NOTES AND CORRESPONDENCE

Comments on a Paper by T. Yasunari, A Quasi-Stationary Appearance of 30 to 40-Day Period in the Cloudiness Fluctuations during the Summer Monsoon over India**By P. R. Julian and R. A. Madden***National Center for Atmospheric Research¹, Boulder, Colorado 80307, U.S.A.**(Manuscript received 23 January 1981, in revised form 16 March 1981)*

We have read with considerable interest Yasunari's (1979; 1980) contributions on fluctuations in cloudiness over the Bay of Bengal. In this short note we intend to draw attention to two previous papers concerning large-scale equatorial circulation cells with essentially the same oscillatory behavior as the above author finds, and also introduce some previously unpublished results of cloud and precipitation data associated with the equatorial circulation cells.

Briefly, in a pair of papers (Madden and Julian, 1971, 1972) we describe an oscillation, oriented principally in the zonal plane, of tropical surface pressure and zonal winds having a relatively broad frequency band feature in the range of period 40-50 days. We demonstrated that although the feature reached its maximum intensity in the central Pacific, its origin was apparently in the Indian Ocean region (Fig. 4, 1972) and was detectable even over the African continent. We point out (again) that the frequency or period resolution of the cross-spectral analysis used was less than that of the width of the resulting sample spectra peaks indicating a broad-band phenomenon. From Fig. 2 of Yasunari we note that the maxima in the cloudiness power spectra are essentially in this same frequency range, especially considering the apparent resolution of his analysis in the frequency range.

Yasunari documents a northward movement of the cloudiness fluctuations and suggested that they might originate from the equatorial circulation cells that we described (Yasunari, 1979). There is little doubt in our minds that this suggestion is

correct and to demonstrate this we present three figures, prepared some years ago but as yet unpublished.² In describing this material we must discuss briefly the compositing technique used to construct them. During the time span October 1964 to October 1969, when we found that the spectrum of the 150 mb winds at Truk (7.5N, 151.8E) had a peak in the 40-50 day period range similar to the one that appeared in earlier data (Madden and Julian, 1972), we defined a series of 29 waves on the basis of a band-pass filtered time series of these winds. Fig. 1 is a histogram of the approximate periods of the wave as determined by the filtered winds at Truk. While the average period is in the 40-50 day range, Fig. 1 further illustrates the fact that the wave is a broad-band one. A mean 40-50 day global wave was derived by averaging variables at various observing sites according to eight arbitrarily defined phase points (at Truk) to allow the global variation in time to be described synoptically. (The details of this compositing may be found in our 1972 paper.) Fig. 2 presents the eight tropical area maps of the deviation of the cloudiness from the local average for our mean wave. The cloudiness data are due to Sadler (see Sadler et al., 1976) and, except for differing time periods (we included all months from October 1964-October 1969 while Yasunari (1980) studied summer months from 1966-1972), are essentially the same used by Yasunari in his second paper. Phase 1 is defined as

¹ The National Center for Atmospheric Research is sponsored by the National Science Foundation.

² Madden, R. A., P. R. Julian, and J. C. Sadler, 1973: Global-scale circulation cells in the tropics varying with an average period in the 40-50 day range. Paper presented at the 53rd Annual AMS Meeting, Tampa, Florida.

Fig. 1 Histogram of the observed periods of 29 waves as determined from the band-pass filtered 150 mb zonal wind at Truk I.

Fig. 2 Deviation from the mean for clouds composited according to the phase of the band-pass filtered 150 mb zonal wind at Truk. Phases 1 and 5 are the times of minimum and maximum westerly winds. Lettered phases apply to those used in Madden and Julian (1972) where compositing was based on Canton I. sea-level pressure. Contour are approximately in eighths.

the time of minimum 150 mb wind at Truk and Phase 5 the maximum. Phases 3 and 7 are at the nodal points. We note immediately the pro-

Fig. 3 Composited clouds and rainfall for Minicoy (dashed) and for Car Nicobar and Port Blair (solid). Phases are as in Fig. 2. Clouds are for the 5×5 lat/lon square over Minicoy and 10×5 lat/lon square over Car Nicobar and Port Blair.

nounced variation (contrast Phases 1 and 6) in cloudiness over the Bay of Bengal.

In our earlier paper, we formulated a model of zonal circulation cells associated with the wave (Fig. 16, 1972). Maximum convection was predicted to occur during the equivalent of phases 4, 5, 6, and minimum convection during phases 8, 1, 2. Although the slow eastward propagation of regions of maximum convection that we predicted is not obvious, the oscillation in amount of cloudiness evident in Fig. 2 is consistent with the model.

Fig. 3 (upper) shows the same information in a 5° by 10° area including the Nicobar (9.2°N , 92.8°E) and Port Blair (11.7°N , 92.7°E) observing stations and in a 5° by 5° area including Minicoy (8.3°N , 73.0°E). The lower portion of the figure shows the variation in rainfall for the eight phases of the mean wave at these stations.

We conclude that the oscillation in cloudiness described by Yasunari is a portion of the (nearly) global equatorial oscillation described in 1971-1972. Further, we agree that a complete understanding of this important tropical dynamical phenomenon must include the convection occurring in the Indian Ocean region and its relation to the monsoon.

References

- Sadler, J. C., L. Oda, and B. J. Kelonsky, 1976: Pacific Ocean cloudiness from satellite observations. Department of Meteorology, University of Hawaii, UHMET-76-01.
- Madden, R. A., and P. R. Julian, 1971: Detection of a 40-50 day oscillation in the zonal wind in the

- tropical Pacific. *J. Atmos. Sci.*, **28**, 702-708.
- , 1972: Description of global-scale circulation cells in the tropics with a 40-50 day period. *J. Atmos. Sci.*, **29**, 1109-1123.
- Yasunari, T., 1979: Cloudiness fluctuations associated with the Northern Hemisphere summer monsoon. *J. Met. Soc. Japan*, **57**, 227-242.
- , 1980: A quasi-stationary appearance of 30 to 40 day period in the cloudiness fluctuations during the summer monsoon over India. *J. Met. Soc. Japan*, **58**, 225-229.
-

「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」に関するコメント

P. R. Julian and R. A. Madden

NCAR, U.S.A.