

A CLOSER EXAMINATION OF HOBART RAINFALL FLUCTUATIONS

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ABSTRACT

Daily rainfall at Hobart has been related to M.S.L. geostrophic wind direction. For rainfall amount, both westerly and southeasterly winds are important. "Easterly rain" is less frequent than "westerly rain" and more variable, but the average falls are about the same. Easterly rain is the result of an east coast depression.

The implications of O'Mahony's (1961) spectral analysis of Hobart's March and June rainfall are examined. Other stations in Tasmania, even those on the north and west side, show the same seven year quasi-period in June, although to a less pronounced degree than Hobart, suggesting a primary mechanism of high level disturbances.

The phase of the seven year regularity in April is opposite to that in March and June, and it is absent in May. Thus there is no coherence of the phenomenon over the autumn season.

1. INTRODUCTION

O'Mahony (1961) has drawn attention to what seems to be an important quasi-periodic variation in Hobart's March and June rainfall, and has implied that this is a lasting feature of rainfall regimes at Hobart in autumn (using this term to cover the period March to June, inclusive). He offers the following in partial explanation.

- (i) "The meteorological situations which are rain-producing at Hobart during winter are very much more homogeneous than those for the other stations which have been considered here." An intense depression located east of Tasmania at 39°S , 153°E . is quoted as an example of such a situation.
- (ii) "It is fairly certain that the oscillatory tendencies of (a) 2-3 years and (b) approximately 7 years which have been observed in rainfall, extend also to the movement of pressure systems and hence to the overall circulation pattern."
- (iii) "Because of its influence on the pressure systems of both hemispheres, the (Southern) Oscillation must exert a major control on rainfall patterns, and this would account for the consistency of the spectral peaks observed in monthly rainfalls near the 2-3 year periods."

The implications of these remarks are that in wet seasons, the autumn period is marked by a strong tendency for cyclogenesis east of Tasmania; and there is a physical control in the hemisphere with a quasi-period of 7 years which favours cyclogenesis at about latitude 40°S in the Australian east coast region in some autumns and not in others.

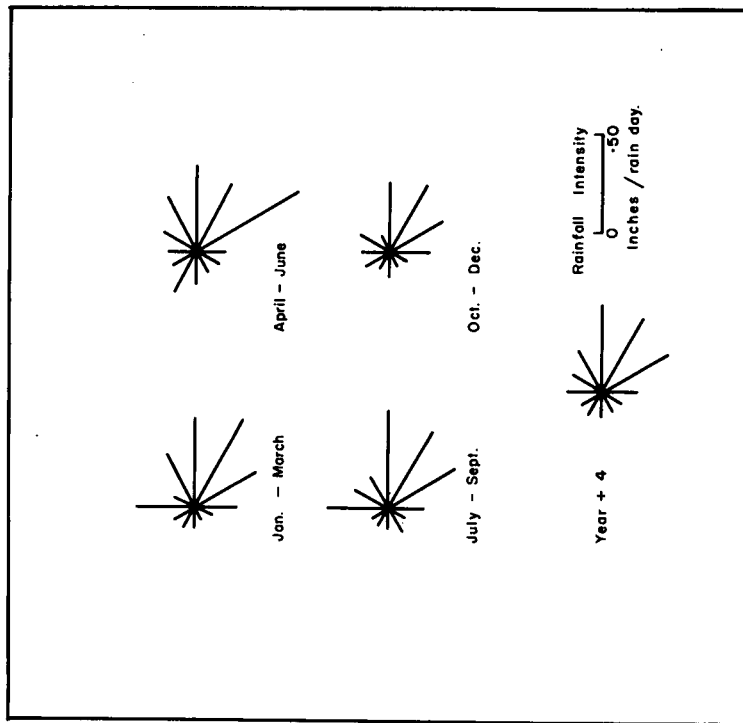


Figure 2. Mean seasonal intensity of Hobart rainfall [inches per rain day] during 1953 - 62 as a function of geostrophic wind direction.

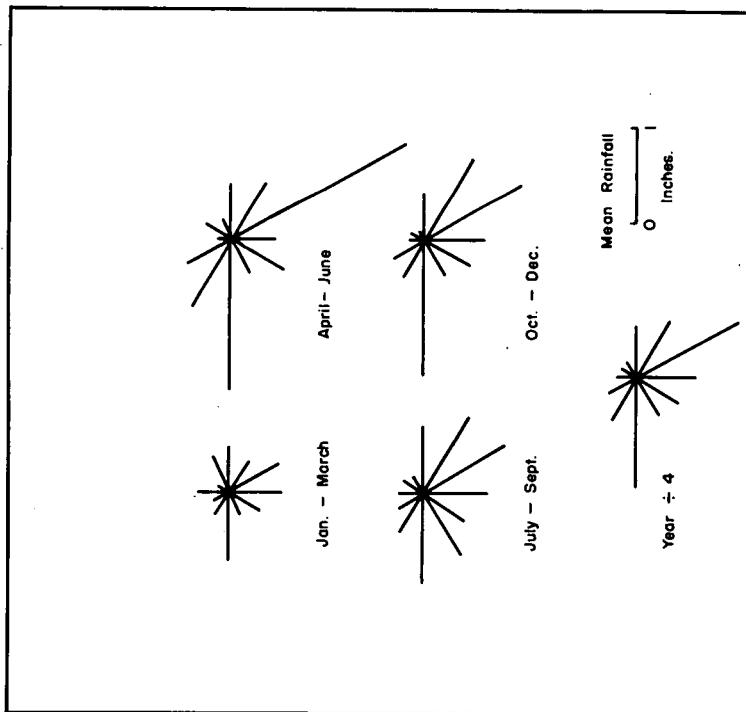


Figure 1. Mean seasonal rainfall at Hobart during 1953 - 62 classified according to M.S.L. geostrophic wind direction.

The first of these requires support by observational evidence, the second requires a closer analysis of the fluctuations of monthly rainfall; for since O'Mahony studied a considerable number of station-months to obtain the one impressive result at Hobart, the 7 year quasi-period might well be a statistical fluke.

2. DAILY RAIN AND SYNOPTIC SITUATION

Daily rainfall for a ten year period at Hobart has been examined in relation to synoptic situation. While Tasmania lies in the "roaring forties", and experiences the frequent westerly disturbances of these latitudes (although sheltered from the westerlies in the Hobart area by a mountain barrier), it is well known, as implied by O'Mahony, that the "east coast depression" is a fruitful source of rain. The relative importance of these two processes can be judged by relating daily rainfall to geostrophic wind direction, on the M.S.L. isobaric map. Good M.S.L. analyses are available, at least since the war, and the period 1953-62 was chosen for investigation, using the 1510 rain days reported at Hobart at 0900 EST, and relating them to the previous 2100 EST maps. A check on the representativeness of these ten years revealed an anomalously high annual rainfall (by 2.5 in.), the excess rain falling mainly in the autumn. Thus April-May-June, which in the 82 year mean supplied 26.4 percent of the total, in this decade provided 32.0 percent. In the light of what follows, this suggests that these years had an anomalously high incidence of "easterly rain", especially in autumn.

It is worth noting that Walpole (unpublished) has made a study of Hobart rainfall, by six-hour periods, in relation to the surface wind direction, based on the years 1918-22. Table 1 gives his results, in terms of percentage of total rain from each direction.

Table 1. Percentage of total rain with surface wind from each direction (1918-22), after Walpole

N	NE	E	SE	S	SW	W	NW	Calm
11	2	2	6	16	32	9	16	6

His main conclusion is that "half the total rainfall comes with winds from the SW quadrant, and this is true for all seasons and all hours, but is slightly more marked in summer than in winter, and in the early afternoon".

Results of the present analysis based on geostrophic wind direction, are shown in Figs. 1 and 2. The former gives total mean rainfall (inches per season) with wind from twelve compass points; the latter mean intensity, in inches per rain day. From these, frequency of rain days with wind from various directions may be deduced; this shows westerly geostrophic wind direction is strongly favoured.

If "westerly rain" (R_W) is the seasonal sum of that falling over 24 hours with the mid-period surface geostrophic wind from between 345 and 195 degrees, "easterly rain" (R_E) that with wind from between 015 and 165 degrees, and the remainder (R_U) is unclassified, then Table 2 shows that over the ten years there is little difference between \bar{R}_W and \bar{R}_E (mean seasonal values of R_W , R_E). However, as shown by the much greater standard deviation (σ_E) of R_E than that (σ_W) of R_W , the former contributes at least three times as much to the variance of total rainfall, both seasonal and annual, as the latter. We may thus think of Hobart's seasonal or annual rainfall as consisting of a rather reliable westerly, and a very variable easterly component. It would thus be reasonable to suppose that the existence of a spectrum peak at 7 years largely reflects a 7 year variation in easterly rain.

Table 2. Mean and standard deviation of R_W and R_E , and mean R_U , (inches) for the years 1953-62.

	\bar{R}_W	\bar{R}_E	\bar{R}_U	σ_W	σ_E
Summer	1.63	1.99	1.01	0.61	2.35
Autumn	3.94	3.87	0.74	2.14	3.89
Winter	2.99	2.90	1.00	1.23	2.14
Spring	3.04	2.88	0.96	1.13	1.84
Year	11.60	11.64	3.71	2.86	5.46

The easterly component of rainfall is associated with a depression, broadly described as an "east coast depression", with centre north of Hobart; the westerly component with depressions normally moving on a southeasterly course well south of Hobart. The importance of the "east coast depression" for heavy rainfall is shown by Fig. 3, where depression centres for all occasions of daily rainfall greater than one inch during the decade are located. The depression may or may not be associated with an intense pressure ridge to the south, and it is not possible without much more information to aver that it is associated with a hemispherical pressure anomaly, or displacement of the west wind belt.

3. MONTHLY RAINFALL FLUCTUATIONS

We cannot doubt the tendency of wet (and dry) Junes to have repeated themselves at roughly 7 year intervals over the past 80 years; in fact, the regularity appears so great that one could well be dealing with a harmonic process, if this month is considered alone. Arrangement of the June rainfalls from 1883 to 1959 in a seven year superposed epoch analysis (arrangement in a 7 year Buys Ballot table and subsequent averaging - see e.g. Conrad and Pollak (1950)) shows a pronounced seven year variation, an effect which is emphasised when the data are normalised by taking logarithms (Fig. 4a). The earlier period, from 1841 to 1881, shows a similar feature, but completely out of phase.

We have also examined the logarithm of June rainfall at nine other stations (marked in Fig. 3), in Tasmania and its vicinity, by the same method. The results for Low Head and Waratah are shown in Fig. 4b. In Fig. 4c are shown the results for all stations (except Hobart) combined. The combination was effected by dividing each Buys Ballot average by the standard deviation of the mean for the station, then averaging over the nine stations. The standard error of the resulting means would be 0.34 if the station rainfalls were independent of one another. Two out of seven of the values obtained exceed 2.6 times this value; the probability of this occurring by chance would be one in 200, which means that the result would be highly significant as a mean of independent station series.

It will be noted in Fig. 4b that both Waratah and Low Head show maximum rainfall in years 1 and 7. This feature is observed at all the stations treated. In view of the situation of these stations, it appears unlikely that this occurs with easterly winds, and hence we should rather suggest that there has been a tendency for a seven year regularity in June rainfall in Tasmania associated with the presence or absence of cut-off lows or cold pools aloft. The normal consequent development of a depression at the surface in the west Tasman Sea produces topographically reinforced rainfall at Hobart, whose averaged rainfall presents (with the possible exception of Swansea) the most regular progression over the 7 years of all the stations considered.

If such a regularity is due to the operation of a non-random physical control, we might expect the latter to be coherent for a season at a time, and the seven year regularity should be found in April and May as in March and June, with the same phase. Failure on either of these points would greatly increase the difficulty of satisfactorily "explaining" the phenomenon.

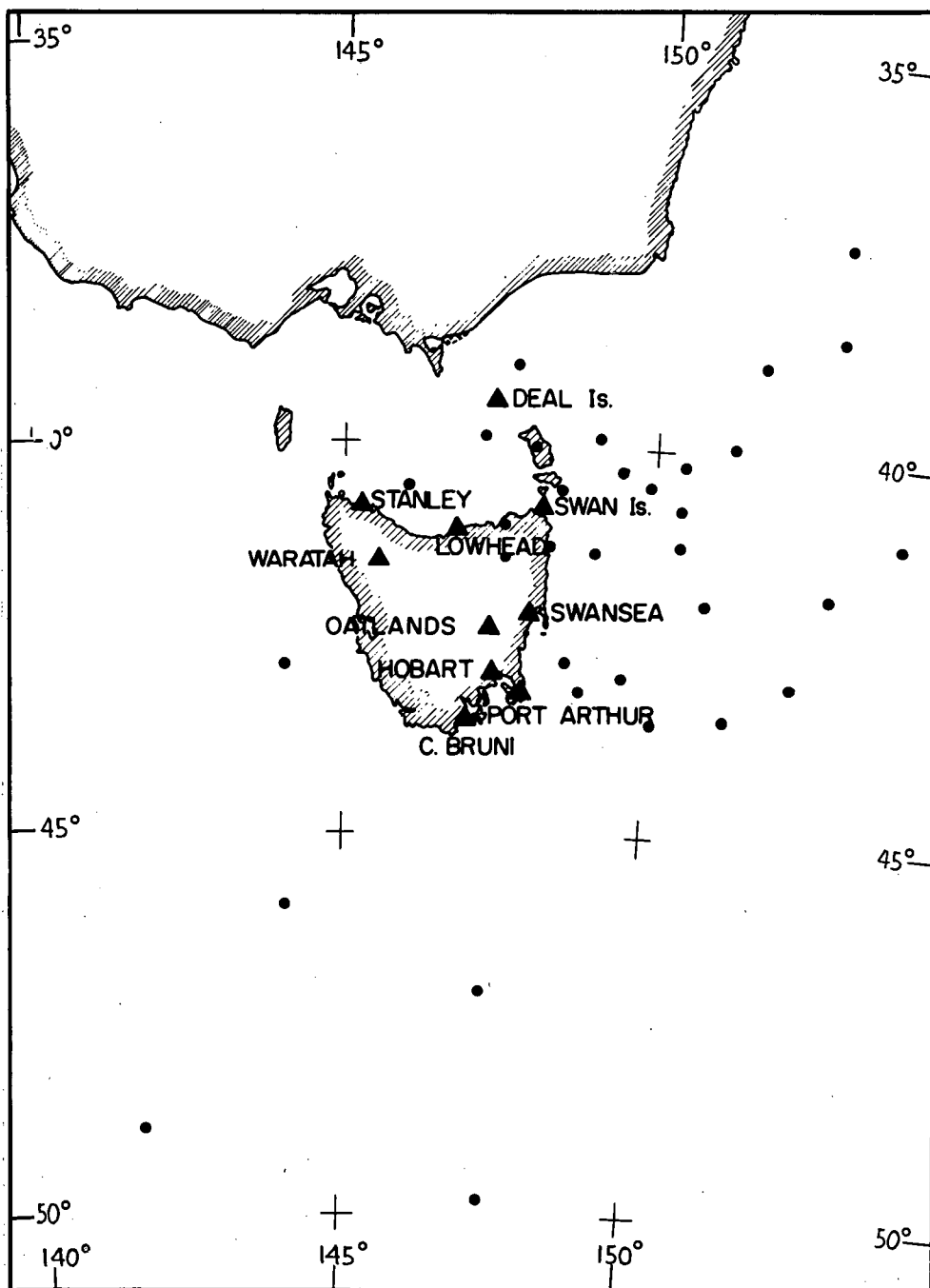


Figure 3. Location of depression centres[●]when 24 hour rainfall at Hobart exceeded one inch [1953 - 62] ; and the location of the rainfall stations[▲]used to derive Fig. 4c.

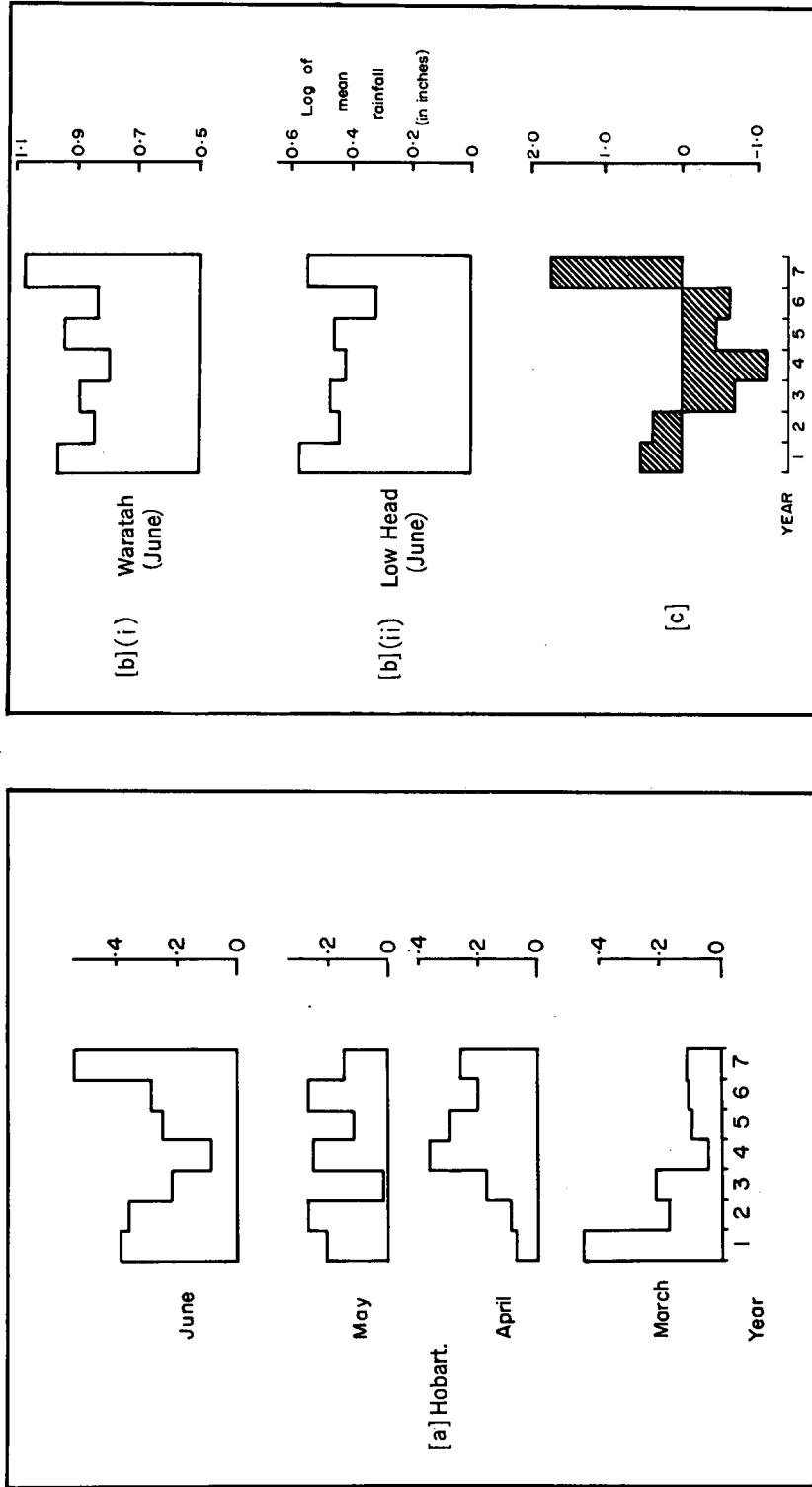


Figure 4. Histograms showing mean of Buys Ballot table for logarithm of monthly rainfall during the 77 years 1883 - 1959. The first column shows the mean for the years 1883, 1890, 1897, . . . 1953, the seventh for the years 1889, 1896, . . . 1959.

- [a] Hobart.
- [b] (i) Waratah (June).
- [b] (ii) Low Head (June).
- [c] Departures from average (fraction of standard deviation) of nine stations (June).

The Buys Ballot tables give results for April and May (Fig. 4a) which do not suggest any coherence over the season. It can be seen that, for April, what seven year period may exist is completely out of phase with March and June, while none exists in May. Confirmation of a lack of seasonal coherence comes from the following correlations between logarithms of monthly rainfalls for the same year (Table 3).

Table 3. Correlation between logarithms of monthly rainfall at Hobart, 1882-1963

March-June	April-June	May-June
0.135	0.051	0.135

None of these correlations is significant at the 10 percent level.

The spectral analysis* for May, shown in Fig. 5, based on 82 years of observation, does not show a peak at 7 years, but at 6 and 2 years.

4. CONCLUSIONS

A study of 10 years' rainfall in relation to M.S.L. synoptic sequences shows that Hobart's rainfall can be thought of as broadly consisting of two types: frequently occurring light rain due to disturbances in the prevailing west winds, with relatively low seasonal and annual variability, and very close in mean amount to a much more variable and infrequently occurring component, due broadly to east coast depressions. There appear to be no important seasonal variations in these relationships.

Seven year Buys Ballot tables of rainfall at other stations indicate that the 7 year regularity at Hobart is also evident over Tasmania and nearby islands in June. However, a study of April and May Buys Ballot tables and the spectrum of May rainfall at Hobart show that there is little seasonal coherence in the behaviour of this regularity; its phase is reversed in April, and it is not evident in May. If it were not so striking in the 80 years of June data, it could be easily dismissed as accidental, and therefore unlikely to recur. As it is, we must be content to point out that one cannot speak of a seasonal regularity, and that a satisfactory physical explanation of the observed behaviour over autumn is certainly called for.

* The spectra were obtained by harmonic analysis of the correlogram using the expression

$$F(n) = 4 \left\{ \frac{R(0)}{N} + \frac{2}{N} \sum_{t=1}^{N-1} R(t) \cos \left(\frac{2\pi k}{N} \cdot t \right) \right\}$$

Where $F(n)$ is the fraction of variance per unit frequency interval at frequency n ; n equals $\frac{k}{N}$. $R(t)$ is the autocorrelation coefficient at lag t , and k is the harmonic number. The spectra were unsmoothed.

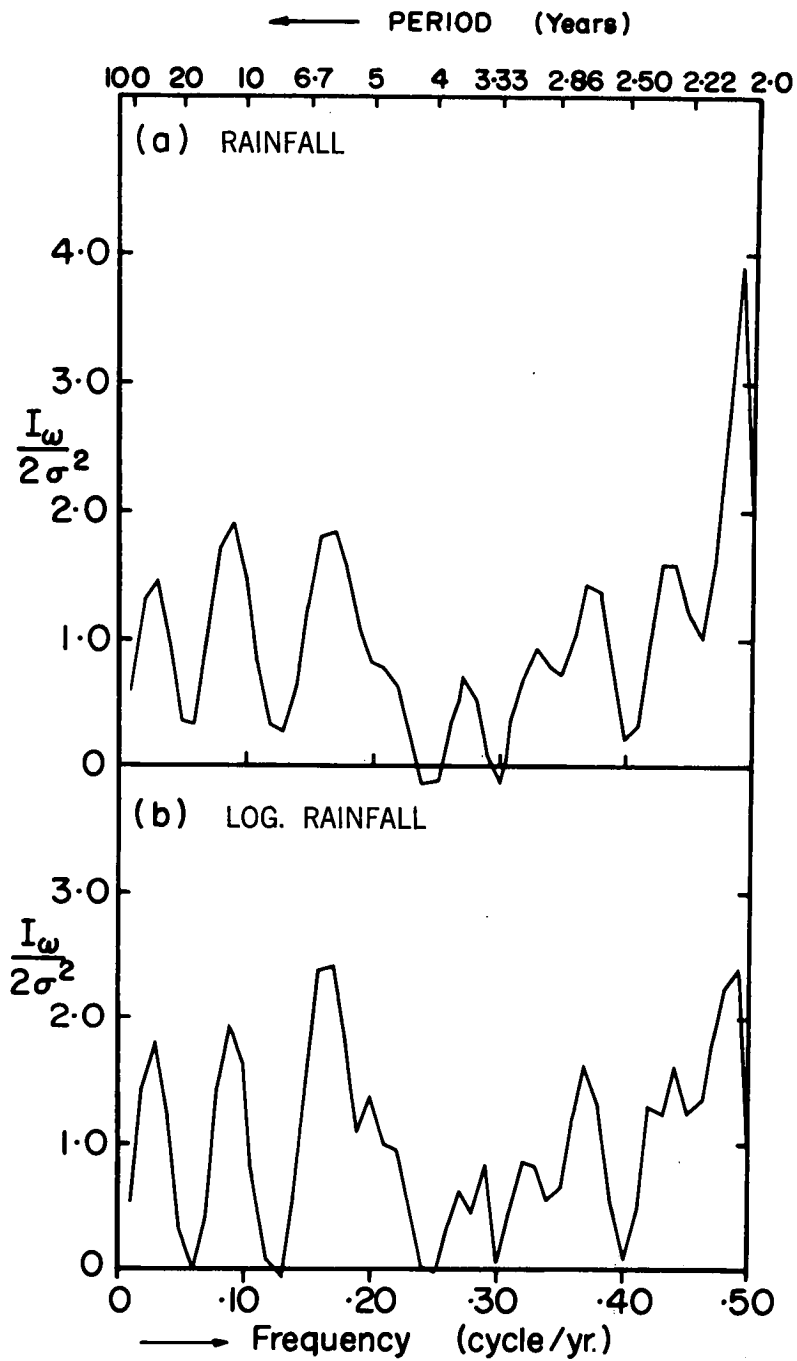


Figure 5. Spectra of [a] rainfall, [b] log. rainfall during May at Hobart for the years 1883 - 1964. The ordinate is $I_{\omega}/2\sigma^2$ [O'Mahony's symbols].

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