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ANNUAL REPORT FOR MAGNETIC OBSERVATORIES AND REPEAT STATIONS - 1987-1988

by

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Geophysics Division

Geological Survey of Canada

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Foreword

In 1987-88, the Geophysics Division of the Geological Survey of Canada operated a network of 12 magnetic observatories. This report describes the station sites, the instrumentation, and methods of data reduction and distribution. The Division also conducted repeat station measurements at 12 previously occupied sites in 1987 and 14 previously occupied sites in 1988 as part of the continuing program of measurements to supplement the observatory determinations. The procedures used for these repeat station measurements are also described in this report.

Tables of hourly mean values and ranges, as well as tables of hourly means grouped according to all days, international quiet days, and international disturbed days are microfilmed. Microfilm copies of these tables and of data plots in the form of magnetograms are sent on a regular basis to World Data Center A. Magnetic tapes containing digital data at 1-minute intervals, along with hourly means and ranges, are deposited at World Data Center A. Repeat station data are also deposited at World Data Center A.

The magnetic observatories and repeat stations in Canada are operated by:

Geophysics Division
Geological Survey of Canada
Energy, Mines and Resources Canada
Ottawa, Canada
K1A 0Y3

TABLE OF CONTENTS

Section I -	INTRODUCTION	3
	INSTRUMENTS	3
	Digital Magnetometer	3
	Digital stand-by system	4
	Absolute instruments	4
	Repeat station instruments	7
	D AND I MAGNETOMETER COMPARISONS AT OTTAWA	
	MAGNETIC OBSERVATORY	5
	Introduction	5
	Instrument Comparison	6
	Discussion	6
	ABSOLUTE OBSERVATIONS AND BASELINE CALCULATIONS	
	Calculations of baselines	7
	Reduction of Repeat Station Data	8
	QUALITY OF DATA	
	Accuracy of data	9
	Quality control of digital data	9
	DATA DISTRIBUTION	10
Section II -	STATION DESCRIPTIONS	11
	ALERT	12
	RESOLUTE BAY	14
	MOULD BAY	15
	CAMBRIDGE BAY	16
	BAKER LAKE	17
	YELLOWKNIFE B	19
	FORT CHURCHILL	21
	POSTE-DE-LA-BALEINE	22
	MEANOOK	23
	ST. JOHN'S	25
	OTTAWA	26
	VICTORIA	29
	GLENLEA (LIMITED ABSOLUTE CONTROL)	31
Section III -	ANNUAL MEANS FOR OBSERVATORIES	34
Section IV -	RESULTS FROM REPEAT STATIONS	35
References -	36

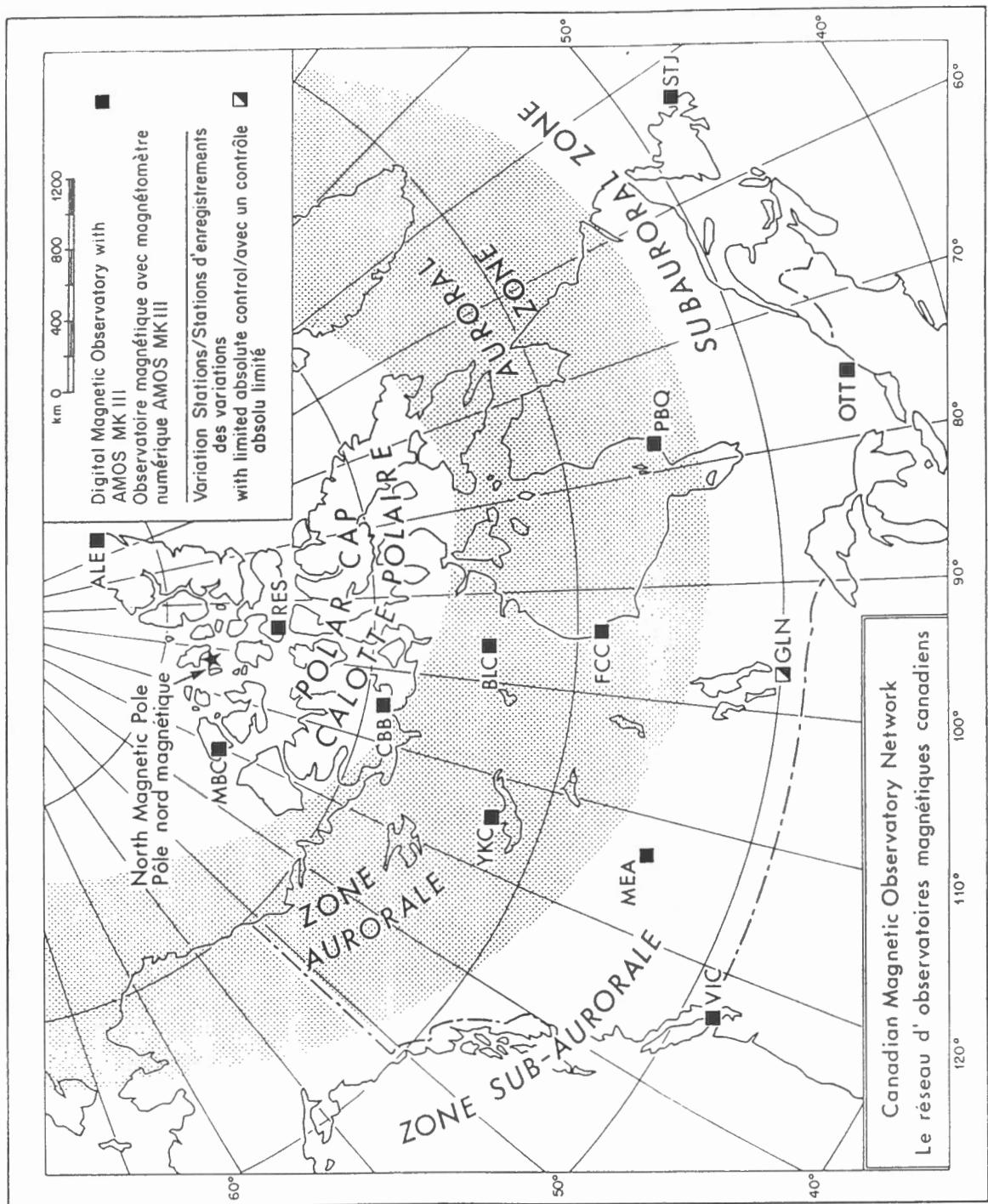


FIG. 1
Canadian Magnetic Observatory Network

ANNUAL REPORT
FOR MAGNETIC OBSERVATORIES - 1987-88

SECTION I

INTRODUCTION

The Canadian Magnetic Observatory Network consisted in 1987-88 of 12 standard observatories incorporating an Automatic Magnetic Observatory System (AMOS) at all sites (Figure 1).

All observatories record the orthogonal components X(North), Y(East), and Z(Vertical). A Telephone Verification System (TVS) is available for monitoring data from all sites except Alert. A digital back-up system has been in operation at all stations. The location, methods of recording, and dates of commencement and closing for Canadian observatories are given in Table 1.

An AMOS station, with limited absolute control, was operated at Glenlea, in cooperation with the University of Manitoba.

INSTRUMENTS

Digital Magnetometer

Automatic digital recording of magnetic data at Canadian geomagnetic observatories was introduced in 1969. The system was subsequently named AMOS I (Automatic Magnetic Observatory System) and has been described by Andersen (1974). AMOS I has now been replaced by AMOS III. AMOS III, incorporating advances in electronics and computer technology, was developed and built by the former Earth Physics Branch (EPB). At an early stage in the development, the technology was transferred to a commercial company, EDA Instruments Inc., who developed and built an EDA version along lines that differ from those of the Earth Physics Branch (Trigg and Nandi, 1984).

The orthogonal elements X, Y and Z are derived from three fluxgate sensors mounted inside a Helmholtz coil system. One pair of coils continuously nulls the principal horizontal component and the second pair nulls Z, so that the fluxgate operates in a relatively small field, less than 15% of the total field at all stations. To minimize temperature variations, the fluxgate sensors and associated Helmholtz coils are placed inside an insulated enclosure, with two thermostatically controlled electric light bulbs powered by alternating current to maintain an elevated temperature, typically near the high summertime temperatures expected at the station.

A proton precession magnetometer measures F. To reduce noise spikes in the F data, the proton precession magnetometer (PPM) sensors are operated inside cubes, 0.6 m to the side, constructed of 3 mm aluminum sheeting.

In the AMOS III, analogue signals from the fluxgate magnetometer are presented to three independent analogue-to-digital converters. Once per minute, digitally filtered values of X, Y and Z, along with an F value, are stored in memory until sufficient data are available to write a record on a cartridge tape recorder.

TABLE 1(a)

OBSERVATORIES		GEOGRAPHIC				GEOMAGNETIC*		
Name	IAGA Code	Lat.	N. ° '	Long.	W. ° '	Lat.	N. ° '	Long. E. ° '
Alert	ALE	82	30	62	21	85.7		168.5
Resolute Bay	RES	74	42	94	54	83.1		287.7
Mould Bay	MBC	76	12	119	24	79.1		255.4
Cambridge Bay	CBB	69	06	105	00	76.7		294.0
Baker Lake	BLC	64	20	96	02	73.9		314.8
Yellowknife B	YKC	62	28	114	28	69.1		292.7
Fort Churchill	FCC	58	48	94	06	68.8		322.5
Great Whale River	GWC	55	18	77	45	66.8		347.2
Poste-de-la-Baleine	PBQ	55	18	77	45	66.8		347.2
Agincourt	AGN	43	47	79	16	55.0		347.0
Meanook	MEA	54	37	113	20	61.8		301.0
St. John's	STJ	47	36	52	41	58.7		21.4
Ottawa	OTT	45	24	75	33	57.0		351.5
Victoria	VIC	48	31	123	25	54.3		292.7
+Whiteshell	WHS	49	48	95	15	59.9		325.3
+Glenlea	GLN	49	36	97	06	59.5		323.0

* Assuming geomagnetic pole 78.3N, 291.0E.

+ Variation stations with limited absolute control.

TABLE 1(b)

OBSERVATORIES	IAGA Code	ELEVATION m	ELEMENTS RECORDED	DATE OF COMMENCE- MENT OF CONTINUOUS RECORDING IN THREE ELEMENTS		CLOSED ELEMENTS
				Analogue	Digital	
Alert	ALE	60	X Y Z	Oct 1961		
Resolute Bay	RES	25	X Y Z	Nov 1953	Jul 1973	
Mould Bay	MBC	40	X Y Z	Jul 1962		
Cambridge Bay	CBB	17	H D Z		Apr 1972	
			X Y Z		Jul 1974	
Baker Lake	BLC	30	H D Z	Mar 1951		
			X Y Z	Jul 1957	Nov 1971	
Yellowknife B	YKC	198	X Y Z		Oct 1974	
Fort Churchill	FCC	15	X Y Z	Jul 1957	Sep 1971	
Great Whale River	GWC	25	H D Z	Jan 1965	Oct 1972	Aug 1984
			X Y Z		Jul 1974	Aug 1984
Poste-de-la-Baleine	PBQ	35	X Y Z		Sep 1984	
Agincourt	AGN	--	H D Z	1898		Mar 1969
Meanook	MEA	700	H D Z	Sep 1931	Nov 1970	
			X Y Z		Jul 1974	
St. John's	STJ	100	H D Z	Aug 1968	Dec 1969	
			X Y Z		Jul 1974	
Ottawa	OTT	75	H D Z	Jul 1968	Sep 1970	
			X Y Z		Jan 1975	
Victoria	VIC	185	H D Z	Jul 1957	Nov 1970	
			X Y Z		Jul 1974	
+Whiteshell	WHS	336	X Y Z		Jan 1976	Sep 1980
+Glenlea	GLN		X Y Z		Oct 1980	

In the AMOS III software, two filtering algorithms are used. First, the data sampled at one second intervals are filtered using the algorithm (A)

$$D_t = D_{t-1} + (D_t - D_{t-1})/C \quad (A)$$

where D_t , D_{t-1} are the outputs at times t and $t-1$, D_t is the instantaneous sample at time t and C is a constant, which equals 10 in the AMOS III system.

The output from the first filter (A) is sampled every 10 seconds. The second filter (B) is a simple average of 7 values, centered on the minute (i.e., samples at -30, -20, -10, 0, 10, 20, 30 seconds)

$$E_t = (D_{t-30} + D_{t-20} + D_{t-10} + D_t + D_{t+10} + D_{t+20} + D_{t+30})/7 \quad (B)$$

The frequency responses of these filters are shown in Figure 2. A detailed analytical derivation of the responses is given by Coles (1983).

All Canadian AMOS stations (except Alert) can be interrogated from Ottawa over commercial telephone lines, to record data actually being produced, together with diagnostic codes indicating any malfunction of the distant equipment. Frequently an AMOS malfunction can be diagnosed immediately from the TVS checks; replacement modules are then shipped to the station. Inspection, maintenance and training visits to the stations are carried out periodically by staff based in Ottawa.

All EPB AMOS III units have the capability of providing raw data outputs at sampling intervals of 5 seconds or greater. During 1987-88, the stations at Ottawa, Meanook and Victoria provided data at 10 second intervals for use in the derivation of K-indices by computer algorithm operating on digital data (Walker, 1987).

Digital stand-by system

A Datel data-logger (Trigg et al., 1971; Trigg, 1974) is the digital stand-by recorder at all stations. It records the voltage output each minute from three orthogonal (XYZ) sensors. In order to use the output from the Datel to interpolate for missing intervals in AMOS data, the Datel values are timed and calibrated by comparison with AMOS for the hours immediately before and after the missing AMOS intervals.

Absolute instruments

The absolute instruments in use throughout the Canadian network are a proton precession magnetometer (Andersen, 1974) for the measurement of total field intensity (F) and a fluxgate magnetometer (Trigg, 1970) with its sensor mounted on the telescope of a Jena 020 theodolite for measurement of declination (D) and inclination (I). The magnetometers in the network are calibrated against Ottawa instruments as standards.

During 1985, a Jena 010B theodolite was obtained; a fluxgate magnetometer was attached to form a D & I fluxgate. This instrument has subsequently been used in

calibration tests, including calibration against an IAGA standard quartz declinometer (Jansen van Beek and Newitt, 1990).

Repeat Station Instruments

Variations in the D, H and Z components are continually monitored using a three-component recording fluxgate magnetometer (Trigg et al., 1971), manufactured by E.D.A. Instruments Inc. The samples of the field components are digitally recorded on a Datel data logger (Trigg et al., 1971; Trigg, 1974) with a sampling interval of one minute. In addition, the total intensity F, is digitally recorded using a GSM-18 proton magnetometer manufactured by GEM Systems, Inc..

Absolute observations of D and I are made using a portable version of the magnetometer-theodolite system used at the observatories. F is measured using a Scintrex MP-2 proton magnetometer. The instruments are routinely calibrated using the Ottawa observatory instruments as standards.

D AND I MAGNETOMETER COMPARISONS AT OTTAWA MAGNETIC OBSERVATORY

Introduction

In 1986, comparison measurements were made between the Canadian declination standard JENA 020, ser. no. 1222 (henceforth called THEO 1222) and the IAGA declination standard (QD17) (Jansen van Beek and Newitt, 1990). The standardization work continued in 1987 with comparisons between THEO 1222 and the newly acquired JENA 010B.

TABLE 1

DECLINATION AND INCLINATION DIFFERENCES BETWEEN
THEO 1222 AND JENA 010B

	DECLINATION (minute portion)			INCLINATION (minute portion)		
DATE	1222	010B	DIFF.	1222	010B	DIFF.
08 Dec.	35.498	35.954	-0.456	50.963	50.970	-0.007
14 Dec.	35.807	35.984	-0.177	51.035	50.985	+0.050
15 Dec.	35.553	35.893	-0.340	51.010	50.958	-0.052
21 Dec.	37.186	37.488	-0.302	50.209	50.248	-0.039
30 Dec.	36.815	37.003	-0.188	50.191	50.189	+0.002
05 Jan.	36.680	36.978	-0.298	50.260	50.237	+0.023
18 Jan.	37.044	37.397	-0.353	50.263	50.235	+0.028

Instrument Comparisons

Between 8 December, 1987 and 18 January, 1988 seven sets of comparative D and I observations were made using THEO 1222 and the JENA 010B magnetometer theodolite. All measurements were made on the Ottawa standard pier, Pier A. Each set of the comparative observations were normally made within a period of 2 or 2.5 hours. Instrument corrections (-0.1' for D and 0.1' for I) were added to the observations made with THEO 1222; no corrections were added to the observations made with the JENA 10B. D and I baselines were computed using the variometer data from the ELSEC 8200 vector proton precession magnetometer. Any difference between absolute D and I observations would then result directly in differences in the corresponding vector PPM baselines. The results of the comparisons are given in Table 1. They may be summarized as follows:

$$\begin{aligned}D_{\text{THEO } 1222} - D_{010} &= -0.302' \pm 0.097' \\I_{\text{THEO } 1222} - I_{010} &= 0.016' \pm 0.033'\end{aligned}$$

The computation of t-statistics shows that the I difference does not differ significantly from zero but that the D difference is most definitely significant.

The comparisons described above imply that a systematic error in D exists in one of the instruments. Fortunately, additional information exists to designate the instrument most likely to have the error.

The JENA 010B underwent rigorous testing for magnetization shortly after its purchase and all offending parts were replaced at that time. It is therefore unlikely that it would possess the residual magnetization which is the most likely source of the error. It is more likely that THEO 1222 may contain magnetic material.

Further evidence for this comes from a series of 15 comparisons carried out using THEO 1222 and the IAGA standard QD 17 (Jansen van Beek and Newitt, 1990). The results of these comparisons are:

$$D_{\text{THEO } 1222} - D_{\text{QD } 17} = -0.26' \pm 0.22'$$

This result is not statistically different from the value obtained using the JENA 010B.

Discussion

The results of this comparison and the previous comparison with the QD 17 indicate that the instrument correction in D of -0.1' which has been added to THEO 1222 should be revised to +0.2'. The instrument correction for I of -0.1' is confirmed. An instrument correction which is in error by 0.3' would lead to an error of 1.4 nT in the Y baseline and 0.4 nT in the X baseline for the Ottawa magnetic variometers.

An examination of Table 1 shows that there is a considerable scatter in the differences obtained from one comparison to the next. For D, the maximum spread in the differences is 0.279' while the mean of the differences has a standard deviation of

0.097'. It is therefore important when standardizing instruments, to make several sets of comparison observations in order to obtain an accurate instrument correction for D. The scatter in the I differences is much less; the standard deviation is 0.033' and the maximum spread is 0.91'. Errors in the I correction for an instrument should seldom exceed 1' based on a single pair of observations.

The scatter in the D differences is much larger than one would expect taking into consideration the precision of the instruments. The reason for this may well be found in the procedure by which the observations are being made as well as in the method used in calculating the baselines. The investigations are continuing.

ABSOLUTE OBSERVATIONS AND BASELINE CALCULATIONS

In the Canadian observatory network, the requirement for adequate absolute control is at least one set a week of declination (D), inclination (I) and total intensity (F) measurements, made during magnetically quiet times in an environment carefully controlled to exclude spurious magnetic effects and large temperature fluctuations.

Calculation of baselines

The automatic magnetic observatory system (AMOS) is a quasi-absolute instrument recording three orthogonal field components and total field intensity once a minute on digital tape. At present, the AMOS is regarded solely as a digital variometer, and edited AMOS values are corrected to the absolute reference pier of the observatory by comparison with the measurements of D,I,F carried out once or twice weekly at each observatory.

Table 3 lists the yearly total of the absolute observations for each magnetic observatory for 1987 and 1988 respectively.

In the AMOS editing process, (DeLaurier et al., 1974) each one-minute value derived from the fluxgate sensor is multiplied by the factor F/F^* where F is the total force reading of the proton precession magnetometer for that minute and F^* is calculated from the three orthogonal fluxgate values ($F^* = (X^2 + Y^2 + Z^2)^{1/2}$). Effects of temperature variation on the fluxgate sensor and associated Helmholtz coils, and other effects which are proportional to the intensity of the field components measured by the sensor, are largely removed by multiplication with F/F^* . Changes in level and azimuth of the fluxgate assembly, assumed to be gradual, are compensated for by the addition of a correction (AMOS baseline) given by comparisons between absolute magnetic field measurements and simultaneous AMOS values.

The absolute values of Z and H are calculated from the relations $Z = F \sin I$ and $H = F \cos I$, where Z, H and F are field values at the time of the I measurement. In determining the absolute value of X and Y, a correction must be calculated to reduce H to the time of the D observations, as X and Y are functions of both H and D. This correction is the change in H (ΔH) between the times of the D and I observations, given by

$$\text{delta } H = (X_D - X_I) \cos D + (Y_D - Y_I) \sin D,$$

where X_D , X_I , Y_D , Y_I are the AMOS values recorded at the times of the absolute determinations of D and I.

The AMOS X, Y, Z baselines are calculated from the following formulae:

$$X \text{ baseline} = (F_I \cos I + \text{delta } H) \cos D - \text{corrected } X(\text{AMOS})_D$$

$$Y \text{ baseline} = (F_I \cos I + \text{delta } H) \sin D - \text{corrected } Y(\text{AMOS})_D$$

$$Z \text{ baseline} = F_I \sin I - \text{corrected } Z(\text{AMOS})_I$$

where F_I is the value of F at the time of the I measurement; corrected $X(\text{AMOS})_D$ and corrected $Y(\text{AMOS})_D$ are the values of X and Y read from AMOS at the time of the D absolute measurement, reduced by multiplication with the ratio F/F^* determined for this time. Similarly, corrected $Z(\text{AMOS})_I$ is the Z AMOS value at the time of the I measurement multiplied by F/F^* .

Reduction of Repeat Station Data

The Canadian Magnetic Repeat Station Network consists of 59 stations (Fig. 5). Four of these stations designated Class A, are visited every 2 years; the 37 Class B stations are visited every four years and the remaining 18 Class C stations are visited approximately once a decade. At each repeat station a temporary magnetic observatory is set up for a period of approximately 72 hours to record declination (D), horizontal (H) and vertical (Z) variations of the magnetic field while absolute observations are being made.

Since 1984, processing of repeat station data has been integrated, as much as possible, with the observatory data processing (Newitt, 1986). Many of the editing routines used for observatory secondary data are directly applicable; others require slight modifications to take into account the fact that the magnetic field components are recorded in different coordinate systems. F data recorded by the GSM-18 are merged with the file of D, H and Z data. This enables $F-F^*$ differences to be calculated as a check on the baseline and instrument stability. However, F/F^* corrections are not applied to repeat station data.

At repeat stations, the 3-component magnetometer is subject to much larger temperature fluctuations and sensor tilt than at an observatory. In addition, absolute observations are often taken under far-from-ideal magnetic and meteorological conditions. Therefore, it is the practice to take absolute observations twice a day during the three days normally spent at a station.

Before calculating baselines, a correction must be added to the F values to reduce them to the site of the D and I observations. Then, absolute H and Z are calculated in the manner described in the previous section.

The D, H and Z baselines are calculated using the following formulae:

$$D_{bl} = \frac{D_{abs} - D_{var}(nT) * \sin(l')}{H_{abs}}$$

$$H_{bl} = H_{abs} - H_{var}$$

$$Z_{bl} = Z_{abs} - Z_{var}$$

where the subscript bl refers to baseline, abs refers to absolute observations, var refers to variational data; $D_{var}(nT)$ refers to D variational data in nanoteslas, which are converted to angular quantities before the calculation of the baselines.

The adopted baselines are added to the variational data to produce a file of absolute one minute data from which a mean value is obtained. Normally, the mean values are computed for the quietest 24-hour period, although if the quiet interval is extensive, a 48-hour mean might be computed instead.

QUALITY OF DATA

Accuracy of data

Assuming uncertainties equivalent to 3 nT in D and I (Serson and Hannaford, 1956), and 1 nT in F, in the absolute measurements, the uncertainty in the final reduced AMOS (X,Y) values is expected to be less than 5 nT. At Canadian observatories, where the inclination is large (greater than 70°), multiplication by F/F* provides an effective absolute control of the AMOS Z component, with an uncertainty of 3 nT.

The secondary data are limited in resolution by a 2 nT digitizing increment.

The accuracy of repeat station data is more difficult to quantify. Although the uncertainty of the absolute observations is normally only slightly greater than those taken at observatories, the variation data contain drifts due to large temperature changes and sensor instability which can not be taken into account entirely through baseline corrections (Newitt, 1986). The uncertainty in an individual datum is estimated to be 20 nT. The uncertainty in a daily mean, however, will be much less than this, of the order of 5 nT.

Quality control of digital data

Mean hourly values for observatories in the Canadian network are derived from edited one-minute digital data. Effective quality control for observatory digital data is extremely important. Several automatic checks are incorporated in the initial computer edit programs: changes in field over one minute which exceed 1200 nT at northern stations and 500 nT at southern stations are removed as data spikes; short records without a reliable time reference are eliminated. Digital data are routinely plotted for all observatories. These plots provide a necessary check for timing errors and data spikes, and for small changes in level over short periods of time which are usually attributable to malfunctioning of an analogue-to-digital converter, or to

changes in the fluxgate excitation current.

Repeat station digital data are also routinely plotted as a check for spikes and offsets. Timing errors are detected by comparing each plot with an analogue record.

DATA DISTRIBUTION

Microfilm copies of computer plots of one-minute AMOS data in magnetogram format, with provisional baselines, are supplied to World Data Center A, Boulder, Colorado, on a monthly basis. Copies of magnetograms may be obtained from:

The Director
Geophysics Division
Geological Survey of Canada
1 Observatory Crescent
Ottawa, Ontario, Canada
K1A 0Y3

or from

World Data Center A, Geomagnetism
NOAA
Boulder, Colorado 80302
U.S.A.

Copies of tables of mean hourly values and hourly ranges (R) may be obtained from the World Data Center A, or from the Geophysics Division, GSC.

In addition to microfilm copies of magnetograms and hourly mean summary tables, a magnetic tape of digital data for each station-year is sent to World Data Center A. Each tape consists of the X, Y, Z, F one-minute values, hourly means in IAGA format, and hourly ranges for one year for each station.

All times on tapes and tables are in universal time (UT).

K indices were sent twice a month from Meanook, Ottawa and Victoria observatories to De Bilt, Netherlands, and Gottingen, Germany. Indices from Meanook and Ottawa were used in preparation of K_p indices published by the International Association of Geomagnetism and Aeronomy (IAGA). K indices from Victoria and Ottawa contribute to the formulation of the index K_n .

The lower limit, in nT, for K=9 is:

1500 for Meanook
500 for Victoria
750 for Ottawa

The Z mean hourly values for Resolute Bay are made available on a monthly basis for transmission to IZMIRAN, Moscow, to assist in the development of an interplanetary

magnetic field index being undertaken by IZMIRAN for IAGA (Resolution 18, IAGA, Moscow 1971).

SECTION II

STATION DESCRIPTIONS

For each observatory, a summary of significant instrumental changes or modifications during 1987-1988 is given. Unusual procedures used in the data processing are noted. Further details of the observatories and their sites are contained in the 1980 Annual Report (Jansen van Beek et al., 1983)

The mailing address for all observatories is:

Magnetic Observatory Manager
Geophysics Division
Geological Survey of Canada
1 Observatory Crescent
OTTAWA, Ontario, Canada
K1A 0Y3

ALERT

<u>Officer-in-charge:</u>	P. Rushforth	1986.5-1987.5
	C. Willis	1987.5-1988.5
	T. S. Mulder	1988.5-1989.1

INSTRUMENTATION

The following instrument changes took place in 1987-1988:

DAY	DETAILS
<u>1987</u>	
030(0243)	replace the P(roton) P(recession) M(agnetometer)
048(1630)	replace JENA 188 by JENA 187 with correction values for D = 0.2' and I = -0.4'
128(1529)	replace the DATEL unit (mass storage device for the secondary data)
161-291	due to excessive temperatures in the absolute observation environment, the permafrost around the footings of the absolute D & I pier became unstable
294	install JENA 349 with correction values for D = -0.5' and I = -0.4'
325	install JENA 345 with correction values for D = 0.1' and I = -0.1'
326	re-install JENA 349 with correction values for D = -0.5' and I = -0.4'
<u>1988</u>	
026-035	service trip by G. Brown
029(1838)	replace the DATEL unit install 4 new U.P.S. batteries
029(1905)	add extra heating elements and insulation to the AMOS fluxgate sensor enclosure
030(1410)	adjust thermostat in the AMOS fluxgate sensor enclosure
030(1700)- (1800)	AMOS off for servicing

031(1955) level the sensor of the AMOS fluxgate magnetometer
031(2139) replace chips on the AMOS analogue output board
033(2000) verification of azimuth mark, an error of 7.8' in the azimuth reading has accumulated since the azimuth value was established in February, 1985
366(1656) replace the DATEL unit

DATA REDUCTION

Corrections that have been added to the post-February, 1985 data in order to reduce it to the pre-February, 1985 data are:

$$\begin{aligned} X_{\text{old}} &= X_{\text{new}} + 0 \pm 5 \\ Y_{\text{old}} &= Y_{\text{new}} + 0 \pm 5 \\ Z_{\text{old}} &= Z_{\text{new}} + 82 \pm 5 \end{aligned}$$

RESOLUTE BAY

Officer-in-charge: Kheraj Enterprises Ltd. 1986.7-

INSTRUMENTATION

The following instrument changes took place in 1987-1988:

DAY	DETAILS
<u>1987</u>	
002(2314)	restart on the AMOS software
197(1500)- (1600)	restart on AMOS after servicing
198(1500)- (1600)	sunshots on the external pier for azimuth verification
<u>1988</u>	
083	install new modem
191(0020)	install 4 new standby batteries for the <u>U(ninterruptab-</u> <u>le) P(ower) S(upply)</u>
191(1410)	replace JENA 188 by JENA 187 with correction values for D = 0.5' and I = -0.3'
215(0444)	install new U.P.S. and restart the AMOS
234(2216)	restart the AMOS
298(2209)	restart the AMOS
322(1926)	restart the AMOS (UPS standby batteries now connected)

MOULD BAY

<u>Officer-in-charge:</u>	R. Sherlock	1986.5-1987.5
	J. Sabourin	1987.5-1988.5
	R. deLuca	1988.5-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
-----	---------

1987

195(0030)- (0110)	restart the AMOS after servicing
195(1900)	insulate the temperature controlled coffin around the AMOS fluxgate sensor
292(1600)	adjust the excitation current of the AMOS fluxgate
303(2334)	replace AMOS fluxgate magnetometer baseline regulator and oscillator cards
321(0025)	change precision resistor in AMOS fluxgate magnetometer

1988

no instrument changes in 1988

DATA REDUCTION

Corrections that have been added to the post-July, 1985 data in order to reduce it to the pre-July 1985 data are:

$$\begin{aligned}X_{\text{old}} &= X_{\text{new}} + 8 \pm 5 \\Y_{\text{old}} &= Y_{\text{new}} + 0 \pm 5 \\Z_{\text{old}} &= Z_{\text{new}} + 44 \pm 5\end{aligned}$$

CAMBRIDGE BAY

Operated under contract by: OMALU Services 1985.3-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
-----	---------

1987

020(0615)	replace JENA 347 by JENA 189 with correction values for D = -0.4' and I = 0.2'
174(2350)	repair telephone modem
200(1030)- (1600)	restart the AMOS after servicing
201(1400)	installation of exterior azimuth pier completed, azimuth verified by sunshot
238(0346)	restart the AMOS
257(2334)	restart the AMOS
267(2350)	replace the polarizing relay in the P(roton) P(recess- ion) M(agnetometer)
274(1500)	repair the telephone modem
291(0046)	restart the AMOS

1988

042	install a VOLKSMODEM telephone modem
110(0258)	replace the standby batteries in the U.P.S. restart the AMOS
261(2052) 261(2100)	replace the COLUMBIA mass storage device on the AMOS replace the telephone modem
268(0205)	replace AMOS interface board for the COLUMBIA

BAKER LAKE

Operated under contract by: Atmospheric Environment Service

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
034(2200)	replace JENA 191 by JENA 342 with correction values for D = 0.1' and I = -0.1'
072(1924)	restart the AMOS
169(1530)	change the sensor of the secondary data magnetometer
170(1300)	AMOS off for servicing
182(2013)	restart the AMOS
234(2218)	exchange the YEW analogue recorder
286(2109)	adjust the AMOS fluxgate magnetometer excitation current
289(1800)	adjust the AMOS excitation current
300(1525)	adjust the AMOS excitation current
313(1619)	adjust the AMOS excitation current
315(2021)	replace precision resistor in the AMOS fluxgate mag- netometer excitation current circuit
<u>1988</u>	
041(1740)	install a VOLKSMODEM telephone modem
109(1600)	install automatic disconnect on modem
147(1846)	restart the AMOS
153(1850)	replace COLUMBIA mass storage device on the AMOS
210(1320)-	AMOS off for servicing

(1350)

- 210(1541) replace the analogue-to-digital converter for the AMOS
Z component
- 210(1950) replace JENA 342 by JENA 345 with correction values for
 $D = -0.7'$ and $I = -0.4'064$
- 293(2000) replace board in telephone modem
- 314(1745) replace the COLUMBIA mass storage device on the AMOS

YELLOWKNIFE B

Operated by: Technical staff of the Yellowknife Laboratory of the Geophysics Division

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
030	replace JENA 348 by JENA 341 with correction values for D = -1.2' and I = 0.0
068(1517)	repair Observatory heaters
121(1555)	restart the AMOS
204(1316)	restart the AMOS
205(1503)-(1700)	change tranformer tap in the U.P.S. and install cooling fans
261(1900)	replace the C(entral) P(rocessor) U(nit) of the AMOS
280	replace the D(ata) Collecting) P(latform) of the secondary data magnetometer
294(1554)	replace the COLUMBIA mass storage device of the AMOS
307(1655)	replace the P.P.M. of the AMOS
307(2115)	replace the AMOS power supply
309(1548)	replace the AMOS power supply
310(2054)	adjust the voltage controlled oscillator of the AMOS P.P.M.
316(1958)	replace the D.C.P. of the secondary data magnetomter
336(1900)	replace the AMOS P.P.M. interface board

1988

022(1945) install a VOLKSMODEM telephone modem
077 re-install the rental telephone modem
201(0146) replace chips on the analogue output board of the AMOS fluxgate magnetometer
203(1643) top up the bottles of the AMOS P.P.M.
203(1812) replace chips on the analogue output board of the AMOS fluxgate magnetometer
229(1603) restart the AMOS
229(1816) reparations to the COLUMBIA mass storage device of the AMOS
253(1620) restarts of the AMOS
255(1555)
256(1553)
285 change light bulbs in the AMOS fluxgate sensor coffin
321(1605) disconnect in the off position in the U.P.S.
replace the levelling base of the JENA 341

FORT CHURCHILL

Operated under contract by: W. Ayotte 1981.8-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
124	change from locally diesel generated electric power to the Manitoba electric power grid
146(1446)	restart of the AMOS
148(2137)	
173(1900)	install new exterior marble azimuth pier with illuminated target
174(1622)	AMOS off for servicing
175(1550)	sunshot on the new azimuth pier
246-248	problems with the excitation current of the AMOS fluxgate magnetometer
248(1725)	change reference voltage and oscillator boards in the AMOS fluxgate magnetometer
<u>1988</u>	
064(2117)	install VOLKSMODEM telephone modem
151(1727)	reset the disconnect on the U.P.S.
177(1818)	install 4 new storage batteries on the U.P.S.
212(0100)	replace JENA 346 by JENA 191 with correction values for D = 0.1' and I = 0.0'
212(1416)	AMOS off for servicing
259(1501)	install automatic disconnect in the telephone modem

POSTE-DE-LA-BALEINE

Operated under contract by: Charles Coté 1977.6-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY DETAILS

1987

066(1952) replace electric bulbs in the AMOS fluxgate magnetometer
 sensor coffin

125(1828) replace JENA 702 by JENA 191 with correction values for
 D = -0.3' and I = 0.0'

278(1725) restart of the AMOS

1988

060 install a VOLKSMODEM telephone modem

081(1905) install 4 new storage batteries on the U.P.S.

083(1950) install an automatic disconnect in the tele-phone modem

117(1310) replace the X component and the voltage reference boards
 in the AMOS fluxgate magnetometer

117(1400) replace JENA 191 by JENA 190 with correction values for
 D = -0.1' and I = -0.4'

117(1740) AMOS off for servicing

118(1500) install new external marble reference pier

119(1340) remove magnetic bolt from the P.P.M. shield

131(1820) adjust the voltage controlled oscillator of the AMOS
 P.P.M.

250(1330) change electric bulb in the AMOS fluxgate magnetometer
 sensor coffin

MEANOOK

Operated under contract by: G. Kowalchuk 1981.8-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY DETAILS

1987

104(0206) install a BEST personal computer for recording the 10-second AMOS data used in calculating the K-indices
104(2039)-
(2137) re-establish base for the AMOS fluxgate magnetometer sensor
 add a temperature controlled coffin around the AMOS fluxgate magnetometer sensor
105(1940) replace electric bulb in the AMOS fluxgate magnetometer sensor coffin
140(0115) restart of the AMOS
357(1606) by-pass the U.P.S.

1988

002(1603) install replacement U.P.S. and storage batteries
016(1711) replace JENA 1218 by JENA 1221 with correction values for D = -0.4' and I = 0.2'
054(2209) restart the AMOS
068(1500) restart the AMOS
162(1430)-
(1830) old Observatory bldg. which had seen service since the early 1930's was demolished and removed from the site
169(1415) AMOS off for servicing
 install automatic disconnect on the telephone modem malfunction in the C.P.U. of the AMOS
173(0601) install replacement C.P.U. in the AMOS

173(1805)	install replacement chips in the fast sample interface board of the AMOS
226(1721)	restart the AMOS
229(1337)	restart the AMOS
253(1500)	restart the AMOS
267(1600)	install replacement U.P.S. and new storage batteries

ST. JOHN'S

Operated under contract by: Moire Sine Neary 1978.8-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
005(1900)	restart the AMOS
292(1200)	install a VOLKS telephone modem
292(1700)	replace JENA 1221 by JENA 702 with correction values for D = 0.0' and I = -0.1'
292(2130)	AMOS off for sevicing
<u>1988</u>	
005(1926)	restart the AMOS
020(1910)	adjust the thermostat in the AMOS fluxgate magnetometer sensor coffin
114(1144)	install new storage batteries for the U.P.S.
140(1000)	install automatic disconnect in the telephone modem
345(2032)	restart the AMOS
357(0120)	main electric power line to the Observatory cut by machines; end of AMOS data for 1988

OTTAWA

Operated by staff of the Geophysics Division

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
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1987

009	P(ersonal) C(omputer) used as a mass storage device for the ELSEC Vector P.P.M. and moved from Bldg. 5 to Bldg. 3
070(1442)	replace the ELSEC P.C. by a COLUMBIA mass storage device
100	air conditioner for Bldg. 3 turned on
163(1200)	removed the DATEL unit from Bldg. 3, secondary data now supplied by the ELSEC Vector P.P.M.
226(1430)	AMOS off for servicing level the sensors for the AMOS fluxgate magnetometer
257	move data storage COLUMBIA for the ELSEC from Bldg. 3 to Bldg. 5
328(1930)	air conditioner to Bldg. 3 turned off
328	replace poured concrete piers in the Absolute Building (Bldg. 4) with new marble piers
341(1541)	restart the AMOS

1988

011(1440)	install a VOLKSMODEM telephone modem
029(1420)	COLUMBIA mass storage device replaced by a P.C. as the the main data storage for the ELSEC Vector P.P.M.
036(1540)	adjustments of the thermostat in the AMOS fluxgate
040(1840)	magnetometer sensor coffin
041(2040)	
042(1455)	

042(1950) change thermostat in the AMOS fluxgate magnetometer
043(1550) sensor coffin

046(1840) adjust thermostat in the AMOS fluxgate magnetometer
047(1635) sensor coffin

048(1800)

048(2140)

068(1410) change telephone modem

091(1601) install automatic disconnect on telephone modem
install interface board in the AMOS and modem on a
dedicated data line for a 1-minute data link to 1
Observatory Cresc.

130(1820) air conditioner for Bldg. 3 turned on

141(1939) move the data storage P.C. for the ELSEC from Bldg. 3
to Bldg. 5

216(1735) replace analogue to digital (A/D) converter for the AMOS
X component
restart the AMOS

217 replace the AMOS magnetometer output buffers

218(1215) replace blown fuse in the AMOS magnetometer

221(1540) replace all AMOS temperature sensors

223(1340) replace the AMOS analogue amplifier board and adjust the
analogue bias potentiometers

223(1503) replace the electric bulbs in the AMOS fluxgate mag-
netometer sensor coffin

224(1700) replace all of the AMOS temperature sensors

228(1755) replace the AMOS fluxgate magnetometer analog output
board

230(1725)- complete overhaul of the AMOS fluxgate magnetometer
(1945)

231(1723) restart the AMOS

251(1300)- replace the U.P.S. and restart the AMOS
(1340)

271(1704) level the sensors of the AMOS fluxgate magnetometer

273(1502) adjust the bias potentiometer of the AMOS X component

279(1650)- sensitivity calibration of the AMOS fluxgate magnetometer
(1900)

281(1500) replace JENA 1222 by JENA 1218 with correction values
for D = 0.2 and I = -0.1

295(1544) air conditioner for Bldg. 3 turned off

330(1403) replace JENA 1218 by JENA 1222 with correction values
for D = 0.2 and I = -0.1

365(1730) replace electric bulb in the AMOS fluxgate magnetometer
sensor coffin

VICTORIA

<u>Officer-in-charge:</u>	M. Wilde	1984.6-1987.3
	Evelyn Bunyan	1987.3-1988.2
	David Bunyan	1988.2-

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
002(0034)	adjust the excitation current of the AMOS fluxgate magnetometer
008	install VOLKSMODEM telephone modem
012	replace JENA 344 by JENA 1220 with correction values for D = -0.6' and I = 0.2'
068	JENA 1220 stolen from the Observatory absolute building
077	install JENA 1219 with correction values for D = -0.1' and I = -0.1'
098	install a P.C. as the mass storage device for the AMOS 10-second data
101(1730)	change an AMOS temperature sensor
183	replace the secondary data D.C.P. (DATEL)
229(2352)	restart the AMOS after C.P.U. verification
<u>1988</u>	
008(1807)	place a VOLKSMODEM telephone modem and install a telephone handset
047(2314)	install replacement U.P.S.
095	electric power line to Observatory destroyed by nearby construction
097(2200)	power restored; AMOS has problems after the restart

104(2309)	replace the C.P.U. of the AMOS
122(2347)	AMOS off replace standby storage batteries replace an A/D converter in the AMOS
154(0013)	adjust the excitation current of the AMOS fluxgate magnetometer
161(2112)	adjust the thermostat in the coffin for the AMOS
163(1806)	fluxgate magnetometer sensor
163(1926)	
168(1956)	
174(2340)	change the temperature sensor for the AMOS fluxgate magnetometer sensor
175(0010)	replace thermostat in the AMOS fluxgate magnetometer sensor coffin
175(1445)	AMOS off for servicing
175(1506)	restart the AMOS
320(0215)	replace A/D converter for the AMOS X component
337(0011)-	secondary 1-minute data, COLUMBIA mass storage device
366(2400)	for the AMOS non-functional

DATA REDUCTION

Corrections that have been added to the post-April, 1985 data in order to reduce it to the pre-April, 1985 data are:

$$\begin{aligned}X_{\text{old}} &= X_{\text{new}} + 23 \pm 2 \\Y_{\text{old}} &= Y_{\text{new}} - 10 \pm 1 \\Z_{\text{old}} &= Z_{\text{new}} - 23 \pm 1\end{aligned}$$

GLENLEA
(LIMITED ABSOLUTE CONTROL)

Operated by: J. Wenham 1980.8-
University of Manitoba

INSTRUMENTATION

The following instrument changes occurred in 1987-1988:

DAY	DETAILS
<u>1987</u>	
109(1410)	turn on the air conditioner for the electron-ics trailer
109(1640)	AMOS off for servicing
109(1715)	replace electric bulbs in the AMOS fluxgate magnetometer sensor coffin
109(2024)	level the sensors for the AMOS fluxgate magnetometer
110(1500)	replace thermostat in the coffin for the AMOS fluxgate magnetometer sensors
139(1908)	replace the secondary data D.C.P. (DATEL)
177(1512)	replace P.P.M. of the AMOS
177(1750)	replace JENA 349 by JENA 347 with correction values for D = -.4' and I = 0.0'
275(1515)	replace the P.P.M. of the AMOS
287(1433)	adjust the excitation current of the AMOS fluxgate magnetometer
293(1447)	tune the voltage controlled oscillator of the AMOS P.P.M.
310(1736)	replace U.P.S. and install 4 new standby storage batteries
310(1820)	replace A/D converter for the AMOS Z component
324(1550)	replace the thermostat in the AMOS fluxgate magnetometer sensor coffin

338(1550) replace the D.C.P. (DATEL) for the secondary data

338(1619) replace the A/D converter for the AMOS Z component

1988

- 004(1901) restart the AMOS
replace YEW analogue recorder
- 018(2028) replace AMOS P.P.M.
- 022(2020) replace the sensor bottles of the AMOS P.P.M.
- 057(1704) adjust the excitation current of the AMOS fluxgate magnetometer
- 071(1558) change X component amplifier circuit board in the secondary data fluxgate magnetometer
- 076(2000) install a VOLKSMODEM telephone modem
- 091(1545)-
(1607) replace the secondary data fluxgate magnetometer and D.C.P.
- 099(1441) install automatic disconnect in the telephone modem
- 099(1448) restart the AMOS
- 130(1928) reset the zero reference for the secondary data fluxgate magnetometer
- 165(2344) change AMOS power supply
- 165(2357) adjust the voltage controlled oscillator of the AMOS P.P.M.
- 166(1245) replace the AMOS fluxgate magnetometer zero reference and oscillator boards
- 166(1450) level the sensors of the AMOS fluxgate magnetometer
verify fluid level in the AMOS P.P.M. sensor bottles
- 166(1723) restart the AMOS
- 190(1421) replace the A/D converter for the AMOS fluxgate magnetometer Z component
- 196(1840) adjust the voltage controlled oscillator of the AMOS P.P.M.

- 214(2305) adjust the voltage controlled oscillator of the AMOS P.P.M.
- 215(0029) adjust the voltage controlled ascillator of the AMOS P.P.M.
- 260(1441) replace the Z component amplifier board in the AMOS fluxgate magnetomter
- 298(1946) replace the AMOS fluxgate magnetometer and the A/D converters for the X, Y and Z components
(mice had performed a number of domestic functions within the AMOS electronics rack)
- 299(1620) service the telephone modem
sensitivity calibration of the AMOS fluxgate magnetometer
- 300(1840) replace Z component amplifier of the secondary data fluxgate magnetometer

SECTION III

ANNUAL MEANS FOR OBSERVATORIES

Tables of annual means for the observatories are given in the following pages. Before 1973.5 for Victoria and 1972.5 for Great Whale River, Meanook, Ottawa and St. John's, the annual means for X, Y, I and F were derived from the recorded components D, H and Z. Presently for all stations the annual means for D, H, I and F are derived from the recorded components X, Y and Z.

TABLE 3

Numbers of Absolute measurements in 1987-1988

	1987	1988
Alert	94	107
Resolute Bay	75	75
Mould Bay	121	126
Cambridge Bay	110	100
Baker Lake	97	95
Yellowknife B	75	80
Fort Churchill	85	84
Poste-de-la-Baleine	111	104
Meanoook	97	99
St. John's	98	91
Ottawa	167	134
Victoria	93	102
Glenlea	51	54

TABLE 4

ALERT

Annual Mean Values

Year	X	Y	Z	D East	I North	H	F
	nT	nT	nT	◦	◦	nT	nT
1984.5	864	-3523	55852	283	47	86	17.1
1985.5	879	-3496	55806	284	07	86	18.2
1986.5	895	-3455	55767	284	31	86	20.3
1987.5	909	-3444	55729	284	47	86	20.6
1988.5	921	-3425	55714	285	03	86	21.5

D, I, H, F are derived from the annual means of X, Y, Z.

TABLE 5

RESOLUTE BAY

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F	nT	nT	nT	nT
1954.5	-96	-915	57971	264	01	89	05.4	920	57978			
1955.5	-69	-906	57999	265	38	89	06.1	909	58006			
1956.5	-41	-904	58020	267	24	89	06.4	905	58027			
1957.5	-24	-903	58065	268	29	89	06.5	903	58072			
1958.5	9	-884	58035	270	35	89	07.6	884	58042			
1959.5	32	-861	58032	272	08	89	08.9	862	58038			
1960.5	54	-850	58052	273	38	89	09.5	852	58058			
1961.5	72	-844	58076	274	53	89	09.9	847	58082			
1962.5	85	-827	58103	275	52	89	10.8	831	58109			
1963.5	108	-815	58120	277	33	89	11.4	822	58126			
1964.5	117	-800	58144	278	19	89	12.2	809	58150			
1965.5	132	-791	58170	279	28	89	12.6	802	58175			
1966.5	141	-780	58208	280	15	89	13.2	793	58213			
1967.5	153	-766	58250	281	18	89	13.9	781	58255			
1968.5	166	-751	58291	282	28	89	14.7	769	58296			
1969.5	179	-732	58320	283	44	89	15.6	754	58325			
1970.5	193	-715	58374	285	06	89	16.4	741	58379			
1971.5	199	-697	58417	285	56	89	17.3	725	58421			
1972.5	222	-686	58444	287	56	89	17.6	721	58448			
1973.5	250	-682	58508	290	08	89	17.3	726	58512			
1974.5	274	-677	58560	292	02	89	17.1	730	58565			
1975.5	303	-677	58578	294	07	89	16.5	742	58583			
1976.5	334	-682	58592	296	06	89	15.5	759	58597			
1977.5	369	-689	58593	298	10	89	14.1	782	58598			
1978.5	399	-696	58597	299	49	89	13.0	802	58602			
1979.5	431	-720	58582	300	54	89	10.8	839	58588			
1980.5	456	-735	58556	301	49	89	9.2	865	58562			

TABLE 5 (cont'd.)

RESOLUTE BAY

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F
1981.5	478	-745	58537	302	41	89	8.0	885
1982.5	491	-747	58518	303	19	89	7.5	894
1983.5	506	-756	58485	303	48	89	6.5	910
1984.5	521	-771	58450	304	03	89	5.3	931
1985.5	551	-775	58416	305	25	89	4.0	951
1986.5	578	-780	58379	306	32	89	2.8	971
1987.5	606	-781	58331	307	48	89	1.7	989
1988.5	636	-790	58308	308	50	89	0.2	1014
								58317

D, I, H, F are derived from the annual means of X, Y, Z.

TABLE 6
MOULD BAY

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F	nT	nT	nT	nT	nT	nT
1962.8	983	2205	57951	65	57	87	37.0	2412	58001					
1963.5	1001	2208	57940	65	37	87	36.3	2424	57991					
1964.5	1015	2212	57948	65	21	87	35.7	2434	57999					
1965.5	1034	2220	57960	65	02	87	34.8	2449	58012					
1966.5	1053	2233	57991	64	45	87	33.7	2469	58044					
1967.5	1067	2247	58019	64	36	87	32.7	2487	58072					
1968.5	1078	2258	58053	64	29	87	31.9	2502	58107					
1969.5	1092	2276	58081	64	22	87	30.8	2524	58136					
1970.5	1115	2306	58120	64	12	87	28.6	2561	58176					
1971.5	1125	2322	58145	64	09	87	27.6	2580	58202					
1972.5	1141	2333	58179	63	56	87	26.6	2597	58237					
1973.5	1161	2343	58211	63	38	87	25.7	2615	58270					
1974.5	1187	2337	58251	63	04	87	25.4	2621	58310					
1975.5	1215	2329	58286	62	27	87	25.2	2627	58345					
1976.5	1230	2328	58293	62	12	87	24.8	2633	58352					
1977.5	1243	2322	58292	61	50	87	24.8	2634	58351					
1978.5	1261	2303	58299	61	18	87	25.3	2626	58358					
1979.5	1274	2287	58287	60	53	87	25.7	2618	58346					
1980.5	1278	2266	58258	60	35	87	26.6	2602	58316					
1981.5	1286	2257	58244	60	20	87	26.8	2598	58302					
1982.5	1287	2237	58235	60	05	87	27.7	2581	58292					
1983.5	1281	2217	58219	59	59	87	28.9	2560	58275					
1984.5	1287	2201	58185	59	41	87	29.5	2550	58241					
1985.5	1293	2166	58139	59	10	87	30.9	2523	58194					

TABLE 6 (cont'd)

MOULD BAY

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F
	nT	nT	nT	o	o	o	nT	nT
1986.5	1311	2149	58096	58	37	87	31.2	2517
1987.5	1316	2131	58055	58	18	87	31.8	2505
1988.5	1328	2104	58032	57	44	87	32.7	2488

D, I, H, F are derived from the annual means of X, Y, Z.

TABLE 7

CAMBRIDGE BAY

Annual Mean Values

Year	X	Y	Z	D	East	I	North	H	F
nT	nT	nT	nT	◦	◦	◦	◦	nT	nT
1972.5	2502	1536	60025	31	33	87	12.0	2936	60097
1973.5	2515	1544	60059	31	33	87	11.2	2951	60131
1974.5	2538	1540	60092	31	15	87	10.3	2969	60165
1975.5	2578	1536	60107	30	47	87	08.5	3001	60182
1976.5	2617	1516	60112	30	05	87	07.2	3024	60188
1977.5	2650	1496	60102	29	27	87	06.1	3043	60179
1978.5	2681	1471	60101	28	45	87	05.2	3058	60179
1979.5	2707	1452	60082	28	13	87	04.4	3072	60160
1980.5	2747	1425	60054	27	25	87	03.0	3095	60134
1981.5	2767	1406	60039	26	56	87	02.4	3104	60119
1982.5	2792	1384	60026	26	22	87	01.7	3116	60106
1983.5	2802	1355	59989	25	49	87	01.8	3112	60070
1984.5	2806	1333	59954	25	25	87	02.0	3107	60034
1985.5	2835	1309	59906	24	47	87	00.9	3123	59987
1986.5	2863	1293	59859	24	18	86	59.8	3141	59941
1987.5	2886	1289	59813	24	04	86	58.5	3161	59896
1988.5	2908	1257	59779	23	23	86	58.0	3168	59863

D, I, H, F are Derived from the annual means of X, Y, Z.

TABLE 7

BAKER LAKE

Annual Mean Values

Year	X	Y	Z	D East	I North	H	F	nT
1951.6	3674	169	60292	2	38	86	30.5	3678
1952.5	3688	174	60279	2	42	86	29.7	3692
1953.5	3711	182	60287	2	48	86	28.4	3715
1954.5	3743	175	60293	2	41	86	26.6	3747
1955.5	3778	175	60354	2	39	86	24.9	3782
1956.5	3840	171	60377	2	33	86	21.4	3844
1957.5	3877	179	60396	2	39	86	19.4	3881
1958.5	3912	186	60401	2	43	86	17.4	3916
1959.5	3953	204	60434	2	57	86	15.2	3958
1960.5	3974	215	60457	3	6	86	14.0	3980
1961.5	4000	220	60470	3	9	86	12.6	4006
1962.5	4033	229	60475	3	15	86	10.7	4039
1963.5	4059	240	60463	3	23	86	9.2	4066
1964.5	4082	246	60453	3	27	86	7.8	4089
1965.5	4118	239	60449	3	19	86	6.8	4125
1966.5	4143	253	60459	3	30	86	6.3	4151
1967.5	4167	273	60496	3	45	86	6.1	4176
1968.5	4196	286	60555	3	54	86	6.6	4206
1969.5	4221	296	60595	4	61	86	6.4	4231
1970.5	4246	309	60650	4	10	85	59.1	4257
1971.5	4273	319	60685	4	16	85	57.7	4285
1972.5	4312	332	60718	4	24	85	55.5	4325
1973.5	4337	328	60756	4	19	85	54.3	4349
1974.5	4366	325	60774	4	15	85	52.8	4378
1975.5	4418	325	60792	4	12	85	49.9	4430
1976.5	4465	307	60787	3	56	85	47.3	4476
1977.5	4507	286	60751	3	38	85	44.9	4516

TABLE 8 (cont'd.)

BAKER LAKE

Annual Mean Values

Year	X	Y	Z	D East	I North	H	F
	nT	nT	nT	nT	nT	nT	nT
1978.5	4534	253	60732	3	12	85	43.4
1979.5	4573	225	60697	2	49	85	41.1
1980.5	4633	201	60650	2	29	85	37.7
1981.5	4663	175	60638	2	09	85	36.0
1982.5	4692	161	60617	1	58	85	34.3
1983.5	4706	151	60572	1	50	85	33.3
1984.5	4737	130	60522	1	34	85	31.4
1985.5	4775	107	60465	1	17	85	29.0
1986.5	4807	92	60412	1	06	85	27.0
1987.5	4850	78	60357	0	55	85	24.3
1988.5	4893	62	60309	0	44	85	21.7

D, I, H, F are derived from the annual means of X, Y, Z. All values corrected to new (1977) observatory standard.

TABLE 9

YELLOWKNIFE

Annual Mean Values

Year	X	Y	Z	D East	I North	H	F
	nT	nT	nT	o	o	nT	nT
1975.5	7564	4217	60249	29	08	81	49.2
1976.5	7605	4193	60246	28	52	81	47.9
1977.5	7648	4160	60227	28	33	81	46.5
1978.5	7669	4129	60230	2	18	81	46.3
1979.5	7693	4094	60208	28	01	81	45.8
1980.5	7711	4073	60179	27	50	81	45.3
1981.5	7734	4035	60172	27	33	81	45.1
1982.5	7741	3999	60152	27	19	81	45.5
1983.5	7743	3979	60109	27	12	81	45.5
1984.5	7770	3934	60067	26	51	81	45.0
1985.5	7794	3893	60014	26	33	81	44.4
1986.5	7813	3860	59969	26	18	81	43.9
1987.5	7837	3825	59920	26	01	81	43.2
1988.5	7862	3788	59881	25	44	81	42.5

D, I, H, F are derived from annual means of X, Y, Z.

TABLE 10

FORT CHURCHILL

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F
nT	nT	nT	nT	◦	◦	◦	nT	nT
1957.7	6648	320	60649	2	45	83	44.2	6656
1958.5	6650	329	60641	2	50	83	44.1	6658
1964.5	6826	459	60646	3	51	83	33.1	6841
1965.5	6866	437	60683	3	39	83	41.1	6880
1966.5	6881	452	60701	3	46	83	31.1	6896
1967.5	6917	462	60736	3	49	83	29.3	6932
1968.5	6941	469	60756	3	52	83	28.1	6957
1969.5	6982	479	60781	3	55	83	25.9	6998
1970.5	7030	497	60816	4	03	83	23.4	7048
1971.5	7075	510	60847	5	07	83	21.1	7093
1972.5	7130	509	60869	5	05	83	18.1	7148
1973.5	7168	493	60881	3	56	83	16.2	7185
1974.5	7221	477	60897	3	47	83	13.4	7237
1975.5	7282	454	60888	3	34	83	10.0	7296
1976.5	7338	432	60863	3	22	83	06.8	7350
1977.5	7401	406	60826	3	08	83	03.1	7412
1978.5	7441	371	60807	2	51	83	00.9	7450
1979.5	7489	341	60752	2	36	82	57.9	7497
1980.5	7549	312	60697	2	22	82	54.3	7555
1981.5	7579	282	60672	2	08	82	52.5	7584
1982.5	7605	259	60636	1	57	82	50.9	7609
1983.5	7633	231	60578	1	44	82	48.9	7636
1984.5	7658	205	60521	1	32	82	47.1	7661
1985.5	7696	186	60455	1	23	82	44.6	7698

TABLE 10 (cont'd)
FORT CHURCHILL

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F
	nT	nT	nT	nT	nT	nT	nT	nT
1986.5	7733	167	60389	1	14	82	42.1	7735
1987.5	7775	155	60321	1	08	82	39.2	7777
1988.5	7809	140	60261	1	02	82	36.9	7810

D, I, H, F are derived from annual means of X, Y, Z.

TABLE 11

GREAT WHALE RIVER

Annual Mean Values

Year	X	Y	Z	D East	I North	H	F
	nT	nT	nT	◦	◦	◦	nT
1967.6	9201	-3401	59302	339	43	80	36.4
1968.5	9246	-3399	59333	339	49	80	34.4
1969.5	9319	-3405	59379	339	56	80	30.8
1970.5	9357	-3407	59430	339	60	80	29.3
1971.5	9430	-3409	59468	340	08	80	25.8
1972.5	9505	-3408	59486	340	16	80	21.9
1973.5	9567	-3417	59489	340	21	80	18.5
1974.5	9641	-3433	59487	340	24	80	14.3
1975.5	9717	-3448	59459	340	28	80	09.7
1976.5	9770	-3460	59417	340	52	79	55.7
1977.5	9855	-3485	59362	340	32	80	00.8
1978.5	9918	-3502	59318	340	33	79	56.7
1979.5	9984	-3523	59242	340	34	79	52.1
1980.5	10057	-3550	59164	340	33	79	46.9
1981.5	10094	-3554	59102	340	36	79	44.2
1982.5	10123	-3599	59054	340	26	79	41.3
1983.5	10196	-3608	58981	340	31	79	36.5
1984.3	10239	-3613	58927	340	34	79	33.6

Values for X, Y, I and F derived from monthly means of D, H, Z to 1972.5. Thereafter D, H, I, F are derived from X, Y, Z.

TABLE 12

POSTE-DE-LA-BALEINE

Annual Mean Values

Year	X	Y	Z	D East	I	North	H	F
	nT	nT	nT	◦	◦	◦	nT	nT
1985.5	10165	-3372	58863	341	39	79	41.3	10710
1986.5	10221	-3380	58784	341	42	79	37.4	10765
1987.5	10271	-3385	58698	341	46	79	33.7	10814
1988.5	10320	-3386	58626	341	50	79	30.3	10861

D, H, I, F are derived from X, Y, Z.

TABLE 13
MEANOOK

Annual Mean Values

Year	D East	H	Z	X	Y	I North	F
o	i	nT	nT	nT	nT	i	nT
1957.5	24	23.1	12921	58801	11768	5335	77
1958.5	24	15.0	12943	58819	11801	5316	77
1959.5	24	13.0	12960	58787	11819	5316	77
1960.5	24	09.7	12985	58774	11848	5316	77
1961.5	24	06.1	13022	58748	11887	5318	77
1962.5	24	02.7	13054	58723	11921	5318	77
1963.5	23	58.7	13076	58711	11949	5314	77
1964.5	23	54.9	13103	58694	11978	5312	77
1965.5	23	51.7	13130	58672	12008	5312	77
1966.5	23	49.6	13150	58663	12029	5312	77
1967.5	23	47.2	13170	58663	12051	5312	77
1968.5	23	45.0	13197	58659	12079	5315	77
1969.5	23	42.1	13234	58662	12118	5320	77
1970.5	23	39.8	13265	58672	12150	5324	77
1971.5	23	36.2	13303	58669	12190	5327	77
1972.5	23	30.8	13333	58668	12226	5319	77
1973.5	23	23.5	13349	58658	12252	5300	77
1974.5	23	13.8	13374	58660	12290	5275	77
1975.5	23	03.2	13399	58640	12329	5247	77
1976.5	22	52.5	13431	58619	12375	5221	77
1977.5	22	38.8	13468	58599	12430	5186	77
1978.5	22	29.9	13466	58576	12441	5153	77
1979.5	22	18.3	13482	58543	12473	5117	77
1980.5	22	08.6	13488	58501	12493	5084	77
1981.5	21	59.6	13484	58478	12503	5050	77
1982.5	21	50.8	13458	58448	12491	5008	77
1983.5	21	39.9	13457	58396	12506	4968	77

TABLE 13 (cont'd.)

MEANOOK

Annual Mean Values

Year	D	East	H	Z	X	Y	I	North	F
	o	i	nT	nT	nT	nT	o	i	nT
1984.5	21	29.5	13464	58342	12528	4933	77	00.3	59875
1985.5	21	20.0	13480	58287	12556	4904	76	58.7	59825
1986.5	21	11.8	13483	58236	12571	4875	76	57.9	59776
1987.5	21	02.4	13487	58171	12588	4842	76	56.8	59714
1988.5	20	52.5	13484	58122	12599	4805	76	56.3	59666

X, Y, I, F are derived from annual means, D, H, Z to 1972.5. Thereafter D, H, I, F are derived from X, Y, Z.

TABLE 14

OTTAWA

Annual Mean Values

Year	D	East	H	Z	X	Y	I	North	F
	o	i	nT	nT	nT	nT	o	i	nT
1968.75	346	18.4	15684	56478	15238	-3713	74	28.8	58615
1969.5	346	18.9	15760	56467	15313	-3729	74	24.3	58625
1970.5	346	17.6	15858	56455	15406	-3758	74	18.6	58640
1971.5	346	18.8	15960	56429	15507	-3776	74	12.4	58643
1972.5	346	18.4	16051	56386	15595	-3800	74	06.6	58626
1973.5	346	18.1	16151	56322	15692	-3825	73	59.9	58592
1974.5	346	16.7	16239	56251	15776	-3852	73	53.8	58548
1975.5	346	15.1	16330	56162	15862	-3881	73	47.2	58488
1976.4	346	13.3	16409	56054	15937	-3908	73	41.0	58406
1977.5	346	10.2	16482	55939	16004	-3940	73	35.0	58317
1978.5	346	07.2	16537	55837	16054	-3967	73	30.2	58234
1979.5	346	03.0	16601	55724	16111	-4002	73	24.6	58144
1980.5	345	57.9	16658	55605	16161	-4040	73	19.4	58047
1981.5	345	54.6	16711	55509	16208	-4068	73	14.7	57970
1982.5	345	51.0	16759	55410	16251	-4097	73	10.3	57889
1983.5	345	48.1	16813	55304	16299	-4124	73	05.4	57803
1984.5	345	44.9	16862	55199	16343	-4151	73	00.8	57717
1985.5	345	42.2	16912	55090	16388	-4176	72	56.1	57627
1986.5	345	40.1	16951	54984	16423	-4196	72	52.0	57538
1987.5	345	37.9	16994	54870	16462	-4217	72	47.5	57441
1988.5	345	35.6	17022	54769	16487	-4235	72	44.1	57353

Values of X, Y, I and F are derived from means of D, H, Z, 1968.5 to 1972.5.
 Thereafter D, H, I and F are derived from X, Y, Z.

TABLE 15

ST. JOHN'S

Annual Mean Values

Year	D	East	H	Z	X	Y	I	North	F
o	i	nT	nT	nT	nT	nT	o	i	nT
1968.8	333	02.0	17441	50772	15545	-7909	71	02.5	53684
1969.5	333	09.7	17508	50780	15622	-7904	70	58.6	53713
1970.5	333	16.5	17603	50790	15723	-7916	70	53.1	53754
1971.5	333	28.3	17691	50764	15828	-7892	70	47.2	53758
1972.5	333	37.7	17783	50737	15932	-7899	70	41.1	53763
1973.5	333	48.7	17875	50702	16040	-7889	70	34.8	53761
1974.5	333	59.2	17966	50640	16146	-7880	70	28.0	53732
1975.5	334	11.6	18047	50569	16247	-7857	70	21.6	53693
1976.5	334	14.7	18127	50492	16349	-7829	70	15.1	53647
1977.5	334	35.6	18194	50415	16434	-7806	70	09.4	53597
1978.5	334	46.3	18246	50336	16506	-7777	70	04.5	53541
1979.5	334	55.6	18307	50238	16582	-7758	69	58.7	53470
1980.5	335	05.7	18375	50133	16666	-7738	69	52.3	53394
1981.5	335	15.9	18435	50046	16744	-7714	69	46.7	53333
1982.5	335	23.2	18478	49961	16799	-7696	69	42.2	53269
1983.5	335	31.5	18523	49879	16859	-7674	69	37.6	53207
1984.5	335	38.6	18569	49795	16916	-7658	69	32.9	53145
1985.5	335	49.4	18626	49702	16992	-7628	69	27.4	53077
1986.5	336	01.1	18670	49617	17058	-7588	69	22.8	53013
1987.5	336	11.4	18716	49525	17123	-7556	69	17.9	52944
1988.5	336	21.0	18749	49448	17174	-7521	69	14.1	52883

X, Y, I and F are derived from annual means of D, H, Z to 1972.5. Thereafter
 D, H, I, and F are derived from X, Y, Z. All values are corrected to the new
 (1977) observatory reference.

TABLE 16

VICTORIA

Annual Mean Values

Annual Mean Values								
Year	D East	H	Z	X	Y	I North	F	
o	i	nT	nT	nT	nT	o	i	nT
1956.6	23	00.2	18689	53427	17203	7303	70	43.2
1957.75	22	57.1	18705	53408	17224	7294	70	41.9
1958.5	22	55.2	18713	53396	17236	7288	70	41.2
1959.5	22	52.8	18736	53377	17262	7284	70	39.5
1960.5	22	50.3	18748	53362	17278	7277	70	38.5
1961.5	22	47.8	18787	53322	17319	7279	70	35.5
1962.5	22	44.4	18804	53288	17342	7268	70	33.8
1963.5	22	41.4	18814	53264	17358	7257	70	32.7
1964.5	22	38.6	18837	53239	17385	7252	70	30.9
1965.5	22	36.0	18860	53205	17412	7248	70	28.9
1966.5	22	34.2	18873	53179	17428	7244	70	27.6
1967.5	22	31.7	18888	53157	17447	7237	70	26.3
1968.5	22	29.4	18902	53138	17464	7230	70	25.1
1969.5	22	27.4	18923	53127	17488	7228	70	23.7
1970.5	22	24.8	18946	53117	17515	7224	70	22.2
1971.5	22	21.8	18971	53099	17544	7218	70	20.4
1972.5	22	19.0	18986	53085	17564	7209	70	19.2
1973.5	22	15.5	19000	53060	17584	7197	70	17.9
1974.5	22	11.3	19007	53046	17600	7178	70	17.2
1975.5	22	06.1	19019	53025	17621	7156	70	16.1
1976.5	21	59.4	19023	53001	17639	7123	70	15.6
1977.5	21	52.3	19024	52967	17655	7087	70	14.6
1978.5	21	45.9	19013	52944	17658	7050	70	14.8
1979.5	21	38.2	19019	52911	17678	7016	70	13.6
1980.5	21	31.3	19016	52877	17690	6976	70	13.2
1981.5	21	25.3	19005	52850	17692	6941	70	13.3
1982.5	21	19.2	18998	52819	17698	6907	70	13.0

TABLE 16 (cont'd.)

VICTORIA

Annual Mean Values

Year	D	East	H	Z	X	Y	I	North	F
	o	i	nT	nT	nT	nT	o	i	nT
1983.5	21	13.4	19006	52773	17717	6880	70	11.6	56091
1984.5	21	07.1	19007	52727	17730	6848	70	10.6	56048
1985.5	21	01.4	19013	52672	17747	6821	70	09.1	55999
1986.5	20	55.5	19010	52619	17756	6789	70	08.2	55948
1987.5	20	49.6	19005	52562	17763	6757	70	07.3	55892
1988.5	20	43.4	18993	52513	17764	6721	70	07.0	55842

X, Y, I, F are derived from annual means of D, H, Z to 1973.5. Thereafter
 D, H, I, F are derived from X, Y, Z.

SECTION IV

RESULTS FROM REPEAT STATIONS

Twelve repeat stations in 1987 and fourteen repeat stations in 1988 were occupied on sites where measurements had been made previously. Results from these stations are listed in Table 17 for 1987 and Table 18 for 1988. Repeat station results for 1986 have been published in the 1986 yearbook (Jansen van Beek et al., 1990). Earlier results have been published in the 1985 yearbook (Coles et al., 1987) and in the references listed in the 1985 yearbook.

TABLE 17
REPEAT STATION RESULTS FOR 1987

STATION	Lat(N)	LONG(W)	DATE	D	H	Z
	°	'	°	'	DAY/MON.	°
BONNE BAY B	49 30.8	57 55.4	16/10	-24 28.0	17081	52442
CHIBOUGAMAU B	49 55.3	74 22.0	7/06	-15 17.0	15193	56241
GOOSE BAY	53 20.0	60 26.5	21/06	-30 13.0	14364	54389
GOOSE BAY B	53 17.8	60 26.6	21/06	-27 28.0	14269	54263
HALIFAX E	44 41.2	63 36.9	29/05	-20 50.5	18641	50833
HALIFAX F	44 41.1	63 36.9	29/06	-21 08.0	18605	50815
INUVIK B	68 19.2	133 32.1	29/07	40 26.8	8582	57993
LOUISBURG C	45 54.4	59 57.4	25/05	-22 38.5	18322	50925
NAIN A	56 32.2	61 41.0	24/06	-33 42.8	13141	55460
PORT HARRISON C	58 27.1	78 08.5	24/07	-22 36.0	9047	60667
QUEBEC CITY C	46 47.2	71 22.6	15/05	-18 34.0	16601	54549
SCHIEFFERVILLE B	54 49.0	66 47.0	7/07	-28 11.0	12800	55472
SEPT ISLES B	50 13.5	66 16.0	3/06	-24 39.0	15236	55073
WOODSTOCK B	46 09.2	67 34.7	20/05	-19 33.2	17320	53086

TABLE 18
REPEAT STATION RESULTS FOR 1988

STATION	Lat(N)	LONG(W)	DATE	D		H		Z
				°	'	°	'	
CORAL HARBOUR D	64 11.0	83 20.0	25/07	-31	11.5	5961	59647	
CORAL HARBOUR E	64 11.0	83 20.0	25/07	-30	52.0	5946	59641	
DAWSON CITY C	64 02.7	139 07.0	11/09	29	55.9	12126	56607	
ENNADAI LAKE	61 07.8	100 53.9	15/08	13	50.8	7082	60658	
FT. CHIMO C	58 06.6	68 24.6	29/07	-32	56.6	10872	57168	
FT. MACLOED	49 42.1	113 24.0	29/09	18	19.0	16542	56072	
FT. NELSON B	58 49.8	112 35.4	04/09	28	02.6	12423	57831	
FT. NELSON C	58 50.5	112 34.2	04/09	28	24.6	12426	57819	
FROBISHER C	63 44.9	68 33.8	14/07	-45	56.5	8836	58479	
PENTICTON B	49 19.0	119 37.5	25/09	20	10.8	18013	54254	
PRINCE GEORGE B	53 53.5	112 39.8	21/09	23	47.6	15619	55982	
SMITHERS E1	54 44.4	127 06.3	17/09	25	03.4	15737	55379	
WHITEHORSE D	60 41.8	135 50.3	7/09	27	40.5	13094	55991	
TYRRELL LAKE	63 14.2	105 26.6	10/08	19	34.0	6512	60305	

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FIG. 2
Responses of AMOS III digital filters.
 A — first order recursive filter
 B — 7-point one minute mean
 BxA — combined response of the two filters.

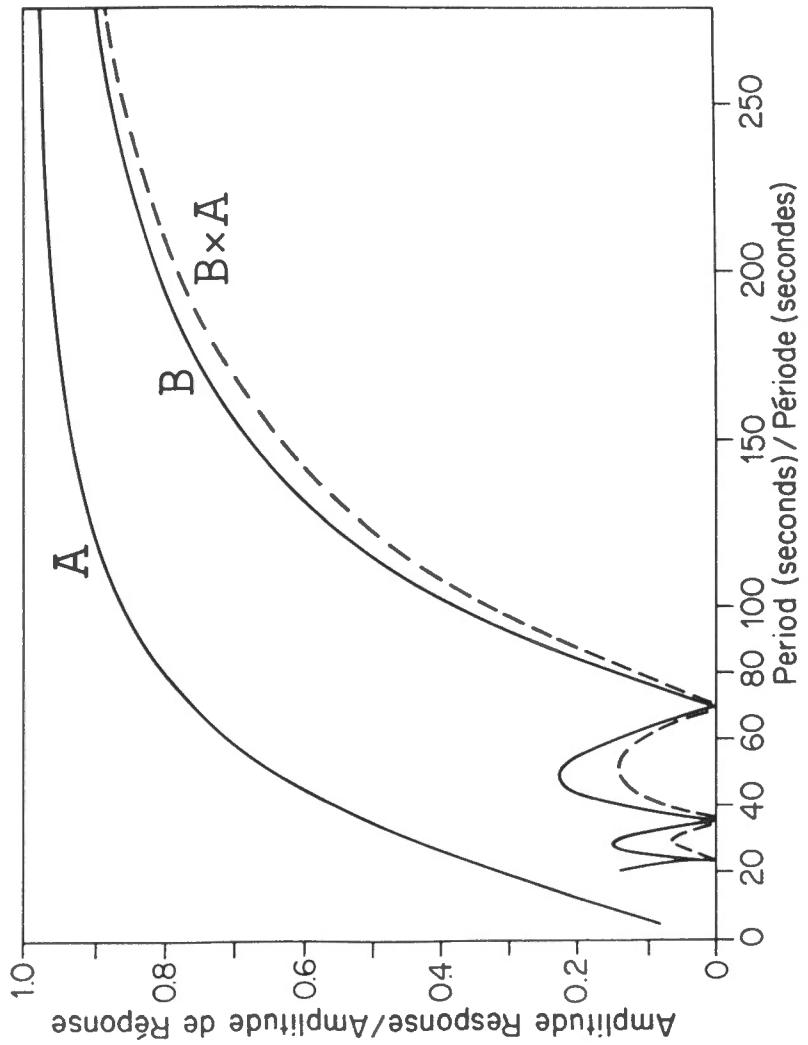


FIG. 2
Les réponses des filtres numériques
AMOS III.
 A — le filtre récursif de premier
ordre
 B — la moyenne de sept points sur la
minute
 BxA — la réponse composée des deux
filtres.

CANADIAN REPEAT STATIONS NETWORK

1985

RÉSEAU CANADIEN DE
STATIONS DE RÉPÉTITION

▲ Magnetic Observatories Observatoires magnétiques

Repeat Stations
Stations de répétition

CLASSE A ■ CLASSE B
CLASSE B ● CLASSE A

CLASS CO CLASSEC

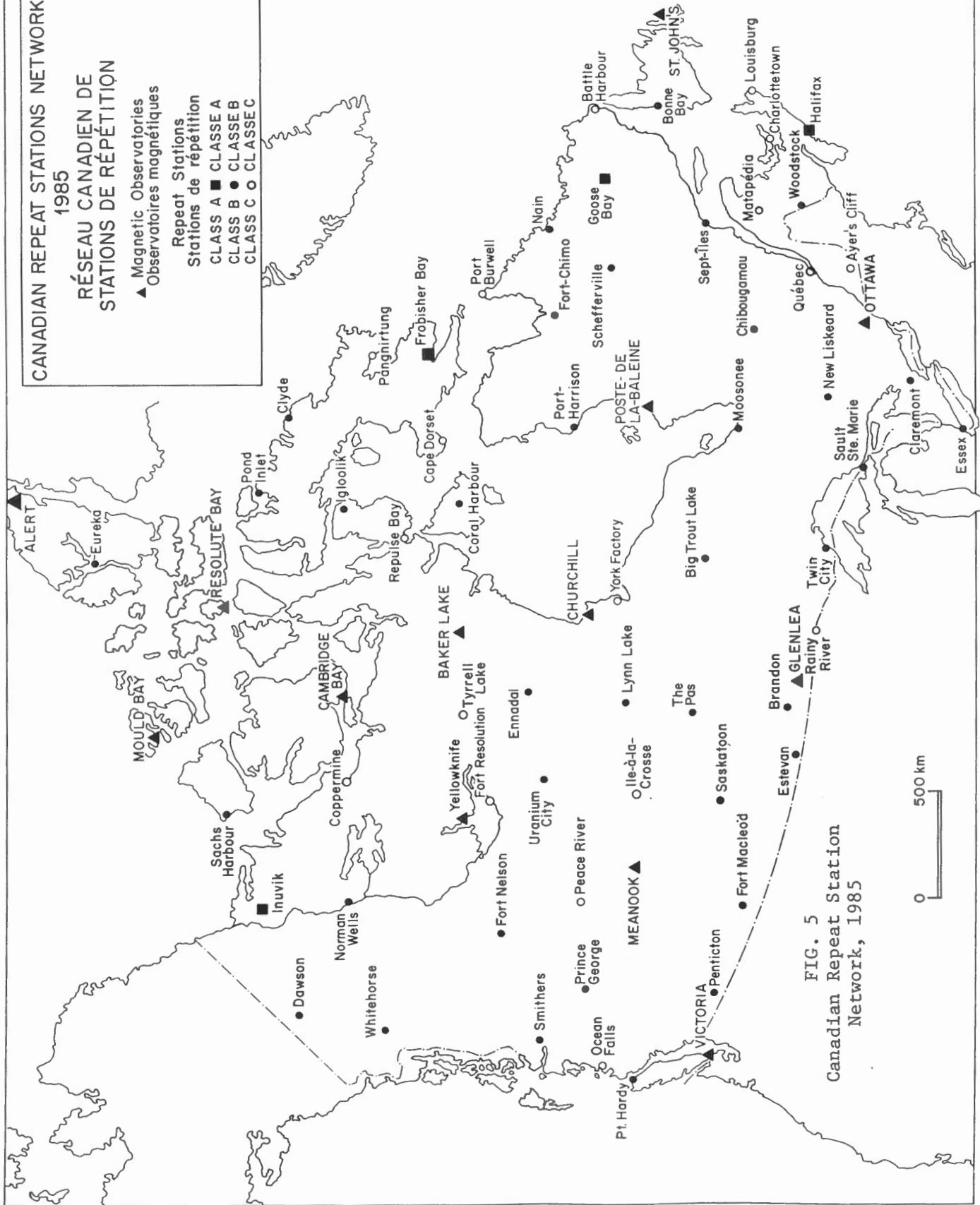


FIG. 5
Canadian Repeat Station
Network, 1985