# Evidence of Secular Variations in Indian Monsoon Rainfall–Circulation Relationships

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ABSTRACT

Detailed correlation analysis of the all-India monsoon rainfall and mean sea-level seasonal pressure at Bombay (19°N, 73°E) up to three lags on either side of the monsoon season during the last 30 years (1951–80) indicates a systematic relationship. The winter-to-premonsoon (March, April, May–December, January, February; MAM–DJF) seasonal pressure tendency at Bombay shows a correlation coefficient (CC) of −0.70 (significant at 0.1% level) with the Indian monsoon rainfall.

Further examination of this relationship over a long period of 144 years (1847–1990), using sliding correlation analysis, reveals some interesting features. The sliding CCs were positive before 1870, negative during 1871–1900, positive in the years 1901–40, and again negative later on, showing systematic turning points around the years 1870, 1900, and 1940. In light of other corroborative evidence, these climatic regimes can be identified as "meridional monsoon" periods during 1871–1900 and after 1940, and as "zonal monsoon" periods before 1870 and during 1901–40, similar to the observation of Fu and Fletcher. It is also observed that the relationship between Bombay pressure and Indian monsoon rainfall becomes dominant when the ENSO variance in Bombay pressure is high and falls apart when the ENSO variance is small.

The paper contains a listing of the long homogeneous data series on all-India monsoon rainfall and monthly MSL pressure at Bombay for the period 1847–1990.

## 1. Introduction

The importance of the study of monsoons as a problem of global atmospheric circulation has received considerable attention in recent years. It has been recognized by a number of observational studies that the Asian monsoon system, of which the Indian summer monsoon is a major component, plays an important role as a major energy source in the global-scale circulation in middle and low latitudes. Large interannual cycles in the release of latent heat over India and surrounding areas during the summer monsoon season could well affect the associated global circulation patterns. There have been several attempts to determine the variability on decadal and longer time scales of Indian monsoon rainfall during recent years (Parthasarathy 1984; Mooley and Parthasarathy 1984a; Mooley and Shukla 1987; Pant et al. 1988; etc.). Also, Elliott and Angell (1987, 1988) and Fu and Fletcher (1988) reported some interesting evidence of large signals of decadal-scale climatic variations over the Asian monsoon region.

The studies of Hastenrath (1986, 1987), Thapliyal (1987), and Parthasarathy et al. (1988a, 1990b) have established that, for the prediction of all-India monsoon rainfall, local parameters [such as the mean location of the 500 mb ridge at 75°E during April, winter-to-premonsoon seasonal pressure tendency at Bombay, and premonsoon surface air temperatures over the west-central Indian (WCI) region] are correlated with Indian monsoon rainfall, along with other parameters reflecting the ENSO cycle and the meridional circulation over the Indian Ocean region. However, it has not yet been possible to develop a stable long-range prediction scheme because the predictor associations with Indian monsoon rainfall have varied considerably with time, in magnitude as well as direction. It is, therefore, necessary to study these variations with long-period data, in the broader perspective of climate variability over the region. Records of Bombay (Colaba observatory) mean sea-level (MSL) pressure, one of the leading predictors of Indian monsoon rainfall, are available from the year 1847 onward. Because of its relationship to the tropical circulation as well as the Southern Oscillation (Wright 1975), Bombay pressure can be taken as a good tracer for studying the climate variability over this region and its association with the Indian monsoon.

This study examines the behavior of the Indian monsoon rainfall and its relationship with variables derived from the long record of Bombay MSL pressure. Simple linear correlations between various datasets are used to describe the relationships.

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## 2. Details of data

### a. *Indian summer monsoon rainfall*

All-India (India taken as one unit) and 29 different meteorological subdivisional summer monsoon (June through September) rainfall data, prepared by area-weighting 306 well-distributed raingages over the country, have been used here. The reader is referred to Mooley and Parthasarathy (1984a) and Parthasarathy et al. (1987, 1990b) for a detailed discussion of preparing these datasets and their listing from 1871 onward.

The all-India rainfall series in the above studies began in 1871 because of the unavailability of data at all 306 raingages prior to that time. However, from an examination of all of the old rainfall records, we found that a far less dense but well-distributed network of 16 stations [namely, Trivandrum, Madras (Nungambakkam), Shimoga, Bangalore, Hyderabad, Bombay (Colaba), Puri, Calcutta (Alipore), Jabalpur, Deesa, Patna, Kanpur, Guwahati, Gorakhpur, Delhi, and Ferozpur] with reliable data records is available from 1841 onward (Sontakke 1990). The arithmetic average of the monsoon rainfall at these stations has been taken to represent the country's mean, denoted by all-India (A) monsoon rainfall to distinguish it from the original all-India series based on 306 stations. Thus, the all-India (A) series is available for the period 1841–1990 and the all-India series for 1871–1990. The correlation coefficient (CC) between these two series is very high (0.84) for the common period 1871–1990, and the extreme (wet and dry) years also match well. These two series are separately used in the present study. Parthasarathy (1984) and Mooley and Parthasarathy (1984a) established that the all-India summer monsoon rainfall series for the period 1871–1978 was homogeneous, Gaussian-distributed, and free from persistence.

### b. *Bombay MSL pressure*

Mean sea level pressure (0830 Indian Standard Time or 0300 UTC) at Bombay (Colaba observatory: 18°51′N, 72°49′E) is available for the period 1847–1990 from the India Meteorological Department (IMD). A uniform time of observation throughout the data period and constancy of site are ascertained from the observatory records. The data have been preprocessed by IMD by scrutinizing the station records and applying the necessary corrections to make the series homogeneous. As such, there was no need for the type of corrections applied by Wright (1975) and Trenberth and Shea (1987), who obtained the data from various sources like World Weather Records, World Monthly Surface Station Climatology, Monthly Climatic Data for the World, etc., and their periodical updates. The homogeneity of the data, however, was confirmed by applying Swed and Eisenhart's test (runs above and below the median: Swed and Eisenhart 1943; Thom 1966) on the seasonal pressure series.

## 3. Methodology

To study the association between Indian summer monsoon rainfall and Bombay pressure, the following approach has been used: (i) simple correlation analysis, (ii) compositing of pressure anomalies during the excess (wet) and deficient (dry) years of all-India monsoon rainfall, and (iii) consistency of CCs over long periods by using sliding windows of different widths.

It is conventional to use a period of 30 years for establishing climatic normals and relationships. To understand the temporal characteristics of the relationship between pressure and the all-India monsoon (JJAS) rainfall, the CCs with seasonal pressures of up to 3 lags on either side of the monsoon season (lag − 3, SON; lag − 2, DJF; lag − 1, MAM; lag 0, JJA; lag + 1, SON; lag + 2, DJF; and lag + 3, MAM) have been calculated for the recent period 1951–80. In addition, the seasonal tendency of pressure from the previous winter (DJF) to the current spring (MAM), i.e., lag − 1 minus lag − 2 (MAM–DJF), denoted hereafter as $P_{\text{MAM-DJF}}$, has also been considered for correlation analysis. The importance of this seasonal feature has been demonstrated by Shukla and Paolino (1983), Parthasarathy and Pant (1985), and Parthasarathy et al. (1988a, 1990b).

The persistence (as indicated by the serial correlations of lags 1 to 3) of the datasets involved has been considered in assessing the statistical significance of the correlations, and the degrees of freedom have been reduced wherever necessary, as suggested by Quenouille (1952). However, the serial correlations (up to 3 lags) of almost all parameters are found to be either negative or insignificantly positive (less than 0.2).

In order to see the strength of the signal during extreme rainfall years in the pressure series, composite values of pressure anomalies (from 1951–80 mean) for lag − 3 to lag + 3 seasons and MAM–DJF have been calculated for years of deficient ($\leqslant \bar{R} - S$) and excess ($\geqslant \bar{R} + S$) all-India monsoon rainfall ($\bar{R}$ is the mean and S the standard deviation) during the period 1951–80. There were seven dry (1951, 1965, 1966, 1968, 1972, 1974, and 1979) and five wet (1956, 1959, 1961, 1970, and 1975) monsoon rainfall situations during this 30-year period, which have also been found to have a definite impact on production of food grains over India (Parthasarathy et al. 1988b).

The consistency of significant CCs over a long period of time has been examined as suggested by Bell (1977) by calculating the CCs over sliding windows of width 11, 21, and 31 years during the period 1847–1990. These window widths are chosen to understand the high-, medium-, and low-frequency changes in the correlation.

## 4. Relationship between all-India monsoon rainfall and Bombay pressure

The CCs between all-India monsoon rainfall and the different seasonal means of MSL pressure at Bom-

bay (lag − 3 to lag + 3 and MAM–DJF) during the period 1951–80 are shown in Fig. 1a. A systematic change in CC values can be observed from small and positive at lag − 2, two seasons before monsoon, to negative and later to near zero at lag + 3 (the negative CC being significant at 5% level or above for lag − 1, lag 0, and lag + 1 seasons). This systematic variation of CC during the course of the seasons suggests that the large-scale circulation features of the monsoon system may be undergoing a low-frequency transition during anomalous monsoon years. Here $P_{MAM-DJF}$ shows a CC of −0.70 (significant at 0.1% level) with the monsoon rainfall.

The composite values of seasonal pressure anomalies for lag − 3 to lag + 3 and $P_{MAM-DJF}$ for extreme years of deficient and excess all-India monsoon rainfall show opposite signs from lag − 3 to lag + 3 (except at lag + 2) and a gradual transition in magnitude with season (Fig. 1b). Here $P_{MAM-DJF}$ has a value of −0.6 mb during excess years and +0.5 mb during deficient years, the range of 1.1 mb against a standard deviation of 0.5 mb during 1951–80 indicating a good signal of the extreme years of monsoon rainfall during this 30-year period.

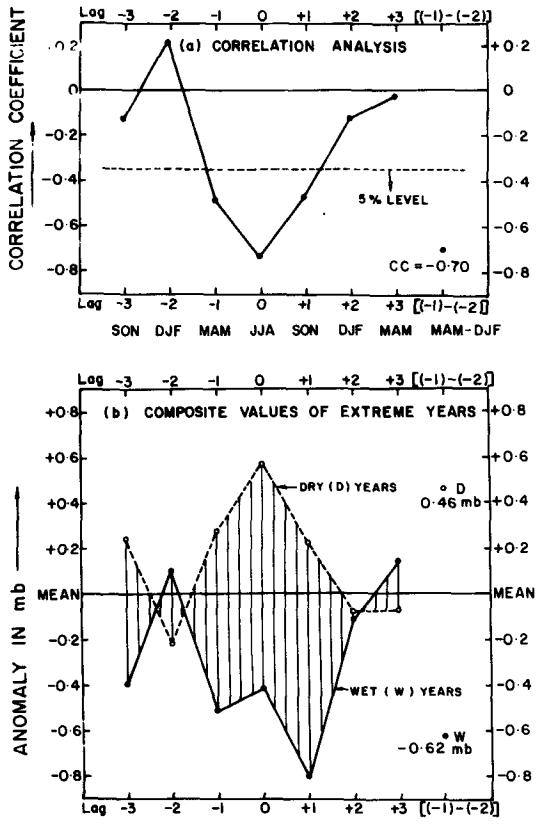


FIG. 1. Relationships between all-Indian Monsoon Rainfall and MSL pressure of Bombay for different seasons during the period 1951–80. (a) Correlation coefficient between the parameters. (b) Composite values of seasonal pressure anomalies for five wet years (1956, 1959, 1961, 1970, and 1975) and seven dry years (1951, 1965, 1966, 1968, 1972, 1974, and 1979) of all-India monsoon rainfall.

Thus, it may be stated that active monsoon conditions over the country in most cases were preceded by below-normal pressure before monsoon season with a steeper pressure drop from winter to premonsoon, and vice versa. Therefore, $P_{MAM-DJF}$ at Bombay would have been a useful parameter in the long-range prediction of Indian monsoon rainfall during this period, and the short-period relationship requires further detailed examination in time and space.

On a subdivisional scale (Fig. 2), the CCs are generally negative in all parts of the country and significant at the 10% level or above for the 21 contiguous subdivisions (76% of the area of India). The CCs are significant at the 5% level or above over the region north of 12°N and west of 80°E. Therefore, it can be concluded that the relationship between $P_{MAM-DJF}$ at Bombay and monsoon rainfall had good spatial coherence over a major part of the country.

## 5. Consistency of the relationship between all-India monsoon rainfall and $P_{MAM-DJF}$ at Bombay over a long period

Figure 3 shows the variation of CCs between all-India monsoon rainfall and $P_{MAM-DJF}$ at Bombay during the period 1871–1990, over sliding windows of widths 11, 21, and 31 years. The CC value is plotted in the central year of the corresponding window. The CCs are generally negative during 1871–1901, positive during 1902–1945, and again negative during 1946–1990; however, the CCs are significant at the 5% level or above only after 1950. It may also be seen that the CCs over windows of 11 and 21 years width are more rapidly fluctuating than those over the windows of 31 years.

The turning points in the signs of the relationship around the years 1901 and 1943, delineating fairly long periods of direct and inverse associations (Fig. 3), have prompted us to extend the data period back to the earliest possible year to obtain further evidence of such changes, if any. For this purpose, we examined the sliding correlations of the all-India (A) rainfall and $P_{MAM-DJF}$ at Bombay during 1847–1990. The sliding CCs are shown in Fig. 4. It may be noted that this rainfall series is based on fewer stations. It is seen that the 31-year sliding width CCs are positive before 1870 and during 1900–1940, and negative during 1870–1900 and after 1940, showing conspicuous turning points of changeover in the signs of CCs around the years 1870, 1900, and 1940. However, the positive CCs before 1870 are small and insignificant. During the recent period after 1940, the CCs were stronger in the case of all-India monsoon rainfall based on 306 stations (Fig. 3) than those in the case of all-India monsoon rainfall based on 16 stations (Fig. 4).

A high negative value of $P_{MAM-DJF}$, indicating a steeper pressure drop from winter to spring, generally leads to a lower pressure during the premonsoon months. In view of this, the negative relationships dur-

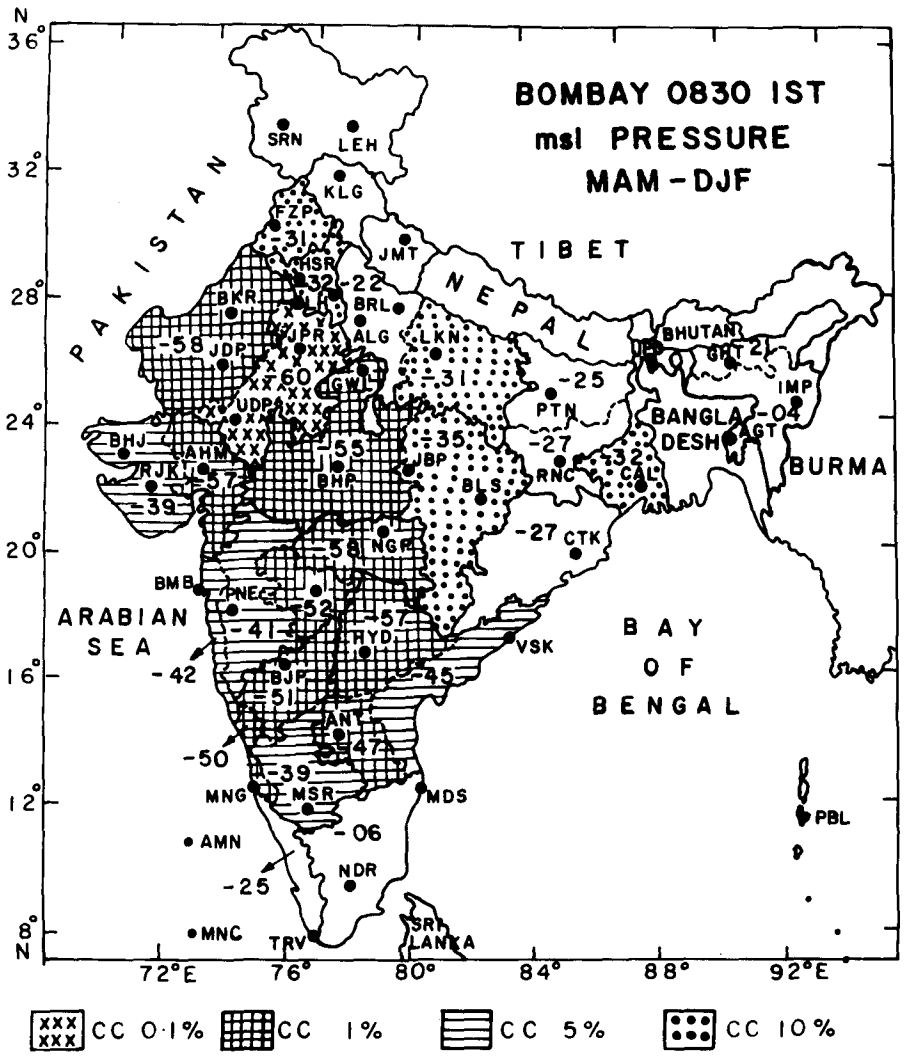


FIG. 2. Correlation coefficients between monsoon rainfall of different meteorological subdivisions of India and MSL pressure tendency (MAM–DJF) of Bombay for the period 1951–80.

ing 1870–1900 and after 1940 are understandable as a lower pressure over the Indian (Asian) landmass during premonsoon months establishes a stronger lower-tropospheric cross-equatorial flow, which in turn transports larger amounts of water vapor into the Northern Hemisphere (Hastenrath 1985). However, during the periods prior to 1870 and 1900–40 Bombay pressure seems to be indifferent or even positively related to monsoon rainfall, which does not correspond with any of the causal mechanisms usually put forth for the development of the monsoon circulation.

Changes in the correlations between Indian rainfall and its predictors were noted quite early by Walker (1910, 1914) and Savur (1931), but a global perspective of such changes was not available at that time. Recent studies have shown marked secular changes in the relationship between the all-India monsoon rainfall and different circulation features such as the Southern Oscillation (Shukla and Paolino 1983; Parthasarathy and Pant 1984; Elliott and Angell 1987, 1988; Pant et al. 1988), sea surface temperature over the tropical Pacific Ocean (Angell 1981; Mooley and Parthasarathy 1984b), mean sea level pressure over equatorial South American regions and snow cover over the Himalayan area (Thapliyal 1987), annual sunspot numbers (Ananthakrishnan and Parthasarathy 1984), surface air temperatures over the west-central Indian region (WCI) (Parthasarathy et al. 1990a), and Northern Hemispheric surface air temperature (Verma et al. 1985). The major turning points in these relationships seem to have some temporal coherence around the years 1900 and 1940. Elliott and Angell (1987, 1988) examined relationships between the Indian monsoon, the Southern Oscillation, and the hemispheric air and sea temperatures for the period 1884–1984 and found a general decrease in correlation between the various

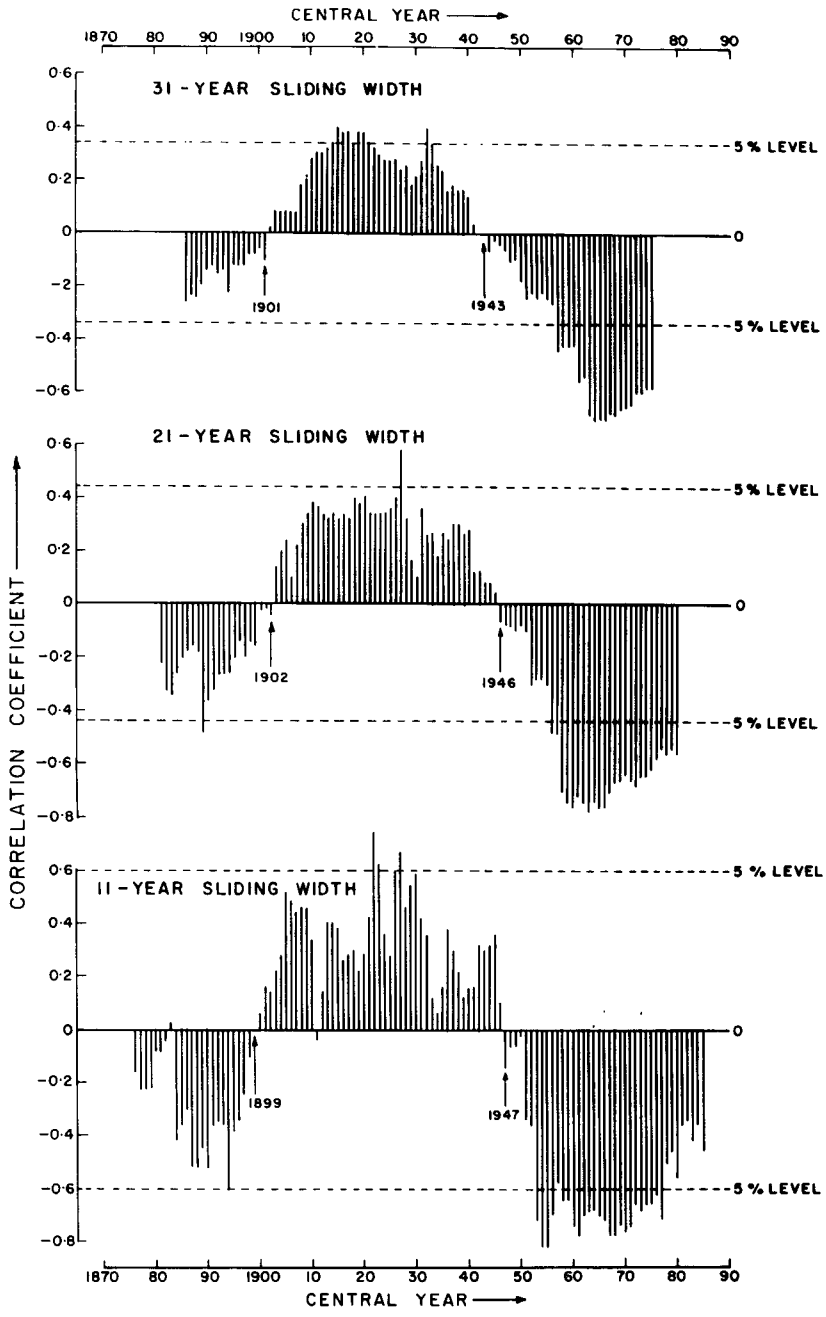


FIG. 3. Variation of correlation coefficient over sliding window of 11, 21, and 31 years, between all-India monsoon rainfall and pressure tendency (MAM–DJF) of Bombay during the period 1871–1990.

datasets between about 1920 and 1950. They suggest that the evidence shows a large change in the circulation some time in the middle of this century.

The positive correlation between premonsoon pressure and monsoon rainfall prior to 1870 and during 1900–40, which belies the conventional theory of associating the strength of cross-equatorial flow with the activity of monsoon, may be due to other types of large-scale circulations dominating the system. This can be broadly visualized as the meridional circulation becoming weaker and the zonal circulation becoming stronger in the monsoon region. In this connection, it is interesting to note that there was a weakening of the trade winds in the eastern Pacific during the late 1930s followed by a warming of the sea surface, and the anomaly spread across the Pacific in the early 1940s in a pattern resembling a slow El Niño–Southern Oscillation (ENSO) event (Cooper et al. 1989).

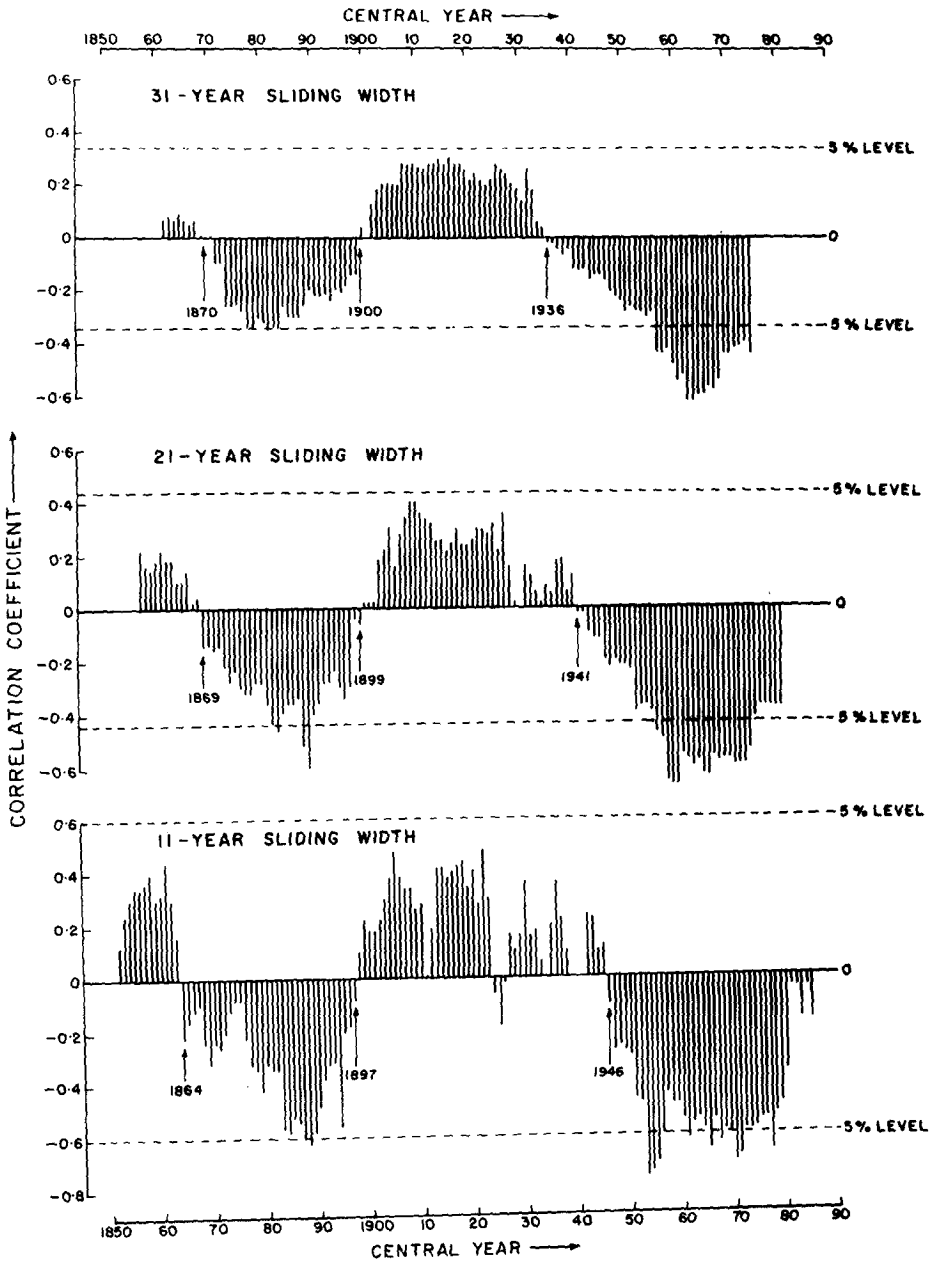


FIG. 4. Variation of correlation coefficient over sliding window of 11, 21, and 31 years, between all-India (A) monsoon rainfall (average of 16 stations) and pressure tendency (MAM–DJF) of Bombay during the years 1847–1990.

In a recent study, Fu and Fletcher (1988) identified large climatic variations in the Asian monsoon region by examining the zonal and meridional components of surface winds (COADS) during the monsoon months (June, July, and August) for the period 1860–1960 over the Arabian Sea, the Bay of Bengal, and the equatorial buffer zone in the Indian Ocean (0°–5°S, 40°–100°E). They concluded that the relative dominance of the two wind components had been undergoing significant decadal-scale variability, more dominantly in the Bay of Bengal (Fig. 5). The cumulative curves of the anomalies of the zonal component during June through August over the Bay of Bengal and the all-India monsoon rainfall anomalies show a striking inverse relationship (Fig. 6). Based on these associations, they identified distinct climatic regimes in wind components with changes around the years 1875, 1900, and 1940. The period 1875–1900 is characterized by what they call the "meridional monsoonal period" and the period 1900–1940 by the "zonal monsoonal period" over the Indian Ocean (Fig. 7), which are also synchronous with the high and low epochs of the Indian

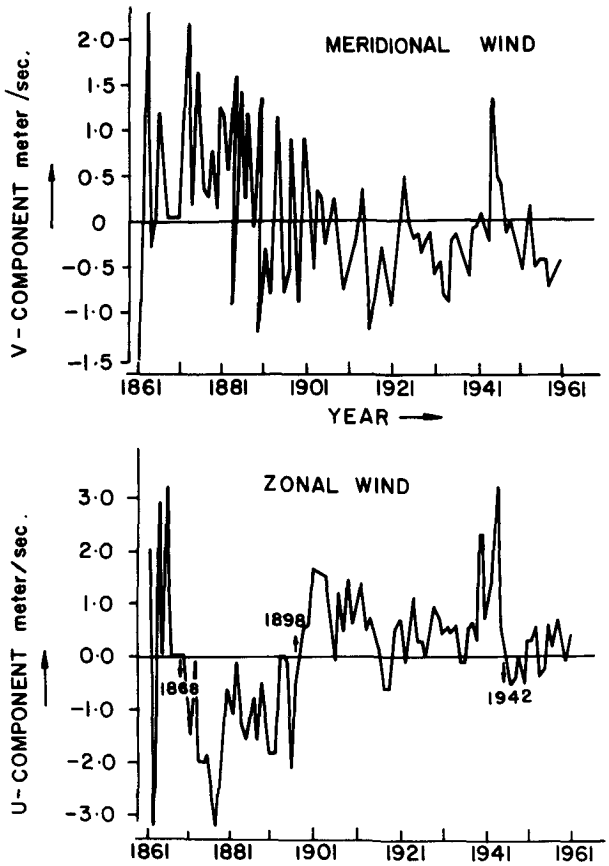


FIG. 5. Monsoon winds ($U$ and $V$ components) in the Bay of Bengal monsoon current from June to August for the period 1860–1960. (After Fu and Fletcher 1988).

monsoon rainfall. It has also been observed that, during the zonal monsoonal period, dry years were more common than during the meridional monsoonal period, when wet years were more common in India. In the present study, changes in the signs of correlations around 1870, 1900, and 1940 may be reasoned to be a part of the large-scale changes in the climatic regimes over the Indian Ocean and Pacific Ocean areas.

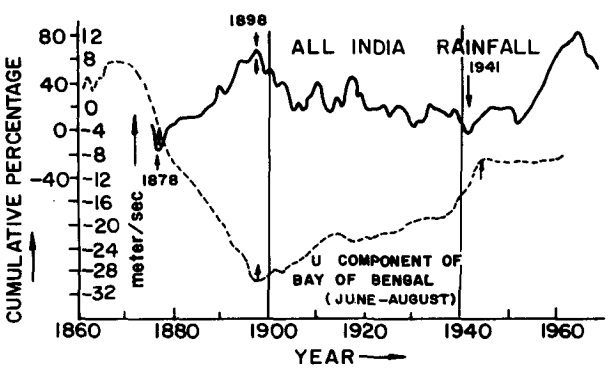


FIG. 6. Cumulative curves of all-India monsoon rainfall and the $U$ component of the Bay of Bengal current (June–August) during the period 1860–1960. (After Fu and Fletcher 1988.)

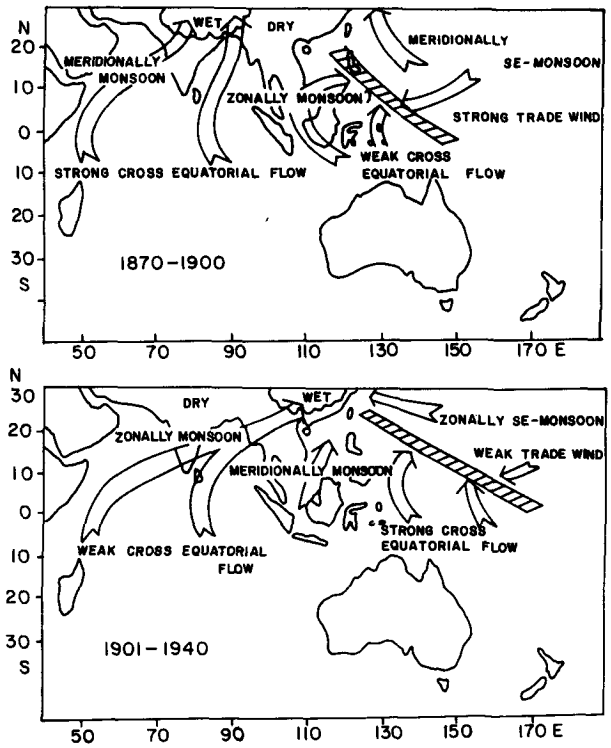


FIG. 7. Schematic maps of two flow patterns of Asian monsoon current (winds) during 1870–1900 and 1901–1940. (Adapted from Fu and Fletcher 1988.)

The activity of the Indian summer monsoon is also strongly linked to the surface air and sea surface temperatures over the Pacific Ocean and associated ENSO parameters (Sikka 1980; Mooley and Parthasarathy 1983; Rasmusson and Carpenter 1982, 1983; and Parthasarathy and Sontakke 1988). Secular variations in the ENSO cycle are known to exist in both amplitude and positions of the centers of action (Trenberth and Shea 1987). Therefore, it is important to determine whether there is a link between the secular changes in the monsoon–pressure relationships over India seen above and those in the ENSO cycle.

Schove and Berlage (1965) and Berlage (1966) constructed Southern Oscillation (SO) indices by simple half-yearly averaging of surface pressure anomalies at some stations in the Indian Ocean area, using data for the period 1841–1960. Using these data for the April–September SO index (mean of pressure anomalies at Bombay, Madras, Djakarta, Darwin, Mauritius, and Perth), we computed its correlations with the all-India (A) monsoon rainfall for different periods. A highly positive SO index of Berlage represents a strong ENSO event. The CCs obtained, along with their significance levels given in parentheses, are: −0.46 (0.1% level) for the whole period 1847–1960; −0.08 (not significant) for the zonal monsoon period 1847–1870; −0.75 (0.1% level) for the meridional monsoon period 1871–1900; −0.36 (5% level) for the zonal monsoon period 1901–40; and −0.68 (0.1% level) for the meridional monsoon

period 1941–60. This indicates that the influence of the SO component in the Indian Ocean sector on the Indian monsoon rainfall, though very strong in general, becomes rather weak during the zonal monsoon periods. In this connection, it is also important to see the secular changes in the ENSO variance in Bombay pressure in comparison with the changes in its relationship with the Indian monsoon rainfall. For this purpose, the sliding correlation analysis of $P_{\text{MAM-DJF}}$ at Darwin was performed with $P_{\text{MAM-DJF}}$ at Bombay, as well as with all-India monsoon rainfall, during the period 1882–1990 (Fig. 8). Darwin $P_{\text{MAM-DJF}}$ shows consistently negative CCs with the Indian monsoon rainfall, but they are significant only after 1950 (Fig. 8b). During the period 1901–1940, the CCs between Bombay and Darwin $P_{\text{MAM-DJF}}$ are indifferent, with relatively higher positive CCs before 1900 and after 1940 (Fig. 8c). The CCs after 1940 are highly significant. It can be clearly seen that Bombay and Darwin $P_{\text{MAM-DJF}}$ both show highly significant negative CCs with the Indian monsoon rainfall only when they are highly interrelated. Therefore, it can be concluded that the relationship between Bombay pressure and Indian monsoon rainfall becomes dominant when the ENSO variance in Bombay pressure is high and falls apart when the ENSO variance is small. Thus, it can be stated

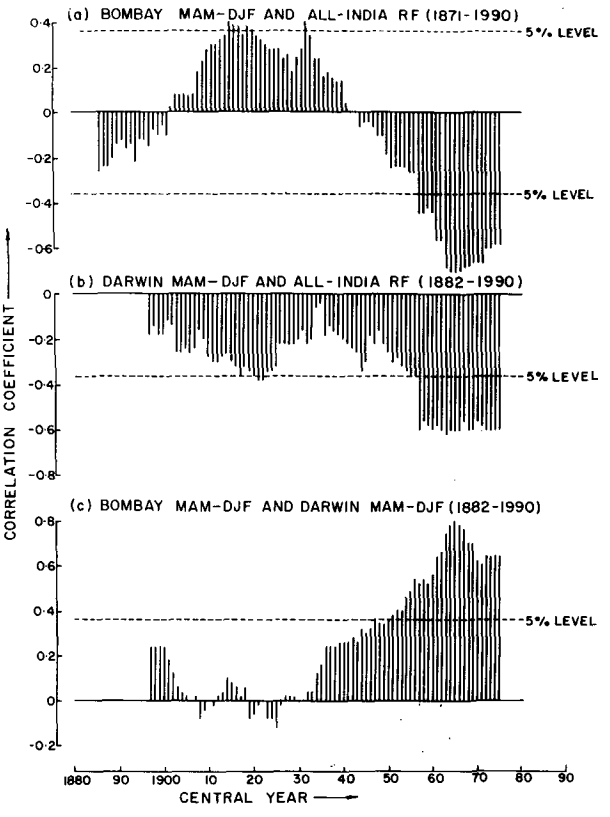


FIG. 8. Variation of the correlation coefficient over a 31-year sliding window width between all-India monsoon rainfall and $P_{\text{MAM-DJF}}$ at (a) Bombay and (b) Darwin and (c) for $P_{\text{MAM-DJF}}$ between Bombay and Darwin.

that the changes in the correlations observed in the present study reflect large-scale changes in the climatic regimes over a wide area.

In view of the importance of the Bombay pressure record for studying multidecadal climate variability as demonstrated above, a listing of the mean monthly MSL pressure at Bombay along with all-India summer monsoon rainfall for the period 1847–1990 is presented in the Appendix.

## 6. Summary and conclusions

A detailed study of the relationship between the mean sea level pressure at Bombay (19°N, 73°E) and the Indian summer monsoon rainfall has been made. Secular changes in this relationship using long-period data during 1847–1990 were examined to identify the decadal-scale variations in the climatic regime over the area. An attempt was made to relate these changes to similar patterns in the global-scale circulation features. The important conclusions are:

(i) The CCs between all-India monsoon rainfall and Bombay pressure for different seasons up to one lag on either side of the monsoon season, for the period 1951–80, are significantly negative, suggesting that the large-scale circulation over India undergoes a low-frequency transition.

(ii) During this period, $P_{\text{MAM-DJF}}$ at Bombay shows a significant CC of −0.70 with the subsequent all-India monsoon rainfall and composite values of +0.5 mb for deficient monsoons and −0.6 mb for excess monsoons, suggesting that during this period active monsoon conditions over the country are preceded by below-normal pressure and a steeper-than-normal seasonal pressure drop before the monsoon season and vice versa.

(iii) Sliding correlation analysis between all-India monsoon rainfall and $P_{\text{MAM-DJF}}$ at Bombay for the period 1847–1990 showed systematic turning points in the CC values around the years 1870, 1900, and 1940. These turning points are temporally coherent with the changes in tropical circulation features observed by Fu and Fletcher (1988) and Elliott and Angell (1987, 1988).

(iv) The positive CC period before 1870 and during 1900–40 can be identified as a "zonal monsoonal circulation period." The negative CC periods during 1870–1900 and 1940 to present can be taken as a meridional monsoonal circulation period.

(v) The relationship between Bombay pressure and Indian monsoon rainfall, which has recently prevailed, is dominant only when the ENSO variance in Bombay pressure is high.

(vi) The most recent data shows a trend toward a more zonal monsoonal period.

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APPENDIX

**All-India summer monsoon rainfall and monthly MSL pressure at Bombay (1847–1990)**

| Year | RF1 | RF2 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1847 | 840 | | 14.5 | 14.0 | 13.3 | 10.2 | 7.7 | 3.7 | 4.6 | 6.7 | 8.4 | 11.4 | 13.9 | 14.0 | 1847 |
| 1848 | 761 | | 14.9 | 14.4 | 11.8 | 9.5 | 8.3 | 4.6 | 4.7 | 6.7 | 10.6 | 11.5 | 14.4 | 14.9 | 1848 |
| 1849 | 879 | | 15.5 | 14.1 | 13.2 | 9.8 | 7.4 | 3.8 | 5.3 | 6.4 | 7.7 | 12.0 | 13.8 | 14.5 | 1849 |
| 1850 | 828 | | 13.2 | 14.8 | 13.7 | 11.1 | 9.1 | 4.3 | 4.3 | 7.7 | 9.7 | 10.1 | 13.8 | 15.8 | 1850 |
| 1851 | 786 | | 15.9 | 13.9 | 12.7 | 9.8 | 8.3 | 4.0 | 2.8 | 6.3 | 9.6 | 11.5 | 12.0 | 15.7 | 1851 |
| 1852 | 945 | | 14.9 | 14.0 | 11.8 | 10.3 | 8.5 | 4.0 | 4.9 | 7.5 | 8.7 | 12.5 | 14.3 | 14.9 | 1852 |
| 1853 | 824 | | 15.3 | 13.0 | 12.8 | 10.4 | 9.5 | 4.5 | 5.3 | 7.9 | 10.0 | 12.4 | 12.9 | 16.0 | 1853 |
| 1854 | 903 | | 15.2 | 14.6 | 13.7 | 10.3 | 9.0 | 5.5 | 3.5 | 6.9 | 7.3 | 10.1 | 14.9 | 15.3 | 1854 |
| 1855 | 715 | | 15.2 | 15.0 | 12.6 | 11.2 | 9.9 | 5.1 | 4.8 | 7.9 | 9.8 | 11.5 | 15.5 | 15.6 | 1855 |
| 1856 | 744 | | 16.8 | 14.6 | 12.0 | 10.1 | 7.6 | 4.7 | 3.2 | 6.7 | 10.2 | 11.7 | 14.0 | 15.2 | 1856 |
| 1857 | 767 | | 15.0 | 12.8 | 11.9 | 10.2 | 8.1 | 4.3 | 4.5 | 5.8 | 10.6 | 12.5 | 14.7 | 16.9 | 1857 |
| 1858 | 738 | | 14.7 | 15.2 | 12.6 | 10.5 | 6.1 | 6.3 | 5.2 | 7.1 | 9.5 | 11.3 | 15.0 | 15.6 | 1858 |
| 1859 | 901 | | 15.1 | 14.5 | 13.5 | 10.1 | 10.0 | 5.1 | 3.8 | 7.5 | 9.5 | 12.4 | 12.5 | 15.2 | 1859 |
| 1860 | 837 | | 15.8 | 13.1 | 12.3 | 11.5 | 9.1 | 4.7 | 3.9 | 7.3 | 8.0 | 10.9 | 14.7 | 14.8 | 1860 |
| 1861 | 936 | | 14.2 | 13.8 | 12.7 | 9.3 | 7.4 | 5.2 | 4.2 | 6.1 | 9.3 | 12.5 | 13.0 | 15.2 | 1861 |
| 1862 | 888 | | 14.6 | 12.9 | 12.9 | 10.6 | 9.9 | 4.1 | 3.7 | 6.1 | 6.6 | 9.9 | 12.5 | 13.7 | 1862 |
| 1863 | 937 | | 15.3 | 13.3 | 12.1 | 8.7 | 8.1 | 3.2 | 4.1 | 6.3 | 9.1 | 11.0 | 14.0 | 15.7 | 1863 |
| 1864 | 763 | | 15.5 | 14.7 | 13.8 | 11.3 | 10.9 | 5.5 | 4.9 | 7.9 | 10.0 | 12.8 | 14.8 | 15.2 | 1864 |
| 1865 | 777 | | 16.4 | 14.2 | 13.3 | 10.5 | 8.3 | 5.3 | 4.8 | 5.3 | 9.8 | 12.2 | 13.8 | 14.7 | 1865 |
| 1866 | 884 | | 16.0 | 14.1 | 13.1 | 11.1 | 9.5 | 5.5 | 4.9 | 6.7 | 10.0 | 10.9 | 15.0 | 16.5 | 1866 |
| 1867 | 853 | | 16.2 | 14.4 | 13.5 | 11.2 | 8.1 | 5.4 | 5.1 | 6.2 | 8.5 | 11.5 | 16.9 | 16.9 | 1867 |
| 1868 | 707 | | 15.2 | 14.6 | 13.6 | 11.6 | 10.2 | 5.4 | 6.2 | 7.9 | 10.8 | 12.5 | 14.8 | 16.3 | 1868 |
| 1869 | 855 | | 16.2 | 15.1 | 13.5 | 11.3 | 9.4 | 5.0 | 5.2 | 6.6 | 7.8 | 11.4 | 14.4 | 14.3 | 1869 |
| 1870 | 879 | | 13.3 | 13.1 | 12.0 | 10.4 | 9.1 | 4.7 | 4.1 | 7.3 | 8.6 | 10.8 | 14.1 | 15.4 | 1870 |
| 1871 | 867 | 846 | 13.8 | 13.6 | 12.9 | 10.3 | 9.3 | 4.3 | 5.3 | 7.6 | 9.5 | 11.3 | 13.1 | 15.2 | 1871 |
| 1872 | 954 | 910 | 15.0 | 14.1 | 12.5 | 9.7 | 9.2 | 4.3 | 4.8 | 5.7 | 8.9 | 11.3 | 13.0 | 13.9 | 1872 |
| 1873 | 740 | 755 | 14.8 | 13.7 | 12.8 | 10.6 | 8.1 | 4.5 | 4.2 | 7.9 | 9.8 | 11.4 | 15.3 | 15.6 | 1873 |
| 1874 | 934 | 971 | 16.5 | 14.7 | 12.7 | 11.4 | 7.6 | 3.9 | 4.7 | 7.1 | 8.2 | 10.6 | 14.8 | 15.9 | 1874 |
| 1875 | 884 | 929 | 14.7 | 14.1 | 12.5 | 9.9 | 9.4 | 4.7 | 4.8 | 7.3 | 8.6 | 11.8 | 14.8 | 15.4 | 1875 |
| 1876 | 721 | 776 | 14.7 | 14.1 | 13.1 | 9.2 | 9.2 | 5.7 | 3.9 | 7.4 | 10.3 | 13.2 | 14.0 | 16.0 | 1876 |
| 1877 | 577 | 604 | 16.5 | 15.2 | 13.7 | 11.4 | 10.0 | 6.7 | 7.9 | 8.6 | 10.4 | 12.7 | 14.8 | 14.7 | 1877 |
| 1878 | 873 | 974 | 15.8 | 15.3 | 14.3 | 11.1 | 9.8 | 5.7 | 4.6 | 5.1 | 6.3 | 9.8 | 12.0 | 13.6 | 1878 |
| 1879 | 871 | 894 | 14.8 | 13.8 | 12.8 | 10.4 | 6.1 | 5.6 | 5.5 | 5.9 | 10.1 | 11.8 | 13.9 | 14.1 | 1879 |
| 1880 | 865 | 817 | 14.5 | 14.2 | 12.2 | 10.2 | 8.5 | 5.3 | 5.8 | 8.3 | 9.4 | 12.2 | 14.5 | 16.7 | 1880 |
| 1881 | 888 | 860 | 16.2 | 15.4 | 14.0 | 11.2 | 8.9 | 6.4 | 6.1 | 6.3 | 9.4 | 11.7 | 12.9 | 14.6 | 1881 |
| 1882 | 883 | 901 | 16.2 | 14.5 | 13.3 | 9.8 | 9.2 | 4.7 | 3.9 | 7.5 | 9.2 | 10.6 | 13.1 | 15.4 | 1882 |
| 1883 | 748 | 849 | 15.0 | 13.9 | 13.6 | 10.3 | 8.3 | 4.2 | 5.3 | 7.1 | 9.8 | 12.1 | 13.1 | 17.2 | 1883 |
| 1884 | 953 | 929 | 17.2 | 15.2 | 12.7 | 11.4 | 9.6 | 6.4 | 4.6 | 6.2 | 8.8 | 13.2 | 14.1 | 15.9 | 1884 |
| 1885 | 838 | 842 | 16.9 | 14.0 | 13.4 | 11.2 | 10.4 | 4.7 | 5.1 | 6.3 | 10.3 | 12.1 | 15.0 | 15.0 | 1885 |
| 1886 | 923 | 870 | 15.4 | 14.7 | 13.0 | 10.8 | 7.7 | 4.8 | 4.7 | 7.1 | 9.9 | 10.2 | 13.9 | 15.7 | 1886 |
| 1887 | 843 | 897 | 13.9 | 15.1 | 12.6 | 10.5 | 9.7 | 5.1 | 5.8 | 7.4 | 10.3 | 11.9 | 14.2 | 15.0 | 1887 |
| 1888 | 806 | 810 | 16.5 | 15.6 | 13.8 | 11.0 | 9.0 | 5.2 | 5.7 | 7.1 | 11.3 | 12.8 | 13.6 | 16.2 | 1888 |
| 1889 | 958 | 927 | 16.2 | 15.6 | 14.8 | 10.8 | 9.5 | 5.0 | 4.3 | 6.1 | 8.3 | 10.4 | 13.3 | 15.0 | 1889 |
| 1890 | 892 | 904 | 14.1 | 13.8 | 12.0 | 10.2 | 8.7 | 3.9 | 4.9 | 8.1 | 9.4 | 12.4 | 14.3 | 15.5 | 1890 |

APPENDIX (*Continued*)

| Year | RF1 | RF2 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891 | 795 | 789 | 15.5 | 14.9 | 12.9 | 11.5 | 9.1 | 7.5 | 4.4 | 7.8 | 9.5 | 12.5 | 13.9 | 16.0 | 1891 |
| 1892 | 925 | 990 | 14.7 | 12.6 | 10.8 | 9.2 | 8.6 | 5.0 | 3.0 | 6.0 | 8.0 | 10.2 | 13.7 | 16.2 | 1892 |
| 1893 | 910 | 954 | 14.0 | 14.8 | 12.8 | 10.0 | 8.6 | 4.7 | 5.7 | 7.2 | 9.1 | 11.3 | 13.8 | 16.0 | 1893 |
| 1894 | 829 | 969 | 14.6 | 14.4 | 12.4 | 10.0 | 9.6 | 4.1 | 4.6 | 5.9 | 8.5 | 10.5 | 15.1 | 15.4 | 1894 |
| 1895 | 811 | 825 | 14.8 | 14.6 | 12.1 | 10.6 | 9.8 | 4.9 | 5.7 | 6.3 | 10.0 | 11.1 | 15.0 | 15.3 | 1895 |
| 1896 | 828 | 824 | 15.2 | 15.2 | 12.3 | 9.6 | 10.1 | 3.6 | 5.0 | 7.3 | 10.8 | 13.2 | 12.7 | 15.7 | 1896 |
| 1897 | 855 | 890 | 15.4 | 13.7 | 12.8 | 11.1 | 9.3 | 5.4 | 3.6 | 5.2 | 8.7 | 11.7 | 13.9 | 15.7 | 1897 |
| 1898 | 896 | 880 | 15.9 | 12.4 | 11.9 | 9.8 | 8.9 | 4.7 | 3.6 | 7.6 | 8.7 | 10.8 | 12.4 | 14.4 | 1898 |
| 1899 | 703 | 629 | 15.4 | 13.5 | 12.6 | 10.4 | 8.8 | 4.9 | 7.1 | 8.1 | 11.7 | 12.0 | 15.1 | 15.9 | 1899 |
| 1900 | 910 | 885 | 15.1 | 14.5 | 13.8 | 11.2 | 11.0 | 5.9 | 4.7 | 5.4 | 10.0 | 13.0 | 13.2 | 15.1 | 1900 |
| 1901 | 729 | 719 | 15.5 | 15.0 | 13.6 | 9.6 | 9.6 | 5.7 | 4.5 | 6.2 | 11.6 | 11.5 | 12.9 | 15.6 | 1901 |
| 1902 | 794 | 791 | 14.5 | 16.5 | 12.1 | 10.4 | 9.6 | 6.4 | 3.4 | 6.8 | 8.7 | 13.2 | 14.7 | 14.0 | 1902 |
| 1903 | 823 | 858 | 15.7 | 16.4 | 13.2 | 10.7 | 8.7 | 5.6 | 2.6 | 6.2 | 8.5 | 10.1 | 13.5 | 14.6 | 1903 |
| 1904 | 772 | 750 | 15.1 | 13.7 | 12.3 | 9.8 | 8.5 | 5.6 | 4.7 | 7.2 | 10.5 | 11.4 | 15.9 | 15.8 | 1904 |
| 1905 | 703 | 715 | 16.2 | 15.4 | 13.7 | 12.3 | 9.0 | 6.6 | 5.1 | 7.4 | 9.3 | 11.1 | 15.3 | 15.3 | 1905 |
| 1906 | 807 | 883 | 15.4 | 13.7 | 14.0 | 10.7 | 9.1 | 5.4 | 3.4 | 6.7 | 9.1 | 12.2 | 14.6 | 14.5 | 1906 |
| 1907 | 809 | 776 | 14.7 | 14.2 | 13.2 | 10.5 | 10.0 | 5.0 | 4.2 | 6.0 | 10.6 | 11.2 | 12.5 | 14.7 | 1907 |
| 1908 | 883 | 895 | 15.6 | 13.1 | 13.3 | 10.0 | 9.9 | 5.7 | 4.6 | 5.9 | 9.1 | 11.4 | 13.9 | 15.5 | 1908 |
| 1909 | 910 | 889 | 14.1 | 13.8 | 12.0 | 10.3 | 8.7 | 4.2 | 4.2 | 7.8 | 8.6 | 11.6 | 13.3 | 14.4 | 1909 |
| 1910 | 863 | 935 | 13.7 | 12.6 | 11.8 | 9.8 | 10.1 | 3.4 | 5.8 | 5.5 | 7.1 | 11.0 | 13.2 | 15.9 | 1910 |
| 1911 | 691 | 733 | 14.0 | 15.5 | 13.0 | 11.3 | 8.8 | 5.9 | 6.1 | 7.0 | 9.6 | 12.7 | 12.9 | 14.7 | 1911 |
| 1912 | 830 | 804 | 16.3 | 14.0 | 13.0 | 11.5 | 9.4 | 4.5 | 3.1 | 6.1 | 9.6 | 11.9 | 13.2 | 15.6 | 1912 |
| 1913 | 802 | 782 | 16.0 | 13.7 | 12.6 | 9.8 | 8.6 | 3.7 | 4.5 | 7.3 | 10.2 | 11.9 | 14.5 | 15.9 | 1913 |
| 1914 | 911 | 899 | 17.0 | 14.8 | 13.7 | 12.0 | 9.4 | 4.6 | 2.9 | 6.4 | 8.5 | 13.2 | 13.0 | 14.4 | 1914 |
| 1915 | 919 | 780 | 15.9 | 14.2 | 14.6 | 11.4 | 8.4 | 4.9 | 5.4 | 6.8 | 8.3 | 10.0 | 11.8 | 15.6 | 1915 |
| 1916 | 931 | 950 | 15.9 | 13.6 | 12.0 | 10.5 | 8.1 | 2.2 | 4.6 | 6.0 | 6.1 | 9.5 | 12.1 | 14.1 | 1916 |
| 1917 | 997 | 1003 | 15.0 | 12.9 | 12.1 | 10.4 | 10.1 | 3.7 | 4.3 | 6.0 | 6.4 | 8.3 | 12.9 | 13.9 | 1917 |
| 1918 | 666 | 648 | 14.1 | 15.2 | 12.4 | 10.9 | 6.0 | 6.1 | 7.2 | 6.7 | 11.0 | 12.5 | 12.0 | 15.3 | 1918 |
| 1919 | 887 | 885 | 15.0 | 14.7 | 14.2 | 11.1 | 9.1 | 4.9 | 4.1 | 6.3 | 9.2 | 8.0 | 11.5 | 14.3 | 1919 |
| 1920 | 706 | 718 | 14.5 | 14.7 | 12.0 | 10.5 | 9.5 | 4.0 | 4.1 | 7.9 | 9.4 | 11.5 | 11.9 | 14.3 | 1920 |
| 1921 | 882 | 863 | 14.3 | 13.1 | 11.3 | 10.3 | 7.9 | 4.6 | 3.8 | 6.0 | 8.9 | 12.0 | 15.0 | 15.2 | 1921 |
| 1922 | 968 | 867 | 14.3 | 13.3 | 12.5 | 9.9 | 8.8 | 4.5 | 4.3 | 6.1 | 8.4 | 12.1 | 12.6 | 15.7 | 1922 |
| 1923 | 850 | 819 | 14.6 | 13.4 | 13.4 | 9.4 | 8.7 | 5.9 | 3.2 | 5.5 | 8.5 | 12.3 | 13.4 | 14.1 | 1923 |
| 1924 | 938 | 862 | 15.3 | 13.2 | 12.0 | 9.4 | 8.2 | 5.2 | 2.9 | 5.7 | 8.3 | 12.0 | 12.6 | 15.5 | 1924 |
| 1925 | 785 | 803 | 13.7 | 14.1 | 11.5 | 10.4 | 8.1 | 3.7 | 6.0 | 6.1 | 10.5 | 11.8 | 13.7 | 15.4 | 1925 |
| 1926 | 814 | 901 | 15.4 | 14.5 | 13.8 | 12.0 | 9.6 | 5.8 | 3.2 | 5.3 | 7.7 | 10.5 | 13.4 | 13.9 | 1926 |
| 1927 | 772 | 849 | 13.8 | 14.0 | 10.7 | 9.8 | 9.2 | 5.5 | 3.9 | 6.7 | 8.5 | 12.4 | 13.5 | 15.0 | 1927 |
| 1928 | 711 | 766 | 15.1 | 14.0 | 12.4 | 9.9 | 9.2 | 4.2 | 4.7 | 7.1 | 9.7 | 10.6 | 14.1 | 14.6 | 1928 |
| 1929 | 744 | 820 | 14.8 | 13.0 | 11.9 | 10.9 | 9.0 | 4.0 | 3.9 | 6.9 | 9.3 | 11.8 | 12.8 | 14.1 | 1929 |
| 1930 | 843 | 800 | 14.6 | 15.3 | 12.0 | 10.0 | 9.4 | 4.6 | 5.9 | 7.4 | 9.3 | 11.2 | 14.5 | 15.2 | 1930 |
| 1931 | 891 | 877 | 14.8 | 14.0 | 13.5 | 10.7 | 9.2 | 6.0 | 4.4 | 4.1 | 8.7 | 10.3 | 13.6 | 14.4 | 1931 |
| 1932 | 728 | 801 | 17.1 | 14.3 | 12.9 | 11.4 | 7.9 | 6.3 | 3.0 | 7.2 | 7.8 | 10.4 | 12.5 | 15.3 | 1932 |
| 1933 | 944 | 973 | 14.9 | 13.2 | 12.1 | 11.1 | 8.2 | 4.9 | 5.2 | 7.2 | 7.6 | 10.3 | 13.2 | 14.1 | 1933 |
| 1934 | 849 | 913 | 14.0 | 13.5 | 11.9 | 10.2 | 10.2 | 4.9 | 4.9 | 6.6 | 9.1 | 12.0 | 14.4 | 15.6 | 1934 |
| 1935 | 785 | 844 | 16.1 | 13.9 | 12.6 | 11.1 | 9.4 | 5.3 | 4.1 | 7.7 | 8.5 | 10.8 | 14.5 | 14.9 | 1935 |
| 1936 | 929 | 904 | 15.0 | 14.1 | 12.7 | 10.9 | 7.4 | 5.0 | 5.5 | 6.9 | 8.5 | 12.7 | 13.5 | 14.5 | 1936 |
| 1937 | 826 | 843 | 14.7 | 14.0 | 11.6 | 9.9 | 9.4 | 4.7 | 3.7 | 7.1 | 9.4 | 11.8 | 12.7 | 14.1 | 1937 |
| 1938 | 860 | 908 | 14.9 | 13.7 | 10.6 | 10.2 | 6.9 | 3.8 | 4.8 | 6.0 | 8.6 | 10.8 | 14.1 | 14.0 | 1938 |
| 1939 | 767 | 789 | 15.0 | 14.2 | 12.0 | 10.4 | 9.1 | 5.8 | 4.9 | 6.2 | 10.3 | 11.5 | 12.6 | 17.3 | 1939 |
| 1940 | 805 | 850 | 15.5 | 14.9 | 13.1 | 12.0 | 8.3 | 5.7 | 5.2 | 6.4 | 10.9 | 12.1 | 12.1 | 16.2 | 1940 |
| 1941 | 730 | 729 | 15.6 | 15.2 | 12.8 | 10.9 | 8.3 | 6.3 | 6.4 | 6.1 | 9.8 | 12.4 | 11.9 | 14.0 | 1941 |
| 1942 | 914 | 958 | 15.5 | 14.4 | 11.1 | 10.7 | 8.6 | 4.6 | 3.9 | 5.8 | 9.1 | 11.1 | 13.5 | 13.4 | 1942 |

APPENDIX (*Continued*)

| Year | RF1 | RF2 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1943 | 813 | 866 | 13.8 | 13.9 | 11.8 | 12.2 | 7.0 | 5.2 | 4.8 | 7.5 | 8.9 | 11.4 | 12.5 | 16.8 | 1943 |
| 1944 | 872 | 922 | 15.3 | 14.6 | 12.7 | 11.4 | 8.4 | 5.4 | 3.9 | 7.2 | 9.8 | 10.4 | 11.8 | 13.4 | 1944 |
| 1945 | 843 | 908 | 13.8 | 12.1 | 12.9 | 11.0 | 9.2 | 5.1 | 4.7 | 5.6 | 9.1 | 12.3 | 13.7 | 14.9 | 1945 |
| 1946 | 799 | 901 | 15.0 | 13.1 | 11.9 | 10.6 | 9.0 | 3.5 | 4.8 | 4.6 | 9.7 | 10.7 | 11.4 | 12.1 | 1946 |
| 1947 | 909 | 943 | 13.2 | 12.8 | 12.3 | 9.2 | 8.9 | 5.3 | 3.9 | 5.5 | 7.4 | 12.6 | 14.8 | 14.0 | 1947 |
| 1948 | 811 | 873 | 14.1 | 14.0 | 13.8 | 10.1 | 8.2 | 4.4 | 3.7 | 4.9 | 8.5 | 12.2 | 12.2 | 14.9 | 1948 |
| 1949 | 919 | 902 | 15.0 | 13.9 | 11.8 | 10.6 | 6.8 | 4.9 | 3.9 | 5.5 | 6.9 | 10.3 | 13.8 | 13.9 | 1949 |
| 1950 | 872 | 875 | 13.9 | 13.4 | 12.1 | 9.3 | 7.9 | 4.5 | 3.2 | 6.4 | 7.9 | 10.6 | 12.3 | 14.5 | 1950 |
| 1951 | 702 | 737 | 13.9 | 12.4 | 11.6 | 10.6 | 9.5 | 3.9 | 4.8 | 7.2 | 9.5 | 10.1 | 12.1 | 14.6 | 1951 |
| 1952 | 757 | 792 | 14.9 | 12.8 | 11.3 | 10.8 | 7.7 | 4.7 | 5.2 | 6.1 | 10.2 | 10.4 | 13.3 | 15.6 | 1952 |
| 1953 | 917 | 920 | 15.0 | 14.6 | 11.6 | 10.9 | 10.0 | 4.6 | 4.4 | 6.0 | 9.2 | 10.8 | 14.2 | 15.6 | 1953 |
| 1954 | 896 | 885 | 13.4 | 13.3 | 12.2 | 9.9 | 7.4 | 3.6 | 3.3 | 5.1 | 6.7 | 11.4 | 15.0 | 13.6 | 1954 |
| 1955 | 910 | 930 | 15.6 | 11.2 | 11.3 | 9.7 | 7.1 | 4.5 | 5.6 | 5.3 | 7.1 | 9.4 | 12.6 | 14.6 | 1955 |
| 1956 | 950 | 980 | 12.9 | 12.7 | 11.2 | 8.9 | 5.4 | 4.2 | 5.4 | 6.4 | 7.4 | 9.5 | 13.6 | 15.5 | 1956 |
| 1957 | 728 | 785 | 14.2 | 14.2 | 13.0 | 11.0 | 9.1 | 5.1 | 4.8 | 6.0 | 10.5 | 11.9 | 14.3 | 14.1 | 1957 |
| 1958 | 922 | 887 | 15.8 | 13.9 | 12.9 | 11.0 | 8.2 | 5.2 | 4.3 | 5.3 | 8.1 | 10.6 | 12.8 | 15.5 | 1958 |
| 1959 | 882 | 938 | 14.7 | 13.7 | 12.6 | 10.0 | 6.9 | 5.3 | 3.3 | 5.2 | 6.9 | 10.1 | 12.9 | 14.3 | 1959 |
| 1960 | 834 | 840 | 14.5 | 13.1 | 12.2 | 10.1 | 6.6 | 5.3 | 4.5 | 6.2 | 7.9 | 11.4 | 13.0 | 14.6 | 1960 |
| 1961 | 1019 | 1017 | 14.7 | 13.0 | 12.2 | 10.1 | 7.7 | 5.3 | 2.7 | 4.7 | 7.2 | 10.9 | 13.7 | 13.5 | 1961 |
| 1962 | 804 | 807 | 13.5 | 14.0 | 12.2 | 10.7 | 7.1 | 6.4 | 3.6 | 6.7 | 7.5 | 10.7 | 13.8 | 14.7 | 1962 |
| 1963 | 862 | 856 | 13.7 | 13.8 | 11.9 | 10.7 | 8.6 | 6.4 | 3.7 | 5.0 | 9.2 | 11.3 | 13.7 | 14.3 | 1963 |
| 1964 | 937 | 920 | 15.3 | 13.1 | 12.1 | 9.1 | 8.7 | 4.4 | 4.4 | 4.4 | 7.2 | 10.3 | 12.6 | 14.5 | 1964 |
| 1965 | 798 | 707 | 14.8 | 12.5 | 12.6 | 10.3 | 8.6 | 6.8 | 5.2 | 7.1 | 9.8 | 11.5 | 13.7 | 12.5 | 1965 |
| 1966 | 766 | 735 | 14.8 | 13.2 | 11.2 | 10.1 | 9.2 | 5.9 | 3.8 | 6.5 | 9.1 | 11.3 | 11.2 | 12.6 | 1966 |
| 1967 | 831 | 859 | 14.4 | 13.2 | 11.6 | 10.5 | 7.7 | 5.5 | 3.1 | 5.3 | 8.8 | 11.9 | 13.7 | 13.9 | 1967 |
| 1968 | 760 | 754 | 13.9 | 14.3 | 11.0 | 10.8 | 9.2 | 5.8 | 4.1 | 7.0 | 9.4 | 11.5 | 14.7 | 14.3 | 1968 |
| 1969 | 798 | 829 | 13.4 | 13.7 | 12.4 | 10.4 | 8.0 | 5.3 | 4.3 | 7.2 | 8.7 | 11.6 | 12.5 | 14.2 | 1969 |
| 1970 | 899 | 940 | 14.6 | 13.9 | 11.7 | 10.7 | 7.0 | 4.8 | 4.6 | 4.8 | 6.9 | 10.3 | 12.8 | 14.4 | 1970 |
| 1971 | 981 | 886 | 13.3 | 12.1 | 12.1 | 9.2 | 8.1 | 4.2 | 4.3 | 5.8 | 7.5 | 11.8 | 15.5 | 13.9 | 1971 |
| 1972 | 635 | 653 | 14.3 | 13.2 | 12.4 | 10.9 | 8.9 | 5.9 | 5.1 | 6.7 | 9.6 | 11.8 | 13.0 | 14.3 | 1972 |
| 1973 | 877 | 912 | 15.2 | 14.1 | 12.2 | 9.2 | 8.2 | 4.7 | 4.0 | 5.4 | 8.5 | 9.5 | 12.8 | 14.6 | 1973 |
| 1974 | 800 | 747 | 13.4 | 12.7 | 11.4 | 9.6 | 7.9 | 5.5 | 3.3 | 5.4 | 8.1 | 9.3 | 13.3 | 15.0 | 1974 |
| 1975 | 1084 | 960 | 15.1 | 13.6 | 12.1 | 9.1 | 8.2 | 3.4 | 5.2 | 3.8 | 7.1 | 8.6 | 12.8 | 14.5 | 1975 |
| 1976 | 849 | 855 | 15.1 | 13.5 | 11.4 | 11.5 | 9.6 | 5.2 | 4.1 | 5.8 | 9.8 | 11.5 | 10.6 | 13.7 | 1976 |
| 1977 | 941 | 881 | 14.2 | 13.5 | 12.6 | 9.9 | 8.4 | 4.3 | 3.0 | 6.6 | 9.0 | 12.3 | 11.9 | 15.3 | 1977 |
| 1978 | 946 | 908 | 15.4 | 14.8 | 12.5 | 10.6 | 7.2 | 4.1 | 4.4 | 5.5 | 9.4 | 11.4 | 13.3 | 15.0 | 1978 |
| 1979 | 672 | 708 | 14.7 | 13.5 | 12.6 | 10.2 | 9.4 | 5.6 | 5.9 | 6.2 | 9.2 | 13.1 | 11.1 | 15.0 | 1979 |
| 1980 | 937 | 883 | 14.2 | 13.4 | 12.4 | 10.0 | 8.8 | 3.9 | 4.5 | 6.3 | 9.9 | 11.1 | 12.7 | 13.7 | 1980 |
| 1981 | 896 | 853 | 15.3 | 13.8 | 12.6 | 10.3 | 8.3 | 4.9 | 4.4 | 5.5 | 8.2 | 11.1 | 12.5 | 15.4 | 1981 |
| 1982 | 778 | 735 | 14.6 | 13.7 | 12.4 | 10.9 | 9.7 | 5.9 | 4.7 | 5.9 | 10.3 | 12.0 | 12.1 | 14.6 | 1982 |
| 1983 | 928 | 956 | 15.6 | 14.6 | 13.3 | 10.9 | 9.2 | 5.3 | 4.5 | 5.1 | 7.1 | 10.5 | 15.0 | 13.9 | 1983 |
| 1984 | 940 | 836 | 12.7 | 11.5 | 11.3 | 9.1 | 7.6 | 3.8 | 4.5 | 6.1 | 9.5 | 11.2 | 14.3 | 12.8 | 1984 |
| 1985 | 949 | 787 | 13.8 | 10.0 | 11.3 | 9.3 | 7.1 | 5.8 | 6.0 | 6.0 | 9.0 | 10.1 | 13.3 | 13.9 | 1985 |
| 1986 | 740 | 747 | 13.8 | 13.2 | 11.2 | 9.3 | 8.7 | 4.4 | 6.3 | 7.1 | 10.2 | 11.9 | 13.0 | 15.2 | 1986 |
| 1987 | 784 | 688 | 15.1 | 15.2 | 12.3 | 11.6 | 10.6 | 5.7 | 6.5 | 6.0 | 10.0 | 10.9 | 11.9 | 14.7 | 1987 |
| 1988 | 1047 | 991 | 14.2 | 13.0 | 11.5 | 10.3 | 8.0 | 4.6 | 4.2 | 5.8 | 5.8 | 10.8 | 13.9 | 15.1 | 1988 |
| 1989 | 908 | 862 | 13.1 | 14.8 | 11.5 | 10.2 | 7.7 | 5.5 | 5.3 | 6.3 | 8.5 | 11.0 | 14.0 | 14.9 | 1989 |
| 1990 | 994 | 917 | 14.4 | 14.7 | 11.5 | 10.0 | 9.0 | 4.9 | 5.2 | 6.2 | 9.1 | 11.3 | 12.8 | 14.3 | 1990 |

Note: (i) RF1: All-India monsoon rainfall (1847–1990) in mm based on arithmetic average of 16 representative stations (for details see text). (ii) RF2: All-India monsoon rainfall (1871–1990) in mm based on weighted average of 306 stations. (iii) Monthly msl pressure values in mb may be obtained by adding 1000 to the values given above.

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