The Storminess Record from Armagh Observatory, N. Ireland 1796-1999.

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Introduction

Armagh Observatory was established in 1790 by Archbishop Richard Robinson.

Robinson was the Church of Ireland Archbishop of Armagh (Butler and Hoskins 1987). Although the main focus of the Observatory was astronomy, daily meteorological records were kept from 1794, when the Observatory became operational. Only air temperature and barometric pressure were recorded during 1794 and 1795. From 1796 to 1843 wind direction was also recorded and a brief written daily weather comment was also included in the daily weather register. The daily description of weather included reference to storms and their effects. The only gap in the record is from mid-1825 to 1832 due to a number of missing daily weather volumes. No copy of this data has ever been found. In addition, no daily weather descriptions were recorded for 1883. From 1844 to the present there is also wind strength data, mostly instrumental but also some observer data. This makes this dataset the longest ongoing weather record on the island of Ireland.

The Observatory is located on top of a drumlin on its own site of approximately 20 acres. The Observatory although located on the edge of Armagh city is still predominantly surrounded by farmland and the playing fields of a number of schools.

The city has grown in size from around 5,000 to 15,000 people over the study period and is highly dispersed and low density. A study by Coughlin and Butler (1998) showed the effects of urbanisation on the mean air temperature at the Observatory were minimal. However, the one threat to the quality of the wind data from the Observatory was the growth of trees around the main building. This led to the original cup anemometer on the roof of the Observatory to be abandoned in favour of the more suitable site of the Back Lawn where the current meteorological site is located.

This paper will examine the weather diary record of storms in Armagh from 1796 to 1999 and the instrumental/observation record from 1844-1999 and will highlight some of the difficulties in assembling such chronologies, even from one site.

The descriptive record from 1796-1999.

This data was abstracted from the daily weather diary. From the earliest weather diaries the recording of storms seems to have been a key component of the description. The definition of a storm used was the use of the words ‘tempest’, ‘storm’ or ‘gale’ in the written description. The description must clearly indicate that this event was not a gust, thunderstorm or snowstorm and that the wind was sustained for a length of time. Figure 1 shows the annual incidence of storms from the descriptive record at Armagh from 1796 to 2000 fitted with a 10 year running mean. Relatively high numbers of storms were recorded from 1796 to 1825 and 1835 to 1844 and it is assumed that the missing volumes would also contain relatively high numbers of storms.

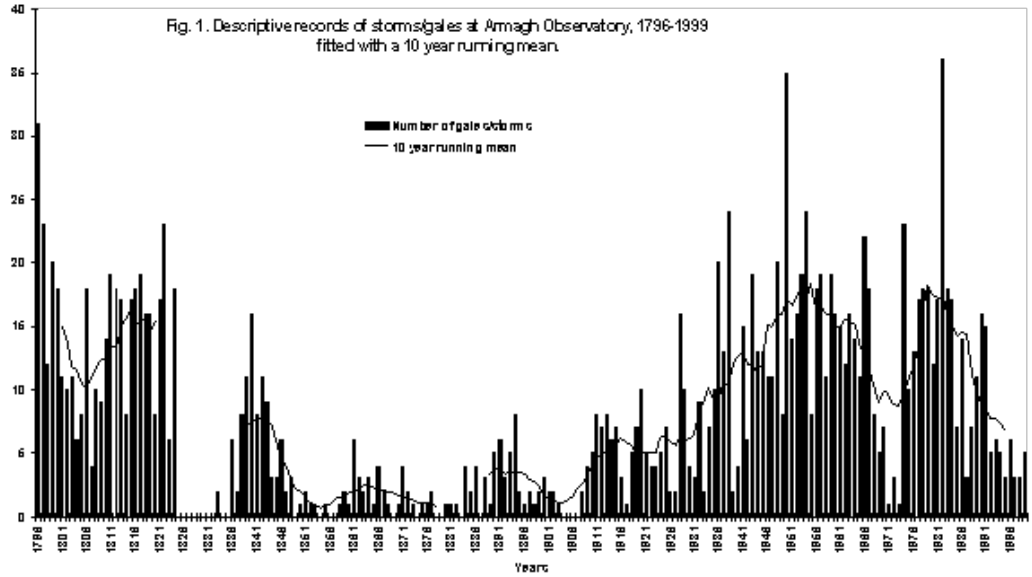

Fig. 1. Descriptive records of storms/gales at Armagh Observatory, 1796-1999, fitted with a 10-year running mean.

Three years have more than 30 storms and this includes 1796 with 31. This block of relatively high numbers of storms can be associated with increased storminess symptomatic of the 'Little Ice Age' that probably extended up to 1850, (Grove 1988). From 1845 to 1910 relatively few storms were recorded at Armagh typically less than 5 per annum. A change occurs in the 1890's with an increase in the numbers of storms being recorded. This coincides with Lamb's (1991) assessment that the 1890's was probably the stormiest decade of the 19th century. From 1911 until 1958 there is a generally rising number of storms being recorded. This includes the exceptional year of 1950 when 35 storms were recorded. There is a decline in the number of storms from 1960 to 1976 and this is followed by a pulse of increased numbers of storms being recorded until 1985. This includes 1982, the stormiest year on record with 36 storms. This is in turn followed by a sharp decline in the number of storms being recorded up to and including 1999. This trend has continued in 2000 and 2001.

One potential weakness with this record is that of observer bias. Work is still ongoing at Armagh in an attempt to identify the meteorological observers and the time periods they covered and so test for bias. At this stage there are still considerable gaps in the list of observers and the periods they covered so any attempt to test the record for bias is premature.

The instrumental/observational record from 1844-1999.

The instrumental/observational record is a much more complex series consisting of six components which have been combined together. The first two components cover the period from 1844 to 1882 and are not directly compatible with the rest of the chronology in a strict methodological sense. The remaining four components from 1883 are relatively easily converted to a single standardised format.

Component 1: 1844 January 1 to 1860 March 3.

The data here appears to be based on an early version of the Beaufort land scale to which actual wind speed was added (Table 1). As a result a gale is defined as force 8 but the given miles per hour is only 24mph (1mph =0.87 knots). The effect of using this scale was the over-recording of gales and their strength. As a result only gales that were given as force 12 or force 12+ were used. This would still include a small number of events that would not be classified as gales today. The data was based on

twice-daily observation of wind speed and direction, recorded from the anemometer located on the roof of the Observatory. A further minor complication is that prior to 1st April 1852 astronomical time was used, after this date standard civil time was used. Astronomical time starts at noon as opposed to midnight. All the data in this component has been corrected to civil time.

Component 2: 1860 March 26 to 1882 December 31.

Component 2 consists of the total number of miles (1 mile =1.609km) travelled by the anemometer in a 12-hour period. Clearly it is very difficult to interpret this data in the context of the overall chronology as the minimum miles travelled to guarantee a gale is 39 and the maximum is 565. Obviously the more miles travelled in a 12-hour period the more likely it is that a gale has occurred. An arbitrary figure of 450 miles travelled was chosen to indicate when gales might have occurred. This was checked against a small amount of hourly data that is available for Armagh from 1874-1882. This showed that the 450 miles travelled was an adequate threshold to use as it picked up two gales that occurred during this time period. However, two additional 12-hour periods which had totals in excess of 450 miles also occurred, but which were not recorded as gales in the hourly data. Both had sustained periods of high winds. This at least indicates that no gales will be missed using the 450 mile threshold, but that there is likely to be some over-recording of gales. When this threshold is applied to the period from 1860 to 1873 a further seven possible gales can be identified (Table 2). This part of the chronology is based on twice daily observation of wind speed and direction, recorded from the anemometer located on the roof of the Observatory.

Component 3: 1883 January 1 to December 31.

The data comes from a separate instrumental hourly time series as the normal twice daily observations appear not to have been taken or recorded during this year.

A gale in this component is designated as 53mph. This is as a result of the correction of the calibration of the Robinson Cup Anemometer which over recorded wind strength by 4/15 or a reduction in the calibration applied to the raw data from 3.0 to 2.2. This calibration correction applies to all measured wind speed using the Robinson Cup Anemometer from 1904 backwards in time. If the earlier data is not recalibrated then the number, duration and strength of gales are dramatically and erroneously increased.

Component 4: 1884 January 1 to 1919 December 31.

The data are based on a modified Beaufort scale using knots where a gale is given as Beaufort force 6 which is given as 34 knots (Table 3). This part of the data set is based on twice-daily observations of wind speed and direction. Any data from 1884 to 1904 was recalibrated as outlined above.

Component 5: 1920 January 1 to 1958 December 31.

This is a standard Beaufort scale where a gale is equal to Force 8 or 39 mph

(Table 3). The data are as a result of twice-daily observations of wind speed and direction from the back lawn of the Observatory.

Component 6: 1959 January 1 to 1999 December 31.

This is a standard Beaufort scale where a gale is 37 knots which is the mid-point of Beaufort Force 8 when using knots (Table 3). The data are based on twice-daily observations of wind speed and direction from the back lawn of the Observatory. From 7th March 1965 onwards the data is based on once a day observation at 0900 GMT.

The instrumental/observational days with gale record was plotted from 1844 to 1999 and fitted with a 10-year running mean

(Fig. 2). This includes the data from 1844 to 1883 which although not directly comparable with the remainder of the data set has been included as outlined in the methodology described above. Four distinct periods of increased occurrence of days with gale can be identified. These are 1884 to 1905, 1917-1919, 1947 to 1964 and 1977 to 1991 Since 1993 no gales have been recorded at Armagh at the 0900 GMT observation. Clearly, from the data there is a quasi-cyclical occurrence of increased numbers of days with gales with a mean cycle of 31 years or

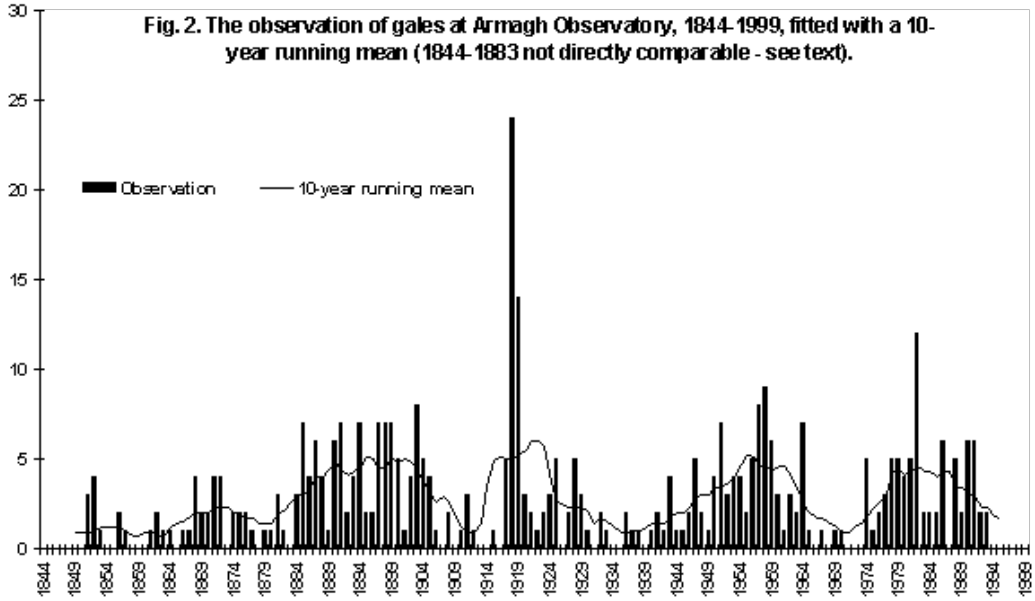

Fig. 2. Number of observation of gales at Armagh Observatory, 1844-1999, fitted with a 10-year running mean (1844-1883 not directly comparable - see text).

27 years if the less prominent increase in days with gales from1868 to 1874 is included. The second item to note is the spike of increased days with gales during 1918 and 1919, these were the two highest individual years with 24 and 12 gales respectively. The only other year that comes close to this number of gales being recorded is 1982 when 12 gales were observed. Clearly this anomaly is worthy of further research. A check of other Irish meteorological stations showed that some had the spike and some did not (Table 4). The spike is clearly evident at Belmullet, is evident only in 1918 at Malin Head, and evident only in 1919 in the two most southerly stations at Roches Point and Valentia; it is not present at Donaghdee. It is not clear what caused this dramatic increase in the number of days with gales being recorded. It is also possible to speculate that the spread of the influenza virus that killed in excess of 20 million people during this time period may have been aided by increased storminess.

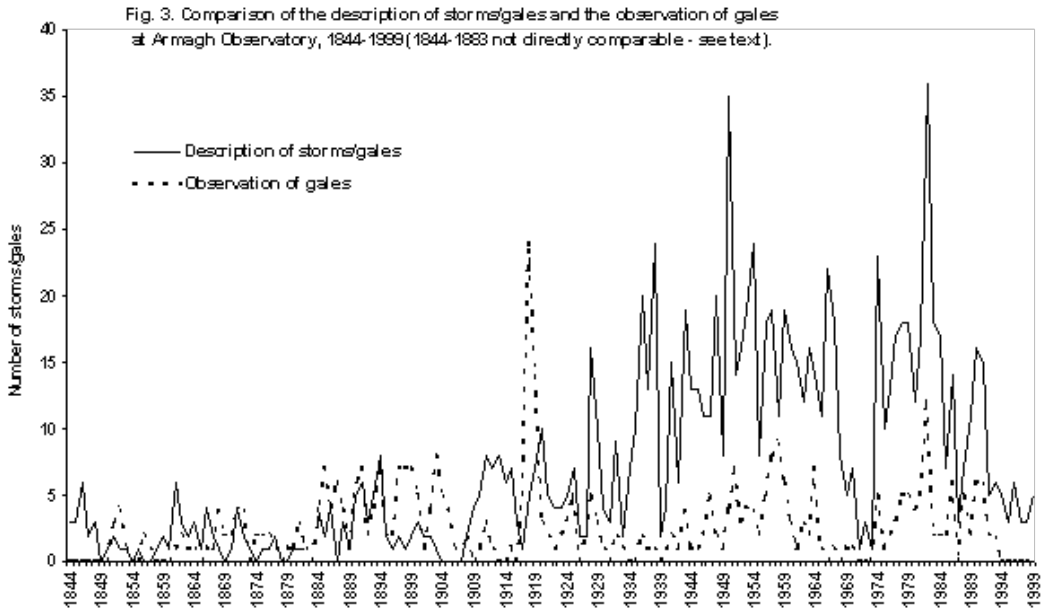

Fig. 3. Comparison of the description of storms/gales and the observation of gales at Armagh Observatory, 1844-1999 (1844-1883 not directly comparable - see text).

Comparison of the two records of storminess at Armagh Observatory

from 1884 to 1999.

As a result of the differences of the two methodologies in generating the storm chronologies it would be exceedingly unlikely that the two records would match

numerically but that they should match in terms of the trends. The weather diary dataset would be expected to produce more gales/storms as it covers the whole day and not just one or two specific measurements per day. At the annual level there is a strong similarity for most of the record (Fig. 3). The only periods when the match is relatively poor is 1896 to 1908 and the spike years of 1918 and 1919. In both these cases there was more observation of gales than that recorded in the weather diary. This indicates that the meteorological observer was failing to record storms in the daily weather diary.

A similar pattern emerges when the 10-year running mean of the two chronologies are compared (Fig. 4). The exception is the period from 1922 to 1936 when the observation record shows a rising incidence of storms, whereas the weather diary shows a declining incidence of storms. The peaks in gale/storm incidence in the 1950's and 1980's are clearly shown as the intervening trough in the 1960's. The decline in gales/storms in the 1990's is evident in both records.

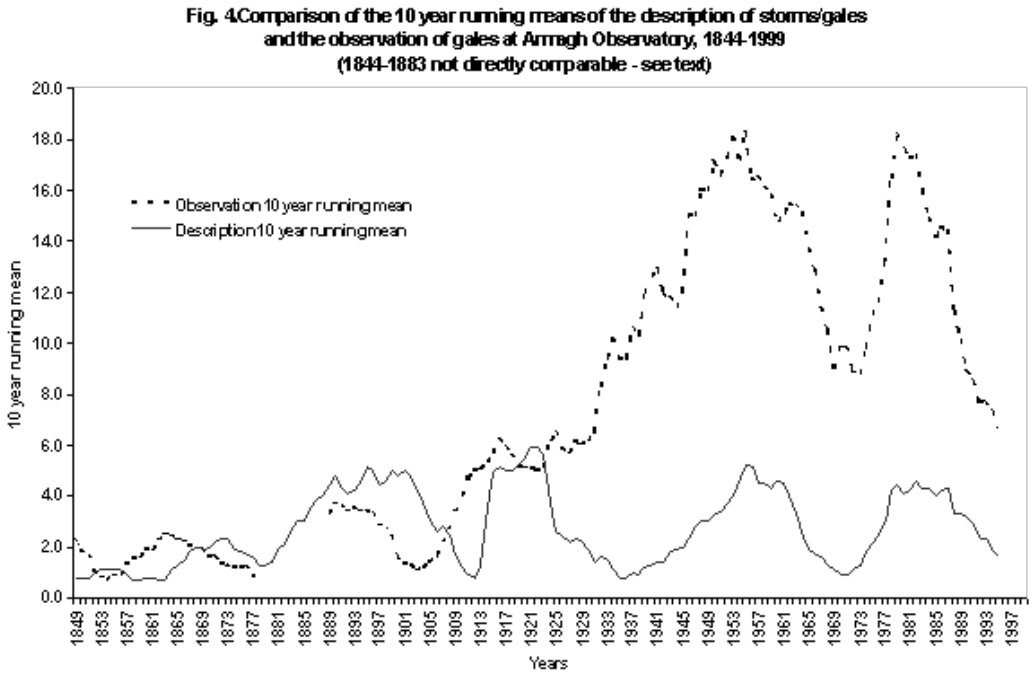

Fig. 4. Comparison of the 10-year running means of the description of storms/gales and the observation of gales at Armagh Observatory, 1844-1999 (1844-1883 not directly comparable - see text).

Long and short term changes in storminess

The long term trend in storminess in Armagh as identified in the two different records was calculated using a linear regression. This was also compared with linear regressions from the three west coast stations at Valentia, Belmullet and Malin Head (Table 5). The regressions at the 95% confidence level show that the Armagh and Valentia records show no significant tend although the Valentia houly shows an increase of 1 gale per year every 14 years. Belmullet shows a decline of 1 gale every 5 years over the length of record, whereas, Malin Head shows an increase of nearly 1 gale every 3 years. There is no overall pattern for these four stations.

In order to examine the recent changes in storminess in Armagh over the 30-year period from 1970-1999 linear regressions of the two different measures of storminess were calculated. Again this was compared with linear regressions from the three west coast stations at Valentia, Belmullet and Malin Head (Table 5). This shows some very different results in comparison with the overall regression figures. Armagh and Valentia show a decline in the number of gales being recorded of the order of 1 every 5 to 7 years, whereas Belmullet shows an increase of nearly 1 gale every 3 years and Malin Head showing an increase of nearly 1 gale every year. This indicates an overall pattern of the south and east receiving fewer gales and the north and west receiving more gales, possibly, indicating a northward shift in storm tracks, which Armagh Observatory because of its low gale environment is not yet picking up. This is supported by the only other published storm chronology for Ireland which is for Dublin from 1715-1999 (Sweeney, 2000). A decadal comparison between the Dublin record and the two Armagh record shows substantial similarities, but also some differences (Fig. 5). As a result of incomplete decadal totals, it is only possible to do the comparison from the 1840's onwards. From 1840 until the early part of the 20th century relative low levels of storms are being recorded. For the next 40 years the Dublin record more closely resembles the Armagh instrumental/observation record, even in terms of numbers of storms being recorded. From the 1960's onwards the Dublin record more closely resembles the description record in terms of the general

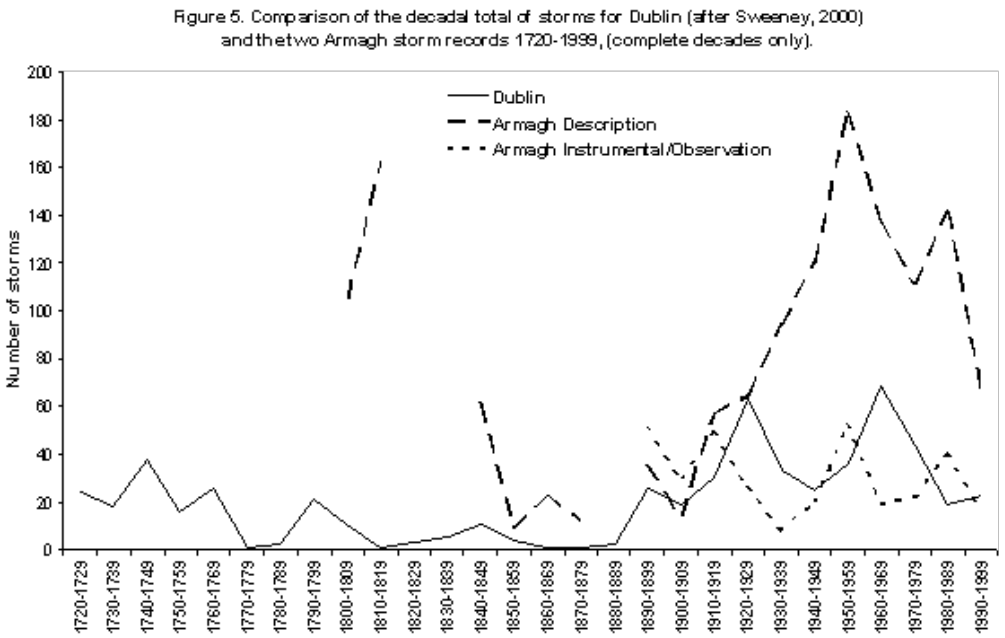

Fig. 5. Comparison of the decadal total of storms for Dublin (after Sweeney, 2000) and the two Armagh storm records, 1720-1999, (complete decades only).

trend, but the actual numbers of storms are very different. The comparison also suggests that there is a decadal lag between Dublin and Armagh in terms of peaks and troughs. The decade with the most storms in Armagh is the 1950's whereas in Dublin it is the 1960's.

Conclusions

Very significant variations in storminess have been recorded over the last 200 years for Armagh observatory despite the sheltered inland nature of the site. This includes evidence for increased storminess at the end of the 'Little Ice Age'. However, there is no evidence of increased storminess over the last 30 years. When similar records from other Irish stations are examined, there is some evidence of a possible northwards movement of the storm tracks that have affected the island of Ireland over the last 30 years.

References

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Table 1 Old Beaufort land scale that was used to cover the period from 1st January 1844 to 3rd March 1860.

Beaufort Number	Miles Per Hour
1	3
2	6
3	9
4	12
5	15
6	18
7	21
8	24
9	27
10	30
11	33
12	36+
12+	?

Table 2 Dates on which miles travelled in a 12 hour period exceeded 450 compared with the hourly data and the weather diary at Armagh Observatory.

Date	Miles travelled in 12 hours	Gale from hourly data	Storm from weather diary
1863/12/11	479	no data	No
1864/2/13	542	no data	No
1867/3/14	455	no data	No
1871/1/16	464	no data	Yes
1872/1/1	478	no data	No
1872/1/31	468	no data	No
1872/11/6	464	no data	No
1875/1/1	461	No	No
1880/11/26	450	Yes	Yes
1881/11/22	499	Yes	No
18812/6	468	No	No

Table 3 Comparison of the different Beaufort scales used from 1st January 1884 to 31st December 1999.

Beaufort Number	Component 4 (Kn)	Component 4 (mph)	Component 5 (mph)	Component 6 (kn)
0	3		<1	0
1	8		1-3	2
2	13	10	4-7	5
3	18	15	8-12	9
4	23	20	13-18	13
5	28	30	19-24	19
6	34	40	25-31	24
7	40	50-60	32-38	30
8	48	50-60	39-46	37
9	56	70	47-54	44
10	65	80-90	55-63	52
11	75	100	64-72	60
12	90	110	73-82	69

Table 4 The number of days with gales recorded at Armagh Observatory, Roches Point, Valentia, Belmullet, Donaghee, Malin Head for 1918 and 1919.

	Days with gale

Station	1918	1919
Armagh Observatory	24	12
Roches Point	4	18
Valentia	9	12
Belmullet	67	28
Malin Head	37	8
Donaghdee	6	4

Table 5 Linear regressions of the number of days with gales recorded at Armagh Observatory, Valentia, Belmullet, Malin Head full record.
(All linear regressions at the 95% confidence level and based on complete years only)

	Full record	1970-99
Armagh (observation) 1884-1999	-0.02	-0.22
Armagh (description) 1796-1999	-0.03	-0.15
Valentia (hourly data) 1874-1999	+0.03	-0.15
Valentia (observation) 1876-1999	+0.07	
Belmullet (observation) 1885-1999	-0.19	+0.29 (hourly
Malin Head (observation) 1885-1999	+0.31	+0.86 (hourly)