

THE CLIMATE AT SLAPTON LEY

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INTRODUCTION

THE location of Slapton Ley is indicated in Fig. 1. A Meteorological Office climatological station was established in the spring of 1960, and the records up to the end of 1973 are the subject of this paper.

South Devon has several other climatological stations, some with records going back to early this century, and these have provided a regional background to the local climate of Slapton. They also provide a basis for estimating some of the aspects of the climate which were not recorded at Slapton. They were further used in the extrapolation of possible long-term averages of temperature and rainfall.

The Slapton weather station is at a height of 32 m in the ground of the Field Centre. The site is on a ridge and effectively exposed in all directions between south and north-east. Only to the north-west does the topography offer much shelter, the land rising to almost 200 m within 5 km.

The climate at Slapton resembles that at Dale Fort (Oliver, 1959), which is also on the coast. Absolute extremes of temperature are close to those observed at Dale, although at Slapton the average maxima and minima are slightly lower in summer and higher in winter. The temperature regime contrasts with that at Nettlecombe, where extremes of cold are common. Rainfall during the study period has been very variable, with two exceptionally dry years, but the average annual rainfall calculated from the records is well within 1% of the estimated long-term average

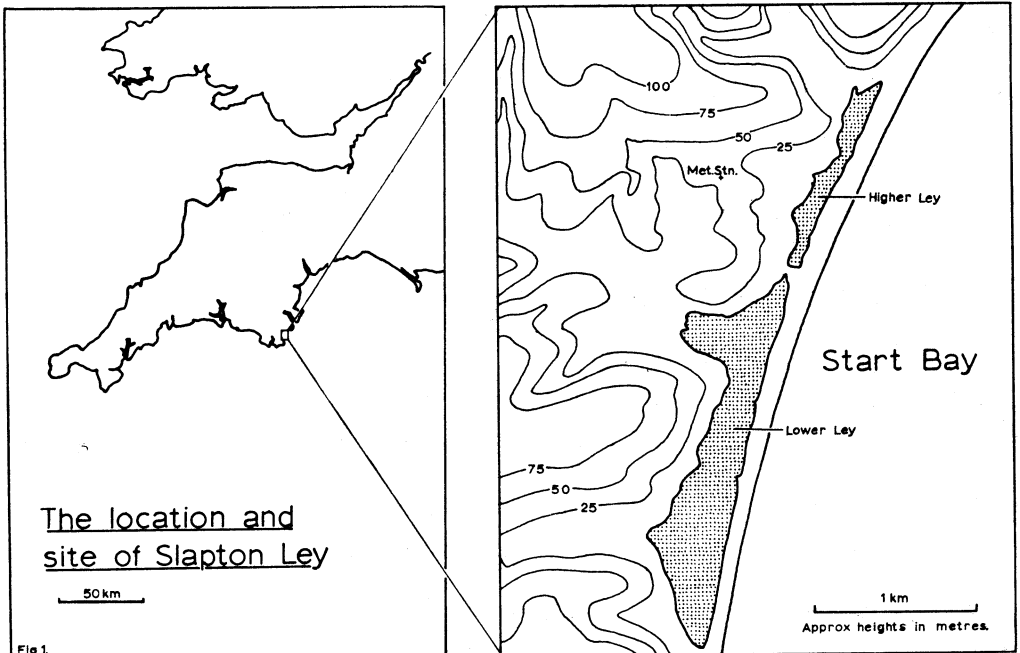


FIG. 1.

TEMPERATURES

Table 1 summarizes the averages and extremes of temperature since May 1960. The extrapolated 1931–1960 mean values are higher than the recorded ones for all months except February and October, and further analysis of the records of the other weather stations used in the calculations showed that their mean values also were below the 1931–1960 values by very similar amounts. This suggests that any slight cooling of the climate has been affecting the whole region, and as it is now recognized that the first few decades of this century were outstandingly mild (Manley, 1953), the recorded values may simply be a return to “normal”.

The monthly average temperatures show a seasonal time-lag that is common in maritime situations; the minimum is reached in February and the maximum in July or August. Available data on sea temperatures, also summarized in Table 1, suggest that in normal years Start Bay does not fall to a minimum until February or even March, and the maximum is not reached until very late in the summer.

The breakdown of average maximum and minimum temperatures shows that it is theoretically possible for the daily maximum temperature to average 10 °C or more throughout the winter, aided no doubt by the relative warmth of the sea. This was almost achieved in 1971, when only January's average was below this figure. Apart from the outstandingly cold months of January and February 1963, the extreme

Table 1. (*All temperatures in Degrees C.*)

a) Monthly mean temperatures (1960–1973)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	5.8	5.7	6.8	8.9	11.3	14.3	15.8	15.7	14.6	12.4	8.5	6.7
Estimated mean, 1931–1960.	6.1	5.7	7.2	9.1	11.6	14.5	16.1	16.0	14.7	12.0	8.9	6.9
b) Monthly average maximum temperatures.												
Mean	8.2	8.1	9.8	12.5	14.6	17.7	19.7	19.2	17.8	15.3	11.3	9.3
Highest Year	10.1	11.7	11.5	13.5	16.6	19.7	21.9	20.8	19.3	17.1	12.9	10.6
Year	1969	1961	1966	1961	1960	1973	1961	1973	1971	1968	1963	1972
Lowest Year	2.7	4.1	7.8	10.9	13.3	13.9	18.3	17.8	15.6	14.2	9.7	7.4
Year	1963	1963	1962	1970	1962	1972	1963	1963	1965	1964	1966	1963
c) Monthly average minimum temperatures.												
Mean	3.3	3.3	3.6	5.8	7.9	10.7	11.9	11.9	11.2	9.6	5.7	3.8
Highest Year	4.7	7.9	4.6	6.3	9.5	12.2	12.4	13.2	12.7	11.3	8.2	6.1
Year	1971	1961	1972	1972	1964	1970	1964	1966	1966	1968	1960	1972
Lowest Year	-1.5	N.R.	1.5	3.9	7.2	8.2	10.7	11.1	8.7	7.9	3.7	2.4
Year	1963	1963	1962	1973	1968	1972	1965	1962	1965	1964	1962	1963
d) Approximate monthly average sea temperatures, Start Bay. (1960–1970)												
	8.0	7.0	7.0	8.0	10.0	12.5	15.0	16.0	16.0	15.0	12.5	10.0
e) Recorded extremes of temperature.												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Highest Max. Year	14.4	14.4	17.2	18.9	21.7	25.2	25.6	26.5	24.4	20.6	16.1	13.9
Year	1969	1971	1972	1962	1965	1970	1969	1973	1961	1971	1960	1962
					1968						1963	
											1969	
Lowest Min. Year	-5.6	-5.6	-3.9	-0.6	+0.6	+3.2	+6.7	+6.1	+5.0	+1.1	-2.2	-4.4
Year	1963	1969	1965	1970	1967	1973	1962	1964	1965	1962	1969	1964
							1967	1970				
							1972					
Lowest Grass Min. Year	-7.2	-8.3	-9.4	-5.6	-2.2	-0.2	+3.9	+3.3	+2.2	-0.4	-6.9	-8.3
Year	1963	1969	1965	1970	1967	1973	1972	1972	1962	1970	1969	1967
	1970								1964	1972		

values are mostly within 2 °C of the mean. This is further illustrated by the graphs in Fig. 2, which suggest that February is the least predictable month of the year. It is interesting that the period 1962–1965 provided most of the cold months, reflecting the cool spell that was affecting the whole of Europe at the time. (Although there is no record of minimum temperatures at Slapton for February 1963, comparison with neighbouring sites suggests an average below 0 °C. Of the other years, only 1969 has even approached this figure.)

To date, the highest temperature recorded is 26.5 °C on 16th August 1973, and the lowest –5.6 °C on 12th January 1963, and on 8th February 1969. The daytime maximum can be expected to exceed 21 °C (70 °F) about 20 times during the summer, although this occurred only 5 times in the cold summers of 1962 and 1965. In 1973, on the other hand, 21 °C was exceeded 42 times between mid-June and mid-September. There is a greater-than-average probability of these warm days occurring with winds from between north and east, which in south-west England are the winds most commonly associated with fine, anticyclonic conditions. Even warmer days, with the temperature rising to 24 °C (75 °F) or more, seem more likely if the wind comes from the north-west. There are three possible reasons for this: first, winds coming down from Dartmoor are likely to warm up slightly by adiabatic processes; secondly, this warming would aid the dispersal of cloud; and thirdly, winds coming in from the sea quite frequently bring in sea mist, causing a marked drop in temperature. Warm days in winter (maximum temperature 12 °C or more) are most common with winds from between south-west and west, as would be expected, since the waters of the Atlantic act as a reservoir of winter warmth for Britain. The percentage frequency of warm winter days with a south-west wind is more than double the frequency of winds from that direction.

Really cold days, with a maximum not exceeding 5 °C, are quite rare, and over 60% of them occur with winds from the north or north-east, either during a brief cold interlude brought by polar air coming direct from the north in the wake of a depression, or during a more persistent cold spell as a cold anticyclone spreads westwards from the Continent. This is more common in late winter, while the former situation may occur at any time, sometimes being the cause of damaging frosts in May. On six occasions in thirteen winters the maximum temperature during a day has remained below 0 °C, the coldest being 19th January 1963, when the maximum was –1.7 °C. All these very cold days had winds from the north-east, the short passage over the edge of Start Bay evidently not affecting the temperature of the air very much. Easterly winds, on the other hand, reach Slapton after a much longer journey over the sea, which, at 7–8 °C even in late winter, raises the air temperature above freezing.

The mean diurnal range of temperature at Slapton is 6.2 °C, compared with 5.2 °C at Dale Fort and 7.7 °C at Nettlecombe. The monthly values range from 4.7 °C in January to 7.8 °C in July, although in exceptionally sunny months the average may reach 10 °C. Extreme diurnal ranges are small when compared with inland sites, reaching or exceeding 11 °C (20 °F) on an average of 14 days in the year. A range of temperature in excess of 14 °C (25 °F) occurs on average less than once a year. The seasonal distribution of ranges over 11 °C is 4:1 in favour of the summer months (April to September inclusive), which is to be expected, as it is bright sunshine that largely controls range of temperature in a coastal position. The warmth of the sea (above 10 °C from May to December) prevents the night

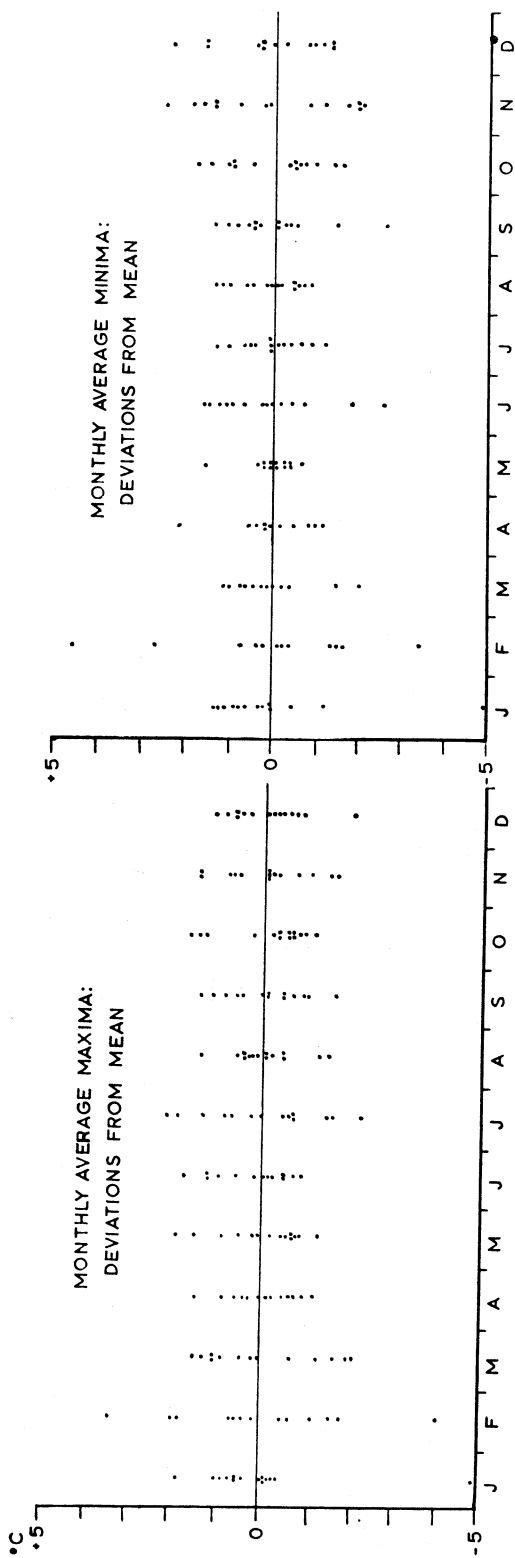


FIG. 2.

minimum falling very far, even under clear skies, and the records suggest that a minimum as low as 5 °C (41 °F) is very unlikely between mid-June and mid-October.

The greatest recorded range, 18.2 °C on 8th September 1961, was largely the result of an unusually warm day; only four of the twelve greatest ranges were associated with noticeably cold nights. The only wind direction that seems positively to favour a wide range of temperature is a few degrees either side of north, while a wide range with the wind between south and south-east is very unusual indeed.

RAINFALL

An interesting feature of rainfall at Slapton has been its variability, on both a monthly and yearly basis. The graph in Fig. 3 shows the 13-year mean monthly values and the scatter of individual values for each month during the study period.

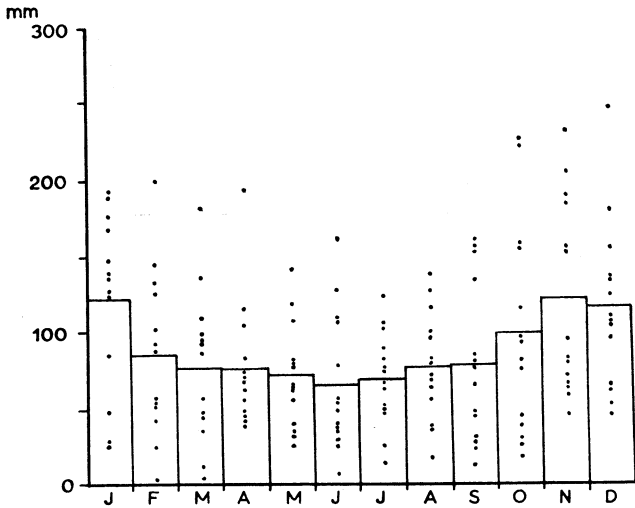


FIG. 3.

The coefficient of variation (that is, the standard deviation of the mean expressed as a percentage of the mean) for each month is in no case less than 40% (see Table 2a). In general, the spring and autumn months show greater variability than the summer and winter ones. November, December and January are markedly wetter than any other 3-month period, accounting for one-third of the total annual rainfall. This is to be expected at a lowland coastal site in western England, where much of the rainfall is of the cyclonic or frontal type. The frequency of depressions is normally highest in these three months.

This pattern of rainfall is reflected in Fig. 4, which shows the relationship between raindays*, rainfall amounts and wind direction. Winds from between south-west and north-west account for 58% of the total rainfall and for 57% of the rain-days. They blow when a depression moves across the north of Britain. Several times in recent summers a depression passing to the south has given heavy rainfall with east or north-east winds. The raininess of winds from any particular direction shows little variation between the summer and winter halves of the year, except for the norther-

* A rain-day is one with 0.1 mm or more of rain, while a wet-day is one with more than 1.0 mm of rain.

Table 2

a) Monthly Rainfall, 1960-1973. Averages and extremes. (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Highest Year	192	199	180	189	140	160	122	137	160	226	240	249
Year	1961	1966	1964	1966	1967	1968	1960	1966	1968	1960	1963	1965
Lowest Year	26	1	4	41	26	7	12	19	12	20	46	46
Year	1963	1965	1961	1969	1971	1962	1971	1969	1971	1969	1973	1963
Average	122	86	77	76	70	65	69	77	78	98	120	116
Coefficient of Variation (%)	47.7	64.4	64.7	54.6	48.4	65.1	44.5	45.0	67.3	70.2	53.1	46.8

b) Extremes of rainfall and occurrence of falls over 25 mm (1960-1973)								
	1960	1961	1962	1963	1964	1965	1966	1967
No. of falls	8	2	2	3	3	6	5	7
Heaviest Date	42 Sep 30	42 Jan 29	28 Sep 29	48 Nov 18	41 Apr 18	33 Jan 24	47 mm Aug 6	54 mm Aug 23
						Jul 11		
No. of falls	7	3	4	4	2	4	5	5
Heaviest Date	59 Jul 22	30 Jun 27	81 Jul 29	58 Sep 11	35 Nov 6	37 Oct 8	54 mm Aug 23	

c) Annual Rainfall Totals, 1961-1973. (mm)												
1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
997	898	1051	885	1146	1261	1286	1098	975	1132	716	1172	720 mm
94	85	100	84	109	119	122	104	92	108	68	111	69 % of Ave.

Estimated mean rainfall 1916-1950 = 1051 mm.
 Coefficient of variation during period of records = 17%.

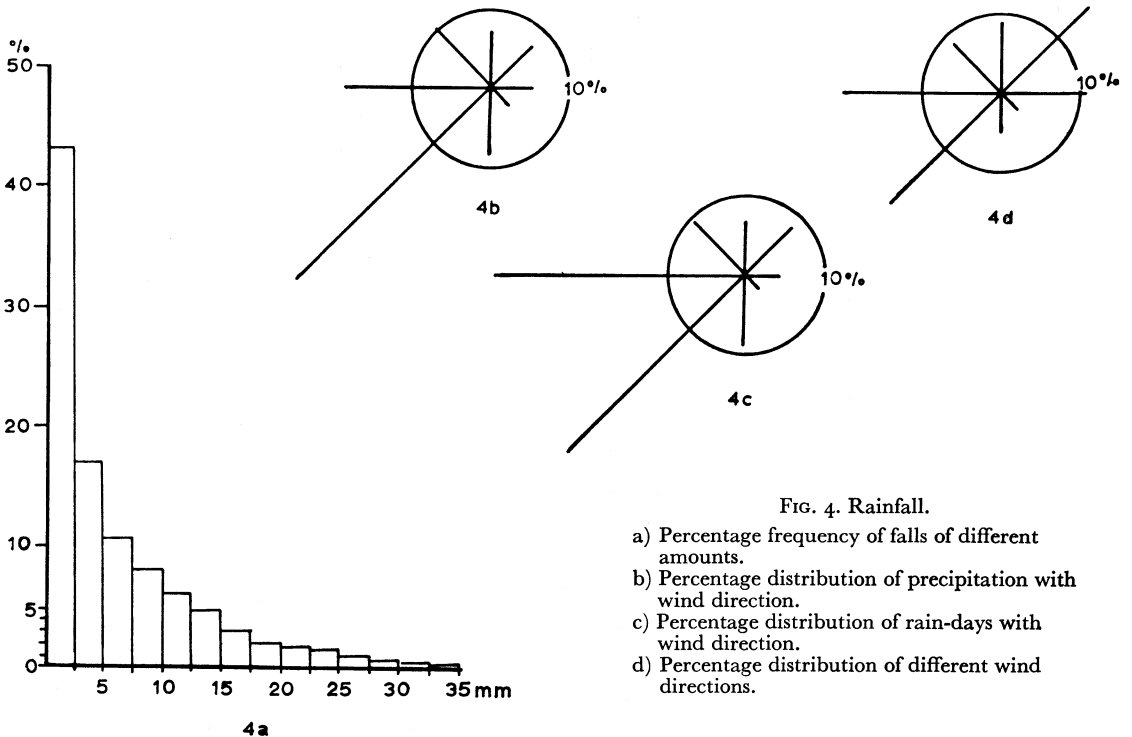


FIG. 4. Rainfall.

- a) Percentage frequency of falls of different amounts.
- b) Percentage distribution of precipitation with wind direction.
- c) Percentage distribution of rain-days with wind direction.
- d) Percentage distribution of different wind directions.

lies which bring slightly more intense rainfall in summer than in winter. This may be accounted for by thundery showers resulting from convectational activity, while in winter the Arctic air would be too cold to contain much moisture, either in the circulation of an anticyclone or of a depression.

The average number of rain-days per year at Slapton was 175, a low figure for a site in the west of England, but one that accords with *The Climatological Atlas of the British Isles* (H.M.S.O. 1952). The number of wet-days was 135, compared with the national average of 130. Fig. 4a shows the percentage frequency of falls of different amounts; 43% of the total is from falls of less than 2.5 mm. 19% of the raindays gave falls over 10 mm, a useful criterion of heavy rain, and 2.5% gave falls over 25 mm (one inch). The frequency of these falls, as well as the heaviest fall of each year, is shown in Table 2b. The wettest day of the year averages 44 mm. The heaviest daily fall in the period was 81 mm on 29th July 1969, when large areas of south-west England experienced unusually heavy rainfall and several sites recorded over 100 mm in 24 hours.

The calculated annual average rainfall for the period 1960–1973 was 1056 mm, very close to the long-term average figure of 1051 mm. This latter figure was derived from a comparison with records dating back five or six decades at other sites in the area. The annual rainfall totals are shown in Table 2c; the values were within 10% of the mean figure in only 6 years. 1966 and 1967 were notably wet, and 1971 and 1973 unusually dry, which increased the coefficient of variation of annual rainfall to 17%, compared with the 12–14% that is normal in southern Britain.

Fig. 5 is a graph of the 12-month running totals of rainfall since 1960. It smooths out the variations from month to month and shows the general trends of rainfall over a longer period. The dry spell of the early 1960s is clear, followed by a peak of wetness in 1966, since when there has been a general downward trend in total annual rainfall.

RELATIVE HUMIDITY

The average relative humidity at 0900 GMT for all wind directions was 81%. Forty per cent of the values fell between 80–90% R.H., with some distinct variations between winter and summer. Easterlies were 5–10% drier in summer than in winter, north-westerlies more than 10% drier, but the values for south and south-westerly winds scarcely varied at all during the year. Southerlies had the highest proportion over 90% R.H. and the smallest under 60%, as would be expected with air that had travelled a long way over relatively warm water, getting cooler and more nearly saturated as it moved north. In contrast, north-westerly winds, after travelling over land for up to 100 km, had the largest proportion of days with the relative humidity below 60% and the smallest proportion above 90%. The lowest recorded relative humidity was 40% on 27th January 1963, when the weather was dominated by a persistent and intensely cold anticyclone. Very low humidities nearly all occurred with anticyclonic conditions, and most readings of 50% or less were on days when the wind was from between north and east, mainly in May and June, when the air would be warmed as it passed from sea to land.

FROST FREQUENCY AND THE LENGTH OF THE GROWING SEASON

Slapton can boast an almost frost-free climate. On average, the air minimum falls to 0 °C or below on 22 occasions during the year, compared with 27 at Teignmouth

and 29 at Torbay, and the grass minimum to 0 °C on 56 occasions. 1963 was the frostiest year, with 43 frosts, while there were only 8 in 1966, 1972 and 1973. Fig. 6 shows the frost-free periods for each year, the winters of 1965–1966 and 1971–1972 being especially favoured. On average, the last ground frost can be expected 33 days after

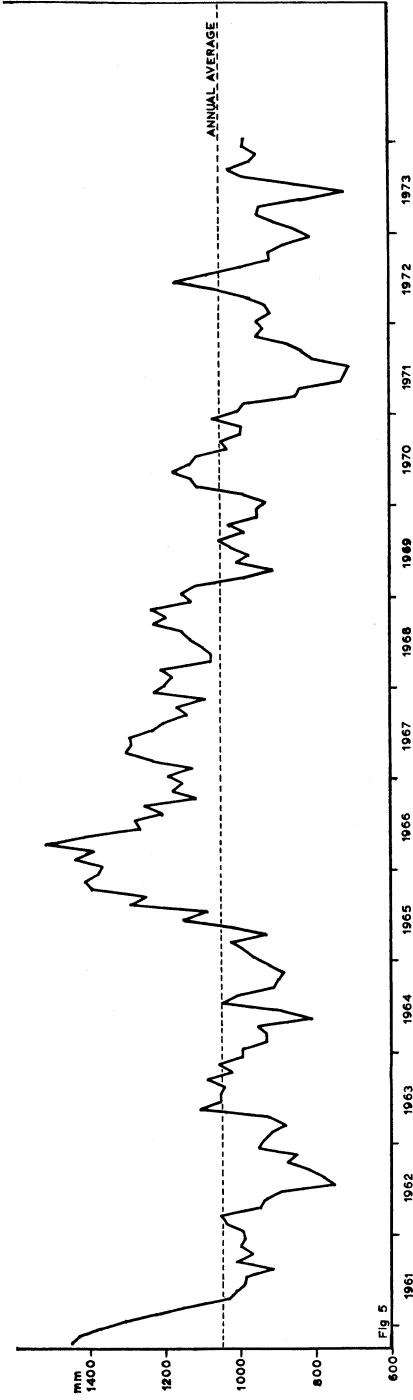


FIG. 5

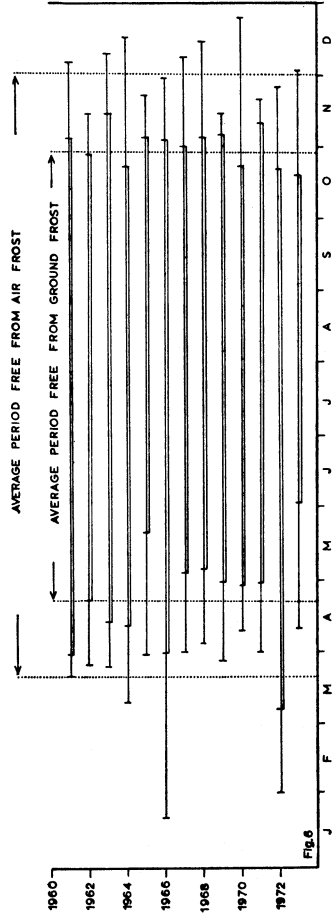


FIG. 6

the last air frost, and the first air frost of autumn 33 days after the first ground frost.

Fig. 7 shows all periods when temperatures averaged over 6 °C (normally recognized as the threshold temperature for grass growth and therefore a useful figure when measuring the growing season), and it emphasizes the relative mildness of 1961,

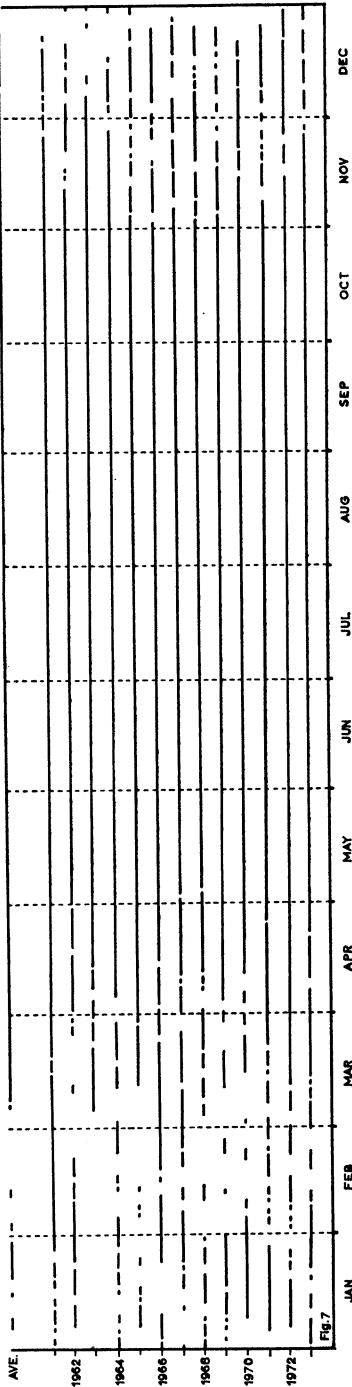


FIG. 7

1966 and 1971–1973. Although on average the growing season, as defined above, lasts from early March until Christmas, there has consistently been recently a spell of mild weather in the second half of January. Cold snaps, with the mean daily temperature more than 3 °C below the average, occurred after the end of March in ten of the thirteen years, but never before the beginning of November. The warmth of the sea produces a marked time-lag in autumn between the decrease in insolation and the decline of mean temperatures. This becomes less pronounced with distance from the coast; compared with coastal sites like Slapton and Teignmouth, Totnes, only 10 km inland, has relatively lower minimum temperatures in autumn and winter than in summer.

WIND

All wind observations at Slapton are made subjectively, but the quantity of data collected during some 13 years smooths out variations or errors resulting from a change of observer.

The percentage frequency of different wind directions during the year is shown in Fig. 4d. The highest frequencies were for south-west (20·8%), west (20·5%) and north-east (15·9%). On only 4·7% of the days was a calm recorded. An analysis of the figures on a monthly basis as in Fig. 8. shows that south-west winds prevail from April until September, with the exception of July, when westerlies just predominate, as they also do for most of the winter months.

Only 30 gales were recorded at 0900, too few to be statistically meaningful, bearing in mind that many others may rise later in the day or at night and thus escape being recorded. Therefore, the occurrence of winds of more than 24 knots (Force 6 on the Beaufort Scale) was taken as an index of windiness, gusts of gale force or more being probable on days when the mean speed is as high as Force 6. Even so, the frequency of such days varied from 7 in 1970 to 82 in 1972. The windiest period is from December to February and the least windy July and August. South-westerly winds account for nearly 30% of these windy days and north-easterlies 26%. Both these figures are high, compared with the frequency of south-west and north-east winds. The proportion of windy days from the north-west is correspondingly much lower than chance would lead one to expect, presumably the result of much greater protection by rising land in that quarter.

SUNSHINE

Slapton has no sunshine recorder, but approximate hours of sunshine have been calculated from records made at Newton Abbot, Totnes, Torbay and Teignmouth. This may be an underestimation, since Totnes is much closer to Dartmoor than the others and on average receives 12% less sunshine a year than does Torbay. The annual average for the Slapton area is 1640 hours, about 100 hours less than the average for Torbay, and the equivalent of a daily average of 4·5 hours. This compares with an average of about 4·7 hours for the south coast generally between Dover and Bournemouth. Even in a dull, cold year like 1965, sunshine averages for the south coast were close to normal, and records suggest that in the Slapton area they are unlikely to deviate from the mean by more than 4%. In only one year was the deviation more than double 4%.

Table 3 below summarizes the monthly averages, as well as giving some idea of the probable range of recordings in the Slapton district.

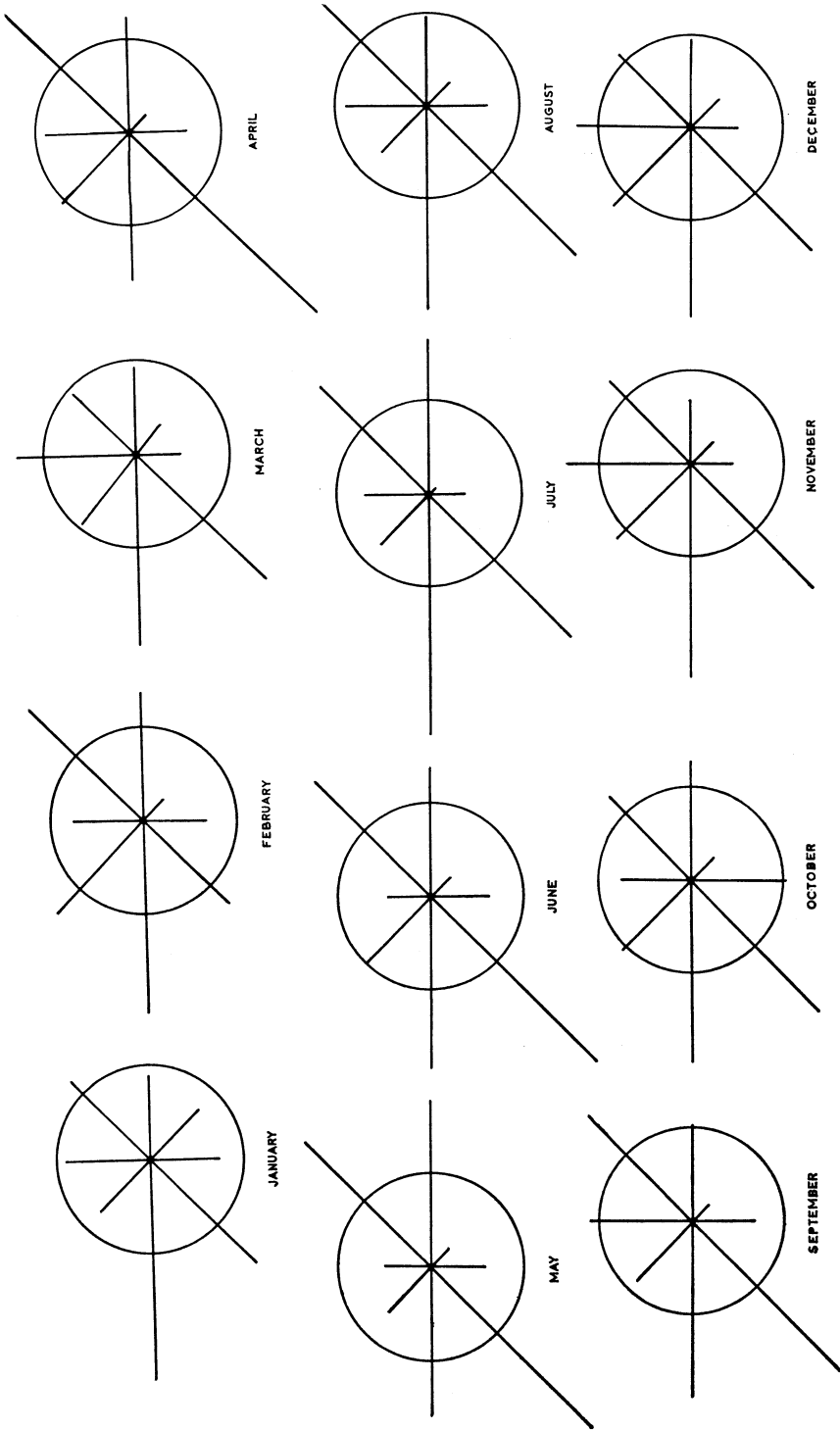


FIG. 8
Wind-roses for each month (Circle=10% of occurrences).

Fig. 8

Table 3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	1.7	2.7	4.4	5.3	6.7	7.6	7.0	5.9	5.2	3.3	2.1	2.0 hr/day
Prob. Max.	2.3	3.8	5.7	7.3	8.8	9.8	8.2	6.9	6.9	4.0	2.7	2.5 hr/day
Prob. Min.	1.0	1.5	2.5	3.7	5.6	6.1	5.4	4.6	4.1	1.9	1.6	1.5 hr/day

While June is clearly the sunniest month, it is interesting that April and May could be as sunny, while amounts of sunshine fall off most noticeably in August, probably because, in spring, while the sea is relatively cold, air moving on to the land will warm up, resulting in dispersal of cloud, while the reverse happens when the sea is relatively warm in late summer and autumn.

VISIBILITY

Slapton has little fog (that is, visibility less than 1000 m). On average, only 7 foggy days a year were recorded, although sea fogs may cover the Ley substantially more often but do not reach the Centre. Almost 40% of those recorded occurred with a north-east or east wind, of which only a small proportion were distinguishable as sea fogs.

The occurrence of mist (visibility between 1–2 km) shows a different distribution, most misty days being associated with south-west winds, during the passage of a warm front in a depression. North-east winds also give a fairly large proportion of misty days; the clearest days occur with north-west winds, with which a mere 14 days with mist were counted during the period of the records. Possible reasons for this have been mentioned above.

SNOWFALL

According to Lamb (1964) the lowest frequency of snowfall in Britain is in Cornwall, where low lying areas average fewer than 5 falls a year. Analysis of the Slapton data gives an average of only 3 snowfalls for the period 1960–1973. In fact nine of the years recorded 3 or less, and three years had no recorded snowfall. The average was raised by the many more falls in 1962–1963 and 1969–1970. The annual frequency of lying snow is even less, since it often melts on the day it falls.

LOCAL CLIMATIC VARIATIONS

The temperatures at Slapton seem to be the most moderate in South Devon: from October to the end of January the average daily minimum was higher even than at Torbay and Teignmouth, while daily maximum temperatures from June to September were consistently lower. The mean diurnal range of temperature is 20% greater at Totnes, only 10 km inland.

Rainfall records vary widely within the region (partly perhaps because of differences in the exposure of rain-gauges). Taking Slapton as 100%, the figures for Totnes, Torbay and Teignmouth are respectively 110%, 83% and 74%. However, since most rainfall in the region is cyclonic and therefore widespread, the number of rain-days does not vary much from place to place.

THE RANGE OF CLIMATIC BEHAVIOUR

It is never easy to foretell the possible extremes of climate from the records collected over a short period, and, climatically speaking, less than 30 years is short, but 1960–1973 included enough extremes to justify tentative estimates.

Rainfall in any one year is not likely to exceed 1300 mm or be less than 700 mm, and no year is likely without at least one day with more than 25 mm of rain. On average, once in every fifteen years more than 80 mm will fall in a day. The return period for over 51 mm in a day would seem to be about $3\frac{1}{2}$ –4 years.

The wettest period on record is from 1st September to 16th November, 1967, which included three 14-day spells without a dry day, and gave a total of 420 mm. The longest spell with rain on every day is 38 days, recorded twice, from the end of October to early December 1962, and again between almost the same dates in 1970. Most wet periods last less than 14 days.

The longest recorded dry spell was 76 days between 10th August and 26th October, 1972, which included only six days with rain, aggregating less than 25 mm. Almost as notable was a 58-day period between August and October, 1971, when the total rainfall was only 17 mm. The longest spell without any rain at all is 25 days; some years pass without a spell as long as 14 days.

The highest temperature recorded was 26.5 °C. Nowhere on the coast of South Devon has a temperature above 27 °C been recorded since 1960. The Slapton minimum could fall below –5.6 °C; –6 °C or less has been recorded at several places on the coast as far west as Penzance.

WEATHER PATTERNS DURING THE YEAR

The graphs in Fig. 9 were prepared from all the relevant data with the aid of a computer. Seven day running averages smooth out day-to-day fluctuations, and the mirror-image plots of rainfall and pressure are quite clear. The correlation coefficient between the two is greater than 0.70 in five months of the year. It is interesting that few of the rain-spells* shown in Fig. 10 coincide with the average rainy periods. The correspondence between dry-spells and periods with higher than average pressure is more obvious, possibly because of the larger number of recorded dry-spells.

The annual temperature curve includes a marked anomaly; during the past decade, January has often included an uncharacteristic mild spell, followed by cold weather in February. The spring warming-up process is then interrupted by two well-established cold spells, in late March and Mid-May, before high summer is reached in mid-July. The mean temperature then remains close to 16 °C until the first week of September. Cooling in autumn is slow, except for a drop of some 2 °C in the first week of November. The coldest day is on average 4th January (4.6 °C); only once in the 13 years did the mean temperature exceed 6.5 °C on that day. The warmest week of the year is 20th–26th July, which, interestingly, is classified as a notably dull, wet week in Lamb's calendar of spells of weather (Lamb, 1964).

Since researchers, including Professor Lamb, now agree that the last decade has seen a marked deterioration in the world's climate, it would be interesting to monitor the records of individual places such as Slapton for further signs of change.

* A rain-spell is a period of at least 15 consecutive days, each with at least 0.2 mm of rain, while a wet-spell is at least 15 consecutive days each with 1 mm or more. A dry-spell is at least 15 days, none with more than 1 mm of rain, while an absolute drought is a similar period with no more than 0.2 mm of rain on any one day (Crowe, 1971).

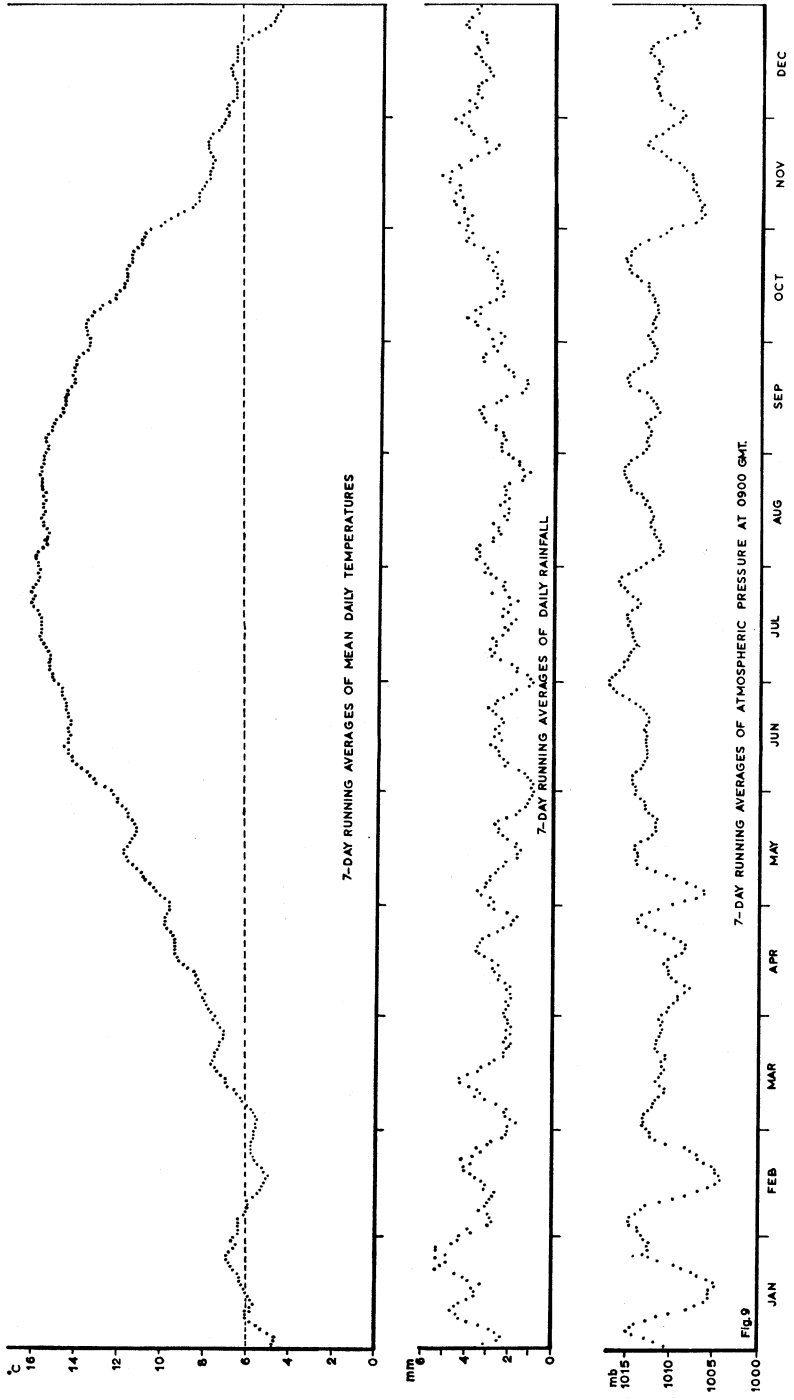


FIG. 9

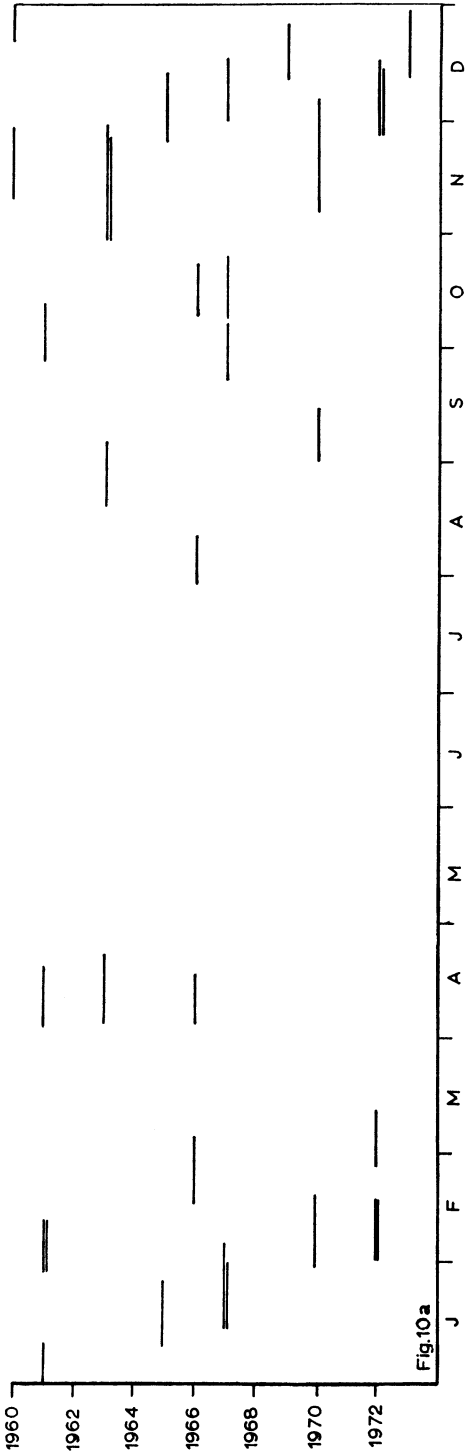


FIG. 10a. The occurrence of rain-spells (single line) and wet-spells (double line), 1960-73.

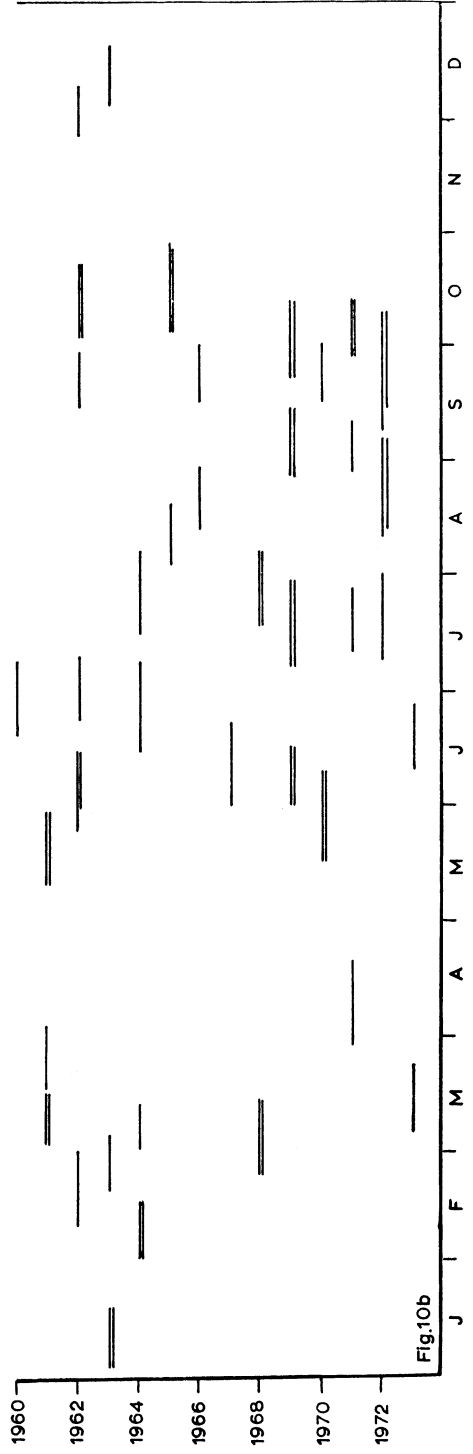


FIG. 10b. The occurrence of dry-spells (single line) and droughts (double line), 1960-73.

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