matters arising

On the 27-day cycle in the rainfall at Los Angeles

ROSENBERG and Coleman[1] reported a 27-d cycle in the rainfall of Los Angeles. Subsequently the former author has used the cycle to forecast, starting from an initial day to be determined each year, 13.5 d wet and 13.5 d dry periods in the winter months of Southern California. Their 27-d cycle was based on the spectral analysis of the rainfall data at the Los Angeles Civic Center. They used the Blackman–Tukey method with the Tukey spectral window[2] and a maximum of 250 lags. I question the significance of the peaks in the Los Angeles rainfall spectrum.

Professor M. Wurtele of the Department of Meteorology at UCLA provided a record of daily rainfall data for Los Angeles covering a period of over thirty years (June 1943–August 1973). (UCLA campus is $\approx$ 17 miles from the Los Angeles Civic Center.)

Spectral analysis of the UCLA rainfall data was done by the method of direct estimation of spectral density using Fast Fourier Transforms[3]. The detailed description of this method is found in Cooley *et al.*[4].

Figure 1 shows the normalised density spectrum of the UCLA data. It has the general red noise (spectrum) feature (that is, most of the energy is at low frequencies) which is typical of geophysical phenomena.

This spectrum shows peaks around 28.4, 22.3 and 16.0 d. The first peak whose period is comparable to the 27 d of Rosenberg and Coleman is the most pronounced. The question, however, is whether or not this peak is statistically significant.

It is generally assumed that each of the spectral estimates has a χ^2 distribution with an equivalent number of degrees of freedom (e.d.f.). The e.d.f. is a function of the total length of the record N and the maximum number of lags (or, equivalently, of half the width of the window of the power spectrum).

Having determined the e.d.f. the significance of any of the peaks depends on whether or not persistence in the data is taken into account. This is done by comparing the density of the peak multiplied by the e.d.f. to the density of the red noise (spectrum) at that particular frequency, rather than to the density of the Gaussian white spectrum[5].

Red noise (spectrum) is the spectrum of the persistence-modelling random process referred to as the first order Markovian (or autoregressive) stationary process.

On the basis of our analysis all three peaks were not significant relative to the red noise (spectrum) even at the 80% confidence level which Rosenberg and Coleman arbitrarily chose. The confidence level for the 28.4-d peak is 1%. The confidence levels for the 22.3-d peak and the 16-d peak are 15% and 75% respectively.

We are therefore led to believe that the spectral peak around 28.4 d is a spurious one. Its statistical significance hinges on whether or not the reference spectrum, with which it is compared, takes into account persistence in the rainfall data.

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1 Rosenberg, R. L., and Coleman, P. J., Jr, *Nature*, **250**, 481–484 (1974).
2 Blackman, R. B., and Tukey, J. W., *The measurement of Power Spectra*, 22 (Dover, New York, 1958).
3 El-Sayed, H., and Landsberg, H. E., *Spectral analysis of the rainfall in Dakar (Senegal)*, *Pub. No. 92, The Graduate Program in Meteorology*, University of Maryland (1973).
4 Cooley, J. W., Lewis, P. A. W., and Welch, P. D., *The Fast Fourier Transform Algorithm and its application*, IBM Research Center, RC. 1743, (New York, 1967).
5 Gilman, D. L., Fuglister, F. J., and Mitchell, J. M., *J. atmos. Sci.*, **20**, 182–184 (1963).

ROSENBERG REPLIES—El-Sayed has analysed a portion of the daily rainfall spectrum shown in his Fig. 1 by compari-

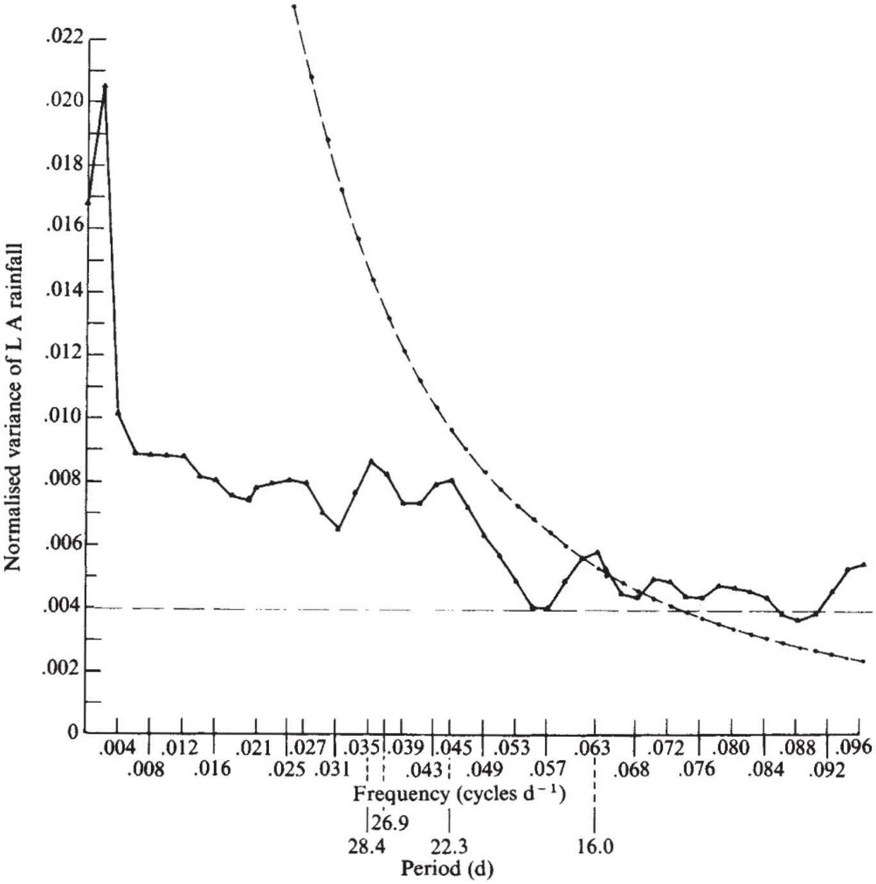

Fig. 1 The normalised variance of Los Angeles rainfall (the area under the curve is unity). The data window used is

$$W(J) = 1-\left(\frac{J-(L-1)/2}{(L+1)/2}\right)^2; j = 0,1,...,L-1$$

which gives a sharp spectral window very close to the shape of the spectral window of a cosine arch[4], and results in an e.d.f. $\approx 3.25N/L = 83$ (ref. 3), where L is the length of the data segment for which the sample spectra are computed. The horizontal line (— — —) represents the white spectrum, while the curve (—.—.—.—.) is for a red spectrum with decay coefficient (ρ) = 0.89.