551	-16370	-51825	54465	16750	-77.761	-72.089
Dec	3538	-16384	-51850	54492	16762	-77.814	-72.085

CHAPTER 7. PROBLEMS & IMPROVEMENTS:

Absolute observations errors:

- **Heat haze during mark readings.** This problem exists year round but worsens with the decrease in temperatures over winter; when the temperature gradient through the viewing hole is around 40 deg C. On still days it is possible to make reasonably accurate mark readings however on days with a consistent light wind a considerable error is introduced due to a horizontal refractive index gradient in the line of sight caused by the mixing of warm inside air with cold outside air being influenced by the horizontal wind. On gusty days it becomes very difficult to sight the mark accurately as the mark appears to move with changing wind speed and direction.
- **QHM Storage height**. The QHM's are currently stored on the bench in the Absolute hut when not in use. This bench is approximately 40cm lower than the operating height of the QHM on the circle on Pier A. Given that the floor temperature is about -15 deg C and the thermostat (150cm high) is 15 deg C, the temperature gradient is 0.2 deg /cm; which represents a temperature difference of about 8 deg C. It takes considerable time for the QHM's temperature to equilibrate when first placed on the circle, this is often overlooked causing unnecessary errors. If the QHM's were stored at the same height as they are used they would already be temperature stable when placed on the circle and the error from thermal disequilibrium removed.
- **Absolute Heater effecting DIM**. It was found that the heater in the Absolute hut has an effect of about 8 units on the DIM output when the sensor is in the horizontal null position and the heater switched on and off. It is uncertain if the interference is a magnetic effect or an electrical effect, however no effect was noticed when a similar test was done using a QHM.

Change over.

The handover period at Mawson is barely adequate. There is not enough time for the incoming geophysicist to become familiar with the observatory equipment, procedures and practices. For the outgoing geophysicist the jobs of instrument comparisons and departure preparations leaves only enough time for a tour of the buildings and equipment with the incoming geophysicist. An extended change over between the first and second voyages would allow enough time for the information gained throughout the year and specific to the observatory to be passed on to the incoming observer. This is vital information in producing continuity of observatory practice, refreshing the memory and skills of the incoming observer, relieving pressure on HO by answering questions and allowing experience to be told to rather than learnt by the new observer. It would also allow enough time for instrument comparisons to be performed in favourable conditions and reduced prior to leaving Mawson.

Computers.

Syquest disks could be used for transferring observers data and files. Upon commencement of training in Canberra the new geophysicist uses a PC for data reduction and monthly report practice. A large number of documents and example files accumulate during training which can act as a very useful reference at Mawson. Similarly at Mawson there are a large number of files which accumulate throughout the year eg mail, obs, comparisons, data, fiducial files etc. which are invaluable for writing the annual report. If Syquest removable hard disks were used for transfer of this data then all files of varying relevancy could be easily transferred and the files directory structure maintained. Syquest disks would also provide an excellent backup system for the observatory.

GPS Clock.

The Antarctic Division is proposing to install a GPS clock in its Auroral and Space Physics Laboratory at Mawson. If an arrangement could be made to receive time signals from this clock, or a separate one purchased it would considerably improve the observatory's timing.

CHAPTER 8. OTHER DUTIES:

Everyone on station is required to perform a share of the day to day work of running the station. This involves such activities as:

- kitchen hand duties,
- cooking- mainly relief cooking,
- daycare-Rubbish collection and cleaning of bar, club, mess,
- Saturday afternoon station duties- General station maintenance.
- General assistance during summer activities, especially during main re-supply and other shipping visits.

The author also held the following jobs on station:

- Tide Gauge Operator - deployment, maintenance and regular data retrieval.
- Sea Ice Monitor- Weekly drilling of sea ice for thickness and strength.
- Fire team- First response BA team.
- Search and Rescue team.
- Social Committee.

The author spent several weeks throughout the year as a field assistant at Auster and Taylor Emperor penguin rookeries for the wintering biologist, Roger Kirkwood.

A Global Positioning System (GPS) satellite tracking unit was operated at Mawson for the Australian Surveying and Land Information Group (AUSLIG) as part of the Lambert Glacier 92/93 summer project. The unit was operated by the author for 5 weeks in January/ February.

ACKNOWLEDGMENTS:

The support and assistance of many fellow expeditions made the task of running the observatory easier, and the experience of an excellent year in Antarctica memorable. In particular I am grateful for the assistance of Glenn Scherell and John Innis in changing charts during my absences and Chris Morrison, Roger Kirkwood and John Innis for many good jollys, peek -bags and memorable times; also Chris Harrison and Mark Reynolds in chasing down problems with the communications lines, Allan Grant for helping with the Tide Gauge and making station life so harmonious. Advice and assistance from Graeme Small, Stewart Dennis, Peter Hopgood and Peter Crosthwaite in Canberra was much appreciated.
A special thanks to everyone who helped eat the 10 Kg box of chocolates in Wombat, and to Stewart for 'caring' for my pens and pencils in Canberra.

REFERENCES:

Crosthwaite, P., 1986,	Mawson Geophysical Observatory Annual Report, 1984 Bureau of Mineral Resources Record 1986/12
Crosthwaite, P.,1991,	Mawson Geophysical Observatory Annual Report, 1989 Bureau of Mineral Resources Record 1991/26
deDeuge, M 1991,	Mawson Geophysical Observatory Annual Report, 1991 Bureau of Mineral Resources Record 1992/
Hutchinson, R., 1987,	Mawson Geophysical Observatory Annual Report, 1986 Bureau of Mineral Resources Record 1987/46
Hutchinson, R., 1989,	Mawson Geophysical Observatory Annual Report, 1988 Bureau of Mineral Resources Record 1989/25
Jamieson, J., 1992,	Mawson Geophysical Observatory Annual Report, 1992 Bureau of Mineral Resources Record 1994/
Lewis, A.M., 1991,	Mawson Geophysical Observatory Annual Report, 1990 Bureau of Mineral Resources Record 1991/59
Kelsey, P.J., 1987,	Mawson Geophysical Observatory Annual Report, 1985 Bureau of Mineral Resources Record 1987/29
Rada, A. 1994,	Geomagnetic Report For Davis & Casey, 1993 Bureau of Mineral Resources Record 1994/29
Welsh, W., 1986,	Geomagnetic Activities at Davis, Mawson and Casey, Antarctica - 1985/86 Summer Bureau of Mineral Resources Record 1986/16

The following references are internal publications of the Auroral and Space Physics Section of the Australian Antarctic Division:

Hesse, M., 1991	Davis magnetometer calibration, 1990
Hesse, M., 1992a	Datpro - Data processing program
Hesse, M., 1992b	Magnetic absolutes and magnetometer calibrations programs
Hesse, M. and Roberts, P., 1991	Casey magnetometer calibration, October/November 1991
Hesse, M. and Symons, L., 1991	Davis magnetometer calibrations, September 1991
Hesse,M. and Symons, L., 1992	Davis magnetomete calibrations, January 1992
Hesse, M., Symons, L. and Burns, G., 1992	Davis magnetometer calibrations, March 1992
Klekociuk A.R. and Barrett D.J., 1991	Antarctic Station Timing Information
Parcell,S., 1994	Davis magnetometer calibrations, 1993
Symons,L and Dubovinsky,M., 1994	Casey magnetometer calibration January 1994

APPENDIX A. HISTORY OF MAWSON INSTRUMENTATION:

A brief summary of the development of the Mawson Geophysical Observatory up to 1993

Geomagnetic Observatory:

May 1955	Absolute instruments used for regular observation of H, D and Z (Oldham, 1957)
July 1955	Recording commenced by three component normal La Cour variometer (Oldham, 1957)
1957	Bar-fluxmeter magnetograph installed (Pinn, 1961)
January 1961	Three component insensitive La Cour magnetograph installed and recording commenced (Merrick, 1961)
December 1967	Bar-fluxmeter magnetograph withdrawn (Dent,1971)
September 1968	Insensitive La Cour magnetograph converted to medium sensitivity and renamed normal magnetograph. The normal La Cour magnetograph was renamed sensitive magnetograph (Smith, 1971)
February 1975	15 mm/hr normal recorder replaced with 20 mm/hr recorder (Hill, 1978)
December 1975	15 mm/hr sensitive recorder replaced with 20 mm/hr recorder (Hill, 1978)
March 1981	MNS2 proton precession magnetometer installed for absolute measurements
August 1982	La Cour sensitive magnetograph removed (Silberstein,1984)
July 1983	PhotoElectronic Magnetometer X and Y components installed (Cechet, 1984) MNS2 proton precession magnetometer ceased operation (Cechet, 1984)
May 1984	Digital recording of PEM X and Y component data began (Crosthwaite, 1986)
December 1985	La Cour normal magnetograph ceased operation. X, Y and Z PEM variometer commenced operation in new variometer building (Kelsey, 1987)
March 1986	X, Y and Z PEM temperature compensated to less than 1nT/°C (Hutchinson, 1987)
January 1988	Declination-Inclination Magnetometer (DIM) introduced for testing as an absolute and field survey instrument (Hutchinson, 1989)
February 1988	MNS2 PPM replaced with Elsec 820 PPM
January 1989	Independent recording of geomagnetic data in Australia via ANARESAT commenced (Crosthwaite, 1991)
May 1989	NEC IBM-AT based digital recording system installed (Crosthwaite, 1991)
August 1989	X and Y PEM altered to +/- 2000nT sensitivity (Crosthwaite, 1991)
January 1991	ASP began monitoring and logging PEM analogue output (deDeuge 1992)
January 1993	Ring Core Fluxgate Variometer & PC logging system installed (This Report)

Seismological Observatory

July 1956	Three component Leet-Blumberg seismograph (pen and ink recorder) installed
1960	Three component seismograph installed consisting of Benioff seismometers (free period 1.0 s) and three channel AGSO single drum recorder. Z galvanometer 0.2s free period, horizontal galvanometers free period 70s (Merrick, 1961)
February 1963	AGSO recorder replace by Benioff 60 mm/hr three channel recorder. 14s free period horizontal galvanometers installed (Black, 1965)
September 1970	14s free period horizontal galvanometer replaced by short period (0.2s) galvanometer (Robertson, 1972)
December 1973	Z seismometer transferred to vault beneath Cosray Building (Almond, 1975)
April 1977	Transfer of Geophysics office, including power and timing, to Wombat (Science Building)
1978	Recording of SP-N Benioff seismometer discontinued (Petkovic, in prep)
July 1981	Helicorder hot pen recorder installed for SP-Z and LP-Z; SP-N Benioff restored
March 1983	Cosray vault fully concreted in readiness for movement of SP-N and SP-E. Thermostatically controlled heating installed to stabilise LPZ (Cetchet, 1984).
August 1983	Four Teledyne Geotech seismic amplifiers (AR320) installed for connection to twin hot pen recorders (Cechet, 1984)
May 1984	Horizontal seismometer and the Benioff photographic recorder disconnected (Crosthwaite, 1986)
February 1985	Horizontal seismometers reinstalled in Cosray Vault, connected to visual hot pen recorders and converted to dual channel (Crosthwaite, 1986, Kelsey, 1987)
February 1986	SPZ rectilinear pen helicorder installed. Two pen helicorder for SP horizontals (Hutchinson, 1987)
January 1988	Guralp wide band seismic system installed in the Cosray Vault (Hutchinson, 1989)
January 1988	Short period horizontal seismometers removed from Cosray Vault (Hutchinson, 1989)

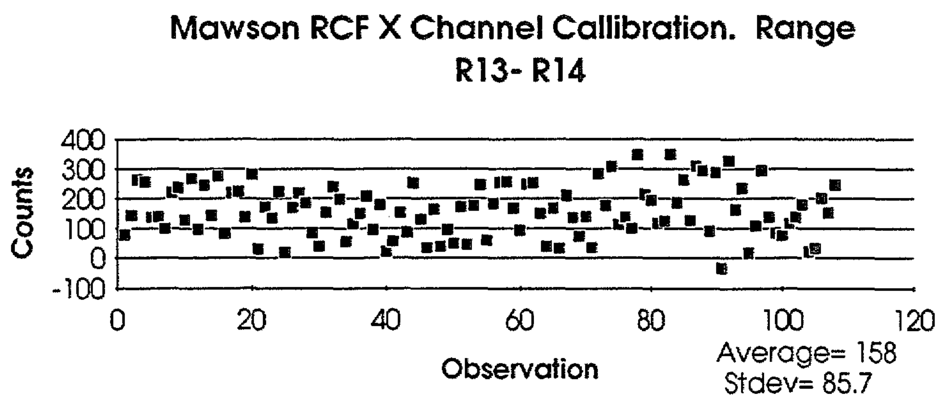
APPENDIX B. SUMMARY OF GEOPHYSICAL LOG

Date/ UTC Time	Log Summary
10 December 1992	V4, Aurora Australis, arrived at Mawson ice edge with AGSO replacement, Anton Rada, who took over responsibility for the observatory.
13 December	New RCF set up in Wombat office for testing.
13 December	V4 departed for Australia with John Jamieason.
15 December	New RCF installed in Variometer Building for testing. Not alligned properly. New 80MB Hard Disk installed in RCF PC.
13 December	Installed new SPZ Helicorder drum.
17 December	Replaced pen on LPZ helicorder.
30 December	Attempted to install 4MB RAM into RCF PC- no luck, RAM Faulty.
04 January 1993	Power cut off from absolute hut- no obs done.
15 January	Attempted to connect fiducials to RCF system- no luck.
22 January	Power failure in variometer Building at approx 11:30 UT, UPS cutting in and out. Power restored at 12:10 UT. PPM power supply replaced at 14:23 UT.
22 January	Took over operation of Auslig's GPS equipment in Wombat.
20 February	Re Centred LPZ Seismometer.
22 February	Re Centred LPZ Seismometer, Vault temp risen from 10.5 deg to 11.5deg.
24 February	First set of RCF calibration runs done.
25 February	Second set of RCF calibration runs done. Fiducial button successfully connected to RCF system. First RCF Absolutes done.
20 March	Attempted to connect time marks to RCF- temporary system installed.
13 April	Station Blackout @ 10:00 UT
23 April	New pier fixed in position.- Verti patch tested with DIM- Herman Nelson heater at hut all day
29 April	Large number of PPM 820 F values being rejected .
3 May	Obs to test effect of electronics box on DIM
15 May	Electrician replaced globes in Variometer building.
18 May	Removed DIM to replace cable.
20 May	DIM cable replaced.
21 May	Obs to test effect of DIM box- at base of pier and on the bench.
22 May	Obs to test effect of differing batteries in DIM box.
23 May	Correction on secondary GED clock not working.
23 May	Electricians tool box found to be at Absolute Hut since 20th.
6 June	DIM Stopped working.
25 June	Power cable in Absolute Building Burnt out.
26 June	Replaced power cable in Absolute Building.
2 July	Retarded one leap second to GED clocks at approximately 15:44 UT.
3 July	DIM working again.
3 July	Clocks re-set after battery failed to backup primary GED when UPS failed at 09:30UT
4 July	Clocks found to be 160ms slow of UT after power failure- corrected.
11 July	PPM E820 No. 137 removed to be looked at.
14 July	PPM comparison E770/199 and E770/206
6 September	Heater in Absolute building was off - no obs.
16 September	PEM PC gave warnings of telemetry errors.
23 September	PPM E770/206 not working properly- faulty wiring.
11 October	'Memory Parity Interrupt' error on PEM PC- PC re booted.
28 October	Helicopter operations until the 30th.
2 November	PEM computer found to be 1 min slow- time set.
01 December	AAMP moved heater in Variometer building from 07:30 to 07:56 UT
11 December	New PPM E820/158 connected to RCF system.
14 December	V4 departed.

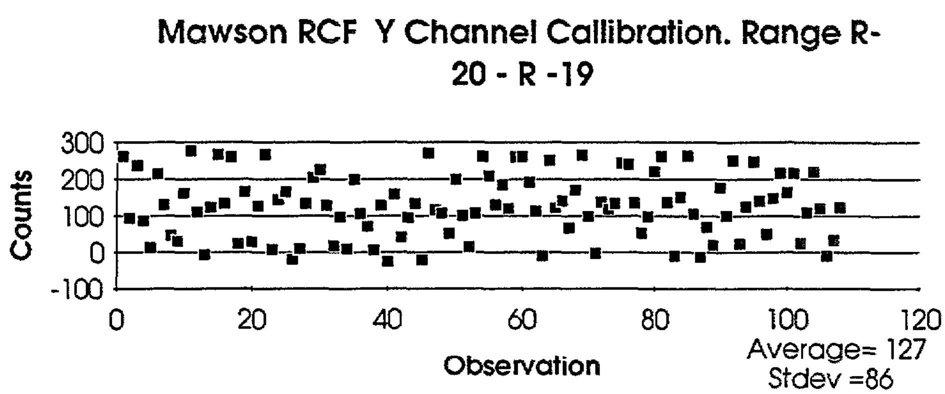
APPENDIX C. RANGE CALIBRATION- MAWSON RING CORE FLUXGATE.

Ordinate range differences for X, Y, Z components averaged from calibration runs. conducted in a quiet field on 25/2/93. Day 56.

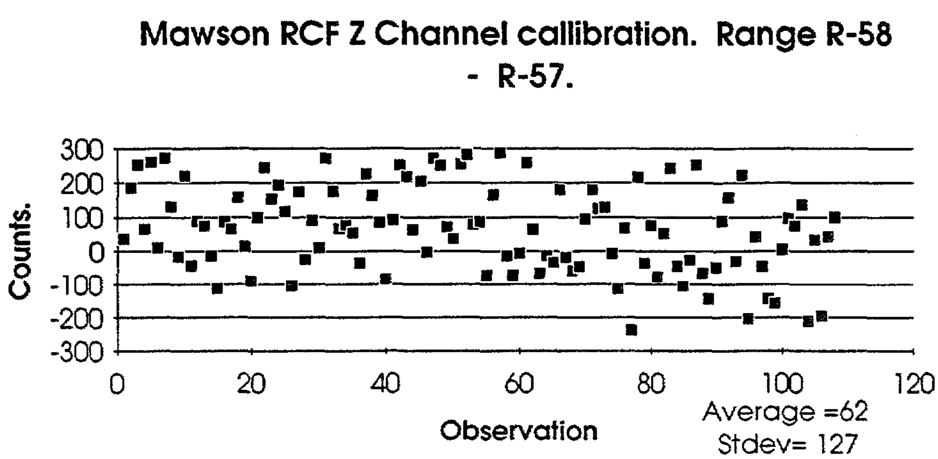
X calibration Results:



Y Calibration Results:



Z calibration Results:



APPENDIX D Preliminary RCF Parameter Calculations.

Note: This procedure was nessary to produce preliminary parameters such as scale value matrix parameters and baseline values. The normal procedure of linear regressions was not appropriate as it requires a large data set and is of no use in this case where only one absolute observation set was available.

RANGE DIFFERENCES:

Ordinate range differences for X, Y, Z components were averaged from 10 calibration runs conducted in a quiet field on 25/2/93 Day 56. Raw results given in Appendix G

Component	Average:	Range:
X:	158	R 13 to R14
Y:	127	R-20 to R-19
Z:	92	R-58 to R-57

ALIGNMENT CORRECTIONS:

Absolute observations were taken on day 56 using the DIM in a quiet field. Fiducial files were recorded for both the PEM and RCF Variometers. The observations were Reduced and Compared using the PEM constants file valid on 25/2/93, and the following file for the RCF:

```
VARIOMETER Maw RCF0 1992 000.0000 1993 366.000\
                        A\
                        RCF0\
                        00000.0 0.0250  0.0000  0.0000  0.0  0.0\
                        00000.0 0.0000  0.0250 +0.0000  0.0  0.0\
                        00000.0 0.0000  0.0000  0.0250  0.0  0.0\
                        0000.00 1.00000          +0.00\
                           0.00 0.23810           +10.00\
                           0.00 0.23810           +10.00\
                            0    0   0\
                            32158   32127   32092 \
                            -0.00   -0.00   -0.00  0.00\
```

BLV File produced for RCF:

```
BEGIN Absolutes              930225  1320  Maw RCF0
Var: 12 25056.87 -19 -22976.79 -57 -19899.32 99999 -17.65 42.03333
Abs D = +295.4417
Abs I =         -67.9824
Abs F =         +49464.9
Cor Var X =  -2307.5      # Xvar =  10273.8
Cor Var Y =     -910.9    # Yvar =  -15834.7
Cor Var Z =      371.2    # Zvar =  -46228.6
Cor Var T = +13.58: +12.0 +24011.7 -19.0 -22832.5 -57.0 -19219.3 +99999.0 -18.0 +42.0
END Absolutes     930225  1415
```

BLV File produced for PEM:

```
BEGIN Absolutes              930225  1320  Maw PEMFPC
Var: 424.5361 -2501.506 2738.109 49347.18 2984.944
Abs D = +295.4583
Abs I =         -67.9729
Abs F =         +49469.4
Cor Var X =                  0.5 # Xvar =    7974.7
Cor Var Y =                  2.5 # Yvar =  -16754.2
Cor Var Z =                  3.2 # Zvar =  -45861.7
Cor Var T = -0.00: -184.4 -2277.3 +3382.8 +49109.3 +2971.5
END Absolutes     930225  1415
```

From BLV Files:

Component:	PEM Var:	RCF Var:
X:	7,974	10,273
Y:	-16,752	-15,834
Z:	-45,858	-46,228
F (xyz):	49,469	49,933

Assuming the calibration of the range differences to be correct, then the vector sum of the orthogonal components will be the total field strength regardless of the variometer's orientation. However there is a significant difference of about 500nT between the two variometers . This lead to an investigation of how the software calculates the components in nT from the Range and Offset values. It appears to use the following formula:

Value(nT) =(RANGE*(32000+RD)+ OFFSET)/40

Where RD=Range Difference.

However this does not take into account the 50% (16000 counts) overlap between even ranges and odd ranges; to form a hysteresis effect. Therefore 16000 counts should be added for the odd ranges. This assumption should be confirmed by a series of tests.
The components were re-calculated using the variometer data from the .BLV file. ie:

Var: 12 25056.87 -19 -22976.79 -57 -19899.32 99999 -17.65 42.03333

As follows:

X(nT)	10,274 nT	= ((12*32158)+25056)/40
Y(nT)	-15,435 nT	= ((-19*32127)-22976+16000)/40
Z(nT)	-45,829 nT	= ((-57*32092)-19899+16000)/40
F (xyz)	49,437 nT	

The RCF F value of 49,437nT compares well to the PEM F value of 49,469nT.
The apparent declination for each variometer was then calculated:

	PEM:	RCF:
X:	7,974 nT	10,274 nT
Y:	-16,752 nT	-15,435 nT
Z:	-45,858 nT	-45,829 nT
D (Tan(x/y))	-64.544 deg	-56.351 deg

RCF Alignment error E = 8.19 deg. West.

The Z axis is assumed to be vertical.

Therefore: X = x Cos E + y Sin E = 7,969 nT
Y = y Cos E - x Sin E = -16,741 nT

Incorporating this in the MAGINFO. constants:

```
VARIOMETER Maw RCF0 1992 000.0000 1999 366.000\
     A\
       RCF0\
        00000.0  0.024744  0.003563  0.0000   0.0  0.0\
        00000.0 -0.003563  0.024744  0.0000   0.0  0.0\
        00000.0  0.0000    0.0000    0.0250   0.0  0.0\
        0000.00 1.00000                      +0.00\
          13.00 0.23810                      +10.00\
          13.00 0.23810                      +10.00\
         0    0   0\
        32158    32127    32092 \
        -0.00    -0.00    -0.00  0.00\
```

This produced the following BLV's:

```
BEGIN Absolutes            930225  1320   Maw RCF0
Var: 12 25056.87 -19 -22976.79 -57 -19899.32 99999 -17.65 42.03333
Abs D = +295.4417
Abs I = -67.9824
Abs F = +49464.9
Cor Var X =                54.5 # Xvar =              7911.8
Cor Var Y =                391.2 #Yvar =              -17136.8
Cor Var Z =                371.2 # Zvar =             -46228.6
Cor Var T = +0.58: +12.0 +24011.7 -19.0 -22832.5 -57.0 -19219.3 +99999.0 -18.0 +42.0
END Absolutes              930225  1415
```

The corrections were incorporated in the Constants file:

```
VARIOMETER Maw RCF0 1992 000.0000 1999 366.000\
        A\
        RCF0\
        00054.5 0.024744 0.003563 0.0000   0.0  0.0\
        00391.2 -0.003563 0.024744 0.0000  0.0  0.0\
        00371.2 0.000000 0.00000  0.0250   0.0  0.0\
        0000.00 1.0000                     +0.00\
        13.00 0.23810                      +10.00\
        13.00 0.23810                      +10.00\
        0   0   0 \
        32158  32127   32092 \
        -0.00   -0.00   -0.00  0.00\
```

This produced the following BLV's:

```
BEGIN Absolutes                 930225  1320   Maw RCF0
Var: 12 25056.87 -19 -22976.79 -57 -19899.32 99999 -17.65 42.03333 Abs D = +295.4417
Abs I = -67.9826
Abs F = +49465.0
Cor Var X =    -0.1 # Xvar =                    7966.3
Cor Var Y =    0.1 # Yvar =                     -16745.6
Cor Var Z =    -0.1 # Zvar =                    -45857.4
Cor Var T = +0.58: +12.0 +24011.7 -19.0 -22832.5 -57.0 -19219.3 +99999.0 -18.0 +42.0
END Absolutes              930225  1415
```

These values compare well to the PEM values.:

Component:	PEM:	RCF:	PEM-RCF:
X:	7,974 nT	7,966 nT	7.70 nT
Y:	-16,752 nT	-16,745 nT	-6.50 nT
Z:	-45,858 nT	-45,857 nT	-0.80 nT
H:	18,553 nT	18,543 nT	9.18 nT
F:	49,469 nT	49,464 nT	4.18 nT
I:	-67.973 deg	-67.983 deg	0.010 deg
D :	-64.545 deg	-64.558 deg	0.013 deg

The errors between the two may be due to the Z component of the RCF not being exactly vertical.

The constants file was adopted for the RCF and monthly comparisons between the RCF and PEM systems for quiet day averages were included in monthly reports.

APPENDIX E. PEM variometer Model: QHM 300 as Primary Instrument.

Geomagnetic elements X, Y and Z are in nanoteslas, temperature is measured in degrees Celsius, time in days from the reference time and variometer output in counts.

Period 1: 00:00 1 January 1993 to 23:59 19 February1993 UTC.

A. Rada observing.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7944 \pm 1.4 \\ -16611 \pm 2.1 \\ -45943 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.00 \pm 0.0 \\ 0.04 \pm 0.0 \\ 0.00 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 1 January 1993}) + ...$$

$$.....+ \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x-0 \\ y-0 \\ z-0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp}-10)$$

Period 2: 00:00 20 February 1993 to 23:59 28 August 1993 UTC.

A. Rada observing.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7944 \pm 1.4 \\ -16609 \pm 2.1 \\ -45943 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.00 \pm 0.0 \\ 0.00 \pm 0.0 \\ 0.00 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 20 February 1993}) + ...$$

$$.....+ \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x-0 \\ y-0 \\ z-0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp}-10)$$

Period 3 : 00:00 29 August 1993 to 23:59 27 October 1993 UTC.

Change in Z drift

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7944 \pm 1.4 \\ -16609 \pm 2.1 \\ -45943 \pm 2.6 \end{pmatrix} + \begin{pmatrix} -0.049 \pm 0.0 \\ 0.000 \pm 0.0 \\ -0.167 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 29 August 1993}) + ...$$

$$.....+ \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x-0 \\ y-0 \\ z-0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp}-10)$$

Period 4: 00:00 28 October 1993 to 23:59 31 December 1993 UTC.

Removal of X drift, small Z drift.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7942 \pm 1.4 \\ -16608 \pm 2.1 \\ -45953 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.00 \pm 0.0 \\ 0.00 \pm 0.0 \\ 0.03 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 28 October 1993}) + ...$$

$$.....+ \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x-0 \\ y-0 \\ z-0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp}-10)$$

APPENDIX F. DIM variometer Model :

Referenced to DIM 810/208 on theodolite 312714 and PPM 770/199, from 150 observations with no instrument corrections. Temperature dependance and scale value matrix have been determined using both standard and secondary instruments.

Period 1: 00:00 4 February 1993 to 23:59 10 April 1993 UTC.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7951 \pm 1.4 \\ -16601 \pm 2.1 \\ -45947 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.00 \pm 0.0 \\ -0.02 \pm 0.0 \\ 0.00 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 11 December 1992}) + ...$$

$$.... + \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x - 0 \\ y - 0 \\ z - 0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp-10})$$

Period 2: 00:00 11 April to 23:59 20 May 1993 UTC.

Period of DIM use.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7951 \pm 1.4 \\ -16600 \pm 2.1 \\ -45947 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.000 \pm 0.0 \\ -0.020 \pm 0.0 \\ -0.150 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 15 February 1993}) + ...$$

$$.... + \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x - 0 \\ y - 0 \\ z - 0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp-10})$$

Period 3: 00:00 21 May to 23:59 28 August 1993 UTC.

DIM repairs required.QHM used as primary instrument.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7951 \pm 1.4 \\ -16611 \pm 2.1 \\ -45945 \pm 2.6 \end{pmatrix} + \begin{pmatrix} -0.037 \pm 0.0 \\ 0.000 \pm 0.0 \\ 0.000 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 5 June 1993}) + ...$$

$$.... + \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x - 0 \\ y - 0 \\ z - 0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp-10})$$

Period 4: 00:00 29 August 1993 to 23:59 27 October 1993 UTC.

Change in Z drift

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7947 \pm 1.4 \\ -16604 \pm 2.1 \\ -45943 \pm 2.6 \end{pmatrix} + \begin{pmatrix} -0.038 \pm 0.0 \\ 0.000 \pm 0.0 \\ -0.180 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 29 August 1993}) + ...$$

$$.... + \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x - 0 \\ y - 0 \\ z - 0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp-10})$$

Period 5: 00:00 28 October 1993 to 23:59 11 December 1993 UTC.

Removal of drift.

NEC/PC recording system with ±2000nT PEM boards for X and Y, ±1000 nT for Z.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} +7946 \pm 1.4 \\ -16604 \pm 2.1 \\ -45954 \pm 2.6 \end{pmatrix} + \begin{pmatrix} 0.0 \pm 0.0 \\ 0.0 \pm 0.0 \\ 0.0 \pm 0.0 \end{pmatrix} * (\text{Time - 00:00 28 October 1993}) + \ldots..$$

$$\ldots. + \begin{pmatrix} 0.05979 \pm 0.00040 & 0.00000 \pm 0.00000 & 0.00000 \pm 0.00000 \\ 0.00000 \pm 0.00000 & 0.06067 \pm 0.00028 & 0.00000 \pm 0.00000 \\ 0.00110 \pm 0.00039 & -0.00027 \pm 0.00092 & 0.03023 \pm 0.00015 \end{pmatrix} * \begin{pmatrix} x-0 \\ y-0 \\ z-0 \end{pmatrix} + \begin{pmatrix} +0.30 \pm 0.24 \\ -0.20 \pm 0.21 \\ -0.40 \pm 0.80 \end{pmatrix} * (\text{temp-10})$$

Appendix G: Mawson 1993 K-indices & Daily K-sums. (K=9 limit: 1500 nT)

Date	January	February	March	April	May	June	Date
01	4553 3325 30	D 6665 4657 45	3343 4566 34	3552 2246 29	5443 2000 18	Q 2310 1134 15	01
02	D 5655 5665 43	5663 3464 37	3564 3565 37	Q 2442 2134 22	1332 2154 21	4421 2233 21	02
03	D 7655 4465 42	4433 3265 30	4664 5775 44	Q 3310 0145 17	3333 3212 20	4333 2334 25	03
04	D 6465 5576 44	4543 3344 30	6643 1435 32	D 3221 3558 29	2231 1212 14	D 4776 4476 45	04
05	4655 5365 39	3343 2335 26	Q 6532 2235 28	D 7665 3463 40	3333 2101 16	D 6675 4466 44	05
06	4554 4455 36	Q 2432 2254 24	Q 4434 2354 29	4322 3236 25	3432 2355 27	5554 3475 38	06
07	4555 4467 40	2655 3476 38	3672 2366 35	4432 2355 28	3443 3366 32	D 5554 3547 38	07
08	5533 4566 37	D 6755 3676 45	5353 4345 32	3544 3565 35	D 7565 4477 45	4643 2373 32	08
09	5544 4465 37	D 5654 4665 41	D 7656 4446 42	5642 2667 38	D 6855 3587 47	4442 2125 24	09
10	D 5676 5323 37	3443 3474 32	6553 4324 32	4553 4465 36	D 6655 4356 40	D 2222 2347 24	10
11	3434 5556 35	6654 3467 41	D 4346 6867 44	3533 3235 27	2421 2143 19	4342 3245 27	11
12	4453 3355 32	1332 3567 30	5443 3577 38	5752 1112 24	2544 3468 36	4444 4336 32	12
13	4332 3436 28	6533 3335 31	6663 3664 40	D 3565 4576 41	7521 2255 29	4445 3245 31	13
14	4655 5456 40	3533 2244 26	3454 4477 38	6654 2657 41	4544 4225 30	4443 3345 30	14
15	5543 4455 35	Q 3222 2244 21	D 7465 4367 42	D 5665 3277 41	2233 2254 23	5342 2112 20	15
16	4532 3355 30	Q 3233 3323 22	D 6564 3772 40	5652 2565 36	5533 2236 29	Q 1121 1114 12	16
17	5564 4343 34	D 3455 6432 32	6644 3376 39	3333 2542 25	D 6653 3377 40	3231 2236 22	17
18	4423 4345 29	2434 3465 31	6453 3335 32	4654 3452 33	2332 1237 23	Q 2100 1201 07	18
19	5543 4355 34	3332 2253 23	Q 2233 3355 26	5433 3434 29	2434 3254 27	0332 3345 23	19
20	4334 4423 27	4655 4447 39	2564 3434 31	3654 4443 33	4453 2223 25	3241 1132 17	20
21	Q 4432 3325 26	4454 4766 40	4555 4455 37	D 5565 3667 43	Q 2221 1013 12	Q 0000 0013 04	21
22	Q 3333 3335 26	D 4555 5656 41	4554 3576 39	5453 3445 33	Q 2321 2123 16	3210 1234 16	22
23	Q 4331 3234 23	3533 4321 24	5342 3226 27	3423 2376 30	Q 1111 1123 11	4432 2274 28	23
24	3654 3362 32	3543 3123 24	D 6675 4657 46	6434 2333 28	Q 2221 0021 10	D 4564 4447 38	24
25	3223 5574 31	3441 3211 19	4444 3554 33	5543 2266 33	Q 2110 0012 07	5555 4444 36	25
26	6663 4365 39	Q 3332 3223 21	Q 3343 2255 27	Q 3221 1114 15	1111 1122 10	4442 3225 26	26
27	4543 3554 33	Q 3322 2015 18	3342 2656 31	Q 2211 1225 16	3563 3245 31	4433 2244 26	27
28	Q 3543 3222 24	4544 5423 31	4653 3657 39	Q 4221 1212 15	D 4554 3765 39	Q 3222 2100 12	28
29	Q 3432 2256 27		4862 2113 27	1111 1356 19	6464 3225 32	2332 3331 20	29
30	5543 3436 33		4554 4535 35	4432 3255 28	2331 1221 15	5451 2324 26	30
31	D 7667 5567 49		Q 5431 3356 30		2211 2213 14		31
Mean K-sum	33.9	30.8	35.0	29.6	24.5	25.3	

Date	July	August	September	October	November	December	Date
01	D 4644 4356 36	Q 3111 0142 13	Q 2210 0123 11	7654 3464 39	5442 3464 32	D 4434 6647 38	01
02	D 4544 4568 40	Q 2100 1124 11	2322 3254 23	2232 2355 24	Q 4322 2223 20	D 5665 5565 43	02
03	D 7752 3223 31	4322 1244 22	D 3544 4567 38	1232 2263 21	3321 2246 23	D 5766 4454 41	03
04	3433 2211 19	D 2343 4457 32	D 6566 3535 39	1322 2263 21	D 6676 5566 47	4333 3365 30	04
05	4331 1132 18	6443 2343 29	4533 3346 31	2321 1235 19	D 5565 5777 47	3333 4464 30	05
06	1123 2022 13	2454 3452 29	5432 3355 30	6642 1144 28	D 5555 5475 41	4333 3344 27	06
07	4431 1102 16	4654 3376 38	5543 3346 33	Q 3321 2111 14	5544 3566 38	4522 5456 33	07
08	1543 4444 29	3554 4231 27	5332 2235 25	3355 4345 32	4443 3576 36	D 7555 5763 43	08
09	3543 3456 33	6644 3243 32	5222 2254 24	D 5586 4467 45	3544 3254 30	Q 3322 1113 16	09
10	5545 3355 35	2223 3345 24	Q 2422 3322 20	D 4675 4366 41	4543 4443 31	4333 3364 29	10
11	D 3654 3343 31	5432 2014 21	4411 3235 23	D 3434 4666 36	3543 3211 22	4332 3343 25	11
12	4444 3224 27	3553 3215 27	3131 3556 27	6553 4355 36	Q 4322 1132 18	4433 4324 27	12
13	4534 3235 29	2542 2114 21	D 4767 6466 46	4454 3265 33	4343 4433 28	Q 3322 2224 20	13
14	Q 3221 1132 15	Q 3000 0001 04	D 6554 3566 40	6442 3245 30	4444 4554 34	Q 4323 2223 21	14
15	3232 1234 20	1111 2446 20	4544 4356 35	Q 4322 1243 21	4652 2256 32	5443 4222 26	15
16	Q 3210 0115 13	D 6566 5776 48	3323 3353 25	Q 3222 2345 23	5533 3564 34	D 3675 4355 38	16
17	Q 2111 0015 11	D 7653 4324 34	Q 2221 2115 16	4522 2256 28	4322 2264 25	5655 4475 41	17
18	3113 2223 17	D 4664 3574 39	Q 3332 1211 16	4533 3434 29	D 3332 5566 33	3554 4666 39	18
19	2423 2104 18	4553 3375 35	Q 3322 2124 19	5443 2265 31	D 5633 4556 37	5444 3354 32	19
20	4443 3357 33	3352 2232 22	1323 3656 29	Q 3221 2344 21	5643 2244 30	5543 3345 32	20
21	5654 4344 35	3333 2133 21	5321 1345 24	3443 2211 20	3443 2235 26	5444 4445 34	21
22	5433 4246 31	3423 2225 23	4443 2302 22	4443 3335 29	4432 2334 25	4344 3235 28	22
23	2542 2102 18	Q 4221 1212 15	2211 3234 18	4663 3233 30	3542 3333 26	3543 3446 32	23
24	Q 3122 2232 17	1233 1104 15	5233 4534 29	5533 1454 30	Q 3422 1224 20	4454 4445 34	24
25	4312 2233 20	Q 3211 1105 14	3443 3345 29	D 2333 1454 25	3432 3345 27	3533 5265 32	25
26	Q 3221 1112 13	4321 3255 25	3553 3124 26	3342 3746 32	5443 3564 34	4433 4456 33	26
27	3321 2235 21	D 4234 5565 34	5332 2453 27	D 4665 5466 42	5332 2235 25	4442 3422 25	27
28	5432 2245 27	3232 2335 23	2222 3454 24	4464 3357 36	Q 3333 3334 25	Q 4422 3233 23	28
29	D 4433 4364 31	4543 2226 28	D 2435 4665 35	5542 3435 31	6533 4465 36	Q 3331 2113 17	29
30	5531 2123 22	2431 0014 15	4553 3237 32	Q 3321 2203 16	Q 4222 2223 19	4432 3213 22	30
31	5423 1034 22	4320 1134 18		2124 2654 26		4665 3445 37	31
Mean K-sum	23.9	24.5	27.2	28.7	30.0	30.6	

APPENDIX H: Linear regression results:

PEM Variometer Linear regression results, QHM 300 Obs:

Period:	*From*	*To:*	*Notes:*
A	-51	-21	Pre RCF installation.
B	-21	43	Post RCF installation QHM 300 obs until DIM use.
C	159	240	QHM used while DIM repaired.
D	240	330	Period of Z drift.
E	-51	328	All obs as one period.

X Component:

Peroid:	*X Drift*	*StDev*	*S Xt*	*StDev*	*S Xz*	*StDev*	*S Xy*	*StDev*	*S Xx*	*StDev*	*X Blv*	*StDev*	*Std BLV*	*Correlation:*
A	-0.37799	0.05410	-0.15514	1.27820	-0.00055	0.00021	0.00069	0.00054	0.06009	0.00068	7940.4	2.5	1.4	0.9994
B	-0.06425	0.03377	-0.76960	1.58874	0.00015	0.00023	-0.00072	0.00071	0.05911	0.00046	7942.1	1.9	1.9	0.9996
C	-0.06224	0.01438	1.64250	1.50300	0.00108	0.00049	-0.00608	0.00148	0.05595	0.00095	7936.5	5.8	1.6	0.9993
D	-0.05340	0.04780	1.88670	2.17730	-0.00015	0.00026	-0.00154	0.00143	0.05901	0.00064	7955.1	15.3	2.7	0.9995
E	-0.01998	0.00441	-0.15660	0.62396	0.00018	0.00017	0.00021	0.00060	0.05979	0.00041	7947.1	1.7	3.5	0.9984

Y Component:

Peroid:	*Y Drift*	*StDev*	*S Yt*	*StDev*	*S Yz*	*StDev*	*S Yy*	*StDev*	*S Yx*	*StDev*	*Y Blv*	*StDev*	*Std BLV*	*Correlation:*
A	-0.13097	0.08327	-0.69350	1.96770	-0.00052	0.00032	0.06122	0.00083	0.00002	0.00104	-16611.9	3.9	2.2	0.9992
B	-0.02666	0.02662	-1.07154	1.25299	0.00002	0.00018	0.06046	0.00053	-0.00071	0.00036	-16611.1	1.5	1.5	0.9993
C	-0.04392	0.00813	1.80078	0.85027	0.00052	0.00028	0.05855	0.00084	-0.00149	0.00054	-16605.9	3.3	0.9	0.9994
D	0.03033	0.02059	0.30284	0.93633	0.00007	0.00011	0.06123	0.00062	0.00007	0.00028	-16615.8	6.6	1.2	0.9997
E	0.00412	0.00211	0.03588	0.29992	0.00005	0.00008	0.06067	0.00029	-0.00024	0.00020	-16610.3	0.8	1.7	0.9990

Z Component:

Peroid:	*Z Drift*	*StDev*	*S Zt*	*StDev*	*S Zz*	*StDev*	*S Zy*	*StDev*	*S Zx*	*StDev*	*Z Blv*	*StDev*	*Std BLV*	*Correlation:*
A	0.02722	0.10294	4.84592	2.43230	0.03036	0.00040	-0.00237	0.00103	0.00063	0.00129	-45952.3	4.8	2.7	0.9993
B	-0.03229	0.04363	0.43597	2.05260	0.03077	0.00029	-0.00027	0.00092	0.00117	0.00059	-45943.9	2.5	2.4	0.9986
C	0.03175	0.01349	0.26206	1.41038	0.03079	0.00046	-0.00048	0.00140	0.00023	0.00089	-45952.6	5.4	1.5	0.9978
D	-0.14520	0.02931	0.07059	1.33329	0.03030	0.00016	0.00148	0.00088	0.00122	0.00039	-45903.5	9.3	1.6	0.9998
E	-9.39140	1.17650	-0.00029	0.00005	0.02903	0.00047	-0.00710	0.00132	-0.00030	0.00110	-45945.6	5.0	10.3	0.9830

APPENDIX I: Rounds Of Angles

Mawson 1993.

Assumed BMR 89/2 Azimuth: 19.23 Deg (Crosthwaite 1989)

DOWN

	89/2		85/2		SOH		89/1		A		89/2	
Date:	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min
18/11	342	393	204	297	237	406	314	105	320	304	342	394
25/10	342	410	204	314	237	488	314	42	320	323	342	411
23/9	342	479	204	372	237	482	314	101	320	379	342	480
30/8	342	479	204	390	237	493	314	101	320	391	342	481

UP

	89/2		85/2		SOH		89/1		A		89/2	
Date:	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min	Deg	Min
18/11	162	394	24	292	57	403	134	26	140	306	162	396
25/10	162	411	24	309	57	419	134	38	140	320	162	411
23/9	162	468	24	379	57	488	134	109	140	392	162	467
30/8	162	482	24	384	57	492	134	109	140	392	162	483

Up Differences (Decimal Minutes):

342.656	221.839	255.021	331.519	337.851
342.684	221.839	255.129	331.386	337.854
342.799	221.821	255.004	331.369	337.833
342.800	221.850	255.022	331.368	337.852

Down Differences:

342.658	221.828	255.013	331.385	337.852
342.685	221.830	255.013	331.378	337.848
342.779	221.853	255.034	331.403	337.874
342.804	221.836	255.016	331.378	337.849

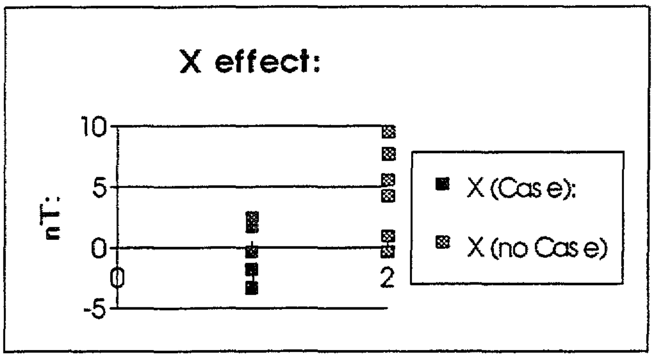
Azimuth corrected to BMR 89/2:

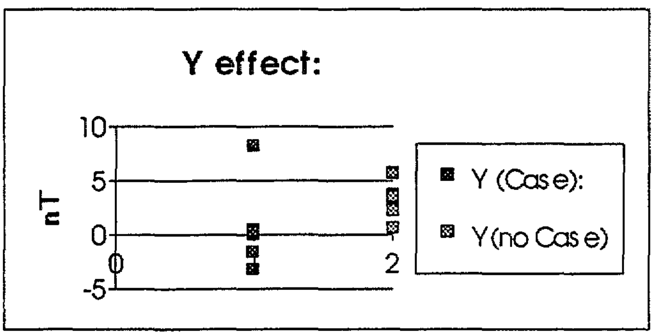
	89/2	85/2	SOH	89/1	A
	19.233	241.073	274.254	350.753	357.084
	19.233	241.073	274.363	350.619	357.088
	19.233	241.054	274.238	350.603	357.066
	19.233	241.083	274.255	350.602	357.085
	19.233	241.062	274.247	350.618	357.085
	19.233	241.063	274.247	350.612	357.082
	19.233	241.086	274.268	350.636	357.108
	19.233	241.069	274.249	350.611	357.083
Ave:	**19.233**	**241.070**	**274.265**	**350.632**	**357.085**
Stdev:	**0**	**0.01073**	**0.04037**	**0.0501**	**0.0113**

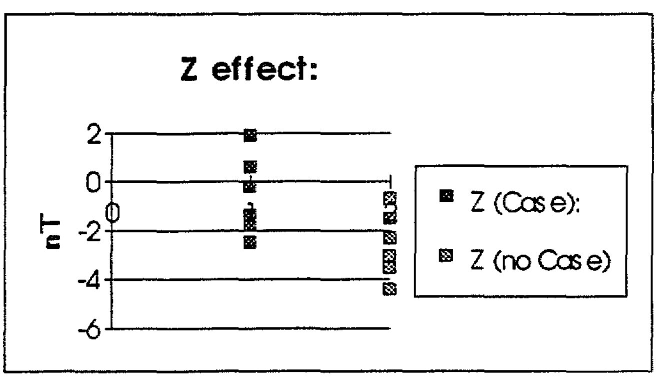
NOTE: The procedure used during the round of angles (ROA) observations was not standard. The DIM theodolite was used for a single clockwise series of mark obs with the sensor in the up position. The series started on mark BMR89/2 and finnished on the same mark; closing the series. This was followed by a second series with the DIM sensor in a down position. This is considerably shorter and less accurate than the correct procedure, hence the standard deviations are larger than would normally be expected.

APPENDIX J: Determination of Absolute Hut Contamination by DIM Case:

Results of a series of DIM observations performed in April 94.







A special series of absolute observations was done on 27 April 1994 with DIM 810/208 on theodolite 312714, to determine the effect of the DIM case which had been on the lower shelf in the eastern corner of the absolute hut. The PPM was 770/199 in the bolts down position.

The routine was :

With case removed -
PPMx3,DIMx3,PPMx3
Case on shelf -
PPMx3,DIMx3,PPMx3 Case on shelf
-
PPMx3,DIMx3,PPMx3 With case removed
-
PPMx3,DIMx3,PPMx3

Results:

Residuals with case on shelf (nT)

	X:	Y:	Z:
Average :	1.18	-0.53	-0.38
Std Dev :	4.14	1.88	1.43

Residuals with case removed (nT)

	X:	Y:	Z:
Average :	4.57	3.2	-2.57
Std Dev :	3.77	1.69	1.35

The correction to the X, Y, Z components due to the DIM case being in the Mawson absolute hut is therefore :

X : +3.39 (+/- 7.91) nT
Y : +3.73 (+/- 3.57) nT
Z : -2.19 (+/- 2.78) nT

There is considerable uncertainity in these results and the more conservative corrections of:

+2 nT in X, +2 nT in Y, and -1nT in Z have been adopted.

APPENDIX K. MAWSON MEAN HOURLY VALUES.

The following monthly averages of mean hourly values have been derived using the variometer model and corrections presented in this report. The UT time given at the head of each column indicates the start of the hour over which the values below have been averaged. Values have been calculated for All days, international quiet days only (Q), and international disturbed days (D). The monthly mean is also given.

North component (X) :

MAWSON ANTARCTIC 1993 7500 + tabular values in nanoTeslas.

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	439	431	401	365	304	272	325	363	400	423	440	468	479	487	498	504	485	483	470	465	472	471	466	457	A	432
	439	418	389	336	276	298	371	404	416	428	438	445	444	460	456	457	449	453	450	452	444	446	455	429	Q	419
	419	412	319	407	369	264	269	236	348	421	453	497	496	512	513	513	473	484	481	489	477	491	469	474	D	429
Feb.	436	427	409	354	302	280	333	357	383	408	432	446	453	464	464	467	456	444	454	446	436	450	447	428	A	416
	437	430	411	383	354	345	374	398	409	414	424	441	450	462	453	445	439	440	444	446	438	443	427	429	Q	422
	423	405	422	306	256	279	342	319	348	401	443	463	466	453	460	457	421	428	478	471	430	462	432	413	D	407
Mar.	401	391	373	344	292	266	288	324	379	414	423	434	443	451	452	447	433	409	407	429	421	430	403	396	A	394
	398	358	324	332	320	345	378	391	406	410	422	434	435	433	440	446	446	446	412	428	443	434	445	418	Q	406
	375	429	364	354	334	315	217	218	301	387	407	435	427	438	436	405	425	402	371	436	438	419	310	364	D	375
Apr.	395	380	356	347	319	309	332	363	379	402	417	421	424	427	430	422	425	409	408	410	406	394	398	377	A	390
	386	399	396	382	379	374	386	399	404	408	413	415	415	418	417	423	428	430	431	426	419	402	407	405	Q	407
	407	377	300	312	301	275	261	301	274	345	388	403	406	419	412	335	371	407	400	414	376	390	409	366	D	360
May	360	371	358	347	339	352	369	378	398	403	416	423	429	430	436	434	432	426	420	409	402	401	395	381	A	396
	405	402	398	392	403	407	403	403	406	409	412	417	417	419	421	420	419	420	422	421	414	412	410	407	Q	411
	206	279	276	200	228	299	347	345	385	373	406	427	446	449	454	444	418	395	406	373	378	340	364	350	D	358
Jun.	390	367	355	361	345	350	361	378	397	410	422	425	430	431	434	434	432	427	424	411	414	409	390	383	A	399
	410	403	399	400	406	403	400	400	405	410	414	414	418	420	422	423	424	424	420	423	420	419	406	409	Q	412
	387	344	329	364	269	278	304	352	398	409	433	438	441	439	451	451	424	414	443	386	409	369	333	336	D	383
Jul.	385	361	340	325	328	358	373	385	396	414	422	428	431	433	436	430	426	427	418	410	405	396	397	390	A	396
	402	391	393	397	394	398	403	404	405	409	413	415	417	419	421	423	424	428	429	426	420	417	416	403	Q	411
	352	277	264	202	176	308	330	351	358	411	430	437	449	461	477	441	417	424	415	379	361	382	373	357	D	368
Aug.	362	363	362	363	354	344	345	380	392	405	414	417	419	423	426	421	423	419	406	407	400	405	388	374	A	392
	365	387	399	405	407	407	404	402	403	404	405	407	409	411	412	414	414	416	414	408	408	408	390	389	Q	404
	339	303	328	344	352	297	257	332	353	395	431	421	423	445	434	393	407	384	372	389	331	395	376	355	D	369
Sep.	376	363	361	345	325	335	353	364	378	390	407	417	422	425	430	428	407	413	408	401	401	400	392	389	A	389
	397	402	379	358	358	377	388	392	397	404	407	406	410	419	425	427	416	416	415	412	409	394	395	397	Q	400
	335	329	344	331	270	293	257	234	290	331	406	439	444	415	421	418	327	388	394	380	415	378	395	392	D	359
Oct.	381	369	334	287	277	288	323	338	371	395	405	414	430	441	438	432	429	416	414	397	397	398	388	395	A	382
	372	375	358	339	362	373	375	381	387	390	398	406	409	410	417	421	428	419	411	416	414	398	409	405	Q	395
	393	365	383	287	204	206	222	187	276	372	379	394	447	478	440	406	416	402	389	356	367	413	333	388	D	356
Nov.	403	386	350	313	267	295	334	368	387	400	411	420	433	448	453	441	436	435	421	411	423	426	423	410	A	396
	418	415	366	332	334	361	380	384	388	397	405	413	416	416	426	427	425	425	420	424	427	430	426	426	Q	403
	385	372	353	309	227	219	248	300	347	369	386	397	423	462	462	454	414	408	415	387	417	440	400	392	D	374
Dec.	408	386	358	324	280	285	295	341	361	388	408	426	447	454	456	457	453	451	434	441	435	428	431	435	A	399
	395	387	348	326	309	351	370	387	394	399	406	415	425	429	432	429	433	432	424	431	433	435	441	432	Q	403
	404	360	395	367	283	216	165	263	313	331	370	396	440	435	442	466	450	472	449	480	431	425	457	453	D	386
Year	395	383	363	340	311	311	336	362	385	404	418	428	437	443	446	443	436	430	424	420	418	417	410	401	A	398
	402	397	380	365	359	370	386	395	401	407	413	419	422	426	429	429	429	429	424	426	424	420	419	412	Q	408
	369	354	340	315	272	271	268	287	333	379	411	429	442	451	450	432	414	417	418	412	402	409	388	387	D	377

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

East component (Y):

MAWSON ANTARCTIC 1993 -16500 - tabular values in nanoTeslas.

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	196	215	226	233	224	222	231	222	226	228	248	283	285	291	295	286	270	261	220	177	176	179	189	193	A	232
	207	225	224	218	190	231	251	238	228	228	244	235	234	253	254	256	258	261	258	250	227	196	198	195	Q	232
	109	134	126	241	246	218	231	165	189	227	284	391	340	336	294	270	243	218	198	120	108	167	165	190	D	217
Feb.	218	232	239	224	211	218	240	226	227	229	230	244	260	262	259	262	246	229	222	175	175	188	197	207	A	226
	241	249	251	255	253	251	248	239	233	226	229	235	248	258	246	241	242	247	250	250	235	225	209	226	Q	241
	178	179	254	191	153	204	247	202	231	256	248	278	297	262	258	245	187	172	161	139	112	128	123	150	D	202
Mar.	200	198	218	222	202	207	211	215	229	239	251	255	259	266	273	254	227	186	158	169	143	154	162	170	A	211
	218	158	153	184	211	246	252	238	233	228	234	236	242	241	252	270	273	265	208	193	165	132	217	210	Q	219
	156	232	259	274	257	246	138	160	238	255	274	272	250	258	259	205	198	126	76	120	198	142	35	80	D	196
Apr.	217	223	200	215	226	210	216	225	223	241	242	244	246	249	254	250	244	223	214	208	184	160	173	180	A	219
	219	237	235	234	240	246	249	249	246	240	235	234	237	240	242	246	253	259	259	253	231	194	217	227	Q	238
	247	234	152	202	242	205	178	195	144	228	245	245	234	240	227	168	169	163	141	158	40	125	178	150	D	188
May	201	216	215	210	217	236	241	244	246	239	245	251	261	263	268	266	262	257	244	220	205	189	201	196	A	233
	247	245	244	240	250	257	256	254	249	247	246	247	249	250	253	255	254	257	260	255	245	243	238	242	Q	249
	82	123	171	117	164	235	238	249	264	222	246	266	286	287	293	288	245	211	209	143	106	55	110	139	D	198
Jun.	221	226	228	237	226	227	232	238	239	243	253	258	268	268	273	273	272	274	264	246	234	225	199	198	A	243
	251	251	250	250	255	254	255	253	250	249	247	250	253	255	257	258	262	266	266	269	265	257	238	244	Q	254
	211	208	236	266	181	175	203	231	231	247	280	280	287	280	296	292	262	271	238	221	205	170	83	96	D	227
Jul.	230	222	208	205	212	238	241	236	235	241	247	257	266	272	277	273	268	269	268	259	241	221	212	211	A	242
	233	244	246	253	252	256	261	258	252	248	247	251	254	257	260	263	266	271	281	278	267	263	254	228	Q	256
	199	182	180	145	139	231	215	197	198	223	247	274	294	314	322	289	270	260	249	234	208	171	166	132	D	222
Aug.	216	225	228	230	237	237	227	244	247	249	252	258	263	271	270	267	264	253	254	246	225	231	211	202	A	242
	224	248	255	259	263	268	268	265	260	256	250	248	252	254	256	260	260	263	263	261	256	247	236	229	Q	254
	183	167	204	217	251	221	161	204	238	242	264	268	280	311	280	253	218	155	216	184	162	230	217	185	D	221
Sep.	226	224	239	243	238	248	252	252	248	246	253	261	267	266	273	271	258	251	229	220	216	212	187	203	A	241
	255	257	244	240	255	263	264	261	259	253	257	254	254	261	266	273	267	269	272	267	256	249	235	244	Q	257
	156	202	241	250	199	241	220	208	201	217	264	302	311	255	252	232	205	208	161	155	141	178	120	106	D	209
Oct.	223	231	226	216	226	234	245	236	244	254	256	271	277	282	279	271	264	253	236	216	193	186	175	213	A	238
	235	249	256	270	279	278	272	265	255	245	244	250	251	255	264	273	281	273	258	255	251	223	227	237	Q	256
	226	229	277	215	184	193	200	153	205	264	261	294	311	297	251	196	197	187	168	163	160	103	36	154	D	204
Nov.	220	250	249	254	242	261	261	261	256	256	270	270	280	289	289	274	265	260	223	202	208	201	203	207	A	248
	258	274	259	267	278	289	283	265	249	245	244	245	253	259	276	286	286	284	277	277	266	245	242	241	Q	264
	182	259	275	277	217	226	233	267	272	294	337	299	277	299	275	218	154	191	140	90	102	185	103	172	D	223
Dec.	233	238	255	263	260	264	254	255	251	254	266	286	306	301	298	288	284	280	247	237	214	200	221	238	A	258
	243	250	264	272	279	286	278	265	252	244	243	258	268	275	283	284	291	291	284	281	269	260	251	251	Q	268
	201	197	290	276	253	243	228	273	289	278	312	328	325	275	257	207	213	241	166	193	158	180	234	235	D	244
Year	217	225	227	229	227	233	238	238	239	243	251	261	270	273	276	270	260	250	231	215	201	196	194	201	A	236
	236	241	240	245	250	260	261	254	247	242	243	245	250	255	259	264	266	267	261	257	244	228	230	231	Q	249
	178	195	222	223	207	220	208	209	225	246	272	291	291	284	272	239	213	200	177	160	142	153	131	149	D	213

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed: 13:35 HRS., Mon. 20 JUN. 1994 .

Vertical intensity (Z) :

MAWSON ANTARCTIC 1993 -45500 - tabular values in nanoTeslas.

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	450	444	459	466	457	405	360	338	344	361	368	353	327	314	303	278	259	284	285	310	332	371	394	435	A	362
	402	406	410	414	352	305	303	318	327	341	346	352	358	356	348	352	342	333	326	326	306	341	348	389	Q	350
	586	519	516	581	578	588	547	426	396	426	412	351	265	301	267	253	193	286	300	332	332	403	453	496	D	409
Feb.	429	436	441	459	465	405	362	336	338	359	347	340	326	320	318	319	295	269	300	313	327	369	386	390	A	360
	359	365	376	374	346	303	299	309	315	319	332	344	348	337	337	343	336	333	332	320	315	323	314	337	Q	334
	462	499	500	534	550	493	445	386	366	431	371	331	268	270	281	250	167	136	269	267	357	429	437	441	D	372
Mar.	473	483	475	477	455	439	415	377	359	350	351	342	337	321	315	293	282	268	284	299	351	393	411	460	A	375
	425	470	428	399	388	357	328	328	340	345	354	361	357	353	347	313	325	311	266	245	288	309	364	391	Q	350
	522	529	471	473	434	541	591	513	422	358	357	355	308	288	270	266	274	306	288	288	365	452	456	529	D	402
Apr.	416	421	439	443	412	390	361	338	336	339	342	345	343	339	328	310	295	285	290	294	318	368	397	408	A	357
	372	375	361	349	341	327	313	314	321	325	332	340	339	338	335	335	331	328	320	314	323	339	351	358	Q	337
	463	454	526	516	447	451	482	418	368	346	341	340	336	330	295	238	250	300	312	270	319	377	426	455	D	378
May	370	392	385	394	370	335	322	313	315	317	325	325	317	318	320	311	308	300	299	294	291	318	351	371	A	332
	334	326	326	323	321	315	310	310	314	315	317	324	323	324	326	326	325	324	316	306	297	292	301	317	Q	317
	417	577	548	561	493	444	393	383	350	328	336	316	284	307	313	289	278	241	267	294	302	368	418	429	D	372
Jun.	346	368	372	362	347	326	305	296	296	305	313	320	318	315	306	308	301	293	279	275	272	296	331	341	A	316
	312	311	312	312	309	305	304	302	303	307	312	316	316	316	316	315	316	314	307	299	297	297	306	311	Q	309
	373	427	411	411	425	422	372	334	312	299	303	311	300	296	267	284	264	266	259	272	265	294	379	397	D	331
Jul.	343	365	367	371	348	322	300	287	291	299	313	316	314	306	300	289	289	286	274	264	271	279	295	322	A	309
	324	322	313	307	305	299	300	300	301	305	310	313	313	314	312	312	311	301	306	294	286	288	294	311	Q	306
	400	442	466	491	438	415	366	315	310	301	315	311	319	289	264	225	243	271	259	231	264	301	334	366	D	331
Aug.	366	378	367	349	337	319	289	286	286	294	305	306	301	293	293	287	285	283	256	264	277	304	330	357	A	309
	361	334	320	307	301	296	294	295	296	298	302	305	307	306	307	307	306	306	299	289	285	287	283	326	Q	305
	375	453	432	391	389	397	328	313	281	290	310	292	253	217	212	196	211	242	156	245	280	362	431	441	D	312
Sep.	382	380	381	372	359	328	296	295	295	301	308	310	309	301	294	283	261	271	277	279	282	310	345	364	A	316
	332	327	347	326	298	286	282	283	286	299	307	309	313	316	317	314	310	308	300	291	287	296	287	317	Q	306
	441	387	412	433	461	430	340	322	309	308	308	293	275	227	227	215	144	245	303	317	289	330	432	428	D	328
Oct.	388	392	396	393	366	329	309	311	299	296	302	293	299	299	287	279	274	261	268	282	294	343	351	376	A	320
	394	391	371	326	291	285	278	282	288	298	309	320	321	322	319	307	295	289	278	282	292	310	331	339	Q	313
	394	404	393	440	447	435	400	378	295	254	243	200	260	258	215	218	247	241	309	321	280	436	351	429	D	324
Nov.	403	401	400	385	346	295	278	277	287	296	293	303	292	281	263	239	245	251	264	271	289	320	360	389	A	309
	372	367	354	338	298	275	274	273	281	293	303	311	314	313	311	304	302	296	287	286	288	304	334	347	Q	309
	419	420	421	400	425	353	337	271	276	287	228	247	235	211	134	140	176	196	273	318	287	364	437	444	D	304
Dec.	387	393	386	374	345	315	278	291	277	279	283	283	273	254	243	249	236	230	239	267	292	314	335	362	A	299
	352	346	332	315	284	271	269	273	277	284	294	305	315	313	306	302	297	291	271	261	268	279	293	322	Q	297
	450	470	478	499	501	463	360	368	290	231	197	133	155	121	127	161	134	200	231	293	292	342	361	397	D	302
Year	396	404	406	404	384	351	323	312	310	317	321	320	313	305	297	287	277	273	276	284	300	332	357	381	A	330
	362	361	354	341	320	302	296	299	304	311	318	325	327	326	323	319	316	311	301	293	294	306	317	339	Q	319
	442	465	464	478	466	453	413	369	331	322	310	290	271	260	239	228	215	244	269	287	303	371	410	438	D	347

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

Total intensity (F) :

MAWSON ANTARCTIC 1993 49000 + tabular values in nanoTeslas.

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	530	529	542	545	525	471	440	422	435	455	471	474	453	444	436	411	385	405	390	398	419	456	479	518	A	460
	489	495	494	487	411	385	401	416	423	438	450	452	458	465	457	462	452	446	438	435	408	430	438	472	Q	446
	624	569	549	662	655	637	605	465	463	515	527	513	417	451	405	384	312	392	398	403	396	484	528	576	D	497
Feb.	517	527	531	534	527	470	446	421	428	452	444	446	438	436	433	435	406	373	402	397	409	453	472	476	A	453
	460	467	475	471	439	397	397	407	412	414	429	445	455	450	444	447	439	439	439	428	417	422	406	433	Q	435
	533	564	593	585	580	547	527	453	449	526	475	451	400	387	398	363	261	229	356	346	414	491	492	502	D	455
Mar.	546	554	550	549	513	496	479	450	447	448	454	449	447	435	433	405	383	353	358	379	417	461	476	523	A	459
	507	522	477	461	458	445	425	423	434	438	451	460	458	453	454	429	441	425	359	337	369	377	458	476	Q	439
	574	613	559	564	519	612	607	542	497	456	465	467	415	400	383	356	365	367	328	353	451	511	461	552	D	476
Apr.	498	502	508	515	486	458	437	424	423	436	442	445	445	443	435	416	399	382	382	384	398	435	467	476	A	443
	457	467	453	440	434	422	412	415	422	424	429	436	436	437	435	438	437	437	430	421	420	420	440	449	Q	434
	554	537	564	574	521	507	525	478	410	429	437	439	431	430	392	307	325	375	377	346	346	431	497	507	D	447
May	445	472	463	468	447	423	415	409	415	415	427	430	427	429	433	424	420	409	403	388	379	399	433	448	A	426
	434	425	424	419	422	420	414	414	416	417	419	426	426	428	431	432	430	431	424	413	400	395	401	417	Q	420
	425	598	587	569	526	515	476	471	451	415	436	427	407	430	438	412	384	334	359	357	353	391	460	477	D	446
Jun.	434	452	455	449	430	411	395	391	394	407	419	428	430	427	421	423	416	408	392	380	373	392	413	420	A	415
	416	413	413	413	414	409	408	405	406	410	414	419	421	423	423	423	425	424	418	412	408	405	405	412	Q	414
	455	497	490	505	475	472	439	420	407	403	421	429	422	415	396	411	377	380	367	365	356	366	409	431	D	421
Jul.	434	448	441	441	422	412	395	383	388	401	417	424	426	421	417	405	402	401	388	374	374	372	385	408	A	407
	419	419	412	409	407	404	406	406	404	408	413	418	419	421	421	421	422	415	423	410	399	399	401	406	Q	412
	471	492	511	514	458	488	441	391	388	396	421	427	443	424	406	353	359	383	367	330	349	374	402	417	D	417
Aug.	446	460	451	436	425	407	376	384	387	398	410	413	411	407	407	400	397	390	364	369	373	400	415	435	A	407
	445	432	423	413	409	406	404	403	402	403	405	408	411	411	413	414	414	415	409	397	392	391	380	418	Q	409
	440	501	498	467	478	466	375	388	374	390	422	404	373	354	337	306	311	314	253	327	343	453	509	505	D	400
Sep.	466	462	467	458	441	418	392	393	393	401	412	418	420	413	410	398	370	378	375	373	375	399	422	444	A	412
	433	430	440	417	396	391	389	390	393	403	412	413	417	424	428	427	420	419	413	402	394	398	385	416	Q	410
	492	456	494	515	514	503	407	382	377	388	416	420	407	340	339	320	231	335	374	383	358	403	480	472	D	409
Oct.	472	476	473	460	437	407	397	399	395	400	407	406	416	419	407	396	388	370	370	374	377	421	423	459	A	414
	480	483	463	423	398	394	386	388	391	397	409	422	424	426	428	420	412	404	386	390	398	402	425	435	Q	416
	480	487	495	503	487	479	450	409	364	360	351	324	394	392	331	309	339	327	382	385	348	481	368	488	D	402
Nov.	489	494	487	469	422	385	376	380	390	401	405	415	410	406	390	361	362	366	364	361	382	409	446	472	A	410
	475	475	450	433	400	386	386	380	383	394	404	413	419	420	426	423	420	414	403	403	402	409	436	447	Q	417
	488	512	515	490	480	416	407	365	380	400	363	370	355	347	267	252	257	288	343	363	344	446	481	509	D	393
Dec.	479	483	478	464	429	403	367	387	376	382	393	404	404	386	375	378	363	356	350	374	389	403	430	461	A	405
	448	443	428	412	383	380	379	380	380	385	396	413	427	428	424	420	419	414	391	382	385	393	403	429	Q	406
	527	536	581	591	572	522	414	452	393	337	323	274	300	251	251	270	245	319	319	390	369	422	462	496	D	401
Year	480	488	487	482	459	430	410	404	406	416	425	429	427	422	416	404	391	383	378	379	389	417	438	462	A	426
	455	456	446	433	414	403	401	402	406	411	419	427	431	432	432	430	428	423	411	403	399	403	415	434	Q	421
	505	530	536	545	522	514	473	435	413	418	421	412	397	385	362	337	314	337	352	362	369	438	462	494	D	430

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

Horizontal intensity (H):

MAWSON ANTARCTIC 1993 18500 + tabular values in nanoTeslas.

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	-13	1	-2	-10	-45	-60	-29	-21	-2	9	35	78	85	94	102	96	75	65	23	-18	-16	-14	-8	-8	A	17
	-2	5	-8	-37	-87	-41	8	11	7	11	31	25	24	48	47	50	47	53	49	42	17	-9	-4	-18	Q	11
	-100	-80	-126	15	3	-67	-53	-126	-58	7	73	188	142	145	108	86	44	26	7	-59	-76	-16	-27	-3	D	2
Feb.	6	15	13	-24	-58	-61	-18	-20	-8	4	15	34	51	58	55	59	40	19	17	-28	-33	-15	-9	-8	A	4
	28	32	25	17	3	-3	6	9	8	4	11	24	39	53	39	31	29	34	38	39	22	15	-6	11	Q	21
	-35	-42	33	-74	-130	-73	-8	-59	-19	26	36	72	90	53	52	39	-28	-39	-28	-50	-92	-64	-82	-65	D	-20
Mar.	-26	-31	-21	-30	-69	-76	-63	-44	-8	16	30	39	46	56	63	43	13	-35	-60	-41	-68	-54	-59	-55	A	-18
	-10	-82	-100	-69	-50	-8	12	5	6	4	15	22	27	25	39	57	60	53	-14	-20	-39	-73	9	-9	Q	-6
	-76	15	12	22	-2	-20	-159	-139	-33	19	45	55	31	43	43	-19	-17	-91	-149	-82	-12	-70	-213	-150	D	-39
Apr.	-12	-14	-44	-35	-37	-56	-40	-18	-13	12	20	23	27	31	36	29	24	-1	-10	-15	-37	-65	-51	-54	A	-12
	-14	7	5	-3	1	5	13	18	18	14	12	11	14	18	20	26	34	40	41	33	10	-30	-7	0	Q	12
	20	-5	-111	-61	-30	-75	-104	-72	-130	-24	10	16	8	18	4	-82	-66	-56	-79	-57	-180	-97	-41	-86	D	-53
May	-41	-24	-30	-40	-36	-14	-2	5	15	11	22	30	42	44	51	49	45	37	23	-4	-20	-35	-27	-37	A	3
	19	16	14	7	21	29	26	25	21	21	21	24	26	28	31	32	31	34	38	33	21	18	13	16	Q	23
	-213	-147	-104	-185	-130	-37	-14	-5	26	-17	18	45	72	74	81	73	23	-18	-15	-88	-120	-182	-122	-102	D	-45
Jun.	-11	-16	-19	-9	-25	-23	-13	-1	8	17	32	37	48	49	55	55	53	52	42	21	11	1	-31	-34	A	12
	24	22	19	19	26	24	24	22	22	23	23	26	29	32	35	37	40	44	43	47	41	34	11	18	Q	29
	-21	-42	-23	19	-98	-100	-64	-18	1	21	61	63	70	63	83	80	40	45	27	-12	-17	-66	-160	-147	D	-8
Jul.	-5	-23	-44	-53	-45	-9	0	1	4	18	26	37	47	54	59	53	47	49	44	32	13	-9	-16	-20	A	11
	5	10	13	21	18	24	30	28	23	22	22	27	31	34	38	41	44	50	60	56	43	39	30	1	Q	30
	-47	-94	-101	-159	-176	-37	-42	-49	-45	0	30	57	80	104	117	73	44	39	25	-4	-35	-60	-68	-106	D	-19
Aug.	-27	-19	-17	-14	-12	-16	-25	6	14	21	28	33	39	48	48	44	42	30	25	19	-3	5	-21	-35	A	9
	-19	12	24	30	35	39	38	34	30	26	21	21	25	28	31	34	35	38	37	33	29	20	3	-4	Q	25
	-67	-97	-52	-34	0	-51	-122	-51	-11	10	46	45	57	94	61	20	-6	-73	-23	-45	-89	0	-21	-58	D	-19
Sep.	-13	-19	-7	-10	-23	-10	1	6	8	12	25	37	44	45	53	51	30	26	4	-7	-10	-15	-41	-28	A	7
	23	27	5	-8	6	22	27	26	26	24	28	26	27	37	45	52	42	44	46	40	29	16	4	13	Q	26
	-93	-54	-13	-10	-82	-34	-68	-88	-72	-40	35	83	93	31	30	11	-52	-24	-64	-75	-73	-54	-101	-114	D	-34
Oct.	-12	-11	-31	-59	-54	-43	-18	-19	1	21	27	44	57	66	62	52	45	29	12	-12	-33	-39	-53	-16	A	1
	-6	8	7	11	30	33	29	25	18	11	13	23	25	29	39	49	59	49	32	31	27	-6	3	10	Q	23
	-5	-14	37	-60	-123	-114	-101	-158	-73	20	21	57	95	95	37	-27	-21	-37	-59	-78	-76	-108	-202	-73	D	-40
Nov.	-6	13	-3	-14	-44	-15	2	15	19	25	42	47	60	75	78	59	48	44	5	-20	-8	-13	-13	-15	A	16
	34	48	13	6	17	38	41	26	13	13	16	21	29	34	54	63	62	61	53	55	46	27	24	22	Q	34
	-48	16	22	5	-83	-79	-60	-7	17	46	92	63	54	91	69	13	-61	-30	-73	-130	-107	-22	-113	-54	D	-16
Dec.	8	3	6	-1	-22	-16	-21	0	4	18	37	64	90	88	87	78	73	68	31	25	2	-13	7	23	A	27
	11	14	10	8	7	31	33	27	18	13	16	33	47	55	63	63	71	70	61	61	51	44	38	34	Q	37
	-22	-46	54	29	-27	-64	-99	-17	18	16	63	89	105	57	44	9	7	43	-36	2	-50	-33	29	29	D	8
Year	-13	-10	-16	-25	-39	-33	-19	-8	4	15	28	42	53	59	63	56	45	32	13	-4	-17	-22	-27	-24	A	6
	8	10	2	0	2	16	24	21	18	16	19	23	29	35	40	45	46	47	40	37	25	8	10	8	Q	22
	-59	-49	-31	-41	-73	-63	-74	-66	-32	7	44	69	75	72	61	23	-8	-18	-39	-57	-77	-64	-93	-77	D	-24

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

Declination East (D) :

MAWSON ANTARCTIC 1993 -64 deg - tabular values in 0.1 min

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	342	370	430	495	591	644	561	490	431	393	382	362	345	337	322	305	323	319	308	283	270	273	291	309	A	382
	350	401	448	531	612	605	499	434	406	386	381	363	364	351	359	359	375	369	372	362	357	329	316	357	Q	404
	306	337	491	431	500	654	656	661	490	396	387	398	360	330	296	276	322	283	272	196	207	231	266	278	D	376
Feb.	364	390	425	507	584	627	555	502	460	419	380	368	369	352	349	348	353	359	337	313	329	316	329	368	A	404
	381	398	432	483	530	542	492	444	421	407	392	370	365	352	357	367	378	380	377	372	375	358	372	382	Q	405
	353	386	417	562	618	617	544	549	522	452	376	367	376	371	355	351	364	340	248	242	288	248	294	349	D	400
Mar.	408	424	469	523	594	643	608	550	469	417	412	396	384	378	381	374	376	384	364	337	330	323	375	392	A	430
	428	448	502	511	553	539	487	456	426	416	400	382	384	388	384	389	391	385	396	357	310	299	349	388	Q	415
	418	386	517	546	566	591	672	689	608	476	456	409	404	393	397	406	367	347	360	286	345	332	432	375	D	449
Apr.	432	462	484	511	567	572	537	493	464	440	415	410	406	403	403	412	403	413	408	400	388	388	393	432	A	443
	450	441	444	468	476	490	473	450	441	428	417	412	414	412	415	409	405	406	406	408	403	403	412	423	Q	429
	436	475	541	560	610	625	627	574	581	526	466	442	426	409	411	494	434	368	363	354	323	367	378	429	D	467
May	479	471	492	508	528	519	495	483	449	436	418	412	410	409	404	405	405	411	411	412	411	400	420	440	A	443
	439	443	448	456	444	444	450	448	440	432	425	419	421	418	417	419	421	422	421	419	422	424	424	431	Q	431
	649	554	596	687	675	608	529	541	486	474	436	418	401	397	393	406	416	426	407	410	373	396	398	446	D	480
Jun.	443	486	508	506	523	515	501	476	445	427	415	414	414	412	411	410	413	423	421	428	412	415	426	437	A	445
	434	445	451	450	443	447	453	453	441	431	424	425	422	420	419	418	419	422	429	426	428	424	430	431	Q	433
	441	511	557	523	618	598	574	515	438	433	417	409	411	407	402	398	419	444	368	451	398	438	430	435	D	460
Jul.	460	493	517	540	541	510	488	463	444	420	411	409	410	413	410	417	420	419	433	441	434	434	425	435	A	449
	434	459	458	457	462	458	453	450	443	433	425	425	425	423	422	421	423	419	425	428	430	431	427	428	Q	436
	489	604	625	702	741	590	540	490	479	409	397	407	402	398	377	412	437	417	424	473	481	416	429	428	D	482
Aug.	487	493	496	496	517	534	525	478	460	440	428	428	427	427	421	428	423	421	443	435	430	426	438	456	A	457
	489	471	455	449	448	452	456	459	453	448	441	436	435	434	434	434	435	433	437	445	442	434	455	451	Q	447
	500	548	535	519	532	601	621	529	519	452	409	428	435	422	418	464	413	401	470	416	497	442	465	473	D	480
Sep.	471	491	507	537	567	557	530	513	486	464	441	430	427	420	418	420	444	428	420	425	421	419	414	431	A	462
	458	453	479	513	524	498	481	473	463	445	444	442	437	427	421	423	436	437	442	442	440	458	446	449	Q	455
	485	532	538	566	628	624	668	697	597	540	451	426	425	429	417	406	538	437	389	408	338	430	355	348	D	486
Oct.	460	487	542	613	638	626	576	544	494	461	445	443	421	406	408	413	413	425	415	428	410	402	411	429	A	471
	485	492	525	568	537	518	509	493	476	462	448	439	436	438	432	432	428	437	437	427	426	432	417	430	Q	464
	443	492	500	614	730	733	711	736	626	508	494	496	418	356	384	397	381	397	403	455	434	310	392	394	D	489
Nov.	421	473	532	600	668	636	570	513	477	454	448	432	418	401	393	399	401	399	393	393	378	367	375	399	A	456
	426	443	514	577	583	546	509	488	468	450	436	423	425	431	426	433	436	434	438	431	416	396	400	400	Q	455
	422	504	548	623	717	737	694	631	557	537	541	495	433	384	365	333	349	390	337	344	304	331	333	400	D	471
Dec.	423	465	524	589	661	655	630	553	516	473	449	434	415	399	395	385	389	389	391	370	362	364	375	382	A	458
	452	472	548	591	625	561	522	483	462	447	434	430	423	422	423	429	426	428	436	422	410	399	382	397	Q	459
	404	477	489	527	649	756	831	699	626	588	550	518	443	411	384	305	336	322	300	269	325	352	341	349	D	469
Year	433	459	494	535	582	587	548	505	466	437	420	411	404	396	393	393	397	399	395	389	381	377	389	409	A	442
	435	447	475	504	520	508	482	461	445	432	422	414	413	410	409	411	414	414	418	412	405	399	402	414	Q	436
	446	484	530	572	632	645	639	609	544	483	448	434	411	392	383	387	398	381	362	359	359	358	376	392	D	459

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

Inclination (I) :

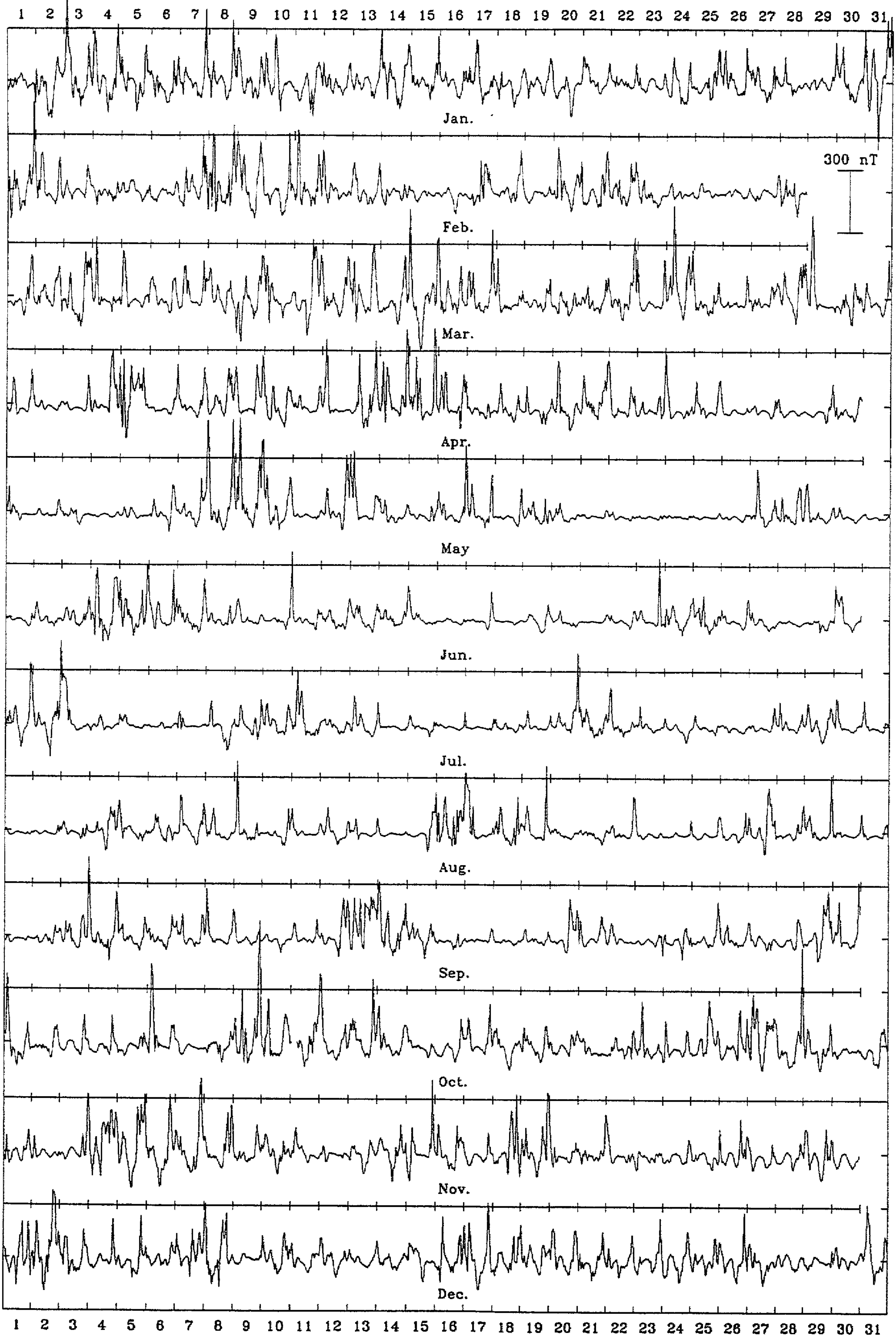
MAWSON ANTARCTIC 1993 -67 deg - tabular values in 0.1 min

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Mean
Jan.	650	639	645	652	672	669	637	626	616	613	598	566	555	546	538	535	544	557	584	618	621	630	632	643	A	608
	631	627	637	656	673	631	599	601	606	606	595	600	602	587	585	584	583	578	578	583	593	619	618	638	Q	609
	741	712	741	666	673	720	701	717	665	631	585	495	502	509	525	535	546	582	598	649	660	640	660	656	D	630
Feb.	632	628	631	659	683	669	631	625	618	616	605	591	576	571	572	570	576	582	592	624	631	631	631	631	A	616
	600	599	607	611	613	606	599	600	602	605	604	599	590	578	588	594	593	590	586	583	593	599	610	605	Q	598
	668	682	634	711	751	700	645	663	632	620	598	564	536	561	564	564	586	585	613	626	677	678	691	681	D	635
Mar.	664	670	662	668	688	688	673	651	623	606	596	589	583	572	566	573	590	617	638	629	660	662	670	679	A	634
	642	700	701	673	658	623	603	607	609	612	608	605	600	600	590	569	571	572	603	602	625	652	614	632	Q	620
	709	652	639	634	639	678	781	748	656	606	589	582	585	572	567	606	607	663	696	653	627	688	781	758	D	655
Apr.	641	643	667	662	656	662	644	625	621	605	601	599	597	593	587	587	586	599	607	611	632	662	661	666	A	626
	631	618	616	617	613	607	598	595	597	600	604	606	604	601	599	595	589	584	582	585	602	632	621	618	Q	605
	632	646	733	698	661	690	717	680	704	630	607	603	607	599	599	640	633	639	657	632	724	686	662	698	D	657
May	648	642	644	653	644	621	610	603	597	600	595	590	580	579	575	574	576	579	588	604	613	630	633	645	A	609
	599	599	601	604	595	588	588	590	593	593	594	593	592	591	589	589	589	587	583	583	589	589	595	597	Q	592
	771	769	734	790	737	664	636	628	599	621	600	578	552	557	554	553	583	599	604	658	681	738	712	702	D	651
Jun.	622	631	634	625	631	624	613	602	596	593	586	584	576	575	569	569	569	567	570	583	588	602	631	636	A	599
	590	592	594	594	588	589	588	589	590	590	591	590	588	586	584	583	581	578	577	572	575	580	597	594	Q	587
	635	663	647	620	699	699	663	623	605	589	565	565	558	561	541	547	567	565	575	603	605	644	727	723	D	616
Jul.	618	634	649	655	644	614	603	599	598	591	589	583	576	570	565	566	570	568	568	572	587	603	612	622	A	598
	606	602	598	591	592	587	583	585	588	590	591	589	587	584	582	579	577	571	565	565	571	575	582	605	Q	585
	659	701	711	755	752	657	647	638	635	603	587	569	556	533	518	536	559	570	576	588	616	642	656	688	D	623
Aug.	638	635	631	625	620	618	616	595	590	588	586	583	578	570	570	571	572	579	575	581	599	601	624	640	A	599
	631	604	593	585	581	577	577	579	583	585	589	591	588	586	585	582	582	580	579	579	580	586	596	612	Q	588
	666	705	671	648	626	661	689	639	605	594	576	572	554	521	540	563	584	635	580	618	655	619	650	677	D	619
Sep.	632	636	629	628	633	617	601	598	596	596	589	582	577	574	567	566	573	579	595	602	605	615	641	638	A	603
	596	592	612	615	598	585	581	581	582	587	586	589	588	583	578	573	579	577	573	575	581	592	597	599	Q	587
	699	660	640	644	697	658	657	665	652	631	582	547	536	564	564	574	596	604	645	655	647	646	702	710	D	632
Oct.	634	634	647	665	655	638	617	618	602	588	586	573	566	560	559	564	567	574	587	606	623	639	651	633	A	607
	631	621	617	602	581	577	578	582	588	595	597	593	593	590	582	573	563	569	577	578	584	609	609	606	Q	592
	631	639	603	678	720	711	694	725	649	578	574	540	531	530	557	599	603	611	643	659	647	708	747	683	D	635
Nov.	634	620	631	634	643	611	596	587	587	586	574	573	562	549	543	549	557	562	591	608	605	616	627	636	A	595
	600	589	608	609	591	572	569	579	589	592	593	592	588	584	571	563	563	562	566	564	570	586	597	601	Q	583
	665	624	620	625	689	667	651	600	586	569	525	548	551	521	515	552	610	595	643	692	668	633	712	675	D	614
Dec.	621	625	622	623	629	617	611	601	594	586	575	557	537	534	532	539	539	540	567	578	599	615	607	604	A	585
	609	606	604	601	594	575	574	578	585	590	591	583	577	571	564	563	556	555	556	553	562	569	577	587	Q	578
	656	676	614	636	673	686	682	631	588	575	535	502	497	519	529	561	555	549	608	600	633	635	600	609	D	598
Year	636	637	641	646	650	637	621	611	603	597	590	581	572	566	562	564	568	575	588	601	614	626	635	639	A	607
	614	612	616	613	606	593	586	589	593	596	595	594	591	587	583	579	577	575	577	577	585	599	601	608	Q	594
	678	677	666	675	693	683	680	663	631	604	577	555	547	546	548	569	586	600	620	636	653	663	692	688	D	630

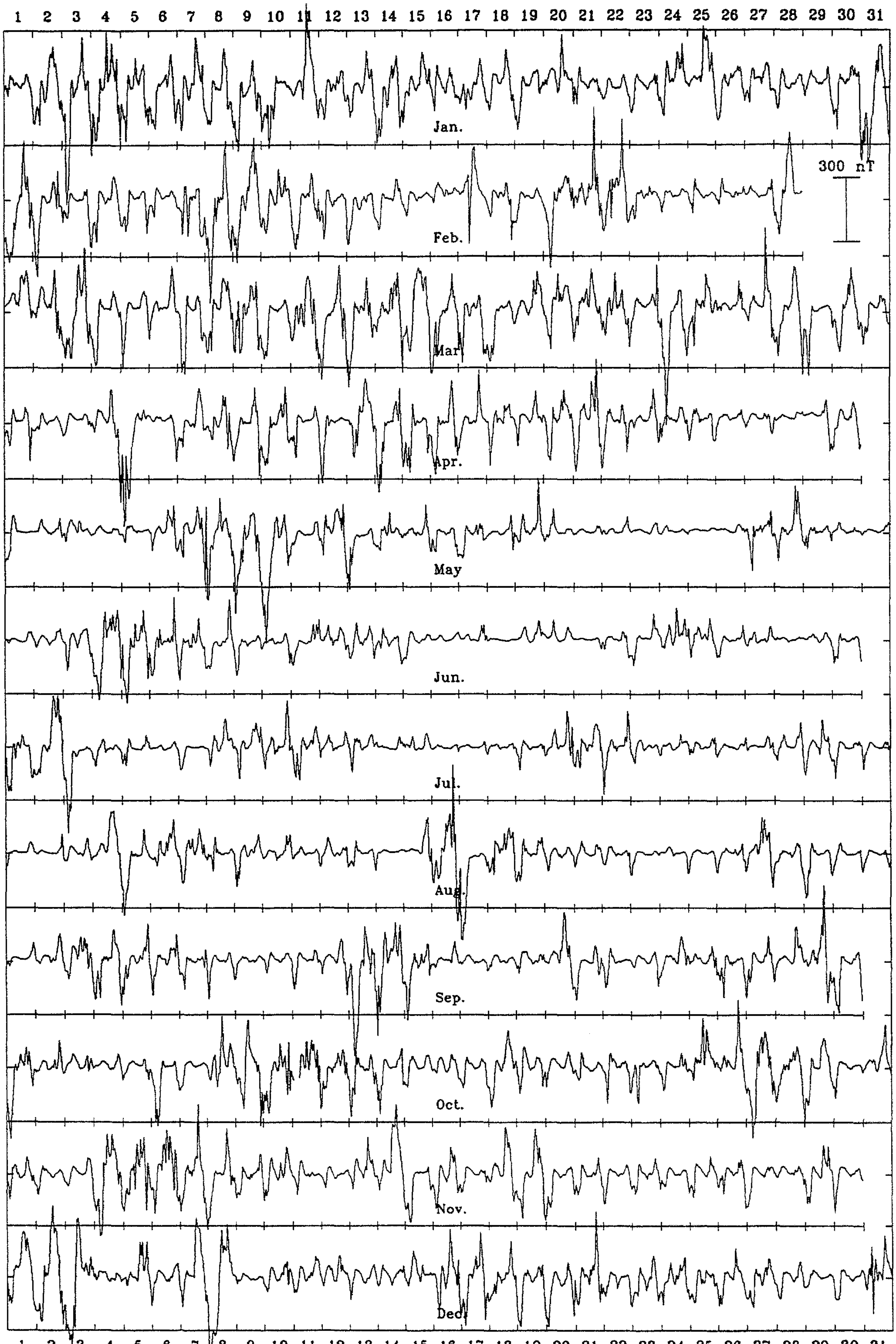
Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:13:35 HRS., Mon. 20 JUN. 1994 .

MAWSON ANTARCTIC 1993 North component (X). Scale:25.0 nT/mm.

MAWSON ANTARCTIC 1993 East component (Y). Scale:25.0 nT/mm.

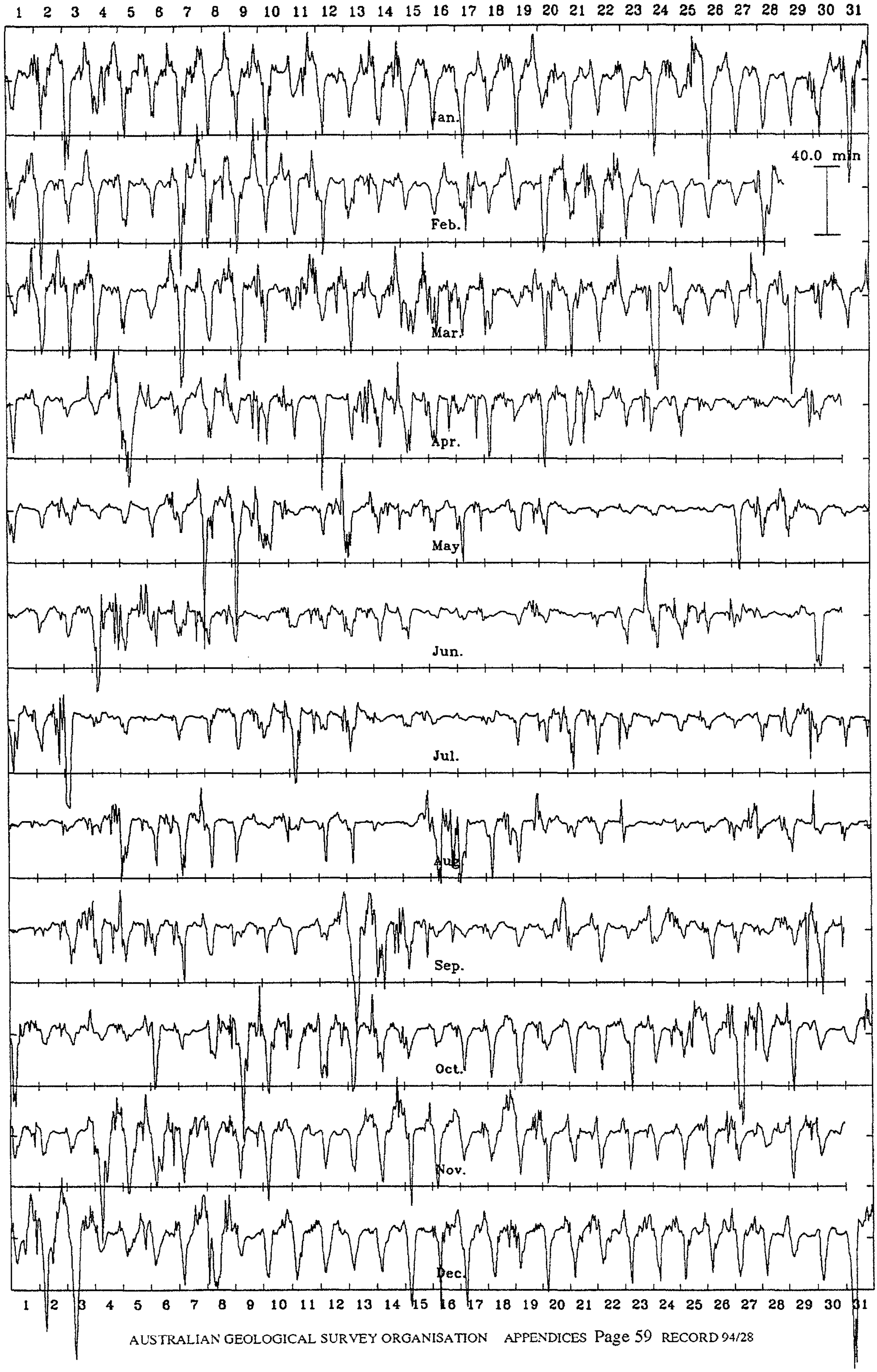


MAWSON ANTARCTIC 1993 Vertical intensity (Z). Scale:25.0 nT/mm.

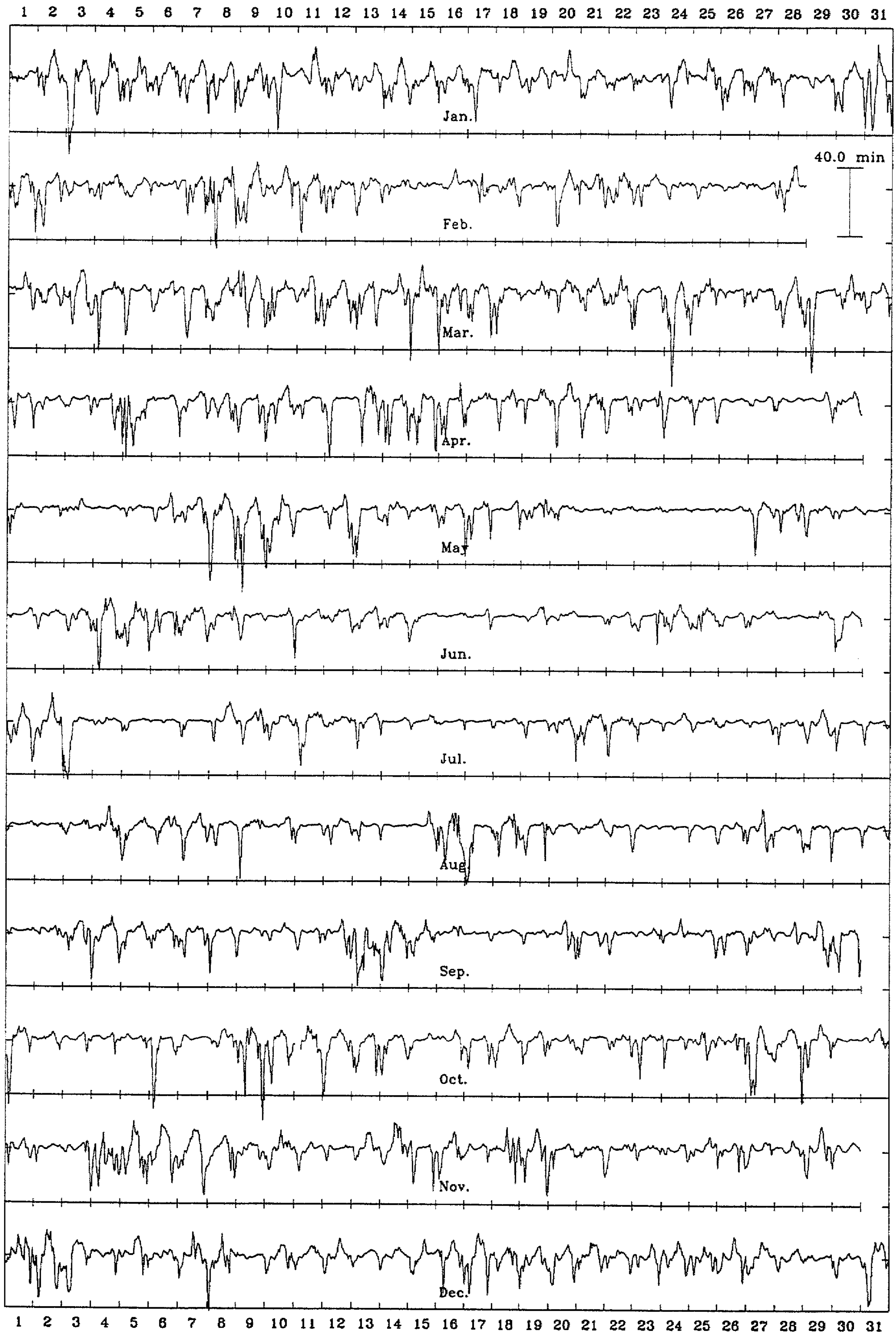


MAWSON ANTARCTIC 1993 Horizontal intensity (H). Scale:25.0 nT/mm.

MAWSON ANTARCTIC 1993 Declination (east) (D). Scale: 3.0 min/mm.



MAWSON ANTARCTIC 1993 Inclination (I). Scale: 3.0 min/mm.



MAWSON ANTARCTIC 1993 Total intensity (F). Scale:25.0 nT/mm.