

## SURFACE TEMPERATURE OF THE EQUATORIAL PACIFIC OCEAN AND THE INDIAN RAINFALL

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### ABSTRACT

The time variation of the monthly mean surface temperature of the equatorial Pacific Ocean during 1982–1987 has been studied in relation to summer monsoon rainfall over India. The ENSO events of 1982 and 1987 were related to a significant reduction in the seasonal rainfall over India in both the years. This effect seems to prevail during a part of the preceding/succeeding seasons. A slow and systematic spread of the Pacific Ocean warm pool to the east during 1984 to 1986 was also related to below normal rainfall over India during these years.

### INTRODUCTION

THE inter-annual variability of the Indian summer monsoon rainfall has been related to the surface temperatures of the Indian and Pacific Oceans by several workers. A rather comprehensive review of the important studies on the Indian summer monsoon rainfall in relation to the oceans has been published recently<sup>1</sup>. The tendency to relate Indian rainfall to sea surface temperature (SST) is primarily due to relatively large thermal energy storage in the oceans and the sluggish nature of the oceanic changes compared to the atmospheric changes. It is well known that the equatorial regions of the oceans supply large amounts of heat to the atmosphere. The changes in the Pacific Ocean are important because of its close link to the Indian Ocean in the tropics and because of its large size. The warmest part of the ocean surface in the climatological yearly mean SST field has a temperature<sup>2</sup> of about 29°C. Bjerknes<sup>3</sup> observed heavy rainfall in the normally low rainfall areas around Canton Island when the SST was above the air temperature. The rainfall was very heavy when SST was above 28.9°C. This was attributed to the high upward transfer of moisture due to the large scale warming of the oceans. The warm part of the ocean surface with temperature more than 29°C has been termed as the Warm Pool (WP). The Pacific Ocean is the warmest of all the oceans and the WP is on the western half of the ocean during the summer monsoon season.

Weare<sup>4</sup> conducted statistical studies on the relationship between the Indian summer monsoon rainfall and the SST of Indian and Pacific Oceans. A warmer Indian Ocean was found to be associated with a decreased rainfall over India. Rasmusson and Carpenter<sup>5</sup> investigated the relationship between

the Indian rainfall and SST of the eastern Pacific Ocean. The Indian rainfall was below normal during 21 years out of the 25 years of El Niño events. According to Nicholls<sup>6</sup>, the SST over Indonesian–Australian area could be used for prediction of the seasonal rainfall over India and its use has the advantage of predicting the seasonal rainfall much earlier than those using either sea level pressure at Darwin or SST of the eastern Pacific Ocean. Khandekar and Neralla<sup>7</sup> have also studied the relationship between the equatorial Pacific SST and the Indian rainfall. Eastward migration of the warm water area of temperature more than 28.5°C associated with the migration of heavy rainfall region in the tropical Pacific Ocean, is a common feature of developing stages of all ENSO events since 1940<sup>8</sup>.

The eastward migration of the WP of the equatorial Pacific Ocean during 1982–1987 and its influence on the Indian summer monsoon rainfall are discussed in this paper.

### MATERIALS AND METHODS

The monthly as well as seasonal Indian rainfall data are periodically published in *Mausam*. The data on actual monthly and seasonal rainfall and percentage departures from normal for the period 1982 to 1986, available for 35 sub-divisions of India, have been utilized for computations. The monthly and seasonal anomalies are based on the mean of the normal rainfalls during the period 1982–1986. The data on time variation of SST in the equatorial Pacific Ocean are from the Climate Analysis Center of the US National Weather Service.

The present study pertains to the period from 1982 to 1987, covering the two ENSO events of 1982 and 1987. The seasonal rainfall anomaly for 1987 is

an approximate value as it is based on the operational data report (Weekly Weather Reports) of the India Meteorological Department.

RESULTS AND DISCUSSION

The percentage variations of the Indian summer monsoon rainfall for the years 1982-87 from the normal are given in figure 1(a). Large deficits in rainfall over India were observed during the ENSO years of 1982 and 1987. The seasonal rainfall was

below normal in all the years, except 1983. The data on monthly rainfall anomalies during 1982-86 are shown in figure 1(b). The rainfall was below normal for 3 months of the season in 1982, 2 months in 1983, 3 months in 1984, all the 4 months in 1985 and last 3 months in 1986. There is a slow, but continuous decrease in the seasonal rainfall from 1984, culminating in the larger deficit of 1987.

The time variation of the monthly mean SST field between 5° N and 5° S latitudes and 100° E and 100° W longitudes in the Pacific Ocean is given in

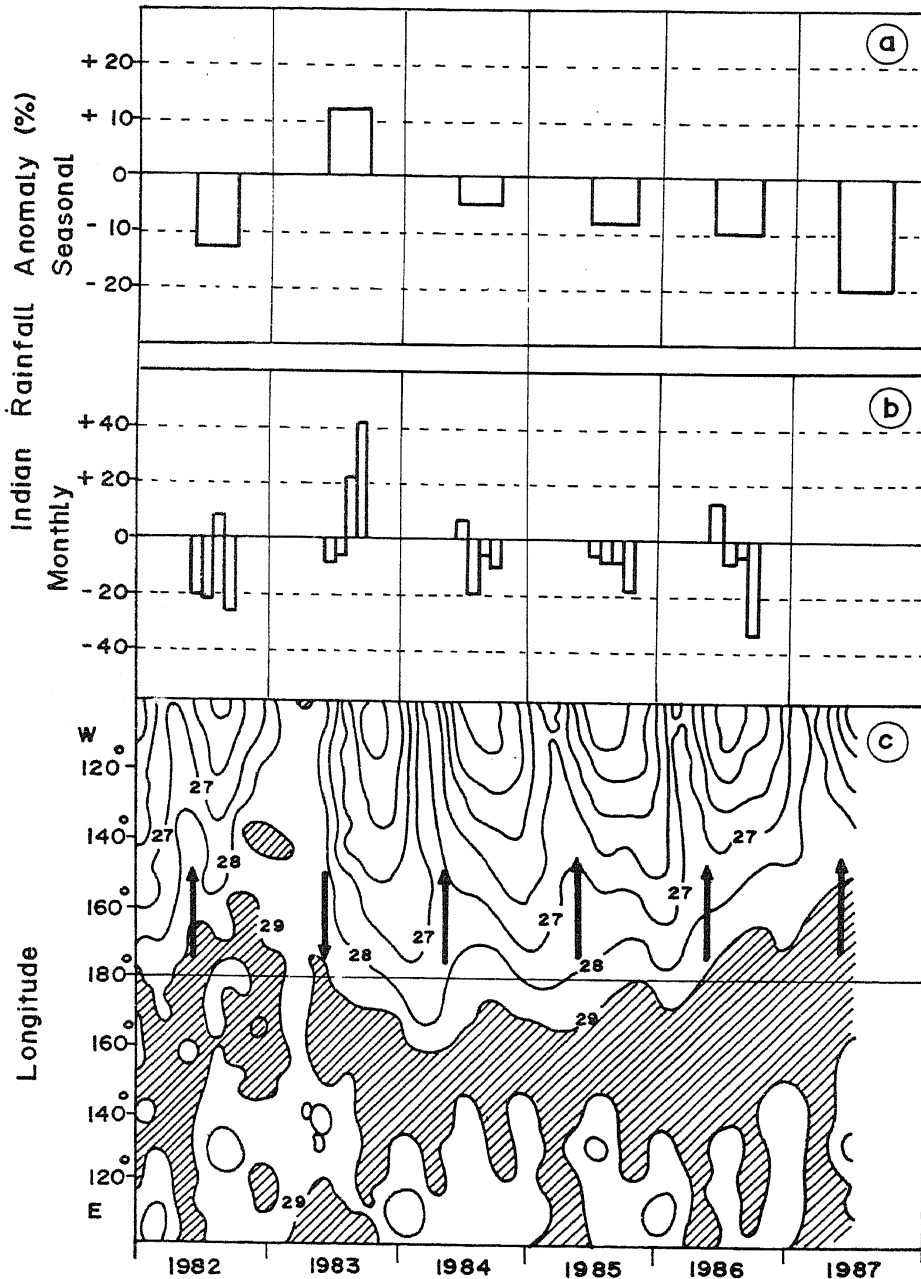


Figure 1a-c. a. Pattern of Indian rainfall (summer monsoon rainfall) anomaly during 1982-1987; b. Monthly Indian rainfall anomaly during 1982-1986, and c. Time variation of the monthly mean equatorial (between 5° N and 5° S) Pacific Ocean SST (°C) between 100° E and 100° W during 1982-1987. The arrows indicate the direction of movement of the warm pool during the season.

figure 1(c). The shaded parts represent the areas of SST more than 29° C, the WP. There was a rapid migration of the WP to the eastern Pacific Ocean during 1982 ENSO which continued till the early months of 1983. This was followed by westward migration during the later part of 1983. Since then, the WP was slowly spreading eastward, especially during the summer monsoon seasons. The Indian rainfall was below normal during all the 3 years when the WP was spreading eastward.

The performance of the Indian summer monsoon seems to depend on the location and spread of the Pacific Ocean WP during the season. When the WP moves to the western Pacific Ocean and gets concentrated there, the seasonal summer rainfall over India tends to increase. On the other hand, if the WP moves or spreads eastward, then the rainfall decreases. The largest decrease occurs during the ENSO years, when the Pacific Ocean WP migrates eastward towards the date line or spreads beyond it. The effect of 1982 ENSO extended to the first half of the 1983 season. The Indian rainfall failed during the second half of the 1986 season, much before the reported 1987 ENSO and it may influence the early part of 1988 season. In either case, the effect extends beyond a season. In the circumstances, the mean summer monsoon rainfall for the entire season gives only a partial picture of the influence of the Pacific Ocean SST on the rainfall. A more complete

picture can be obtained by considering the behaviour of the monthly rainfalls not only during the year of pronounced monsoon abnormality but also during the preceding and following years.

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