11

IRELAND

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INTRODUCTION

Ireland functions as a meteorological sentry post for much of north-western Europe, and it is in its vicinity that the skirmishes between air masses which determine the climatic fingerprints of much of the continent are often first observed, and their sting removed. It is here that the harbingers of weather for areas further east may be first assessed and the knowledge used to provide early warning of imminent weather events. The shelter effect of Ireland constitutes one of the principal controls on climate for much of Britain, and it is in the vicinity of Ireland that any significant changes in oceanic circulation associated with global warming in Europe will be first detected.

It is important to realise that Ireland possesses a rich and varied climatic mosaic of its own within its 84,000 km^2. About 5 per cent of its area lies over 300 m above sea level (ASL), and the sometimes complex interplay between airstreams and relief ensures that the stereotypical view of the island's climate as a relatively homogeneous maritime one is only partly correct.

Unlike most islands of its size, Ireland possesses a mountainous perimeter of hard ancient rocks and a relatively flat interior composed of softer, younger rocks. This can be seen in Figure 11.1, where the almost unbroken chain of north-west- to south-east-trending mountains of Caledonian age form much of the western and eastern coasts. Significant gaps in the western uplands at Sligo Bay and Galway Bay, and along the Shannon estuary, provide easier access routes for maritime influences to penetrate inland, and the interdigitation of land and sea influences gives western Ireland a complex climatic character, some parts being quite sheltered and others exposed to the full rigours of the Atlantic. To the south, the east–west trending folds of the Hercynian orogeny along the Cork and Kerry coastline provide a partial bulwark against south-erly airstreams, whilst even in the extreme north-

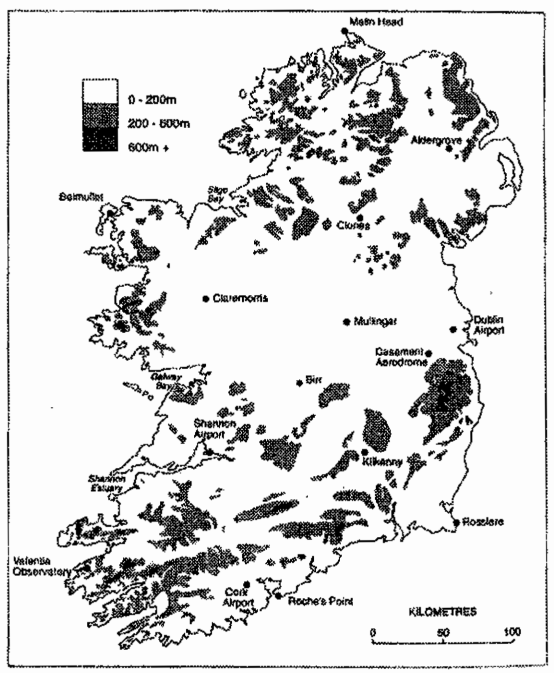

Figure 11.1 Location of weather stations and places referred to in the text

east the Antrim Basalt Plateau offers some protection from polar air masses to the lowlands around Belfast. Within this mountain perimeter the softer Carboniferous Limestones of the Central Plain are generally less than 150 m ASL and enjoy considerable shelter, often from several directions. Such a relief configuration inevitably produces a distinctive coastal-versus-interior set of climatic contrasts as well as producing distinctive geographies of most of the main weather elements associated with a particular airflow.

The Instrumental Record and Other Direct Sources of Climatic Information

Regular meteorological observations in Ireland began at Armagh Observatory in 1794 and have continued there without interruption since. During the early nineteenth century, observations commenced at a number of locations such as the Botanic Gardens, Dublin (1800), Markree Castle, County Sligo (1824), and Phoenix Park, Dublin (1829). Whilst these early records must be used with caution, from about 1880 onwards they are fairly reliable and are today supplemented by fourteen synoptic stations in the Republic of Ireland and one (Aldergrove) in Northern Ireland (Figure 11.1). These stations are manned by trained observers and provide hourly observations. Approximately seventy climatological stations and 650 rain-gauge sites (10 per cent of these are recording rain-gauges) exist, and further data from lighthouses, oil rigs, ships and buoys complete the network (Fitzgerald 1994). An overwhelming concentration on lowland locations is in evidence, though Betts (1982) notes the addition of sixteen stations above 300 m ASL since the 1960s in Northern Ireland. As with their counterparts in the UK Meteorological Office network, sites are chosen to minimise (though they cannot wholly exclude) site-specific influences on the recorded weather.

In common with countries such as Japan, Iceland and China where a long tradition of chronicling significant meteorological and other events exists, there is in Ireland also a wealth of documentary material which may be used for inferring climatic conditions before the era of observations got under way (Shields 1983; Tyrrell 1995). Early newspapers, estate records, weather diaries (some with instrumental observations such as those of William and Samuel Molyneux of Dublin (1684–1709), Thomas Neve of Ballyneilmore, County Derry (1711–1725) and Richard Kirwan of Cavendish Row, Dublin (1780–1808)) provide useful data back into the Little Ice Age times of the seventeenth and eighteenth centuries. Early Christian manuscripts are an as yet untapped source of weather information for the Medieval Warm Period around the end of the first millennium AD, whilst in even earlier times, reference to a storm on Lough Conn in the Annals of the Four Masters (Figure 11.2), allegedly in 2668 BC, is claimed to be the earliest documentary refer-

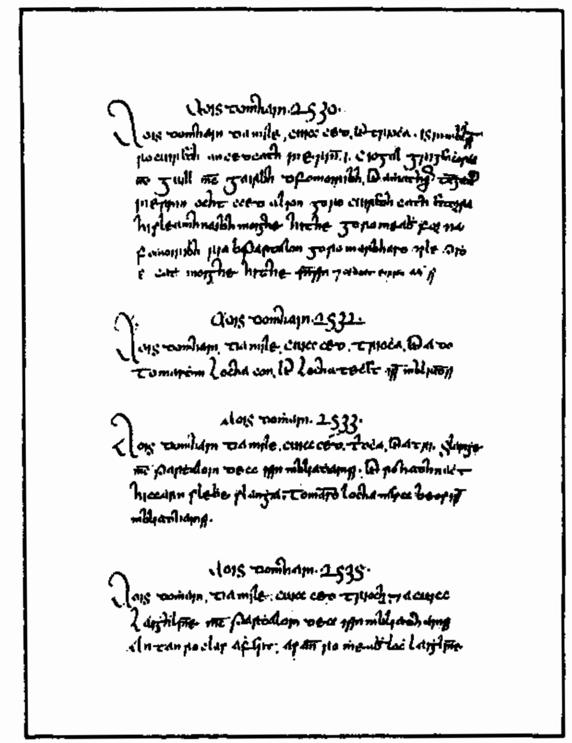

Figure 11.2 The earliest documentary reference to a meteorological event in Britain or Ireland: a storm on Lough Conn allegedly in 2668 BC – from the Irish Annals of the Four Masters

ence to a meteorological event in Ireland or Britain (Britton 1937).

TEMPERATURE

The equability of Irish climate is the characteristic which distinguishes it most from that of Britain, with the moderating influence of the North Atlantic Drift the primary cause. Flowing at 16–32 km/day, the surface water takes about eight months to reach the Kerry coast from Florida, by which time its temperature in January is about 10°C. This is some 3 to 4 degrees C warmer than the air over Ireland and has a dual effect in winter. First, it enables a transfer of sensible and latent heat to frontal systems, which are thus rendered more active at this season in western parts. Stable tropical maritime air masses which have cooled gradually on their journey from the Azores to the British Isles produce the stratus so prevalent in Irish weather. They may also be incorporated into rapidly developing wave depressions in mid-Atlantic and induced to release their water vapour load over western upland areas. Second, the winter warmth of the nearby ocean triggers convective motions in the vicinity of Ireland, particularly in unstable polar maritime air moving from the north-west in the rear of a depression. Such airflows may be warmed by up to 9 degrees C as they pass across the main axis of the North Atlantic Drift between Ireland and Iceland (Sweeney 1988). The convective cells generated tend to release the bulk of their precipitation over western Ireland, especially where their forced ascent over the mountains occurs.

The location of Ireland astride this oceanic conveyor, however, means that both the seasonal rhythm and year-to-year variations in annual average temperature are determined principally by changes in the thermal characteristics of the nearby sea. This is vividly demonstrated in Figure 11.3, where the Malin Head monthly temperature cycle and annual mean temperatures follow slavishly the offshore water temperatures at that location. The site's notably temperate regime is given statistical support in Table 11.1. The highest recorded sea temperatures at this location not surprisingly were during 1995, when the warmest summer on record occurred.

Thermally conservative marine influences also explain the relatively small year-to-year variations in annual temperatures apparent in Figure 11.3. Throughout Ireland, only one year in ten typically departs from the annual average by more than 0.5 degrees C. Mean annual temperatures also exhibit a south-west to north-east gradient as a consequence of differences in offshore sea temperatures, which range from 10°C off the south-west coast to less than 7°C off the north-east coast in late winter, and from 15°C to 13.5°C respectively in the same locations towards the end of summer. Accordingly, equability between summer and winter temperatures decreases towards the north-east as well as with distance from the coast. Mean minimum temperatures in the Belfast region (Aldergrove), for example, do not exceed 4°C until early May on average, whilst in the extreme southwest only briefly in February do mean minimum temperatures fall below this level (Table 11.1). In contrast, mean maximum temperatures at Aldergrove exceed those of Valentia from May until the beginning of September.

Mean January temperatures range from just over 7°C along the south-west coast to 3.5°C in the interior of Northern Ireland (Figure 11.4). The coldest month at coastal stations is typically February, as opposed to January at inland locations. The month of lowest average temperatures is also typically the month with the highest variability, since at this time of the year marked tendencies for prolonged spells of similar weather exist and either high- or low-index circulations frequently get entrenched for a few weeks at a time. In favourable years, winter can pass almost unnoticed in the extreme south-west; unfortunately, some summers have a similar tendency!

Even though July temperatures inland tend to be higher than on the coast, with daytime maxima above 19°C as opposed to 16°C, the contrast in summer mean temperatures is much less than in winter and the pattern of isotherms is not explicitly

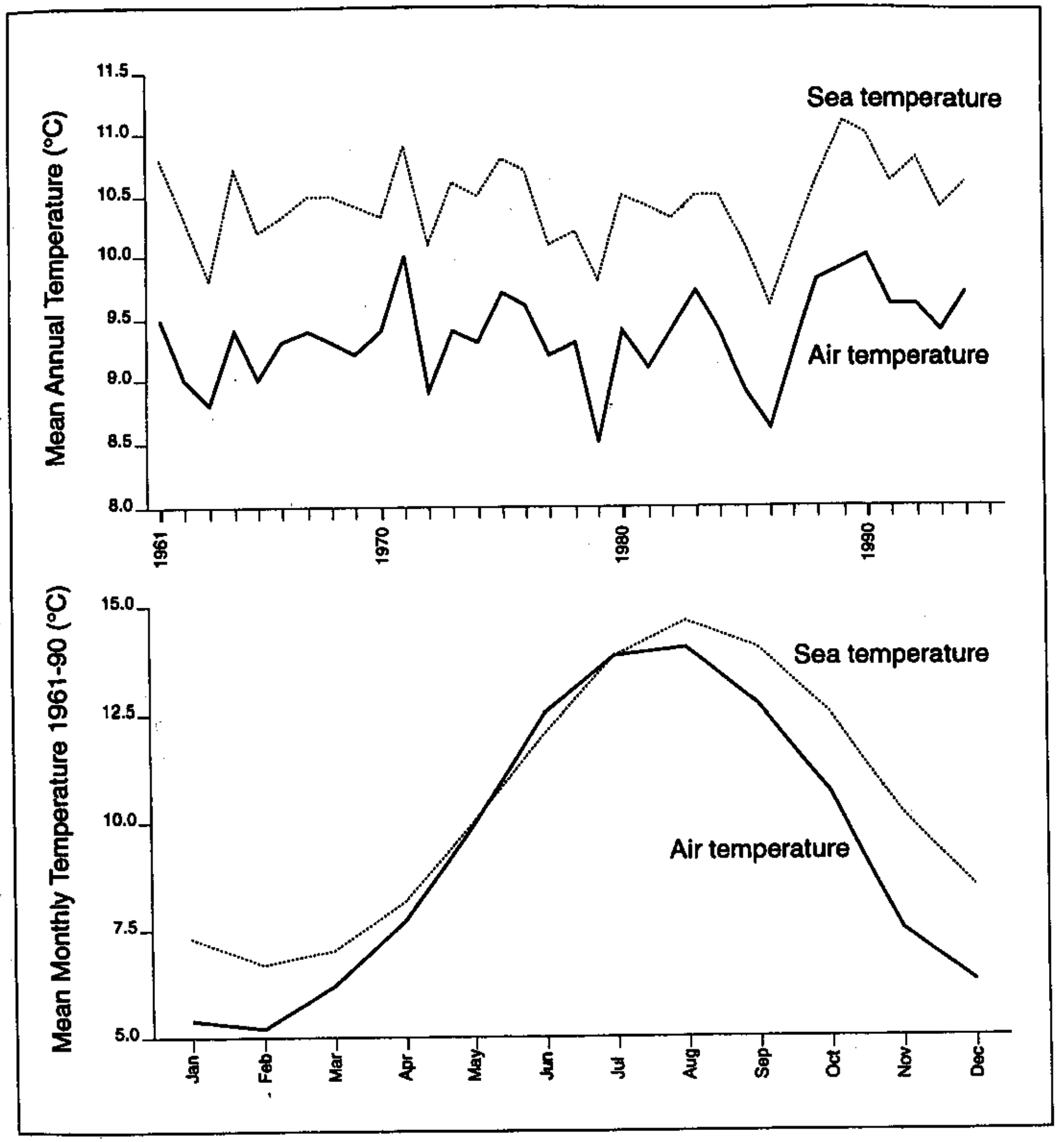

Figure 11.3 Yearly and mean monthly variations in air and offshore sea temperatures for the period 1961–94 at Malin Head

concentric, with more of a tendency to reflect radiation income differences. The latitudinal control is clearly detectable, with Cork at 16°C in August almost 2 degrees C warmer than Malin Head (Figure 11.4). Throughout the year, cities such as Dublin and Cork probably enjoy an enhancement of their temperatures by over 1 degree C due to their urban heat-islands (Sweeney, 1987; see also Box 11.1).

The oceanic influence also manifests itself in the absence of marked temperature extremes. Meskill (1995b) has described the summer of that year, which was one of the warmest in Ireland since at

Table 11.1 Mean monthly maximum and minimum temperatures (°C) for the period 1961–90

Location	*Alt. (m ASL)*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Dublin	81	7.4	7.6	9.6	11.8	14.7	17.8	19.4	19.0	16.8	13.7	9.7	8.2	13.0
(Casement)		1.8	1.7	2.6	3.6	6.1	8.9	10.8	10.6	9.0	6.9	3.4	2.5	5.7
Valentia	12	9.4	9.3	10.5	12.3	14.4	16.5	17.9	18.0	16.7	14.3	11.4	10.1	13.4
		4.2	3.9	4.7	5.8	7.8	10.3	12.0	12.0	10.7	8.8	6.1	5.1	7.6
Kilkenny	66	7.7	7.9	10.0	12.4	15.1	18.1	19.9	19.6	17.2	13.9	10.1	8.4	13.4
		1.4	1.6	2.3	3.4	5.6	8.4	10.4	9.9	7.9	6.1	2.8	2.1	5.1
Claremorris	71	7.2	7.6	9.6	12.0	14.5	17.0	18.4	18.2	16.1	13.2	9.5	7.9	12.6
		1.4	1.3	2.3	3.3	5.5	8.2	10.2	9.8	8.1	6.3	3.0	2.3	5.1
Malin Head	22	7.6	7.5	8.7	10.3	12.7	15.0	16.2	16.6	15.3	13.0	9.8	8.4	11.8
		3.2	2.9	3.7	5.0	7.1	9.6	11.4	11.4	10.1	8.3	5.2	4.2	6.8
Aldergrove	69	6.2	6.6	8.8	11.6	14.4	17.3	18.5	18.2	15.9	13.0	8.9	7.3	12.2
Airport		0.7	0.7	1.9	3.5	6.1	9.1	10.9	10.7	9.0	6.9	3.1	2.0	5.4

Note: ASL = above sea level

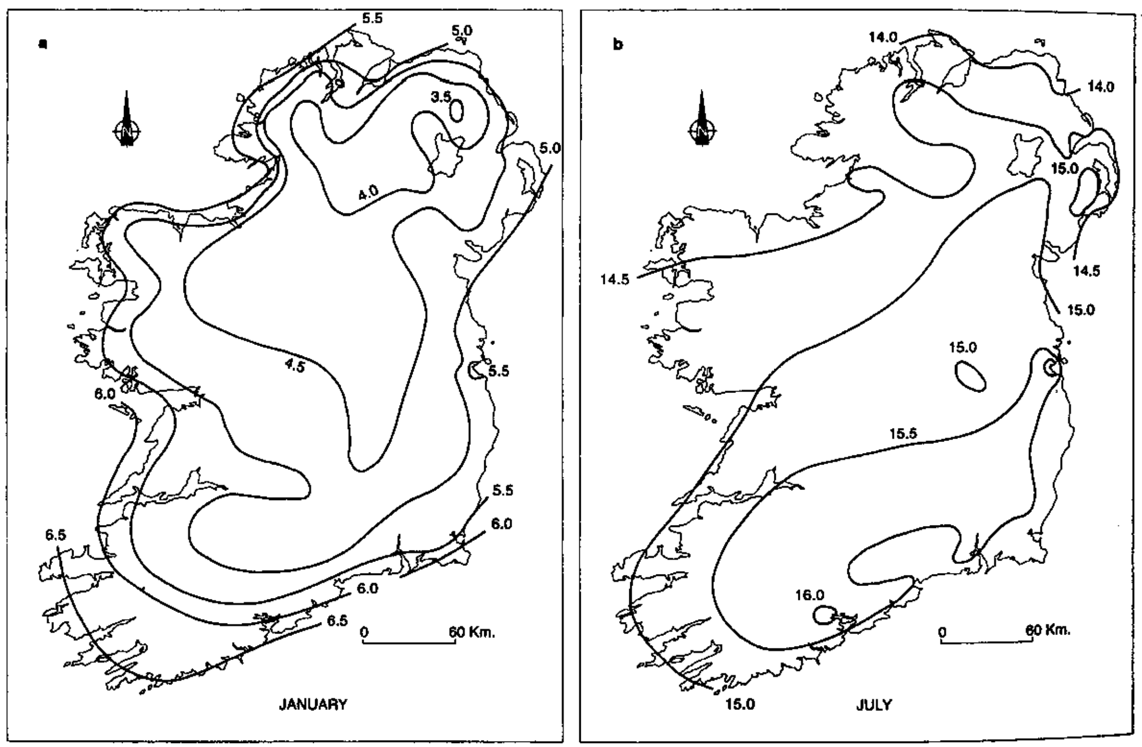

Figure 11.4 (a) Mean January temperatures (°C) for the period 1951–80
(b) mean July temperatures (°C) for the period 1951–80

Box 11.1

URBAN HEAT ISLAND OF DUBLIN CITY

The relationship between city size and the intensity of urban heat-islands in European conditions was suggested by Oke (1973) as capable of being expressed by the equation:

$$T_{(u-r)max} = 2.01 \log P - 4.06$$

in which T is temperature, P is population and the subscripts u and r refer to urban and rural respectively. This suggests a maximum intensity for a city the size of Dublin of 8 degrees C. A maximum urban–rural difference of 6 degrees C is shown in Figure 11.5 for the night of 22 November 1983, when light westerly winds of 5 knots and 3 oktas cloud cover (i.e. three-eighths of the sky had cloud cover) was observed at the airport just north of the city. The temperature 'cliff' close to the edge of the urban area and the peak warmth of the central business district are clearly apparent. The displacement towards the city of the isotherms on its south side reflects the influence of katabatic drainage of cold air downslope from the nearby Wicklow Mountains, while warm marine air is also in evidence on the low-lying tombolo on the north-east of the city. Like many cities in Britain (see Box 3.1) and Ireland, the urban heat-island is complicated by topographic and oceanic influences.

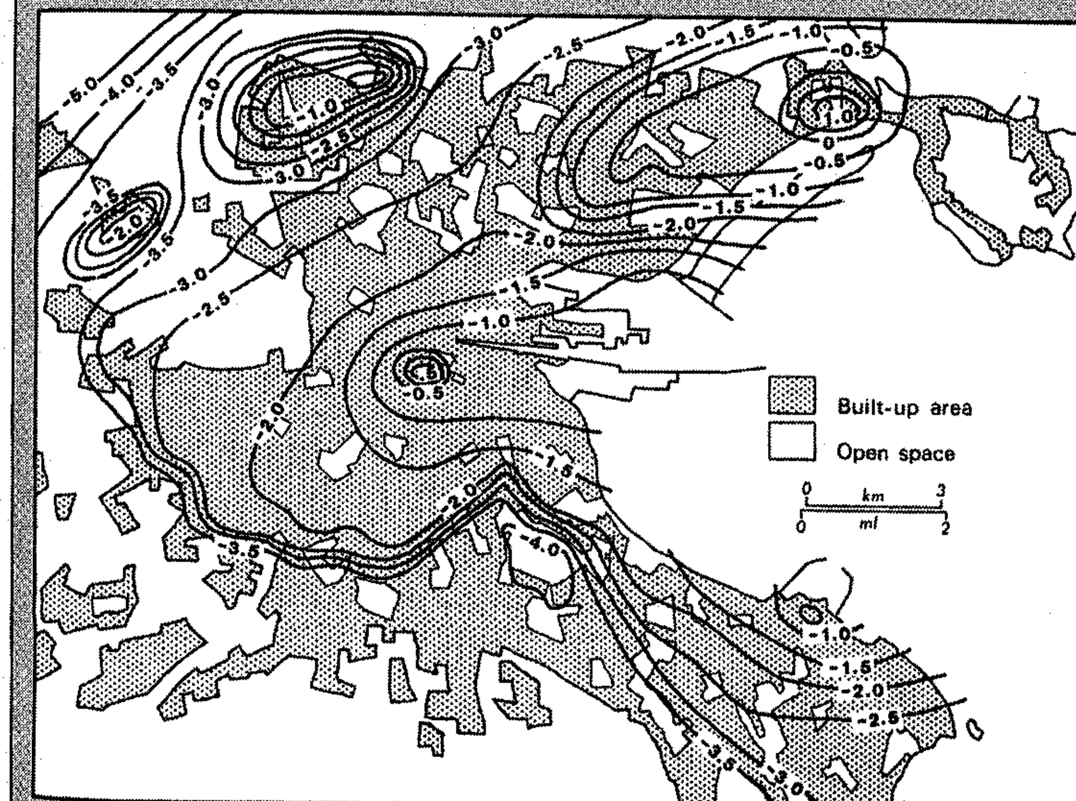

Figure 11.5 Isohyets showing Dublin's urban heat island (°C) on 22 November 1983

least, 1959. Westerly winds certainly subdued the maxima in exposed coastal areas but did not prevent Casement Aerodrome to the south-west of Dublin from recording 30.2°C on 29 June. In early August, in contrast, high pressure centred to the north encouraged an easterly airflow and it was the turn of western districts now to enjoy the warmest conditions, with maxima in excess of 30°C being widespread. Despite the record-breaking warmth of summer 1995, the highest temperature recorded in Ireland under standard conditions remains 33.3°C, measured at Kilkenny Castle on 26 June 1887 (Perry 1976). This is not a remarkably high value outside Ireland; temperatures 3 degrees C higher and more were observed in south-east England several times during the 1990s, and the comparable extreme maximum for Britain is 37.1°C (Burt 1992).

January 1987 provided an example of the synoptic conditions under which Ireland can anticipate some of its coldest weather. Betts (1987) described the conditions in Northern Ireland. On 10 January a strong anticyclone was situated over continental Europe while a depression moved south-eastwards to bring a cold polar continental airstream to much of the British Isles. This general situation persisted until 17 January, during which time Britain experienced some of its coldest weather of the century. Temperatures in Northern Ireland remained below freezing throughout the period 11–13 January. Aldergrove's maximum on the 12th was −3.2°C, whilst at Dungonnell to the north temperatures failed to rise above −4.5°C. The minima was also exceptionally low, falling to below −10°C at Newry (County Down) and at Loughall (County Armagh). Minima of −8°C were widespread, and on this occasion coastal districts were scarcely more than a degree or so warmer (Downpatrick, for example, noted −5.0°C) in strong easterly winds.

Generally, Ireland suffers less from very low minima than the rest of the British Isles. The absolute minima of −19.1°C (Markree Castle, County Sligo, 16 January 1881) and −19.4°C (Omagh, County Tyrone, 23 January 1881) are comparable to values reached in the end-of-year cold polar outbreak in central Scotland in 1995 and have been surpassed on several occasions by cold snaps even in southern England. Table 11.2 shows the overall contrast between coastal and inland locations for extreme temperature values, with maxima of over 30°C being more than a once in a century event at coastal locations though of less than a once in a half-century occurrence inland. Similarly, a value of approximately −7°C occurs every second year in the central plain, though only once in a hundred years at Valentia.

These spatial contrasts in temperature mean that frost susceptibilities, accumulated degree days, and therefore the length and efficiency of the thermal growing season are largely regulated by winter temperature variations.

Causes and Incidence of Frost

One of the situations most likely to give rise to frosts has been discussed in the preceding paragraphs. Generally, along the south, west and north-west coasts air temperature falls below freezing only on about ten nights during a typical winter. Frost may, however, be experienced on up to sixty-five nights in the midlands, especially where katabatic ponding of chilled air occurs. This may be common especially along the river valleys of the Barrow, Nore and Suir; the Shannon's multitude of lakes inhibits low nocturnal temperatures. The enclosed depressions in the karst limestone areas of north-west Clare make ideal frost hollows, and though extremely cold air is rare at this westerly location it does appear that in some circumstances substantial frost hollow effects can occur in such poljes. Reports from the cold winter of 1947 of cattle perishing in the Carran depression may be indicative of this (Haughton 1953). Sharp contrasts in the date of early and late frosts occur with distance from the coast. Along the south coast the last air frost of spring (2-year return period) is around 1 March; along the other coasts it is 1 April, and this recedes to 1 May throughout much of the rest of the island. Air frosts have been recorded in every month of the year at low elevations, though rarely from June to the end of September (Rohan 1975).

If an air temperature of 5.6°C is selected as corresponding to a soil temperature of 6°C, at which grass growth commences, the all-year-round growing season of the south coast gives way to 220 days of growth in the extreme north-east of the island. Of course altitude is the main determinant of growing season changes, with losses of about twenty days for every rise in altitude of 150 m. Frequently, it is wind and moisture excesses that limit cultivation at higher levels and not temperature alone, though in Northern Ireland isolated areas of crops may be found up to 300 m ASL (Betts 1982).

Isophene analysis shows that spring diffuses from Kerry north-eastwards over a period of about three weeks, an important economic consequence of Ireland's climate in providing a comparative advantage for the south-west in crop and cattle production. Such is the general mildness of winters in most parts of Ireland, though, that experiments comparing live-weight gains for outwintered and stall-fed cattle habitually show no significant differences between the two groups (Gleeson and Walsh 1967).

Table 11.2 Extreme temperatures in Ireland and their return periods

Location	Return period (years): 2		5		10		50		100	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Inland										
Birr	26.0	−7.3	27.8	−9.7	28.9	−11.4	30.7	−14.4	31.4	−15.5
Phoenix Park	25.5	−7.4	27.2	−9.8	28.3	−11.4	30.5	−14.4	31.3	−15.7
Coastal										
Roche's Point	23.0	−1.9	24.3	−2.9	25.0	−3.8	26.8	−5.2	27.4	−5.7
Valentia	24.9	−3.3	26.5	−4.6	27.4	−5.3	29.1	−6.7	29.5	−7.2

PRECIPITATION

In terms of its ability to convert oceanically derived water vapour into precipitation, Ireland possesses one of the world's most efficient climatic regimes. Located on an oceanic margin where an abundant supply of water vapour exists, and sitting astride the main depression tracks of the north-eastern Atlantic, Ireland has both the raw materials and the forcing mechanisms to ensure that precipitation will be a central feature of its climatology. The orographic effects of a relief configuration where all the land above 750 m lies within 56 km of the coast further emphasises these relationships.

Spatial and Seasonal Characteristics

The 1961–90 annual distribution confirms first the classic west-to-east gradient, with isolated mountain areas in the south and west receiving over 3,000 mm annually, compared with less than 750 mm for the Dublin area (Figure 11.6 and Table 11.3). The highest annual totals invariably occur in the west. In 1964, for example, 4,235 mm of rainfall was measured at Glenvickee, County Kerry (126 m ASL), though some insplashing from obstacles near the gauge may render this figure somewhat suspect (Rohan 1975). In contrast, some particularly dry years have been observed in eastern Ireland, such as 1887, when only 357 mm of rainfall was recorded at Dublin (Glasnevin). Second, the intimacy of the interaction between relief and receipt is clear, with significant rain shadow effects in the lee of the uplands, east of the Donegal and Wicklow Mountains and south east of the Cork and Kerry Mountains. Perhaps the strongest expression of the shelter effects of the surrounding topography is apparent in the upper parts of the Shannon estuary, where annual totals less than 1,000 mm are more typical of the English Midlands or the South

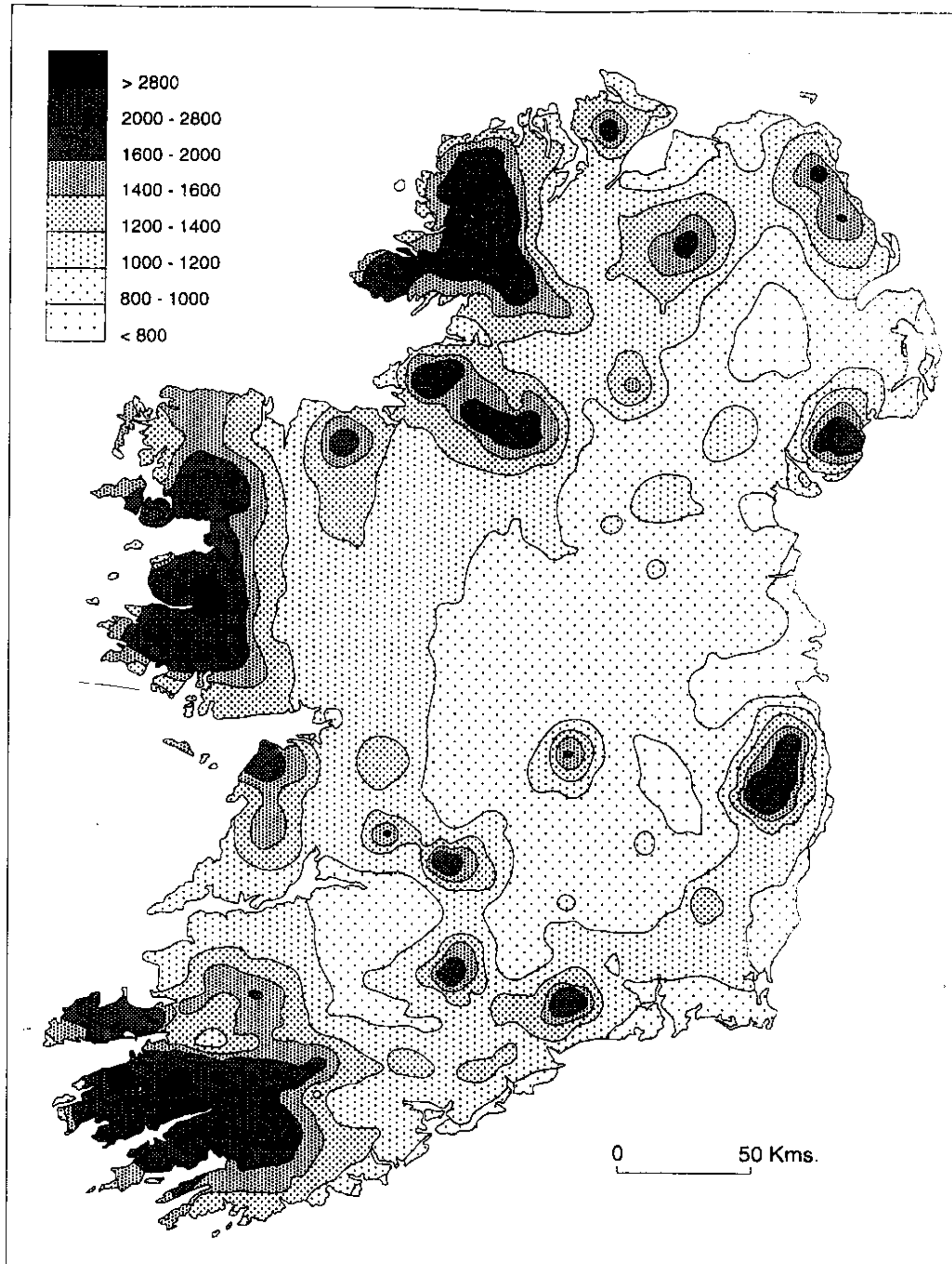

Figure 11.6 Mean annual precipitation for the period 1961–90

Table 11.3 Mean monthly and annual precipitation totals (mm) for the period 1961–90

Location	*Alt. (m ASL)*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Malin Head	25	114	77	87	58	59	65	72	92	102	119	115	103	1,061
Aldergrove	69	86	58	68	53	60	63	64	80	85	89	78	78	862
Belmullet	10	124	80	96	57	68	68	68	94	109	134	127	119	1,143
Dublin (Casement)	81	70	50	54	51	55	56	50	71	66	70	64	76	733
Shannon Airport	6	98	72	71	56	60	63	57	82	82	93	95	99	927
Valentia	9	167	123	122	77	89	80	73	111	125	157	147	159	1,430
Cork Airport	154	148	116	97	70	84	68	65	90	97	126	109	136	1,205
Mangerton, Co. Kerry	808	402	297	280	177	196	174	168	223	266	340	316	391	3,230

Note: ASL = above sea level

Downs than the west coast of Ireland. This area enjoys the protection of the mountains of Connemara and north Clare in northerly airstreams, and the mountains of Cork and Kerry in southerly airstreams. It is therefore largely dependent on precipitation borne only on westerly winds. This is the only location where the 1,000 mm isohyet reaches the west coast, which probably means that this is one of the most sensitive locations in Britain or Ireland to changes in the frequency of westerly-borne precipitation. Indeed, during the lull in westerliness in the 1960s and 1970s, the annual rainfalls at Shannon Airport, for example, have shown a significant downward trend (Sweeney 1985). Such contrasts are also overlain with other spatial gradients at a less significant scale, such as the north–south contrasts identified by Perry (1972). Most often these relate to preferred depression tracks, and the trend is most marked with systems passing to the north. Overall, however, the highest totals invariably occur in the west.

The spatial contrasts in annual receipt do not derive from contrasts in intensity, but rather from contrasts in duration. Precipitation is observed for about 6.5 per cent of the time in the Dublin area (comparable with much of lowland England), as compared with over 10 per cent of the time at sea level in the west. The number of days with rain changes from 150 to approximately 240 at these two locations and it is not uncommon for rain to be measured on all but three or four days during wet winter months along the western seaboard. Indeed, the recent increase in westerly circulation frequency (Mayes 1991) has caused severe hardship in some areas, especially in parts of counties Clare and Galway which are particularly exposed to airflows from this direction (see Box 11.2).

Some of the contrast between the east and the west is also due to a seasonal imbalance. For most parts of Ireland the February to July period is significantly drier than August to January (Logue 1978). This is especially so in western areas (Figure 11.8), and is undoubtedly related to the role of sea surface temperatures. During winter the warmth of the offshore areas means that convection is concentrated on the westerly areas; indeed, thunderstorm days reach a maximum in winter in western Ireland, in contrast to most places in Britain, where a marked summer maximum exists. Typically, thunder is observed on six or seven days per year: Valentia's annual mean is 7.1 days, Clones's 5.7 days and Cork's only 3.7 days. These frequencies are less than one-third of those from parts of south-east England. Summer is the most thundery of the seasons in most areas but in south-west Ireland at locations such as Valentia (Figure 11.9) about 50

Box 11.2

THE RETURN OF THE WESTERLIES AND WINTER WETNESS IN WESTERN IRELAND

After a long period of declining westerlies, signs of a resurgence in westerly circulation frequencies appeared in northern and western parts of Britain and Ireland during the 1980s and 1990s (Mayes 1991). This has meant increased winter rainfall in parts of western Ireland without the benefit of mountain shelter, in particular the coastal lowlands between Galway Bay and the Shannon estuary. Winter 1994/95 exemplified the problem, with many areas receiving double their normal winter complement of rainfall. Figure 11.7 illustrates the problems of these areas, many of which are karstic limestone areas with high winter water tables. This makes the flooding problems acute and long-lasting into the spring. At Gort, County Galway (155 m ASL), for example, it will be seen that measurable rain was recorded on every day except one between 1 December 1994 and 1 March 1995. Seventy-one wet-days (days with more than 1 mm of precipitation) were recorded during these eighty-nine days of winter 1994/95, with total amounts of 713 mm during this period (and in excess of 1,077 mm for the October to March period as a whole). It is hardly surprising that flooding of much farmland persisted well into the spring. In the longer term the picture is not promising since wetter winters in western Ireland seem to be likely consequences of CO_2-led global climate changes.

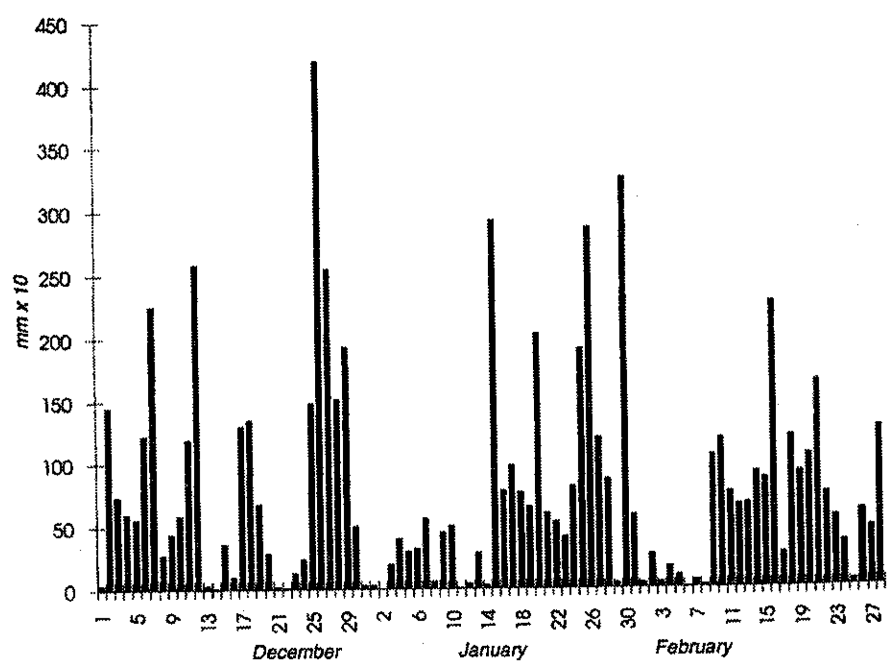

Figure 11.7 Daily rainfall (mm) at Gort (Derrybrien), Co. Galway, during the winter 1994–5

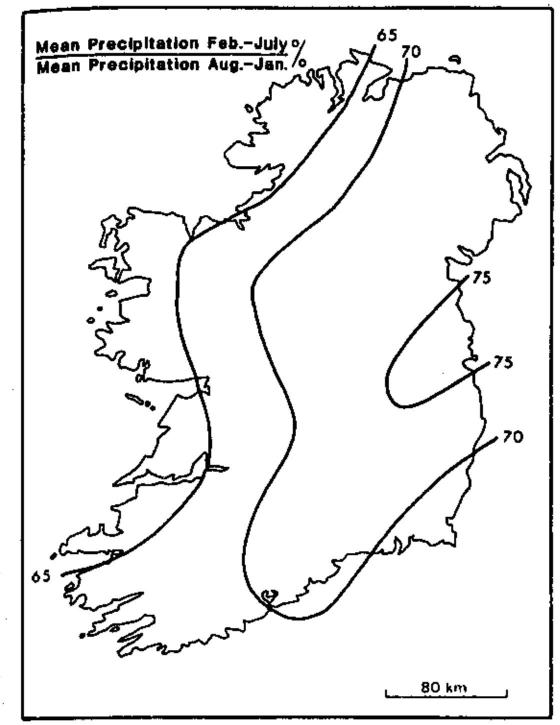

Figure 11.8 Seasonality in precipitation: February to July as a percentage of August to January totals

per cent of observations occur in the three winter months. The abiding warmth of the summer of 1995 has already been described. The frequently anticyclonic conditions also imposed stability on the atmosphere and limited the scope for thunderstorm activity despite the notably high surface temperatures. Nevertheless, occasional interruptions to this regime did occur, especially towards the close of June when southern Ireland experienced widespread thunder, hail and intense rainfall (Meskill 1995a). On 30 June a weak front over northern districts disturbed the atmosphere's stability by introducing cold air at high level. During the afternoon a convergence zone between south to south-east and north-easterly winds developed over the Galty Mountains to the north of Cork. Deep cumulus clouds formed in the rising air above the high ground where instability was sufficient to sustain several hours of intense thunderstorm activity. Rainfall, though typically localised, exceeded 30 mm in many places and hailstones of 20 mm diameter were recorded.

The oceanic warmth also assists the transfer of sensible and latent heat to frontal systems which are at their most active at this season in western parts. During summer, by contrast, the main focus of convective activity is over land, especially the warmer areas of the east. This characteristic is seen in Figure 11.9, where the Clones and Aldergrove monthly thunder frequencies have a marked summer peak. Even stable westerly airflows may be rendered unstable by heating from below in their passage across the island, and cloud cover and rainfall amounts may increase from west to east on such occasions. The east thus gains a convective summer rainfall component which balances out its annual regime of precipitation. The wettest month over the century of records from the Phoenix Park in Dublin for example is August – rather unexpected for an island often heralded as exemplifying a maritime-controlled climate.

Daily extremes of rainfall tend not to be associated with frontal passages alone, of which there are about 170 in a typical year, but rather where orographic and/or convectional enhancement occurs, especially in summer. The two highest 24-hour totals exemplify this. First, the Mount Merrion thunderstorm of 11 June 1963 produced 184.2 mm in a 24-hour period in this south Dublin suburb. Some 75 mm of this amount fell in one hour (Morgan 1971). The annual average precipitation at this site is approximately 800 mm. In this case the urban heat-island was probably also an instrumental factor in intensifying convective influences. Even more exceptional, however, was the remnants of Hurricane Charley, which produced 24-hour falls of up to 280 mm in the Wicklow Mountains on 26 August 1986 (see Box 11.3 and Figure 11.10).

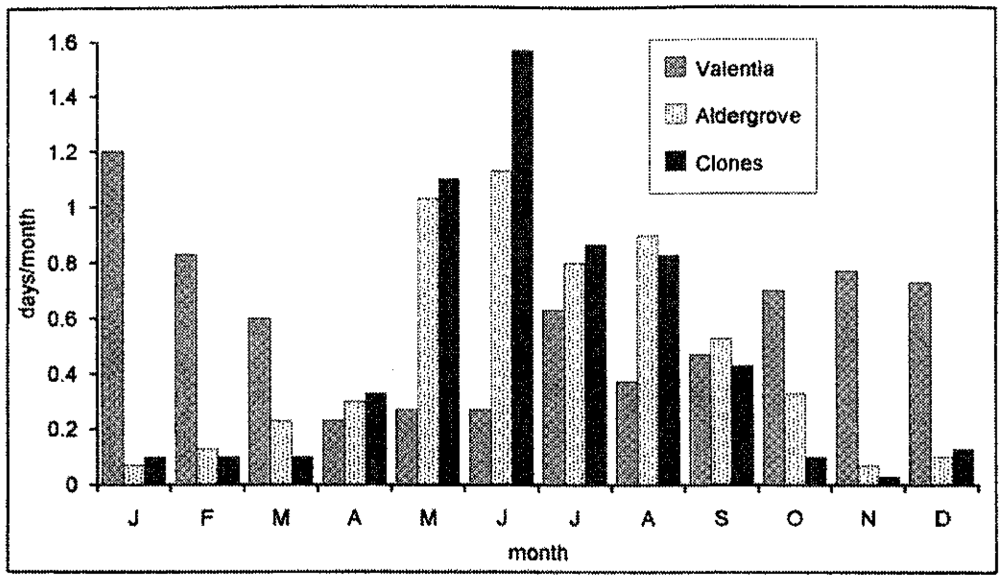

Figure 11.9 Mean monthly number of days with thunder for the period 1961–90

> **Box 11.3**
>
> **HURRICANE CHARLEY – 25 AUGUST 1986**
>
> What is popularly known in Ireland as 'Hurricane' Charley can be traced back to a tropical storm which appeared off the coast of the Carolinas (USA) on 15 August 1986. Strengthening to formal hurricane status by the 17th, the disturbance tracked eastwards across the Atlantic and became incorporated into the mid-latitude circulation as a progressively weakening depression. On 24 August, when it was still over 500 km south-west of Kerry, it began to deepen rapidly. Over the next twenty-four hours it tracked along the south coast and into the Irish Sea, where it produced gusts in excess of 55 knots (force 10) and exceptionally large amounts of rainfall in the east and south of the country.
>
> Although an estimated 280 mm of rain fell at Kippure (about double the average August total) this site is located at 750 m ASL and is not considered representative for official purposes. However, at Kilcoole, a lowland station just south of Dublin, 200 mm was measured for the day, thereby setting a new maximum daily record for Ireland. Over extensive areas of eastern Ireland record amounts of rainfall were recorded, enhanced by orographic lifting of this tropical airstream over the eastern slopes of the Wicklow Mountains (Figure 11.10).
>
> Major geomorphological changes in the uplands were caused by the swollen mountain rivers and, inevitably, further downstream, severe problems arose, where the worst flooding for a century occurred in Dublin city. Both of the river Liffey's mountain tributaries, the Dargle and the Dodder, burst their banks during the height of the storm and flooded a total of 416 houses in the city, some to a depth of 2.5 m. Floating debris threatened to block the arches of city centre bridges dangerously close to being overtopped. Many thousands of trees were blown over, particularly fine old deciduous trees in full leaf and thus at a considerable aerodynamic disadvantage.

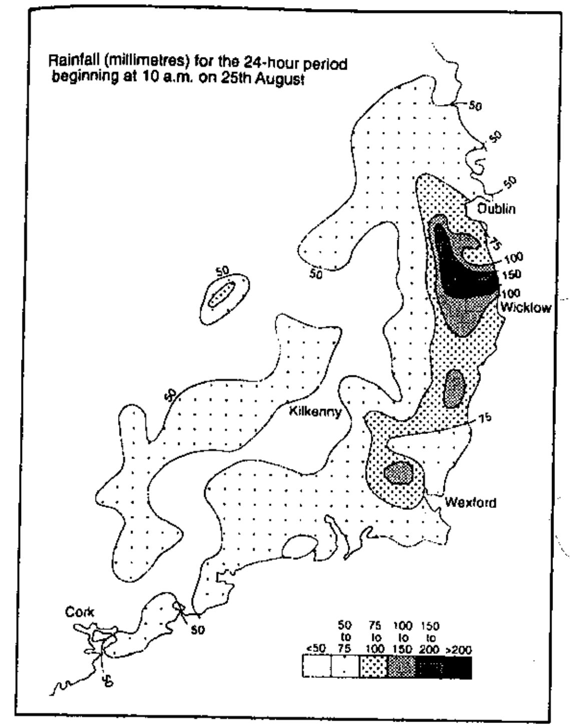

Figure 11.10 Rainfall in south-east Ireland associated with the passage of Hurricane Charley (for the 24 hours beginning 1000 GMT on 25 August 1986)

Snowfall

With January and February mean temperatures over 4°C, snowfall is not a major component of Ireland's precipitation regime. At locations near sea level, snow seldom persists for more than a day or so and is most likely to linger in the eastern and north-eastern interior areas where maritime influences are minimised. At all sites snow is observed to fall on far more days than it is seen to lie. Aldergrove has the highest number of days with snow or sleet observed to fall (averaging thirty-five days per year) but the cooler inland locations of Birr, Mullingar and Clones tend to record higher number of days with snow lying (the annual average at Clones is 11.3 days, one of the highest in the Republic). By way of a contrast, Valentia averages less than six days with snow or sleet falling, and in many southern parts no significant falls of snow occur in one year out of two. Valentia's average annual total of days of snow lying is only 0.9. Elsewhere the annual mean ranges mostly between two and seven days. The western mountains are remarkably free of heavy snowfalls, and westerly airstreams seldom cool sufficiently in their passage over these areas. Rather it is the mid-winter blast of continental polar air as the Siberian anticyclone grows westwards across Europe that ushers in bitterly cold air from the east. In its passage across the North Sea and then the Irish Sea enough moisture may be picked up to provide sometimes significant snowfalls in eastern coastal areas. Characteristically, though, it is the polar northerlies, often with small embedded polar lows, which brings the risk of heaviest falls, particularly if the boundary with warmer maritime air is stationary in the vicinity of Ireland. Snow rarely lies at low level beyond April anywhere in Ireland and is equally uncommon before November. Figure 11.12 shows that the snow 'season' is longer at more exposed locations such as Malin Head than at Valentia, which is protected from snow-bearing northerlies.

Synoptic Origins of Irish Precipitation

The sensitivity of precipitation receipt to airflow type can be demonstrated by mapping yields according to Lamb circulation types (Figure 11.13). This demonstrates that it is S, C and W airflow types that produce the heaviest falls of rain. Of these, the C type produces a relatively even distribution of precipitation across the island with only a slight reduction in the interior where oceanic water vapour may be less abundant. There appears to be a significant increase in rainfall with C airflows along the County Antrim coast, and this may well reflect the destabilising effect of the North Channel under such unstable conditions (Sweeney and O'Hare 1992), as well as convergence in low-level airflows as they squeeze between the Antrim Plateau and the Southern Uplands of Scotland.

West–east contrasts are, as expected, most marked with westerly circulations. Receipts in the extreme

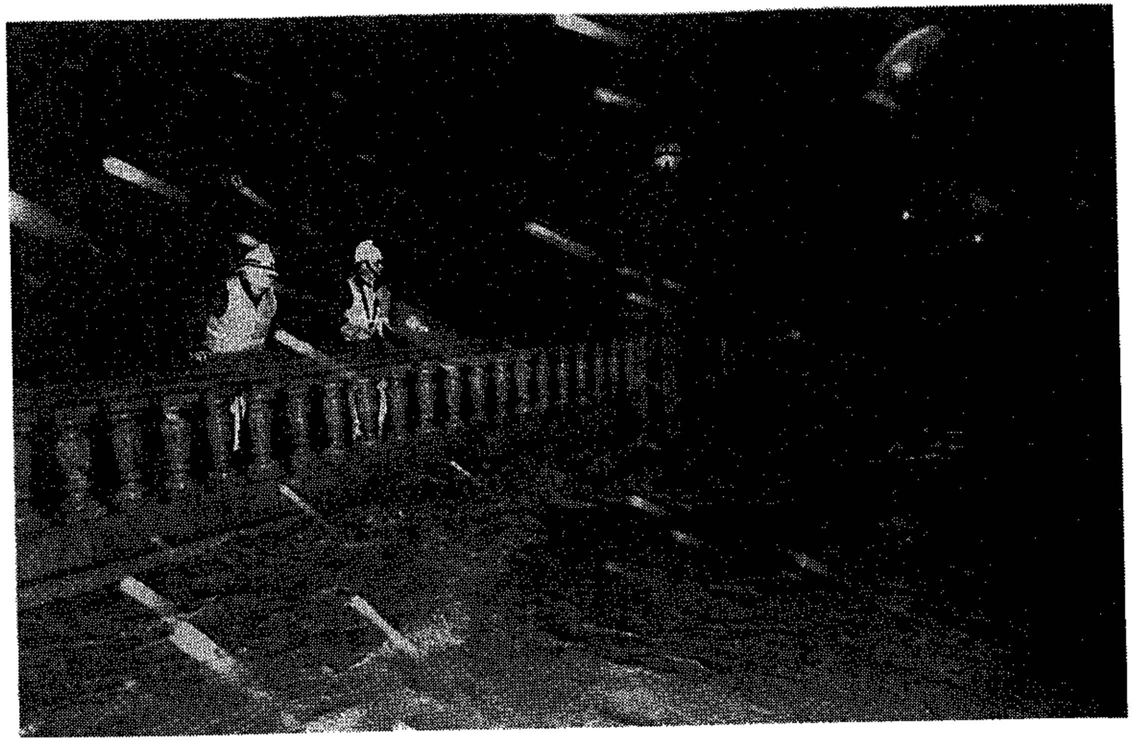

Figure 11.11 Firemen monitoring the level of the river Dodder in central Dublin as it threatens to overtop the parapet of Ball's Bridge, 26 August 1986
Photo by courtesy of the Irish Times

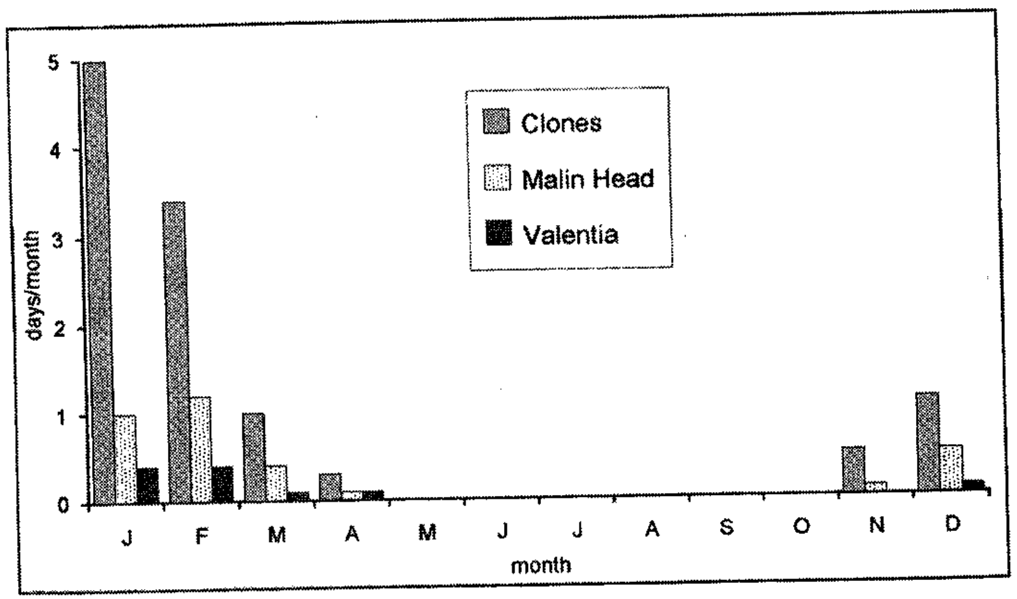

Figure 11.12 Mean monthly frequency of days with snow lying and covering more than 50 per cent of the ground at 0900 GMT for the period 1951–80, Malin Head, 1956–80

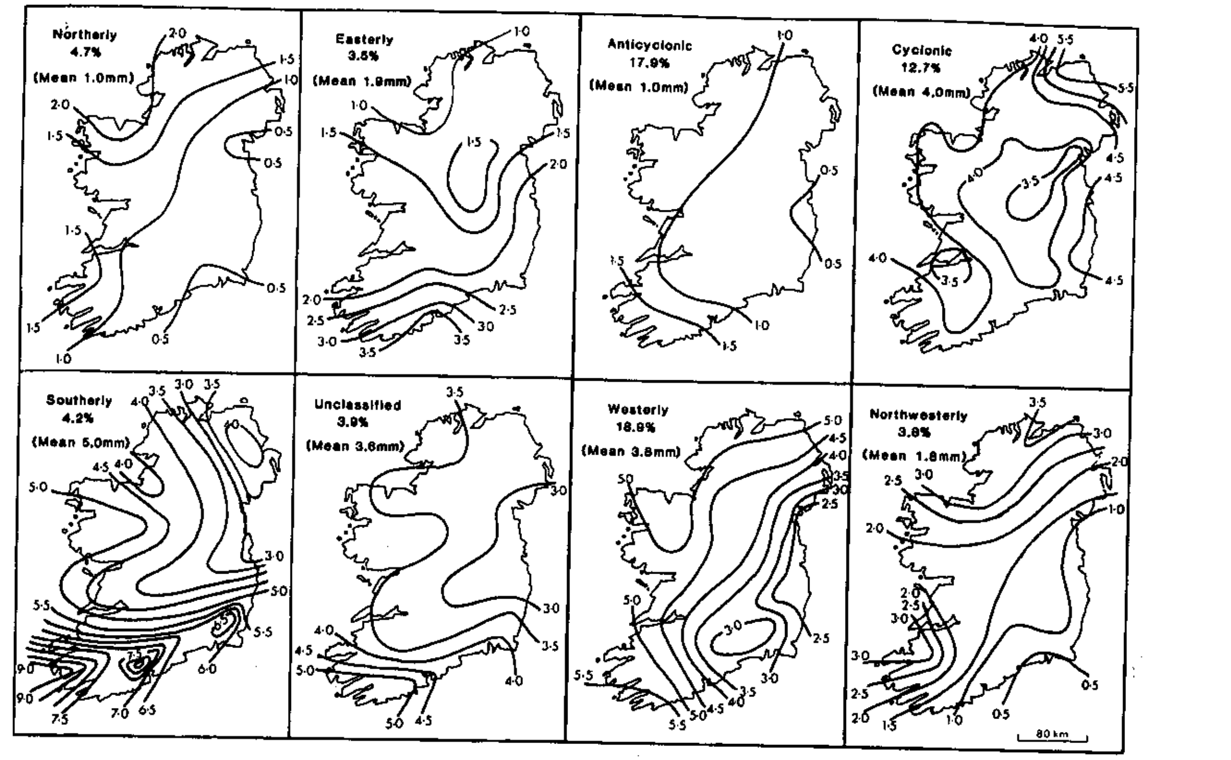

Figure 11.13 Geographical distribution of rainfall under different Lamb airflow types

west may be up to three times those along the east coast, especially in the shelter of the Wicklow Mountains. The dry winter of 1988/89 produced in Ireland a similar response to that over the British Isles as a whole, with an intensification of the west-to-east rainfall gradient as a consequence of the dominant westerly airflow (Betts 1990). On the other hand, May 1989 was generally dry in response to the pervasive anticyclonic character of the weather, the usual rainfall gradient being diminished at this time. The persistence of dry weather during much of 1988 and 1989 provoked problems of water shortages not usually associated with a country widely regarded as having an abundance of rainfall.

Different synoptic conditions can provide distinctive spatial patterns of rainfall. In easterly airflows marked rain shadows can be seen to the west of the Wicklow Mountains. Interestingly, Cork City experiences a daily average rainfall amount from westward-moving air across the Celtic Sea similar to that it receives from eastward-moving Atlantic airflows. Southerly circulations, especially in autumn when the sea offshore is warmest, are the highest rainfall-yielding airflows in Ireland, and this confirms the role of sea temperatures as the root cause of the autumn and winter maximum in most of the island.

Since cyclonic and westerly circulations account for about two-thirds of Irish rainfall, changes in the balance between these are of great potential significance for the national pattern. The make-up of the precipitation totals at four synoptic stations are shown in Figure 11.14. It is apparent that in eastern Ireland C airflows are the dominant provider, while in the west it is generally W airflows which are most important. Major reductions in the frequency of westerlies have occurred between the 1930s and the 1970s. The effect of these can be seen in the

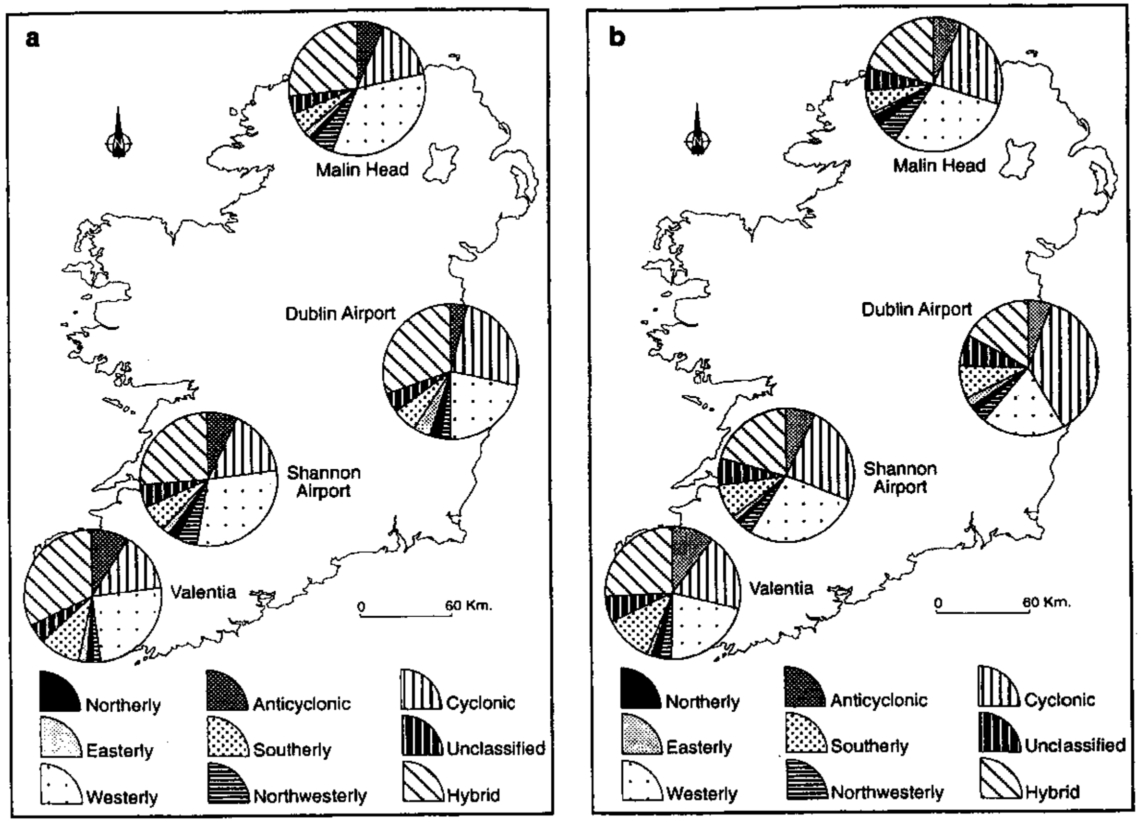

Figure 11.14 Contributions to annual totals at Malin, Shannon, Dublin and Valentia from Lamb circulation types for the periods (a) 1861–1961 and (b) 1961–90

precipitation make-up of the stations for the two periods also depicted in Figure 11.14.

Potential evapotranspiration averages 450–500 mm throughout the island, resulting in moisture surpluses at lowland locations ranging from 200 mm in the east to over 700 mm in the west. Potential evapotranspiration is highest during the best summer month, June (approximately 75 mm). From June on, therefore, soil moisture deficits may become pronounced in eastern parts. In dry summers these may become acute by September, making irrigation desirable on cultivated soils derived from sandy fluvioglacial deposits, particularly for vegetables and sugar beet. On average deficits in excess of 75 mm, measured at the end of 10-day periods, occur approximately four times per year in eastern parts, and water supply problems occur, especially in Northern Ireland (Betts 1990). During the exceptional summer of 1995 deficits in excess of 100 mm were recorded along much of the east coast of Leinster.

WIND

Wind is the most feared of the meteorological elements in Ireland, and severe storms are etched indelibly in the public consciousness. The Irish language has a rich variety of descriptors for wind hazards, perhaps inevitably in an island where the relatively frictionless surface of the sea is close by and where the North Atlantic depres-

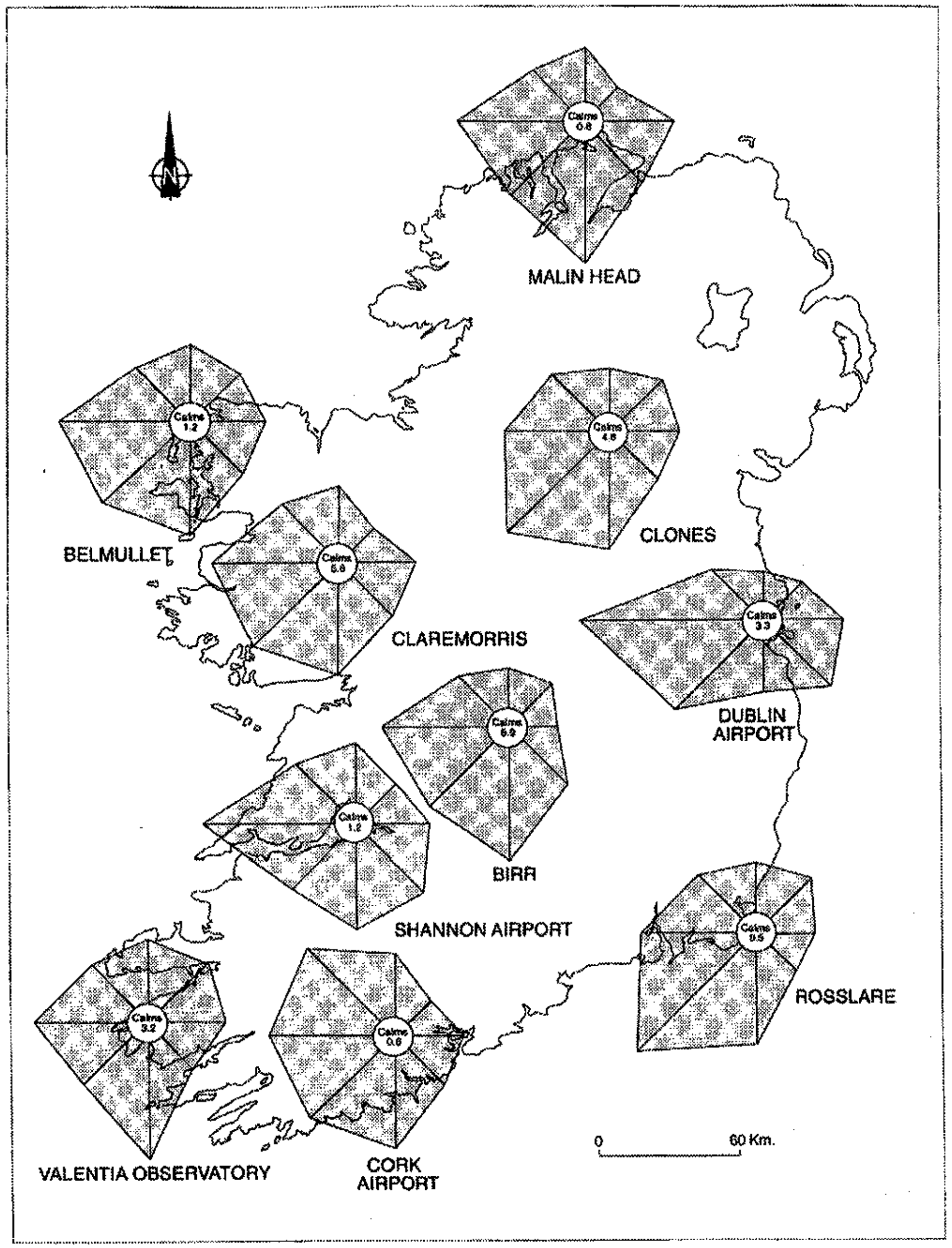

Figure 11.15 Wind roses for the period 1951–80

sions are often at their most mature state. For the fisherman of north-west Donegal, or the farmer from Clare, the ferocity of wind is a reality not often appreciated by the urban dweller of eastern Ireland, or the Brussels bureaucrat.

As with all regions of Ireland and Britain, the prevailing wind directions are from the southwest, though all quadrants except north and east are generally well represented in the annual wind rose (Figure 11.15). Directional frequencies are, however, modified considerably by the sheltering effect of nearby relief features. This is clearly seen in the reduction of southerly frequencies at Shannon and Dublin Airports, where funnelling of winds from the west and south-west along the river valleys is implied. Figure 11.16 shows a good example of the sheltering effect at Dublin Airport in July 1995. Such funnelling has also been noted in various locations in Northern Ireland, such as the Foyle valley (Betts 1982).

In contrast with some other parts of the British Isles, westerlies tend to be more frequent during the summer months. The northward displacement of the Azores High tends to sharpen the south-to-north pressure gradient across Ireland at this time. Southerlies tend to peak in autumn and winter, while northerlies peak in April, contributing to delayed spring grass growth in some years. Approximately 20 per cent of the easterlies typically occur during February, associated with persistent blocking over Scandinavia which occasionally occurs at this time of the year.

A native of County Meath, Sir Francis Beaufort devised the scale of wind force which is now so widely used for relating wind speed to the movement of everyday objects such as leaves, trees, waves, etc. Force 8 (or gale force) on his scale is attained when the mean velocity over a period of not less than 10 minutes exceeds 34 knots, an event which occurs almost one day in five in north-western Ireland. It is perhaps inevitable that north and western Ireland should be one of Europe's windiest locations, close to the main depression tracks and with no sheltering landmasses upwind. Recent investment in wind farms has therefore been concentrated in the north-

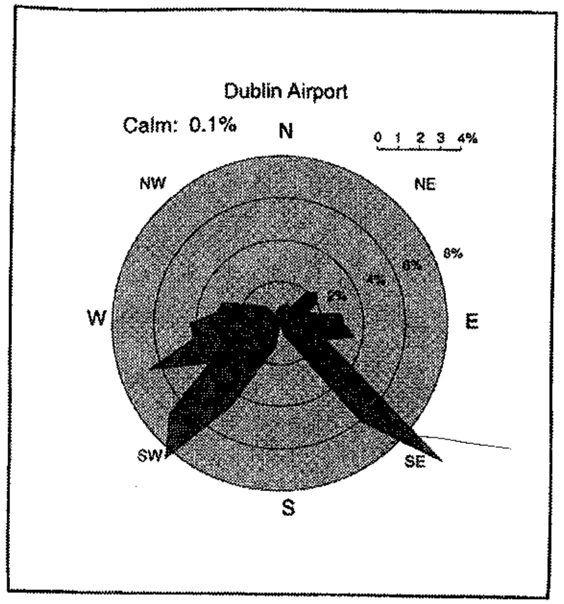

Figure 11.16 Wind rose for Dublin Airport for July 1995

west. Yet the geographical variations in wind speed across Ireland are quite dramatic, illustrating well the frictional effect of terrain in removing the worst excesses of wind, even a short distance inland.

Average annual wind speeds range from over 16 knots in the extreme north-west to approximately half this amount in the south-central part of the island. Ireland thus exhibits a spatial variation in wind climate which is similar to the Western Isles–lowland England contrast in Britain. Table 11.4 highlights this by showing that the number of days with gales falls by over an order of magnitude, from over sixty days per year along the north-west coast to just over one day per year in the sheltered parts of the Central Plain. The popular perception of Ireland as an island of high winds and copious rainfall is thus once again demonstrably an image of the north-west coast. The 'two Irelands' are highlighted, with a much more quiescent climate prevailing in the interior of the island as opposed to a more robust variant on the western perimeter.

This is not to say that intense depressions do not result in high wind speeds on occasion at all loca-

Table 11.4 Average number of gale days per month for the period 1961–90 and highest gusts observed

Location	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*	*Maximum gust (knots)*
Malin Head	11.2	8.6	8.0	3.4	2.3	1.3	0.8	1.5	3.8	6.7	8.7	9.7	66.0	98
Claremorris	1.2	0.9	1.0	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.5	0.7	5.2	96
Kilkenny	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	1.4	77
Cork Airport	3.2	2.3	1.8	0.7	0.4	0.0	0.1	0.2	0.7	1.2	1.8	2.6	15.1	94

Box 11.4

THE 'NIGHT OF THE BIG WIND' – 6/7 JANUARY 1839

This most notorious of all storms to affect Ireland was well recorded in early instrumental records and its effects dramatically reported in newspaper reports and first-hand accounts. An unusually deep depression travelling in a north-easterly direction to the north of Ireland seems to have been responsible. A pressure gradient of 37 mb seems to have existed over Ireland, producing gusts in excess of 100 knots in places (Shields and Fitzgerald 1989). Though loss of life was surprisingly low, damage to buildings, shipping and crops was severe. Between 20 and 25 per cent of the housing in Dublin was damaged and unusual occurrences were reported, such as salt deposition well inland and other 'freak' phenomena (Shields and Fitzgerald 1989), a sample of which are reproduced here.

> The damage which it has done is almost beyond calculation. Several hundreds of thousands of trees must have been levelled to the ground. More than half a century must elapse before Ireland, in this regard, presents the appearance she did last summer.
>
> (*Dublin Evening Post*, 12 January 1839)

> What appeared to be the most astonishing effect of the storm was the blowing of water out of the canal near this town. I visited it this morning, and it was nearly dry.
>
> (*Tuam Herald*, 19 January 1839)

> Trees, ten or twelve miles from the sea, were covered in salt brine – and in the very centre of the Island, forty or fifty miles inland, such vegetable matter as it occurred to individuals to test had universally a saline taste.
>
> (*Dublin Evening Post*, 12 January 1839)

> Comparing it with all similar visitations in these latitudes, of which there exists any record, we would say that, for the violence of the hurricane, and deplorable effects which followed, as well as for its extensive sweep, embracing as it did the whole island in its destructive career, it remains not only without a parallel, but leaves far away in the distance all that ever occurred in Ireland before. Ireland has been the chief victim of the hurricane – every part of Ireland, – every field, every town, every village in Ireland – have felt its dire effects, from Galway to Dublin – from the Giant's Causeway to Valentia. It has been, we repeat it, the most awful calamity with which a people were afflicted.
>
> (*Dublin Evening Post*, 12 January 1839)

tions. Table 11.4 shows also that most coastal locations experienced maximum gusts close to 100 knots during the 30-year standard observation period. It is likely that inland sites above 300 m have wind climatologies comparable to those of the exposed coastal locations. The highest wind speed at a low-level site was measured at Kilkeel in County Down during January 1974, when a gust of 108

Table 11.5 Mean monthly and annual sunshine totals (hours) for the period 1951–80

Location	*Alt. (m ASL)*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Year*
Aldergrove	68	45	66	101	158	185	177	141	142	108	81	57	37	1,298
Claremorris	69	50	68	98	140	172	154	122	130	98	78	55	38	1,203
Malin Head	25	41	64	106	158	200	182	136	145	110	75	47	29	1,293
Rosslare	25	63	77	122	179	219	212	194	183	144	109	75	57	1,634

knots was recorded. Not surprisingly, this was a storm which blew down many trees, damaged many buildings and interrupted the electricity supply for 150,000 consumers before going on to wreak further havoc in Britain. But not all storms causing damage in Britain pass over Ireland *en route*. Some of the most severe events to affect Britain, such as the October 1987 storm, passed Ireland by, as did the greatest British storm of recent centuries: Daniel Defoe's storm of 1703. Ireland was not so fortunate, however, on the night of 6/7 January 1839 when the 'Big Wind' struck large areas (see Box 11.4).

The so-called 'cyclonic bomb' whereby explosive deepening of an Atlantic depression occurs west of Ireland is the chief source of extremes of wind speed. Sometimes difficult to forecast, these are often associated with the rapid development of a secondary depression which may race across Ireland in a few hours. Even in an age of satellite observations, the value of the terrestrial Irish meteorological network in acting as an early-warning facility for areas further east is unquestionable in such circumstances.

SUNSHINE AND CLOUD

The seasonal and topographic controls on precipitation discussed above are instrumental also in explaining cloud cover and sunshine variations in Ireland. Table 11.5 shows that May and June are the sunniest months, with durations over seven hours per day in the extreme south-east of Ireland. This represents up to 46 per cent of the possible maximum figure and a sunshine regime which is very similar to that of the south-east coast of England. The north-west by contrast only manages between 5 and 6 hours during this the season of driest airflows across the country. It is striking how much of a reduction typically occurs in July and August when the European 'summer monsoon' sets in (see also Chapter 10).

December is the dullest month everywhere, with less than an hour per day of sunshine in the extreme north, representing only 13 per cent of the maximum possible even at this time of short days, and only 50 per cent of the corresponding figure for Rosslare in the extreme south east. These are values directly comparable with most of western Scotland at this time.

Sunshine data are reinforced by the cloud data, which, as expected, are almost a mirror image. Everywhere in Ireland cloud cover averages between 5.5 and 6 oktas, fairly typical of a maritime climate at these latitudes. On average skies are completely cloud covered about 33 per cent of the time and relatively clear (less than 2 oktas) about 16 per cent of the time. Cloud cover downwind of major mountain barriers may be noticeably less on occasion owing to föhn effects. This is noticeable, for example, in Dublin, which habitually enjoys higher sunshine on light southerly breezes because of subsidence after the air mass has traversed the Wicklow Mountains.

CONCLUSION

The climate of Ireland, like that of Britain, is the product of a struggle between tropical and polar air masses, a battleground invaded periodically by one or other variant of these air masses only to be reconquered by another. Thus whilst its oceanic location ensures that equability will be the major feature of its climatology, constant alternation in air mass dominance ensures that variability in weather types will be an equally striking characteristic.

The stage on which this struggle is acted out is not a featureless plain, but rather a distinctive topography of coastal upland and interior plain. This makes for a climatology of contrasts between a maritime fringe with all the oceanic influences for which Ireland is well known and an interior where shelter and continental influences produce conditions more representative of lowland England.

A winter climatic gradient from south-west to north-east, conditioned by the advection of heat energy from the Atlantic Ocean, and a summer one from south-east to north-west, reflecting a complex interplay between latitudinal, relief and oceanic influences, provides further layers of variation for the Irish climatic mosaic. This mosaic is essentially a compendium produced by the frequency of occurrence of specific airflow trajectories, and the extremes of weather embedded in them. The snapshot in time presented here will undoubtedly change in the future, as it has in the past, in response to the external forcing factors which provide the boundary conditions for the climate of Ireland.

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