Mawson Geophysical Observatory Annual Report 1994

By

A.J. Giffen

Record 1995/47

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Department of Primary Industries & Energy

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

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Mawson Geophysical Observatory Annual Report 1994

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Geomagnetism Section
Geophysical Observatories and Mapping Division, AGSO

Canberra 1995

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SUMMARY

Mawson is an Australian National Antarctic Research Expedition base on the Antarctic mainland managed by the Australian Antarctic Division. Geomagnetic and seismological recording and processing equipment, were maintained and calibrated by an observer provided by the Australian Geological Survey Organisation during 1994.

Earthquake phase data were reported weekly to AGSO and to the National Earthquake Information Service (Boulder, Colorado) via email. Magnetic results were reported monthly to AGSO, and then to the French Department de Geomanetisme et Paleomagnetism for use in the Oersted magnetic satellite project.

The magnetic results indicate the secular variation of the field at Mawson was relatively unchanged over the year, with only a three nanoteslas decrease in total intensity and a 5.5 minute increase in westerly declination. Magnetic data recorded at the Casey and Davis Antarctic bases were also processed by the Mawson observer and indicated similar relative stability.

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 Environment, Sport and Territories. This report describes the Mawson Geophysical Observatory and gives a summary of the geomagnetic data and results for 1994. 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, 1994

<u>Magnetic Absolute Hut - Pier A</u> (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

<u>Magnetic Variometer Building - Mark N1</u> (Crosthwaite, 1986)

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

<u>Cosray Vault - Seismometer Platform</u> (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 1994 are listed in Appendix A.

The author arrived at the Mawson ice-edge aboard the M.V. Aurora Australis on 10 December 1993, flew by helicopter into Mawson and assumed responsibility for the observatory. The previous observer, Anton Rada performed instrument comparisons before departing on 15 December 1993 (Rada, 1994). The following summer, the replacement observer for 1995, Suzanne Barr, flew by helicopter from Davis to Mawson arriving on 15 November 1994 after her voyage to Davis aboard the M.V. Aurora Australis. No instrument comparisons were carried out during this changeover as previous comparisons had shown all AGSO DIMs to have zero instrument corrections. I departed Mawson by helicopter on 19 November 1994 to board the M.V. Aurora Australis in Prydz Bay for the return voyage to Hobart.

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 17 observations of F, D, I and H were carried out every month using the absolute 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, 1994). The first absolute observation by the author was carried out on 18/12/93 and the last on 11/11/94.

A typical monthly observation schedule for 1994 comprised of:

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

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

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

All QHM observations followed the standard 9 minute QHM observing schedule with a sighting on azimuth mark BMR 89/2 taken before and after, so both H and D could be 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 with the weight hanging between sets of absolute observations.

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. All D measurements were referenced to the azimuth mark BMR 89/2. 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. After periods of blowing snow in the second half of 1994 the mark became obscured from view and was dug clear by hand.

Temperature calibrations were performed at the start of the absolute observation. This was done by manually recording the temperature of the variometer room, as displayed on the Doric Trendicator, while a fiducial file on the acquisition PC recorded digital temperature counts for the RCF sensor head.

2.2 Absolute Instruments

The primary absolute instruments used at Mawson in 1994 were :

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

The secondary instruments were :

QHM 300, Thermometer 1650, Askania glass circle 611665	for H and 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

QHM constants and thermometer correction factors are given in Table 2 and instrument parameters (QHM α angles corrected to H=18500 nT 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.

Table 2. QHM Constants, Reduction Formula and Thermometer Corrections 1994

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'

QHM reduction formula:

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

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 2π. Whereas the software used to calculate H throughout 1994 used values of n as the multiples of π. Consequently the value of K in this table is half the value of K that is often quoted for the instruments.

Thermometer Correction Factors 1994

Thermometer	*-10°C*	*0°C*	*+10°C*	*+20°C*	*+30°C*	*+40°C*
1650	-0.10	0.00	+0.05	+0.20	+0.10	+0.15
1401	+0.10	+0.10	+0.05	0.00	-0.50	
1416	-0.10	-0.10	-0.10	-0.05	-0.10	-0.10
619		-0.05	0.00	-0.05	-0.10	-0.10
704	0.00					0.00

The secondary instruments were included in the observation routine and comparison with the standard instruments produced the instrument differences listed in Table 4. All differences for 1994 have been calculated from paired observations with the respective instruments.

Table 3. QHM and Declinometer Parameters at Mawson 1994

QHM α Angles

Instrument	*Mean α Angle*	*Samples*	*1993 Average*
QHM 300	13.1 ' ± 0.4	86	12.7 ' ± 0.3
QHM 301	-11.4 ' ± 0.6	12	-11.8 ' ± 0.7
QHM 302	-0.4 ' ± 0.9	17	-0.1 ' ± 0.6

Declinometer Erect-Inverted Angles

Instrument	*Mean Erect-Inverted Angle*	*Samples*	*1993 Average*
Declinometer 630332 Circle 611665	0.8 ' ± 0.3	104	1.2 ' ± 0.4

Table 4. Instrument Differences Through Baselines

Instrument A	*Instrument B*	*Field Component*	*1994 Instr. Difference A-B*	*Samples*	*1993 Instr. Difference*
Decl 630332	QHM 300	D	-2.0 ' ± 0.6	80	-2.1 ' ±0.8 [1] -2.3 ' ± 0.6 [2]
Decl 630332	QHM 301	D	0.6 '± 0.8	10	0.2 ' ± 1.0
Decl 630332	QHM 302	D	0.2 ' ±1.2	9	0.4 ' ± 0.9
Decl 630332	DIM 208	D	-1.0 '± 0.5	54	-1.4 ' ±0.6
QHM 300, PPM 199	DIM 810/208	I	-0.8 ' ± 0.9	57	-0.2 ' ± 0.6
QHM 300	QHM 301	H	6.6 nT ± 1.8	9	6.6 nT ±0.9
QHM 300	QHM 302	H	-2.4 nT ± 2.0	9	-0.9 nT ± 1.3
QHM 300	DIM 208,PPM 199	H	3.7 nT ± 3.0	57	5.6 nT ± 3.4 [3] 2.0 nT ± 4.1 [4]

[1] Average of day 220 to 320 , 1993
[2] Average of day 335, 1992 to day 40 ,1993
[3] Average of day 0 to 183, 1993. Instruments not used together
[4] Average of day 183 to 330, 1993. Instruments not used together

Figure 1 shows the difference between X, Y and Z measured by DIM 810/208 and QHM 300 for all paired observations done with these instruments. An instrument correction for QHM 300 has been determined from this plot and is given in Table 5. These corrections have been applied to the X, Y and Z residual plots in Figure 5.

The DIM operated without fault during the year with the only alteration being a battery change on 18 December 1993 when the metal jacketed "Eveready Energizer" ™ batteries were replaced with cardboard jacketed "Eveready Red Heavy Duty" ™ batteries.

Elsec PPM 770/199 also operated without fault and had the "Energizer" ™ batteries replaced with "Eveready Red Heavy Duty" ™ batteries on 18 December 1993.

The fibre in Declinometer 611665 was broken during changeover on November 15, 1994 and during an attempt to replace the fibre, one of the top clamping screws had its thread stripped and made a successful fibre replacement impossible. Before this repair was attempted a search was made for the tube that is supplied with each declinometer to hold a spare fibre under tension ready for loading. One was not found nor was the box that should be used to transport the declinometer. To allow repairs to be made to Declinometer 611665, Askania Nr. 509320 was sent in January 1995 to provide spare parts.

All three QHMs (300, 301 and 302) functioned correctly through 1994 and no repairs or adjustments were required.

Figure 1. Instrument difference between DIM 810/208 and QHM 300.

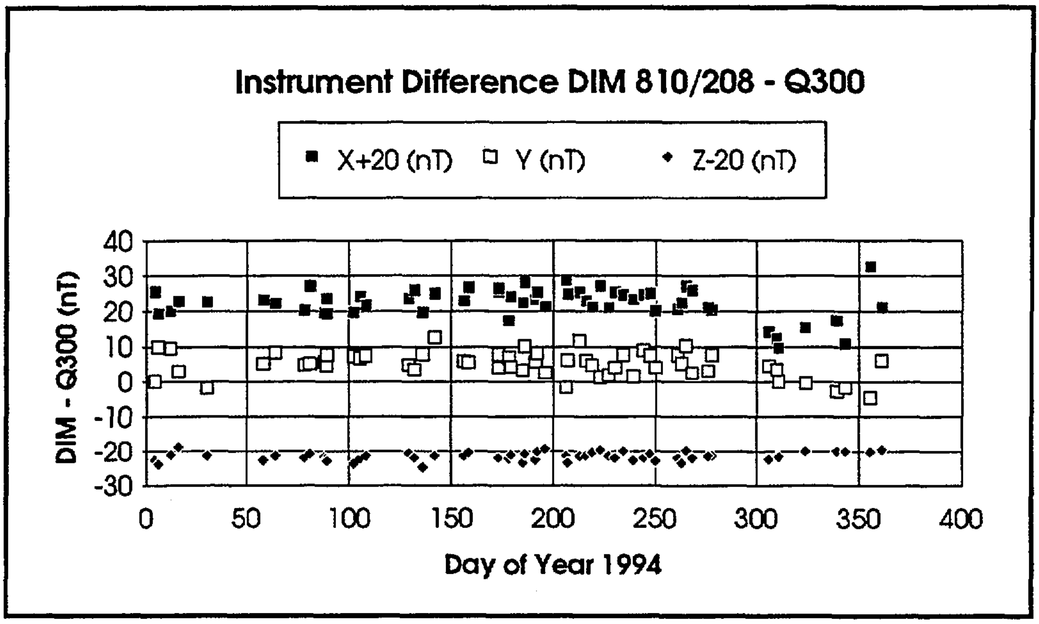
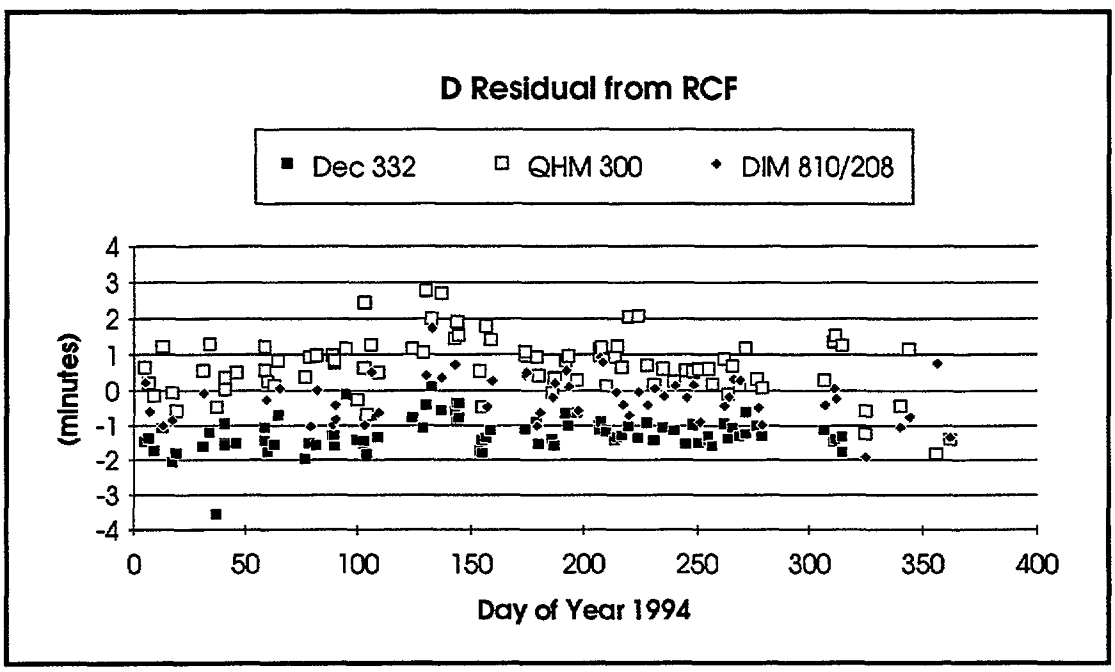


Table 5. Instrument Corrections for QHM 300

Days of 1994	*X correction (nT)*	*Y correction (nT)*	*Z correction (nT)*
1 - 279	3 - 5 [1]	6 - 5 [1]	-1.5
280 - 365	0 [2]	0 [2]	0

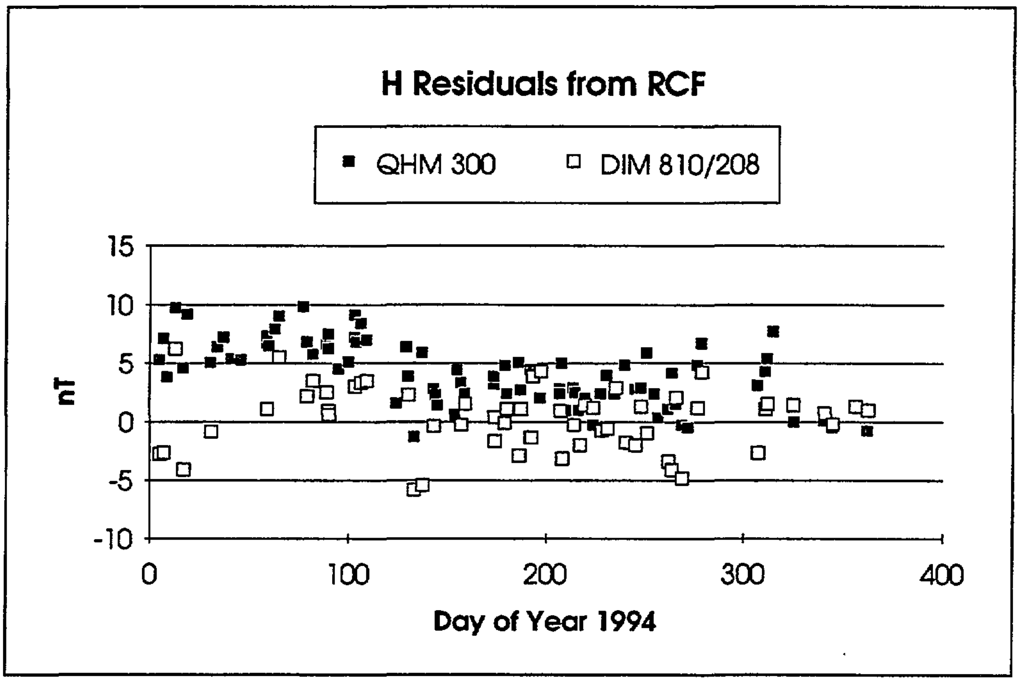
[1] Applied with a linear drift from day 1 to 279
[2] No instrument correction applied to this period due to the high scatter and inconsistency with the rest of the year

Figure 2. Declination Instrument difference through RCF Variometer.



Note: This graph shows the difference between absolute instrument declination and the RCF variometer (abs D- var D). Absolute instrument corrections have not been applied to produce this graph but final variometer parameters have been used for RCF.

Figure 3. Standard Instrument H Comparison.



Note: This graph shows the difference between absolute instrument and RCF variometer horizontal field strength (abs H- var H). Absolute instrument corrections have not been applied to produce this graph but final variometer parameters have been used for RCF. Figure 3 shows a change between H measured by DIM 810/208 and H measured by QHM 300 from day 0 to approximately day 80.

2.3 Standard Instrument Comparisons and Corrections

The only travelling standard taken to Mawson during the summer of 1994/95 was Elsec PPM 770/210 and a comparison between it and 770/199 was performed by Suzanne Barr on 10 January 1995. Pre and post Mawson comparisons between PPM 210 and the Australian F standard were performed at the Canberra Observatory and results of all comparisons are given in Table 6.

Table 6. PPM Comparisons - August 1994 to May 1995

Date	*Place*	*Primary Instrument A*	*Secondary Instrument B*	*A-B*
31/08/94	Canberra	MNS 2.3	PPM Elsec 770/210	1.2 nT ± 0.3
10/01/95	Mawson	PPM Elsec 770/210	PPM Elsec 770/199	2.8 nT ± 0.7, 3.4 nT ± 0.4
23/05/95	Canberra	MNS 2.3	PPM Elsec 770/210	0.8 nT ± 0.2

The most recent set of full comparisons were made between the travelling standard instruments and the Mawson standards during the change over in December 1993 by Anton Rada. 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 770/210	in bolts down orientation	for F

A summary of these comparison results are given in Rada, 1994.

An analysis of absolute instrument corrections for Mawson for 1991 - 1993 can be found in Dennis, 1993. Adopted corrections for the standard instrument combination in 1993 of QHM 300, Dec 630332 and PPM 199 and the 1994 standard instruments are given in Table 7. The difference between the 1993 and 1994 corrections are consistent with the instrument difference between the two combinations of instruments. This supports the use of zero corrections for the DIM as suggested in Dennis, 1993, assuming no significant drift has occurred in Q300 or Dec 332.

Table 7. Adopted instrument corrections for 1993 and instrument differences 1994

Field Component	*Adopted correction 1993 (Q300, Dec 332, PPM 199)*	*Adopted Correction 1994 (DIM 208, PPM 199)*
H	- 3.5 nT	+1.5 nT
D	+ 1.4 '	+ 0.0 '
F	+1 nT	+4 nT

The corrections adopted for 1994 to bring the Mawson standard instrument combination of: DIM 810/208 and PPM E770/199 into line with Australian and international standards are :

I: 0.0 ', D: 0.0 ', F: +4 nT

In terms of X,Y,Z and H this corresponds to : X: +0.6 nT, Y: -1.3 nT, Z: -3.7 nT, H: +1.5 nT

These instrument corrections have been compared against previous years, adopted as the best available and incorporated into the mean field values in this report.

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 1993, and remained there until a series of observations were performed on 27 April 1994 to calculate the level of contamination (See Rada (1994)). Additional observations were done with QHM 300, Dec 332 and PPM 199, with the DIM case in the same position in the absolute hut, on days 180, 207 and 257 with the results presented in Appendix G.

The results determine the effect of the magnetic case to be :

-1 nT in X, -3 nT in Y, and +1nT in Z

For absolute observations made with DIM 810/208 and PPM 199 on pier A in 1994 the corrections are :

For 1 January to 27 April

Component	*X (nT)*	*Y (nT)*	*Z (nT)*
Instrument Correction:	+0.6	-1.3	-3.7
DIM Case Correction:	+1.0	+3.0	-1.0
Total Correction:	**+1.6**	**+1.7**	**-4.7**

For 28 April to 31 December

Instrument Correction:	+0.6	-1.3	-3.7
Total Correction:	**+0.6**	**-1.3**	**-3.7**

These corrections have been incorporated into the mean field values in this report.

2.4 Variometers and Recording Equipment

A Ringcore Fluxgate Variometer (RCF) and Photo Electronic Magnetometer (PEM) were used to measure geomagnetic variation during 1994. 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.

The Ring Core Fluxgate variometer was installed at Mawson in December 1992 and run in parallel with the PEM variometer until blasting in the quarry on 19 January 1994 caused misalignment of the optics in all channels of the PEM. The magnet in the QHM of the Y channel PEM also flipped.

The RCF had been performing satisfactorily during the comparison period so operation of the PEMs was discontinued. The magnet in the Y channel of the PEM was unflipped and all magnets were clamped. All three components were covered with plastic sheeting and power to the PEM controller was disconnected. See Chapter 5 for details on the damage caused to geomagnetic buildings by the quarry blast.

Ringcore Fluxgate Variometer (RCF)

The RCF system was installed by A. Rada in the Variometer Building on December 11 1992 (See Rada (1994)). 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.

The PPM stopped logging data on 6 September 1994 due to a faulty E820 sensor head. There was no spare E820 head at Mawson at this time so the head from Elsec E770/206 was used as the replacement and gave acceptable results. The head was replaced on 8 September 1994.

Fiducial recording was possible for most absolute observations during the year using the three fiducial buttons located :

1. On the wall adjacent to the acquisition PC in the variometer building (for temperature calibrations)
2. On the bench in the absolute hut (for PPM readings)
3. Hanging from Pier A in the absolute hut (for declinometer, QHM and DIM readings)

None of the pulses from any of the fiducial buttons were recorded during an absolute observation on 20 June 1994. The problem was traced to a faulty digital I/O card (Computer Boards Inc CIO-DIO24) in the acquisition PC. The faulty card, serial number 7102, was replaced with serial number 6697 on 4 July 1994. During a blizzard on 12 June 1994 the acquisition PC locked up and it is likely that static electricity was the cause of the PC hanging and the damage to the I/O card.

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 was also logged with an Elsec 820 proton precession magnetometer (PPM).

The temperature of both the sensor housing (T_h) and the electronics (T_e) were monitored by sensors inside the perspex RCF sensor cover, and the electronics box, respectively. Temperature in the variometer room was regulated by a fast-cycle heater, nominally set at 10^o C. The temperature difference between the thermostat of the heater and temperature sensor for T_h was found to vary by as much as 5^o C during winter when heat losses from the room were at a maximum. Seasonal adjustment of the thermostat is required to compensate for this fluctuation.

The digital X, Y, Z, T_h, T_e and PPM data were recorded on an NEC IBM-AT compatible Powermate 1 Personal Computer located in the recorder room of the Variometer Building. The six channels of digital data were recorded as minute averaged values onto hard disk for all of 1994 except for the periods indicated in Table 8. One second recording of X, Y, Z, T_h,and T_e began on 28 February 1994 using Peter Crosthwaite's acquisition software "MACQ" (Version 2.13).

The telemetry line from Canberra (via Wombat) was connected to port COM3 on the RCF PC on 12 August 1994. The line had not been used since the satellite communication equipment at Mawson was moved from the ANARESAT building into the new Operations building during the summer of 1993/94. All modems and statistical multiplexers were reconfigured with a baud rate of 300 bits per second, no parity, 8 data and 1 stop bit. A switch in the Geophysics office in Wombat allows this line to be connected to either a terminal in Wombat or to AGSO in Canberra, via the modem and statistical multiplexer in the Operations building.

The timing for the digital recording system was taken from the computer DOS clock with a correction factor applied in the acquisition software. Several attempts were made to synchronise the DOS clock with the minute pulses from the GED clock in the Science Building using the digital I/O card but without success. The DOS clock was maintained to within 15 seconds of UTC between 1 January 1994 and 27 May 1994 and within 1 second of UTC from 31 May 1994 onwards. From 27 May to 31 May the clock correction factor was entered with the incorrect sign causing the clock to drift by 3 minutes and 15 seconds by 31 May. 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 twice per month.

Photo Electronic Magnetometer (PEM)

A description of the PEM measurement and recording systems is in Jamieson and Dennis (1993) and Rada (1994). The system only recorded for the first 19 days of 1994 and was not used for the reduction of absolute observations or for the calculation of geomagnetic field elements presented in this report.

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,

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

where X, Y and Z are the magnitudes of the geomagnetic elements in nanotesla
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
q_x, q_y, q_z are temperature coefficients
t_h is the digital temperature ordinate for the variometer sensor

The variometer temperature is derived using the equation:

$$T_h = B_t + S_t{*}(t_h)$$

where T_h is the variometer sensor temperature in degrees Celsius
B_t is the temperature baseline
S_t is the temperature scale value
t_h is the digital temperature ordinate for the variometer sensor

Calibration of the variometer temperature channel T_h was achieved using a Doric Trendicator Model 410A at the start of each absolute observation. The Doric readings (averages of 6 x 10s samples over an UTC minute) were regressed against the variometer temperature counts (also averages of 6 x 10s samples). Ninety two calibrations were used in the regression; covering the period 01/01/94 to 31/12/94. The resulting temperature model is :

$$T_h = (\mathbf{11.81} \pm 0.17) + (\mathbf{0.137} \pm 0.0068)(t_h) \text{ deg C}$$

Calibration of this temperature sensor was initially done by Jamieson (AGSO file 1989/1097) in September 1991 indicating the temperature model to be :

$$T_h = (\mathbf{10.8} \pm 1.5) + (\mathbf{0.263} \pm 0.015)(t_h) \text{ deg C}$$

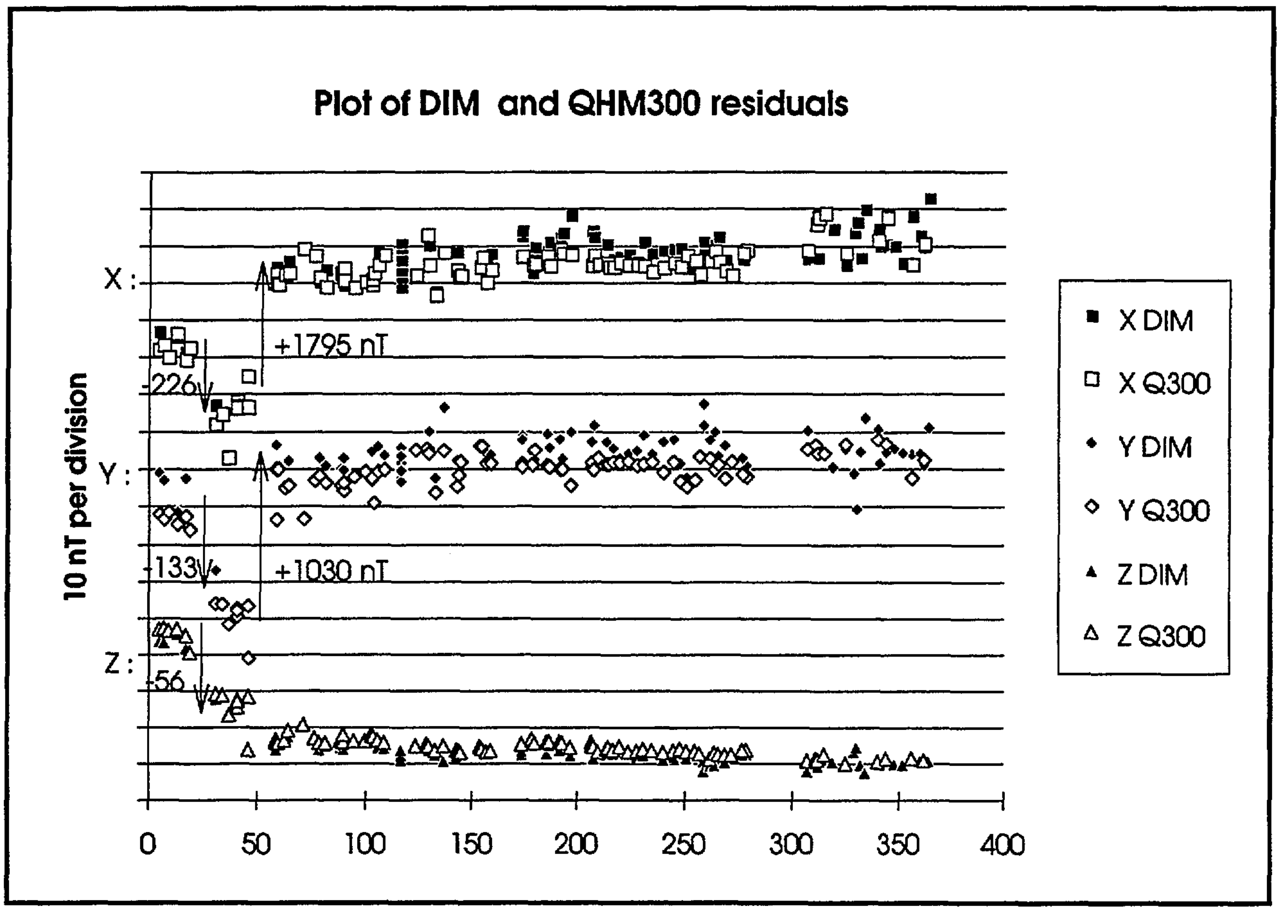
The significant difference between the scale values for these two sets of calibrations may be attributed to the separation between the temperature sensors of the Doric and the ringcore for the in-situ calibrations at Mawson in 1994. However, absolute calibration of the ringcore sensor temperature is not necessary for the variometer model as scale values for the dependence of the geomagnetic elements X, Y and Z on the sensor temperature are determined in terms of the digital ordinate t_h.

The scale value 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 applying baseline steps and drifts to the variometer model.

From results of linear regression analysis of several periods over the year, two scale value parameter matrices were adopted. The first applies to RCF data collected before the blast in the quarry on 19 January 1994 and the second applies to RCF data after this date. The analysis used a total of 171 observations with DIM 810/208, QHM 300 and PPM 199 on Pier A. The model is presented in Appendix D. Regression analysis results are presented in Appendix C.

Plots of the residuals determined using single, fixed baselines for the whole year are shown in Figure 4.

Figure 4. Plot of DIM and QHM300 residuals using fixed baselines and scale values



Note: This graph shows the difference between absolute instrument and variometer results using constants in force at 1/1/94 with baseline changes due to building repairs applied on 19/1/94 and 27/2/94 as indicated by the arrows.

Shown below are plots of residuals determined using the adjusted baselines and new variometer parameters. The contamination corrections of +1 nT in X, +3 nT in Y, and -1nT in Z, due to the DIM case, have been applied to the absolute observations from day 1 to day 117.

Figure 5a. Plot of X residuals determined using final variometer parameters.

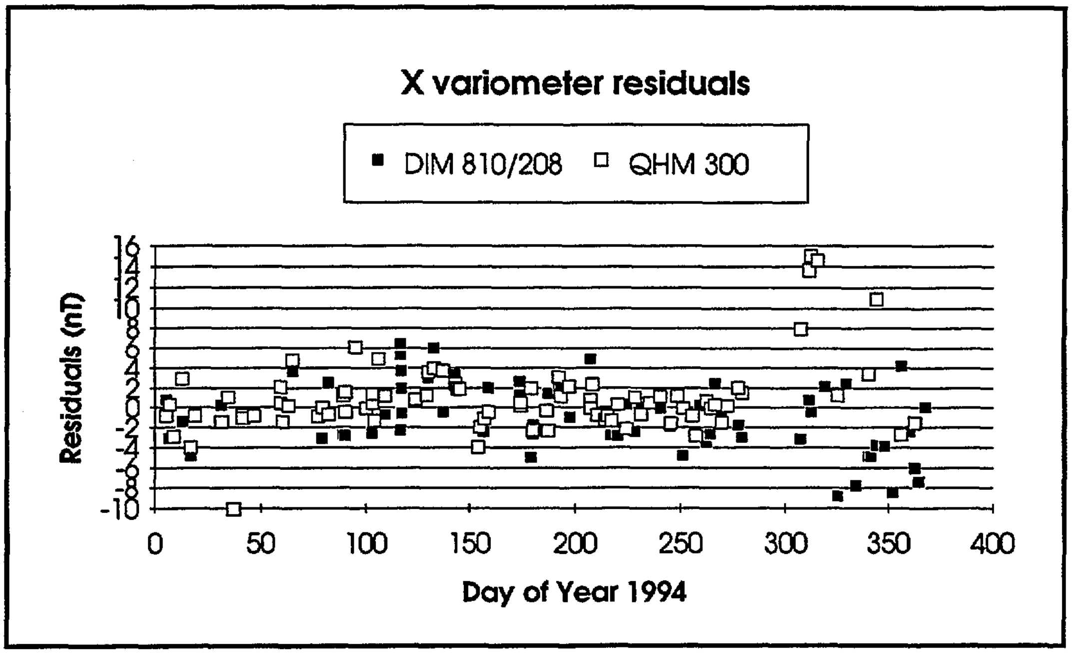


Figure 5b. Plot of Y residuals determined using final variometer parameters.

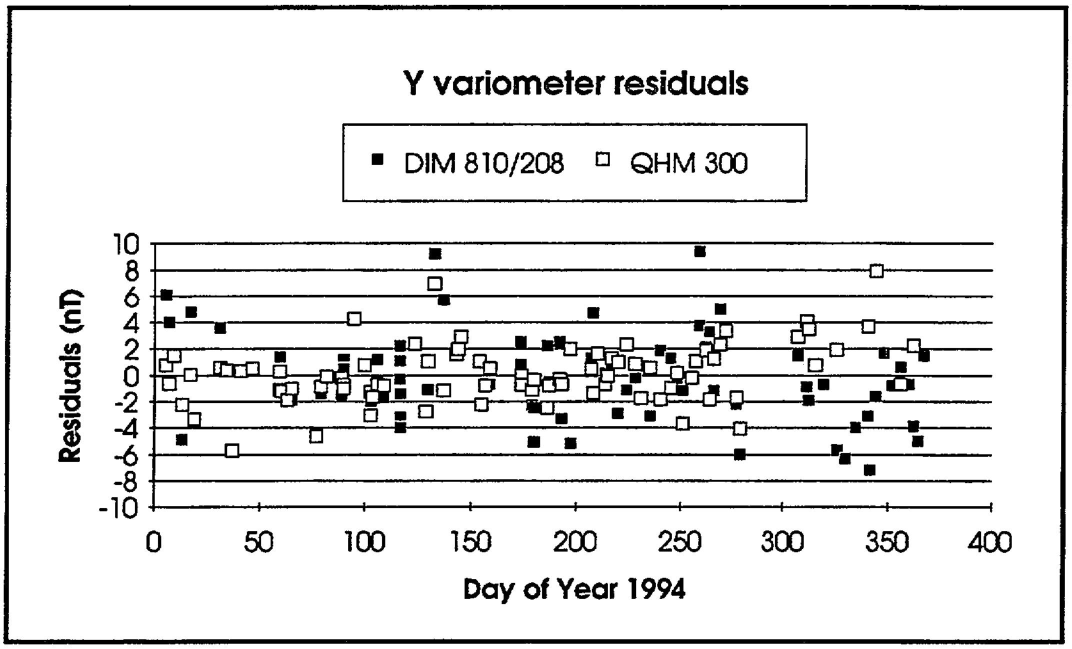
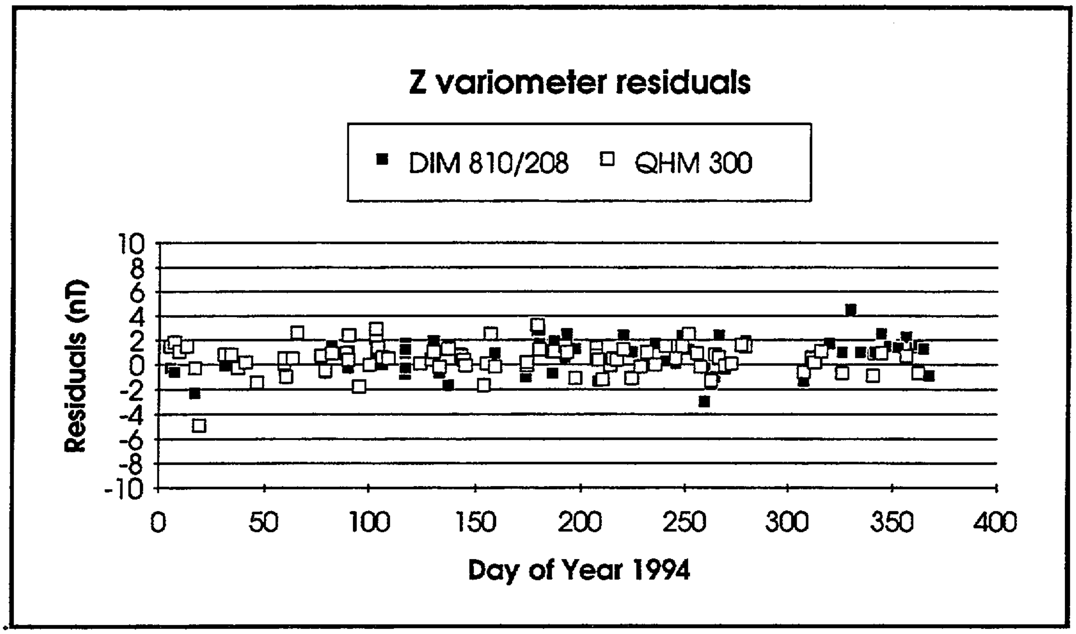


Figure 5c. Plot of Z residuals determined using final variometer parameters.



Orientation Calibrations

Calibrations using orientation coils are not possible on the RCF variometer system but the orientation of the X,Y, and Z channels can be determined from the system parameters. The matrix equation describing the system model can be written algebraically :

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

where: **F** is the geomagnetic vector field
$\mathbf{v}$-$\mathbf{v}_0$ is the variometer output vector
b, d, q are the baseline, drift rate and temperature coefficient vectors
s is the scale value matrix in the variometer coordinate system
t_h is the digital temperature ordinate for the variometer sensor

These vectors/matrix parameters refer to the reference system defined by the axes of the RCF 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

$$\mathbf{s}^{-1} = \mathbf{S}^{-1}.\mathbf{U} \qquad \text{where } \mathbf{S} = \begin{pmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & S_z \end{pmatrix} \text{ and } \mathbf{U} = \begin{pmatrix} \mathbf{u}_1 \\ \mathbf{u}_2 \\ \mathbf{u}_3 \end{pmatrix} = \begin{pmatrix} u_{11} & u_{12} & u_{13} \\ u_{21} & u_{22} & u_{23} \\ u_{31} & u_{32} & u_{33} \end{pmatrix}$$

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

$$\mathbf{U}.\mathbf{F} = \mathbf{U}.\mathbf{b} + \mathbf{U}.\mathbf{d}\Delta t + \mathbf{S}.(\mathbf{v}-\mathbf{v}_0) + \mathbf{U}.\mathbf{q}t_h$$

Taking the x component of this vector equation gives

$$\mathbf{u}_1.\mathbf{F} = \mathbf{u}_1.\mathbf{b} + \mathbf{u}_1.\mathbf{d}\Delta t + S_x(x-x_0) + \mathbf{u}_1.\mathbf{q}t_h$$

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 sensor 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, and x-x_0 is the variometer output.

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, giving :

$$\mathbf{U} = \begin{pmatrix} 1.0000 & 0 & 0 \\ 0 & 1.0000 & 0 \\ 0 & 0 & 1.0000 \end{pmatrix} \qquad \mathbf{S} = \begin{pmatrix} 0.0250 & 0 & 0 \\ 0 & 0.0238 & 0 \\ 0 & 0 & 0.0245 \end{pmatrix}$$

The orientation angles of the variometer can be derived from **U**,
ie. the deviation of the X sensor from north is arctan u_{12}/u_{11},
the deviation of the Y sensor from east is arctan u_{21}/u_{22},
the deviation of the Z sensor from north is arctan u_{32}/u_{31},
the deviation of the Z sensor from vertical is arctan $[\text{sqrt}\,(u_{31}^2 + u_{32}^2)\,/\,u_{33}]$

For 1994 the true scale values are identical to the diagonal elements of the variometer scale value matrix, as no significant interdependence was found between any channels. This implies perfect orientation of the ringcore sensors.

Data loss

Mawson RCF data loss for 1994 is summarised below:

Table 8. Mawson RCF data loss 1994

Start		*End*		*Channel*	*Duration*	*Cause*
Date	*UTC*	*Date*	*UTC*		*(hr:min)*	
19 Jan	9:49	29 Jan	9:31	All	239:43	Blasting in quarry damaged variometer building and power cables 1
6 Feb	8:43	6 Feb	8:46	All	0:04	Acquisition stopped when keyboard reconnected. PC rebooted
8 Feb	3:59	9 Feb	10:01	All	30:03	Start of repairs to variometer building 1
16 Feb	2:29	28 Feb	5:12	All	290:44	Repairs to variometer building and internal cabling 1
12 Jun	22:46	15 Jun	5:35	All	54:50	Acquisition PC locked up during a blizzard. PC cold booted
4 Jul	5:50 6:04 15:13	4 Jul	5:55 6:07 15:14	All	0:06 0:04 0:02	Acquisition PC turned off for replacement of digital I/O card
1 Sep	5:38	1 Sep	7:32	X,Y,Z,T_e,T_h	1:55	No data recorded from RCF for unknown reason. PC rebooted
6 Sep	3:04	8 Sep	14:51	F	59:48	PPM sensor head faulty
8 Sep	7:39	8 Sep	7:39	All	0:01	PC rebooted to check PPM operation

1 Some data is available for these periods but is not of observatory standard due to contamination of the variometer building during the repairs. See Table 9 for the times that variation data is available.

Table 9. Variation data available during repairs to the variometer building

Start	*End*
24 Jan 7:38	29 Jan 9:30
8 Feb 3:59	9 Feb 10:01
16 Feb 2:29	28 Feb 5:12

Data Continuity

Field values determined from the variometer data show reasonable consistency across the change of year from December 1993 to January 1994, as indicated by a comparison of daily averages. The average daily values for the comparison were calculated using (1) PEM data and parameters derived by Rada for period 4 of 1993, and (2) RCF data and the parameters derived for period 1 of this report. These values are compared in table 10. The differences for X are consistent to 2 nT or less. The Y and Z values differ by up to 4 nT for the last 5 days of 1993, and by up to 6 nT for the first 5 days of 1994. Hourly averages of the two datasets shows that this increase in the difference between RCF and PEM data occured after a magnetic storm (K6 level) on the morning of 31 December 1993. This implies a baseline step in either the RCF or PEM variometer that has not be accounted for in the adopted models.

A comparison between the total field strength measured by the RCF and the variometer PPM showed no deviation of the order of 2 nT after the storm and it is, therefore concluded that a baseline step occurred in the PEM Y and Z channels during the morning of 31 December 1993.

The true comparison between the models is during the four days before the baseline change for the PEM system.

Table 10. Comparison of daily averages during changeover period.

Day	*1993 PEM Model*			*1994 RCF Model*			*PEM - RCF*		
	X (nT)	*Y (nT)*	*Z (nT)*	*X (nT)*	*Y (nT)*	*Z (nT)*	*X (nT)*	*Y (nT)*	*Z (nT)*
27/12/93	7908.1	-16784.3	-45815.3	7909.2	-16779.8	-45811.4	-1.1	-4.5	-4.0
28/12/93	7906.8	-16771.1	-45806.8	7906.8	-16766.7	-45803.5	0.1	-4.4	-3.3
29/12/93	7899.3	-16773.8	-45796.6	7901.0	-16770.2	-45795.2	-1.7	-3.6	-1.4
30/12/93	7889.4	-16760.3	-45809.3	7889.5	-16756.7	-45807.5	-0.1	-3.6	-1.8
31/12/93	7853.6	-16732.7	-45766.6	7854.7	-16730.4	-45762.9	-1.1	-2.4	-3.7
1/1/94	7908.5	-16790.6	-45763.9	7910.2	-16784.0	-45757.5	-1.7	-6.6	-6.4
2/1/94	7899.2	-16760.7	-45776.2	7899.8	-16754.9	-45770.1	-0.6	-5.7	-6.1
3/1/94	7912.1	-16775.8	-45776.8	7913.6	-16770.0	-45771.2	-1.5	-5.8	-5.6
4/1/94	7890.2	-16774.2	-45797.5	7891.9	-16768.5	-45791.6	-1.7	-5.7	-5.8
5/1/94	7911.5	-16775.2	-45786.7	7912.8	-16769.7	-45781.2	-1.3	-5.5	-5.5

2.6 Final Data

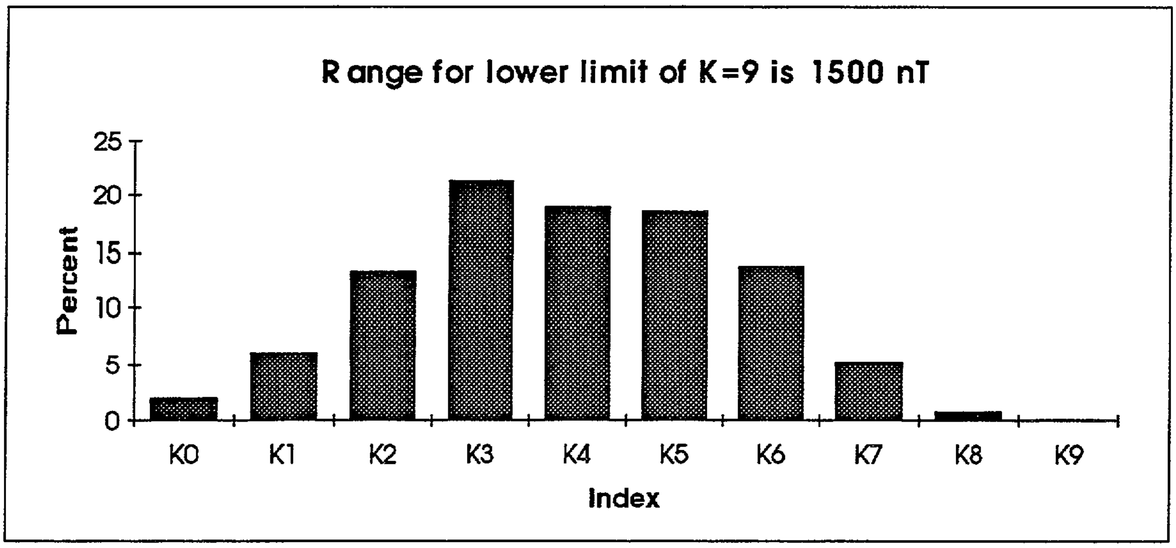
K Indices

Preliminary magnetic data reports were sent monthly to the Geomagnetism section in Canberra, previously 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. K indices were derived as range indices from the digital data using software written by Crosthwaite (1991,1994). 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 11 and summarised as the yearly K index distribution in Figure 6. Full final K indices and daily sums are presented in Appendix I.

Table 11. Mawson Monthly average K index and K index distribution for 1994

Month	*Mean K-index*	*K0 %*	*K1 %*	*K2 %*	*K3 %*	*K4 %*	*K5 %*	*K6 %*	*K7 %*	*K8 %*	*K9 %*
Jan	4.26	0.0	3.4	10.8	19.9	17.6	24.4	20.5	1.7	1.7	0.0
Feb	5.01	0.0	2.3	3.9	14.8	14.1	23.4	21.1	17.2	2.3	0.8
Mar	4.39	0.8	3.2	10.1	18.5	17.3	21.0	18.5	9.3	1.2	0.0
Apr	4.29	3.3	5.8	12.9	14.6	12.9	19.6	15.8	12.1	2.1	0.8
May	4.60	0.4	2.4	8.1	19.0	16.5	16.5	25.4	9.7	2.0	0.0
Jun	4.13	2.2	3.6	9.8	21.0	18.3	21.4	19.2	4.0	0.4	0.0
Jul	3.27	6.0	8.9	18.5	24.2	17.3	13.7	8.1	3.2	0.0	0.0
Aug	2.87	7.3	13.7	22.6	22.2	17.3	10.5	5.2	1.2	0.0	0.0
Sep	3.23	1.3	15.4	21.3	17.1	21.3	15.0	7.1	1.7	0.0	0.0
Oct	3.88	1.2	6.9	14.9	18.5	21.0	17.7	15.3	4.0	0.4	0.0
Nov	3.78	0.0	2.9	12.9	29.2	25.0	20.8	7.1	2.1	0.0	0.0
Dec	3.86	0.0	1.2	9.3	32.7	25.0	23.0	8.5	0.4	0.0	0.0
Annual	3.91	2.0	6.1	13.4	21.3	18.9	18.5	13.9	5.2	0.8	0.1

Figure 6. Mawson K index distribution for 1994



Final Monthly Mean Field Values

Monthly mean values were calculated for January to December 1994 using variometer counts and the variometer parameters presented in Appendix D. 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 12. Final corrections given in Section 2.3 have been applied. Hourly values are summarised in Appendix H.

Table 12. Mawson Final Monthly Mean Values 1994

Month	*Days*	*X (nT)*	*Y (nT)*	*Z (nT)*	*F (nT)*	*H (nT)*	*D (deg)*	*I (deg)*
January	All days	7892.5	-16757.2	-45802.0	49405.9	18522.9	-64° 46.8'	-67° 58.9'
	5xQ days	7904.9	-16777.4	-45779.3	49393.4	18546.4	-64° 46.3'	-67° 56.7'
	5xD days	7889.5	-16753.2	-45815.7	49416.8	18518.1	-64° 47.0'	-67° 59.5'
February	All days	7865.0	-16723.7	-45811.3	49398.9	18481.0	-64° 48.8'	-68° 1.8'
	5xQ days	7887.0	-16778.3	-45799.7	49409.8	18539.6	-64° 49.4'	-67° 57.7'
	5xD days	7804.9	-16673.0	-45831.0	49390.8	18409.8	-64° 55.0'	-68° 6.9'
March	All days	7851.1	-16740.8	-45832.9	49422.4	18490.5	-64° 52.5'	-68° 1.8'
	5xQ days	7875.3	-16768.2	-45802.2	49406.8	18525.5	-64° 50.6'	-67° 58.7'
	5xD days	7823.6	-16707.6	-45875.5	49446.5	18448.9	-64° 54.5'	-68° 5.5'
April	All days	7841.6	-16739.5	-45837.9	49425.2	18485.4	-64° 54.0'	-68° 2.2'
	5xQ days	7872.5	-16774.4	-45785.9	49393.4	18529.9	-64° 51.5'	-67° 58.0'
	5xD days	7797.7	-16691.5	-45897.8	49457.9	18423.6	-64° 57.6'	-68° 7.7'
May	All days	7836.6	-16742.2	-45823.7	49412.0	18485.7	-64° 55.1'	-68° 1.8'
	5xQ days	7871.6	-16775.4	-45795.7	49402.7	18530.4	-64° 51.7'	-67° 58.2'
	5xD days	7797.9	-16709.9	-45855.2	49424.4	18440.3	-64° 59.1'	-68° 5.6'
June	All days	7856.3	-16761.2	-45790.5	49390.7	18511.2	-64° 53.2'	-67° 59.3'
	5xQ days	7876.2	-16782.8	-45780.0	49391.4	18539.1	-64° 51.6'	-67° 57.2'
	5xD days	7840.6	-16735.8	-45794.6	49383.5	18481.6	-64° 53.9'	-68° 1.3'
July	All days	7857.3	-16767.2	-45784.0	49386.8	18516.9	-64° 53.5'	-67° 58.8'
	5xQ days	7871.8	-16782.3	-45772.2	49383.2	18536.7	-64° 52.3'	-67° 57.2'
	5xD days	7837.7	-16746.2	-45786.6	49379.2	18489.8	-64° 55.2'	-68° 0.6'
August	All days	7857.9	-16771.1	-45769.6	49374.9	18520.8	-64° 53.7'	-67° 58.1'
	5xQ days	7867.9	-16781.5	-45769.9	49380.3	18534.4	-64° 52.8'	-67° 57.3'
	5xD days	7834.1	-16744.3	-45759.2	49352.5	18486.4	-64° 55.6'	-68° 0.1'
September	All days	7850.4	-16769.9	-45774.3	49377.7	18516.5	-64° 54.9'	-67° 58.5'
	5xQ days	7860.2	-16782.9	-45778.0	49387.1	18532.4	-64° 54.3'	-67° 57.6'
	5xD days	7826.7	-16749.3	-45775.4	49368.0	18487.9	-64° 57.3'	-68° 0.4'
October	All days	7834.6	-16759.9	-45780.6	49377.7	18500.9	-64° 56.8'	-67° 59.7'
	5xQ days	7862.1	-16782.9	-45771.5	49381.3	18533.2	-64° 53.9'	-67° 57.4'
	5xD days	7787.7	-16723.9	-45781.3	49358.9	18448.6	-65° 1.9'	-68° 3.1'
November	All days	7855.6	-16777.5	-45764.7	49372.2	18525.7	-64° 54.6'	-67° 57.7'
	5xQ days	7872.2	-16793.4	-45761.8	49377.5	18547.0	-64° 53.1'	-67° 56.3'
	5xD days	7812.5	-16748.9	-45737.4	49330.6	18481.7	-64° 59.7'	-67° 59.8'
December	All days	7866.5	-16789.7	-45756.7	49370.7	18541.3	-64° 53.7'	-67° 56.5'
	5xQ days	7866.4	-16794.8	-45757.1	49372.7	18545.8	-64° 54.2'	-67° 56.2'
	5xD days	7861.2	-16769.0	-45727.6	49335.9	18520.4	-64° 53.0'	-67° 57.1'
Annual	All days	7855.4	-16758.3	-45794.0	49392.9	18508.2	-64° 53.1'	-67° 59.6'
Mean	5xQ days	7874.0	-16781.2	-45779.4	49390.0	18536.7	-64° 51.8'	-67° 57.4'
Values	5xD days	7826.2	-16729.4	-45803.1	49387.1	18469.7	-64° 55.8'	-68° 2.3'

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 records at a chart rate of 60 mm/minute (four revolutions per hour) and the long period records at a rate of 15 mm/minute (one revolution per hour). The system parameters are set out in Table 13 below.

Table 13. Mawson Seismic System Parameters

Component	*SPZ*	*LPZ*
Seismometer	Benioff	Press-Ewing
Model	1051	SV-282
Serial No.	55	11
Free Period (secs)	0.95	(12.2)
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)	1.538	(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 12°C provided by the electric heater and fast cycle AGSO heater controller ensured that conditions were stable in the vault.

Both SPZ and LPZ records were intermittently affected by high frequency interference, lasting several minutes, caused by HF radio communications (typically 4-5 MHz) with field parties and helicopters, transmitted from aerials close to Cosray. Noise during windy days (particularly over summer when sea ice was absent from Horseshoe Harbour) made it necessary to increase the AR320 amplifier attenuation on those days.

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 Australian Seismological Centre and the National Earthquake Information Service in the United States. Quick Epicentre Determination files (QEDs) were available on the ASC Sun via the terminal line in Wombat. 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 fax. There were two presumed nuclear explosions in 1994, both from Lop Nor in China. The first was on 10 June at 06:26 UTC and the second on 7 October at 03:26 UTC. Neither was recorded on the local helicorders at Mawson.

There were several short periods of data loss from the locally recorded system due to malfunctions or late chart changes. Data loss, other than daily loss during chart changes, are reported in table 14.

Table 14. Mawson Seismic System Data Loss

	SPZ		*LPZ*		
Date	***From***	***To***	***From***	***To***	***Cause***
17 Jan	-	-	12:00	23:59	Pen heat cut out
18 Jan	-	-	0:00	3:39	"
1 Feb	-	-	8:30	9:31	"
6 Mar	12:20	13:48	12:53	13:50	Chart change late
17 Apr	12:56	16:52	13:39	16:53	"
14 May	11:57	18:58	12:41	19:00	"
10 Jul	8:00	11:10	-	-	Pen heat cut out
28 Jul	13:06	14:30	13:43	14:31	Chart change late
24 Aug	7:54	11:37	7:54	11:38	Annual calibration
25 Aug	7:37	10:35	7:38	10:36	"
15 Sep	13:16	17:13	14:06	17:15	Chart change late
1 Oct	15:20	23:59	-	-	Pen heat cut out
2 Oct	0:00	8:10	-	-	"
8 Oct	12:47	17:32	13:28	17:34	Chart change late

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 August. 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 using a Hewlett Packard Universal Counter (Model 5315A). Input currents were monitored with a Tektronix oscilloscope (Model 2235 S/n 2536A20625) across a 1004 Ω resistor. From the results, the seismometer amplification for sinusoidal input functions of various frequencies is calculated using the equation :

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

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 0.797, 1.693, 3.187 and 3.815 mA

The results gave a mean value of G = 1.538 N/A
The measured free period was T = 0.946 seconds

The results of the frequency response tests are given below in Table 15. Note that the measured frequency is that measured on the HP Universal Counter.

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.

When the equipment was set up to do the current pulse tests the function generator was connected to the 'INPUT' plugs of the LPZ calibrator and caused a resistor on the back of the LPZ SSC-1 to glow red hot. The test was abandoned and the resistor checked and found to be at its nominal resistance.

From notes written on the previous calibrations it was discovered that the 'INPUT' plugs on the SPZ calibrator apply calibration signals to both the LPZ and SPZ seismometers and should be used for both calibrations. Circuit diagrams at Mawson do not reflect the current state of the calibrator units and it is unknown what the LPZ 'INPUT' plugs achieve. Obviously, they should not be used until the circuit is understood. There are, therefore, no calibration results for the LPZ for 1994. The most recent calibration is that of Rada (1994) and is given in Figure 8. Other recent seismometer parameters are presented in table 16.

Table 15. Frequency response of the SPZ seismometer

Nom Freq (Hz).	*Measured Freq. (Hz)*	*Period (s)*	*Amplitude (mm)*	*Magnification*
0.10	0.100	10.010	1.1	19
0.20	0.199	5.014	2.7	186
0.30	0.303	3.303	5.1	810
0.40	0.401	2.493	8.1	2258
0.50	0.503	1.990	12.5	5469
0.60	0.602	1.661	17	10674
0.70	0.702	1.425	21.6	18442
0.80	0.801	1.248	26.3	29235
0.90	0.899	1.112	30.4	42567
1.00	1.008	0.992	33.8	59500
1.05	1.047	0.955	35.7	67801
1.10	1.102	0.907	36.0	75743
1.15	1.148	0.871	35.5	81057
1.20	1.205	0.830	34.3	86287
1.30	1.306	0.766	30.8	91015
1.40	1.398	0.715	27.0	91423
1.50	1.500	0.667	23.5	91607
1.60	1.602	0.624	19.9	88482
1.70	1.701	0.588	17.0	85218
1.80	1.804	0.554	14.7	82883
1.90	1.908	0.524	12.4	78209
2.00	1.998	0.501	11.0	76078
2.50	2.497	0.400	5.4	58332
3.00	3.013	0.332	2.8	44039
3.50	3.497	0.286	1.7	36018
5.00	5.000	0.200	0.5	21656

The frequency response is graphed logarithmically below in Figure 7.

Figure 7. Frequency response of the SPZ seismometer.

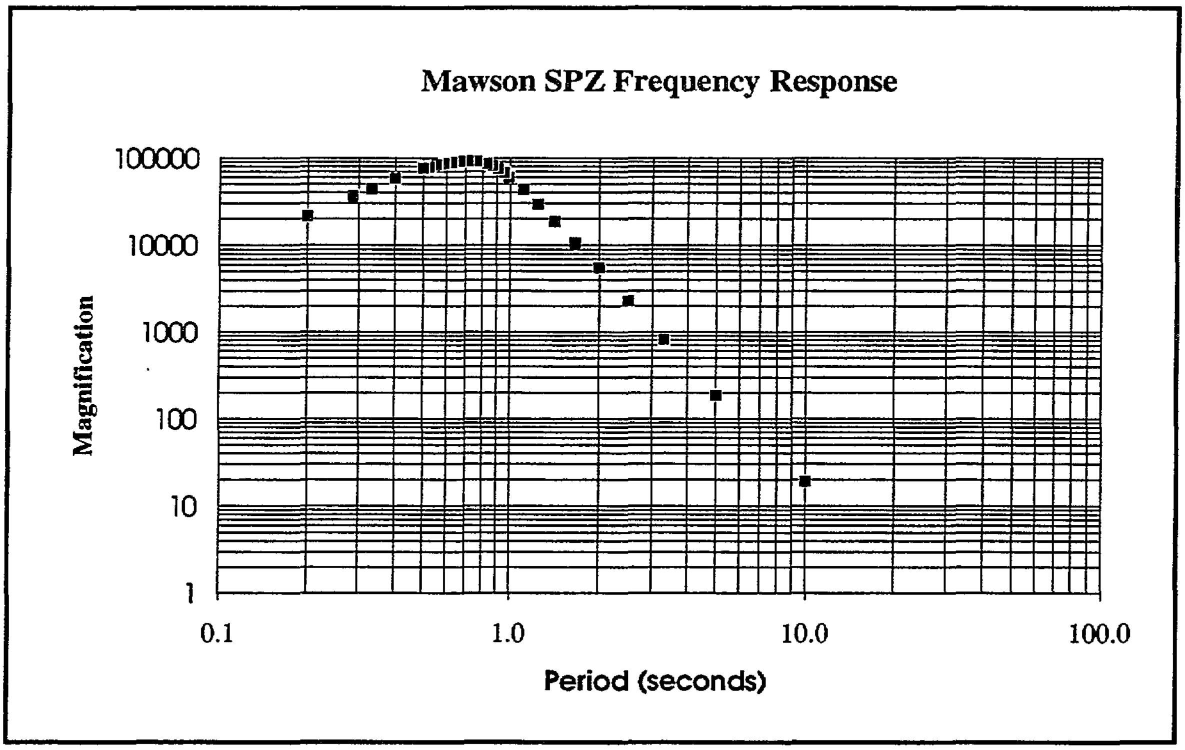
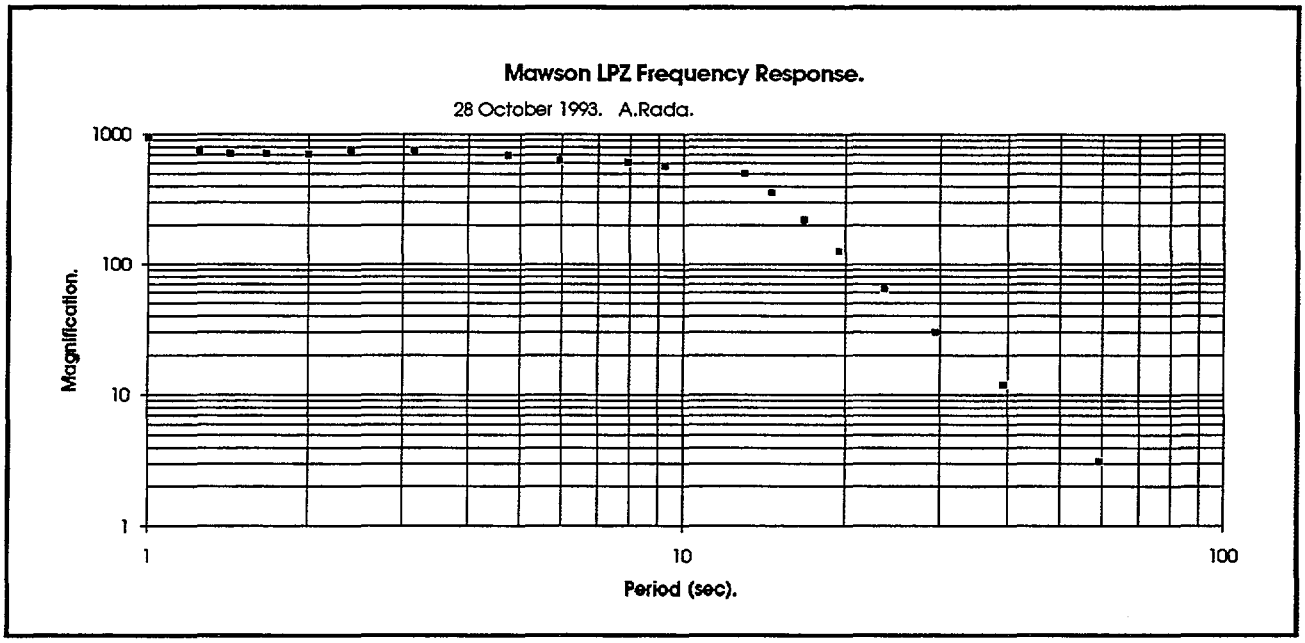


Figure 8. Frequency response of the LPZ seismometer.



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 ± 50 ms of UTC. For further information see section 4.1 TIME KEEPING.

Table 16. SPZ and LPZ Seismometer parameters 1985 - 1994

	LPZ		SPZ	
Year	**G (N/A)**	**Free Period (s)**	**G (N/A)**	**Free Period (s)**
1994	---	---	1.54	0.95
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

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 Operations Building 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 computer 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 but usually only for 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 the seismic modem in the Operations Building entering a remote loopback with the modem in Kingston. The cause of this is unknown and it can only be rectified by the communication technicians resetting the modem. The PDP11 required rebooting three times during the year. The Guralp seismometer masses only required re-centring after the quarry blast on 19 January 1994.

Calibration of the Guralp wide band seismometers was last done on 28 July 1993; results were calculated by Graeme Small at ASC and are given in Table 17.

Table 17.1 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 17.1 the formula: Ground displacement = Accln./ $(4\pi^2 f^2)$ is used.

Table 17.2 Guralp seismometer Vertical Channel Calibration results

Vertical channel:			
T (sec)	*Disp(nm)*	*P-P counts*	*Counts/nm*
0.1	10	188	18.3
0.15	23	368	15.9
0.26	70	952	13.7
1.05	1130	4128	3.64
2.07	4400	8128	1.85
5.2	27800	20608	0.74
10.8	120000	41984	0.35
15.5	247000	54016	0.22
27.2	760000	55296	0.073
57.5	3400000	31232	0.0042
127.2	16660000	15104	0.00041

Table 17.3 Guralp seismometer East- West Channel Calibration results

East - West channel:			
T (sec)	*Disp(nm)*	*P-P counts*	*Counts/nm*
0.1	8	172	20.6
0.15	19	380	20.3
0.26	56	928	16.5
1.07	950	4160	4.36
2.04	3470	8000	2.31
5.2	22500	20992	0.93
11.1	103000	43520	0.42
15.5	200000	54784	0.27
27.2	616000	55296	0.089
58	2800000	30464	0.011
126.4	13310000	14976	0.00113

Table 17.4 Guralp seismometer North- South Channel Calibration results

North- South channel :			
T (sec)	*Disp(nm)*	*P-P counts*	*Counts/nm*
0.1	9	172	19
0.15	20	384	18.9
0.26	61	888	14.6
1.06	1020	4128	4.07
2.06	3800	8128	2.12
5.2	24400	20736	0.85
11	109000	42240	0.39
15.1	207000	53504	0.26
27.3	673000	54528	0.018
56.8	2910000	30720	0.011
127.2	14610000	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
	Primary GED clock (also uses battery backup)
	Secondary GED clock
	AR320 seismic amplifiers
	W&W chart recorder
SPS 1000:	Ionosonde acquisition PC

The SPS1000 was on loan to the Ionospheric Prediction Service (IPS) to provide backup power for the digital acquisition system that was installed for the ionosonde in early 1994. IPS will provide their own UPS during 1995.

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 (1 PC only after 19 January 1994)
PEM control unit (until 19 January 1994)
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

The batteries in the SPS1000 were cycled for between 30 and 60 minutes several times during the year.

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 DC 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. 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 +5 ms/day; the secondary GED maintained a drift rate of around +10 ms/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 5, 10, or 15 MHz using a Sony ICF2001D portable world band receiver. 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 1st 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 1994 or remnants from previous years. Those buildings were the Science Building (known as Wombat), new Variometer Building, Absolute Hut, Cosray Building and the old Variometer Building.

Table 18. Observatory buildings

Building	*Room*	*Equipment Summary*	*Use*	*Condition*
Science Building ("Wombat")	AGSO office	Seismic helicorders, GED clocks, office PC	General office and processing duties	Good
"	IPS office	Ionosonde and computers. Biologists paraphernalia	Ionosonde operation and scaling. Biologists office. Maintenance supervisor's office during summer.	Good
"	AGSO workroom	Tools, equipment spares, test equipment	Repairs and testing. Biologists lab.	Good
"	IPS darkroom	Developing equipment and chemicals	Develop ionosonde films	Good
"	AGSO darkroom	-	Tea room	Good
Variometer Building	Sensor room	Ringcore variometer	Variometer	Excellent
"	Recorder room	Acquisition PC, Doric Trendicator, relay box	Data logging	Excellent
Absolute Hut	-	Absolute magnetometers	Magnetic observations	Fair
Cosray building	Seismic vault and cosray hut	Analogue and digital seismometers, PDP computer	Seismic monitoring	Good
Old Variometer Building	-	Nil	Nil	Destroyed by quarry blast on 19/01/94

The Absolute Hut was adequate for the purpose of doing absolutes. The pier is, however, unstable in strong winds and the hut allows some drift snow inside during blizzards. The heater usually melts and evaporates this snow and ice within several days but the temperature inside the hut can drop by 10° C during long, very windy periods.

The Science Building was in a good state of repair and provided adequate room for observatory operation. Waste water from the building was connected to site services during 1994 and the diesel fired boiler was needed for much of the year to supplement the heating provided via site services. The unsealed underfloor space in Wombat caused the floor temperature to drop to sub-zero temperatures during cold and windy periods.

The new Variometer Building was in excellent condition and provided adequate, temperature stable housing for the variometers. The roof and cold porch of the building were significantly damaged by fly rock from blasting in the nearby quarry on 19 January 1994. A hole approximately 1m x 1m was opened in the roof above the cold porch by a large rock which then punched a hole in the concrete slab. Roof panels and timber roof beams required replacement and numerous lighting circuits were cut. The partition wall and internal door for the cold porch were also replaced.

The old Variometer Building was unused at the time of the quarry blast and was levelled by the unexpected force of the blast. No materials were salvageable from this building.

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 and no maintenance was necessary during the year.

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.

Table 19 gives the quiet day averages for Davis and Casey for 1994, determined from the variometer data using the adopted baseline values given in Geomagnetic Report Davis And Casey 1994 (Giffen, 1995), and the scale value and temperature parameters given in the Casey and Davis Fluxgate Magnetometer Annual Reports (Dubovinsky, 1995 and Williams, 1995).

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 an appropriate approximation to make.

Table 19.1 Casey 1994 Monthly 5 Quiet Day Averages

	X (nT)	*Y (nT)*	*Z (nT)*	*F (nT)*	*H (nT)*	*D (deg)*	*I (deg)*
Jan	-385	-9624	-63817	64540	9632	-92.291	-81.417
Feb	-386	-9612	-63818	64539	9619	-92.302	-81.428
Mar	-378	-9625	-63840	64563	9632	-92.247	-81.420
Apr	-391	-9616	-63847	64569	9624	-92.330	-81.428
May	-392	-9610	-63852	64572	9618	-92.337	-81.434
Jun	-392	-9626	-63833	64556	9634	-92.330	-81.418
Jul	-387	-9619	-63823	64545	9627	-92.301	-81.422
Aug	-387	-9617	-63819	64541	9625	-92.307	-81.424
Sep	-383	-9624	-63808	64531	9632	-92.281	-81.416
Oct	-358	-9634	-63805	64529	9641	-92.130	-81.408
Nov	-379	-9628	-63812	64536	9635	-92.256	-81.414
Dec	-389	-9620	-63817	64539	9628	-92.313	-81.421
Annual	**-384**	**-9621**	**-63824**	**64547**	**9629**	**-92.285**	**-81.421**

Table 19.2 Davis 1994 Monthly 5 Quiet Day Averages

	X (nT)	*Y (nT)*	*Z (nT)*	*F (nT)*	*H (nT)*	*D (deg)*	*I (deg)*
Jan	3529	-16365	-51800	54438	16742	-77.832	-72.089
Feb	3521	-16379	-51808	54449	16753	-77.868	-72.080
Mar	3513	-16388	-51830	54473	16761	-77.900	-72.080
Apr	3500	-16397	-51818	54463	16767	-77.953	-72.070
May	3507	-16392	-51814	54459	16763	-77.925	-72.072
Jun	3504	-16400	-51806	54452	16770	-77.939	-72.063
Jul	3515	-16407	-51797	54447	16779	-77.909	-72.051
Aug	3504	-16407	-51794	54443	16777	-77.945	-72.052
Sep	3500	-16410	-51791	54441	16779	-77.960	-72.049
Oct	-	-	-51799	-	-	-	-
Nov	3501	-16392	-51779	54424	16761	-77.942	-72.063
Dec	3495	-16383	-51765	54408	16752	-77.957	-72.068
Annual	**3508**	**-16393**	**-51800**	**54445**	**16764**	**-77.921**	**-72.067**

CHAPTER 7. OTHER DUTIES

All participants in ANARE are required to assist in the general station operations that are not covered by a particular person on station. These duties are rostered on a rotational basis for regular tasks or organised on an ad hoc basis for less routine jobs. Regular duties include 'slushies' in the kitchen to assist with meal preparation and cleaning, and required two weeks during the year. Relief cooking was also required several times through the year. Daycare duties cover the daily cleaning and restocking of the bar, cleaning of general use areas and rubbish disposal. These required about 10 days during the year. Each Saturday afternoon everyone was assigned a job related to general station maintenance and these would take around one to four hours to complete.

Other regular jobs around the station are assigned on a voluntary basis at the beginning of the year and I volunteered for the positions of :

Projectionist - screening of 16 mm films every Sunday and Wednesday evening
Tide gauge monitor - monthly data retrieval
Anaesthetic assistant - assist doctor with anaesthetics during an operation. Not required during 1994 but 2 weeks training in Hobart is necessary.

During shipping visits (particularly the main re-supply) assistance was required with loading, unloading, and storage of goods.

Extra work related jobs included the operation of the ionosonde for the Ionospheric Prediction Service which involved the weekly changing, developing and scaling of ionograms on 16 mm film. This took about one morning each week.

The Auroral and Space Physics group of the Antarctic Division did not have a physicist at Mawson in 1994 so when the ASP engineer was off station I was responsible for routine checks, chart changes etc of ASP experiments and operation of the Fabry Perot Spectrometer each evening. This included a three week period in September when the engineer was on a traverse to the northern Prince Charles Mountains. In early October I flew to the PCMs to replace the engineer and spent one week searching for a vehicle abandoned in the area in the 1950s before returning to Mawson with the traverse vehicles on 1 November.

Several visits were also made to the Auster or Taylor Emperor Penguin rookeries to assist the biologists with their field work.

ACKNOWLEDGMENTS

The successful operation of an Australian Antarctic station depends on the actions of many people, both at the station and in Australia. I, therefore, thank my fellow expeditioners at Mawson during 1993 and 1994, and the Antarctic Division personnel in Kingston for the contribution they each made to the successful operation of Mawson station during my time there. In particular I am grateful for the assistance of Michael Manion (ASP engineer) and for his willingness to take care of the observatory in my absence and provide technical advice. Station leader, Bob Jones, managed the station in a way that allowed us all to maximise our enjoyment of the experience and carry out our jobs with minimum interference. At AGSO in Canberra, the advice from Stewart Dennis, Graeme Small and Peter Crosthwaite was very much appreciated and important in maintaining observatory standards.

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APPENDIX A. HISTORY OF MAWSON INSTRUMENTATION

A brief summary of the development of the Mawson Geophysical Observatory up to 1994

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 (RCF) Variometer & PC logging system installed (Rada, 1994)
January 1994	PEM recording (by AGSO and ASP) discontinued after blasting in quarry caused misalignment in all channels. RCF used as primary variometer

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 replaced 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 SPN Benioff seismometer discontinued (Petkovic, in prep)
July 1981	Helicorder hot pen recorder installed for SPZ and LPZ; SPN Benioff restored
March 1983	Cosray vault fully concreted in readiness for movement of SPN and SPE. 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 MAWSON GEOPHYSICAL LOG 1994

Date	Log Summary
10 December 1993	Aurora Australis (Voyage 4) arrived at Mawson ice edge with AGSO replacement, Adrian Giffen, who took over responsibility for the observatory.
15 December	V4 departed for Australia with Anton Rada.
16 December	Station power failure from 4:15 to 4:45 UTC
19 January 1994	Rock blasting in quarry at 09:48:56 UTC caused damage to variometer building, internal power cables and power and data cables to variometer building severed. Power cable to absolute hut severed. PEM channels out of alignment. UPS in variometer switched off at 10:38 UTC. Primary GED clock stopped. Guralp horizontal seismometers off scale.
20 January	Replaced fuse (FH 102) in primary GED clock. Centred Guralp horizontal seismometers.
24 January	RCF system restarted at 11:30 UTC. PEM recording not restarted.
26 January	Replaced fuse (FH 101) in primary GED clock.
28 January	Power cable to absolute hut repaired.
5 February	Guralp north channel only recording +ve part of trace.
15 February	Inputs to Guralp controller for the horizontal components were changed from 'ACC' to 'BB VEL' at 8:06 UTC.
8 February	Repairs to variometer building begin at 3:59 UTC.
16 February	DOS clock correction rate on RCF PC changed from -3600 to -4070 at 4:30 UTC.
22 February	One second logging of RCF data began using MACQ version 2.13.
24 February	Seismic modem entered remote loopback with Kingston. Corrected at 10:00 UTC.
28 February	Changed PPM range in MACQ to MIN=45000, MAX =55000 (nT) at 4:59 UTC as PPM values were being rejected.
7 April	Seismic PDP rebooted at 5:00 UTC.
14 April	Replaced faulty tantalum capacitor on +ve regulated supply for north component Guralp seismometer. North trace then normal.
17 April	Seismic modem in remote loopback, corrected at 10:11 UTC.
26 April	Cosray 12 V DC power supply switched off to replace batteries at 6:25 UTC. Power back on at 9:28 UTC.
27 April	Series of DIM obs to determine effect of DIM case in absolute hut. Case then removed from hut.
21 May	Seismic modem in remote loopback, corrected ~ 9:00 UTC.
27 May	DOS clock correction rate on RCF PC changed from -4070 to 3548 at 8:23 UTC. Negative sign left off correction rate by mistake.
31 May	DOS clock correction rate set to -3548 at 8:42 UTC.
2 June	Heater in absolute hut not working. Fixed by electrician.
20 June	Fiducial recording failed from all fiducial buttons.
1 July	GED clocks retarded 1 second at 5:00 UTC for leap second.
4 July	Replaced DIO card #7102 with #6697 to fix fiducial recording. Attempted to connect time marks to RCF using GED 1 minute signal without success.
27 July	Seismic PDP rebooted at 8:27 UTC after 'Output Conversion Error' generated.

12 August	Telemetry line from Wombat connected to COM 3 on RCF PC using the 10 pair cable and an RS232/485 converter at each end. COM 3 set at 300,N,8,1 in MACQ initialisation file.
19 August	Station power failure from 4:00 to 4:25 UTC.
24 August	Annual calibration of SPZ seismometer between 07:57 and 11:37 UTC.
25 August	Annual calibration of LPZ seismometer begun at 7:37 UTC. Aborted during frequency response calibration when LPZ calibration 'INPUT' was used instead of SPZ 'INPUT' which applies signal to SPZ and LPZ. Calibration circuit damaged.
29 August	Removed 1 kΩ used in calibration from across 'INPUT' terminals of SPZ and replaced with short. Daily calibration pulses then returned to correct amplitude.
1 September	RCF data not logged after 5:37 UTC until PC rebooted at 7:32 UTC.
6 September	PPM began giving erratic values at 3:04 UTC.
8 September	Sensor head for E820/158 in variometer building replaced with E770/206 at 14:50 UTC.
12 September	Seismic PDP rebooted at 8:28 UTC after 'Output Conversion Error '.
19 September	Telemetry line for RCF failed with MACQMON reporting " Line : IV cmd 5 s30 C0". PC rebooted to clear but could have been cleared with MACQCMD "CANCEL IV".
24 September	Station power failure from 3:35 to 4:20 UTC.
26 September	Electrician entered variometer building at 9:35 UTC with tools to replace faulty fire detectors . Left at 10:50 UTC.
8 October	Adrian Giffen left to join traverse in PCMs. Michael Manion (ASP engineer) took control of observatory.
26 October	Rock blasting in quarry at 6:36 UTC.
1 November	Adrian Giffen returned from PCM traverse. Doric Trendicator in Wombat displaying seismic vault temperature became erratic. Fault isolated to Trendicator, not cable or thermistor.
15 November	1995 observer, Suzanne Barr, arrived at Mawson.
19 November	Adrian Giffen departed on V2.

APPENDIX C. LINEAR REGRESSION RESULTS

Regression results for the first 58 days of 1994 gave very poor results or were unobtainable due to the limited number of absolute observations that were possible while repairs were carried out to the variometer building after the quarry blast on 19 January 1994. Scale values adopted for this period were those obtained by Rada (1994). They are listed below in Table 1.

The results of regressing DIM observations against the digital variometer data for days 59 to 365 are presented in Table 2. One set of scale values were adopted for this period and then all observations for all instruments were recalculated to obtain baselines for the RCF variometer. See Section 2.5 and Appendix D.

Table 1. RCF Scale Values for 1 January - 27 February 1994

Component	*Blv Drift*	*S* t_e	*S* t_h	*S z*	*S y*	*S x*
X	0.0	0.0	0.0	0.0	0.0036	0.0247
Y	0.0	0.0	0.0	0.0	0.0247	-0.0036
Z	0.0	0.0	0.0	0.0250	0.0	0.0

Table 2. RCF Scale Values for 28 February - 31 December 1994

Table 2.1. X Component

Period Days of 1994	*X Drift*	*S* Xt_e	*S* Xt_h	*S Xz*	*S Xy*	*S Xx*	*X blv*	*Degrees of Freedom*	*Correlation*
59 - 365	0.008 (0.009)	-0.027 (0.296)	-0.372 (0.426)	0.0011 (0.0006)	0.0010 (0.0007)	0.0245 (0.0005)	9652 (49)	66	0.986
59 - 165	0.042 (0.063)	1.58 (2.74)	1.97 (2.35)	0.0022 (0.0014)	0.0007 (0.0026)	0.0247 (0.0016)	9626 (179)	16	0.985
166 - 290	-0.021 (0.018)	0.327 (0.208)	-0.8224 (0.873)	-0.0006 (0.0007)	-0.0001 (0.0010)	0.0253 (0.0011)	9713 (99)	24	0.982
291 - 365	-0.050 (0.138)	-20.4 (8.2)	-3.69 (2.24)	0.0017 (0.0009)	0.0016 (0.0011)	0.0242 (0.0008)	9996 (193)	12	0.997
Adopted values for days 59 - 365	**-1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0250**	**-1**	**-**	**-**

() bracketed values are one standard deviation

Table 2.2. Y Component

Period Days of 1994	*Y Drift*	*S* Yt_e	*S* Yt_h	*S Yz*	*S Yy*	*S Yx*	*Y blv*	*Degrees of Freedom*	*Correlation*
59 - 365	0.025 (0.008)	-0.412 (0.255)	-1.35 (0.37)	-0.0002 (0.0005)	0.0237 (0.0006)	-0.0015 (0.0005)	-16206 (42)	66	0.987
59 - 165	0.105 (0.035)	-1.91 (1.51)	0.52 (1.30)	0.0003 (0.008)	0.0239 (0.0014)	-0.0015 (0.0009)	16191 (99)	16	0.991
166 - 290	0.027 (0.023)	-0.412 (0.268)	-0.665 (1.13)	0.0010 (0.0010)	0.0238 (0.0013)	0.0000 (0.0014)	-16117 (128)	24	0.968
291 - 365	0.303 (0.171)	18.6 (10.3)	-2.08 (2.79)	-0.0018 (0.0011)	0.0223 (0.0013)	-0.0025 (0.0010)	-16689 (240)	12	0.992
Adopted values for days 59 - 365	**-1**	**0.0**	**0.0**	**0.0**	**0.0238**	**0.0**	**-1**	**-**	**-**

Table 2.3. Z Component

Period Days of 1994	*Z Drift*	*S Zt_e*	*S Zt_h*	*S Zz*	*S Zy*	*S Zx*	*Z blv*	*Degrees of Freedom*	*Correlation*
59 - 365	-0.003 (0.010)	0.194 (0.319)	0.019 (0.459)	0.0235 (0.0006)	-0.0007 (0.0008)	-0.0005 (0.0006)	-46262 (53)	66	0.985
59 - 165	-0.040 (0.017)	0.834 (0.742)	0.046 (0.637)	0.0248 (0.0004)	0.0004 (0.0007)	0.0004 (0.0004)	-46196 (49)	16	0.999
166 - 290	-0.034 (0.010)	0.189 (0.121)	-0.108 (0.507	0.0242 (0.0004)	0.0004 (0.0006)	-0.0003 (0.0006)	-46228 (57)	24	0.995
291 - 365	0.794 (0.275)	30.5 (16.4)	-4.83 (4.46)	0.0194 (0.0017)	-0.0049 (0.0021)	-0.0044 (0.0016)	-47332 (385)	12	0.980
Adopted values for days 59 - 365	- [1]	**0.0**	**0.0**	**0.0245**	**0.0**	**0.0**	- [1]	-	-

[1] See Appendix D for the values of Xblv, Yblv, Zblv, X drift, Y drift and Z drift adopted for 1994. These values have been determined from plots of residuals for absolute observations, not from the above regression results.

APPENDIX D. RCF VARIOMETER MODEL

The following variometer model has been determined using DIM 810/208 on theodolite 312714 with PPM Elsec 770/199, as the standard instruments. Scale values were derived using multilinear regression with the results presented in Appendix C. Baseline values and drifts were then calculated from plots of the difference between field values measured by the absolute instruments and the corresponding values measured by the RCF variometer. See Section 2.5 for more detail and plots of the absolute measurement residuals.

The model is presented in the format required for Peter Crosthwaite's software and a description of this format is in Crosthwaite (1994).

```
VARIOMETER   Maw      RCF0     1994     1.0000   1994     29.3964\
         A\
         RCF0\
         8113.0            0.0247   0.0036   0        0        0\
         -16995.0 -0.0036  0.0247   0        0        0\
         -46165.0 0        0        0.0250   0        0\
         0000.00  1.00000  +0.00\
         11.81    0.137    +10.00\
         11.81    0.137    +10.00\
         13       -20      -58\
         32158    32127    32092    \
         -0.00    -0.00    -0.00    0.00\
         F

#        Baseline step in X, Y and Z due to explosion in quarry (at 19.4090 but
#        new constants not derived until day     29)
VARIOMETER   Maw      RCF0     1994     29.3964  1994     40.4173\
         A\
         RCF0\
         7887.0            0.0247   0.0036   0        0        0\
         -17128.0 -0.0036  0.0247   0        0        0\
         -46221.0 0        0        0.0250   0        0\
         0000.00  1.00000  +0.00\
         11.81    0.137    +10.00\
         11.81    0.137    +10.00\
         13       -20      -58\
         32158    32127    32092    \
         -0.00    -0.00    -0.00    0.00\
         F

VARIOMETER   Maw      RCF0     1994     40.4173  1994     59.2166\
         A\
         RCF0\
         7891.0            0.0247   0.0036   0        0.0      0.0\
         -17129.0 -0.0036  0.0247   0        0.0      0.0\
         -46216.0 0        0        0.0250   0.0      0.0\
         0000.00  1.00000  +0.00\
         11.81    0.137    +10.00\
         11.81    0.137    +10.00\
         13       -20      -58\
         32158    32127    32092    \
         -0.00    -0.00    -0.00    0.00\
         F
```

```
#	Baseline step in X, Y and Z due to replacement of panels in variometer
#	building
VARIOMETER	Maw	RCF0	1994	59.2166	1994	117.9999\
	A\
	RCF0\
	9686.0		0.0250	0	0	0.0	0.0\
	-16099.0 0	0.0238	0	0.0	0.0\
	-46225.0 0	0	0.0245	0.0	0.0\
	0000.00	1.00000	+0.00\
	11.81	0.137	+10.00\
	11.81	0.137	+10.00\
	13	-20	-58\
	32158	32127	32092	\
	-0.051	+0.005	-0.026	0.25\
	F

VARIOMETER	Maw	RCF0	1994	117.9999 1994	137.3999\
	A\
	RCF0\
	9683.0		0.0250	0	0	0.0	0.0\
	-16098.71	0	0.0238	0	0.0	0.0\
	-46226.53	0	0	0.0245	0.0	0.0\
	0000.00	1.00000	+0.00\
	11.81	0.137	+10.00\
	11.81	0.137	+10.00\
	13	-20	-58\
	32158	32127	32092	\
	+0.087	+0.005	-0.026	0.25\
	F

VARIOMETER	Maw	RCF0	1994	137.3999 1994	175.4999\
	A\
	RCF0\
	9684.69		0.0250	0	0	0.0	0.0\
	-16098.61	0	0.0238	0	0.0	0.0\
	-46227.0 0	0	0.0245	0.0	0.0\
	0000.00	1.00000	+0.00\
	11.81	0.137	+10.00\
	11.81	0.137	+10.00\
	13	-20	-58\
	32158	32127	32092	\
	+0.087	+0.005	+0.052	0.25\
	F

VARIOMETER	Maw	RCF0	1994	175.4999 1994	263.5999\
	A\
	RCF0\
	9688.0		0.0250	0	0	0.0	0.0\
	-16098.42	0	0.0238	0	0.0	0.0\
	-46225.0 0	0	0.0245	0.0	0.0\
	0000.00	1.00000	+0.00\
	11.81	0.137	+10.00\
	11.81	0.137	+10.00\
	13	-20	-58\
	32158	32127	32092	\
	-0.015	+0.005	-0.028	0.25\
	F
```

```
VARIOMETER  Maw     RCF0     1994     263.5999 1994     308.3999\
        A\
        RCF0\
        9686.68          0.0250   0        0        0.0       0.0\
        -16098.0 0       0.0238   0        0.0      0.0\
        -46227.47        0        0        0.0245   0.0       0.0\
        0000.00  1.00000 +0.00\
        11.81    0.137   +10.00\
        11.81    0.137   +10.00\
        13       -20     -58\
        32158    32127   32092    \
        -0.015   +0.089  -0.028   0.25\
        F

VARIOMETER  Maw     RCF0     1994     308.3999 1994     350.9999\
        A\
        RCF0\
        9686.0           0.0250   0        0        0.0       0.0\
        -16094.0 0       0.0238   0        0.0      0.0\
        -46228.72        0        0        0.0245   0.0       0.0\
        0000.00  1.00000 +0.00\
        11.81    0.137   +10.00\
        11.81    0.137   +10.00\
        13       -20     -58\
        32158    32127   32092    \
        +0.108   -0.164  -0.028   0.25\
        F

VARIOMETER  Maw     RCF0     1994     350.9999 1995     365.9999\
        A\
        RCF0\
        9690.6           0.0250   0        0        0.0       0.0\
        -16101.0 0       0.0238   0        0.0      0.0\
        -46230.0 0       0        0.0245   0.0      0.0\
        0000.00  1.00000 +0.00\
        11.81    0.137   +10.00\
        11.81    0.137   +10.00\
        13       -20     -58\
        32158    32127   32092    \
        +0.108   +0.0    +0.144   0.25\
        F
```

APPENDIX E. ROUNDS OF ANGLES

Rounds of angles were performed following the standard technique of sighting all marks in one round and then rotating the circle or theodolite base by 120° and sighting all marks again. The base is then rotated in the same direction another 120° and another series of mark readings taken. When the DIM theodolite was used, rounds of all marks were done in the sensor up and sensor down orientations giving six measurements of azimuth.

All measurements are referenced to mark BMR 89/2 with an assumed azimuth of 19 deg 13.7 min (Crosthwaite 1989).

Mark :	*A*		*Lee*		*89/1*		*SOH*		*85/2*	
	deg	*min*	*deg*	*min*	*deg*	*min*	*deg*	*min*	*deg*	*min*
31/01/95 [1]			357	4.9			274	14.3	241	3.6
"			357	5.1			274	16	241	3.8
"			357	4.5			274	15	241	3.6
"			357	5.0			274	15.2	241	3.5
"			357	4.6			274	13.9	241	3.5
"			357	4.1			274	14.6	241	4.1
24/04/95 [2]	358	34.4	357	4.4	350	36.3	274	12.8	241	3.7
"	358	35.6	357	4.4	350	36.3	274	15.0	241	4.2
"	358	34.7	357	4.5	350	36.1	274	15.2	241	3.9
8/08/94 [2]	358	34.5	357	4.6	350	36.4	274	15.4	241	4.2
"	358	34.7	357	4.2	350	36.6	274	15.5	241	3.9
"	358	33.7	357	4.4	350	36.2	274	15.3	241	3.8
Average :	358	34.60	357	4.56	350	36.32	274	14.85	241	3.82
(decimal)	(358.562)		(357.073)		(350.603)		(274.255)		(241.063)	
Stdev :		0.61		0.31		0.17		0.85		0.25
(decimal)	(0.010)		(0.005)		(0.003)		(0.014)		(0.004)	

[1] Using Theodolite 312714
[2] Using Askania circle 611665

APPENDIX F. PPM INTERCOMPARISONS

PPM comparisons were conducted on Pier A in the Mawson Absolute Hut. PPMs were used in the bolts down orientation with readings taken every 10 seconds for one minute before switching instruments. Measurements were synchronised with the PPM readings in the variometer building by triggering the PPMs on the 10 second boundary. The program REDUCE was used to obtain an F difference between the comparison instruments and the variometer PPM.

Time	*E770/199*			*E770/206*		
U.T. 29/04/94	*Mean 49000 nT +*	*Stan. dev.*	*PPM - Variometer F*	*Mean 49000 nT +*	*Stan. dev.*	*PPM - Variometer F*
7:58	361.50	0.55	-0.7			
8:00				359.17	1.33	-1.0
8:02	355.83	0.75	-0.8			
8:04				359.67	1.63	-0.7
8:06	359.33	1.97	-0.7			
8:08				357.67	1.37	-0.9
8:10	362.67	0.52	-0.3			
8:12				361.83	0.75	-0.3
8:14	363.17	1.17	0.1			
8:16				366.50	1.38	-0.2
8:18	362.17	1.17	-0.4			
8:20				366.67	0.52	0.4
8:22	362.83	1.47	-0.4			
8:24				361.17	0.98	-0.3
8:26	364.33	0.52	-0.5			
		Average	**-0.46**			**-0.43**
		Stan. dev.	**0.29**			**0.48**

Time	*E770/199*			*E770/206*		
U.T. 12/08/94	*Mean 49000 nT +*	*Stan. dev.*	*PPM - Variometer F*	*Mean 49000 nT +*	*Stan. dev.*	*PPM - Variometer F*
9:14	323.00	0.89	0.6			
9:18				338.83	2.48	0.2
9:20	354.50	2.17	0.2			
9:22				338.83	2.04	0.0
9:24	350.17	4.83	0.6			
9:27				353.00	3.16	-0.5
9:29	344.83	6.91	-0.2			
9:31				351.67	10.48	0.1
9:33	336.00	13.39	-0.1			
9:35				369.17	8.11	-0.2
9:37	356.50	2.51	-0.9			
9:39				351.53	2.25	0.1
9:41	372.17	6.18	-1.5			
9:43				367.50	6.16	0.2
9:45	364.00	2.53	-0.6			
		Average	**-0.24**			**-0.01**
		Stan. dev.	**0.73**			**0.25**

Instrument differences for E770/199 -E770/206 are therefore :

29/04/94 : 0.0 nT ± 0.2
12/08/94 : -0.2 nT ± 0.3

APPENDIX G. MAGNETIC EFFECT OF DIM CASE IN ABSOLUTE HUT

Using DIM 810/208 on theodolite 312714 and PPM 199

Date (1994)	*Case OR No Case*	*X residual (nT)*	*Y residual (nT)*	*Z residual (nT)*
27 April	No case	6.5	1.1	-2.4
27 April	No case	7.5	-1.1	-1.5
27 April	No case	-1.5	0.8	-3.8
27 April	Case	-4.2	-0.5	-1.7
27 April	Case	-2.9	-0.1	-1.4
27 April	Case	7.3	-3.3	1.9
27 April	Case	-1.5	0.6	-1.3
27 April	Case	0.8	-4.2	1.0
27 April	Case	0.7	-1.3	0.0
27 April	No case	4.6	2.8	-0.6
27 April	No case	0.2	4.7	-2.7
27 April	No case	3.0	2.4	-1.2
Average	No case	-3.4 ± 3.5	1.8 ± 2.0	-2.0 ± 1.2
Average	Case	0.0 ± 4.0	-1.5 ± 1.9	-0.2 ± 1.5
Average	No case - case	3.4 ± 2.4	3.3 ± 1.2	-1.8 ± 0.9

Using QHM 300 and PPM 199

Date (1994)	*Case OR No Case*	*X residual (nT)*	*Y residual (nT)*	*Z residual (nT)*
29 June	Case	1.5	-1.7	1.8
29 June	No case	2.0	4.0	0.8
26 July	Case	1.5	-0.8	0.9
26 July	No case	1.2	0.0	0.6
14 September	Case	-1.8	0.2	-1.5
14 September	No case	-0.8	2.2	-2.3
Average	No case	0.8 ± 1.4	2.1 ± 2.0	-0.3 ± 1.7
Average	Case	0.4 ± 1.9	-0.7 ± 1.0	0.4 ± 1.7
Average	No case - case	0.4 ± 1.1	2.8 ± 1.0	-0.7 ± 1.1

From these data the correction for the presence of the DIM's steel case in the Mawson Absolute Hut has been adopted as :

+1 nT in X, +3 nT in Y and -1 nT in Z

APPENDIX H. MAWSON HOURLY MEAN VALUES

The following monthly averages of hourly mean 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 (Q) and international disturbed days (D). The monthly mean is also given.

North Component (X)

MAWSON ANTARCTIC 1994 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		Mean
Jan.	406	366	340	318	276	259	283	341	384	395	413	425	446	455	453	460	446	435	429	413	417	429	420	410	A	392
	402	391	363	360	357	357	362	373	387	395	407	412	419	419	419	433	439	441	431	431	425	429	430	433	Q	405
	392	352	317	361	332	217	207	304	384	385	416	442	472	479	466	464	460	445	431	405	408	431	423	355	D	389
Feb.	381	352	332	290	236	274	301	322	350	371	366	407	428	425	403	398	386	379	375	375	391	385	396	398	A	365
	406	378	353	303	345	350	353	347	340	366	424	415	419	428	421	416	412	392	396	400	406	410	405	403	Q	387
	417	267	272	171	-10	164	264	272	337	340	248	399	403	377	203	286	384	364	319	167	420	385	446	469	D	305
Mar.	333	336	322	297	280	259	265	315	350	368	391	406	417	415	410	403	370	343	344	355	375	369	367	334	A	351
	392	375	344	352	348	355	363	362	373	371	380	385	386	386	388	389	391	391	396	391	385	388	365	355	Q	375
	345	352	320	277	277	262	218	310	339	358	416	426	451	407	397	386	254	230	236	234	347	289	292	344	D	324
Apr.	324	290	281	284	276	272	272	314	359	369	388	400	403	403	399	393	366	335	335	351	343	347	366	326	A	342
	373	364	366	357	329	313	338	357	370	378	381	383	385	387	387	388	387	388	397	391	385	387	375	374	Q	373
	323	108	96	208	188	192	222	238	308	280	363	384	412	415	378	372	362	350	270	337	341	356	359	283	D	298
May	319	290	283	261	233	230	263	315	359	388	404	403	409	408	402	387	370	353	345	326	327	349	343	310	A	337
	363	356	345	328	318	343	366	372	377	380	381	385	388	391	396	398	394	384	395	386	385	370	360	359	Q	372
	274	135	135	140	168	193	240	295	379	407	424	409	428	417	399	359	286	255	229	287	285	360	350	295	D	298
Jun.	333	321	296	292	263	279	299	337	368	382	399	410	409	404	408	406	401	386	373	374	353	339	372	337	A	356
	344	342	340	353	359	372	369	371	371	383	389	385	385	385	389	388	389	390	387	388	378	378	390	376	Q	376
	278	298	255	263	189	207	255	316	365	375	398	431	426	415	434	414	408	377	353	370	355	295	376	315	D	341
Jul.	334	314	300	278	289	313	339	359	374	377	386	394	396	399	395	393	396	391	381	367	358	349	354	340	A	357
	369	348	350	344	341	357	367	373	375	377	379	381	383	382	381	381	382	382	383	380	376	374	382	376	Q	372
	258	230	269	226	282	279	280	322	347	360	378	419	415	424	415	389	413	384	365	341	342	299	342	327	D	338
Aug	321	324	320	319	314	323	341	360	372	376	376	382	385	390	392	393	394	385	376	377	351	348	335	335	A	358
	320	340	353	357	373	373	371	371	373	373	374	375	378	380	379	383	385	386	378	381	375	368	360	323	Q	368
	254	267	293	289	238	230	265	306	356	371	367	395	407	416	404	399	394	371	339	380	321	329	293	333	D	334
Sep.	315	311	310	280	275	284	309	329	360	366	376	384	393	389	392	396	395	385	371	358	364	353	368	348	A	350
	319	294	291	275	314	351	365	369	371	371	371	375	376	376	382	388	393	388	384	380	382	384	378	369	Q	360
	309	312	301	228	217	162	229	229	327	345	376	400	426	406	394	413	401	360	333	339	316	308	351	359	D	327
Oct.	333	324	286	257	217	213	247	296	329	340	364	374	387	385	381	391	385	374	348	352	360	369	371	345	A	335
	338	317	315	331	343	332	331	346	363	371	378	382	384	385	383	379	380	381	386	381	368	380	394	343	Q	362
	323	314	242	209	139	144	76	155	217	239	335	325	362	348	307	373	386	334	270	343	350	401	372	340	D	288
Nov.	369	342	302	257	210	213	276	325	348	366	373	375	399	407	420	420	416	399	393	385	385	390	390	374	A	356
	368	344	306	288	310	318	334	349	358	367	371	378	389	400	405	415	413	414	406	403	406	399	397	395	Q	372
	349	337	264	175	57	34	140	250	298	336	310	272	340	367	429	413	410	401	378	382	384	393	387	393	D	312
Dec.	367	356	319	256	223	252	294	333	354	370	386	404	422	434	426	430	432	405	398	400	383	382	387	384	A	367
	375	361	335	263	245	274	303	349	366	373	381	392	405	408	408	409	416	407	403	381	384	389	386	381	Q	366
	353	377	356	265	167	178	201	267	334	363	392	426	448	463	436	441	451	400	384	439	416	378	372	360	D	361
Year	345	327	308	283	258	264	291	329	359	372	385	397	408	409	407	406	396	381	372	369	367	367	373	353	A	355
	364	351	338	326	332	341	352	362	369	376	385	387	391	394	395	397	398	395	395	391	388	388	385	374	Q	374
	323	279	260	234	187	189	216	272	333	346	369	394	416	411	388	392	384	356	326	335	357	352	364	348	D	326

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995.

East Component (Y)

MAWSON ANTARCTIC 1994 -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		Mean
Jan.	233	216	226	244	246	250	265	268	263	266	285	314	322	314	308	310	288	259	249	213	190	207	215	220	A	257
	272	284	292	298	300	300	288	278	267	259	263	262	258	261	264	279	290	292	289	279	262	278	277	266	Q	277
	197	179	164	294	300	253	253	249	263	277	324	396	381	351	325	319	290	252	220	186	142	164	179	118	D	253
Feb.	205	210	238	256	244	260	269	264	260	274	308	339	330	309	260	236	220	178	97	86	84	156	176	196	A	224
	256	265	284	283	318	311	299	291	271	242	273	276	279	291	280	288	277	264	271	274	268	268	265	286	Q	278
	215	89	199	147	51	175	242	257	259	277	326	405	364	253	28	89	152	46	-67	-75	78	122	251	290	D	173
Mar.	209	237	243	241	261	254	236	249	263	279	291	298	305	299	286	267	243	219	200	172	184	166	194	183	A	241
	279	278	260	280	285	290	284	280	277	271	261	261	262	265	268	269	274	275	277	265	252	261	218	246	Q	268
	232	285	252	210	293	290	211	266	285	325	333	361	364	315	262	198	98	87	-17	-39	66	30	101	174	D	208
Apr.	190	173	209	254	258	260	248	264	279	267	295	302	301	296	300	287	262	250	223	203	156	142	160	170	A	240
	256	272	276	271	264	256	268	274	270	270	270	273	274	279	281	286	285	288	295	291	282	277	264	262	Q	274
	218	-147	10	240	215	226	276	281	281	233	321	321	309	302	267	261	205	197	96	85	112	50	114	122	D	191
May	213	214	219	223	209	211	222	245	261	282	298	299	310	312	307	289	278	265	248	212	186	181	168	157	A	242
	266	267	267	257	251	265	279	277	280	278	276	278	282	287	295	304	296	296	299	285	271	244	254	254	Q	275
	175	150	142	155	185	196	209	224	262	312	319	311	335	336	311	246	217	219	244	114	49	153	57	118	D	210
Jun.	215	250	247	247	228	236	239	242	264	272	280	298	305	303	310	309	308	297	293	282	237	202	209	189	A	261
	267	258	263	275	279	284	286	287	278	280	279	278	284	285	288	288	292	295	298	301	289	284	285	269	Q	283
	120	232	229	236	182	192	202	205	239	265	269	314	322	312	335	320	306	279	277	267	177	127	138	81	D	236
Jul.	232	231	231	241	241	260	269	275	276	276	282	291	297	303	300	299	306	303	298	276	257	227	218	225	A	267
	280	268	272	266	263	278	285	285	281	279	280	282	285	285	287	288	290	291	294	298	295	281	283	277	Q	282
	129	99	186	231	262	230	224	247	249	278	283	319	316	325	317	298	320	306	299	238	190	206	157	199	D	246
Aug.	228	251	258	259	258	268	274	277	280	278	277	282	290	296	297	296	301	293	285	279	259	255	235	231	A	271
	238	265	275	278	292	295	290	285	282	280	282	284	285	285	286	289	294	298	298	295	286	280	275	239	Q	281
	92	203	238	246	195	209	214	238	273	274	274	283	310	313	313	298	293	272	266	262	239	225	156	175	D	244
Sep.	229	244	259	253	261	262	271	271	278	280	288	290	297	292	304	304	304	294	281	248	244	220	250	255	A	270
	251	226	242	253	287	301	305	299	289	281	277	280	283	286	291	297	305	301	300	295	294	290	280	280	Q	283
	226	248	262	230	239	186	232	228	262	278	316	317	329	295	307	310	310	271	254	202	145	100	196	239	D	249
Oct.	237	261	254	257	248	245	258	271	279	288	295	290	292	281	275	281	287	269	238	227	217	217	241	230	A	260
	241	254	279	305	312	300	289	280	276	281	282	284	288	290	290	289	294	297	298	286	265	281	290	240	Q	283
	193	257	236	229	219	233	203	215	243	271	301	277	268	225	180	237	247	176	144	163	190	226	219	219	D	224
Nov.	270	273	266	271	257	261	271	281	283	289	304	309	312	309	320	317	311	291	271	239	220	234	251	249	A	277
	270	292	287	306	320	305	296	284	275	270	270	278	290	304	310	316	323	325	314	312	284	268	267	275	Q	293
	259	258	228	202	142	161	204	248	293	321	355	317	295	264	312	264	262	264	233	190	171	222	249	260	D	249
Dec.	267	289	281	271	287	298	302	289	286	292	298	310	336	338	333	331	328	298	283	276	248	222	235	252	A	290
	299	301	293	272	288	305	305	297	287	277	282	293	313	324	321	321	326	314	304	274	270	260	275	272	Q	295
	243	300	307	286	268	277	264	229	272	299	305	338	393	349	322	305	285	199	217	263	203	161	161	211	D	269
Year	227	237	244	252	250	255	260	266	273	279	292	302	308	304	300	294	286	268	247	226	207	203	213	213	A	258
	265	269	274	279	288	291	290	285	278	272	275	278	282	287	288	293	296	295	295	288	276	273	269	264	Q	281
	191	179	205	226	213	219	228	241	265	284	311	330	332	303	273	262	249	214	180	155	147	149	165	184	D	229

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995.

Vertical intensity (Z)

MAWSON ANTARCTIC 1994 -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		Mean
Jan.	371	392	402	390	377	357	320	275	281	286	285	278	278	272	245	227	216	221	220	247	283	324	348	355	A	302
	309	302	286	267	259	254	253	257	265	272	280	287	302	303	304	302	295	285	268	265	258	265	272	293	Q	279
	393	474	513	541	523	506	420	280	281	290	263	210	228	205	164	157	160	180	176	236	257	328	402	389	D	316
Feb.	460	453	490	474	447	363	313	288	286	291	248	215	214	183	175	160	153	197	290	281	321	362	376	408	A	311
	388	376	347	339	304	269	268	264	266	285	299	284	296	298	296	296	294	291	289	290	282	271	295	307	Q	300
	536	448	498	466	482	490	413	298	298	288	11	97	96	72	54	112	198	273	375	347	400	506	433	441	D	331
Mar.	431	448	454	452	422	384	326	306	315	308	304	302	278	255	256	252	238	236	254	292	304	383	391	402	A	333
	327	342	348	327	305	284	278	274	279	286	298	301	307	305	304	303	300	296	288	280	288	296	331	306	Q	302
	502	517	577	596	554	504	474	402	372	345	306	268	220	162	160	204	187	250	309	262	333	533	438	537	D	376
Apr.	428	449	448	467	438	392	371	347	337	320	302	299	278	286	262	262	254	245	252	263	282	341	375	412	A	338
	285	295	292	293	283	257	253	263	281	288	293	299	300	300	299	300	297	293	292	278	269	276	287	287	Q	286
	513	533	553	652	598	550	539	481	429	363	292	254	272	267	181	208	278	318	229	246	351	449	475	517	D	398
May	418	424	440	452	441	400	331	306	300	297	299	292	287	280	271	261	253	233	249	248	255	283	346	402	A	324
	313	328	318	340	322	286	272	280	287	287	294	301	302	302	300	291	285	278	288	261	253	289	305	317	Q	296
	512	474	624	599	583	511	373	358	343	311	310	295	274	238	251	212	238	185	142	234	307	265	413	474	D	355
Jun.	371	369	369	359	333	296	267	271	267	279	286	289	284	287	277	260	251	245	218	231	251	271	309	345	A	290
	308	316	292	280	283	280	272	271	272	279	282	284	286	287	286	285	287	286	277	269	262	248	257	287	Q	280
	409	389	428	405	364	295	252	295	281	295	278	288	287	279	235	202	186	201	164	232	274	300	383	366	D	295
Jul.	336	340	342	339	303	279	260	263	267	266	274	281	281	272	275	271	269	263	247	240	260	275	297	314	A	284
	294	297	286	275	263	266	263	265	267	271	276	278	279	275	275	278	278	276	275	263	250	252	256	270	Q	272
	400	376	379	373	343	280	252	269	270	248	234	267	279	266	260	246	248	225	204	196	292	271	328	373	D	287
Aug.	326	324	315	310	284	264	248	246	250	257	264	268	269	269	265	264	258	246	240	233	240	254	265	310	A	270
	307	291	280	267	267	264	259	258	258	261	270	272	271	271	271	276	277	267	253	263	256	257	267	295	Q	270
	368	371	360	366	306	278	241	235	237	246	247	243	249	250	230	242	226	204	200	172	172	232	222	325	D	259
Sep.	343	346	349	346	304	276	254	242	243	252	258	264	262	255	253	255	247	237	231	230	243	275	295	324	A	274
	347	345	329	333	294	257	243	246	252	258	261	268	271	271	271	274	273	266	260	254	253	262	293	294	Q	278
	349	373	405	428	389	356	293	254	221	228	217	242	210	204	214	222	203	166	204	243	232	307	312	334	D	275
Oct.	374	372	361	347	327	303	265	251	255	246	247	247	236	232	225	225	218	225	216	257	292	305	342	369	A	281
	340	328	299	270	254	237	232	241	255	266	272	276	277	271	274	274	274	267	257	250	254	257	272	321	Q	272
	408	377	331	362	419	446	347	291	261	215	206	177	168	184	113	177	176	212	161	310	352	318	359	382	D	281
Nov.	332	352	360	350	315	275	251	243	250	258	246	227	228	238	228	215	207	195	200	220	256	274	307	326	A	265
	311	316	302	263	230	220	225	241	254	261	265	272	280	280	279	275	256	231	218	221	234	258	292	301	Q	262
	322	342	374	408	415	335	286	240	237	233	138	49	93	142	180	112	137	160	160	227	263	265	275	305	D	237
Dec.	340	345	355	331	274	232	218	223	234	252	267	271	245	227	213	215	205	186	193	214	232	269	301	320	A	257
	308	340	336	303	265	223	209	213	230	245	258	273	275	273	271	261	245	217	193	190	225	271	260	287	Q	257
	336	311	350	351	294	197	183	219	225	243	271	260	158	115	68	98	122	80	129	197	245	298	354	356	D	228
Year	377	385	390	385	355	319	285	272	274	276	273	269	262	255	245	239	231	227	234	246	268	301	329	357	A	294
	320	323	309	296	277	258	252	256	264	272	279	283	287	286	286	284	280	271	263	257	257	267	282	297	Q	279
	421	415	449	462	439	396	339	302	288	275	231	221	211	199	176	183	197	204	205	242	290	339	366	400	D	303

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995 .

Total intensity (F)

MAWSON ANTARCTIC 1994 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		Mean
Jan.	464	471	480	471	454	433	408	376	387	394	403	407	414	407	380	365	345	338	333	343	370	415	439	445	A	406
	419	415	398	381	374	370	366	368	373	379	390	397	410	412	414	419	418	410	391	385	372	384	391	407	Q	393
	469	533	559	635	616	566	484	368	387	400	397	375	392	361	313	304	296	299	282	323	328	405	477	434	D	417
Feb.	533	524	564	549	511	445	406	384	386	398	369	355	355	318	291	267	254	279	338	326	365	426	447	484	A	399
	487	475	450	435	421	387	382	375	369	380	413	399	412	419	412	414	408	398	399	401	393	383	403	422	Q	410
	613	465	550	487	441	517	484	383	394	391	137	268	253	189	68	156	272	303	353	301	441	549	533	558	D	391
Mar.	500	525	531	524	500	459	401	395	413	415	419	421	404	380	376	364	338	324	334	362	380	447	463	464	A	422
	436	447	441	430	410	394	387	382	388	392	401	405	411	410	411	410	409	406	400	387	390	401	415	400	Q	407
	575	608	648	644	633	584	522	489	472	464	439	414	375	298	277	294	224	275	296	244	363	527	464	588	D	447
Apr.	489	498	508	541	513	471	447	438	440	422	418	419	400	406	384	379	359	341	339	345	346	396	437	468	A	425
	386	400	399	396	380	351	356	369	387	395	400	407	408	410	411	413	410	407	410	395	383	387	392	390	Q	393
	578	442	510	696	634	594	605	556	519	437	413	382	399	392	294	316	361	393	265	287	394	467	513	543	D	458
May	487	489	504	513	494	456	400	393	400	409	419	412	412	407	395	378	364	338	346	330	328	356	409	451	A	412
	414	427	416	431	411	386	381	389	397	397	402	411	413	415	417	412	404	395	407	377	363	386	402	413	Q	403
	554	489	626	608	607	547	431	431	443	435	439	420	412	377	377	313	316	263	227	278	324	331	435	503	D	424
Jun.	446	454	449	439	404	375	352	363	372	388	400	411	408	409	403	387	377	365	337	345	345	350	393	414	A	391
	407	411	390	385	391	391	384	384	382	391	394	395	398	400	401	399	403	403	396	389	377	362	373	393	Q	391
	441	463	491	474	406	348	319	369	376	399	388	418	419	406	377	338	317	316	278	340	347	345	439	394	D	384
Jul.	420	420	419	416	384	373	362	370	377	377	387	398	400	394	396	391	392	385	366	351	362	364	382	398	A	387
	403	397	389	376	364	374	375	378	379	382	387	390	392	389	389	392	393	391	392	382	368	365	370	380	Q	383
	432	396	433	437	427	359	330	360	366	357	350	398	408	401	391	367	381	350	325	293	366	345	388	441	D	379
Aug.	407	414	406	402	377	363	353	356	362	368	374	381	385	388	385	384	380	365	355	347	342	354	355	395	A	375
	392	390	385	374	382	381	373	371	370	373	382	384	385	385	384	391	394	386	372	380	370	367	375	382	Q	380
	390	432	437	445	364	342	314	323	345	356	356	360	377	380	360	365	348	316	306	285	268	320	282	390	D	352
Sep.	422	429	437	428	390	366	353	345	353	363	373	380	382	373	376	378	371	356	344	330	342	362	393	418	A	378
	433	419	409	415	395	372	363	364	366	370	371	379	383	384	387	393	395	386	380	372	370	378	403	403	Q	387
	425	456	489	487	453	396	363	326	321	336	345	372	351	329	342	353	333	279	304	324	291	344	388	424	D	368
Oct.	456	461	442	426	398	375	348	348	360	356	363	363	355	348	338	342	336	335	312	347	378	392	434	451	A	378
	427	417	398	382	372	350	342	349	363	377	384	389	392	387	389	388	390	385	376	365	360	370	389	410	Q	381
	471	463	402	424	461	492	379	344	336	306	323	286	280	278	191	280	284	286	217	374	423	411	443	459	D	359
Nov.	434	449	448	433	390	354	345	348	359	372	366	352	357	366	363	349	340	319	316	322	349	371	408	422	A	372
	414	423	402	370	347	334	338	351	362	368	373	383	396	403	404	404	388	366	350	351	354	369	400	411	Q	378
	418	434	442	451	420	349	334	322	343	354	274	173	216	256	317	235	257	277	264	312	339	360	377	409	D	331
Dec.	440	450	452	416	363	333	327	334	346	367	386	397	385	370	355	356	346	314	314	332	336	362	396	419	A	371
	423	451	440	391	358	330	321	330	345	357	372	391	402	404	401	392	380	348	322	306	337	378	372	395	Q	373
	426	426	461	441	367	281	267	300	330	360	393	399	328	275	218	241	258	182	231	318	339	368	418	435	D	336
Year	458	465	470	463	432	400	375	371	379	386	390	391	388	380	370	362	350	338	336	340	353	383	413	436	A	393
	420	423	410	397	384	368	364	368	373	380	389	394	400	401	402	402	399	390	383	374	370	377	390	400	Q	390
	483	467	504	519	486	448	403	381	386	383	355	355	351	329	294	297	304	295	279	306	352	398	430	465	D	387

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995.

Horizontal intensity (H)

MAWSON ANTARCTIC 1994 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		Mean
Jan.	7	-26	-27	-20	-36	-40	-16	11	25	32	57	88	105	101	94	99	73	42	31	-8	-27	-8	-3	-3	A	23
	41	46	42	46	46	46	38	33	29	26	34	36	34	38	40	60	72	75	68	59	41	57	57	48	Q	46
	-32	-65	-93	43	36	-54	-59	-22	24	37	94	169	169	145	116	109	81	41	5	-36	-75	-45	-35	-119	D	18
Feb.	-29	-37	-21	-21	-55	-25	-5	-1	8	29	58	103	104	84	30	6	-14	-55	-129	-139	-134	-72	-49	-31	A	-19
	28	24	31	9	58	54	44	34	13	-2	50	49	54	68	55	61	49	29	36	41	38	40	35	53	Q	40
	-5	-183	-80	-169	-332	-148	-45	-29	0	18	24	160	124	12	-264	-175	-76	-181	-302	-373	-127	-103	40	86	D	-90
Mar.	-46	-19	-20	-32	-21	-36	-51	-18	10	32	52	66	76	70	57	36	1	-32	-50	-70	-51	-69	-45	-69	A	-9
	42	34	5	26	29	37	35	30	32	26	21	23	25	27	31	32	37	39	42	29	15	24	-25	-4	Q	26
	-21	30	-13	-69	6	-2	-93	-4	25	70	102	131	144	81	29	-34	-180	-199	-292	-312	-170	-226	-161	-73	D	-51
Apr.	-67	-97	-68	-26	-26	-26	-36	-4	29	22	55	66	67	63	64	50	16	-8	-33	-43	-89	-100	-76	-84	A	-15
	13	24	28	20	2	-11	9	23	25	28	29	33	35	40	42	47	46	49	59	53	42	38	21	19	Q	30
	-41	-462	-325	-71	-102	-90	-32	-20	9	-46	68	77	78	73	26	17	-37	-50	-174	-156	-130	-179	-121	-146	D	-76
May	-48	-59	-57	-64	-88	-87	-64	-21	12	44	65	65	78	79	72	49	32	13	-5	-46	-69	-64	-78	-103	A	-14
	19	16	11	-4	-14	9	31	32	37	36	35	39	44	49	58	67	59	54	62	45	32	2	6	6	Q	30
	-102	-182	-189	-176	-138	-117	-86	-48	21	78	92	79	109	105	74	-2	-58	-70	-58	-150	-210	-85	-176	-144	D	-60
Jun.	-41	-14	-27	-29	-59	-44	-33	-14	19	31	46	67	73	69	78	76	72	56	47	38	-12	-50	-30	-62	A	11
	11	2	5	22	29	38	39	41	33	39	41	38	43	45	49	49	53	56	58	61	46	41	47	27	Q	39
	-150	-40	-61	-51	-131	-114	-85	-57	-5	22	36	91	96	83	111	89	74	36	24	22	-65	-136	-92	-169	D	-18
Jul.	-25	-35	-40	-40	-36	-8	11	24	32	33	42	54	61	67	63	61	68	64	55	29	8	-23	-29	-28	A	17
	33	14	18	10	7	27	37	40	37	36	38	41	43	43	45	46	48	49	52	54	50	37	42	33	Q	37
	-150	-189	-94	-71	-20	-50	-55	-16	-4	28	41	90	86	98	87	58	89	63	49	-16	-59	-63	-89	-57	D	-10
Aug.	-34	-11	-7	-7	-10	3	16	27	35	34	33	41	49	57	58	58	63	52	41	36	7	2	-21	-26	A	21
	-25	7	22	27	46	49	43	39	37	36	37	40	42	43	43	48	53	57	54	52	42	33	25	-23	Q	34
	-185	-79	-36	-31	-99	-89	-70	-31	22	29	27	47	77	84	78	63	55	27	8	22	-23	-33	-111	-77	D	-14
Sep.	-35	-23	-11	-28	-23	-19	0	8	28	32	44	49	59	52	64	67	66	53	35	0	-2	-27	6	2	A	17
	-14	-48	-34	-30	16	45	54	51	42	35	32	36	39	42	49	57	66	60	58	52	51	48	37	34	Q	32
	-41	-19	-11	-71	-68	-139	-69	-72	-1	21	69	80	102	63	69	79	74	22	-5	-50	-111	-155	-50	-8	D	-12
Oct.	-21	-3	-25	-34	-60	-64	-38	-5	16	29	45	45	52	41	34	44	46	26	-13	-22	-27	-23	-1	-22	A	1
	-15	-12	9	39	51	36	26	24	27	36	39	43	47	49	49	46	51	55	57	43	20	39	53	-14	Q	33
	-65	-10	-59	-79	-118	-103	-159	-115	-64	-29	38	12	19	-25	-83	-3	11	-75	-131	-84	-56	-1	-20	-33	D	-51
Nov.	24	16	-8	-22	-54	-49	-14	16	28	40	57	63	75	76	92	89	82	56	36	3	-14	1	16	7	A	26
	25	34	13	23	45	34	33	28	24	24	26	35	51	69	76	85	91	93	80	77	53	36	34	40	Q	47
	6	0	-58	-119	-222	-214	-131	-46	16	56	77	26	35	18	88	38	34	33	-5	-42	-59	-9	13	25	D	-18
Dec.	21	36	13	-23	-21	1	22	26	33	45	57	76	107	113	106	106	103	65	48	44	11	-13	1	14	A	41
	53	49	31	-19	-12	16	28	41	38	33	40	55	79	89	88	88	95	80	70	33	31	24	37	32	Q	46
	-7	55	52	-5	-62	-50	-52	-56	11	48	66	110	170	136	100	87	73	-26	-17	48	-16	-70	-73	-33	D	20
Year	-24	-23	-25	-29	-41	-33	-17	4	23	34	51	65	75	73	68	62	51	28	5	-15	-33	-37	-26	-34	A	8
	18	16	15	14	25	32	35	35	31	29	35	39	45	50	52	57	60	58	58	50	38	35	31	21	Q	37
	-66	-95	-81	-72	-104	-97	-78	-43	5	28	61	89	101	73	36	27	12	-32	-75	-94	-92	-92	-73	-62	D	-30

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995 .

Declination East (D)

MAWSON ANTARCTIC 1994 -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		Mean
Jan.	426	479	531	583	658	689	659	564	488	471	455	458	430	408	407	397	402	398	400	398	373	367	389	409	A	468
	464	492	544	555	562	561	544	517	484	466	448	439	424	426	429	417	416	414	428	421	417	424	420	406	Q	463
	422	474	521	551	604	761	778	611	486	496	480	495	433	398	399	397	380	376	374	391	350	329	355	421	D	470
Feb.	448	500	555	641	723	670	631	592	542	518	553	507	466	454	453	443	450	428	369	362	332	401	397	410	A	488
	445	499	555	639	596	582	568	572	566	500	428	446	441	434	438	453	451	474	473	468	454	447	453	473	Q	494
	392	551	627	758	990	789	674	672	563	572	764	573	535	490	607	515	399	348	334	588	279	373	374	366	D	550
Mar.	530	547	577	617	660	691	667	592	545	525	497	478	464	463	462	458	496	521	505	463	439	435	460	508	A	525
	486	514	551	554	565	557	539	538	516	515	492	484	483	486	485	484	483	484	478	477	476	478	484	523	Q	506
	528	558	586	627	691	713	727	614	580	580	488	493	455	490	465	432	576	610	515	502	392	464	514	483	D	545
Apr.	531	576	618	647	665	673	663	605	541	517	506	492	485	482	490	490	517	559	537	494	472	453	434	512	A	540
	500	528	527	539	580	601	569	541	515	502	497	496	494	494	497	497	499	500	490	497	501	493	503	503	Q	515
	555	636	777	766	781	784	771	747	631	642	567	532	477	466	500	505	478	491	549	424	438	364	410	546	D	576
May	557	607	623	663	700	708	658	589	527	496	481	484	482	485	491	503	523	541	542	544	522	482	480	527	A	551
	525	538	555	576	588	558	531	518	513	506	502	498	494	494	493	496	497	512	496	502	492	495	519	522	Q	517
	603	825	816	815	791	757	688	606	495	487	465	482	470	490	498	516	616	670	734	532	482	440	380	523	D	591
Jun.	535	583	622	629	664	643	611	550	515	497	476	471	478	485	483	487	494	511	529	520	518	515	464	509	A	532
	558	554	561	549	541	524	530	527	520	501	492	498	502	503	499	501	501	502	509	510	517	513	494	505	Q	516
	553	608	679	670	754	730	656	556	501	503	468	448	463	474	460	482	481	512	550	513	466	529	401	459	D	539
Jul.	546	580	604	648	629	604	567	538	515	510	499	492	494	494	497	500	501	507	519	525	526	518	501	531	A	535
	525	551	551	556	559	544	533	522	515	511	509	507	506	508	512	511	512	513	513	521	526	518	507	511	Q	523
	595	619	620	729	657	638	633	578	539	540	512	472	477	470	478	506	483	521	546	540	500	585	474	532	D	552
Aug.	565	579	591	594	600	593	567	538	519	512	511	505	507	502	501	498	500	510	517	511	539	541	547	545	A	537
	575	563	547	543	529	531	530	527	520	518	518	518	514	512	512	509	509	511	525	516	521	528	537	570	Q	528
	571	636	621	633	681	704	649	599	542	518	524	485	484	472	493	489	494	516	564	492	573	550	556	504	D	556
Sep.	577	594	609	654	669	656	620	586	540	531	519	508	499	502	506	498	501	510	523	520	505	505	503	542	A	549
	586	610	628	663	624	572	551	539	529	523	521	516	516	518	513	508	505	511	515	518	515	508	510	526	Q	543
	584	597	626	724	750	802	724	721	582	564	543	503	468	475	505	475	496	534	565	514	507	486	490	510	D	573
Oct.	552	587	646	697	758	762	714	641	592	580	546	526	506	499	501	488	504	509	529	513	491	476	491	526	A	568
	547	592	615	609	593	603	596	564	532	523	512	506	507	507	510	516	518	519	512	510	515	507	491	538	Q	539
	534	600	708	759	868	870	963	837	754	739	600	597	528	518	552	485	471	503	586	477	487	429	472	526	D	619
Nov.	517	566	628	706	776	774	676	600	564	537	538	538	500	484	472	469	472	483	478	467	452	453	467	492	A	546
	519	576	637	682	657	630	597	562	540	521	514	509	499	492	489	477	486	486	491	494	466	465	469	479	Q	531
	542	562	662	794	948	1002	853	702	655	613	684	719	585	516	450	439	443	459	474	433	414	439	471	470	D	597
Dec.	519	554	610	709	778	737	668	594	555	533	512	490	481	463	471	464	458	479	479	470	477	458	460	478	A	537
	530	555	594	698	741	706	655	573	535	516	506	497	491	495	492	492	483	489	488	501	492	476	494	499	Q	542
	523	527	568	706	858	845	797	659	577	550	506	475	482	422	446	424	393	409	450	394	386	415	426	487	D	530
Year	525	563	601	649	690	683	642	582	537	519	508	496	483	477	478	475	485	496	494	482	470	467	466	499	A	531
	522	548	572	597	595	581	562	542	524	508	495	493	489	489	489	488	488	493	493	494	491	488	490	505	Q	518
	533	599	651	711	781	783	743	658	575	567	550	523	488	473	488	472	476	496	520	483	440	450	443	486	D	558

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995 .

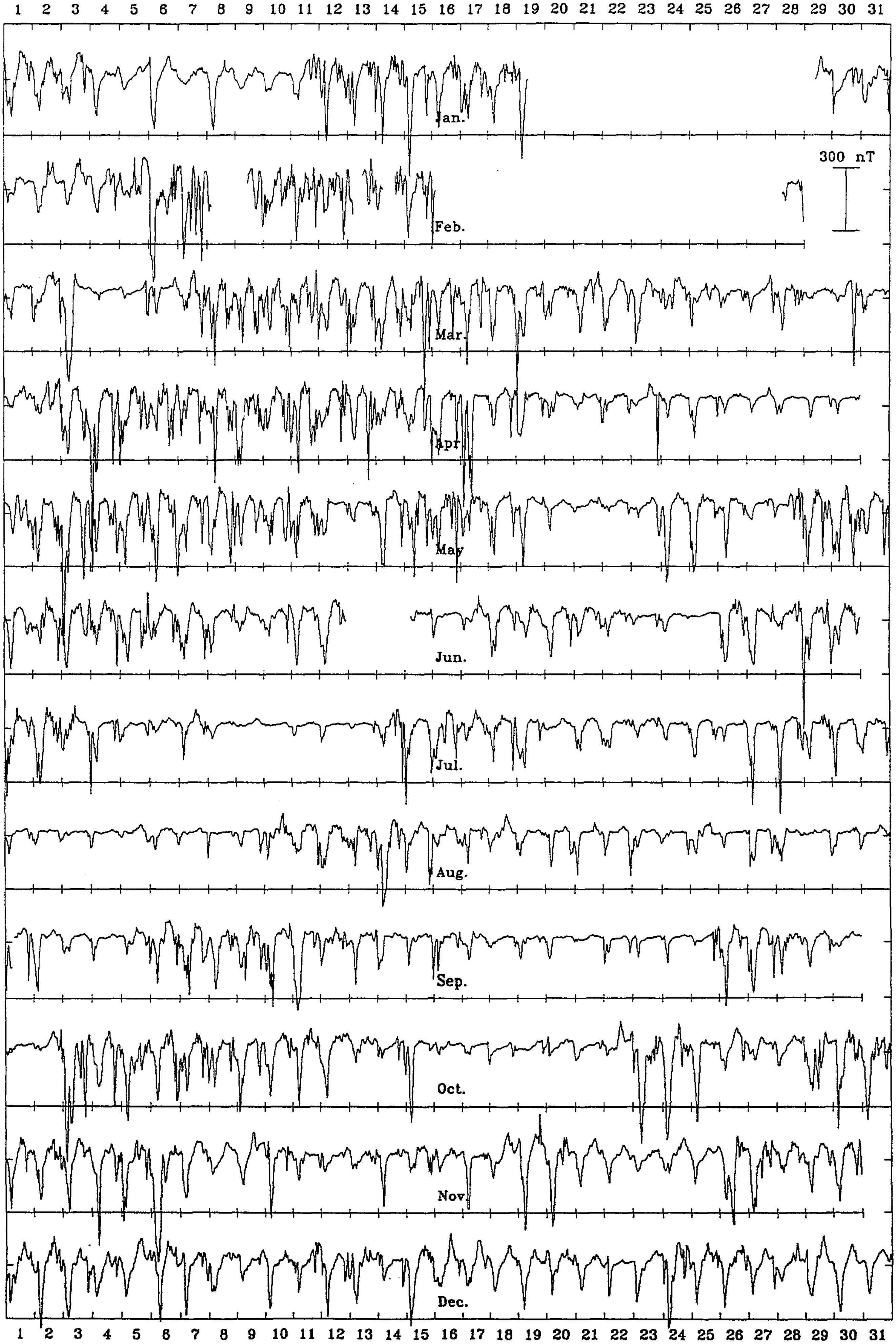
Inclination (I)

MAWSON ANTARCTIC 1994 -67 deg - tabular values in 0.1 min

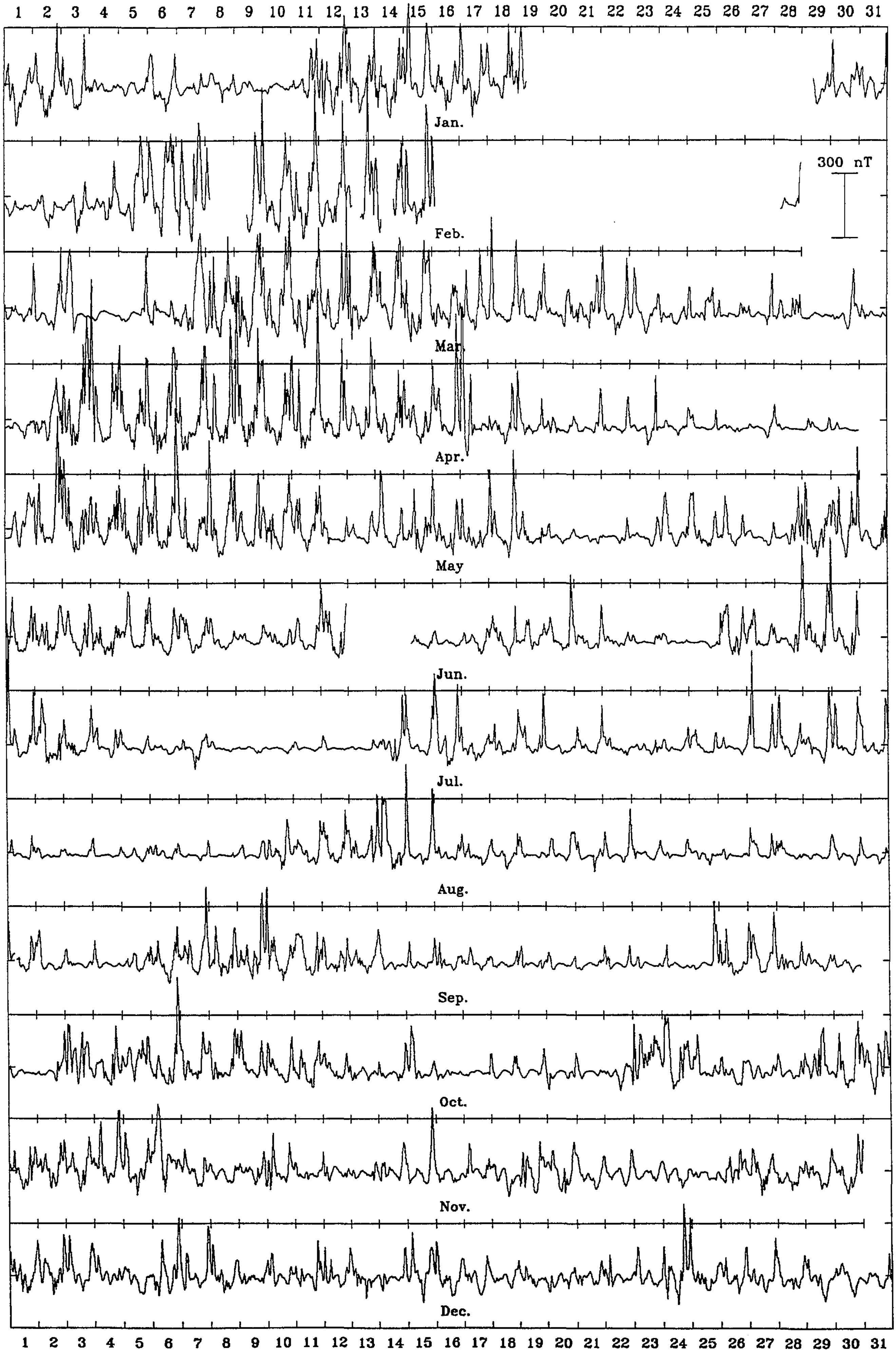
UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Mean
Jan.	617	643	647	639	646	644	618	589	582	579	562	540	529	531	528	520	534	555	562	594	616	614	618	619	A	589
	579	573	572	565	562	561	566	570	575	579	576	576	581	579	578	564	555	551	551	555	565	557	559	570	Q	567
	648	690	718	638	638	691	672	612	582	576	533	470	475	485	493	495	514	545	567	609	640	639	652	703	D	595
Feb.	663	667	665	662	677	635	610	601	594	582	552	514	513	518	551	563	573	611	684	688	695	666	654	651	A	618
	608	607	595	607	566	560	566	571	586	600	570	567	567	558	566	563	570	582	577	574	574	570	579	571	Q	577
	667	759	706	755	864	747	661	621	602	588	511	446	469	535	710	667	625	713	817	856	711	722	612	584	D	669
Mar.	666	654	655	663	648	648	642	616	600	584	570	561	548	546	555	567	586	607	623	646	637	669	655	674	A	618
	582	592	612	593	585	575	575	577	576	582	589	588	589	587	584	583	579	577	573	579	590	586	627	607	Q	587
	668	640	683	724	665	657	708	632	605	570	539	510	489	514	547	600	690	719	794	795	721	809	743	711	D	655
Apr.	679	704	685	663	655	644	645	617	594	594	568	560	554	559	551	561	581	594	611	621	656	678	671	686	A	622
	590	586	583	588	597	599	585	578	582	581	582	581	580	577	576	573	572	570	563	563	568	572	586	587	Q	580
	685	962	878	739	745	725	686	663	630	649	557	541	545	547	555	568	621	640	698	690	700	757	726	753	D	677
May	664	673	676	683	696	685	652	618	595	574	561	559	549	547	549	561	570	577	593	619	636	640	665	696	A	618
	594	600	600	616	618	593	575	577	576	576	579	578	575	571	565	557	561	562	560	564	570	599	600	603	Q	582
	724	766	808	793	765	733	677	649	600	555	546	551	526	519	542	581	624	618	599	683	741	649	746	741	D	656
Jun.	648	630	638	637	649	630	615	604	582	577	569	557	552	555	547	544	544	552	551	560	598	628	624	655	A	593
	598	606	597	584	580	573	570	569	574	572	571	574	571	570	568	567	565	563	560	555	563	563	561	582	Q	572
	728	652	675	663	704	675	645	638	601	587	574	541	537	544	514	520	526	554	551	571	638	691	684	730	D	613
Jul.	628	636	640	639	627	602	586	577	574	573	569	563	559	552	556	556	551	552	554	569	588	611	621	625	A	588
	580	593	587	590	589	577	569	568	570	572	572	571	569	568	567	567	566	565	563	558	558	567	565	573	Q	572
	725	745	684	667	627	630	626	605	598	571	560	536	542	531	536	551	532	542	546	586	639	636	667	659	D	606
Aug.	631	617	611	610	605	591	579	571	568	570	572	568	563	558	556	556	551	555	561	562	582	589	607	622	A	581
	621	596	583	577	565	562	564	567	568	570	571	570	568	568	568	566	563	558	556	560	564	570	578	616	Q	573
	740	672	642	640	669	655	633	606	573	570	571	557	540	536	534	547	548	560	571	555	585	606	655	659	D	601
Sep.	637	630	623	633	619	609	591	583	570	570	564	562	555	557	549	548	546	552	562	585	589	614	598	608	A	585
	624	645	632	631	590	563	553	556	563	569	572	571	570	568	564	559	553	555	555	557	557	562	577	580	Q	576
	642	634	637	682	670	707	646	638	583	570	537	536	514	537	536	531	530	554	581	620	657	705	638	617	D	604
Oct.	635	623	635	637	648	645	618	593	581	570	560	560	553	559	561	555	551	566	589	606	618	619	614	635	A	597
	623	618	597	569	558	564	568	572	574	571	571	569	566	564	565	566	563	559	555	562	578	566	561	617	Q	574
	673	629	649	670	710	707	717	675	634	600	554	563	556	589	608	573	563	628	651	659	652	608	631	646	D	631
Nov.	596	606	623	630	642	628	599	578	572	566	552	543	535	538	525	523	526	539	553	580	600	595	594	605	A	577
	590	585	595	578	556	560	562	569	575	577	577	573	565	553	548	541	533	525	530	533	552	569	579	578	Q	563
	605	614	659	707	776	750	684	617	576	549	511	520	526	550	515	529	538	545	570	611	631	600	588	588	D	598
Dec.	600	591	609	626	610	585	567	566	564	561	557	546	520	511	512	512	511	531	544	552	578	603	603	599	A	565
	571	582	592	616	601	572	561	554	560	567	566	560	546	538	539	536	527	529	530	553	563	580	569	579	Q	562
	617	570	582	620	641	608	606	618	576	557	553	521	456	466	477	494	509	562	569	545	599	647	664	639	D	571
Year	639	639	642	643	644	629	610	593	581	575	563	553	544	544	545	547	552	566	582	599	616	627	627	639	A	596
	597	599	596	593	581	572	568	569	573	576	575	573	571	567	566	562	559	558	556	559	567	572	578	589	Q	574
	677	694	694	692	706	691	663	631	597	579	545	524	515	529	547	555	568	598	626	648	659	672	667	669	D	623

Q and D indicate International Quiet and Disturbed days respectively; A indicates all days.
Printed:14:49 HRS., Thu. 06 JUL. 1995 .

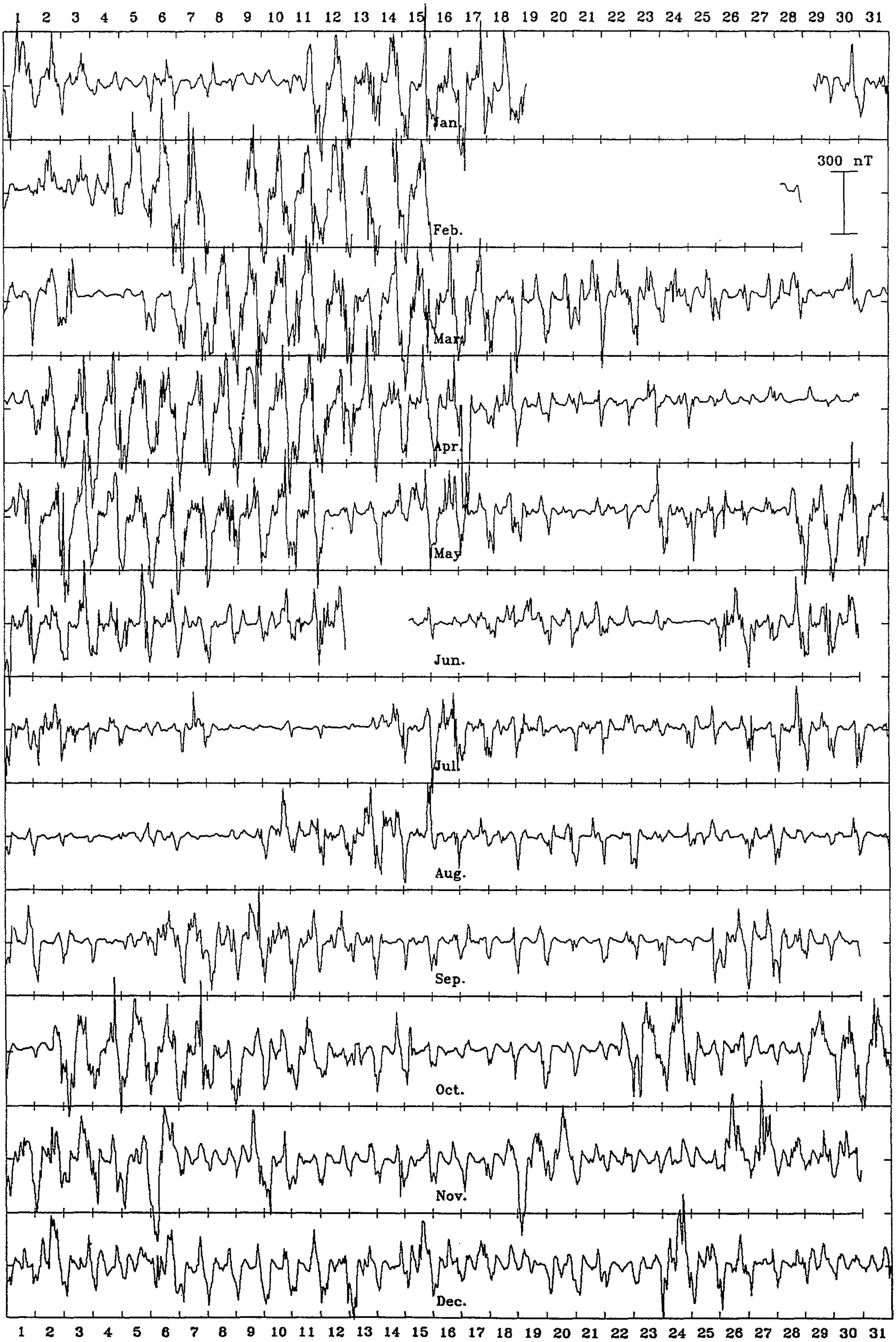
MAWSON ANTARCTIC 1994 North component (X). Scale:25.0 nT/mm.



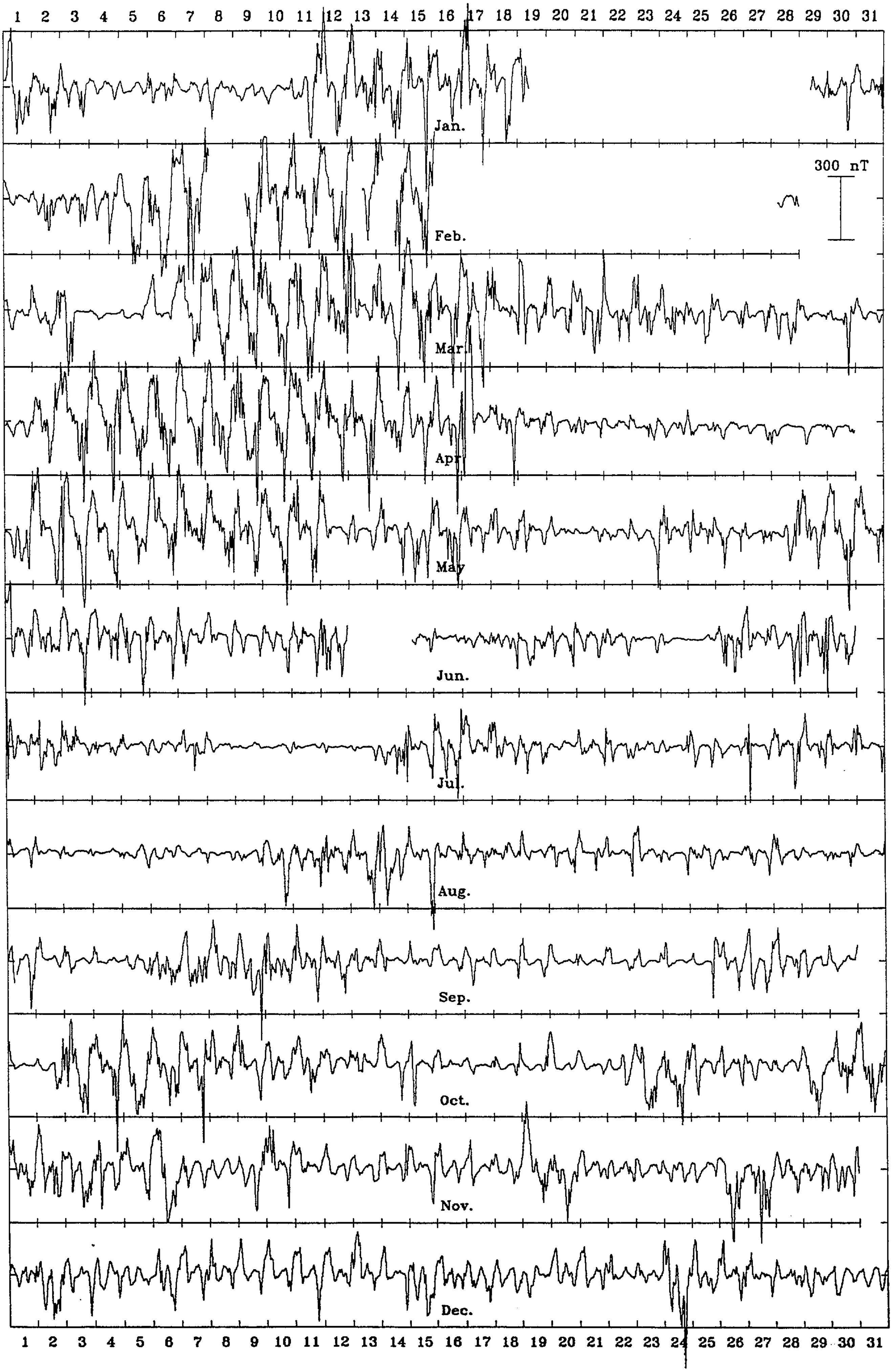
MAWSON ANTARCTIC 1994 East component (Y). Scale:25.0 nT/mm.



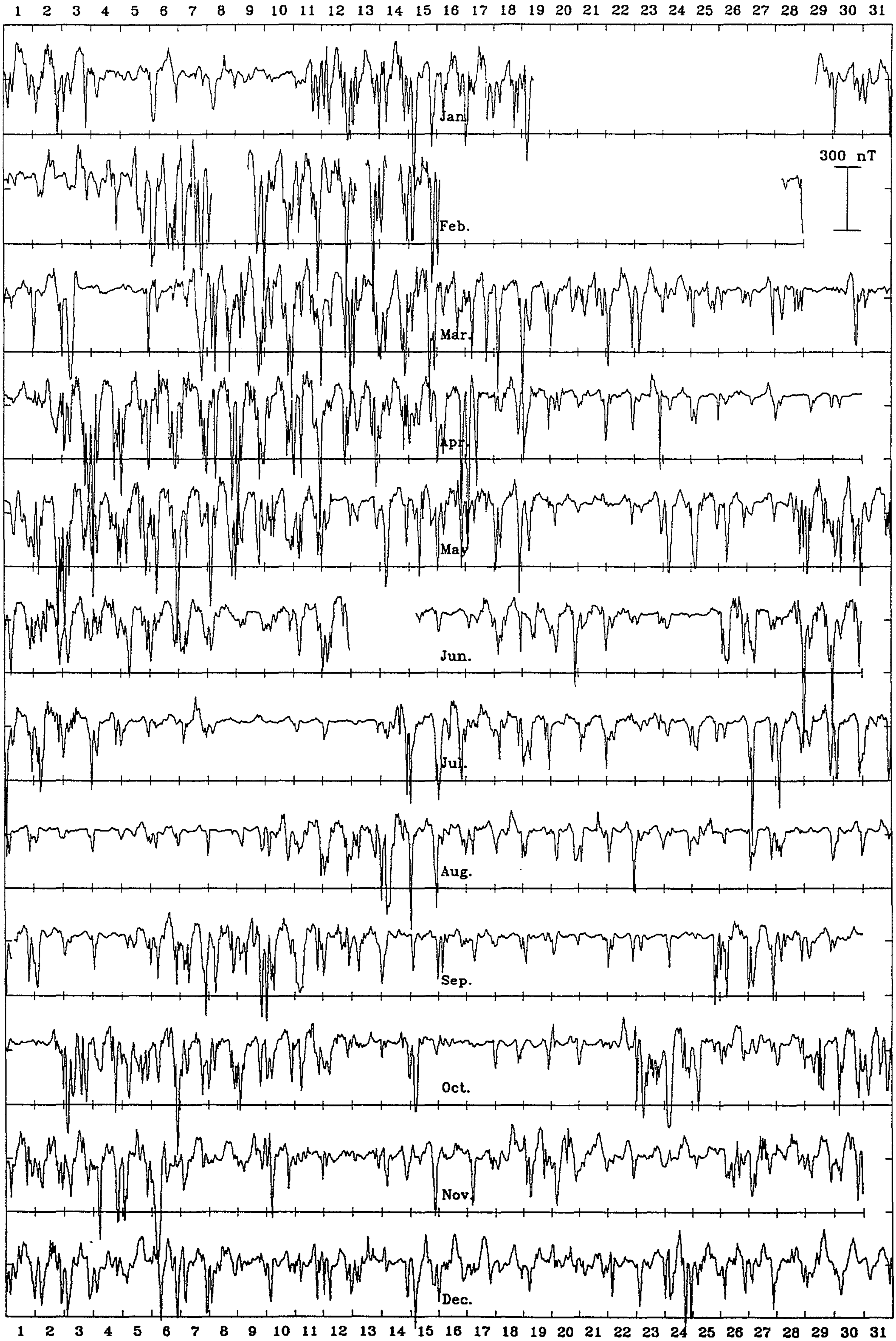
MAWSON ANTARCTIC 1994 Vertical intensity (Z). Scale:25.0 nT/mm.



MAWSON ANTARCTIC 1994 Total intensity (F). Scale:25.0 nT/mm.

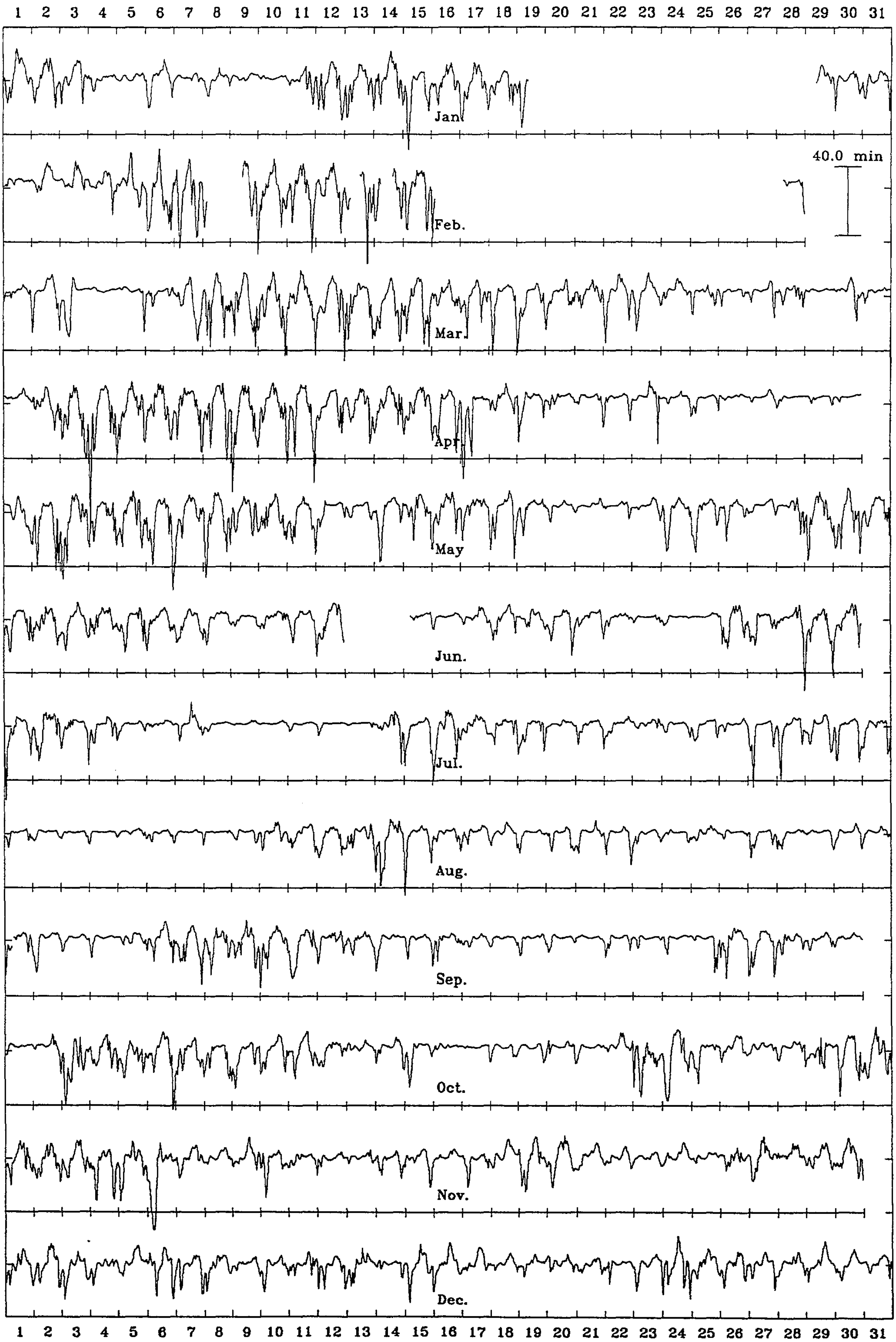


MAWSON ANTARCTIC 1994 Horizontal intensity (H). Scale:25.0 nT/mm.



MAWSON ANTARCTIC 1994 Declination (east) (D). Scale: 3.0 min/mm.

MAWSON ANTARCTIC 1994 Inclination (I). Scale: 3.0 min/mm.



APPENDIX I. MAWSON 1994 K-INDICES AND DAILY K-SUMS

K=9 Limit : 1500 nT

Date	January	February	March	April	May	June	Date
01	D 5565 5454 39	Q 3323 3212 19	4343 2336 28	2332 2323 20	2344 4466 33	5665 4466 42	01
02	5455 4564 38	3454 4331 27	6443 3356 34	D 4444 5465 36	D 6664 3487 44	D 5565 4476 42	02
03	5344 3463 32	3333 4453 28	5666 3211 30	D 6665 5687 49	D 8765 5776 51	D 5665 3565 41	03
04	3442 3133 23	4342 4565 33	Q 2232 2100 12	D 8664 4587 48	6665 4568 46	5554 4556 39	04
05	Q 3332 2124 20	4535 5565 38	Q 2312 1136 19	6555 5667 45	D 5665 4676 45	5554 4776 43	05
06	6543 3345 33	D 7746 6576 48	3543 2244 27	5565 4777 46	5765 3477 44	5555 4376 40	06
07	Q 3222 3243 21	D 5766 7673 47	D 4556 6576 44	6555 5676 45	6665 4574 43	4664 3366 38	07
08	4452 3224 26	D 7--- ---- --	D 5675 5675 46	6675 5677 49	7666 4577 48	5534 2344 30	08
09	Q 3123 2212 16	---- 5877 --	D 5765 5877 50	D 7666 5577 49	5655 4675 43	3454 2234 27	09
10	Q 3232 2112 16	6456 4775 44	D 6665 5577 47	6665 5677 48	5666 4667 46	3434 4365 32	10
11	3444 4666 37	5665 5787 49	5565 6657 45	6675 4767 48	5664 4776 45	4565 3256 36	11
12	D 6665 6666 47	4555 5676 43	5564 4577 43	5554 3497 42	5553 3315 30	D 6654 565- --	12
13	D 6665 4557 44	5565 4686 45	6655 3367 41	4654 4777 44	Q 4453 1245 28	---- ---- --	13
14	D 5655 5565 42	6555 4667 44	6765 4687 49	6555 4576 43	3663 3336 33	---- ---- --	14
15	6763 3476 42	6654 4675 43	D 6556 5877 49	6545 3657 41	3566 4466 40	Q --33 2236 --	15
16	4654 4565 39	---- ---- --	4554 4766 41	6653 4487 43	6665 4685 46	Q 5222 2222 19	16
17	D 6565 4566 43	---- ---- --	5664 4775 44	D 9778 3233 42	5565 3432 33	3323 3334 24	17
18	5556 5865 45	Q ---- ---- --	6753 3347 38	5564 4476 41	6664 4447 41	6654 2336 35	18
19	566- ---- --	---- ---- --	7563 3356 38	6553 3235 32	4664 3234 32	3345 3236 29	19
20	---- ---- --	---- ---- --	6432 2455 31	2554 3225 28	Q 3533 2203 21	5554 4366 38	20
21	---- ---- --	D ---- ---- --	3564 4575 39	3342 2235 24	Q 3232 2133 19	4456 3346 35	21
22	---- ---- --	D ---- ---- --	6534 4356 36	4322 3226 24	Q 2322 3235 22	5443 3144 28	22
23	---- ---- --	---- ---- --	4654 4434 34	2322 4347 27	2322 2336 23	Q 3221 0054 17	23
24	Q ---- ---- --	Q ---- ---- --	5435 4324 30	3452 2323 24	4754 3334 33	Q 3321 1113 15	24
25	---- ---- --	---- ---- --	6343 3665 36	4531 1115 21	6655 3336 37	Q 0220 0112 08	25
26	---- ---- --	Q ---- ---- --	Q 4344 2354 29	Q 3331 2210 15	3554 3326 31	D 5664 3466 40	26
27	---- ---- --	Q ---- ---- --	3422 2346 26	Q 1322 1234 18	Q 3322 1334 21	5563 3375 37	27
28	---- ---- --	--33 2146 --	3543 3545 32	Q 4320 1000 10	3113 4466 28	3433 3568 35	28
29	---- 5865 --		Q 3342 2112 18	Q 1332 1114 16	D 7765 5767 50	D 7664 3477 44	29
30	5333 3545 31		2333 3665 31	Q 1320 0023 11	D 6565 5668 47	6554 3667 42	30
31	5433 3336 30		Q 4433 2222 22		4464 4377 39		31
Mean K-sum	33.2	39.1	35.1	34.3	36.8	32.9	

Date	July	August	September	October	November	December	Date
01	D 7655 3247 39	3522 2253 24	6443 2265 32	Q 3321 1002 12	3543 3655 34	4544 4435 33	01
02	D 5665 3566 42	Q 3321 1014 15	Q 5511 2123 20	3222 2446 25	5554 4565 39	D 5653 5456 39	02
03	5554 3336 34	2312 2024 16	4321 1223 18	D 7765 5775 49	4443 4564 34	5544 3255 33	03
04	4433 2366 31	Q 4100 0103 09	Q 4311 1111 13	4554 4674 39	D 4754 3474 38	Q 4333 3253 26	04
05	3331 0225 19	2112 2234 17	2424 3245 26	5665 4566 43	6524 4365 35	3423 3324 24	05
06	3332 2123 19	3322 2134 20	4543 3447 34	4654 5368 41	D 6775 4553 42	D 4564 4566 40	06
07	3544 4345 32	Q 2110 1205 12	D 3564 5467 40	D 5564 4776 44	5433 2354 29	4543 3546 34	07
08	Q 2321 3122 16	Q 4010 0022 09	D 3654 3466 37	5644 3366 37	Q 4322 3242 22	5445 3355 34	08
09	2100 0221 08	3310 1154 18	D 5565 5476 43	6542 3364 33	3333 4455 30	4433 2345 28	09
10	Q 1121 0123 11	5433 4663 34	6564 4355 38	5543 3365 34	5753 3464 37	5533 3344 30	10
11	3310 0111 10	D 3344 4335 29	6564 3364 37	3653 4465 36	3453 2225 26	3532 3665 33	11
12	Q 4300 0000 07	D 5544 3365 35	5324 4345 30	4553 2244 29	Q 4331 2333 22	5653 4355 36	12
13	Q 2341 0024 16	D 5553 4575 39	2443 3235 26	3434 3334 27	3322 3344 24	4554 5433 33	13
14	D 3433 3557 33	D 6765 3556 43	5521 3222 22	4312 2545 26	4532 2365 30	4333 3265 29	14
15	D 7543 3246 34	D 6454 3367 38	5322 2326 25	6553 3154 32	3332 3265 27	D 5544 5456 38	15
16	D 6555 4475 41	4424 2245 27	5532 2254 28	3343 2122 20	3431 3331 21	5554 4355 36	16
17	4454 4345 33	4443 2324 26	3442 2224 23	Q 3231 1114 16	3552 2145 27	4333 3453 28	17
18	3644 4265 34	4333 4325 27	3332 2124 20	4221 0144 18	4322 4332 23	Q 4332 3334 25	18
19	5453 3356 34	4331 2123 19	5220 1453 22	2211 2245 19	5653 4664 39	4533 3213 24	19
20	3232 2212 17	2532 2265 27	Q 4421 1114 18	4332 2335 25	D 4653 5454 36	4533 3334 28	20
21	4444 3235 29	5410 2433 22	3221 2125 18	Q 4222 1133 18	5443 3333 28	Q 4343 3243 26	21
22	4343 2233 24	4311 1226 20	4421 1145 22	3223 4445 27	3422 3355 27	Q 4522 3112 20	22
23	3322 2243 21	6432 2124 24	Q 2411 0104 13	D 6666 5565 45	Q 3322 2235 22	5533 2235 28	23
24	3324 1125 21	3220 0216 16	3411 1112 14	6654 4756 43	Q 3332 2332 21	D 6656 5766 47	24
25	4443 2245 28	2443 3342 25	3221 1175 22	4662 3132 27	Q 4411 2133 19	D 4544 4446 35	25
26	Q 2321 1122 14	2331 0113 14	D 5563 3433 32	4433 3364 30	D 3556 6543 37	5534 4466 37	26
27	5732 1266 32	5452 2264 30	D 5544 3446 35	Q 3332 2244 23	D 5565 5454 39	4433 3265 30	27
28	6743 3367 39	4433 1333 24	4544 3244 30	Q 4222 2145 22	4444 4344 31	4323 3334 25	28
29	4553 3456 35	2231 1115 16	3421 2235 22	D 4456 6533 36	4443 3455 32	6453 3432 30	29
30	5542 3236 30	Q 3412 2234 21	Q 3122 2213 16	D 5766 4576 46	4543 4465 35	3453 3322 25	30
31	5433 4226 29	3210 2224 16		5565 5465 41		Q 3342 2235 24	31
MeanK-sum	26.2	23.0	25.9	31.1	30.2	30.9	