Bureau of Mineral Resources, Geology & Geophysics

RECORD

BMR Record 1991/72

National repeat station network descriptions

(IAGA magnetic repeat station reporting scheme)

Compiled by C.E. Barton, for IAGA Working Group V-4

1991/72
c.4

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A scheme has been developed by IAGA Working Group V-4, Magnetic Surveys and Charts, to set standards for reporting and classifying magnetic repeat station data. This document lists the "Regional Magnetic Repeat Station Network Descriptions" currently held by the Working Group. A description of the reporting scheme is appended.

BMR Record 1991/72

Introduction

A scheme for classifying and reporting magnetic repeat station data, developed by IAGA Working Group V-4 (Magnetic Surveys and Charts), was formally adopted at the IAGA General Assembly in Exeter, July 1989. The scheme is designed to ensure regular reporting of repeat station data in a standardized form. One of the principal aims of the scheme is to provide sufficient information for repeat station data to be used properly for global field modelling.

Each agency conducting repeat station surveys is asked to submit the following to World Data Center-A, Boulder, Colorado:

- a "Regional Magnetic Repeat Station Record Sheet" for each occupation of a station;
- a "Computer File" summarizing the results of a particular survey (a "survey file") and/or a compilation of results from many surveys (a "master file");
- a "Regional Magnetic Repeat Station Network Description".

Some explanatory notes, which accompanied the fifth circular, are contained in the Appendix. These notes describe how to prepare repeat station record sheets and computer files.

The network description is a short document summarizing the characteristics of a regional network of magnetic repeat stations, the instruments and observational procedures employed, the data reduction methods used, and a list of the models and charts produced. A diagram showing the locations of the stations, and a list of related publications may also be included. Copies of the magnetic repeat station network descriptions should be sent to IAGA Working Group V-4, as well as to WDC-A (addresses are given in the Appendix).

National magnetic repeat station descriptions

The Working Group currently holds network descriptions for the following countries (revision dates are given as day/month/year):

Australia (17/7/91)	Brazil (19/8/89)	Britain (12/90)
Canada (19/10/88)	China (1/2/89)	Finland (1/12/88)
France (9/7/89)	Indonesia (21/7/89)	Italy (28/11/90)
Japan (18/12/90)	New Zealand (30/5/89)	South Africa (19/6/91)
Sweden (14/1/89)	USA (26/11/90)	USSR (12/12/89)
West Africa, via France (17/7/89)		

Magnetic repeat station network descriptions for these countries are listed below.

Country **AUSTRALIA** Revised: 17 July 1991

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NETWORK CONFIGURATION

Repeat stations	Reoccupation interval
68 Australia	5 years
6 Papua-New Guinea	5 years
9 SW Pacific islands	5 years
≈50 Antarctica	very variable

Magnetic observatories

Canberra	35°19'S	149°22'E	(1979 +)
Gnangara	31°47'S	115°57'E	(1919 +)
Charters Towers	20°05'S	146°15'E	(1983 +)
Learmonth	22°13'S	114°06'E	(1987 +)
Macquarie Island	54°30'S	158°57'E	(1952 +)
Mawson	67°36'S	62°53'E	(1955 +)

The Antarctic repeat stations are occupied on an opportunistic basis; the interval between occupations is often irregular and in most cases only spot observations of the vector field are possible with little, or no, diurnal control.

Station markers: a brass plaque plus three footpads, set in concrete at ground level; the precise station is marked by a "+" on the brass plaque, or inscribed in the concrete.

Auxiliary stations: installed at almost every location, usually within 1 km of the main station, preferably in line of sight. Station differences are checked during reoccupations.

Logistics

Access: most stations are accessible by road; the remainder by commercial aircraft
Fieldwork: approximately 3 months each year
Staff: 1 skilled observer plus 1 assistant; sometimes no assistant

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I	- DIM fluxgate-theodolite (ELSEC) consisting of a fluxgate coil mounted on a Zeiss/Jena 020B non-magnetic theodolite
F	- proton precession magnetometers (Elsec 770 and Geometrics G816)
True north	- Zeiss theodolite
Backup	- QHM for **H** & **D**

Variometers

D,H,Z	- triaxial fluxgate magnetometer (EDA FM-100B)
F	- Elsec 820 PPM basestation recording at 1-minute intervals
Temp	- temperature of fluxgate sensors (coefficient ≈ 3 nT/°C)
Recording	- analog on a W&W or Tigraph chart recorder.

Frequency and Duration of Observations

- Variometers are operated for at least 2 nights of low magnetic activity (up to a maximum of 5 days, subject to logistical constraints).
- A minimum of 4 sets of absolute observations are made each day, and up to 8 sets might be made depending on the need for station difference measurements and more accurate determination of variometer scale values (best accomplished when the amplitude of the diurnal variation is large). Special importance is placed on the 2 sets made early in the morning and the 2 sets made late in the afternoon (to get the best calibration of the night-time variations).
- Each set of absolute measurements consists of sequential observations of **F**, **D**, **I**, **I**, **D** & **F** (taking about 20 minutes).
- Sun observations are made to check reference mark azimuths (determined separately by Australian Survey Office surveyors)

Comments

- The auxiliary stations are used as a back-up incase the main station becomes lost or magnetically contaminated; station differences are checked routinely to test for contamination.
- The absolute PPM is set up at a point several meters from the main station marker; tie-in observations between this point and the station marker are carried out at the beginning and end of the station occupation.
- Survey and data reduction methods are chosen to produce "Classification 1" data (on the IAGA WGV-4 scale of 1 to 3) for all the non-Antarctic stations. Normally only a few spot absolute measurements are made at the Antarctic stations (Classification 3 data) on an irregular, opportunistic basis.

DATA REDUCTION PROCEDURES

Data reduction procedures follow normal observatory practice.

- The analog variometer records are digitized at hourly intervals.
- The absolute observations are used to calibrate the digitized variometer data to produce mean hourly absolute values of **D**, **H**, **Z**, **F** and temperature (instrument corrections for **H**, **D**, **Z**, **F**, and temperature corrections for **H** and **Z** having been applied).
- The station variations are compared with 3 months or more of data from the nearest appropriate observatory/ies (not necessarily the nearest) and adjusted to eliminate any long-term, atypical disturbance effects in the field.
- Adjusted station values for **H**, **D**, **Z** and **F** near local midnight are considered to represent the long-term undisturbed field at the station for the epoch of occupation.
- Stations values are later updated to a common epoch using an appropriate plot or model of the secular variation.

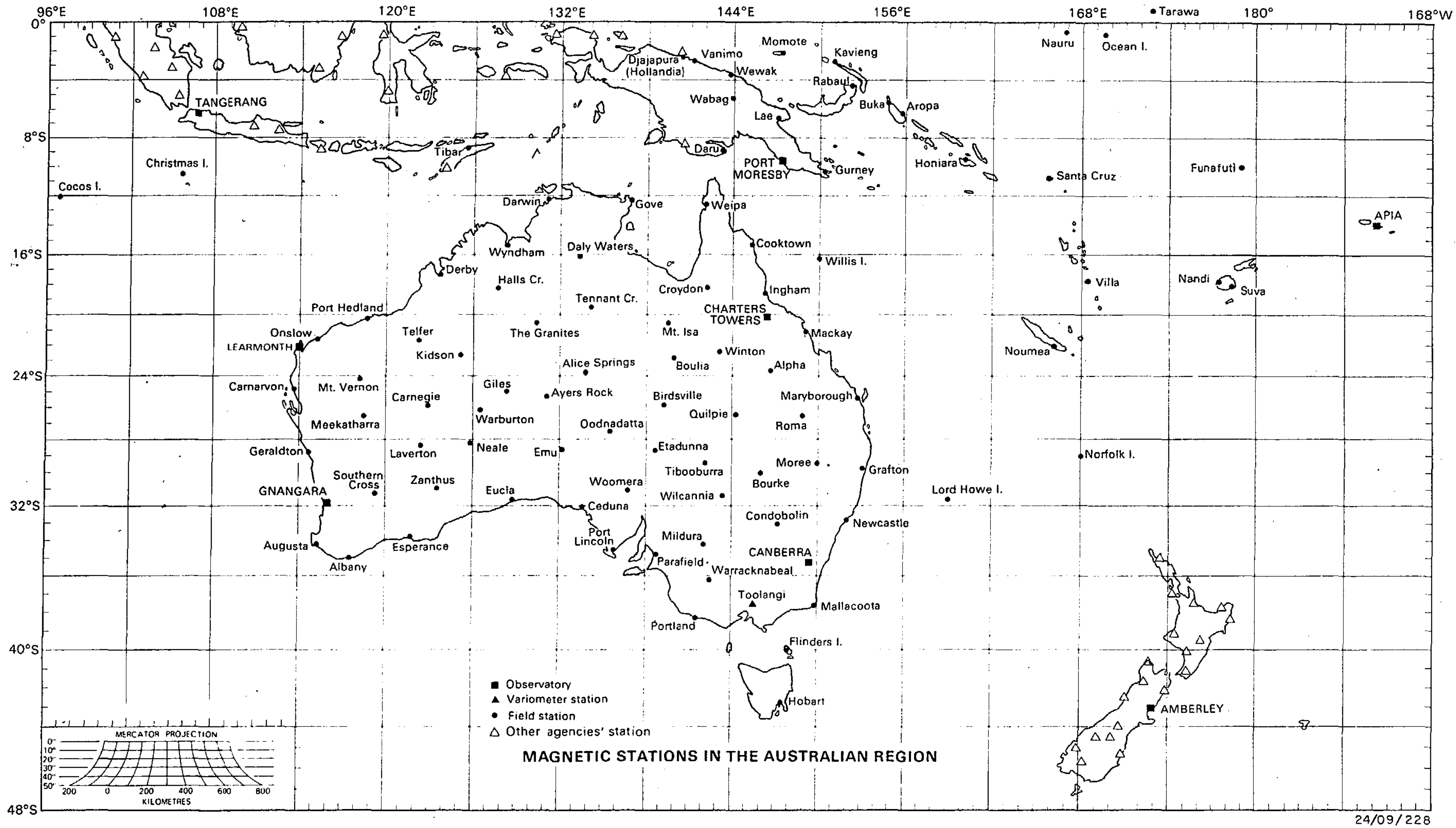
MODELS & CHARTS

All charts and models produced include annual change information

1944.4	hand-contoured chart of **D**
1950.5	hand-contoured chart of **D**
1955.5	hand-contoured chart of **D**
1957.5	hand-contoured charts of **F**, **D**, **H**, **I**, **Z**
1960.5	hand-contoured chart of **D**
1965.0	hand-contoured chart of **D**
1970.0	cubic spline/hand-contoured charts of **F**, **D**, **H**, **I**, **X**, **Y**, **Z**
1980.0	polynomial model and chart for **F**, **D**, **H**, **I**, **X**, **Y**, **Z**
1985.0	a rectangular harmonic model (the Australian Geomagnetic Reference Field, AGRF1985), and corresponding charts for **F**, **D**, **H**, **I**, **X**, **Y**, **Z**.

SELECTED PUBLICATIONS

Prior, L.S. (1954). Magnetic surveys in Australia and sub-Antarctic islands, 1951-1953. BMR Record, No. 1954/21.
Parkinson, W.D. & R.G. Curedale (1960). Isomagnetic maps of Australia for the epoch 1957.5, part 1 - Eastern Australia. BMR Record, No. 55.
Parkinson, W.D. & R.G. Curedale (1960). Isomagnetic maps of Australia for the epoch 1957.5, part 2 - Central and Western Australia. BMR Record, No. 62.
Van der Linden, J. (1964). Regional magnetic stations on some islands in the Pacific and Indian Oceans, 1957 and 1959. BMR Record, No. 1964/47.
Van der Linden, J. (1965). Regional magnetic surveys in Australia, Australian Antarctica, and the territory of Papua New Guinea during 1962. BMR Record, No. 1965/20.
Van der Linden, J. (1968). Regional magnetic surveys in Australia, Australian Antarctica, and on some islands in the Pacific and Indian Ocenas during 1964. BMR Record, No. 1968/2.
Finlayson, D.M. (1973). Isomagnetic maps of the Australian region for epoch 1970.0. BMR Report, No. 1973/159.
McEwin, A.J. (1984). First-order regional magnetic survey of Australia for epoch 1980.0, March 1978-July 1979, operations report. BMR Record No. 1984/15.
Hitchman, A.P. & L.P. Bibot (1987). First-order regional magnetic survey of Papua New guinea. BMR Record, No. 1987/1.
Hitchman, A.P. (1988). Reoccupation of the Heard Island magnetic station, Sept-Nov 1985. BMR Record, No. 1988/39.
Barton, C.E., A.P. Hitchman & A.J. McEwin (1989). First-order regional magnetic survey of Southwest Pacific Islands, May-July 1985. BMR Report, No. 289.
Hitchman, A.P. (1990). First-order regional magnetic survey of Southwest Pacific Islands, June-July, 1989. BMR Record, No. 19890/90.



MAGNETIC STATIONS IN THE AUSTRALIAN REGION

REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country: **BRAZIL** Revised: 19 August 1989

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NETWORK CONFIGURATION

Stations	**Reoccupation interval**
105 repeat stations	every 5 years on average

Magnetic observatories

Vassouras	(1915+)
Tatuoca	(1957+)

Station Markers: concrete pillar 40x40x70cm, 10cm above ground level, with a circular aluminium plate marked O.N.

Auxiliary Stations: none in general. In some cases there are two auxiliary stations.

Logistics
Access: by road or boat
Fieldwork: throughout the year, averaging 20 reoccupations per year
Staff: 1 engineer (geographer) plus 2 skilled observers

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I	- fluxgate theodolite (1979+), 3 instruments
F	- proton precession magnetometer (1965+), 3 instruments
Azimuth	- gyroscope-theodolite, 2 instruments

Classical instruments were used from 1880 until 1979.

Variometers
Triaxial fluxgate magnetometer (EDA FM-100), 2 instruments

Frequency and Duration of Observations
Stations are reoccupied every 5 years on average (see table below).
Two sets of absolute observations are made.

Comments
Early repeat station observations were made for **D, H** and **F**. Measurements are now made for **D, I** and **F**.

DATA REDUCTION PROCEDURES

- Up until 1960 no instrumental corrections were applied generally, and no reduction was made to obtain normal (undisturbed) values of the field.
- Before 1970 it was usually not possible to obtain local records of diurnal variations. For this reason an interpolative scheme using data from two magnetic observatories was used for epochs 1960.0 and 1965.0. Such a method proved to be acceptable except during perturbed periods or at stations under the influence of the equatorial electrojet.
- For epoch models 1960.0, 1965.0 and 1970.0 it has been estimated that the seasonal and solar cycle contributions are generally of the same order as observing errors.

MODELS & CHARTS

- Prior to 1960 all charts were hand-contoured.
- For 1960.0, 1965.0 and 1980.0 a parabolic trend (linear in a few cases) was fitted to the observations at each repeat station to permit reduction to a specific epoch. A second degree polynomial (Taylor expansion) in latitude and longitude was then fitted for each field element (**D**, **I** and **H**). Assuming time as an independent variable, secular change values were calculated by finite differences.
- For 1985.0 a more elaborate model was produced, using all available repeat station data from 1880 to 1960. Fourth-degree polynomials in latitude, longitude and time were fitted to **D**, **I** and **F** (35 coefficients). Data from anomalous stations (usually those sited on large magnetic anomalies) and very old data were not used in the model. Annual variations for a geomagnetic element (**E**) at any given points were calculated by finite differences from the 4th degree expansion as follows:

$$\frac{dE}{dt} = \mathbf{E}(t+0.5) - \mathbf{E}(t-0.5)$$

MODELS & CHARTS

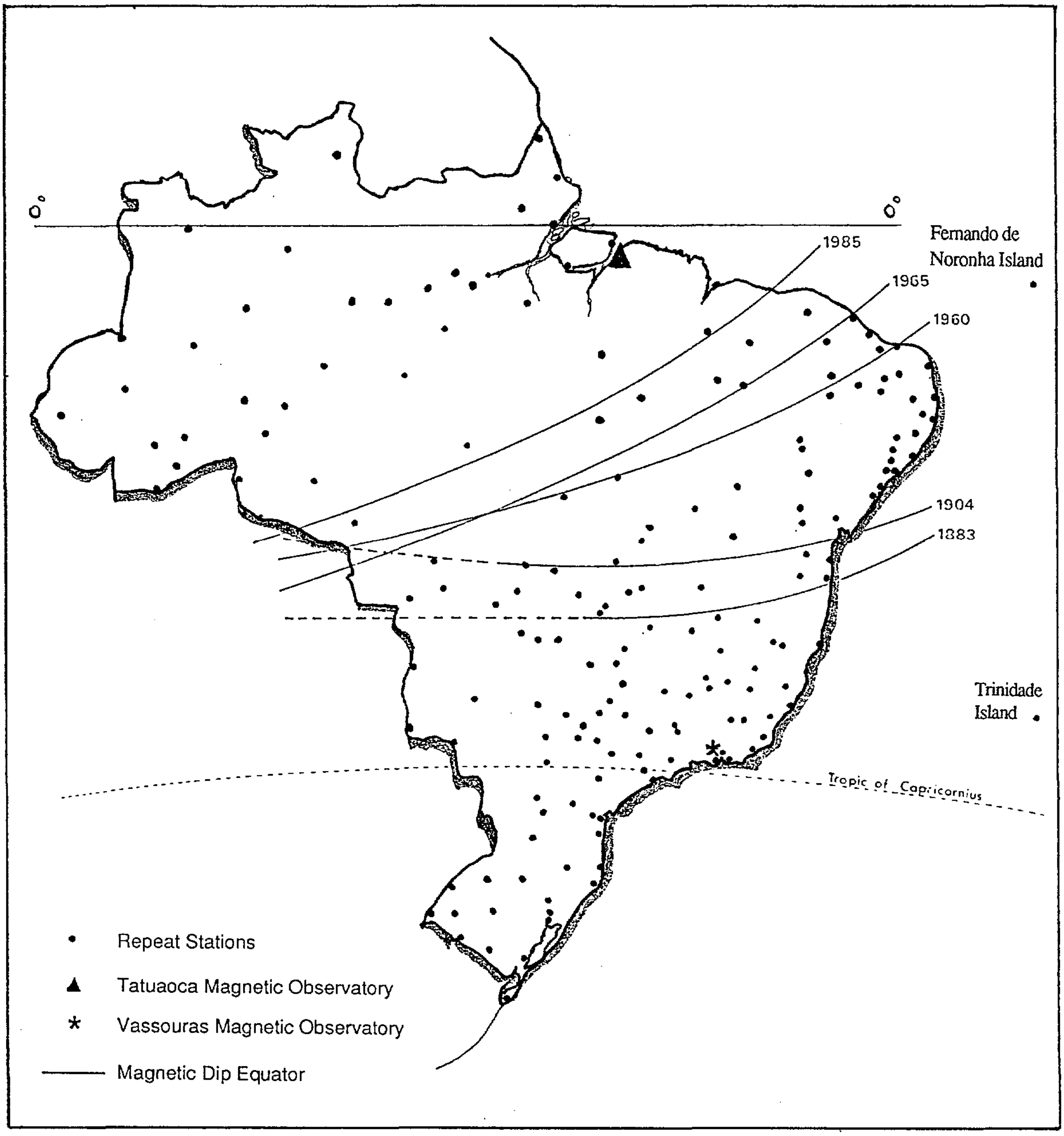
Epoch	*Observations Period*	*Cmpts*	*No. Stns*	*Corrections Inst**	*Diurnal*	*Model Interval*	*Model Type*
1883.0	1880-1885	**D H I**	120	yes	crude	1880-1855	Hand contoured
1904.0	1903-1904	**D H I**	25	no	no	1901-1904	Hand contoured
1910.0	1910-1911	**D H I**	48	yes	no	1880-1911	Hand contoured
1915.0	1913-1915	**D H I**	54	yes	no	1800-1915	Hand contoured
1915.0	1915-1917	**D H I**	14	no	no	1880-1917	Hand contoured
1920.0	1922	**D H I**	10	no	no	1880-1922	Hand contoured
1925.0	1923-1924	**D H I**	16	yes	no	1880-1924	Hand contoured
1930.0	1927-1932	**D H I**	44	yes	crude		
1935.0	General analysis of all observations					1880-1932	Hand contoured
1940.0	Small corrections to earlier models					1880-1932	Hand contoured
1950.0	1935-1949	**D H I**	60	no	no	1880-1949	Hand contoured
1955.0	1950-1954	**D H I**	50	no	no	1923-1954	Hand contoured
1960.0	1951-1960	**D H I**	80	yes	yes	1880-1960	Polynomial deg=2
1965.0	1960-1965	**D H I**	90	yes	yes	1880-1965	Polynomial deg=2
1980.0	1965-1979	**D H I F**	90	yes	yes	1800-1979	Polynomial deg=2
1985.0	1979-1985	**D I F**	105	yes	yes	1880-1985	Polynomial deg=4

* Correction applied for instrument calibration

GENERAL NOTES

- The network of magnetic repeat stations has been gradually built up from 1880 onwards.
- Stations are usually named after the nearest city, with a letter (A, B, C, ...) designating the particular pillar.
- Many station heights have uncertainties of up to about 50m.
- Southern Brazil is a basaltic region, hence the repeat station data from the south are often influence by large magnetic anomalies.

MAGNETIC REPEAT STATIONS - BRAZIL



Country **BRITAIN** (England, Scotland, Wales) Revised: December 1990

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NETWORK INFORMATION

The current magnetic survey programme began in 1985 and a total of 47 repeat stations have been established. A list of the repeat stations and a map showing their locations, and those of the UK magnetic observatories, are appended to this description.

Repeat station occupations	**Reoccupations**
14 during 1985	6 during 1989
15 during 1986	10 during 1989
6 during 1987	
12 during 1988	

Reoccupation interval = about every 4 or 5 years

Magnetic observatories

	Geographic	
Lerwick (LER)	60° 08' N	358° 49' E
Eskdalemuir (ESK)	55° 19' N	356° 48' E
Hartland (HAD)	51° 00' N	355° 31' E

Station markers: a 6-sided paving slab buried to a depth of about 0.5 metre and relocated by taking measurements from nearby permanent fixtures, together with photographs taken on each visit to monitor changes in local features.

Logistics
All stations are accessible by car to within a reasonable walking distance.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I	fluxgate-theodolite (Elsec type 810)
F	proton precession magnetometer (Elsec type 820)
True north	Wild GAK-1 gyro-attachment

Frequency and Duration of Observations
Each station is occupied for between 4 and 6 hours during which time up to about 10 absolute observations of D and I are obtained. F is recorded at one-minute intervals during the whole of the occupation.

The true north azimuth is determined at each visit.

DATA REDUCTION PROCEDURES

The diurnal variations at the survey stations are eliminated by reference to the two UK observatories closest in latitude to the station. (In the case of stations south of Hartland only Hartland records are used).

The measurements made in the field are reduced to a quiet night-time level close to the time of observation. If an observation is made at time t, then the values of the observed element at the two observatories closest in latitude to the station (also at time t) are required. By examining records over several days the quiet night-time level of the field at the two observatories for the period of the survey is identified. If the observed element is denoted by **E**, then the final value of **E**, reduced to the quiet level, is calculated as follows:

$$\mathbf{E}_q(\text{t,station}) = \mathbf{E}(\text{t,station}) + C$$

$$C = l_2 \,.\, [\, \mathbf{E}_q(\text{t,obs}_1) - \mathbf{E}(\text{t,obs}_1)] + \Delta l_1 \,.\, [\, \mathbf{E}_q(\text{t,obs}_2) - \mathbf{E}(\text{t,obs}_2)] \,/\, (\, l_1 - l_2\,)$$

where

l_1 = latitude of the observatory north of the station
l_2 = latitude of the observatory south of the station
l_s = latitude of the station
$\Delta l_1 = l_1 - l_s$
$\Delta l_2 = l_s - l_2$
E(t,station) = value of **E** at the station at time, t
E(t,obs$_1$) = value of **E** at observatory-1 at time, t
E(t,obs$_2$) = value of **E** at observatory-2 at time, t
$\mathbf{E}_q$(t,station) = quiet level of **E** at the station at time, t
$\mathbf{E}_q$(t,obs$_1$) = quiet level of **E** at observatory-1 at time, t
$\mathbf{E}_q$(t,obs$_2$) = quiet level of **E** at observatory-2 at time, t

The estimated errors in the final values are:

D & I	0.5 - 1'
F	5 - 10 nT

EARLIER SURVEYS OF THE BRITISH ISLES

- The first survey was carried out in Scotland in 1829-1830 by Mr James Dunlop and measured the Horizontal Intensity relative to the value in Edinburgh, which was taken as unity.

- The next 2 surveys were of the British Isles, superintended by Sir Edward Sabine, and took place between the years 1834-1838 when **I,H** & **F** were measured and 1857-1862 when **D,I** & **F** were measured.

- Rucker & Thorpe carried out 2 surveys of the British Isles between 1884-1888 and 1890-1892 when 205 and 677 stations were visited respectively, measuring **D,I,H** & **Z**.

- In 1907 **D,I** & **H** were measured at 12 stations around the coast of the British Isles, led by Commander L.W.P.Chetwynd.

- Walker occupied 183 stations in the British Isles between 1913-1915 measuring **H,D** & **I**.

- Between 1925-1929, **D,I** & **H** were measured at 117 stations in the British Isles by the Ordnance Survey.

- The Ordnance Survey measured D only at 56 stations in Great Britain between 1947-1949.

- The Geological Survey of Great Britain, now the British Geological Survey, measured **D,H** & **Z** at 29 stations in Great Britain during 1955-1956.

PUBLICATIONS RELATING TO MAGNETIC SURVEYS OF THE BRITISH ISLES

Avann, F.M. & Barraclough, D.R. (1975). Chart of the magnetic declination for the British Isles, epoch 1975.0. *Institute of Geological Sciences Report*, **75/10**.

Kerridge, D.J. (1984). Progress in planning for the magnetic re-survey of the United Kingdom. *British Geological Survey Technical Report, Geomagnetism Series*, **84/14**.

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O'Beirne, T.H. (1949). Magnetic survey work 1947-1949. (Unpublished report of the Ordnance Survey, dated 31-8-1949).

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Ordnance Survey (1929). Results of the magnetic observations made by the Ordnance Survey in England in 1927 and preliminary results (declination only) of those made in England and Wales in 1928. (London HMSO).

Ordnance Survey (1930). Results of the magnetic observations made by the Ordnance Survey in England and Wales in 1928 and preliminary results (declination only) of those made in Scotland in 1929. (London HMSO).

Rucker, A.W. & Thorpe, T.E. (1890). A magnetic survey of the British Isles for the epoch January 1, 1886. *Phil. Trans. R. Soc. London, Ser.A*, **181**, 53-228.

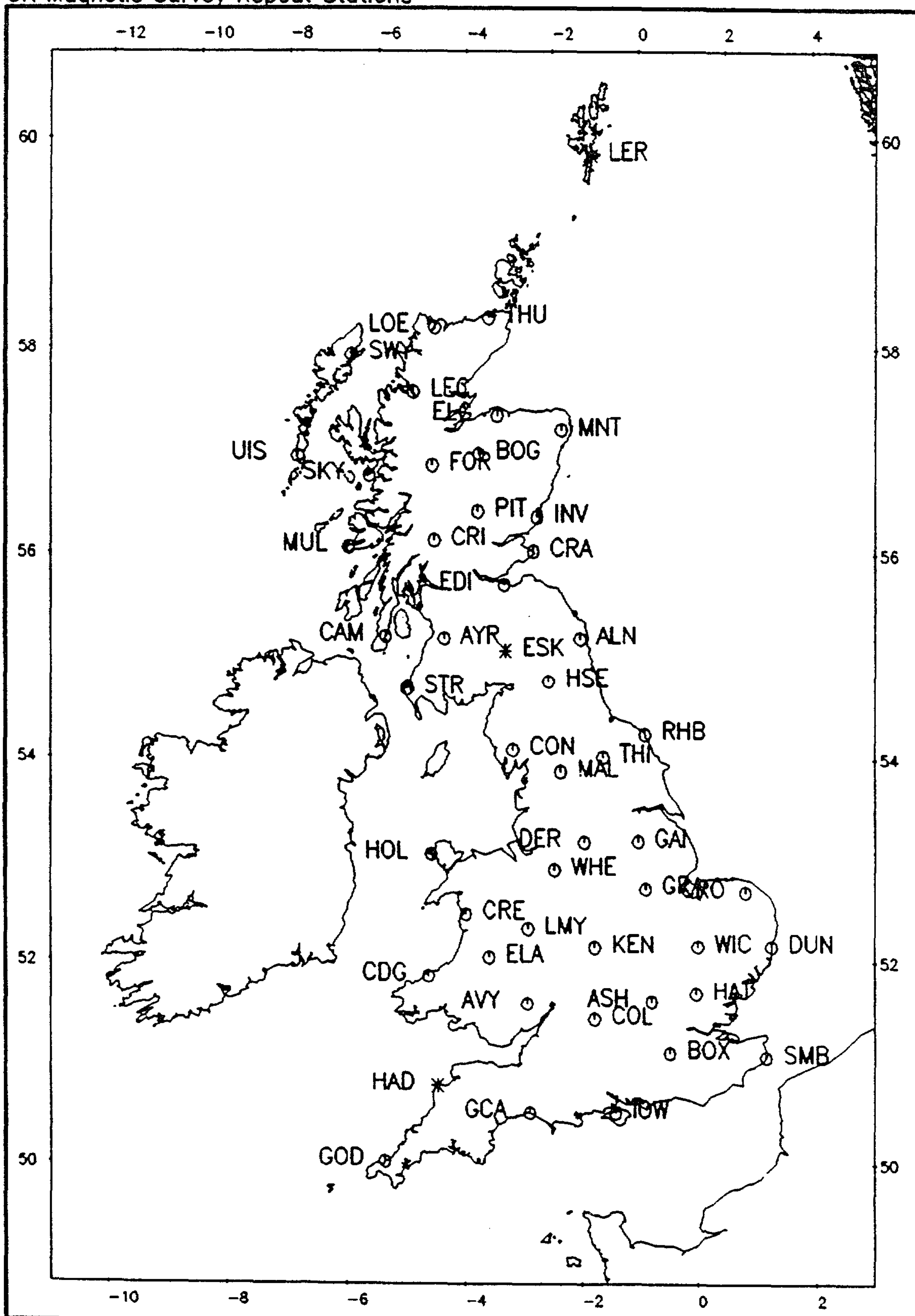
Rucker, A.W. & Thorpe, T.E. (1896). A magnetic survey of the British Isles for the epoch January 1, 1890. *Phil. Trans. R. Soc. London, Ser.A*, **188**, 1-661.

Walker, G.W. (1919). The magnetic re-survey of the British Isles for the epoch January 1, 1915. *Phil. Trans. R. Soc. London, Ser.A*, **219**, 1-72.

UNITED KINGDOM REPEAT STATIONS

#	*Station*	*Code*	*Date 1*	*Date 2*	*Latitude*	*Longitude*	*Alt*
1	Elgin	ELG	13/05/1985	05/06/1989	57°37.9'N	3°19.6'W	28
2	Thurso	THU	15/05/1985	03/07/1989	58 35.3'N	3 29.9'W	60
3	Loch Eriboll	LOE	16/05/1985	04/07/1989	58 29.8'N	4 39.9'W	8
4	Pitlochry	PIT	27/05/1985	08/06/1989	56 41.6'N	3 43.8'W	120
5	Boat of Garten	BOG	29/05/1985	06/07/1989	57 1S.S'N	3 42.9'W	213
6	Mintlaw	MNT	30/05/1985	06/06/1989	57 28.6'N	1 59.9'W	70
7	Alnwick	ALN	03/06/1985	18/07/1990	55 25.2'N	1 43.7'W	82
8	Wheelock	WHE	17/06/1985	06/08/1990	53 07.9'N	2 19.7'W	68
9	Gainsborough	GAI	19/06/1985	07/08/1990	53 23.0'N	0 44.6'W	30
10	Thirsk	THI	20/06/1985		54 14.1'N	1 21.2'W	38
11	Edinburgh	EDI	25/07/1985	28/06/1990	55 57.9'N	3 12.9'W	25
12	Kenilworth	KEN	12/08/1985	23/08/1990	52 21.2'N	1 36.7'W	100
13	Cardigan	CDG	15/08/1985	21/08/1990	52 05.3'N	4 39.9'W	55
14	Holyhead	HOL	16/08/1985	20/08/1990	53 17.8'N	4 38.3'W	20
15	Godrevy Point	GOD	13/05/1986	04/09/1990	50 14.1'N	5 23.4'W	15
16	Stonebarrow Hill	GCA	15/05/1986	06/09/1990	50 43.7'N	2 51.3'W	91
17	Robin Hood's Bay	RHB	02/06/1986		54 26.6'N	0 31.6'W	137
18	Coniston	CON	04/06/1986		54 20.2'N	3 04.2'W	50
19	Housesteads	HSE	06/06/1986	19/07/1990	55 00.1'N	2 21.4'W	229
20	Hatfield Forest	HAT	16/06/1986		51 50.4'N	0 12.6'E	85
21	Box Hill	BOX	17/06/1986		51 16.1'N	0 18.7'W	137
22	St Margarets Bay	SMB	19/06/1986		51 09.5'N	1 23.9'E	61
23	Grantham	GRA	30/06/1986		52 54.9'N	0 38.1'W	61
24	Derwent Estate	DER	02/07/1986		53 24.0'N	1 45.9'W	305
25	Malham	MAL	04/07/1986		54 06.2'N	2 10.4'W	400
26	Cregennan	CRE	01/09/1986		52 42.4'N	3 58.9'W	278
27	Long Mynd	LMY	03/09/1986		52 33.4'N	2 50.5'W	472
28	Ashridge	ASH	29/09/1986		51 47.3'N	0 36.2'W	183
29	Coleshill	COL	01/10/1986		51 38.4'N	1 39.3'W	100
30	Elan Village	ELA	18/05/1987		52 16.6'N	3 33.3'W	213
31	Abergavenny	AVY	19/05/1987		51 48.6'N	2 52.1'W	91
32	Newport (IOW)	IOU	21/05/1987		50 42.2'N	1 20.4'W	30
33	Crianlarich	CRI	14/09/1987		56 24.2'N	4 37.5'W	190
34	Lechmelm	LEC	16/09/1987		57 51.8'N	5 05.5'W	10
35	Stornoway	SWY	18/09/1987		58 12.6'N	6 23.7'W	15
36	Campbeltown	CAM	31/05/1988		55 27.0'N	5 32.8'W	15
37	Ayr	AYR	01/06/1988		55 26.3'N	4 25.1'W	122
38	Stranraer	STR	02/06/1988		54 56.1'N	5 07.2'W	105
39	Fort Augustus	FOR	14/06/1988		57 08.5'N	4 40.8'W	25
40	Inverkeilor	INV	16/06/1988		56 37.7'N	2 31.8'W	15
41	Crail	CRA	17/06/1988		56 17.4'N	2 37.1'W	10
42	Mull	MUL	27/06/1988		56 19.1'W	6 19.3'W	30
43	S Uist	UIS	29/06/1988		57 11.4'N	7 24.7'W	5
44	Skye	SKY	01/07/1988		57 01.7'N	5 57.6'W	20
45	Cromer	CRO	19/09/1988		52 48.7'N	1 13.4'E	30
46	Dunwich Heath	DUN	20/09/1988		52 15.3'N	1 37.3'E	15
47	Wicken Fen	WIC	22/09/1988		52 18.6'N	0 17.6'E	4

UK Magnetic Survey Repeat Stations



TRANSVERSE MERCATOR

REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **CANADA** Revised: 19 October 1988

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NETWORK CONFIGURATION

Repeat stations	Reoccupation interval
4 class A	2 years
37 class B	4 years
18 class C	10 years
TOTAL = 59	

Station Marker

Normally a bronze disc set in bedrock or set in concrete flush with the ground.

Auxiliary Stations

At a few locations.

Logistics

Access: Approximately half the stations are accessible by road; the remainder by commercial or charter aircraft.

Field work: Approximately 6 to 8 weeks each year.

Staff: 1 skilled observer; sometimes 1 skilled observer plus 1 assistant; some legs of the repeat station survey are let out to contract.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I - Magnetometer theodolite consisting of a fluxgate coil mounted on a Jena 020A non-magnetic theodolite.

F - Scintrex MP-2 proton precession magnetometer and Gem GSM-18 PPM with solid state memory for continual recording.

Sun observations - Jena 020A theodolite as above.

Variometers

D, H, Z - triaxial fluxgate magnetometer (EDA FM-100)

T - temperature of fluxgate sensors (coefficient up to 5 nT/deg)

Recording - digital on cassette at one minute intervals

Frequency and Duration of Observations

- Variometer is operated for 72 hours.
- 2 sets of absolute observations are made each day, normally one early in the morning and one late in the afternoon, to detect diurnal temperature effects in the variometer.
- Each set of absolute measurements consists of 6 observations of **D**, **I** and **F** (taking 1 to 2 hours).

Comments

- The Scintrex PPM is set up several meters from the station marker and tie-in observations are carried out after each set of absolute observations.
- Observations of the sun are carried out to determine reference mark azimuths as necessary.

DATA REDUCTION PROCEDURES

Repeat station data are processed in a similar manner to data obtained from the Canadian digital magnetic observatories. The variometer data are read from the cassettes, plotted and edited. The absolute observations are used to establish baseline values which are added to the variometer data to produce a file of temperature-corrected one-minute absolute values of **D**, **H** and **Z**. **F** values are derived from **H** and **Z** and are compared with the PPM values as a check of data quality. A mean of the quietest 24 hour period is chosen to approximate the undisturbed level of the magnetic field at that time. Occasionally, under good conditions, a 48 hour mean is computed. When conditions are disturbed, a shorter interval of time, preferably near local midnight is meaned. No further reduction, (i.e. to a mean-of-the-year value) is attempted because of the great distance from most repeat stations to the nearest observatory.

MODELS & CHARTS

- Repeat station data are used to help update the 3-component aeromagnetic and Magsat data sets used to produce the Canadian Geomagnetic Reference Field (CGRF), modelled via spherical cap harmonic analysis.
- The latest CGRF model is for epoch 1987.5
- The latest charts are for **D**, **H**, **Z**, **I** and **F** for epoch 1985.0, and are based on CGRF.

Country **CHINA** Revised: 1 February 1989

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NETWORK CONFIGURATION

Stations	Reoccupation interval
98 repeat stations	10 years
1684 class-3 stations	1968-1972, once only

Station Markers: Most stations are marked by a "+" on a limestone pillar set in the ground in concrete. Some stations are defined by distances from nearby objects, as recorded on a sketch.

Auxiliary Stations: at most stations, usually within 10 km of the main station.

Logistics Access: All stations are accessible by road or ship
Fieldwork: Approximately 3-6 months each year.
Staff: 2 skilled observers + 1 assistant

OBSERVATIONAL PROCEDURES

Absolute Instruments

- **D** - Askania fibre declinometer
- **D,I** - Fluxgate theodolite, DIM-100
- **H** - Quartz Horizontal Magnetometer (QHM)
- **F** - Proton precession magnetometer, CZM-2

Variometers - none

Frequency and Duration of Observations

- Four sets of absolute observations of **D,H** & **F** (or **D,I** & **F**) are made each day, taking about 4 hours.
- If the difference between the predicted and observed values is greater than 15 minutes for **D**, 80 nT for **H**, or 100 nT for **F**, then observations are made again.

Comments

- **D, H** & **F** (or **D, I** & **F**) are measured near the station marker.
- Observations of the Sun are made in the morning and in the afternoon.
- The auxiliary stations are used as a back-up in case the main station becomes lost.

DATA REDUCTION PROCEDURES

Station values are updated to a common epoch by using the hourly values at the nearest magnetic observatory.

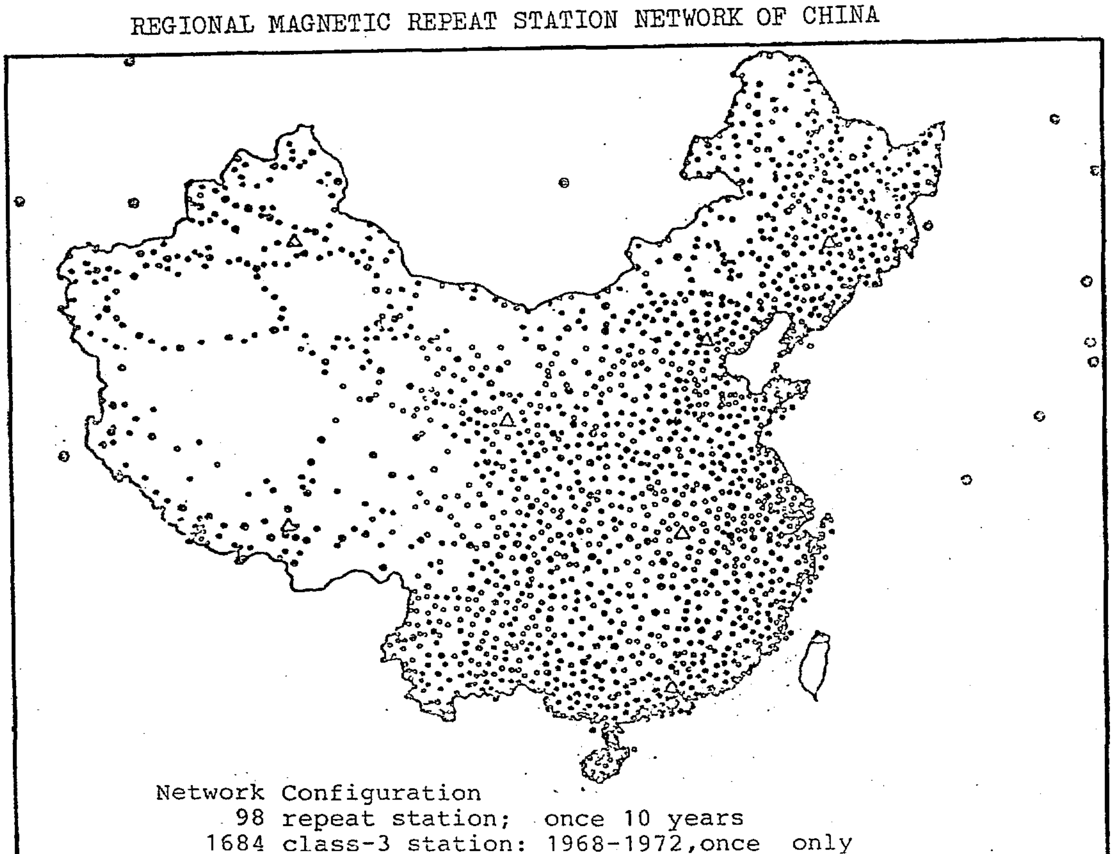
MODELS & CHARTS

Models of the normal geomagnetic field and the secular variation are produced by using Taylor polynomials fitted by the method of least squares. Each of the three elements of the field are modelled independently.

Charts:

1950.0 - Hand-contoured charts of **D, H, Z, I & F**
1960.0 - Taylor polynomial models and charts for each of **D, H, Z, I & F**
1970.0 - Taylor polynomial models and charts for each of **D, H, Z, I & F**
1980.0 - Taylor polynomial models and charts for each of **D, H, Z, I & F**

REGIONAL MAGNETIC REPEAT STATION NETWORK OF CHINA



REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **FINLAND** Revised: 1 December 1988

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NETWORK CONFIGURATION

Repeat stations	**Reoccupation interval**
25 approximately	2 or 3 years

Station Markers: a cross chisled (or painted?) on bedrock

Auxiliary Stations: none

Logistics

Access: all stations are accessible by road or boat
Fieldwork: about one month to visit entire network
Staff: 2 skilled observers plus one assistant

Repeat station measurements were commenced in 1910-1912. Some of these stations are still in use.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D - one Askania declinometer
H - two quartz horizontal magnetometers (QHM)
F - one Elsec proton precession magnetometer
Askania Reisetheodolite

Variometers - none

Frequency and Duration of Observations

- One complete set of absolute observations is made at each station.
- A set comprises **D**, **H** and **F** observations made once each minute for exactly one hour beginning on the hour.
- A complete set of measurements at a station, including the preliminary tie-ins (see below) takes approximately two hours.

Comments

- The QHM and PPM are set up at "H" and "F" points 20 to 30 m from the station marker and tie-in observations (of **H** and **F** respectively) are made between these points and the station marker (the S-point) before commencement of absolute measurements.
- Thereafter the declinometer is set up at the station marker, and appropriate station-

difference corrections are applied to observations at the H- and F-points.

- At the H-point the QHM is in the $+2\pi$ position during the first half of the hour, and in the -2π position during the second half.
- Usually Sun measurements are not needed as there are many reference marks with known azimuths from the station.

DATA REDUCTION PROCEDURES

One-minute values measured at the station are averaged to give an hourly mean value for each component. Reduction to a mean-of-the-year value is carried out using hourly mean values from the two Finnish magnetic observatories, Nurmijärvi in the south and Sodankylä in the north near the auroral zone. The distance between the two observatories is approximately 800 km. The reduction is based on a correction at each repeat station obtained by linear interpolation between the observatory means using latitude differences only. The reason for making exactly a one hour sequence of observations is so that the hourly averages produced routinely at the observatories can be used directly in the data reduction process. The final accuracy in repeat station annual means is estimated to be 3-5 nT. Errors are bigger in the north of Finland which is magnetically more disturbed.

Country **FRANCE** Revised: 9 July 1989

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Antarctica and sub-Antarctic islands

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NETWORK CONFIGURATION

Repeat stations		**Reoccupation interval**
33	in France, used routinely	every 5 years
2	on Réunion Island	
4	on French sub-Antarctic Islands	every 4 years (1981+)
1	in Antarctica (Terre Adélie)	variable

Magnetic observatories

Chambon-la-Forêt	
Dumont d'Urville	(1957+)
Port aux Francais	(Kerguelen, 1957+)
Crozet	(1974+)
Martin de Vivies	(Amsterdam Is., 1981+)

The repeat station networks operated by France in Polynesia and West Africa are described separately.

Station Markers - the following have been used

- Triangulation stations
- Concrete pillar, non-magnetic, 125 cm high, diameter ≤30 cm, grooved at 120° to fit the DIM and PPM legs,
- Concrete slabs at ground level, 150 x 150 cm, with centred station mark and inset cylindrical tubes (Al, brass or Arcap) to fix the tripod legs; sometimes with studs near the outside to mark F-reference points (see below). Antarctic station markers are of this type.
- Suitable non-magnetic landmarks.

Logistics

Access:	Motor vehicle (4x4) for mainland stations
Fieldwork:	During the middle of a year
Staff:	1 skilled observer + 1 assistant

Comments

- The spacing between stations in Metropolitan France is typically ~100 km, and somewhat less in geologically variable regions.
- Stations are sited so as to be representative of the surrounding regions, in places with low gradients, and avoiding large magnetic anomalies and subsurface electrical conductivity structures (at least 10 km from coastlines).
- Fieldwork is timed for the mid-year to facilitate comparisons with observatory annual means.
- For the Antarctic/sub-Antarctic stations, measurements made at distances of 10 to 80 km away show large magnetic anomalies (100 to 2000 nT).

OBSERVATIONAL PROCEDURES

Absolute Measurements

D, I - portable fluxgate theodolite (DIM), constructed by "IPGS"
F - 2 proton precession magnetometers (PPM's), ELSEC or GEOMETRICS, one with memory
Azimuth - Zeiss Iena 010B theodolite

- Instrument comparisons/calibrations, and optical adjustment of the theodolite are carried out at the reference magnetic observatory.
- The PPM sensor is set up at the F-substation marker approximately several metres from the main station.
- Care is taken to ensure that DIM and PPM observations are made at the same height as for the previous station occupation (usually both at the same height).
- Several surveyed reference marks are used for azimuth control; angles between reference marks are remeasured every occupation; sun observations are used to check azimuths, one set in the morning and one set in the afternoon.

Variometer Measurements

H, D, Z (or **X, Y, Z**) - Triaxial magnetometer, with temperature insulation or thermostatic control of both the sensor and associated electronics
F - PPM, interfaced with a micro-calculator for data acquisition (1984-1987)
Time - Radio receiver to record hourly time-signals

Data acquisition is either digitally (by portable PC with double disk-drive and printer) or by chart recorder. Recording is every minute, on the minute (Universal Time) to synchronise with observatory data.

Frequency and Duration of Observations

- Observations are spread over 1 or 2 days if a reference magnetic observatory can be used.
- Observations are spread over 3 to 5 days if a local variometer station is used.
- A set of absolute observations comprises an alternation of six (4 in Antarctica) measurements of each of **D** and **I**, each with an **F** measurment.
- At least two sets of absolutes are made daily, one early in the morning and one late in the evening (to reduce the effect of the diurnal change).

Comments

- Two F-substations, marked by reference studs placed several metres from the main station, are used for making PPM measurements at the same time as D and I measurements are made at the main station.
- Several series of PPM observations are made simultaneously at the F-substation and the main station to obtain a station difference value.
- A local total field survey is conducted around each stations to test for changes in the magnetic environment since the previous station occupation. Observations of **F** are made at distances of 2 m, 10 m and 20 m from the station in each of four different directions, and also at 20 cm intervals above the station marker. Permanent reference marks are sometimes placed in the ground to help ensure reproducability.
- A programmable calculator is used in the field for data reduction.

DATA REDUCTION PROCEDURES

The stability/reliability of the variometer records are assessed from the consistency of the baseline values calculated from the absolute observations, and also by comparison with records from the nearest reference magnetic observatory.

Reduction to a common epoch (used 1982+)

Observations must be averaged and reduced to a common epoch. The latter is chosen to be 1st July in the year in which observations are made, i.e. 19xx.5 (to permit direct comparison with conventional annual mean values from magnetic observatories).

Let **E**(S,t) = value of field element **E** at the field station at time (epoch) t
E(O,t) = corresponding value at the reference magnetic observatory
Emy = annual mean values for the element (for the year centred on t)
T = mid-year epoch, 19xx.5

If the reference observatory is representative of the field station, then

$$\mathbf{E}(S,t) - \mathbf{Emy}(S,t) = \mathbf{E}(O,t) - \mathbf{Emy}(O,t)$$

Assuming that the secular change in **E** from time t to T is the same at both the reference observatory and the field station, then

$$\mathbf{Emy}(S,T) - \mathbf{Emy}(O,T) = \mathbf{E}(S,t) - \mathbf{E}(O,t)$$

i.e. $$\mathbf{Emy}(S,T) = \mathbf{Emy}(O,T) + \Delta\mathbf{E} \quad , \qquad \text{where } \Delta\mathbf{E} = \mathbf{E}(S,t) - \mathbf{E}(O,t)$$

Given the conventional observatory annual mean value, **Emy**(O,T), the problem is that of estimating Δ**E** from the corresponding pairs of observations at the field station and reference observatory at the various times, t.

(a) Direct method using data from central reference observatory

Given several set of observations of **D**, **I** & **F** made at different times t_i spread over one or two days, then calculate the estimates

$$\mathbf{E}(S,t_i) - \mathbf{E}(O,t_i) \qquad i = 1,2,....$$

These are weighted with regard to the level of magnetic disturbance at time t_i, and according to the departure of **E** from the quiet night time value at the reference observatory. Δ**E** is the weighted mean of the above estimates.

(b) Reduction using local variometer station

This method is used at stations that are remote from a magnetic observatory, or at stations for which the best reference observatory is considered to be non-representative. The field variometer records provide 1-minute values of **H**, **D**, **Z** & **F**, baselines being derived from the absolute observations at the field station. A reduction is made to get quiet night time values. The time when this occurs (t_q) is assigned on the basis of data from a chosen reference magnetic observatory (O), and is different for each element of the field. Hourly mean values of **H**, **D**, **Z** & **F** are calculated from the variometer records and baselines. For each element, E, the difference $\mathbf{E}(S,t_q) - \mathbf{E}(O,t_q)$ is used as the estimate of ΔE.

Errors

Typical uncertainties in the annual mean values derived from repeat stations (1982.5 occupation) and the reference magnetic observatory at Chambon la Forêt (1982) are shown in the table below:

Element	Repeat Station	Chambon-la-Forêt
D	1 minute	0.1 minute
H	4 nT	0.5 nT
Z	3.5 nT	0.5 nT
F	4 nT	0.5 nT

Antarctic & sub-Antarctic stations (1981-1986)

For **D**, **H**, **Z** components, method (a) above was used, preference being given to quiet data.
For **F**, a mean of the quietest intervals was calculated; adjusted station values for **F** near local midnight were adopted to represent the undisturbed field at the station for the epoch of occupation.

REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **INDONESIA** Revised: 21 July 1989

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NETWORK CONFIGURATION

Repeat stations
59

Reoccupation interval
5 years (planned)

Magnetic observatories
Tangerang
Tuntungan (Medan)

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I EDA magnetometer-theodolite (DIM 100)
F Geometrics G826 proton precession magnetometer

Country **ITALY** Revised: 28 November 1990

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NETWORK CONFIGURATION

Repeat stations	**Reoccupation interval**
46 for epoch 1935.0 to 1959.0	
53 for epoch 1973.0	
106 for epoch 1979.0	
110 for epoch 1985.0	about every 5 years
2550 second-order stations	used for the 1979 model & charts

Magnetic observatories

L'Aquila	42°23'N, 13°19'E	(1958 +)
Castel Tesino	46°03'N, 11°39'E	(1965 +)
Gibilmanna	37°59'N, 14°01'E	
Roburent	44°18'N, 07°53'E	

Temporary observatories (used during field surveys)

Locorotondo	40°48'N, 17°22'E	in S. Italy
Corongui	39°18'N, 09°17'E	in Sardinia

- The first modern comprehensive magnetic survey was carried out by the Instituto Geografico Militare Italiano (IGMI) in 1932-1938, comprising 1496 primary stations, including 46 magnetic repeat stations, for **D**, **I** & **H**, and 33 secondary stations for **D**. **D** was measured to a final accuracy of ±1' and **H** to ±30nT.
- 28 repeat stations, some of them new ones, were set up in 1957-1958 as part of the World Magnetic Network. Measurements were made of **D, H, Z, I** & **F**
- The Progetto Finalizzato Geodinamica (PFG) network, set up in 1977-1979, comprised 106 repeat stations (34 old IGMI stations + 72 new ones) and 2252 normal field stations.
- The mean distance between first-order repeat stations is about 60 km. The mean distance between second-order stations is about 10 km

Station markers: A pillar

Auxiliary stations: none

Logistics

Access: stations are accessible by road
Fieldwork:
Staff: 1 observer + 1 assistant

OBSERVATIONAL PROCEDURES

Absolute Instruments

D & I - fluxgate-theodolite (EDA DIM type 100)
F - proton precession magnetometer
Azimuths - gyroscopic theodolite

Variometers

None at repeat stations; the four permanent observatories and the two temporary observatories listed above were used during the 1977-1979 field work. The maximum distance from a reference observatory is about 250 km.

Frequency and Duration of Observations

- For each primary network station 10 sets of measurements are performed: five in the morning at about 7.30 - 9.30 am, and five in the afternoon at about 1.30 - 5.30 pm. Each measurement is carried out about 30 minutes after the preceding one.
- For new stations the azimuth marks are determined using the gyroscopic theodolite before the station is occupied.

DATA REDUCTION PROCEDURES (for 1979.0 and 1985.0)

- Magnetic elements observed at the repeat stations were reduced to epoch 1985.0 by reference to digital data from the L'Aquila Observatory (only photographic recording was available during previous surveys)
- The following expression was used for reduction of measurements at the Observatory:

$$\mathbf{E}\,(t,s) - \mathbf{E}\,(85.0,s) = \mathbf{E}\,(t,Obs) - \mathbf{E}\,(85.0, Obs)$$

where
E (t,s) = value of an element (**D**, **F**, **H** or **Z**) observed or computed at station s at time t
E (t,Obs) = value of the element measured at the Observatory at the same time t
E (85.0,s) = value of the element at station s reduced to epoch 1985.0
E (85.0, Obs) = mean value of the element at the Observatory for epoch 1985.0

- A similar expression was used for the previous survey for reduction of data to epoch 1979.0.

- The estimated errors in the elements after all reductions are:

for **F**, **H** & **Z**	:	± 8nT
for **D**	:	± 1'

- Annual secular change values for each element at station s were obtained from the expression

$$dE(s) = [E\,(85.0,s) - E\,(79.0, s)]/6$$

MODELS & CHARTS

All charts and models produced include annual change information

1935.0	first normal field model
1940.0	charts for **D**, **H**
1948.0	charts for **D**, **H**
1959.0	charts for **D**, **H**
1965.0	charts for **D**, **H**
1973.0	charts for **D**, **H**
1979.0	second-order polynomial model and charts for **F**, **H**, **Z**
1985.0	second-order polynomial model and charts for **F**, **D**, **H**, **Z**

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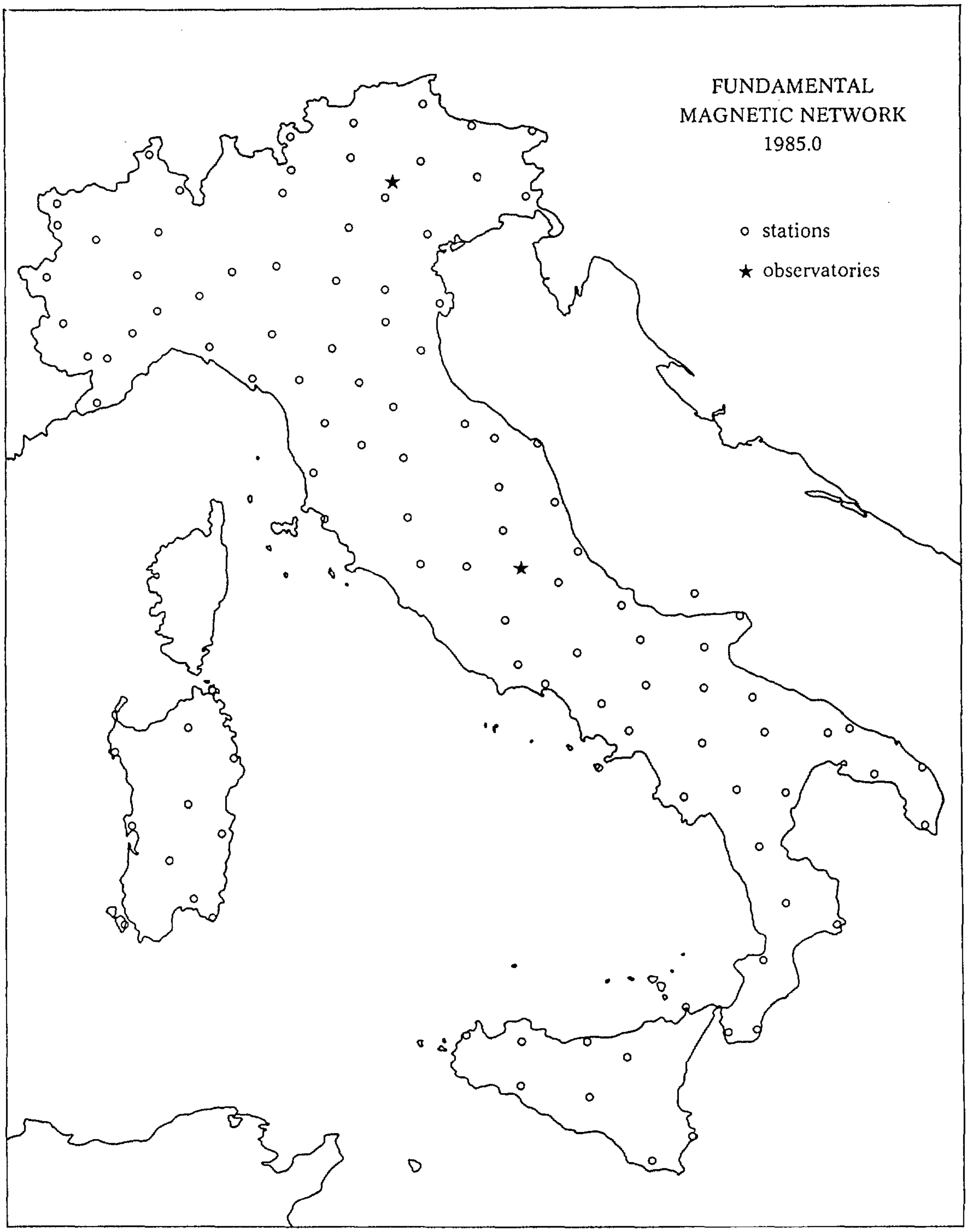
E. Armando, R. Balia, O. Battelli, E. Bozzo, N. De Florentiis, A. De Santis, V. Iliceto, R. Lanza, M. Loddo, A. Meloni, F. Molina, E. Pinna and R. Zambrano (1981), *Sui campi normali degli elementi del campo geomagnetico in Italia.* Cons. Naz. Ricerche, Progetto. Finalizzato Geodinamica, publ. No. 462.
A. Meloni, O. Battelli, G. Dominici, S. Arca & A. Marchetta (1988), *Italian Magnetic Network at 1985.0.* Bollettino di Geodesia e Scienze Affini, **57**, No.4, 339-350.
F. Molina, E. Armando, R. Balia, O. Battelli, E. Bozzo, G. Budetta, G. Caneva, M. Ciminale, N. De Florentiis, A. De Santis, G. Dominici, M. Donnaloia, A. Elena, V.

Iliceto, R. Lanza, M. Loddo, A. Meloni, F. Molina, E. Pinna, G. Santorato and R. Zambrano (1985), *Geomagnetic survey of Italy.* Repeat station network and magnetic maps: a short report, Annal. Geophys., **3**, No.3, 365-368.

R. Talamo (1975), *Le carte magnetiche d'Italia delle isodinamiche nella H e delle isogone, dell'Instituto geografico Militare, e loro aggiornamento al 1973.0.* Bollettino di Geodesia e Scienze Affini, vol.34, No.1.



Italian Magnetic Network at 1985.0.

Country **JAPAN** *Revised:* 18 December 1990

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NETWORK CONFIGURATION

Repeat stations	**Reoccupation interval**
105 first-order stations	2 to 4 years
850 second-order stations	

Observatories

Kakioka	36°13'45"N,	140°11'23"E	(1913 +)
Kanoya	31°25'14"N,	130°52'56"E	(1958 +)
Kanozan	35°15'11"N,	139°57'32"E	(1961 +)
Memambetsu	43°54'30"N,	144°11'35"E	(1952 +)
Mizusawa	39°06'32"N,	141°12'25"E	(1970 +)

Repeat station surveys were started by the Geographical Survey Institute (GSI) in 1949.
Station density: one first-order station every 3,600 km^2
First-order station occupations: 1983 - 37 , 1984 - 29 , 1985 - 31 , 1986 - 29

Station markers: a granite pillar of 15 cm square head and 70 cm length is laid upon the ground. It's head is about 10 cm above ground level. The precise position of the station is marked by a "O" at the centre of the pillar head.

Auxiliary stations: nil

Logistics

Access:	most stations are accessible by road
Fieldwork:	approximately 3 to 4 months per year
Staff:	1 skilled observer plus 1 assistant per party

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I	G S I type precise magnetometer (fluxgate theodolite, 0.1' precision)
F	Geometrics G856 proton precession magnetometer
Polaris obs.	G S I type precise magnetometer

Variometer

D,H,Z	triaxial fluxgate magnetometer (MB-162)
T	temperature of fluxgate sensors (coefficient 0.1 nT/°C)
Recording	**H** is recorded continuously on a chart recorder
	D, H and **Z** are digitized at minute intervals and recorded onto cassette tapes.

Frequency and Duration of Observations

Variometers are operated for 24 hours from 0^h to 24^h UT on a calm day of magnetic activity.

Absolute observations are performed simultaneously at four times (0^h, 4^h, 8^h and 24^h UT) to determine the baseline values of the variometers used.

At each of these four times 3 sets of observations of **F, D, I** are made.

If for any reason the variometer cannot be operated (e.g. topographical constraints) absolute observations of **D, I, F** are conducted at hourly interval from 21^h UT to 13^h UT the next day.

Polaris observations are made to check the azimuths of reference marks.

Comments

In addition to the above first-order stations, 850 second-order stations have been established. Data from these second-order stations are used for preparing magnetic charts.

DATA REDUCTION PROCEDURES

The variometer records are digitized at 1-minute intervals; these data are averaged at hourly and daily intervals.

The absolute observations are used to calibrate the digitized variometer data to produce mean daily absolute values of **D, H, Z** and **F.**

The station variations are compared with data from a reference station and adjusted to eliminate atypical disturbance effects in the field; the reference station is the Kakioka Geomagnetic Observatory.

Adjusted station values for **D, H, Z** and **F** near local midnight are considered to represent the long-term undisturbed field at the station for the epoch of occupation.

Station values are later updated to a common epoch using appropriate plots or models of the secular variation.

MODELS & CHARTS

Isomagnetic charts are prepared from geomagnetic survey and reference station data.

1952+	Charts of **D, I, H, Z & F** (hand-contoured
1985	Charts for 7 components by polynomial least squares

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Geographical Survey Institute: Results of the first order magnetic survey, Bull. G.S.I., vol XXV - part 1 (1981).

Tanaka, M., K. Hiroishi & S. Matsumura (1984), J. Geomag. Geoelectr., **36**, 463-470.

Geomagnetic observations at Mizusawa and Kanozan 1988, First order geomagnetic stations 1979-1988, G.S.I. publication B4 - No.8, March 1990.

Country **NEW ZEALAND** *Revised:* 30 May 1989

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NETWORK CONFIGURATION

Repeat stations	Reoccupation interval
18 on the North and South Islands	2 or 3 years
1 on Raoul Island	1 weekly observations
1 on Campbell Island	1 weekly observations
3 on Sub-Antarctic islands	5 years approx.
5 on Pacific Islands (some shared with Australia)	5 years approx.
3 in Antarctica	5 years approx.

Station Markers

Brass plaque set in a concrete slab.
Several remote stations are still marked by a wooden peg.

Auxiliary Stations: none

Logistics

Access: All 18 stations in the North and South Islands are on airports and are accessible by road. Four stations are on remote islands that cannot be visited on scheduled services. Six stations are on islands than can be reached by air
Field work: Approximately 2 weeks each year
Staff: 1 skilled observer.

At Raoul and Campbell Islands observations are made by staff of the Meteorological Service.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D, I - EDA magnetometer-theodolite consisting of a fluxgate coil mounted on a Zeiss 020A non-magnetic theodolite.
F - Proton precession magnetometer (PPM).

Weekly absolute observations made on Raoul and Campbell Islands are made with a QHM (**D** and **H**) and a proton precession magnetometer.

Variometers - none

Frequency and Duration of Observations

Two complete sets of absolute observations are made at each station. A set comprises **D**, **I** and **F** observations.

Comments

- The PPM is set up at a point 20m from the station marker and tie-in observations are made between this point and the station marker.
- The repeat station observing procedure is scheduled to be upgraded to first-order (IAGA Classification 1) within the next year by commencing continuous recording of three components for several days at each site.

DATA REDUCTION PROCEDURES

- For stations in the North and South Islands a correction for diurnal variation is made using the Eyrewell Observatory record. The difference between each observed component and the Eyrewell value is determined after making an allowance for the difference in longitude by adjusting the time at which the Eyrewell values are read. These differences are then averaged for the two sets of observations and added to Eyrewell values at a point in time. Values of X, Y, and Z are determined for both the repeat station and Eyrewell at this time, and the difference in these components at the two sites is determined. This is added to the annual mean values at Eyrewell based on the 6 months either side of the month of observation to give an "annual mean value" at the repeat station.

- Observations made on remote islands are not corrected for diurnal variation. The weekly observations made on Raoul and Campbell Islands are averaged to give annual mean values.

MODELS & CHARTS

- Coefficients for a regional model (consisting of quadratic expressions in latitude, longitude, and time for each of X, Y, and Z) are updated at least every 5 years. Data from Eyrewell, Apia, Canberra, Toolangi, and Macquarie Island magnetic observatories are used together with the repeat station data to determine the secular variation coefficients. Project Magnet aeromagnetic data are used to supplement these in the determination of the spatial coefficients.

- Maps based on the regional model or on a global model are computer-plotted on demand.

- The possibility of adopting a spherical cap harmonic model of the regional field is being investigated. This would involve the combination of vector data from the Magsat satellite and the Project Magnet aircraft, and possibly also scalar marine observations.

REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **SOUTH AFRICA** *Revised:* 19 June 1991

Contact Dr G. J. Kuhn
Magnetic Observatory
P.O. Box 32
Hermanus 7200

Tel: +27-283-21196
Fax: +27-283-22039

NETWORK CONFIGURATION

Repeat stations		**Reoccupation interval**
39	Republic of South Africa	5 years approx.
19	Namibia	5 years approx.
6	Botswana	5 years approx.
9	Zimbabwe	5 years approx.
1	Marion Island	2 years approx.
1	Gough Island	2 years approx.

Magnetic observatories

Hermanus	(1941 +)
Tsumeb	(1964 +)
Hartebeesthoek	(1972 +)
Sanae	(1960 +)

Station Markers - concrete beacon, 1.20 m high for observations
concrete beacon, 0.30 m high for PPM

Auxiliary Stations - none.
Unsatisfactory stations are replaced and magnetically tied into the network during the 5 years between surveys.

Logistics

Access:	All stations accessible by road; Marion & Gough Islands by ship.
Fieldwork:	Approx. 9 months every 5th year; Marion & Gough Islands approx. 5 weeks every year.
Staff:	1 skilled observer plus 1 assistant.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D - Askania fibre declinometer
H - Quartz Horizontal Magnetometer (QHM)
F - Elsec or Geometrics proton precession magnetometer (PPM)

Variometers - none

Frequency and Duration of Observations

- Absolute observations are normally made starting 2 hours before sunset and ending 4 hours after sunset.
- Sets of observations are made at 30-minute intervals.

Comments

- **D** and **H** are measured on the station pillar.
- **F** is measured on a nearby concrete pillar for which tie-in differences are determined.
- Night-time observations made under non-magnetic fluorescent lamp illumination.

DATA REDUCTION PROCEDURE

The field station data are reduced to a common epoch by interpolation/extrapolation between the preceeding survey (epoch T1) and the present survey (epoch T2). For a particular magnetic field component (**E**, say) the differential secular variation at the field station (FS), relative to that at the control observatory (CO), is given by

$$\Delta S(\mathbf{E}) = \frac{\mathbf{E}_{CO}(T2) - \mathbf{E}_{FS}(T2) - \mathbf{E}_{CO}(T1) - \mathbf{E}_{FS}(T1)}{(T2 - T1)}$$

where $\mathbf{E}_{CO}(T2)$ denotes the value of **E** at the control observatory at epoch T2, etc. The mean secular variation at the station is therefore given by:

$$S(\mathbf{E}) = \text{annual change at control observatory} - \Delta S(\mathbf{E})$$

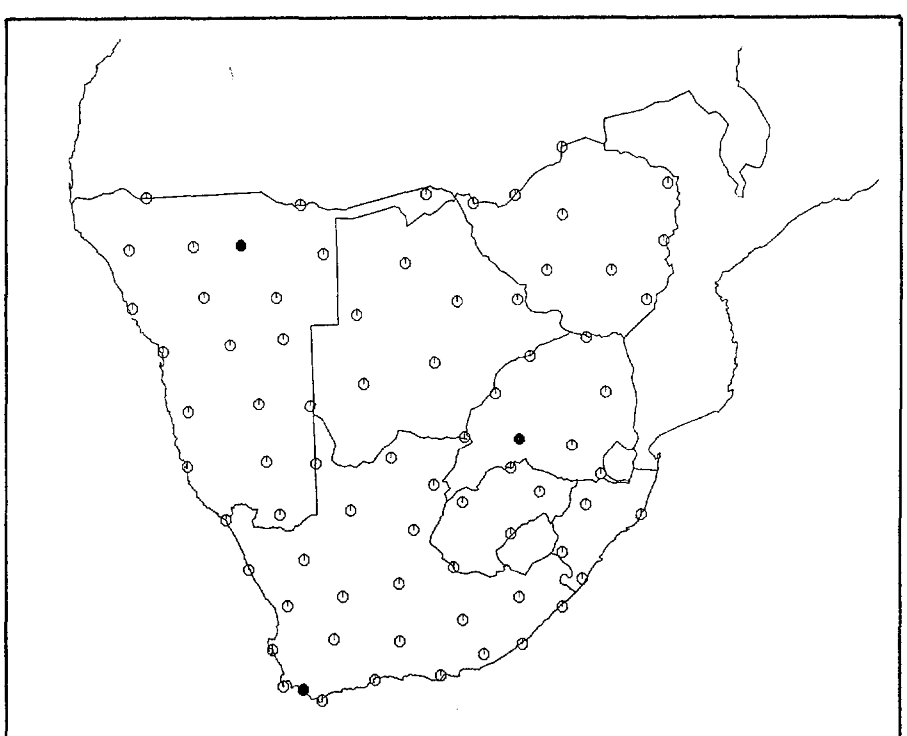
The value of the field component (**E**) at the field station for the epoch of interest, T3 (e.g. 1985.0) is then calculated from

$$\mathbf{E}_{FS}(T3) = \mathbf{E}_{CO}(T3) - \mathbf{E}_{CO}(T2) - \mathbf{E}_{FS}(T2) - \Delta S(\mathbf{E}) * (T3 - T2)$$

where $\mathbf{E}_{CO}(T3)$ is the annual mean value of the component, centred on epoch T3, at the control magnetic observatory.

MODELS & CHARTS

First survey done in 1938/39
1948.0 - Hand-contoured charts of **D** and **I**
1953.0 - Hand-contoured charts of **D**, **H**, **I** and **Z**
1961.0 - Hand-contoured charts of **D**, **H**, **I**, **Z** and **F**
1965.0 - Polynomial model of **D**; hand-contoured charts of **D**, **H** and **Z**
1971.0 - Polynomial models and hand-contoured charts of **D**, **H**, **Z** and **F**
1975.0 - Polynomial models and computer-drawn charts of **D**, **H**, **Z** and **F**
1980.0 - Polynomial models and computer-drawn charts of **D**, **H**, **Z** and **F**
1985.0 - Polynomial models and computer-drawn charts of **D**, **H**, **Z** and **F**
1987.0 - Polynomial model and chart of **D**
1990.0 - Polynomial models and computer-drawn charts of **D**, **H**, **I**, **Z** and **F**



Country **SWEDEN** *Revised:* 14 January 1989

Contact Kjell Borg
Geological Survey of Sweden
Geomagnetism Division
Box 670
S-751 28 UPPSALA

Int. tel: + 46-18-179000
Telex: 76154 geoswed s
Cable: Geosurvey

NETWORK CONFIGURATION

Stations	Reoccupation interval
10 repeat stations	2 or 3 years

Station Markers A brass bolt set in bedrock

Auxiliary Stations The 10 stations are selected from a set of 90 originally measured and marked in 1929. If any of the 10 stations are destroyed then the nearest one in the denser network will be used.

Logistics
Access: All stations are accessible by car or boat
Fieldwork: About 1 month to visit the 10 stations
Staff: 1 skilled observers + 1 assistant

Notes
There are 6 reliable magnetic observatories in Scandinavia (Abisko, Sodankyla and Lovo in Sweden; Dombas in Norway; Nurmijarvi in Finland; and Rude Skov in Denmark. These are well distributed over the area and are sufficient for most secular variation purposes. All four countries have networks of repeat stations. The Swedish network, originally with 88 stations, was established in 1928-1930. The whole network was remeasured in 1936, 1942, 1949 and 1955. Thereafter a selection of 10 stations has been measured at irregular intervals - every 2nd or 3rd year in later years.

OBSERVATIONAL PROCEDURES

Absolute Instruments
D - Askania fibre declinometer
H - two Quartz Horizontal Magnetometers (QHM)
F - Proton precession magnetometer

Variometers - None

Frequency and Duration of Observations
D,**H** & **F** are measured each minute during at least 4 hours - often spread over 2 days.

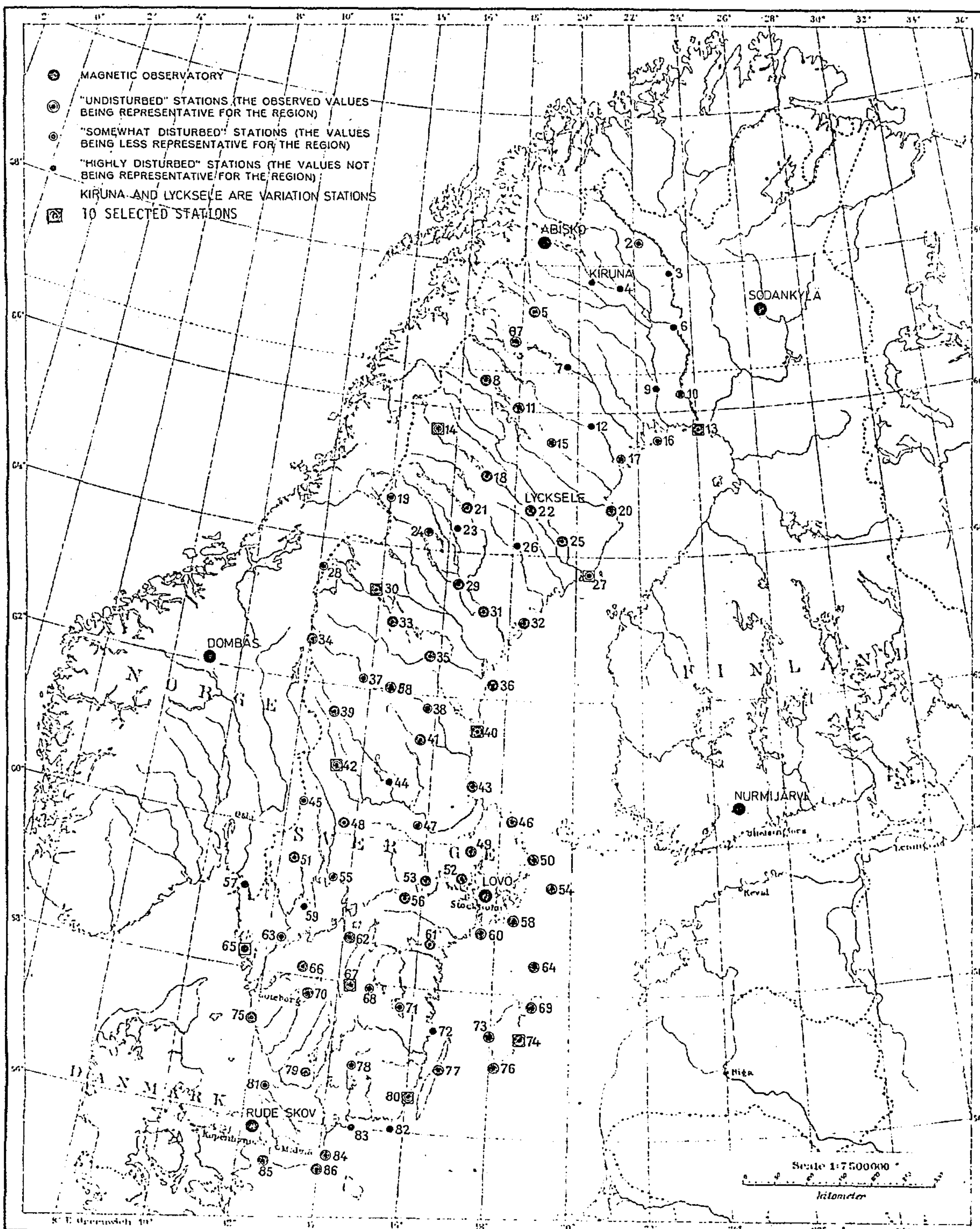
Comments
D is measured at the station; QHM and PPM measurements are made at points 20 to 30 m away. Tie-in differences are determined.

DATA REDUCTION PROCEDURES

The one-minute values are aveaged to give hourly means for each component. H and F are corrected to the station. Reduction to a mean-of-the-year value is carried out using corresponding hourly means from the 2 or 3 nearest magnetic observatories.

Repeat station data are used to help update the aeromagnetic and ground survey sets used to produce component maps.

THE STATIONS 1929.5



REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **U.S.A.** *Revised:* 26 November 1990

Contact Jill Caldwell
U.S. Geological Survey
Global Seismology & Geomagnetism
Denver Federal Center, Box 25046, MS 968
Denver, CO 80225

Intl. tel: +1-303-236 1369
Intl. fax: +1-303-236 1519

NETWORK CONFIGURATION

Stations	**Reoccupation interval**
About 250 stations located in the conterminous states, Alaska, and the Pacific Islands	
About 110 stations in current use	5 years

Magnetic observatories

	Analog	*Digital*
Barrow	Oct 1949 -	July 1984 +
Boulder	Jan 1961 -	July 1981 +
College	Jul 1941+	July 1984 +
Del Rio		Aug 1982 +
Fredericksburg	Apr 1901+	Nov 1982 +
Fresno		July 1982 +
Guam	Jan 1957+	Dec 1982 +
Honolulu	Jan 1902+	Dec 1982 +
Norda		Apr 1986 +
Newport	Apr 1966 -	Oct 1982 +
San Juan	Jan 1926 +	Jan 1983 +
Sitka	Mar 1902 -	Dec 1983 +
Tucson	Nov 1909 +	Oct 1982 +

Station markers: usually a bronze of aluminium survey marker set in concrete at ground level

Auxiliary stations: installed at about half of the repeat stations

Logistics

Access: all conterminous U.S. and many Alaska stations are accessible by road; some Alaska stations and Pacific Island stations require air travel.
Fieldwork: variable.
Staff: 1 skilled observer in the field; 1 employee in the office.

OBSERVATIONAL PROCEDURES

Absolute Instruments

D & I - Fluxgate-theodolite (EDA DIM 100 magnetometer)
F - proton precession magnetometer (Geometrics G816)
Azimuths - theodolite

Variometers

D, H, Z - triaxial fluxgate magnetometer (EDA FM-100)
Recording - single channel Rustrak analog recorder for each element (20 mm per hour, approximately 5 nT/mm scale value)

Frequency and Duration of Observations

- At each station the fluxgate magnetometer is buried, or otherwise installed, to stabilize temperature variations. The system is allowed to operate for about 8 hours to achieve temperature stabilization before data are used.
- Absolute observations are made during quiet magnetic times - usually early morning and late afternoon.
- A set of absolute observations comprises measurements of D,I,F
- Routine station procedures require a minimum of 48 hours of recording with at least 2 quiet midnight periods.

DATA REDUCTION PROCEDURES

- The absolute observations are used to establish baseline values for the variometer.
- Midnight values (for the period 2 hours before and 2 hours after local midnight) are scaled from the variometer record and computed.
- Stations values are the means of these "midnight" values for the dates of occupation of the stations. Users are given this information and must determine how to use it in epoch date reductions, etc.

MODELS & CHARTS

Charts of D are produced every 5 years
Charts of D, Z, I, F are produced every 10 years

The repeat station survey data are used with observatory data, satellite, air- and ship-borne data to compile a master data base that is used for all USGS magnetic mapping and research activities.

PUBLICATIONS

The repeat station data and station descriptions are deposited in World Data Center-A in Boulder, Colorado, for general dissemination.

REGIONAL MAGNETIC REPEAT STATION NETWORK DESCRIPTION

Country **U.S.S.R.** *Revised:* 12 December 1989

Contact Yu. A. Burtsev
Geomagnetic Variations Laboratory
IZMIRAN
Troitsk
Moscow Region 142092

NETWORK CONFIGURATION

Stations	**Reoccupation interval**
about 100 south of latitude 64°N	5 years
about 30 north of latitude 64°N	5 years

Station markers:
All the"stations of geomagnetic field secular dependence" (SSD) are marked by either a pillar, or by stones, or by several inscriptions

Auxiliary stations: None

Logistics

Access:	most stations are accessible by road; the remainder by aircraft
Fieldwork:	approximately 3 to 4 months each year
Staff:	1 skilled observer plus 1 assistant

OBSERVATIONAL PROCEDURES

Absolute Instruments

D & I - Fluxgate-theodolite
H - QHM
F - proton precession magnetometer (total field)
Sun observations - theodolite

Variometer

Used for stations north of latitude 64°N

Frequency and Duration of Observations

- Usually four groups of absolute measurements are taken during the observation period at each repeat station.
- Each group consists of one series of observations of **D, H & F** before 7 a.m. and a second series after 5 p.m.
- Astronomic observations include mire azimuth determination according to the solar hour angle. If necessary the latitude of the station is determined according to the solar zenith distance.

Comments

- For the Arctic stations, north of latitude 64°N, the magnetic elements are recorded continuously for 5 days in addition to the usual absolute measurements. At least three of the 5 days must be classified as magnetically undisturbed.

DATA REDUCTION PROCEDURES

Corrections are applied to reduce the observations to the middle-of-the-year epoch. The corrections are obtained by comparisons between the repeat station observations and the corresponding ordinates of magnetic elements on magnetograms at adjacent magnetic observatories.

MODELS & CHARTS

1945	second order polynomial model and chart for **D, H, Z**
1950	second order polynomial model and chart for **D, H, Z**
1955	second order polynomial model and chart for **D, H, Z**
1960	second order polynomial model and chart for **D, H, Z**
1965	second order polynomial model and chart for **D, H, Z**
1970	second order polynomial model and chart for **D, H, Z**
1975	second order polynomial model and chart for **D, H, Z**

Country **WEST AFRICA** (France) *Revised:* 17 July 1989

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ORSTOM B.P. 50
M'bour
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NETWORK CONFIGURATION

Stations	Reoccupation interval
33 in Burkina-Faso	every 5-6 years (1986+)
6 in Guinea	every 5-6 years (1986+)
6 in Ivory Coast	every 5-6 years (1986+)
14 in Mali	every 5-6 years (1986+)
7 in Niger	every 5-6 years (1986+)
8 in Senegal	every 5-6 years (1986+)
6 in Togo	every 5-6 years (1986+)
Total = 50	

Magnetic observatories

M'bour	(1952 +)
Bangui	(1954 +)

Station Markers

- 25 stations have concrete pillars, non-magnetic, 135 cm high (BM ORS 1986)
- 18 stations are marked by non-magnetic landmarks (levelling mark, landmark in airport...)
- 7 stations are non-marked

Auxiliary Stations - none

Logistics

Access:	Motor vehicle (4x4)
Fieldwork:	between October and May
Staff:	1 skilled observer + 1 assistant

OBSERVATIONAL PROCEDURES

Absolute Measurements

D, I	- fluxgate theodolite, three components
F	- proton precession magnetometers (ORSTOM)
Azimuth	- Chasselon theodolite (sun), or gyroscopic theodolite

Instrument comparisons/calibrations are carried out at the reference magnetic observatory at M'bour.

Variometer Measurements

H, D, Z	- Askania photographic recorder (1986) For 1990: digital data acquisition MOSNIE
Time	- Radio receiver to calibrate the internal clock

Frequency and Duration of Observations

- At least 2 sets of absolutes are made daily, one early in the morning and one late in the evening to reduce the strong effect of the diurnal change (electrojet proximity).
- Observations are spread over no less than 1 day and 2 nights.

DATA REDUCTION PROCEDURES

The stability/reliability of the variometer records are assessed from the consistency of the baseline values calculated from the absolute observations, and also by comparison with records from the nearest reference magnetic observatory.

Reduction to night level using local variometer station

Baseline values are calculated from the absolute observations. A reduction is made from the field records to get quiet night time values. The averaged values for each element of the field give the station values at time t, namely **E(S,t)**. The field at the reference observatory at time t is E(O,t)

Reduction to a common epoch

Because the geographical spread of the stations is very large, there are big differences in secular variation between stations (for example Z varies from 0 to 130 nT/yr). Thus we use the secular varilation given by IGRF to reduce data to a common epoch.

The value of the field element at the station reduced to common epoch t_0 is:

$$E(S,t_0) = E(O,t_0) + E(S,t) - E(O,t) + (t_0-t)*VS(O)$$

where

VS(S) = IGRF secular variation at the field station
VS(O) = IGRF secular variation at the reference observatory
t_0 = the common mid-year epoch, 19xx.5

This method gives better results than the classical reduction method.

Errors

Typical uncertainties in the reduced values at the repeat stations are:

D	2 minutes
H,Z ,F	5 nT

APPENDIX

Explanatory notes for regional magnetic repeat station records and computer files

IAGA Working Group V-4

REGIONAL MAGNETIC REPEAT STATION RECORD

(Revised: 11 March 1991)

For information on how to complete record sheets refer to the document "Regional Magnetic Repeat Station Records - Explanatory Notes" issued by IAGA Working Group V-4. If the information requested below is inappropriate please modify the form to suit your situation. Return record sheets to: *Geomagnetism Services, WDC-A Solid Earth Geophysics, 325 Broadway, Boulder, CO 80303-3328, U.S.A.* Fax: +1-303-4976513

STATION NAME : **COUNTRY :**

Latitude :		Is this a new station:	No / Yes *
Longitude :		Is this an exact reoccupation:	Yes / No *
Height above mean sea level (m) :		Year of previous occupation:	

RESULTS **CLASSIFICATION**

Mid-date of station occupation: ....

Duration of station occupation: .... days / hours *

....
(see Explanatory Notes)

	Uncertainty in instrument relocation (m)	Gradient of total field at station (nT/m)
Horizontal	:	:
Vertical	:	:

Field element	(a) Mean night-time value and estimated uncertainty		(b) *Undisturbed* night-time/ annual mean value* and estimated uncertainty @ epoch† = ...	
1. :		±	:	±
2. :		±	:	±
3. :		±	:	±

Estimated annual change for element	@ previous epoch = ...	@ new epoch = ...
1.	:	:
2.	:	:
3.	:	:

MAGNETIC DISTURBANCE

	Observatory name	Distance from repeat station	Disturbance indicator (state what)
1.	:	km	: ....
2.	:	km	: ....

Notes (continue on reverse side if necessary)

* circle one † if annual is mean quoted then give mid-year epoch

IAGA Working Group V-4

REGIONAL MAGNETIC REPEAT STATION RECORDS - EXPLANATORY NOTES

(Revised: 11 March 1991)

These notes provide information about how to complete the "Regional Magnetic Repeat Station Record" sheets issued by IAGA Working Group V-4. In many cases it may not be possible to fill in all the information specified - please complete as much as possible on *every* record sheet, including details (such as country) that will be repeated for a set of sheets. If possible a table of results should be provided in the form of an ASCII computer file as specified below.

STATION NAME

Do not use the same name for different station markers at the same locality. For example use names such as Station-A, Station-B etc. to denote different sub-stations, and ensure that names agrees exactly with those given on previous record sheets and data files.

Station coordinates should be given in geodetic coordinates, i.e. on a spheroidal Earth. The distinction between coordinates on different spheroids is unimportant. The distinction between geodetic coordinates and geocentric coordinates (on a spherical Earth) is important. Coordinates should be in decimal degrees (preferred), or in degrees and decimal minutes; latitude positive north, negative south; longitude positive east of the Greenwich meridian.

If the height above mean sea level is not known accurately please enter an approximate value (to the nearest few hundred metres), and indicate that it is approximate.

RESULTS *(Enter "N/A", if a particular result is not available, or is not applicable)*

- Mid-date of station occupation is the date about which the observations are centred, given either in decimal years or as year,month,day (yyyy mm dd) - e.g. 1989 06 23 for 23rd June 1989.
- Duration of station occupation is the time interval spanned by the run of absolute/variometer observations - rounded to the nearest day or hour as appropriate.
- *Information about the uncertainty in station relocation is very important.* Errors in relocating the absolute instruments between successive occupations may vary from less than 1 cm up to many metres.
- Record the average horizontal gradient of the total field (e.g. mean of N-S and E-W values) and the vertical gradient of the total field at the point where the absolute instruments are placed at the repeat station. These values serve as a useful test of whether any magnetic contamination has been introduced since the previous station occupation, and are also used to estimate the error associated with non-exact relocation of the absolute instruments.

- Field elements

  (a) List the three field elements observed and enter your best estimate of the 'night-time' values of the field. If four elements are observed then enter the three most accurate ones. 'Night-time' refers to the time when diurnal effects are at a minimum, although the field could still be disturbed. Enter approximate errors for the results, e.g. the standard deviation of a set of night-time field determinations (it may only be possible to make a guess, taking into consideration the accuracy of the instrumental and data reduction corrections applied).

  Conventions are: **+X** northwards, **+Y** eastwards, **+Z** downwards, **+D** east of north, **+I** downwards.
  Enter angles (**D** & **I**) in decimal degrees, to three decimal places if possible, and field strengths in nanotesla.

  (b) Enter values for the three field elements after a correction has been made to get an estimate of the completely undisturbed night-time value of the field. This correction is important unless it is known that observations were made during extremely quiet conditions. If data are reduced to get an equivalent annual mean value for the repeat station, using neighbouring observatory records for reference, then give the appropriate epoch in decimal years. Enter estimates (guesses if necessary) of the errors in determining the undisturbed field/annual mean values.

- Annual change estimates. *(It is not essential to complete this section)*
  Enter the values previously determined for the annual change in each field element at the last 5-year epoch, e.g. 1985.0, and your new estimates for the next 5-year epoch, e.g. 1990.0. Record the epochs concerned. Estimates might be based on simple differences between corrected observations at successive station occupations, or on the gradient of an appropriate curve fitted to a time-series of observations at the repeat station.

CLASSIFICATION *(Please pay special attention to this question)*

Assign a classification letter and number (range 1 to 3) to the results for each station. If an intermediate classification best describes your results, then assign an appropriate decimal value.

Classification 1 - applies to results when considerable care has been taken to correct fully for external fields and associated induction effects to get an *undisturbed* night-time value of the field. In most cases this requires that on-site continuous variometer, or nearby magnetic observatory records are available. Unless observations were made under very quiet magnetic conditions, a correction for the long-term after-effects of storms and other transients may also be necessary.

Classification 2 - applies to results when an approximate correction has been made for the effects of external fields. For example, if absolute observations have been made throughout the day then an approximate diurnal correction can be made. 'Night-time' observations made under magnetically quiet conditions would qualify for a "2" classification, or possibly "1" if the observer has reason to believe that the completely undisturbed field was measured.

Classification 3 - is appropriate for spot measurements of the vector field made during relatively low levels of magnetic disturbance. (Spot observations made under disturbed conditions are not suitable for deriving secular variation information).

The classification number should be prefixed by one of the following classification letters to denote the type of diurnal control applied:

V - an on-site variometer was used, and calibrated using the absolute observations
M - one or more magnetic observatories were used as a reference standard
A - absolute observations at the repeat station alone were used

Examples of classifications

V 1	Day-time absolutes used to provide baselines to calibrate an on-site variometer; observations made on magnetically quiet days only.
V 1.3	As above, except that observations are made under moderately disturbed conditions and only an approximate correction, based on observatory records, is possible to obtain the undisturbed night-time value of the field.
M 1.1	Morning and evening absolutes corrected by means of a neighbouring reference observatory to obtain equivalent annual mean values. Depending on how accurately the reference observatory represents the diurnal variation at the repeat station, the classification number could be anywhere between 1 and 2.
A 1.2	Sets of absolute measurements made in the middle of the night on a magnetically quiet day.
A 2	A good spread of day-time absolute observations including early morning and late evening (the nearest reference observatory being too far away to provide any improvement in diurnal control).
A 3	Spot measurement of the field made early in the morning on a fairly quiet day.

Note the important distinction between the 'night-time' value, i.e. the field in the middle of the night when the diurnal variation and disturbances are at a minimum, and the *undisturbed* night-time value which represents only the main core field (including crustal remanence and main field-induced contributions) with no external field contributions. It may be necessary to undertake a special study to establish how accurately records at the nearest observatory represent the diurnal signal at a repeat station, particularly if either site is suspected of being under the influence of crustal or coastal induction effects.

MAGNETIC DISTURBANCE

Give information from the one or two nearest magnetic observatories (or recording stations, possibly the magnetic repeat station itself) to show the typical level of magnetic disturbance for the period during which results were obtained. Daily range values are convenient, but any commonly used index/indicator of geomagnetic disturbance is acceptable.

COMPUTER FILE FORMAT

If possible, please provide a computer file summarizing the results of your repeat station surveys. This should be done in addition to completing a regional magnetic repeat station record sheet for each reoccupation of each station. The file can be either a **Survey file** of the results from a particular survey, and/or a **Master file** containing a compilation of results from several reoccupations of the same stations. It will be assumed that any new revision of a master file replaces earlier versions, unless stated otherwise in the header line(s) of the file.

Files should be written in ASCII and recorded on any commonly used medium (preferably IBM diskette). Files should have the following format:

```
HEADER
*STATION   LATITUDE   LONGITUDE   ELEVATION   ESTABLISHED
CLASS   DATE/YEAR   ELT1  ELT2  ELT3    EPOCH  dELT1  dELT2  dELT3
CLASS   DATE/YEAR   ELT1  ELT2  ELT3    EPOCH  dELT1  dELT2  dELT3
        etc....
*STATION   LATITUDE   LONGITUDE   ELEVATION   ESTABLISHED
CLASS   DATE/YEAR   ELT1  ELT2  ELT3    EPOCH  dELT1  dELT2  dELT3
        etc....
```

where

HEADER = descriptive header *including the revision date*, occupying as many lines as you wish
*STATION = name of the repeat station, preceded by an asterisk, spaces are not allowed
LATITUDE = latitude of station in decimal degrees; positive north, negative south
LONGITUDE = longitude of station in decimal degrees; positive east of Greenwich
ELEVATION = height of station above mean sea level in metres
ESTABLISHED = year when station was first used (optional)
CLASS = a 10-character classification code of the form R EEE Lm.n (include the spaces)
put R = D if data are reduced to undisturbed values for a particular day
= Y if data are reduced to an effective annual mean value
put EEE = any three of **X,Y,Z,H,F,D,I** to designate the three elements reported
put L = V if on-site variometer control was used
= M if comparison with magnetic observatory records was used to obtain *undisturbed* night-time or annual means values
= A if absolute observations alone were used
= ? if the type of diurnal control is not identified
put m.n = the classification number for the results, e.g. 1.0, 1.5, 2.0, etc...
DATE/YEAR = yyyymmdd for data reduced to a particular day (code D above), e.g. 19890717 for 17 July 1989
Enter a pair of 9's if the day or month are unknown
= yyyy.y for data reduced to an annual mean (code Y above), e.g. 1989.5
ELT1,.....3 = values of the three field elements, reduced to *undisturbed* night-time or annual mean values. Angles in decimal degrees; field strengths in nT
EPOCH = the epoch (i.e. decimal year) for the annual change estimates
dELT1,....3 = best estimates of the annual change in each element at the epoch specified. Angles in decimal degrees per year; field strengths in nT per year.

Notes

- Upper or lower case lettering is acceptable.
- There is no restriction on the number of characters per line, or the number of characters per data-field, but each field should be the same size throughout the file.
- Station names must be unique and match *exactly* those on corresponding record sheets and data files.
- Data-fields should be separated by one or more spaces, or a comma, or a tab character.
- Enter a string of 9's in the appropriate data-field to denote missing values.
- Angles (latitude, longitude, **D, I**) should be in decimal degrees.
- As a general rule the three elements measured should be entered in the file. However, any three elements defining the field vector may be specified, e.g. **D,H,Z** or **X,Y,Z.** If a combination such as **D,H,F** is used, which does not specify the sign of **Z**, then **F** should be give the sign of **Z.**
- Comments relating to a result can be appended to the end of the line.
- For master files it will be assumed that the annual change estimates are the original (usually prospective) ones made at the time of each survey. If the annual change values in a master file have been recalculated retrospectively, then add a note of explanation to the file header, and/or onto the end of the appropriate lines of results.

Examples

A **Survey file** would look like this:

```
BMR Australia, Repeat station survey 1986-1989      Rev: 17 December 1990
This file contains data from continental Australia, surrounding islands,
Papua New Guinea and SW Pacific Islands.  No Antarctic data
--------------------------------------------------------------------------
*Albany_C          -34.945   117.805    075   1965
D DHZ V1.1  19870413  -3.083    21433  -56195    1990.0  0.042   -13.4   -1.9
*AliceSprings_B    -23.807   133.897    500   1942           (approx.elevation)
D DHZ V1.1  19891206   5.070    29941  -44697    1990.0  0.027   - 3.0    0.1
*AyersRock_A       -25.348   131.062    560   1947
D DHZ V1.1  19891225   4.322    28877  -46751    1990.0  0.026   -09.7    0.6
....etc.....
```

Variometer control was used to make a diurnal correction, and a subsequent adjustment for night-time disturbance was applied. However, observations were not made strictly under magnetically quiet conditions - hence a classification of V1.1 has been used instead of V1.0. Absolute observations of **D,I,F** were made, but the results have been expressed as **D,H,Z** throughout to be consistent with earlier results. A comment about the approximate elevation for Alice Springs has been added to the station line.

A **Master file** would look like this:

```
BMR Australia, Repeat station masterfile 1969-1989   Rev: 25 December 1990
This file contains data from continental Australia, surrounding islands,
Papua New Guinea and SW Pacific Islands.  No Antarctic data.
Annual changes are the original forward estimates, not recalculated.
--------------------------------------------------------------------------
*Albany_C         -34.945   117.805   075   1965
D DHF A2.0  19780627  -3.015  21722  -60184   1980.0 -0.016 9999.9    3.6
D DHZ V1.1  19831002  -3.099  21548  -56231   1985.0  0.022  -15.6 -11.5
D DHZ V1.1  19870413  -3.083  21433  -56195   1990.0  0.042  -13.4   -1.9
*AliceSprings_B  -23.807   133.897   590   1942
D DHZ V1.5  19690803   4.720  30463  -44232   1970.0  0.008  -21.6   -5.3
....etc.....
```

As an illustration, the Albany 1978 results are specified for **D,H,F** so the sign of **Z** has been transferred to **F**. The annual change in **H** at 1980.0 is missing.

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WDC-A keeps descriptions of the regional magnetic repeat station networks for each contributing country. Please check whether the description of your network is up-to-date. If not send a revised version to WDC-A and a copy to IAGA Working Group V-4. Requests for repeat station information should be addressed to WDC-A.

This scheme for reporting and classifying results from regional magnetic repeat stations is organized by IAGA Working Group V-4, Magnetic Surveys and Charts. Enquiries and comments should be addressed to the Chairman, currently:
C.E.Barton, BMR Geology & Geophysics, PO Box 378, Canberra ACT 2601, Australia.
Tel: +61-6-2499111; Fax: +61-6-2576041).