NOTES AND CORRESPONDENCE

A Quasi-Stationary Appearance of 30 to 40 Day Period in the Cloudiness Fluctuations during the Summer Monsoon over India

By Tetsuzo Yasunari

The Center for Southeast Asian Studies, Kyoto University, Kyoto 606
(Manuscript received 18 March 1980, in revised form 6 May 1980)

Abstract

By using the cloudiness data from 1966 to 1972, a quasi-stationary appearance of 30 to 40 day period was confirmed during the summer monsoon season over India, which is recently found in the data for 1973 as a predominant mode of the monsoon fluctuations (Yasunari, 1979). In the same manner as the result of Yasunari (1979), the fluctuation of this mode shows a northward movement over India-Indian Ocean area in each year. This periodicity seems to appear annually except for the severe drought years such as 1972.

1. Introduction

This is an extention of the previous study by Yasunari (1979), which will be hereafter be referred to as Y79. The cloudiness fluctuations associated with the Northern summer monsoon were examined in Y79 using the data for 1973 obtained from meteorological satellite pictures. It was shown that a periodicity of about 40 days exists predominantly and that of around 15 days is also apparent as a second mode. The fluctuation of 40-day period appeared as simultaneous northward movement from the southern equatorial zone to the zone of about 30°N, which was most distinct over the India-Indian Ocean sector. In contrast, that of around 15-day period included two clockwise rotations, one over India and Southeast Asia, and the other over the western Pacific.

Several authors already commented on the 15 day (or quasi-biweekly) period appearing in the Asian summer monsoon (*e.g.*, Krishnamurti and Bhalme, 1976; Murakami, 1976 etc.) from the data of different years. However, it has remained unknown whether the mode of 40-day period happened to appear in 1973 or may appear stationarily in every year.

In this paper, the daily cloudiness fluctuations over India - Bay of Bengal region are examined for the summer months (June to September) of 1966 through 1972, to see the year to year stationarity of the periodicity of around 40 days.

2. Data

The global daily cloudiness data (30°N–30°S) from February 1965 to July 1973 were kindly offered by Prof. Sadler of University of Hawaii. The cloudiness values were determined at every 2.5° latitude-longitude grid square from 0 to 9 levels, as defined in Sadler (1969). By use of these data, areal averaged cloudiness was composed for each square block of 5° latitude×10° longitude to eliminate small scale cloud disturbances. As the data for 1965 have a larger amount of missing data (15–30%) compared to other years (less than 8%), those are excluded from the present analysis. The same cloudiness data used in Y79 are also referred to as the data for 1973.

3. Spectral analysis of monsoon cloudiness for the years from 1966 to 1973

Spectral analysis by the maximum entropy method (MEM) was applied to the daily cloudiness data for the period from June 1 to September 30 (122 days) of the years from 1966 to 1973. As is well known already, this method has an advantage of giving high resolution, especially for short time record (*e.g.*, Ulrych and Bishop, 1975; Hino, 1977 etc.). In the present analysis,

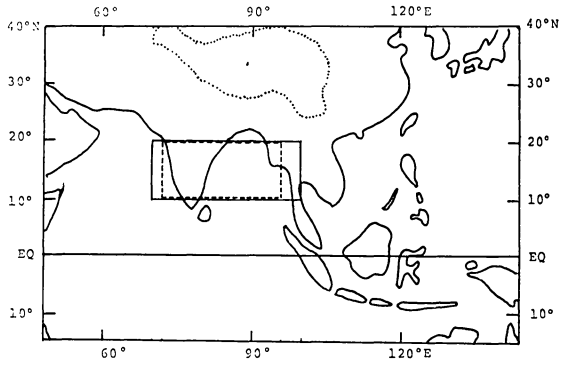

Fig. 1 Selected area for spectral analysis. The area enclosed by dashed lines is adopted for 1973.

the length of the prediction error coefficient of 25 days was adopted. As a representative area of Indian summer monsoon, the square area over India through the Bay of Bengal (10°–20°N, 70°–100°E but 72°–96°E in the case of 1973) was selected as shown in Fig. 1. Mean cloudiness of the square area was obtained by averaging the data of the six unit blocks as mentioned in the previous section.

The results of power spectrum computations for the years from 1966 to 1973 are shown in Fig. 2. The area of the cloudiness measured for 1973 is a little different from the other years as shown in Fig. 1, because of the difference of size of a unit block (refer to Y79). In all of the years except 1972, the periodicities of 30 or 40 days exist as a predominant mode. This mode seems to be at 30 or 40 day period with every passing year. In 1972, in contrast, the most dominant mode is found at about 60 day period. It is noteworthy that this region (around India) was subject to a severe drought in this year. The drought appeared over northern and central India associated with abnormally long period of "break" from the middle of July to the beginning of August (Kanamitsu and Krishnamurti, 1978). Therefore, the longer periodicity of 1972 relative to other years may be attributed to the long-lasting "break" of this year. Fig. 2 also shows the yearly stationarity of the quasi-biweekly mode over this region during the summer monsoon season.

No other distinct modes common to most of the years were found in the shorter period range in Fig. 2, mainly by the filtering effect of the relatively large averaged area (10° lat. × 30° long.) for cloud disturbances of small time-space

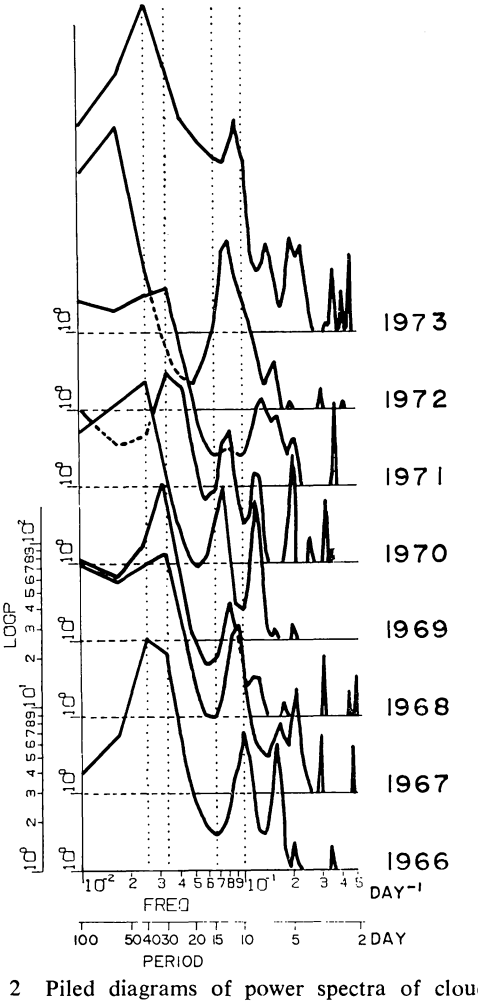

Fig. 2 Piled diagrams of power spectra of cloudiness for 1966 through 1973. Units are (cloudiness values^2·day). The spectral bands of 30 to 40 day period and 10 to 15 day period are indicated by dotted lines.

scales.

4. Cross sectional analysis of cloudiness along the India-Indian Ocean sector for the years from 1966 to 1972

As is noticed in Y79, the cloudiness fluctuation of about 40-day period shows a marked northward movement over the whole Asian monsoon area, most apparently over the India-Indian Ocean sector. To examine this feature for each year, the time-latitude cross sections of band-pass filtered cloudiness were composed over the longitudinal sector of 70°–90°E. The band-pass filters were determined to have a maximum frequency response at a 30- or 40-day period

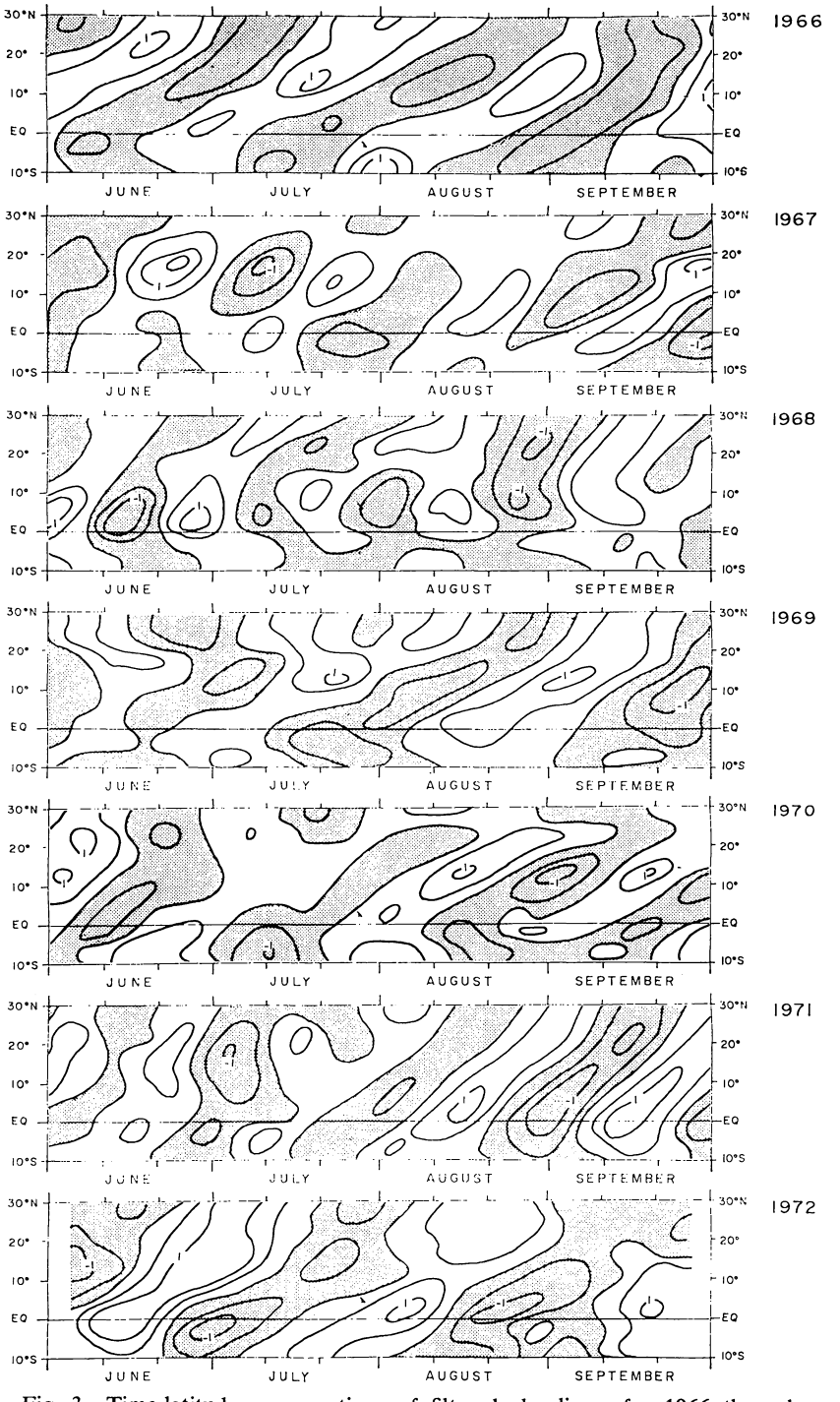

Fig. 3 Time-latitude cross sections of filtered cloudiness for 1966 through 1972. Unit of contour line is 0.5 and negative values are shaded.

(or 60-day period in the case of 1972) corresponding to the frequency of maximum frequency for the respective years.

The results for the years from 1966 to 1972 are shown in Fig. 3. In every year a northward movement of the filtered cloudiness can clearly

be seen with the phase speed of about 1° latitude/day. As mentioned already, the dominant periodicity of 1972 is at about 60 days, but a northward movement of cloudiness can be seen similarly to those of the other years. These results are consistent with that of Y79.

5. Conclusion and remarks

Through the analysis of the daily cloudiness data from 1966 to 1972, it is confirmed that the periodicity of 30 to 40 days appear as a predominant mode in all the years except 1972 during the summer monsoon months over India. As for the cases of previous years to 1966, we happened to find the dominancy of the same periodicity in the rainfall fluctuations in 1962 through 1964 in the figure of Ramage (1971), as quoted here in Fig. 4. It is noted in Fig. 4 that the weekly percentage anomalies of rainfall over northern and central India (18°–27°N) fluctuate periodically with roughly a 30 to 40 day period, and that the daily pressure anomalies at Jacobabad (as indices of the intensity of heat low over Pakistan) are roughly negatively correlated to the rainfall anomalies. Power spectral analysis of rainfall anomalies in Fig. 4 confirmed the dominancy of the 30 to 40 day period as shown in Fig. 5.

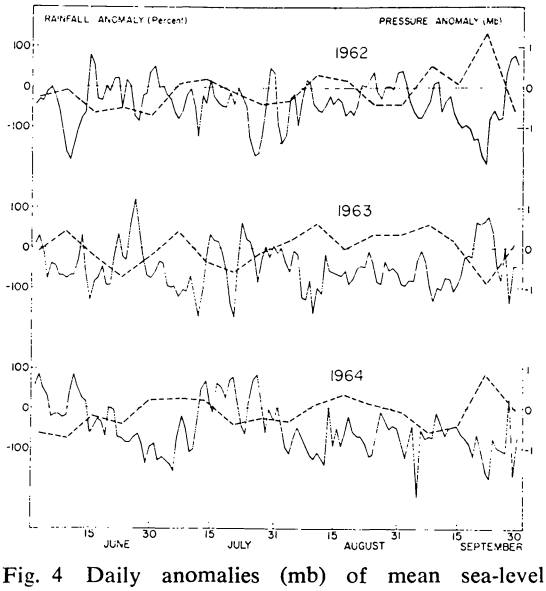

Fig. 4 Daily anomalies (mb) of mean sea-level pressure measured at Jacobabad (28°18′N, 68°28′E; full lines) and weekly percentage anomalies of rainfall for Indian subdivisions lying roughly between 18° and 27°N (dashed lines) for the summer of 1962, 1963, and 1964 (after Ramage, 1971).

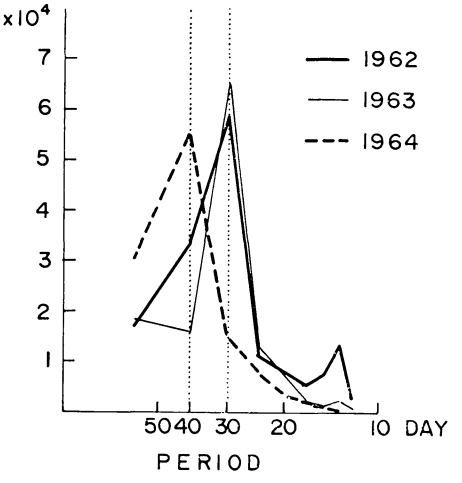

Fig. 5 Power spectra of weekly anomalies rainfall in Fig. 4. Units are (percentage^2·day). The spectral band of 30 to 40 day period is indicated by dotted lines. Power spectra for less than 2 weeks are omitted, as the original time unit of data is 1 week.

These results suggest that the periodicity of 30 to 40 days related to the summer monsoon as described in Y79 exists quasi-stationarily as a dominant mode at least for normal (or active) monsoon years as well as the quasi-biweekly mode. The cloudiness fluctuations in 1972 exceptionally show the mode of larger period (of about 60 days), which may be concerned with the abnormally weak monsoon of that year. It is well known that 1965 was also a severe drought year as well as 1972, but unfortunately we could not obtain the exact estimates of dominant modes of that year due to a lot of missing data. Further study will be needed on the association between the dominant periodicities and the monsoon activity of each year.

As commented already in Y79, the major "active" and "break" cycles of the monsoon activity seem to be related more closely to the period range of 30 to 40 days than the quasi-biweekly mode. From this point of view, the time-spatial structure of the monsoon circulation system over and around India are being investigated relevant to the fluctuation of this period range. The results of this study will be reported soon.

Acknowledgements

The author wishes to express his hearty thanks to Prof. J. C. Sadler and Prof. T. Murakami of University of Hawaii, for their kind arrange-

ment and supply of the cloudiness data. He would like to thank Prof. C. Nakajima of Kyoto University for his encouragements throughout the work.

References

Hino, M., 1977: Spectral analysis (in Japanese). Asakura Shoten, 210–226.

Kanamitsu, M. and T. N. Krishnamurti, 1978: Northern summer tropical circulations during drought and normal rainfall months. *Mon. Wea. Rev.*, **106**, 331–347.

Krishnamurti, T. N. and H. N. Bhalme, 1976: Oscillations of monsoon system. Part I, observational aspects. *J. Atmos. Sci.*, **33**, 1937–1954.

Murakami, M., 1976: Analysis of summer monsoon fluctuations over India. *J. Met. Soc. Japan*, **54**, 15–31.

Ramage, C. S., 1971: Monsoon meteorology. Academic Press, 36–38.

Sadler, J. C., 1969: Average cloudiness in the tropics from satellite observations. *Int. Indian Ocean Expedition, Meteor. Monogr.* 2.

Ulrich, T. J. and T. N. Bishop, 1975: Maximum entropy spectral analysis and autoregressive decomposition. *Rev. Geophys. and Space Phys.*, **13**, 183–200.

Yasunari, T., 1979: Cloudiness fluctuations associated with the Northern hemisphere summer monsoon. *J. Met. Soc. Japan*, **57**, 227–242.

インド周辺の夏季モンスーンにおける雲量変動の30~40日周期の準定常的出現

安 成 哲 三

京都大学東南アジア研究センター

7年間（1966-1972）にわたる雲量データの解析により，インド周辺のモンスーンの変動には，Yasunari (1979)の1973年についての結果と同様に，30～40日周期がほぼ毎年卓越して現われ，その位相の動きは，インド洋上を北上する様相であることが示された。この周期性は，モンスーンが非常に弱かった1972年にのみ現われていない。