THE CLIMATE OF GREAT BRITAIN

GLASGOW AND THE CLYDE VALLEY

Climatological Memorandum 124

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The front cover shows a view of Scotland from the satellite Tiros N , taken at 1518 GMT on Saturday 17 May 1980 – photograph by courtesy of the Department of Electrical Engineering and Electronics, University of Dundee.

An anticyclone was drifting slowly northwards across the Norwegian Sea, but a ridge of high pressure was still being maintained over Scotland with the result that many places in the Clyde valley recorded temperatures of around 22 °C. Glasgow Airport had over 15 hours of sunshine and the afternoon temperature there reached 23.5 °C.

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INTRODUCTION

This memorandum is one of a series which will cover the whole of Great Britain and seeks to present the main features of the climate of the area in a form suitable for use in schools and by members of the general public.

Industrial and commercial interests who are concerned with meteorological information for planning and design will probably require more complex analyses of the available data, and details of the services offered by the Meteorological Office to meet these needs are given on page 16.

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Meteorological Office, Edinburgh
March 1988

THE AREA

This memorandum describes the main features of the climate of Glasgow and the Clyde Valley, an area some 100 to 120 kilometres long, 30 to 40 kilometres wide and varying in altitude from sea level in the north-west to over 700 metres in the south. It is an area of contrasts in which the heavy industry of the lower reaches of the Clyde is offset by the wild, unspoilt countryside of the Southern Uplands.

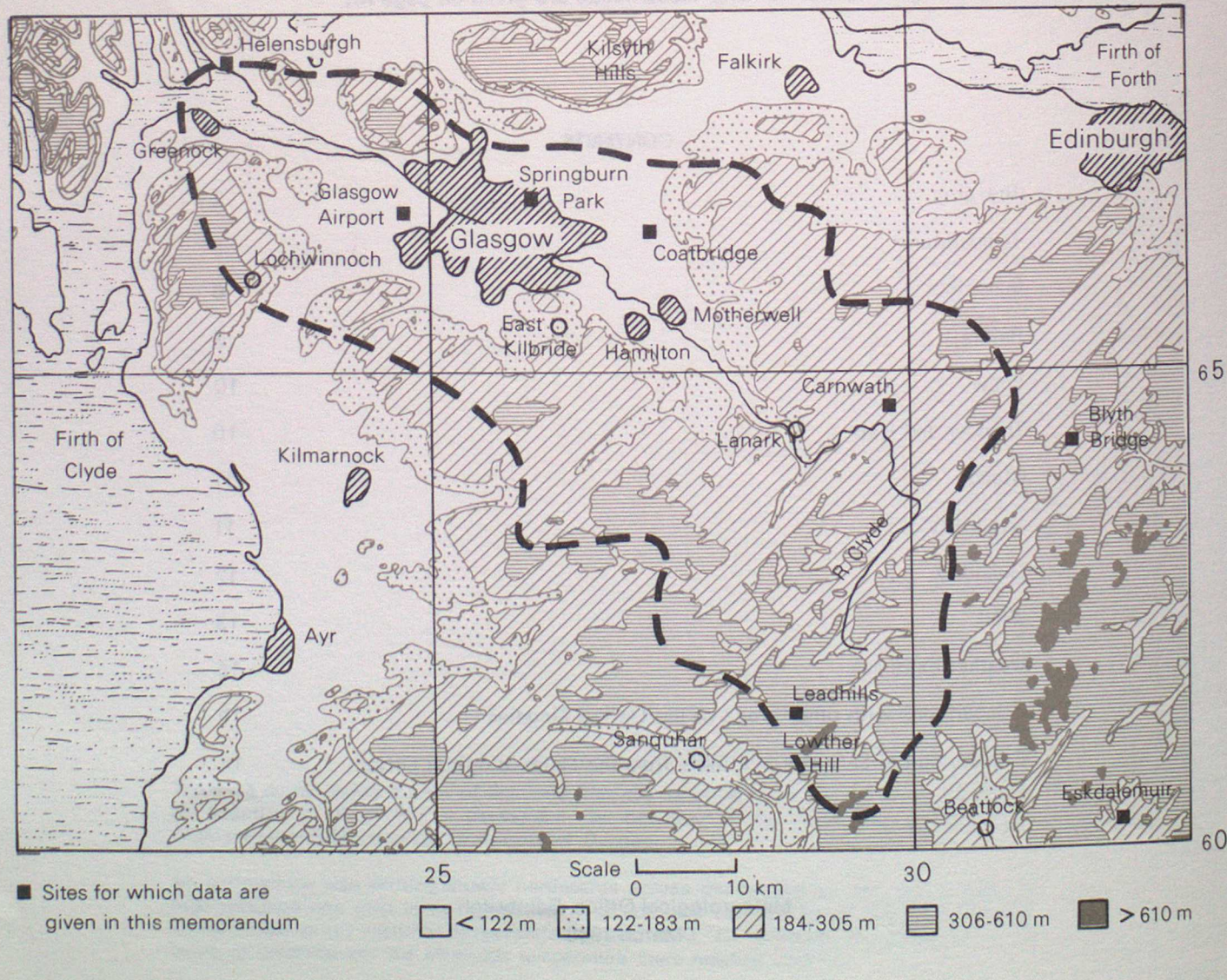
The map below shows the main topographical features of the area along with the main centres of population. Weather recording stations whose data have been used in this memorandum are also included. Within this area only the Meteorological Office at Glasgow Airport makes routine hourly weather observations. Therefore hourly data from the observatory at Eskdalemuir are used where necessary to illustrate differences at higher levels.

At the north-western extremity of the area, the river estuary widens into the Firth of Clyde with the Dunbartonshire and Renfrewshire hills reaching almost to the river banks. On the north side, the high ground continues eastwards towards the Glasgow city boundary, being broken only by the valley of the River Leven linking Dumbarton to the southern shore of Loch Lomond at Balloch. On the south side of the Clyde, the narrow coastal plain widens out between Greenock and Glasgow to give a good stretch of agricultural land before Renfrew, Paisley and the outskirts of the city are reached.

The city of Glasgow is fairly flat over much of the built-up area, although the ground rises from the city centre to a height of around 100 metres at its northern boundary. The valley of the Clyde is at its widest around Glasgow but narrows further south near the industrial areas of Hamilton and Motherwell.

By the time Lanark is reached, the valley is quite steep-sided with extensive fruit-growing areas in the valley bottom and on south-facing slopes. Outside the valley itself, most of the land lies between 100 and 200 metres above sea level with intensive agriculture giving way to hill farming and forestry as the open moors and rounded hills of the Southern Uplands are reached. To the south of Lanark, high ground predominates with the highest points being Tinto Hill (707 metres), Green Lowther (732 metres) and Culter Fell (748 metres). The main road and railway to the south run between the latter two peaks, and reach a height of around 300 metres at Beattock Summit.

Topographical map of the area. Co-ordinates are national grid reference.

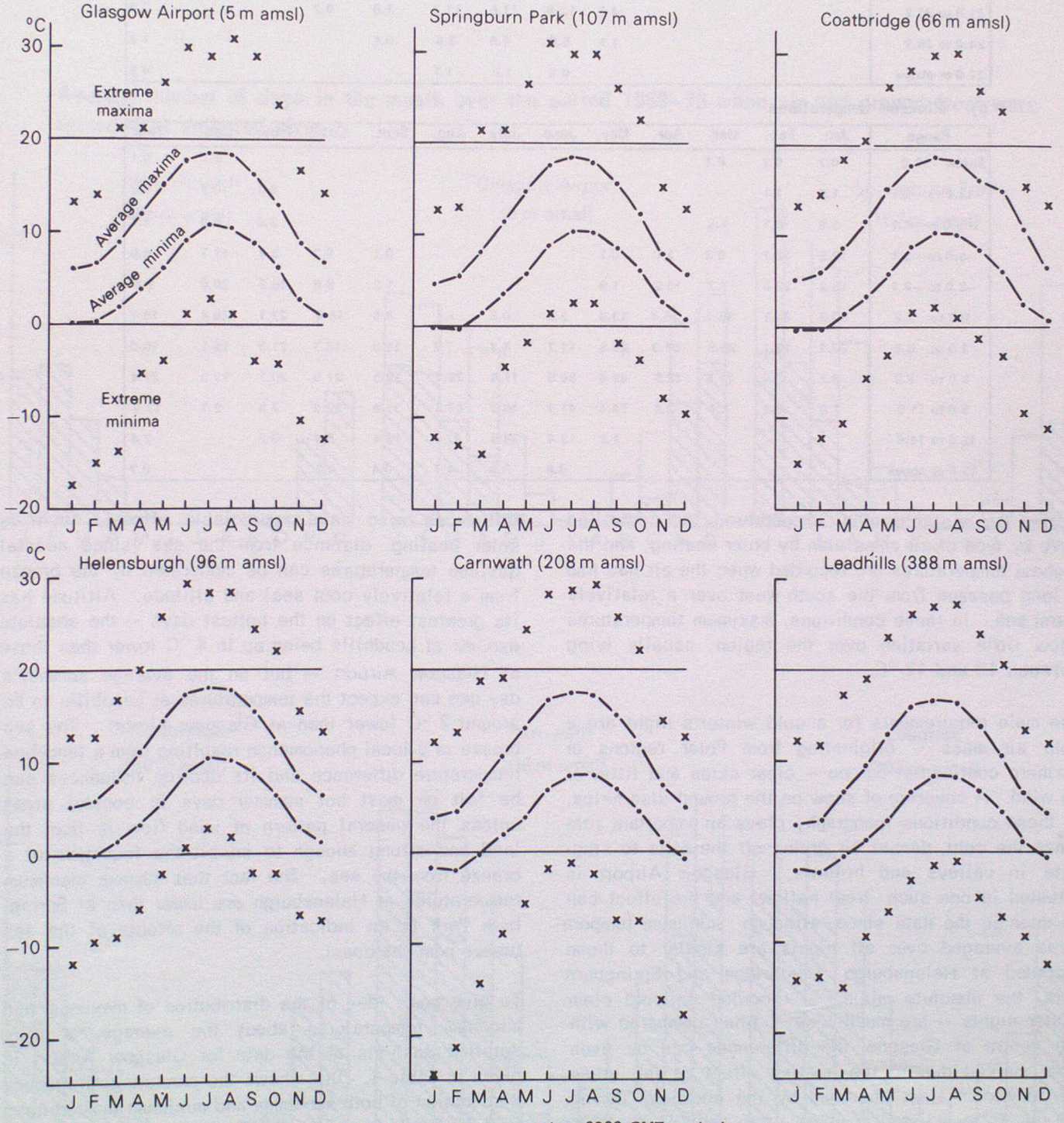


TEMPERATURE

Along with latitude, the main factors controlling the climate of any area in Great Britain are distance from the sea and altitude. In the Clyde Valley, the altitude range is 0 to over 700 metres and much of the valley is within 75 kilometres of one of three areas of sea — the Firth of Clyde, the Solway Firth and the Firth of Forth. These two factors are very important in determining the temperature regime of the area and their influences should be kept in mind when one part of the area is being compared with another.

There are a number of ways in which the temperature regime of an area can be described, of which average and absolute extreme values are probably the most familiar. For a selection of places in the area, the diagram below shows, for each month, the absolute maximum and minimum temperatures recorded during the period 1941 to 1979 and also the average values of daily maximum and minimum temperatures over the standard averaging period 1941–70.

Average daily maximum and minimum air temperatures at selected sites month by month over the period 1941–70 and the absolute maximum and minimum temperatures for each month recorded between 1941 and 1979.



Notes: 1. Data based on 24 hour temperature extremes read at 0900 GMT each day.
2. amsl = above mean sea level.
3. Observations started at Coatbridge in 1951, at Carnwath in 1952 and at Leadhills in 1953. The absolute maxima and minima shown above were recorded between these dates and 1979. The average maxima and minima shown above have been adjusted to the standard period 1941–70 by comparison with data from nearby stations.

TABLE 1 Distribution of daily maximum and minimum air temperatures (°C) at Glasgow Airport during the period 1949–78

(The information is presented as the percentage frequency of occurrence in each 3 degree range in each month and the year)

a) Maximum temperatures

Range	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Below –3.0	0.3										0.2	0.3	0.1
–3.0 to –0.1	2.3	0.7									0.8	0.9	0.4
0.0 to 2.9	12.8	10.2	1.3								2.7	8.9	3.0
3.0 to 5.9	28.6	31.1	12.6	2.2						0.1	12.0	26.6	9.3
6.0 to 8.9	31.6	35.3	36.5	13.9	1.1				0.1	5.5	32.2	33.1	15.7
9.0 to 11.9	23.1	20.9	38.8	36.5	13.8	0.9	0.2		2.4	23.4	38.5	26.3	18.7
12.0 to 14.9	1.3	1.9	9.2	32.8	38.1	13.9	4.5	4.4	25.0	48.2	13.2	3.9	16.4
15.0 to 17.9			1.5	12.3	30.0	45.2	40.4	42.9	53.0	20.0	0.3		20.6
18.0 to 20.9			0.1	2.2	11.5	21.3	37.0	36.1	15.0	2.6			10.6
21.0 to 23.9					4.5	12.9	11.6	11.9	3.9	0.2			3.8
24.0 to 26.9					1.1	5.0	4.6	3.5	0.4				1.2
27.0 or above						0.8	1.6	1.1					0.3

b) Minimum temperatures

Range	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Below –12.0	0.7	0.2	0.1									0.1	0.1
–12.0 to –9.1	1.8	1.1	–								0.2	0.7	0.3
–9.0to –6.1	5.8	6.1	1.8								2.0	4.9	1.7
–6.0 to –3.1	12.2	12.2	6.3	2.0	0.1				0.1	0.7	8.4	11.7	4.5
–3.0 to –0.1	18.2	22.6	17.7	13.2	1.9				1.8	6.6	16.5	20.0	9.8
0.0 to 2.9	30.6	33.1	35.1	28.4	13.9	2.5	0.2	1.1	4.8	14.0	27.1	28.4	18.1
3.0 to 5.9	20.4	17.1	26.9	31.3	25.9	11.7	4.2	7.2	12.0	18.7	21.9	19.1	18.0
6.0 to 8.9	9.2	7.4	11.6	22.5	42.6	30.9	17.8	20.1	29.5	31.0	20.7	12.9	21.4
9.0 to 11.9	1.0	0.2	0.4	2.4	14.4	41.7	46.1	40.3	37.9	23.8	2.9	2.1	17.9
12.0 to 14.9					1.2	12.4	28.6	27.0	13.4	5.1	0.2		7.4
15.0 or above						0.8	3.0	4.3	0.4	0.2			0.7

During the winter months, temperatures are controlled more by type of air mass than by solar heating, and the highest temperatures are recorded when the air has had a long passage from the south-west over a relatively warm sea. In these conditions, maximum temperatures show little variation over the region, usually lying between 10 and 12 °C.

The main requirements for a cold winter's night are a cold air mass – originating from Polar regions or northern continental Europe – clear skies and little or no wind. A covering of snow on the ground also helps. In these conditions topography plays an important role since the cold, denser air drains off the hills to stagnate in valleys and hollows. Glasgow Airport is situated in one such 'frost hollow' and the effect can be seen in the data since, although minimum temperatures averaged over all nights are similar to those recorded at Helensburgh, Coatbridge and Springburn Park, the absolute minima – recorded on cold clear winter nights – are much lower. When compared with the centre of Glasgow the differences can be even more marked due to the heating effect of the urban environment. Heat absorbed by the buildings during the day is re-radiated at night, often keeping minimum temperatures at Glasgow Weather Centre (in Waterloo Street) as much as 5 or 6 °C above those at the Airport.

In summer, the air mass is still important, but other influences also have appreciable effects, such as solar heating, distance from the sea (since coastal daytime temperatures can be moderated by the breeze from a relatively cool sea) and altitude. Altitude has its greatest effect on the hottest days – the absolute maxima at Leadhills being up to 4 °C lower than those at Glasgow Airport – but on the average summer's day one can expect the temperatures at Leadhills to be around 2 °C lower than at Glasgow Airport. The sea breeze is a local phenomenon resulting from a land/sea temperature difference and its cooling influences can be felt on most hot summer days in coastal areas unless the general pattern of wind flow is from the land and strong enough to inhibit the formation of a breeze from the sea. The fact that summer maximum temperatures at Helensburgh are lower than at Springburn Park is an indication of the effects of the sea breeze near the coast.

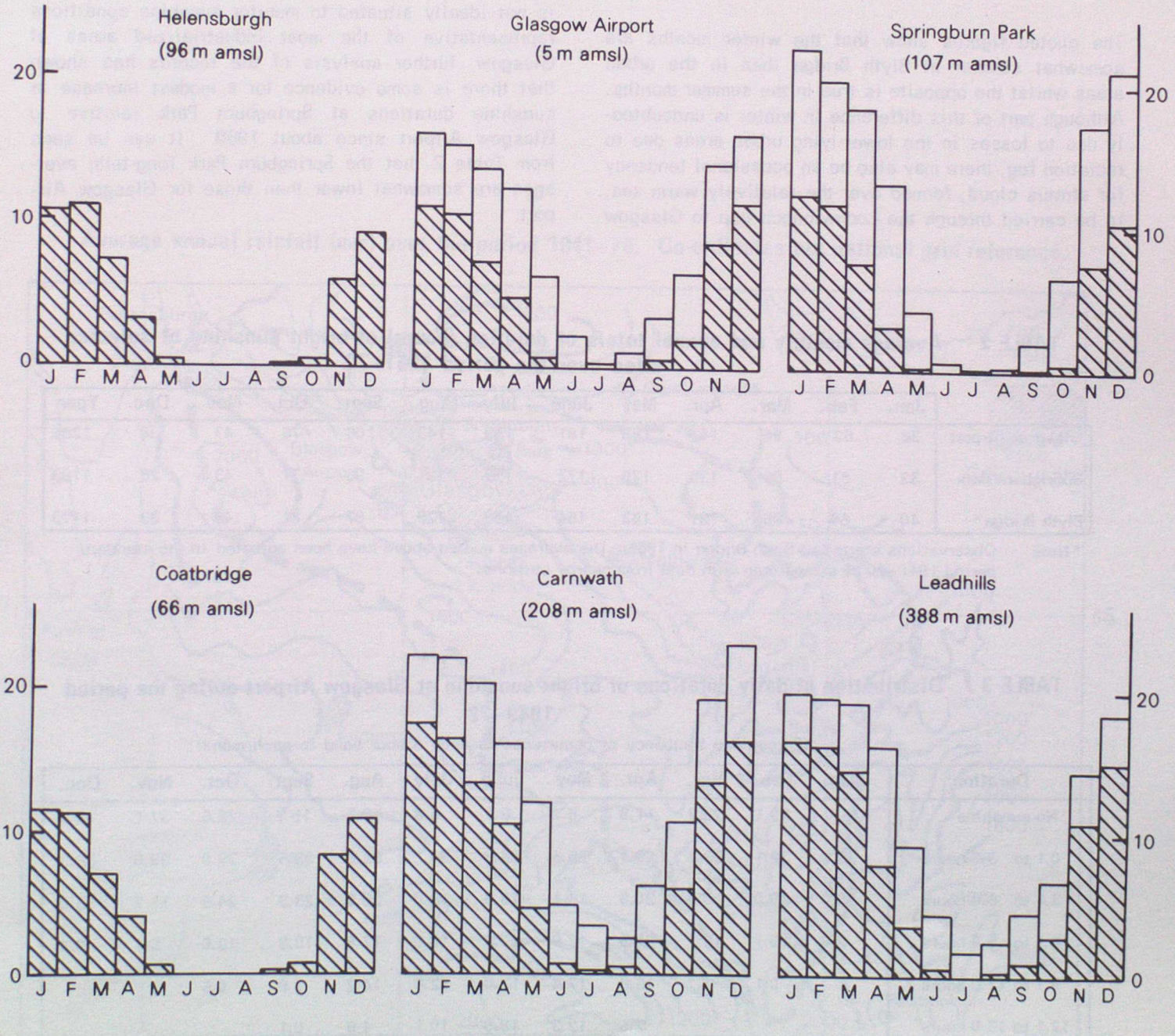
To give some idea of the distribution of maximum and minimum temperatures about the average, a more detailed analysis of the data for Glasgow Airport is given in Table 1. This shows the percentage frequency distribution of both maximum and minimum temperatures in 3 °C bands for each month. It can be seen that, for example, on 5.8 per cent of days in the 30 Januarys between 1949 and 1978 the minimum temperature was within the band –6.1 to –9.0 °C whilst only on 0.7 per cent of days was it below –12.0 °C. The sharp cut-off

of maximum temperatures at 12 °C in December, January and February is particularly noticeable and emphasizes the point made earlier that maximum temperatures in winter are effectively controlled by the sea surface temperatures to the south-west.

The diurnal variation of temperature is generally much greater in summer than in winter. Average temperatures at Glasgow Airport for January and July each hour of the day over a 20-year period are shown in the diagram on page 13 and it can be seen that the average daily range of temperature in January is less than 2 °C whereas in July it is about 6 °C.

Many outdoor activities are affected by prevailing temperatures and probably the most critical temperature threshold is 0 °C. Air frost and ground frost are defined as occurring when the temperature of the air and the temperature close to a grass covered surface respectively, fall below this threshold. The diagram below shows the monthly distribution of average number of days of air frost at six places and of ground frost at four of them. As the diagram illustrates, ground frost can occur at any time of the year even at lowland sites, although it is uncommon in the summer months. On the other hand, air frost occurs in the summer months at the higher level sites only. During the autumn the increasing hours of darkness allow greater overnight falls of temperature, with the result that first ground frost and then air frost become more frequent until the winter peak is reached in December, January and February.

Average number of days in the month over the period 1959–78 when air and ground frost were recorded at selected sites.



Note: Frequency of ground frost at Helensburgh and Coatbridge not available. Whole columns show ground frost, hatching denotes air frost.

SUNSHINE

Over the year as a whole, the variation from place to place in the duration of bright sunshine received in the Clyde Valley is significantly less than for many other weather elements; there is a difference of less than 8 per cent in the average annual total between Glasgow Airport and an upland site such as Blyth Bridge (250 m a.m.s.l.). The average annual total of around 1175 to 1250 hours per year compares favourably with other areas of Scotland and many parts of northern England (see page 16). Table 2 gives the monthly and annual average sunshine totals for Glasgow Airport, Springburn Park and Blyth Bridge.

It should be noted from Table 2 that, on average, the May sunshine total is marginally greater than that for June, despite the greater possible duration in the latter month. This is largely due to the higher incidence of anticyclonic conditions in May, often with easterly winds over Central Scotland. Any low-level cloud carried from the North Sea is generally dissipated before reaching the Clyde Valley.

The quoted figures show that the winter months are somewhat sunnier at Blyth Bridge than in the urban areas whilst the opposite is true in the summer months. Although part of this difference in winter is undoubtedly due to losses in the lower-lying urban areas due to radiation fog, there may also be an occasional tendency for stratus cloud, formed over the relatively warm sea, to be carried through the Lochwinnoch gap to Glasgow in south-westerly winds. In these situations, since much of the upper Clyde Valley lies to the lee of high ground, there is some tendency for shallow layer cloud, once removed from its source of moisture (the sea), to clear by a combination of subsidence and mixing with drier air. In summer, the upland areas favour development of convective cloud and so the Glasgow area experiences more sunshine.

Table 3 gives the percentage frequency of daily sunshine amounts in various bands at Glasgow Airport and shows, for example, that in January 46 per cent of days are completely sunless whereas in June the corresponding figure is less than 7 per cent.

Sunshine is one of the few weather elements which is affected by social and economic factors as well as meteorological ones. The progressive decrease in smoke pollution over the last few years has had the effect of increasing the amount of winter sunshine recorded in urban areas. Although Springburn Park is not ideally situated to monitor sunshine conditions representative of the most industrialized areas of Glasgow, further analysis of the records has shown that there is some evidence for a modest increase in sunshine durations at Springburn Park relative to Glasgow Airport since about 1960. It can be seen from Table 2 that the Springburn Park long-term averages are somewhat lower than those for Glasgow Airport.

TABLE 2 Average monthly and annual totals of duration (hours) of bright sunshine at selected sites over the period 1941–70

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Glasgow Airport	36	62	94	147	185	181	159	143	106	76	47	30	1266
Springburn Park	33	61	86	135	175	172	153	131	96	71	43	26	1183
Blyth Bridge *	40	69	95	131	163	154	133	129	97	81	49	33	1173

* Note: Observations started at Blyth Bridge in 1956. The averages quoted above have been adjusted to the standard period 1941–70 by comparison with data from nearby stations.

TABLE 3 Distribution of daily durations of bright sunshine at Glasgow Airport during the period 1949–78

(Percentage frequency of occurrence in each 3 hour band in each month)

Duration	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No sunshine	46.0	30.1	23.7	11.9	8.7	6.7	8.8	10.1	15.7	22.6	37.1	48.3
0.1 to 3.0 hours	36.0	39.1	33.7	26.1	25.6	24.8	30.2	32.8	33.5	39.0	39.5	38.3
3.1 to 6.0 hours	15.0	20.0	20.7	20.8	18.4	18.9	19.0	20.5	23.3	24.9	17.7	13.0
6.1 to 9.0 hours	3.0	10.7	18.2	21.9	17.0	17.4	18.0	17.8	19.8	13.0	5.7	0.4
9.1 to 12.0 hours		0.1	3.7	16.8	17.4	17.0	12.6	14.2	7.6	0.5		
12.1 to 15.0 hours				2.5	12.3	13.0	10.1	4.6	0.1			
More than 15 hours					0.6	2.2	1.3					

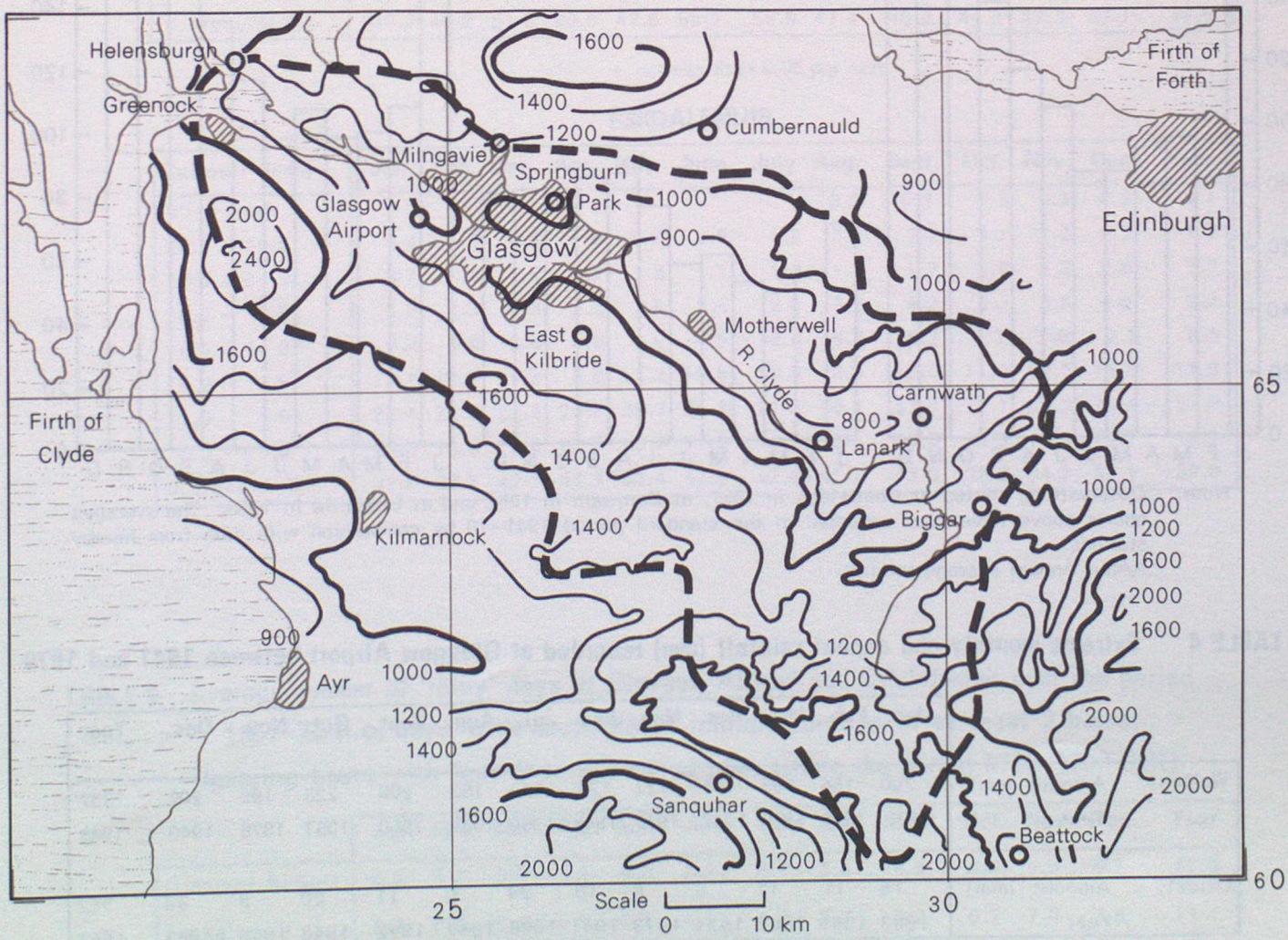
RAINFALL

Rainfall (or, more precisely, precipitation, since data quoted below include melted snow and very small contributions from hail and dew) is one of the most variable of the meteorological elements, in both space and time. Reasonably uniform precipitation can occur over several hundred kilometres for many hours as the result of the passage of a depression and its associated fronts whereas an individual shower cloud can precipitate heavily for perhaps just a few minutes over an area only a few kilometres in extent.

Because of the need for detailed knowledge of rainfall for water resources and drainage purposes, a relatively dense network of rain-gauges has become established over the last century. Data from all the rain-gauges in the area have been analysed to produce in map form as shown below the annual average rainfall for the period 1941–70. If this map is compared with the topography (Map on page 2) the similarity between the isohyets (lines of equal rainfall) and the contours can be appreciated. The increase in rainfall in upland areas is a result of two physical effects. Firstly, the presence of the hills intensifies the ascent of air on occasions of widespread persistent rain, and secondly, the hills act as preferred centres for convective activity resulting in increased precipitation in showery airstreams.

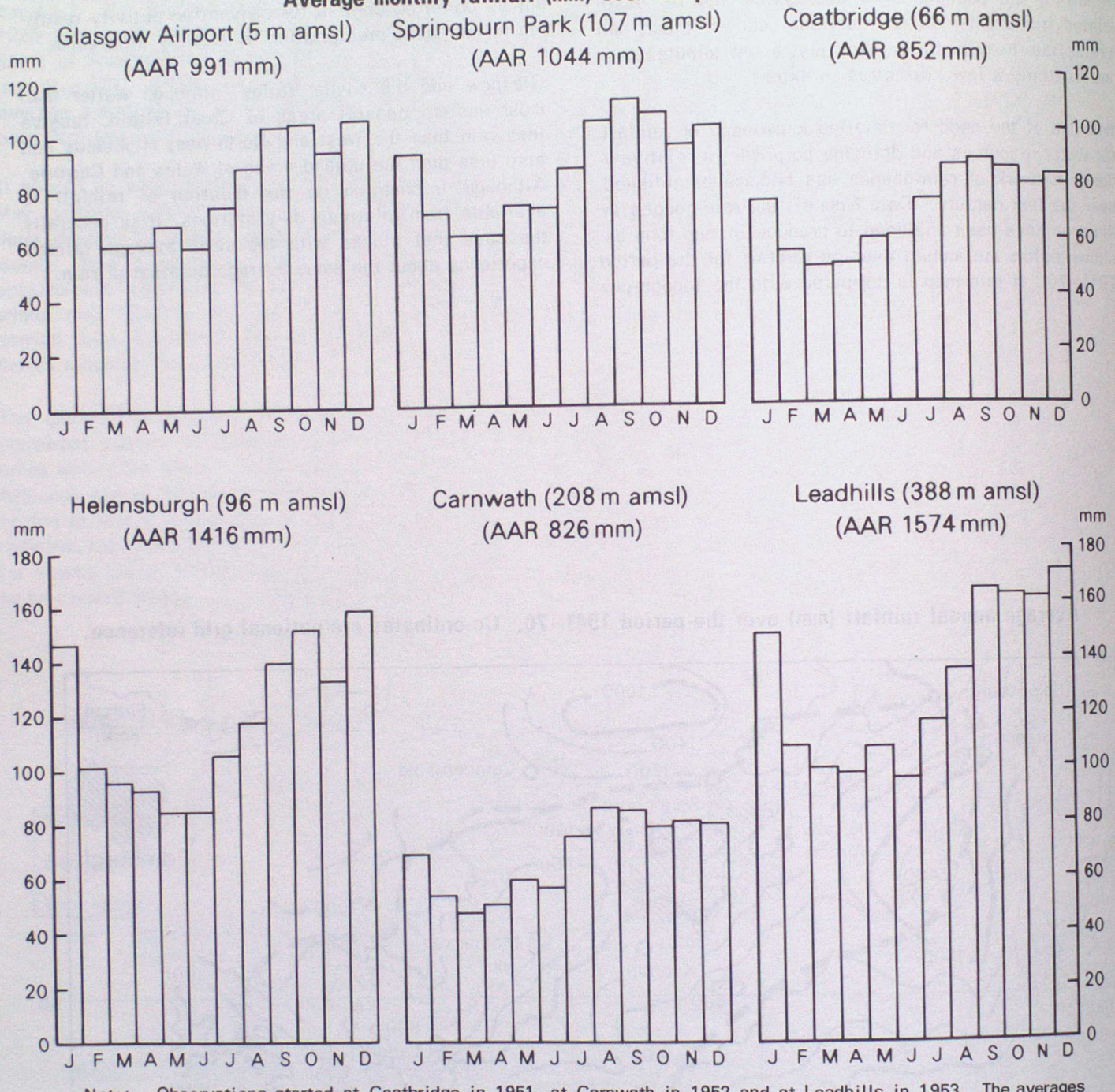
Glasgow and the Clyde Valley, although wetter than most eastern coastal areas of Great Britain, receive less rain than the West and North-west Highlands and also less than the upland areas of Wales and Cumbria. Although information on the duration of rainfall is available from relatively few stations, it is generally the case that places with the same average rainfall experience about the same average duration of rain.

Average annual rainfall (mm) over the period 1941–70. Co-ordinates are national grid reference.



The contribution of individual months to the average annual rainfall values is shown in the diagrams on this page for six locations in the region. It can be seen that the first half of the year is, on average, drier than the second half. There are considerable variations in rainfall about the average from year to year and Table 4 shows the highest and lowest rainfalls in each month of the year at Glasgow Airport since 1941. The wettest months in the period have experienced about twice the long-term monthly average rainfall and no rain at all was recorded in August 1947.

Average monthly rainfall (mm) over the period 1941–70.



Note: Observations started at Coatbridge in 1951, at Carnwath in 1952 and at Leadhills in 1953. The averages shown above have been adjusted to the standard period 1941–70 by comparison with data from nearby stations.
AAR = Annual average rainfall.

TABLE 4 Extreme monthly and annual rainfall (mm) recorded at Glasgow Airport between 1941 and 1979

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Wettest:	Amount (mm)	200	154	153	159	127	123	144	153	208	223	189	202	1337
	Year	1975	1945	1978	1947	1945	1948	1950	1943	1950	1967	1979	1949	1948
Driest:	Amount (mm)	18	11	17	5	8	16	29	0	11	20	8	34	752
	Year	1963	1963	1969	1974	1978	1941	1966	1947	1972	1946	1945	1963	1955

Turning to individual rainfall days (0900–0900 GMT), Table 5 shows the frequency of daily falls in various bands at Glasgow Airport and Eskdalemuir over a 20-year period. It can be seen that at both lowland and upland sites, dry days are marginally more frequent in June than in other months and that falls of over 25 mm are rather more common in autumn than at other times of year. Over the year as a whole 2 per cent of days at Eskdalemuir have more than 25 mm of rain, whereas the corresponding frequency at Glasgow is less than 1 per cent.

Unless rainfall at night is heavy and prolonged, it has less effect on the life of the average person than the equivalent fall during the daytime but the definition of a 'rainy' day is a purely subjective matter, involving a combination of both rainfall amount and duration. A total of 10 mm of rain falling steadily from dawn to dusk would definitely constitute a 'rainy' day, but the same amount falling in half an hour during a late afternoon shower may well have been preceded by a hot sunny day. For the purposes of this publication, a 'rainy' day has been defined as one with an accumulated rainfall duration of at least 2 hours within the period 0700–1700 GMT, excluding those hours with less than 0.2 mm of rain. Twenty-year averages for Glasgow Airport and Eskdalemuir are given in Table 6. On average, June has the fewest 'rainy' days and January the most.

TABLE 5 Distribution of rainfall amounts in the rainfall day (0900 to 0900 GMT) during the period 1957–76 at Glasgow Airport and Eskdalemuir

(percentage frequency of occurrence in each rainfall range in each month and the year)

GLASGOW AIRPORT

Rainfall (mm)	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
50 or more								0.2		0.2			+
25.0 – 49.9	0.5	0.4		0.2	0.3	0.3	0.8	1.3	1.0	0.7	1.0	0.8	0.6
20.0 – 24.9	1.1	0.4		0.2	0.5	0.5	0.5	1.0	1.0	0.8	1.3	1.0	0.7
15.0 – 19.9	2.4	0.5	1.3	1.3	0.6	1.3	1.3	1.1	2.2	3.1	2.2	1.9	1.6
10.0 – 14.9	5.5	3.7	2.1	2.7	3.6	2.3	3.4	3.1	5.7	5.3	6.0	6.1	4.1
5.0 – 9.9	14.7	11.3	11.0	9.0	11.6	7.7	8.9	7.7	10.2	11.1	13.0	12.4	10.7
1.0 – 4.9	24.4	26.0	20.3	21.5	25.5	21.3	20.2	23.9	23.0	21.6	22.8	25.7	23.0
0.2 – 0.9	11.1	11.5	13.7	14.7	10.3	13.8	14.2	14.7	11.0	13.1	16.3	15.0	13.3
0, trace or 0.1	40.3	46.2	51.6	50.5	47.6	52.7	50.8	47.4	46.0	44.2	37.3	37.1	46.0

+ = less than 0.05 per cent

ESKDALEMUIR

Rainfall (mm)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
50 or more								0.2	0.3	0.2	0.2	0.2	0.1
25.0 – 49.9	3.4	1.8	0.8	1.5	0.3	0.8	1.8	2.1	2.7	3.1	2.2	2.2	1.9
20.0 – 24.9	3.7	1.1	1.8	0.7	1.5	1.7	1.3	1.1	1.7	1.8	2.2	2.6	1.7
15.0 – 19.9	4.0	2.3	2.3	2.2	2.6	2.5	2.6	3.2	4.2	3.7	4.5	4.6	3.2
10.0 – 14.9	7.4	6.9	5.5	6.0	6.6	4.5	6.0	5.7	8.2	6.3	7.8	7.1	6.5
5.0 – 9.9	13.4	12.7	11.3	9.8	13.2	10.8	10.5	10.0	12.0	11.8	12.7	13.8	11.8
1.0 – 4.9	22.4	22.7	21.3	22.7	22.7	21.2	21.3	23.1	17.5	22.1	21.3	23.4	21.8
0.2 – 0.9	13.9	13.8	15.0	12.5	10.7	11.2	14.2	13.6	10.5	12.3	15.0	14.1	13.1
0, trace or 0.1	31.8	38.8	42.1	44.7	42.4	47.5	42.6	41.1	43.0	38.9	34.2	32.1	39.9

TABLE 6 Average number of 'rainy' days at Glasgow Airport and Eskdalemuir over the period 1957–76 (i.e. days with accumulated rainfall duration of at least 2 hours, ignoring hours with less than 0.2 mm of rain, within the period 0700–1700 GMT)

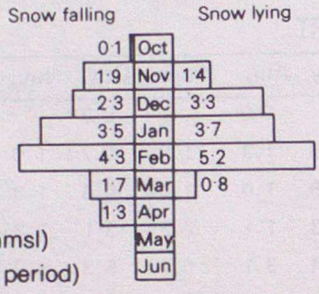
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Glasgow Airport	6.9	4.2	3.9	3.0	4.0	2.9	3.7	3.5	4.8	4.9	5.0	5.7	52.5
Eskdalemuir	8.7	6.5	5.7	5.1	6.1	4.5	4.8	5.8	6.2	6.7	7.0	7.8	74.9

SNOW

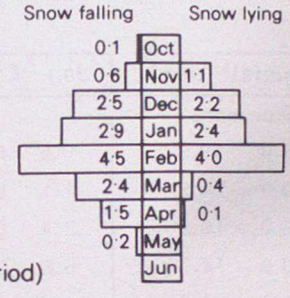
The incidence of snow is extremely variable from year to year. During the severe winter of 1962–63 there were 84 days with snow lying at Carnwath compared with only 14 days the following winter. In any given year, altitude is the most important factor governing both the frequency with which precipitation falls as snow and also the persistence of the resultant snow cover. The persistence of snow is also affected by the lie of the land and nearby shelter, since snow tends to lie longer on north facing slopes and in areas shaded from direct sunshine. As the diagram below shows, the average number of days with snow lying increases steadily with increasing altitude, but it should be remembered that most of the populated areas are less than 200 metres above sea level and for these areas an average of between 10 and 20 days per year with snow lying is appropriate. (A day of snow lying is defined as one when half or more of the ground is covered by snow at 0900 GMT.)

When considering the number of days with snow falling it should be noted that Glasgow Airport is the only one of the six named places staffed by Meteorological Office personnel keeping a 24-hour watch on the weather. At all other places the observations are carried out by volunteer observers who combine this duty with their everyday jobs. For this reason there will be occasions, especially at night, when a short-lived fall of snow will be missed by the voluntary observers and this probably explains the relatively high number of days with snow falling at Glasgow Airport compared with the other places quoted.

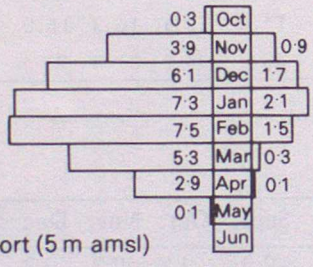
Average number of days per month with (a) snow falling and (b) snow lying over the period 1959–78 at selected sites.



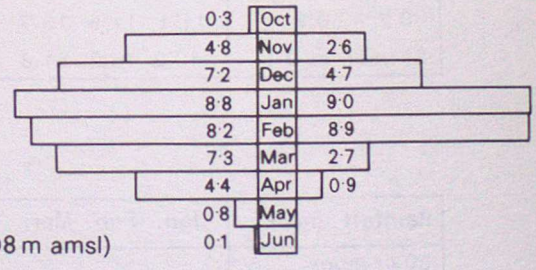
Helensburgh (96 m amsl)
(15 years within the period)



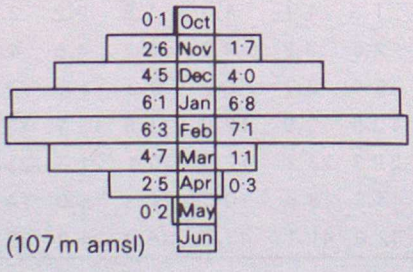
Coatbridge (66 m amsl)
(16 years within the period)



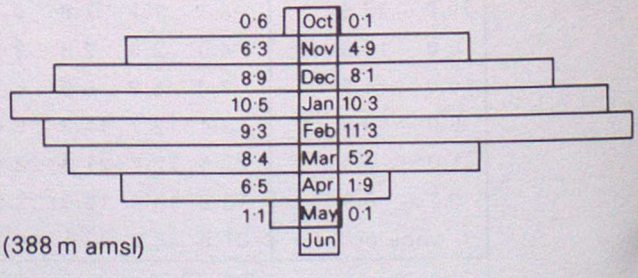
Glasgow Airport (5 m amsl)



Carnwath (208 m amsl)



Springburn Park (107 m amsl)



Leadhills (388 m amsl)

THUNDER AND HAIL

The thunderstorm is one of the most spectacular of all weather phenomena, especially when it is accompanied by a display of lightning. In Great Britain, the highest frequency of thunderstorms occurs in parts of central and southern England. Thunder is heard in these areas on between 15 and 20 days per year on average, whereas at Glasgow Airport the corresponding frequency is about 7 days. In Glasgow, thunder is rare in the winter months, being heard on average less frequently than 1 day in 3 years in each month between October and April. The tendency, mentioned earlier, for hills to increase convective activity also has an effect on the frequency of thunderstorms; on average, about 11 days of thunder per year are recorded at Eskdalemuir with over 80 per cent of these occurring in the months April–September.

Precipitation accompanying a thunderstorm is usually intense, and sometimes the rainfall is accompanied by hail. Although both hail and thunder result from intense convection, they do not necessarily occur together. At Glasgow Airport, hail of over 5 mm diameter is only observed on average between 1 and 2 days per month at any time of the year but it rarely occurs at all during June–September.

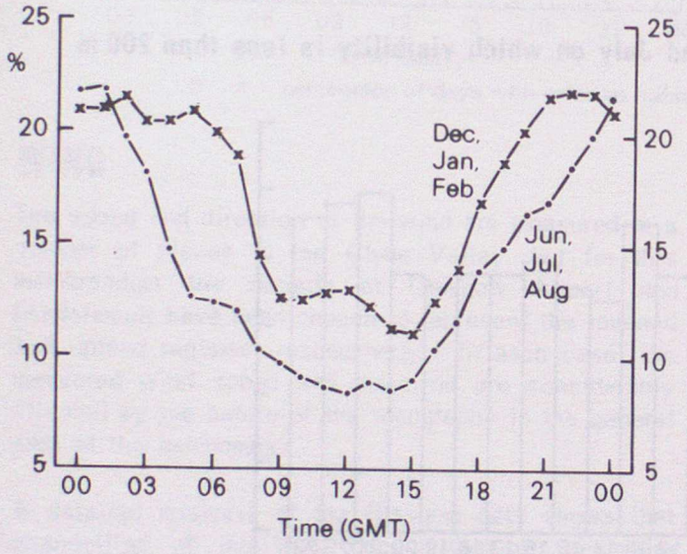
CLOUD

Cloud cover is reported as the estimated fraction of the sky (in eighths) covered by cloud at the time of observation. If cloud reports from Glasgow Airport are separated into three ranges, 0–2, 3–6 and 7–8 eighths, then, over the year as a whole, overcast skies (i.e. cloud cover between 7 and 8 eighths) occur on average for 58 per cent of the time. This percentage changes little through the year ranging between 63 per cent in January and 52 per cent in April. Clear skies (0–2 eighths) on the other hand only occur on average for 16 per cent of the time, and the frequency of occurrence shows little change throughout the year, though that for the 3–6 eighths range does have a slight seasonal variation with a maximum in spring and summer.

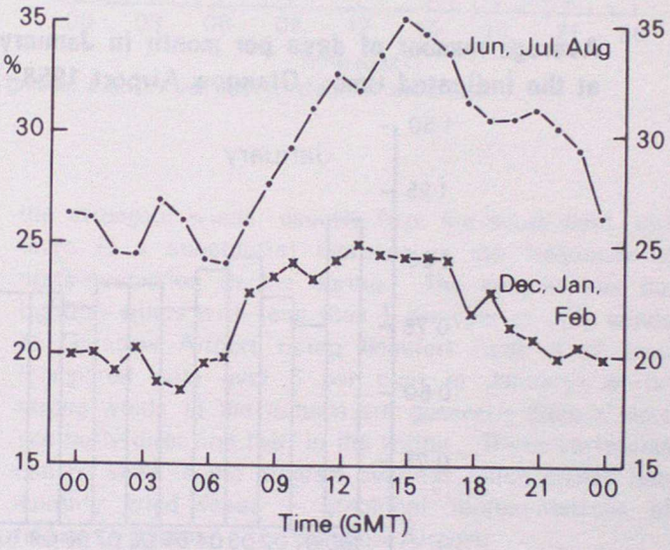
In addition to seasonal changes, there is also a variation in cloud cover throughout the day. The diagram below shows the variation in frequency of clear skies (0–2 eighths) and of partial cloud cover (3–6 eighths) throughout the day at Glasgow Airport in the winter and summer months. On the whole, the incidence of clear skies is greatest and that of overcast skies is least during the hours of darkness. The frequency of partial cover increases steadily through the day, particularly in summer. This is largely due to the growth of convective (cumulus) cloud as a result of solar heating.

Regarding cloud cover in other parts of the Clyde Valley, information is sparse, but data from Eskdalemuir show a somewhat higher frequency of overcast conditions than at Glasgow, especially in the summer. This is consistent with the lower summer sunshine figures in upland areas discussed in an earlier section.

Diurnal variation of cloud cover at Glasgow Airport (1949–78) in winter and summer.



Percentage of days with clear skies (amount 0–2 eighths)



Percentage of days with partial cloud cover (amount 3–6 eighths)

VISIBILITY

Like snow, poor visibility causes considerable disruption to transport and is very variable in its occurrence from year to year. Fog is formed when air is cooled below the temperature at which it can retain its moisture in the form of vapour. This cooling can be caused by loss of heat from the ground by radiation to clear skies (radiation fog), by the movement of warm moist air over a cold land or water surface (advection fog) or by air being forced to rise by a range of hills (hill fog, i.e. low clouds in contact with the surface).

Most of the fog experienced in the lower and more populous parts of the region is radiation fog and the visibility is often further reduced by smoke from both domestic and industrial sources. Control over the past two decades has seen a reduction of smoke emission and so 'smog' conditions are now unusual. For this reason, the data in this section are confined to the period 1959 to 1978.

The only station in the region at which observations of visibility are made throughout the 24-hour period is Glasgow Airport. Therefore the incidence of fog at other climatological stations in the region can be compared only by considering the visibility at the time of their single daily observation (0900 GMT). For the purpose of this memorandum, fog has been defined as a condition when the visibility is less than 200 metres. This threshold is approximately that at which transport begins to be affected. Table 7 shows the average number of days in each month with fog at 0900 GMT. It can be seen that fogs occur most frequently during the winter months and in the heavily populated lowland areas.

Fog occurs rarely during the summer at Glasgow Airport, the diagram overleaf illustrates the differences between January and July in the frequency of fog throughout the day. The distribution for January is typical of

winter months when the heat of the sun is generally insufficient to dissipate the fog and so there is little change in frequency between night and day. In July, visibility is below 200 metres at 0500 GMT on average only once in five years, but rapidly improves after dawn.

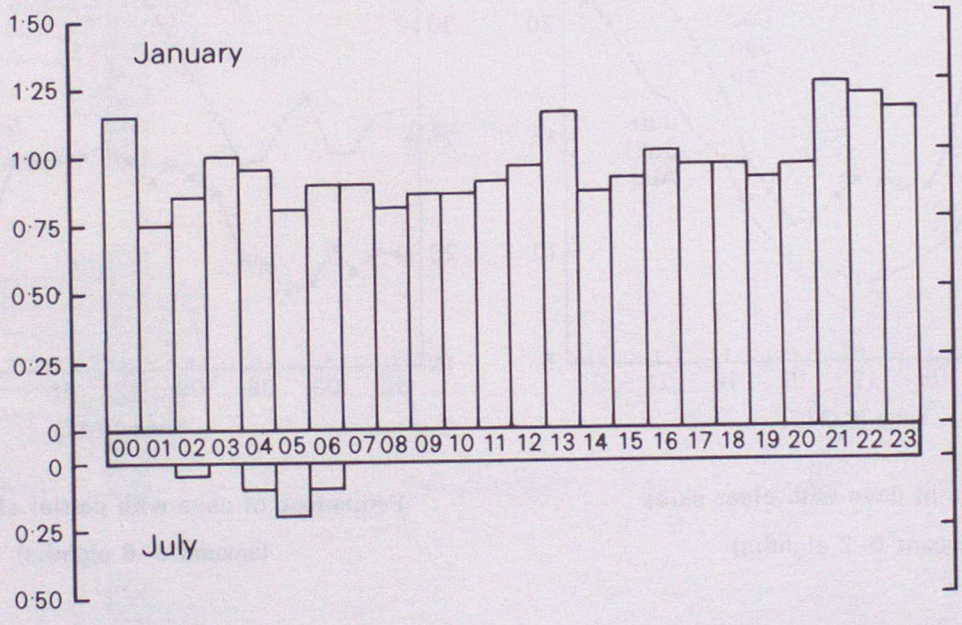
The upland areas experience less radiation fog than the lowlands and so frequencies of visibility less than 200 metres in winter are less than those at Glasgow Airport (see Table 7). However, hill fog occurs throughout the year in the upland areas, although it rarely reduces visibility to below 200 metres. If a threshold of 1000 metres is considered, Eskdalemuir experiences about four times as many days of poor visibility at dawn in summer as does Glasgow Airport.

TABLE 7 Average number of days in each month and the year with visibility of less than 200 metres at 0900 GMT at selected sites over the period 1959–78

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Helensburgh	0.3	0.2	0.3	0.1	0.1			0.1	0.3	0.3	0.3	0.3	2.1
Glasgow Airport	0.8	0.9	0.5	0.1					0.1	0.7	1.1	0.9	5.2
Springburn Park	0.6	0.3	0.5	0.2						0.1	0.5	0.5	2.7
Coatbridge	0.6	0.4	0.2	0.1						0.3	0.6	0.4	2.5
Carnwath	0.5	0.5	0.2	0.1				0.1	0.1	0.1	0.5	0.7	2.5

Note: Annual averages quoted may not agree precisely with totals of monthly averages owing to rounding errors.

Average number of days per month in January and July on which visibility is less than 200 m at the indicated time: Glasgow Airport 1958–77.



HUMIDITY

The humidity of a sample of air can be expressed in absolute terms as a vapour pressure (i.e. that part of the total atmospheric pressure exerted by the water vapour) or as a vapour concentration (i.e. the mass of water vapour present per unit volume of moist air). In a given season, changes are brought about largely by changes of air mass, those of maritime origin normally being warmer and moister than those of continental or arctic origin. When averaged over all days these measures of humidity have a very small diurnal variation, and values in summer are typically almost twice those in winter.

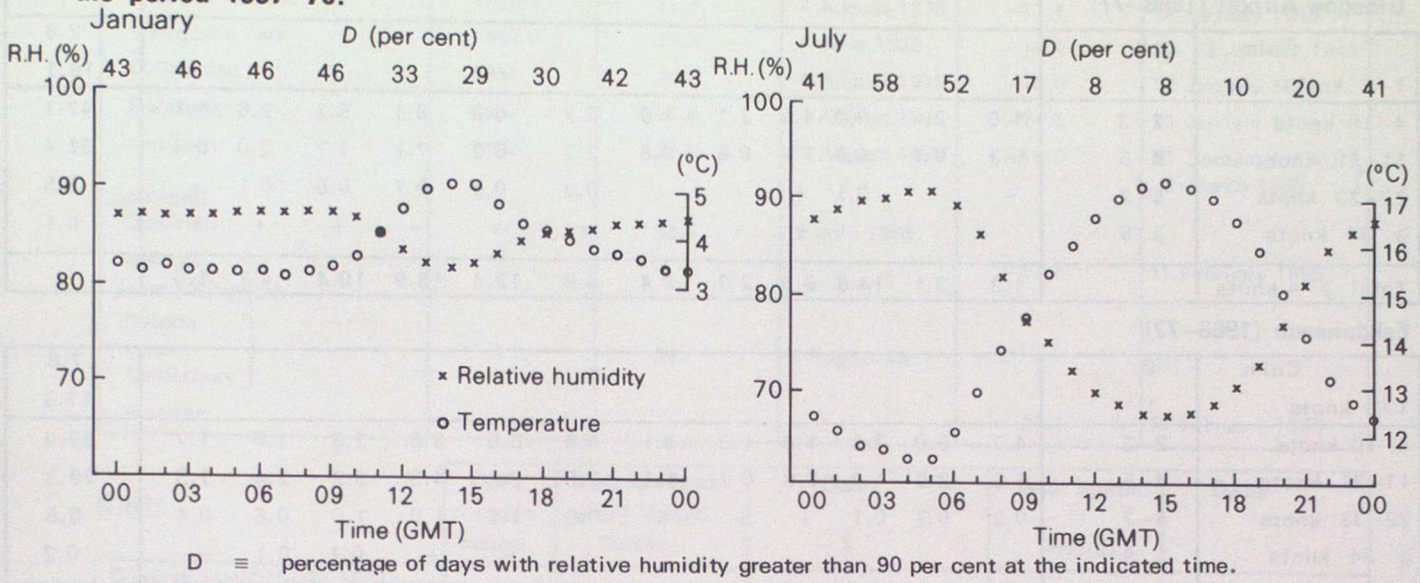
The relative humidity (RH) of an air sample is the ratio, expressed as a percentage, of the actual vapour pressure to the maximum (saturation) vapour pressure which could be sustained at the given air temperature. The saturation vapour pressure increases significantly with increasing temperature, and so the relative humidity displays a substantial diurnal variation as the temperature varies. The diagram shows the change in average relative humidity with time of day in January and July at Glasgow Airport along with the corresponding variation of average temperature over the period 1957–76. When the temperature reaches its maximum value during the afternoon, the relative humidity reaches a minimum and vice versa. Since the average daily range of temperature in winter is much less than in summer, the variation of average relative humidity throughout the day is also less.

The variability of relative humidity from day to day is large, and values can reach 100 per cent (i.e. saturation) at any time of the day during fog or rain. The figures entered along the top of the diagram give at 3-hour intervals the percentage of occasions in the period 1957–76 when the relative humidity exceeded 90 per cent. For example, on only 8 per cent of days in July is the relative humidity above 90 per cent at 1500 GMT, whereas in January 29 per cent of days are above 90 per cent at this time. During the early hours of the morning, the relative humidity exceeds

90 per cent on about half the days in both January and July.

Variations in humidity from place to place are small compared with the large changes which can occur over short periods of time, so the data presented for Glasgow Airport can be considered representative of the lower Clyde Valley.

Average diurnal variation of temperature and RH at Glasgow Airport for January and July over the period 1957–76.



D ≡ percentage of days with relative humidity greater than 90 per cent at the indicated time.

WIND

The speed and direction of the wind are measured at a number of places in the Clyde Valley, but for this memorandum the records at Glasgow Airport and Eskdalemuir have been chosen to represent the lowland and upland regimes, respectively. In each case, the measured wind speed and direction are considerably affected by the nature of the topography in the general area of the anemometer.

A detailed analysis of the Glasgow data shows that channelling of the wind occurs through the major gaps in the hills surrounding the city. Winds from between south and west tend to be channelled through the Lochwinnoch gap whereas those from between north and east are steered along the south side of the Kilsyth Hills. The wind recorder at Eskdalemuir in the Southern Uplands is sited at 250 metres above sea level on the eastern shoulder of high ground overlooking the north–south valley of the White Esk. The ground rises steeply again on the eastern side of the valley, and so the recording site is sheltered from easterly winds whereas northerlies and southerlies are channelled to a certain extent along the valley. Thus it can be appreciated that wind regimes are extremely dependent on local topography, and it should not be assumed automatically that the prevailing wind at all sites in the Clyde Valley is south-westerly.

Table 8 shows annual percentage frequency tables of hourly mean speed versus hourly mean direction at the two sites. The directions have been divided into 30° sectors and the speeds into groupings on the Beaufort scale. Over the year as a whole, it can be seen that at Glasgow Airport 2.6 per cent of hours experience winds of Beaufort force 6 or stronger, whereas the corresponding Eskdalemuir figure is 5.7 per cent. Seasonal variations can be appreciable, both in speed and direction. The winter months experience the strongest winds, usually from the south-west, and there is a substantial increase in the frequency of north-easterlies in the spring. The summer has the lightest winds with less than 1 per cent of July winds at Glasgow Airport being Beaufort force 6 or over (compared with over 6 per cent in January) whilst strong winds in the autumn are generally from a more southerly direction than in the winter. These variations can be seen in the diagram overleaf which shows four monthly wind roses – graphical representations of frequency tables – for Glasgow Airport.

Wind speeds also display a diurnal variation, being generally greater in the daytime than at night. The effect of solar heating is to increase the vertical mixing in the lowest layers of the atmosphere and so allow the influence of stronger winds aloft to be felt nearer the surface. At Glasgow in July, 49 per cent of hourly mean wind speeds in the middle of the day (1200–1500 GMT) are above 11 knots whereas only 14 per cent are above this threshold at night (0000–0300 GMT). In January, the range of frequencies is less being from 35 per cent over 11 knots at night to 45 per cent in the daytime.

Glasgow Airport experiences an average of about 6 days with gales (mean wind speed exceeding 33 knots) per year, with most of these occurring in the months December to March. The most severe gale on record in the Glasgow area is the storm of 15 January 1968, when an hourly mean wind speed of 53 knots (Beaufort force 10) and a gust of 89 knots were recorded. Much higher speeds are experienced on exposed hilltops in the upland areas. The wind recorder mounted 27 metres above the summit of Lowther Hill (725 metres) registered an extreme gust of 116 knots and an hourly mean speed of 84 knots on 2 January 1976.

TABLE 8 Annual percentage frequencies of hourly mean wind speed and direction for Glasgow Airport and Eskdalemuir

	Beaufort force equivalent	30° sectors centred on												All directions
Glasgow Airport (1968–77)		360°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	
Calm	0													2.8
1–3 knots	1													16.1
4–10 knots	2–3	1.0	2.4	9.7	4.9	2.1	1.6	2.2	5.3	9.1	5.2	2.6	1.1	47.1
11–21 knots	4–5	0.3	0.7	4.8	1.6	0.6	0.8	2.2	6.3	7.1	4.7	2.0	0.4	31.4
22–23 knots	6–7	+	+	0.1	+	+	+	0.2	0.8	0.7	0.5	0.1	+	2.5
⩾ 34 knots	⩾ 8				+	+	+	+	+	+	+	+	+	0.1
Total ⩾ 4 knots		1.3	3.1	14.6	6.5	2.7	2.4	4.6	12.4	16.9	10.4	4.7	1.5	
Eskdalemuir (1968–77)														
Calm	0													7.8
1–3 knots	1													17.3
4–10 knots	2–3	4.7	5.0	3.6	1.3	1.3	3.1	4.9	6.5	3.6	2.3	1.9	1.7	39.9
11–21 knots	4–5	1.6	2.6	1.3	0.6	0.7	1.1	3.0	7.2	4.3	3.2	2.4	1.3	29.3
22–33 knots	6–7	0.2	0.2	0.1	+	+	+	0.6	1.5	1.0	1.0	0.5	0.4	5.5
⩾ 34 knots	⩾ 8							+	+	+	0.1	0.1	+	0.2
Total ⩾ 4 knots		6.5	7.8	5.0	1.9	2.0	4.2	8.5	15.2	8.9	6.6	4.9	3.4	

\+ Observations recorded for these values but for less than 0.05 per cent of the time

Wind roses for Glasgow Airport. (1968–77)

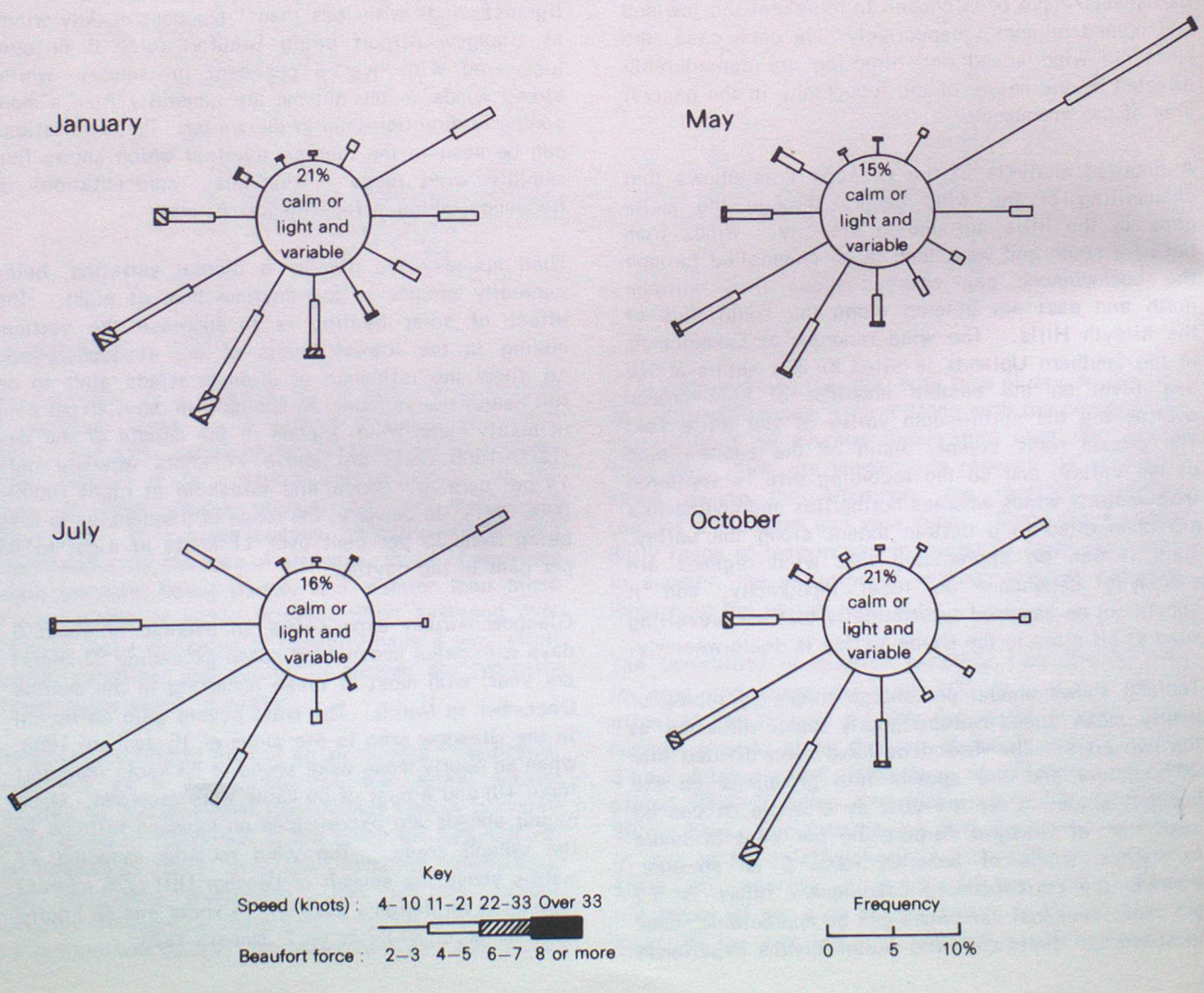


TABLE 9 Weather extremes

TEMPERATURE	Date records began	Maximum daily temperature (°C)	Date	Minimum daily temperature (°C)	Date
Glasgow and Clyde Valley					
Helensburgh	1882	29.4	6 June 1950	−13.9	16 January 1918
Glasgow Airport	1920	31.2	4 August 1975	−17.4	22 January 1940
Springburn Park	1913	31.3	4 June 1939	−14.4	22, 23 January 1940
Coatbridge	1951	30.2	4 August 1975	−15.0	13 January 1979
Carnwath	1952	29.4	4 August 1975	−24.6	13 January 1979
Leadhills	1953	27.2	11 August 1975	−15.0	31 December 1961 2 March 1965
Scotland					
Dumfries	–	32.8	2 July 1908		
Braemar	–			−27.2	11 February 1895
United Kingdom					
Raunds Epsom Canterbury	–	36.7	9 August 1911		
Braemar	–			−27.2	11 February 1895

WIND	Date records began	Hourly mean wind speed (knots)	Date	Gust speed (knots)	Date
Glasgow and Clyde Valley					
Glasgow Airport	1946	53	15 January 1968	89	15 January 1968
Eskdalemuir	1908	52	2 January 1976	87	15 January 1968
Lowther Hill	1961	84	2 January 1976	116	2 January 1976
United Kingdom (Low level sites only)					
Dounreay (Caithness)	–	69	28 September 1968		
St. Ann's Head (Dyfed)	–	69	23 November 1938		
Kirkwall (Orkney)	–			118	7 February 1969

RAINFALL	Date records began	Maximum daily fall (mm)	Date
Glasgow and Clyde Valley			
Helensburgh	1882	87	9 October 1948
Glasgow Airport	1920	71	17 August 1920
Springburn Park	1913	53	27 July 1917
Coatbridge	1951	51	8 August 1961
Carnwath	1952	59	30 October 1977
Leadhills	1953	99	30 October 1977
Scotland			
Sloy Filters (Loch Lomondside, Strathclyde)	–	238	17 January 1974
United Kingdom			
Martinstown (Dorset)	–	279	18 July 1955

SUNSHINE	Date records began	Maximum monthly duration (hours)	Date	Minimum monthly duration (hours)	Date
Glasgow and Clyde Valley					
Glasgow Airport	1920	291	July 1955	9	December 1956
Springburn Park	1913	292	July 1955	5	January 1944
Blyth Bridge	1956	242	June 1957	15	December 1971
Scotland					
Tiree	–	329	May 1975		
Paisley	–			1	December 1890
United Kingdom					
Eastbourne	–	384	July 1911		
London (Westminster)	–			0	December 1890

TABLE 10 Climatological data for places in the United Kingdom based on the period 1941–70 except where indicated

	Altitude (metres)	Average annual rainfall (mm)	Average daily temperatures (°C) #				Average annual duration of bright sunshine (hours)	Average annual no. of days with*	
			Minimum		Maximum			Air Frost	Snow lying
			Jan.	July	Jan.	July			
England									
Abingdon (Oxfordshire)	69	605	0.3	11.6	6.3	21.6	1544	57	13
Acklington (Northumberland)	42	644	0.0	10.3	5.5	17.9	1429	60	20
Birmingham Airport (W. Midlands)	96	679	0.1	11.2	5.7	20.5	1385	62	15
London (Kensington Palace)	25	640	1.7	13.3	6.6	22.2	1384×	35	7
Manchester Airport (Gr. Manchester)	75	819	0.5	11.7	5.8	19.6	1334	47	10
Plymouth-Mount Batten (Devon)	27	990	3.1	12.7	8.3	19.0	1678	25	3
Shawbury (Shropshire)	72	670	0.0	11.2	6.0	20.2	1368	63	17
Southsea (Hampshire)	2	702	2.4	13.9	7.1	20.7	1748	25	6
Waddington (Lincolnshire)	68	598	0.1	11.6	5.2	20.3	1503	54	18
Wales									
Cardiff (Wales) Airport (S. Glamorgan)	67	947	1.3	11.9	6.6	19.3	1571	36	8
Valley (Gwynedd)	10	871	2.5	12.0	7.5	18.1	1612	27	3
Northern Ireland									
Belfast Airport (Antrim)	68	912	0.6	10.7	6.1	18.1	1281	53	9
Scotland									
Aberdeen Airport (Grampian)	58	872	−0.9	9.6	5.0	17.5	1341	75	30
Balmoral (Grampian)	283	834	−2.8	8.1	3.7	17.4	1120†	116	63
Edinburgh Airport (Lothian)	35	677	−0.6	10.3	5.7	18.5	1294	66	14
Lerwick (Shetland)	82	1172	0.6	9.3	5.0	14.0	1067	53	32
Stornoway (Western Isles)	3	1094	1.3	10.1	6.4	15.7	1244	49	11
Glasgow Airport (Strathclyde)	5	991	0.1	10.8	5.8	18.6	1266	58	6

* Based on 1956–70 only.

† For Braemar.

× For Regents Park.

\# Referring to 24-hour (09–09 GMT) extremes. Adjustments have been made to those stations normally recording night minimum (21–09 GMT) and day maximum (09–21 GMT). See Introduction to the series.

CLIMATOLOGICAL SERVICES AVAILABLE FROM THE METEOROLOGICAL OFFICE

The Meteorological Office collects and archives regular weather reports from a national network of observing stations, consisting of both Meteorological Offices manned by professional staff and co-operating stations operated by interested organizations or individuals. All these data are subjected to close scrutiny before being archived, to ensure consistency of standards, and are then available to meet the needs of the community.

Any undertaking which is at all weather-sensitive can benefit from a prior knowledge of the climate within which it is expected to operate. The building industry can use past weather statistics to estimate likely delays on contracts, architects and civil engineers need to know the likely extremes of weather which a design must withstand, and many industrial processes are dependent on atmospheric conditions for their success. The agricultural industry uses such information for a variety of purposes, many relating to the viability of new crops and the weather-related incidence and spread of pests and diseases.

In addition to special analyses of weather data for these purposes, the Meteorological Office can supply factual statements on weather conditions for legal or insurance purposes.

Enquiries related to aspects of past weather data should be directed to the appropriate address given on the back cover or, if more convenient, initially to your local weather centre (see opposite). Charges for the supply of information depend mainly on the staff time taken to meet the request.

Further information

Information leaflets and brochures describing in more detail the range of specialized services available from the Meteorological Office are available free from the same addresses. These leaflets and brochures also indicate the range of complex analyses that the Meteorological Office can undertake.

Forecasting services

For the day-to-day planning of outdoor work, special weather forecasts and warnings can be arranged to cover specific weather elements at agreed sites. Details may be obtained from:

The Director-General
Meteorological Office (Met O 7)
London Road
Bracknell
Berkshire RG12 2SZ

or from your local weather centre.

WEATHER CENTRES AND PUBLIC SERVICE OFFICES

Weather Centres

Bristol
The Gaunts House
Denmark Street
Bristol BS1 5DH

Bristol (0272) 279272

Cardiff
Southgate House
Wood Street
Cardiff CF1 1EW

Cardiff (0222) 390420

Glasgow
33 Bothwell Street
Glasgow G2 6TS

041—248 7272

Leeds
Oak House
Park Lane
Leeds LS3 1EL

Leeds (0532) 457703

London
284–286 High Holborn
London WC1V 7HX

01—430 5627

Manchester
Exchange Street
Stockport SK3 0ER

061—477 1017

Newcastle
7th Floor
Newgate House
Newgate Street
Newcastle-upon-Tyne NE1 5UQ

Tyneside 091—232 3808

Norwich
Rouen House
Rouen Road
Norwich NR1 1RB

Norwich (0603) 630164

Nottingham
Main Road
Watnall
Nottingham NG16 1HT

Nottingham (0602) 384094

Plymouth
Royal Air Force Mount Batten
Plymouth
Devon PL9 9SH

Plymouth (0752) 493377

Southampton
160 High Street-below-bar
Southampton SO1 0BT

Southampton (0703) 220646

Public Service Offices

Meteorological offices at:

Aberdeen (Dyce) Airport
Aberdeen, Grampian AB2 0DU

Aberdeen (0224) 724986

Belfast (Aldergrove) Airport
Belfast
Northern Ireland BT29 4AB

Crumlin (084 94) 22804

Birmingham Airport
Birmingham B26 3QN

021—743 6240

Kirkwall Airport
Kirkwall
Orkney KW15 1TH

Kirkwall (0856) 3802

Sella Ness
Port Admin Area
Craven, Mossbank
Shetland ZE2 9QR

(0806) 242069

THE CLIMATE OF GREAT BRITAIN

This memorandum is one of a series which will cover the whole of Great Britain in due course, published in the Climatological Memoranda range. The Introduction (CM 113) to the series explains how various weather elements are measured. The areas to be covered are:

SCOTLAND

114 Borders Region
115 Edinburgh, Lothian Region and Stirling
116 Fife, Dundee and Perth
117 Aberdeen and Buchan
118 Moray Firth coastal Region
119 Northern Isles
120 Western Isles
121 Skye and the North-west
122 Argyll and the Inner Hebrides
123 The Grampians and Perthshire Highlands
124 Glasgow and the Clyde valley
125 Ayrshire and the Firth of Clyde
126 Dumfries and Galloway Region

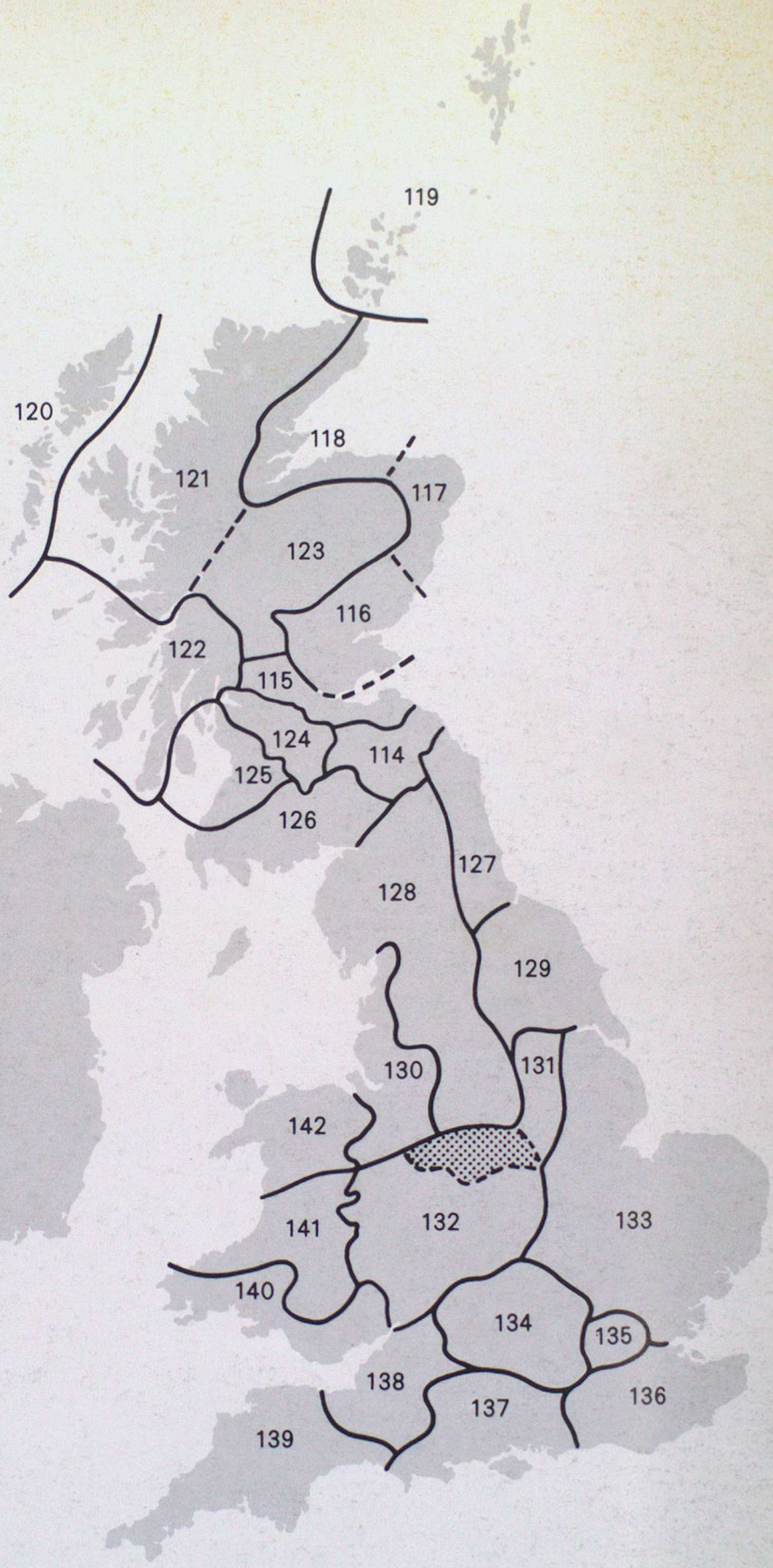
ENGLAND

127 North-east England
128 Pennines and Lake District
129 East Yorkshire and North Humberside
130 Lancashire and Cheshire and Isle of Man
131 Trent Valley
132 Midlands
133 East Anglia and Lincolnshire
134 Thames Valley
135 London
136 South-east England
137 South England
138 Somerset and Avon
139 South-west Peninsula and Channel Islands

WALES

140 South Wales
141 Mid Wales
142 North Wales and Anglesey

} Now issued in one Volume No. 140 Wales



Further details of these memoranda and of the services mentioned on page 16 can be obtained from:

FOR ENGLAND AND WALES

Advisory Services
Meteorological Office (Met O 3b)
London Road
Bracknell
Berkshire RG12 2SZ

FOR SCOTLAND

The Superintendent
Meteorological Office
Saughton House
Broomhouse Drive
Edinburgh EH11 3XQ

For information on the climate of Northern Ireland please contact:

The Principal Meteorological Officer
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