METEOROLOGICAL SERVICE

THE SECULAR VARIATION OF MAGNETIC DECLINATION IN IRELAND
(1980)

By

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Summary

Since the previous publication [2] measurements of the magnetic Declination have been continued at a network of "repeat stations" throughout Ireland. The deduced annual mean values for those stations during the past decade together with the corresponding annual mean values at the three observatories at Valentia, Hartland and Eskdalemuir are analysed to obtain a revised equation for the secular variation of Westerly Declination over the country.

Using this equation the survey map for 1970.0 [2] has been up-dated to epoch 1980.0. From this up-dated map and the equation for the annual change in Declination (or the 1980 Isopors) the value of Declination for any place in Ireland may be conveniently extrapolated for any subsequent time. The extrapolation should be reasonably accurate until about 1985.0 when, hopefully, more measurements will be available to again revise and up-date the map and equation of change.

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1. Introduction

A comprehensive magnetic survey of Ireland was completed during 1964-1965 [1] as Irelands contribution to the World Magnetic Survey and involved a programme of observations at 57 stations. Since then the Meteorological Service has made magnetic survey observations at a number of "repeat" stations to provide data on the secular variation of the magnetic elements (Declination, Horizontal Force and Vertical Force) and enable the comprehensive maps to be up-dated at frequent intervals.

In 1969 McWilliams [2] analysed the available data for magnetic Declination and prepared a survey map for epoch 1970.0. All measurements made since then have now been analysed to up-date this map for epoch 1980.0.

Throughout the area covered by the survey the Declination is West so where "Declination" alone is used for convenience it should be interpreted as Westerly Declination.

2. Procedure

The instruments used, the calibration and measurement procedure were identical to those used in the comprehensive survey [1]. The control centre to which all the survey observations were referred and at which continuous records were available to provide instantaneous deviations from the mean values at each particular time of observation was Valentia Observatory.

Table 1 shows the Latitude and Longitude of the repeat stations together with Valentia Observatory, the control centre, and the Observatories at Hartland and Eskdalemuir which were also used in this analysis.

Table 1

Annual Mean Values of Magnetic Declination (Degrees and Minutes - West)

Station	Latitude (N)	Longitude (W)	1970.5	1971.5	1972.5	1973.5	1974.5	1975.5	1976.5	1977.5	1978.5	1979.5
Malin Head	55°22'	07°20'		11 38.5		11 27.8			11 07.3			10 28.2
Glencolumbkille	54°42'	08°45'	12 23.2	12 17.9		12 07.4			11 35.3			
Belmullet	54°14'	10°00'		12 56.8					12 15.9			11 41.2
Clones	54°11'	07°14'	11 41.4			11 24.3			11 01.2			
Claremorris	53°43'	09°00'	12 14.8			11 58.9						10 58.7
Leenane	53°37'	09°41'	12 21.4	12 15.3		11 58.9			11 31.1			
Mullingar	53°31'	07°21'	11 28.9	11 24.1		11 11.6			10 51.4			
Baldonnel	53°18'	06°26'	10 52.1			10 35.1		10 15.8				9 38.3
Birr	53°05'	07°54'	11 31.0	11 26.3		11 11.4					10 26.9	
Shannon Airport	52°42'	08°56'	12 00.2	11 51.4		11 38.7		11 21.4				
Kilkenny	52°40'	07°16'	11 03.9	10 59.0				10 31.8			9 56.7	
Charleville	52°21'	08°40'	11 37.2	11 31.6		11 19.9		11 01.6				
Rosslare	52°15'	06°20'	10 16.4			9 58.0		9 40.2			9 09.4	
Roches Point	51°48'	08°15'	11 18.3	11 11.4				10 41.8				9 58.7
Bantry	51°40'	09°29'	11 50.8			11 34.5						10 42.8
Valentia	51°56'	10°15'	12 20.6	12 14.8	12 08.2	12 00.7	11 52.0	11 43.0	11 33.0	11 22.7	11 11.9	11 01.0
Hartland	51°00'	04°29'	9 06.5	9 01.1	8 55.3	8 48.2	8 40.4	8 32.3	8 23.1	8 13.7	8 03.6	7 53.5
Eskdalemuir	55°19'	03°12'	9 41.6	9 36.8	9 31.5	9 25.2	9 17.4	9 09.8	9 01.1	8 51.2	8 40.5	8 30.5

3. Reduction of the Observations

The values of the Declination as measured at the survey stations were adjusted by means of the instrument calibration data, to conform to the Valentia standard.

Following the procedure discussed in [2] it was assumed that the diurnal variation was a simple function of local time, and that the annual variation at the survey station was the same as at Valentia. For each individual time of observation at the survey station the value of the instantaneous deviation of Declination (D) from the base line was computed from the Valentia magnetograms for the corresponding local time. Combining this instantaneous deviation with the base line value gave the Valentia Declination (Dv) for the same local time as the survey value (Ds). The annual mean value of Declination at Valentia (Vm) was computed from the hourly mean values tabulated from the magnetograms. The value of the corresponding annual mean at the survey station was obtained from the relation:

$$\text{Annual Mean of D at Survey Station} = V_m + D_s - D_v$$

The annual mean values of D at the repeat stations as reduced by the method indicated above, are given in Table 1. Corresponding values for Valentia, Hartland and Eskdalemuir are also included.

Table 2 Annual Means and Annual Decrease of Westerly Declination at Valentia

Year	Annual Mean	Annual Change	Year	Annual Mean	Annual Change	Year	Annual Mean	Annual Change
	° '	'		° '	'		° '	'
1899	21 35.0		1926	18 10.8	11.6	1953	14 03.6	6.7
1900	21 30.0	5.0	1927	17 59.5	11.3	1954	13 55.9	7.7
1901	21 27.7	2.3	1928	17 48.0	11.5	1955	13 48.5	7.4
1902	21 24.2	3.5	1929	17 37.3	10.7	1956	13 41.6	6.9
1903	21 18.7	5.5	1930	17 27.6	9.7	1957	13 35.1	6.5
1904	21 15.2	3.5	1931	17 16.8	10.8	1958	13 29.0	6.1
1905	21 10.4	4.8	1932	17 05.4	11.4	1959	13 22.9	6.1
1906	21 06.3	4.1	1933	16 54.5	10.9	1960	13 16.4	6.5
1907	21 01.4	4.9	1934	16 43.7	10.8	1961	13 10.3	6.1
1908	20 55.7	5.7	1935	16 32.7	11.0	1962	13 04.1	6.2
1909	20 50.3	5.4	1936	16 21.6	11.1	1963	12 57.6	6.5
1910	20 44.6	5.7	1937	16 11.7	9.9	1964	12 51.6	6.0
1911	20 38.1	6.5	1938	16 02.4	9.3	1965	12 46.1	5.5
1912	20 29.3	8.8	1939	15 54.1	8.3	1966	12 40.8	5.3
1913	20 19.6	9.7	1940	15 45.3	8.8	1967	12 35.7	5.1
1914	20 12.3	7.3	1941	15 36.8	8.5	1968	12 30.7	5.0
1915	20 03.8	8.5	1942	15 28.0	8.8	1969	12 25.8	4.9
1916	19 53.1	10.7	1943	15 19.8	8.2	1970	12 20.6	5.2
1917	19 43.0	10.1	1944	15 11.6	8.2	1971	12 14.8	5.8
1918	19 36.2	6.8	1945	15 03.6	8.0	1972	12 08.2	6.6
1919	19 27.2	9.0	1946	14 54.2	9.4	1973	12 00.7	7.5
1920	19 17.9	9.3	1947	14 45.1	9.1	1974	11 52.0	8.7
1921	19 06.5	11.4	1948	14 37.2	7.9	1975	11 43.0	9.0
1922	18 57.0	9.5	1949	14 30.1	7.1	1976	11 33.0	10.0
1923	18 46.5	10.5	1950	14 23.9	6.2	1977	11 22.7	10.3
1924	18 34.9	11.6	1951	14 16.5	7.4	1978	11 11.9	10.8
1925	18 22.4	12.5	1952	14 10.3	6.2	1979	11 01.0	10.9

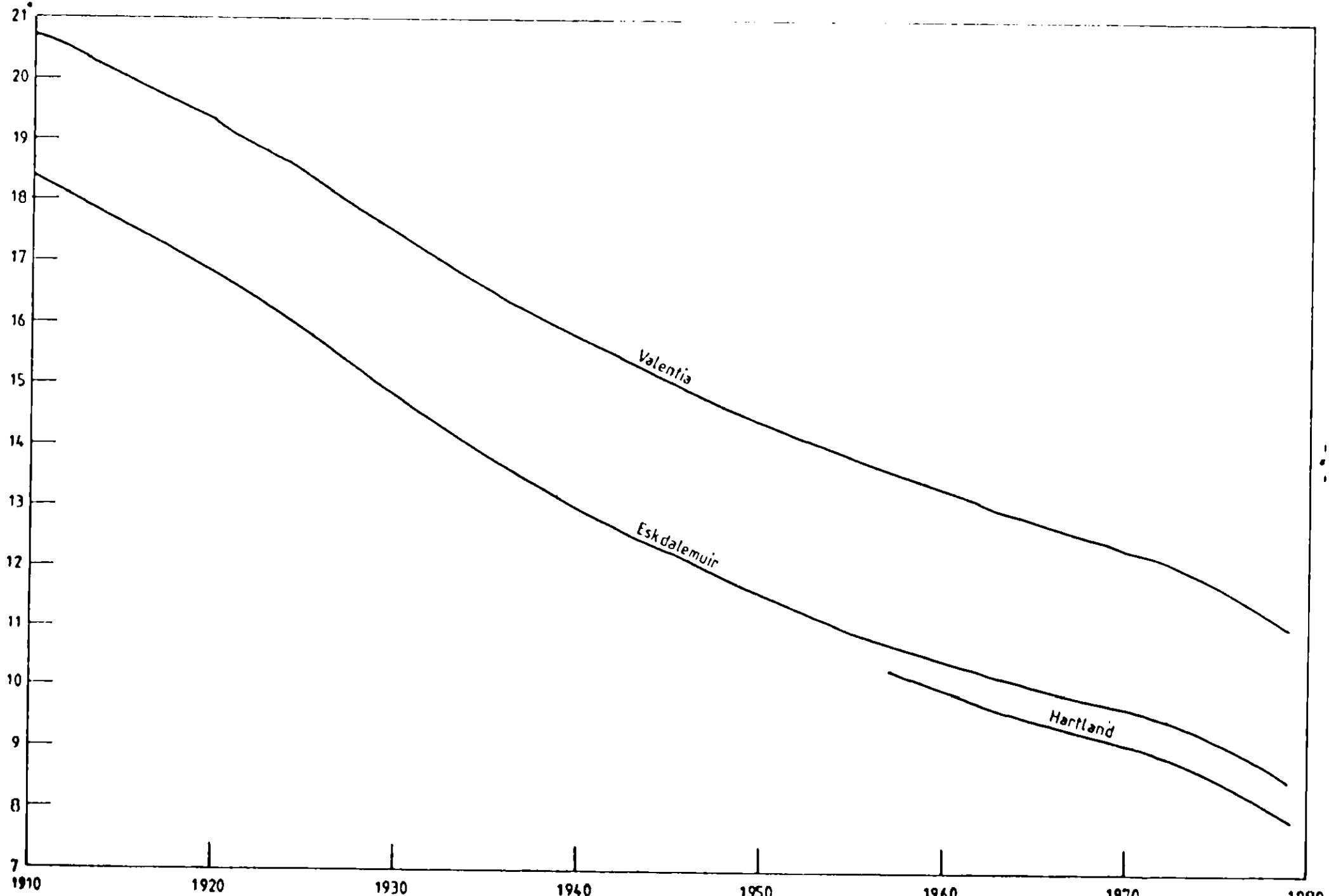

Fig. 1. Secular variation of D at the Observatories.

4. Analysis of the Data

The secular variation of Westerly Declination at the three Observatories since epoch 1910.5 is shown in Fig. 1 from which it can be seen that Declination has continued to decrease. However the annual rate of change which had been steadily decreasing since about 1929 began to increase again in 1970. This can be seen in Fig. 2, based on the data in Table 2, which shows the year to year change in Declination at Valentia since 1910. Individual annual values show some scatter probably due to variation in solar activity but the overall pattern is clear from the curve for 11-year means which is also drawn on the diagram.

An examination of the rate of change at the Observatories and repeat stations suggested as in [2] that the annual rate of change (R) over the area since 1970, may be represented by a function of Latitude and Longitude in the form:

$$R = a_1(\varphi-50) + b_1(\lambda-5) + c_1 + t\{a_2(\varphi-50) + b_2(\lambda-5) + c_2\} \quad \ldots\ldots\ldots\ldots(1)$$

where φ is the Latitude North and λ the Longitude West in degrees and a_1, b_1, c_1, a_2, b_2, and c_2 are constants.
R is in minutes.

Using all the available measurements since 1970 at the Observatories and repeat stations and using the method of least squares the equation for rate of change was found to be:

$$R = 0.17(\varphi-50) - 0.208(\lambda-5) - 4.667 - t\{0.033(\varphi-50) - 0.012(\lambda-5) + 0.710\} \ldots(2)$$

Integrating equation (2) with respect to "t" and taking t = 0 at epoch 1970.0 we get the general equation for Declination D (in minutes) in the form:

$$D = D_{70.0} - t\{4.667 - 0.17(\varphi-50) + 0.208(\lambda-5)\} - t^2\{0.355 + 0.017(\varphi-50) - 0.006(\lambda-5)\} \quad \ldots\ldots\ldots\ldots(3)$$

Putting t = 10 we get

$$D_{80.0} = D_{70.0} - 82.17 - 1.48(\lambda-5) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Equation (4) may be used to up-date all the stations occupied in the general survey to epoch 1980.0. These up-dated values together with the change since 1970.0 are given in Table 3 and form the basis of the Isogonic map for epoch 1980.0 which is appended to this paper.

In [2] the terrestrial isogonals for epoch 1970.0 were found to be

$$D_{70.0} = 16.85(\varphi-50) + 30.87(\lambda-5) + 551.82 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Combining this with equation (4) we get the terrestrial isogonals for epoch 1980.0 in the form:

$$D_{80.0} = 16.85(\varphi-50) + 29.39(\lambda-5) + 469.65 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

These terrestrial isogonals are drawn in red on the map appended to this paper.

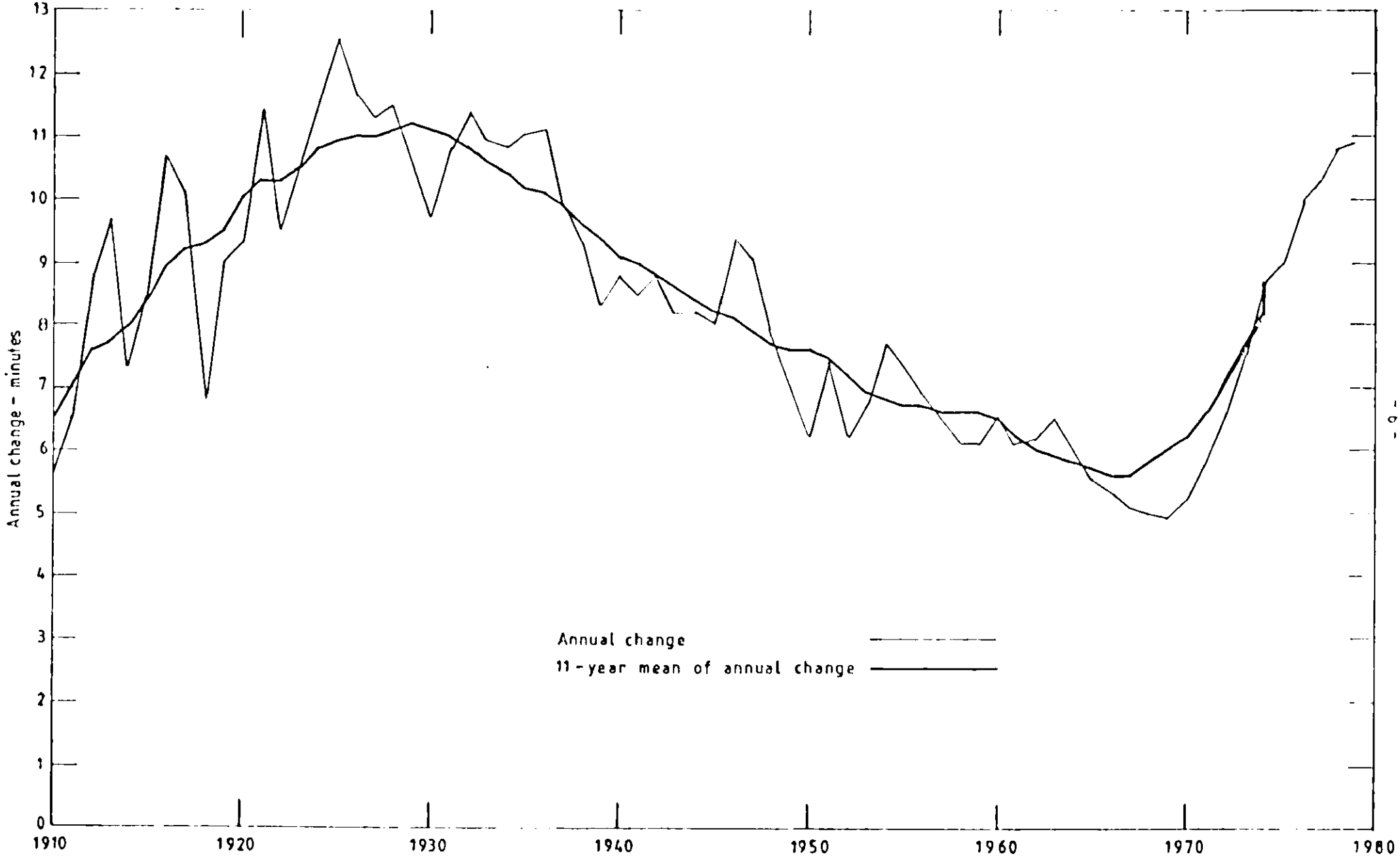

Fig. 2. Annual change in declination at Valentia.

To facilitate extrapolation of the data on the 1980 map to future years (to 1985 say) equation (3)may be adjusted so that zero time is at epoch 1980.0. The equation then becomes

$$D = D_{80} - t\{11.77+0.17(\varphi-50)+0.09(\lambda-5)\} - t^2\{0.355+0.017(\varphi-50)-0.006(\lambda-5)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

The use of this equation for extrapolation of Declination values for future years assumes that the annual rate of decrease will continue the increasing trend which has been the feature of the past 10 years. However it may be noted that the annual rate of change at Valentia at epoch 1980.0 has equalled the maximum annual rate of change experienced since observations began in 1888 i.e. 12.5 minutes, which was last reached in 1925 (See fig. 2). It is likely therefore that the annual rate of change may now settle at the 1980 value for the next few years.

At epoch 1980.0 the annual rate of change is given by the equation

$$\left(\frac{dD}{dt}\right)_{80.0} = -\{11.77 + 0.17(\varphi-50) + 0.09(\lambda-5)\} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

This equation gives the Isopors or lines of equal change in Declination which are shown on the map as broken red lines running approximately South West to North East. Whether we use these Isopors or equation (7) for future extrapolation the difference will be small, and accumulating to only 4 to 5 minutes of arc by 1985. For most practical purposes.for which the map will be used this difference in a forecast for 5 years hence should not be very significant.

References

[1] McWilliams, J. & Byrne, J.
A Magnetic Survey of Ireland for Epoch 1965.5
Meteorological Service, Dublin, 1966.

[2] McWilliams, J.
The Secular Variation of Magnetic Declination in Ireland.
Meteorological Service, Dublin, 1969.

Table 3 Declination Values at Epoch 1970.0 and Up-dated Values for Epoch 1980.0

Station	1970.0	$D_{70.0}$ to $D_{80.0}$	1980.0	Station	1970.0	$D_{70.0}$ to $D_{80.0}$	1980.0
	° '	'	° '		° '	'	° '
Malin Head	11 46.3	85.6	10 20.7	Carrick-on-Shannon	12 02.1	86.7	10 35.4
Dunfanaghy	11 59.5	86.5	10 33.0	Westport	12 18.0	88.8	10 49.2
Coleraine	11 56.1	84.7	10 31.4	Castlereagh	12 15.4	87.4	10 48.0
Waterfoot	11 18.7	83.7	9 55.0	Claremorris	12 16.3	88.1	10 48.2
Derry	11 48.8	85.6	10 23.2	Drogheda	10 58.5	84.2	9 34.3
Tobermore	11 30.7	84.8	10 05.9	Kells	11 19.0	84.9	9 54.1
Glencolumb-kille	12 25.4	87.7	10 57.7	Leenane	12 26.4	89.1	10 57.3
Donegal	11 47.8	86.8	10 21.0	Mullingar	11 30.9	85.6	10 05.3
Bangor	10 38.9	83.1	9 15.8	Clifden	12 38.5	89.6	11 08.9
Streefe Fort	10 54.2	85.3	9 28.9	Athlone	11 32.4	86.5	10 05.9
Armagh	11 17.7	84.6	9 53.1	Oughterard	12 42.3	88.5	11 13.8
Enniskillen	11 54.6	87.6	10 27.0	Baldonnel	10 52.0	84.3	9 27.7
Sligo	12 04.9	87.3	10 37.6	Galway	12 31.7	88.1	11 03.6
Belmullet	13 05.3	89.6	11 35.7	Kildare	11 08.8	84.9	9 43.9
Clones	11 40.0	85.5	10 14.5	Birr	11 32.8	86.4	10 06.4
Ballina	12 14.9	88.3	10 46.6	Gort	11 54.8	87.8	10 27.0
Greenore	11 13.5	83.8	9 49.7	Lisdoonvarna	12 10.8	88.5	10 42.3
Cavan	11 32.9	85.6	10 07.3	Wicklow	10 23.0	83.7	8 59.3

Table 3 Declination Values at Epoch 1970.0 and Up-dated values for Epoch 1980.0

Station	1970.0	$D_{70.0}$ to $D_{80.0}$	1980.0	Station	1970.0	$D_{70.0}$ to $D_{80.0}$	1980.0
	° '	'	° '		° '	'	° '
Shannon Airport	12 00.6	88.0	10 32.6	Waterford	10 41.8	85.4	9 16.4
Bagnalstown (Muinebeag)	10 57.1	85.0	9 32.1	Tralee	12 21.2	89.2	10 52.0
Kilkenny	11 05.1	85.5	9 39.6	Rosslare	10 22.2	84.1	8 58.1
Limerick	11 50.8	87.6	10 23.2	Lismore	11 17.9	86.5	9 51.4
Kilrush	12 19.4	88.8	10 50.6	Killarney	12 11.9	88.9	10 43.0
Tipperary	11 28.4	86.9	10 01.5	Valentia	12 24.7	89.9	10 54.8
Ballywilliam	10 44.2	84.9	9 19.3	Cork	11 34.9	87.3	10 07.6
Wexford	10 29.2	84.3	9 04.9	Roches Point	11 19.4	87.0	9 52.4
Charleville (Rathluirc)	11 44.1	87.6	10 16.5	Bantry	11 57.7	88.8	10 28.9

ISOGONIC MAP OF IRELAND 1980·0

IRELAND

10 0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETRES

DECLINATION WEST

TRUE ISOGONICS :- BLACK
TERRESTRIAL ISOGONICS :- RED
ISOPORS :- BROKEN RED

10° 20'·7 Malin Head
10° 33'·0 Dunfanaghy
10° 31'·4 Coleraine
9° 55'·0 Waterfoot
10° 23'·2 Derry
Letterkenny
10° 05'·9 Tobermore
Strabane
10° 57'·7 Glencolumbkille
10° 21'·0 Donegal
9° 28'·9 Streefefort
9° 30'
Antrim
Bangor
9° 15'·8
BELFAST
Lisburn
10° 27'·0 Enniskillen
9° 53'·1 Armagh
11° 35'·7 Belmullet
Killala
10° 37'·6 Sligo
10° 46'·6 Ballina
10° 14'·5 Clones
Newcastle
10° 07'·3 Cavan
9° 49'·7 Dundalk
Greenore
10° 35'·4 Carrick-on Shannon
Newport
10° 49'·2 Westport
Castlerea
10° 48'·2
10° 48'·0
Claremorris
Longford
9° 54'·1 Ceanannas Mór (Kells)
9° 34'·3 Drogheda
An Uaimh (Navan)
10° 57'·3 Leenaun
11° 08'·9 Clifden
10° 05'·3 Mullingar
Tuam
11° 13'·8 Oughterard
10° 05'·9 Athlone
Edenderry
DUBLIN
9° 27'·7 Baldonnel
Tullamore
Loughrea
9° 43'·9 Kildare
Bray
11° 03'·6 Galway
10° 06'·4 Birr(Syngefield)
10° 42'·3 Lisdoonvarna
Gort
10° 27'·0
Riverstown
8° 59'·3 Wicklow
Abbeyleix
Ennis
Nenagh
Arklow
Shannon Airport
10° 32'·6
Kilrush
10° 50'·6
10° 23'·2 Limerick
Thurles
Met. Station
9° 39'·6
9° 32'·1
Mine Bheag (Bagenalstown)
Kilkenny (White Bridge)
10° 01'·5 Tipperary
Ballywilliam
9° 19'·3
9° 04'·9
10° 16'·5
Clonmel
New Ross
Wexford
Rosslare
10° 52'·0 Tralee
Rath Luirc (Charleville)
9° 16'·4
8° 58'·1
Waterford
9° 51'·4
10° 43'·0
Fermoy
Lismore
Killarney
10° 54'·8 Valentia Observatory
Valentia Island
10° 07'·6
Youghal
Kenmare
CORK
9° 52'·4
Roches Point
10° 28'·9 Bantry
Kinsale
Skibbereen

11° 15' 11° 00' 10° 45' 10° 30' 10° 15' 10° 00' 9° 45' 9° 30' 9° 15' 9° 00'
-12·9 -12·8 -12·7 -12·6 -12·5 -12·4 -12·3 -12·2

10° 9° 8° WEST 7° 6°
55° 54° 53° 52°

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