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Letters to the Editor

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INDIAN MONSOON RAINFALL IN RELATION TO SURFACE PRESSURE ANOMALIES

Forecasting seasonal rainfall of India has been attempted on the basis of various predictors. Temperature over different regions and levels, rainfall in Zanzibar and Seychelles during May, the mean surface pressure in May in Mauritius, April 500 mb ridge position over India, ENSO, sunspot cycle etc, are some of the parameters used as predictors for monsoon rainfall in India, which amounts to 75 to 90 % of annual rainfall of the sub-continent. Bhalme *et al.* (1985) have used the monthly mean of sea level pressure and surface temperature, and the geopotential height and temperatures of 850, 500 and 200 mb pressure surface for the month of May during 1963 to 1981 (19 years) at selected 14 stations (of which 7 are in India and others in countries, like Malaysia, Singapore etc) as possible predictors of monsoon rainfall. A prediction equation from multiple regression analysis was drawn by them, with the conclusion that the May mean values of the meteorological parameters "at selected stations in India" are useful for forecasting monsoon rainfall departure over the whole of India, the most useful parameter being the mean sea level pressure of Jodhpur in northwest India.

An attempt is made here to find the correlation between the mean sea level pressure anomalies for May for a large number of stations over India and adjoining Pakistan, Burma and Bangladesh, over a number of years, with the area weighted average monsoon rainfall of India for those years, with the objective of providing a predictor in the nature of mean pressure anomaly over an area during the month of May.

2. *Data* — Rainfall anomalies for India as one unit provides a useful tool for analysis. Mooley and Parthasarathy (1984) have worked out average monsoon rainfall of India (1 June to 30 September) excluding hilly regions, for each year of the period since 1871. The updated values of this data set (hereafter denoted as seasonal rainfall) up to 1987 form the Indian rainfall time series for this work. The data sources for mean sea level pressure of May are the *Monthly climatic data for the world.* A data coverage of 30 years from 1958 to 1987 were chosen for the area considered with a network of 60 stations.

3. *Method of analysis* — Mean sea level pressures for May of each of these 60 stations were collected for the 30 years mentioned. The pressure anomalies for these 30 years were plotted and analysed. These showed good correspondence with the fluctuations of the rainfall of each year in the series. The standard deviation of rainfall for 1958 to 1987 was worked out as 9.1 cm, the mean rainfall being 83.6 cm. One unit of standard deviation below and above this mean was considered for this work as bad monsoon and good monsoon respectively. The years corresponding to these values were chosen and composites of pressure anomalies for these were made. Marginal cases near about these values were also considered (1968, 1986, 1974 and 1964 are with marginal values). The years so chosen are given below :

Weighted average rainfall for 30 years = 83.6 cm

Standard deviation = 9.1 cm

(a) *Years of rainfall deficit*

Years :	1965	1966	1968	1972	1974	1979	1982	1986	1987
Rainfall: (cm)	70.7	73.5	75.4	65.3	74.7	70.8	73.5	74.7	68.8

(b) *Years of rainfall surplus*

Years :	1959	1961	1964	1970	1975	1983
Rainfall: (cm)	93.8	101.7	92.0	93.9	96.0	95.5

During years of bad monsoon the heat low is not well developed during May and the minimum pressure in May is above 1000 mb; the pressure gradient is weak. During years of good monsoon the heat low is developed in its normal location with pressures below 1000 mb. The gradient of pressure also is strong there. Correspondingly the reported years of good monsoon are showing negative pressure anomalies, in general and those of bad monsoon years are showing positive values of pressure anomalies. Example of two extremes individual years are shown in Figs. 3 & 4. An year of average rainfall corresponds approximately with the values of 1969 with 82.9 cm of total seasonal average. The year 1983, even though being a good monsoon year as per statistics, exhibits a positive pressure anomaly during May. Such exceptions are rare.

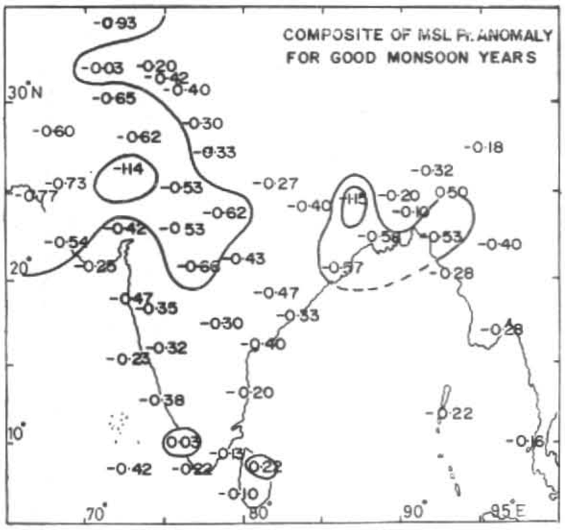

Fig. 1

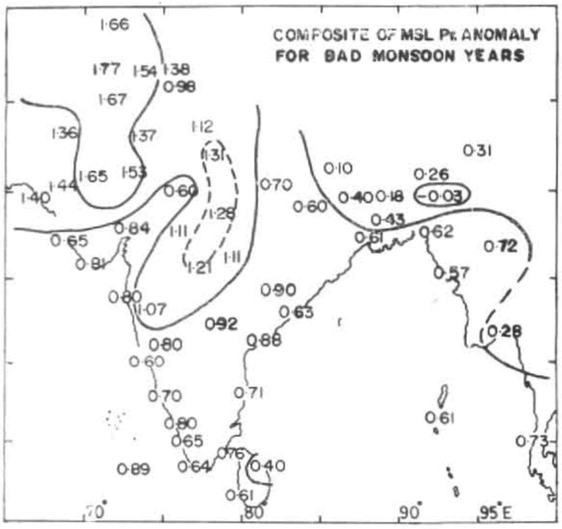

Fig. 2

Figs. 1 & 2. Composites of pressure anomalies for good and bad monsoon years

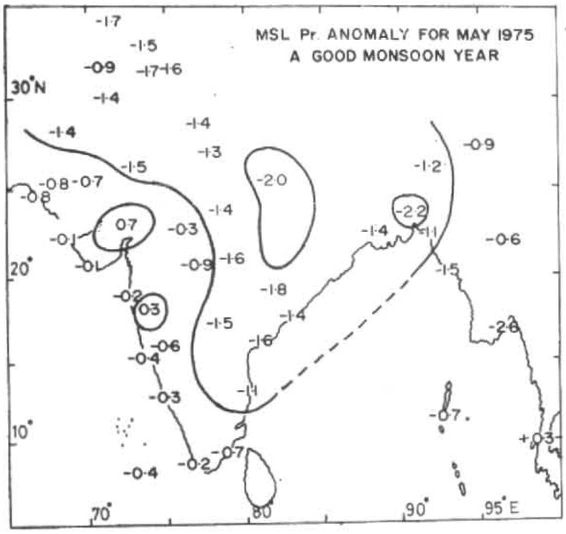

Fig. 3

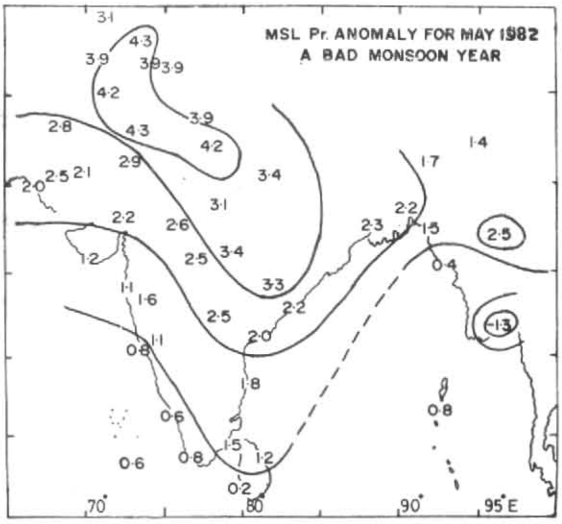

Fig. 4

Figs. 3 & 4. MSL pressure anomaly for good (May 1975) and bad (May 1982) monsoon years

Figs.1 and 2 correspond to the pressure composites for good and bad monsoon years respectively. These composites show that rainfall surplus years reflect a negative pressure anomaly pattern for May and *vice versa* for rainfall deficit years. Especially the pressure anomaly over the area covered by 20°N and 35°N, and west of 80°E, appears to be sensitive to monsoon rainfall. The heat low over this region has a definite say over the rainfall potential of the monsoon. The regions of west Rajasthan, north Gujarat and Punjab in India, and the adjoining areas of Pakistan show as much as 1.5 mb positive anomaly during bad monsoon years; even though the negative anomaly is not well pronounced during the good monsoon years, an overall trend of negative anomaly area in the region specified above is recognisable.

The correlation coefficient between monsoon rainfall of India and pressure anomalies for mean sea level pressures of individual stations were worked out. Only those stations having at least 20 years of data pairs as above, were considered. Also the standard deviation of the pressure anomalies for these stations were worked out. Analysis of the standard deviation shows that it is as high a value as 2 mb towards the heat low region. The correlation study brings out the fact that the stations in the sector covered by 20°N & 30°N and 65°E & 80°E, show correlation co-efficients significant at 95% level.

The correlation coefficients and significance levels are appreciable. The maximum value of correlation co-efficient is 0.7; Jodhpur shows the maximum correlation.

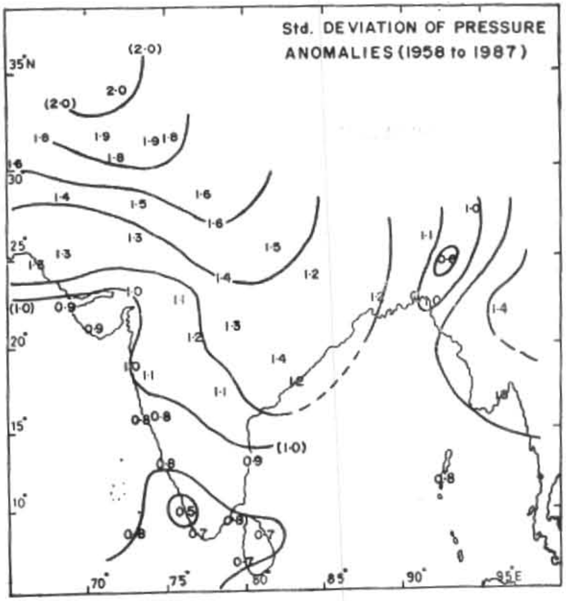

Fig. 5. Std. deviation of pressure anomalies

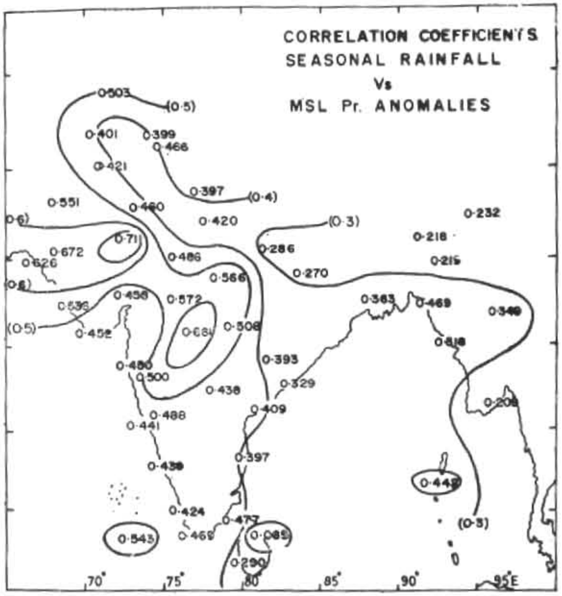

Fig. 6. Correlation coefficients of pressure anomalies

Also the stations, Ahmedabad, Akola, Sagar, Nagpur, Veraval, Bombay, Pune, Belgaum, Indore and Hyderabad in India, and Peshawar, D. I. Khan, Jacobabad, Hyderabad and Karachi in Pakistan depict high correlation of rainfall with their May pressure anomalies. Especially Hyderabad (Pak.), Karachi, Jodhpur, Pune, Indore, Akola, Sagar, Nagpur and Peshawar correspond well with the results obtained and are significant at 99% level; others are significant at 95% level. Figs. 5 and 6 show the analyses of standard deviations of pressure anomalies and correlation coefficients respectively.

4. Pressure anomalies for the month of May for the selected stations in northwest India, *viz.*, Jodhpur, Ahmedabad, Akola, Sagar, Indore & Nagpur and stations in Pakistan, *viz.*, Peshawar, Karachi, Jacobabad & Hyderabad may be used as predictors for the long range forecasting of monsoon rainfall in India.

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R. S. SUNDAR

Meteorological Office, Pune

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