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On some aspects of interaction between middle latitude westerlies and monsoon circulation

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ABSTRACT. Day to day zonal index between 30°-50° N has been computed and discussed in relation to the break monsoon conditions. Relation between the mean zonal index and general distribution of the precipitation in the central parts of the country has been investigated. Distortion in the 500 mb flow pattern across Tibet due to the interaction between westerly trough and monsoon circulation has also been discussed.

1. Introduction

Striking fluctuations in the intensity of southwest monsoon over India are observed in association with some typical synoptic situations. Pisharoty and Dasai (1956) concluded that passage of westerly waves across Tibetan Plateau and Himalayas in quick succession led to break monsoon conditions over India, when the rainfall over most parts of the country becomes deficient.

Ramaswamy (1976) made a review of his earlier extensive synoptic studies and showed that large scale break conditions occur in the Indian sub-continent in association with large amplitude troughs which give rise to low index circulation in the mid-latitudes. He further stated that these large ampliude troughs pull up the monsoon current further northwards, thus establishing break monsoon conditions over the sub-continent. Similar synoptic studies have also been undertaken by many other authors and were summarised exhaustively by Rao (1976).

As it has been pointed out by Ramaswamy, owing to the high variability of middle latitude patterns, it may be very difficult to find in the monthly pictures the associations between the middle latitude patterns and low latitude weather. So an attempt has been made by the author in this study to establish a link between the extra-tropical flow and the monsoon circulation on a day to day basis. Though it is almost a recognised fact that low index circulation prevails in the middle latitudes during break monsoon regime over India, the actual zonal index in relation to the position of surface monsoon trough has not been discussed so far.

Keeping this aspect in view the zonal index between 30° - 50°N was computed along the meridians 40°, 50°, 60°, 70° and 80°E at 500 mb and then averaged out to get mean pictures of the flow pattern in middle latitude.

Second aspect of interaction, *viz.*, the relationship of circulation pattern to summer precipitation in monsoon Asia, has also been studied extensively by large number of workers (*e.g,* Pisharoty and Asnani 1960, Ramdas 1960). This problem has been investigated in great details by Wada (1971) in terms of correlation coefficients between monthly mean zonal index and monthly precipitation. He took into consideration only three staions in India. *viz.,* Calcutta, Bombay and Madras from among the eight stations in Monsoon Asia and concluded that a significant relation exists only for Calcutta for the month of August. Desai (1975) also studied the linkage between monsoon rainfall and mid-latiude zonal index. An attempt has been made to study the influence of zonal index on daily as well as monthly precipitation. Since the effect of break is most pronounced on the central India rainfall, computations of area weighted average daily precipitation only in respect of meteorological sub-divisions in the central parts of the country have been made.

Not only the surface monsoon trough shifts to the foot-hills during breaks, but significant changes also take place in the upper air flow patterns, the most important change being the

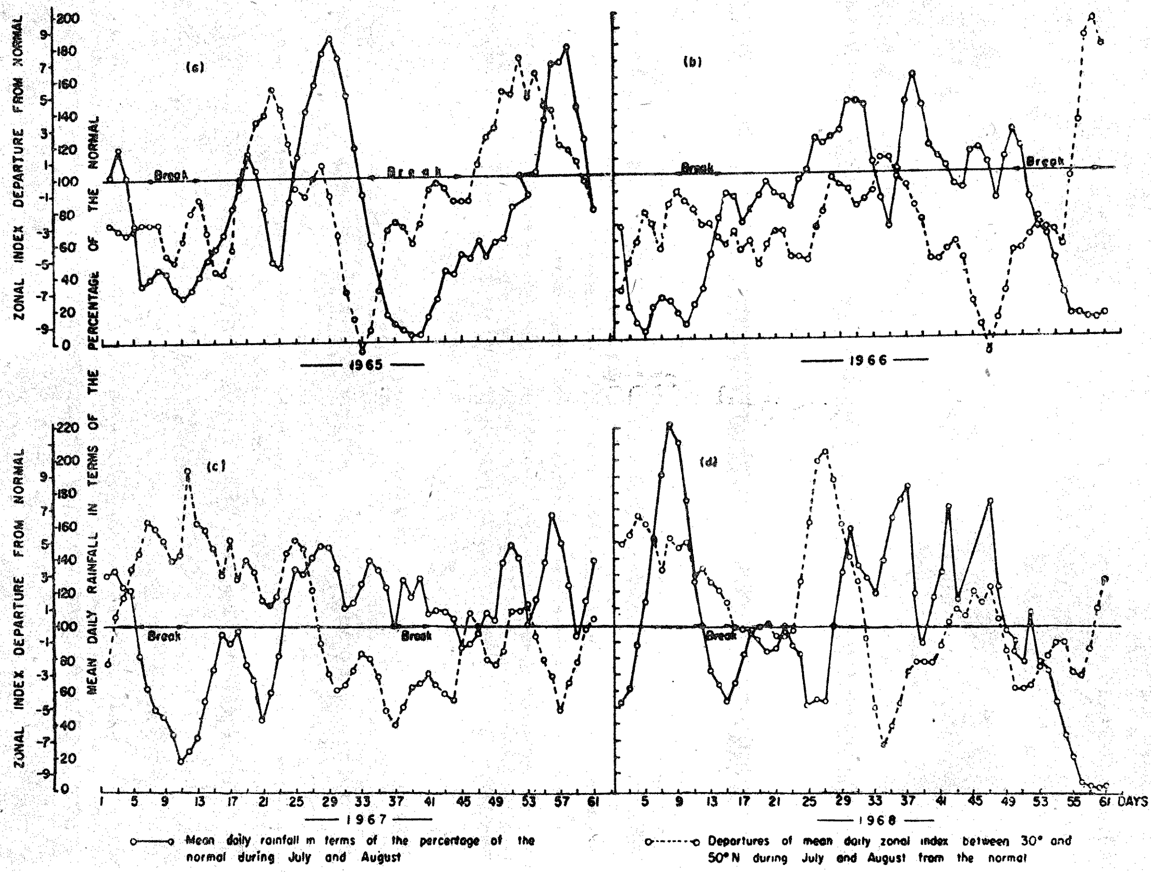


Fig. 1 (a-d). Mean daily zonal index and average daily precipitation.

annihilation of Tibetan anticyclonic circulation. This is the third aspect of the present study.

2. Data used

500 mb Russian and Japanese daily weather charts for July and August for the period 1965-68 have been utilised to compute the zonal index because according to Ramaswamy the troughs in the westerlies are best seen only at 500 mb level over India during break monsoon regime. Contour values were read along 30° and 50° N and along 5 meridians and difference worked out as a zonal index. For each sub-division representative number of stations were selected and their daily rainfall data copied out. Monthly rainfall departures from the normal in respect of all the sub-divisions chosen for this study were obtained from Hydrology Section, India Met. Dep. For data on the periods of breaks, those days were picked up from *Indian Daily Weather Report* for which the surfarce monsoon trough lay close to foot-hill.

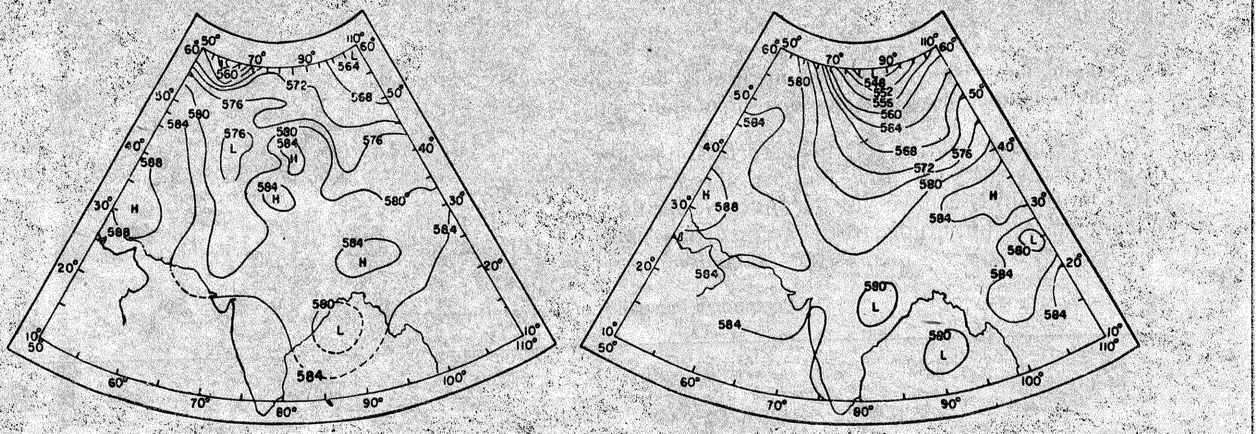
3. Zonal index and break monsoon

The zonal index is a highly fluctuating parameter. During the period under study, it ranged from 4.8 to 20.8 decametres. Moving average over 3 days have been calculated. The computations show that there are epochs of high and low index. These low index epochs usually precede the breaks over India and sometime extend into the period of break monsoon regimes over India. The normal zonal index for the latitude belt under consideration as extracted from the *climatic Atlas of the Northern Hemisphere* brought out by Hydrometeorological Service of U.S.S.R. is about 15 decametres for July and August. So an epoch with index more than 15 decametres is defined as high index epoch and less than 15 decametres as the low index epoch.

Following are the 7 cases in which the monsoon trough lay close to foot-hills during July and August of 1965-68:

(1) 7-13 July 1965
(2) 3-14 August 1965
(3) 9-14 July 1966
(4) 19-29 August 1966
(5) 6-11 July 1967
(6) 6-10 August 1967.
(7) 11-15 July 1968.

A mere glance at Fig. 1 (a) gives us low index epochs between 2 to 17 July 1965 and 29 July to 15 August 1965 and high index epochs between 19 July to 29 July and 16 August to 28



(a) 3 AUG 1965 (b) 5 AUG 1967

Fig. 2 (a-b), 500 mb flow patterns during the interaction between mid latiude westerlies and monsoon circulation

August 1965. Isolated one or two days high or low values of index are ignored for this purpose. So breaks during 7-13 July 1965 and 3-14 August 1965 followed as well as accompanied low index. Fig. 1(b) shows that low index prevailed almost throughout July and August 1966. This clearly proves why rainfall distribution was so poor in July and August 1966 particularly in July 1966.

Fig. 1(c) shows that the break during 6-10 August 1961 followed as well as accompained low index epoch in the middle latitudes. The breaks during 6-11 July 1967 and 11-15 July 1968 neither followed low index nor accompanied it. On the other band, they accompanied high index in the middle latitudes. These high index epochs were due to intense synoptic systems moving long 50°N which gave rise to strong pressure gradients at 500 mb and thus to high index. It is interesting to note that these breaks are of short duration 4 to 6 days. It, therefore, appears that short duration breaks may or may not be the consequences of the fluctuations in the mid-latitude circulation. But the large scale breaks over longer periods are definitely related to the low index circulation in the mid-latitudes.

4. Zonal index and precipitation distribution in central parts of the country

Wada averaged index over the entire eastern hemisphere and tied to correlate it with the monthly precipitation in 8 stations in Monsoon Asia. He utilised 22-year data and concluded that monthly precipitation amounts at these 8 stations do not always correlate well with the zonal index. To study the influence of zonal index on precipitation, area weighted mean daily precipitation over the central parts of the country has been worked out. In all the diagrams, moving average over 3 days of this precipitation in terms of percentage of its normal has also

TABLE 1

Year	Mean zonal index between 30° and 50° N in decametres	
	July	August
1965	13.8	11.2
1966	12.4	13.6
1967	14.0	14.4
1968	16.8	14.0

been superimposed on the zonal index curves. It is worthwhile to mention here that though there is indication in Fig. 1(a) and (b) that low index has influenced daily precipitaton during July and August of 1965 and 1966, apparently such an influence is not seen in Figs. 1(c) and (d) for 1967 and 1968. The breaks during these two years were of short duration (5 to 6 days). The daily rainfall during these years was governed purely by the more dominant synoptic features of monsoon circulation prevailing in the central parts of the country. We may argue that short term fluctuations in rainfall distribution in the central parts of the country are, perhaps, not the consequences of the variations in the mid-latitude flow patterns.

In this study mean monthly zonal index was also computed and studied in relation with the distribution of percentage departures of monthly precipitation from the normal in the central parts of the country. Table 1 gives the mean monthly index and Table 2 shows the percentage departure of precipitation from the normal in the different meteorological sub-divisions of the country. In August 1965 lowest index (11.2 decametres) is associated with extremely poor rainfall in the central parts of the country (10 divisions with departures more than 10 per cent from the normal). Mean zonal index for July and August is comparatively high in 1967 and 1968 as compared to that in 1965 and 1966 and correspondingly there was good rainfall in 1967 and 1968 as compared to that in 1965 and 1966.

5. 500mb flow patterns during interaction between middle latitude flow and monsoon circulation

One common feature of this interaction is the distortion of 500 mb flow pattern across Tibet where normally we have got an anticyclonic flow. When large amplitude troughs protrude into Indo-Pak area and travel across Tibet, anticyclonic circulation is either obliterated or gets annihilated or is replaced by cyclonic circulation or trough. In all the 'breaks' which have been listed above, it is observed that there is complete breakdown of Tibetan anticyclonic circulation at 500 mb a day or two before the onset of break monsoon conditions over India. There is a pronounced meridional flow which perhaps is responsible for northward transport of moisture across Himalayas. This is shown in Fig. 2.

TABLE 2

Percentage departure of precipitation from the Normal

Met. sub-div.	1965		1966		1967		1968	
	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug
Gangetic West Bengal	—6	—12	—55	—31	—28	—12	17	37
Orissa	—14	—31	—5	—43	—4	9	—19	—3
Bihar plateau	0	—39	—53	—18	—24	23	0	13
Bihar plains	—4	1	—54	—32	—16	—12	2	—11
East U.P.	—34	—29	—49	—4	—19	58	3	—23
West U.P.	—6	—20	—33	+29	1	82	19	—19
East Rajasthan	—16	—51	—49	—29	—33	23	29	—17
Gujarat region	9	—28	—9	—67	5	—14	—24	31
East M.P.	—41	—57	—33	—35	—8	33	—11	—30
West M.P.	—28	—47	—25	—26	—29	2	20	3
Vidarbha	—25	—24	8	—22	7	—12	—13	—10

6. Conclusions

Since only 4 years data of July and August have been utilised it is difficult to derive a conclusion, but nevertheless it may be tentatively argued that the weak index circulation in the middle latitudes influences monsoon circulation. Prolonged breaks of duration 10 days or more follow and accompany very low index which, therefore, can serve as a predictor to forecast prolonged breaks. Computed values of zonal index throw light on the hitherto little known fact that almost all breaks are preceded by low index criculation in the middle latitudes which of course continues to prevail even during break monsoon regime over India. Persistence of large amplitude troughs which are accompanied with low index circulation in the extra tropics gives rise to poor rainfall in the central parts of the country. The circulation in the area between 30° - 50°N and 40°-80°E in the middle latitudes has revealed close connections with the monsoon circulation and precipitation distribution over India. Further a common feature of all the breaks is the distortion of 500 mb flow pattern across Tibet as a result of the interaction between middle latitude flow and monsoon circulation. This gives rise to pronounced meridional flow north of 30°N which perchaps is responsible for northward transport of moisture across Himalayas.

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References

Desai, D.S., 1975, India's monsoon rainfall related to mid-latitude zonal index, *Indian, J. Met. Hydrol. Geophys.*, **26**, pp. 537–538.

Pisharoty, P.R. and Asnani, G.C., 1960, Flow pattern over India and neighbourhood at 500mb during monsoon Proc. Symp. on *Monsoons of the World*, India met. Dep., pp. 112–117.

Pisharoty, P.R. and Desai, B.N., 1956, Western disturbances and Indian Weather, *Indian J. Met. Geophys.*, **7**, p. 333.

Ramaswamy, C., 1976, Synoptic Aspects of Droughts in the Asiatic Monsoon Area, *Proc. Indian Nat. Sci. Acad*; **42**, pp. 109-131.

Ramdas, L.A., 1960, The establishment fluctuation and retreat of the southwest monsoon of India. Proc. Symp. on *Monsoons of the World*, pp. 251-256.

Rao, Y.P., 1976, Meteorological Monograph, Synop. Met No. 1/1976. India Met. Dep.

Wada, H., 1971, Characteristic features of general circulation in the atmosphere and their relation to the anomalies of summer precipitation in Monsoon Asia, *Water Balance of Monsoon Asia* 111-130.