551.577.33(54)

A quasi-biennial oscillation in precipitation at some Indian stations

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(*Received 27 July 1968*)

ABSTRACT. A search has been made for a quasi-biennial oscillation in precipitation from an analysis of yearly rainfall data from seven Indian stations. Results indicate the presence of a significant oscillation at Bombay and of a weak oscillation at five of the six other stations.

1. Introduction

Systematic search of cyclic variations in a variety of meteorological time-series had been the subject of many investigations. One of the important cycles in climatic series is the 2·2-year cycle which was discovered by Clayton, and is often referred to as the 'Southern Oscillation'. The cycle is very prominent in the equatorial stratosphere. Its existence has been noticed in several astro-geophysical series including indices of solar activity, ozone and geomagnetic activity. A comprehensive review of the quasi-biennial cycle in climatic series has been given by Landsberg (1962). In this survey the stations in whose precipitation data the biennial oscillation has been noticed are, with the exception of one, all from Europe and North America. In the present report, a search has been made for this oscillation in precipitation data of stations in the Indian region.

2. Analysis and results

The method of spectral analysis has, in recent years, become a standard and important tool for the analysis of astro-geophysical time series and for the search of periodicities. This method has been applied here to the time-series composed of yearly precipitation of those stations in India from which observations for 90 years or more are available. The series were subjected to spectral analysis by the method outlined by Blackman and Tukey (1959). The computational procedure implies a filter the width of which depends inversely on the truncation length, broad filters (small truncation length) providing enough equivalent degrees of freedom and hence better stability of estimates while narrow filters provide higher resolution. In the present computation auto-correlations were successively truncated at 10, 20 and 30 lags to obtain spectra with progressively higher degrees of resolution. It was found that truncation at 20 lags provided adequate resolution with reasonably good stability of estimates. The spectra are shown in Fig. 1.

At the peaks confidence intervals for 90 per cent confidence have been indicated. These have been computed from chi-square values corresponding to the number of degrees of freedom, $2N/M$, where N is the number of data points and M is the maximum lag (Granger and Hatanaka 1964). A peak corresponding to a particular frequency may be considered significant with 90 per cent confidence, if in attempting to draw a smooth curve, after taking into account the confidence limits, a departure towards higher value is found inevitable. The spectral peaks corresponding to periods between 2 and 3 years together with the number of degrees of freedom and the number of years contributing to the data are shown in Table 1 against each station. The peaks corresponding to a period between 2·22 and 2·50 years appear at 5 of the seven stations. For Mysore, a broad spectral peak appears and is centred about a frequency corresponding to 2·94 years. The estimate for Bombay is significant at 90 per cent confidence level, those for Cochin, Madras and Nagpur are of marginal significance and those for Calcutta and Mysore are not significant. For Delhi, there is no evidence of a biennial oscillation. According to Blackman and Tukey (1958) and Jenkins (1961) a more reliable test of the reality of spectral peaks is the consistency of maxima about a given frequency in independent data samples. Since the spectra from five of the seven independent data sets show peaks at frequencies corresponding to periods between 2·22 and 2·50 years, the reality of a quasi-biennial oscillation in the precipitation in the region is established with fair certainty. For Bombay another peak, also significant at 90 per cent confidence level, appears at a frequency corresponding to the period of 4·70 years as a sub-harmonic of the quasi-biennial peak and further confirms the reality of the oscillation at this station. None of the other peaks in the spectra occur in more than two independent data samples.

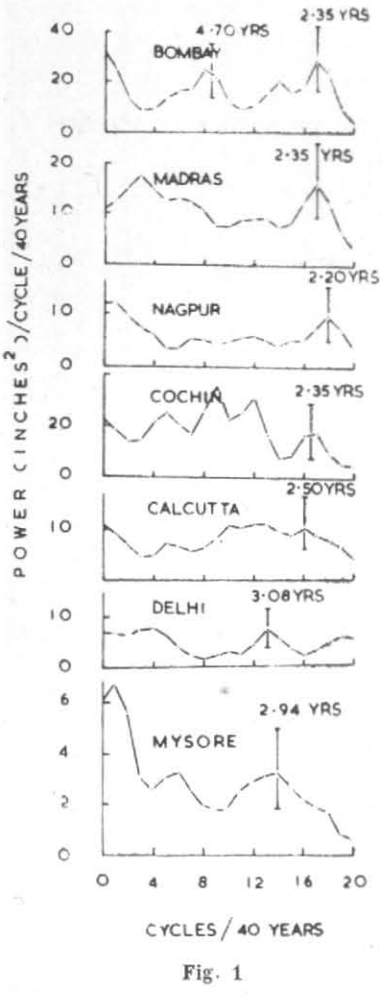

Fig. 1

TABLE 1

Station	Number of years contributing to data	Periodicity (years)	Number of degrees of freedom ($2N/M$)
Bombay	150	2·35	15
Madras	148	2·35	15
Cochin	97	2·35	10
Calcutta	124	2·50	12
Nagpur	106	2·22	11
Mysore	128	Broad peak centred at 2·94 yrs	13
Delhi	105	—	11

3. Discussion

The origin of the quasi-biennial oscillation has not been established with certainty. Landsberg (1962) excluded the possibility of a solar origin. Shapiro and Ward (1962), however, found a small peak in the spectrum of Zurich Sunspot Numbers and its coincidence with the oscillation of the zonal wind component in equatorial stratosphere (Veryyard and Ebdon 1961; Reed and Rogers 1962) prompted them to ascribe the oscillation to a quasi-biennial cycle in solar ultraviolet radiation. However, Belmont *et al.* (1966) did not find any 26-month oscillation in the slowly varying component of solar flux at 10·7 cm, which is highly correlated with sunspot number as well as with the temperature and density of the thermopause. The biennial oscillation in ozone (Funk and Granham 1962, Ramanathan 1963), in the geomagnetic field (Kalinin 1952, Stacey and Westcott 1962) and in the quiet-day magnetic variation (Yacob and Bhargava 1968) supports the view that the oscillation is associated with a similar cycle in solar ultraviolet radiation. The occurrence of this oscillation in precipitation in several North American and European stations and in the Indian region, reported here, suggests that it is spread over a large part of the world.

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