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Distinct synoptic patterns associated with pre-break onset phase and revival of normal monsoon phase

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सार – इस शोध–पत्र में भारतीय ग्रीष्मकालीन मानसून ऋतु की अंतः मौसमी विभिन्नता की पहले से ही मौजूद सक्रिय और व्यवधानित मानसून स्थितियों को छोड़कर दो नई मानसून स्थितियों को सिनॉप्टिक रूप से वर्गीकृत करने का प्रयास किया गया है । ये परिवर्ती अवस्थाएं मानसून व्यवधान के पहले (आगे से ''पूर्व व्यवधानित की आंरिभक अवस्था'') और व्यवधानित मानसून की चरम अवस्था के बाद सामान्य मानसून की वापसी के समय (आगे से ''सामान्य मानसून' अवस्था की वापसी'') पाई गई । इसके विशिष्ट सिनॉप्टिक पैटर्न, सक्रिय/व्यवधानित मानसून स्थितियों सें संबद्ध पैटर्नों से भिन्न प्रकार को होते हैं । व्यवधानित मानसून के आरम्भ से पूर्व और सामान्य मानसून की वापसी की अवस्थाओं से संबद्ध विशिष्ट परिसंचरण, वर्षा, दाब के वितरण की भी यहां पर चर्चा की गई है । इस अध्ययन से यह पता चलता है कि उत्तर भारत में ऋणात्मक दाब की अधिकता की असमनता एवं वर्षा की अधिकता तथा प्रायद्वीपीय भारत में सकारात्मक दाब की अधिकता की असमनता एवं वर्षा की कमी, व्यवधानित मानसून के आरम्भ की अवस्था से लेकर सामान्य मानसून की वापसी की अवस्था से जुड़ी हैं ।

ABSTRACT. In the present study, an attempt has been made to synoptically classify the intraseasonal variation of Indian summer monsoon into two new monsoon conditions except already existing active and break monsoon conditions. These are transitional phases found prior to occurrence of break monsoon (here after "Pre-break onset phase") and during revival of normal monsoon after the culmination of break monsoon phase (here after "Revival of normal monsoon phase") and they have distinct synoptic patterns differing from patterns that are associated with active/break monsoon conditions. The distinct circulation, rainfall and pressure distribution associated with pre-break onset and revival of normal monsoon phases are also discussed.

The study shows that strong negative pressure anomaly and excess rainfall over north India and strong positive pressure anomaly and deficient rainfall over Peninsular India are associated with pre-break onset phase and vice-versa with revival of normal monsoon.

Key words – Break monsoon, Active monsoon, Pre-break onset phase, Revival of normal monsoon.

1. Introduction

Ramamurthy (1969) first statistically documented break monsoon days or events during 1898-1967 on the basis of position of the monsoon trough. He also studied characteristics of some regional features *e.g.*, pressure, rainfall and upper wind flow patterns associated with these events. He found that break monsoon is mainly associated with change of following few regional features;

(*i*) Rise (fall) of pressure over central India (near foot hills of Himalayas).

(*ii*) Significant decrease or absence of rainfall over most part of India particularly over central India and above normal rainfall over foot hills and Tamil Nadu.

(*iii*) Practically absence of easterlies at surface and low levels over north India and westerlies flows dominate whole India at these levels.

It is beyond our doubt that with subsequent increase of data coverage through special international/national monsoon experiment *e.g.*, BOBMEX-1999, ARMEX-2002 & 2003 and with the help of modern days Satellite data, our understanding on intraseasonal variation of monsoon has increased tremendously. Also "Breaks in the monsoon" has been the subject of investigation by various workers for last many years particularly during the last two or three decades and considerable number of research papers exists on the subject. With reanalysis of available daily data and Satellite data in recent years, many authors have also followed different objective criteria for the

classification of period of break monsoon. Goswami and Ajayamohan (2001) have proposed a circulation based definition of active and break monsoon conditions. A reference point just south of the monsoon trough (90° E, 15° N) is selected for this purpose and the 30-60 day filtered zonal winds at 850 hPa are analysed. The days for which the filtered zonal winds at 850 hPa are greater than + 1 standard deviation are considered as active days, while those less than −1 standard derivation (*i.e*., stronger easterly anomalies) are considered as break monsoon days. Similar to Webster *et al*. (1998), Krishnan *et al*. (2000) have also classified break monsoon days based upon OLR anomalies values over Bay of Bengal, central and northwest India. Krishnmurty and Shukla (2000) used daily rainfall data over 260 stations of India for defining active/break monsoons. They used rigours statistical tools for those classifications. They identified the active and break phases based on PC1 of the standardised daily rainfall anomalies.

Date-wise classification into active and break monsoon for each year of July and August which are the main monsoon months, broadly by criteria of these two monsoon conditions defined by Ramamurthy (1969) based on circulation, pressure and rainfall patterns over lndia shows many years without any break/active monsoon days (Jenamani and Thapliyal, 1999). Webster *et al*. (1998) and Ramage (1973) have also mentioned that except few composite cases of active and break monsoon events, synoptic patterns of other days in the season is much more complex in intraseasonal time scale and these synoptic patterns did not follow any criteria of active monsoon or break monsoon conditions as defined by Ramamurthy (1969) for their day-to-day or week-to-week evolution. These days are mostly occurred at transition days in between active/break monsoon phases of a season. Also during the period just before the prevailing of break monsoon phase or during the period just after termination of break, monsoon trough at lower tropospheric levels moves slowly to the foot hills from its normal position or re-establishes from foot hills of Himalayas to its normal position. For these processes to occur, monsoon trough has to pass through two intermediate phases, which are neither active monsoon nor break monsoon conditions.

The period of one intermediate phase is from the date the monsoon trough starts moving towards the foot hills from its normal position till the date it reaches at the foot hills of Himalayas *i.e*., just one day prior to the prevailing of break monsoon phase. The period of other intermediate phase is from the date the monsoon trough starts re-establishing at the normal position till the date it is seen along the normal position (Sikka & Gadgil, 1980). Normally, during the revival case, it may be the revival of a break monsoon or revival of a weak monsoon pattern

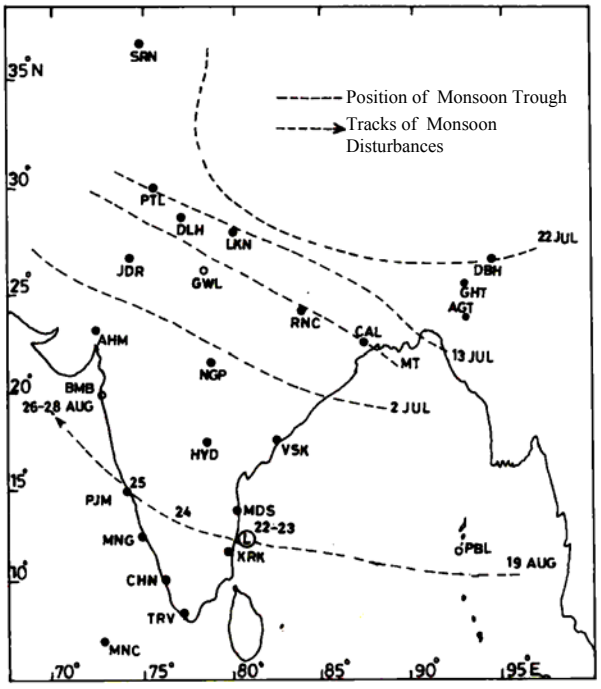


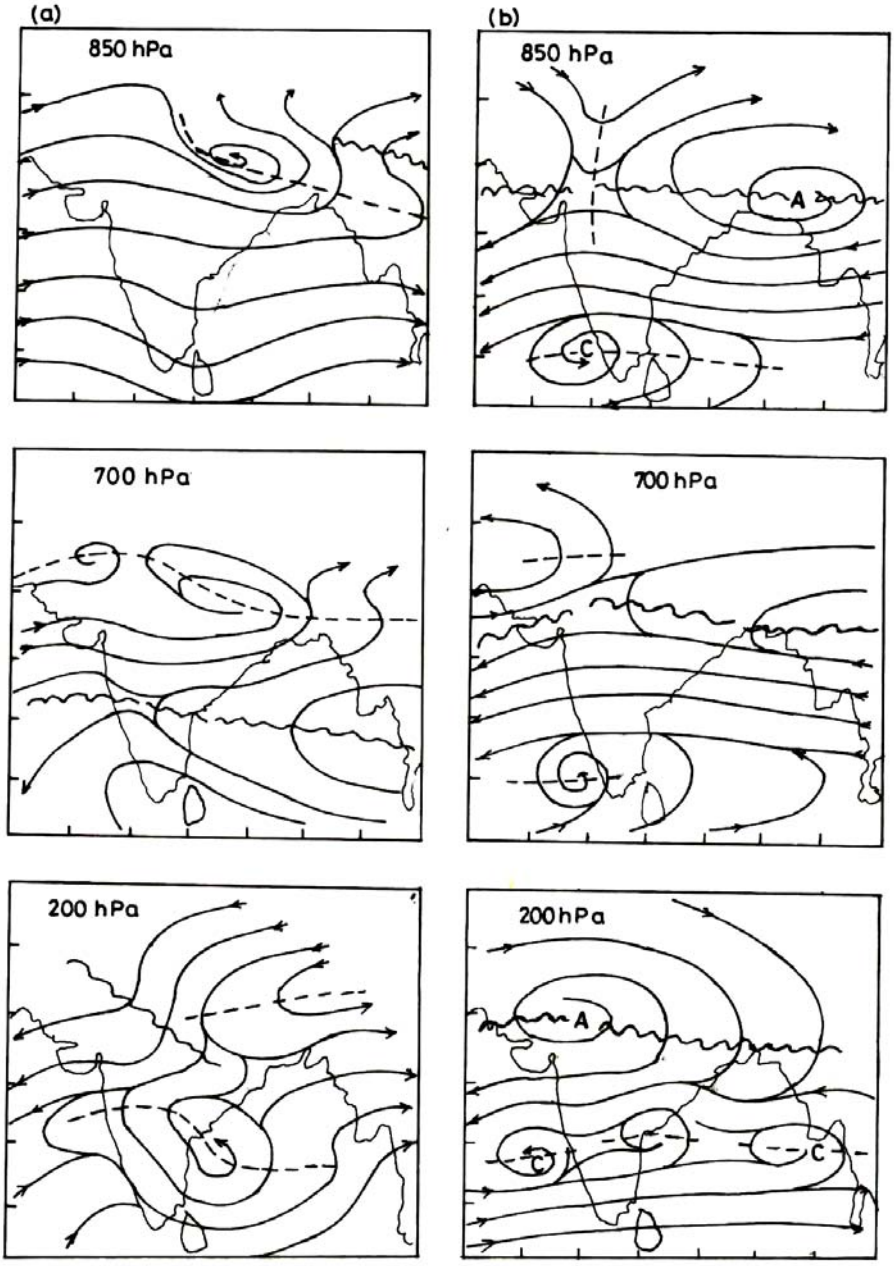
Fig. l. Position of monsoon trough and track of a disturbance

that prevailed before over India. The former phase may be called as "pre-break onset phase" as it occurs just before the start of the break monsoon phase and the later phase may be called as "revival of normal monsoon" in the present study as monsoon activities revives during this phase.

In the present study, these two intermediate phases have been defined properly with their associated features *e.g*., circulation, rainfall, pressure distribution, characteristics of weather systems etc. In Section 2, data and methodology is given. In Section 3 & 4, synoptic pattern associated with pre-break onset phase and revival of normal monsoon phase is discussed respectively. In Section 5, formation and movement of monsoon disturbances during occurrence of pre-break onset phase and revival of normal monsoon phase are studied followed by conclusions in Section 6.

2. Data and methodology

Two well defined cases of two intermediate monsoon conditions from 8-15 July and 19-25 August as observed during 1998 are considered alongwith day to day surface and upper air data over India, available from Office of Deputy Director General of Meteorology (Weather Forecasting), India Meteorological Department (IMD), Pune. Composite



Figs. 2(a&b). Weekly circulation anomalies during (a) pre-break onset phase (8-14 July) and (b) revival of normal monsoon phase (19-25 August)

surface pressure anomalies, weekly mean and anomaly circulations and rainfall anomalies are prepared from data available in the same office. Cloud pictures received from INSAT 1D are also referred from the same office.

3. Pre-break onset phase

The dominating presence of such monsoon conditions occurs when time taken for the monsoon trough to reach foothills of Himalayas from its normal position is too long. During 8-14 July 1998, this monsoon condition was prominently seen over India. Fig. 1 shows monsoon trough (indicated by 13/7) running north of normal position at the surface during such monsoon condition. Fig. 2(a) shows the composite weekly circulation anomalies prevailed during these days. The surface monsoon trough is also seen extending upto 500 hPa and much to the north of the normal position

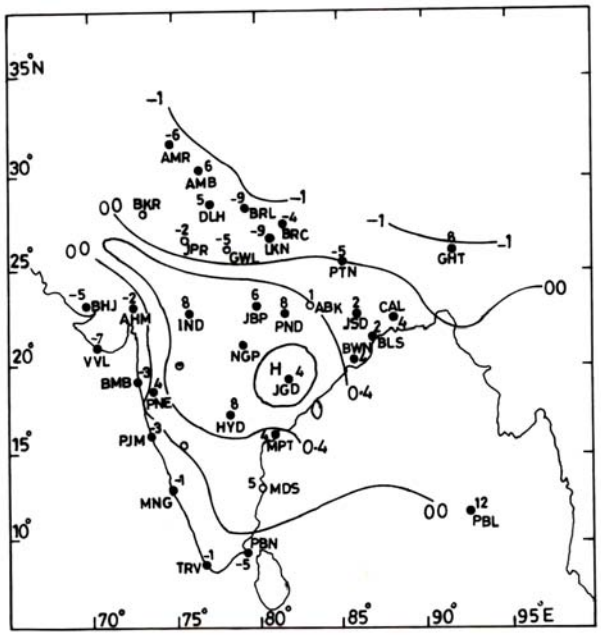


Fig. 3. Composited sea level pressure anomalies during pre-break onset phase (8- 14 July 1998)

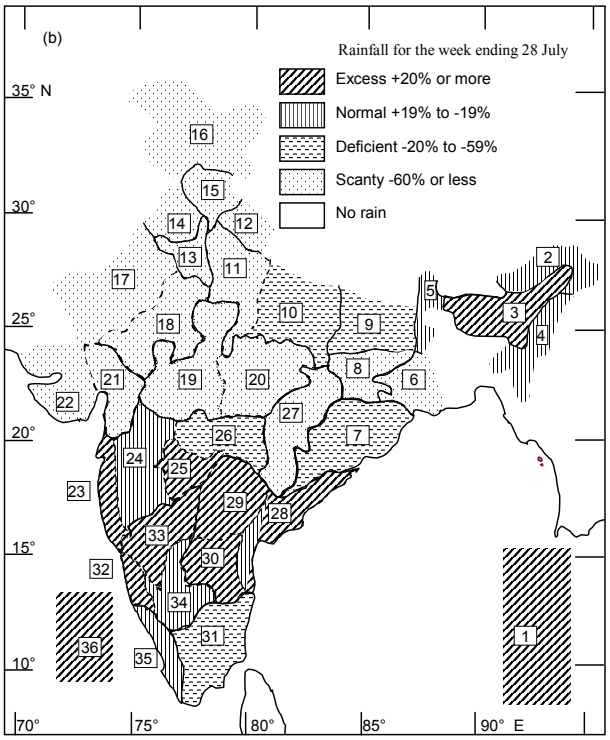


Fig. 4(b). Subdivision wise area weighted rainfall departure from normal in revival of normal monsoon phase (22-28 July)

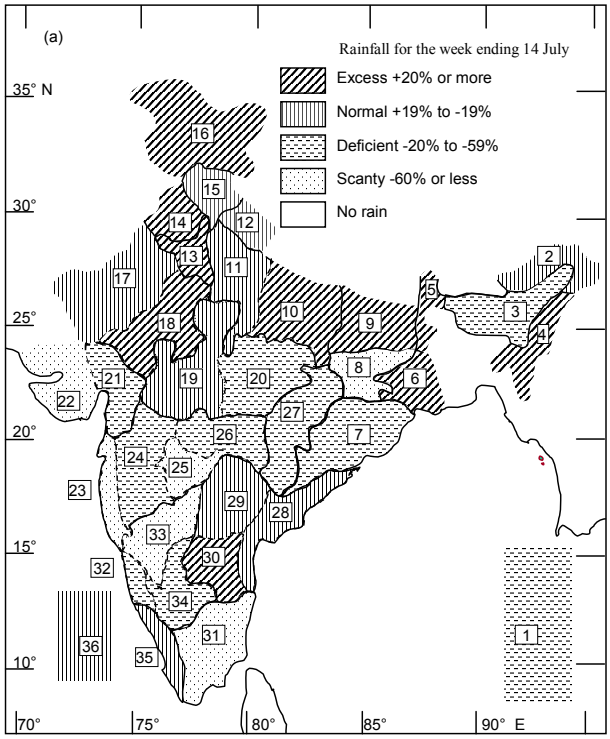


Fig. 4(a). Subdivision wise area weighted rainfall departure from normal in pre-break onset phase (8-14 July)

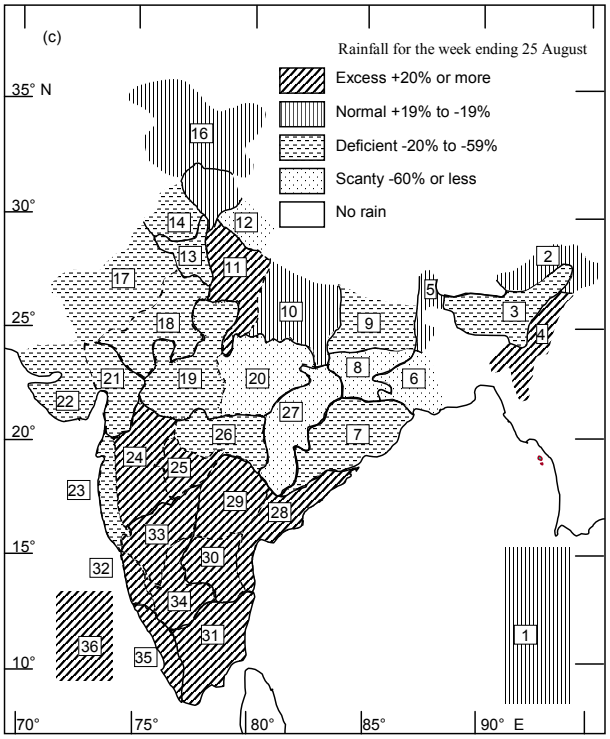
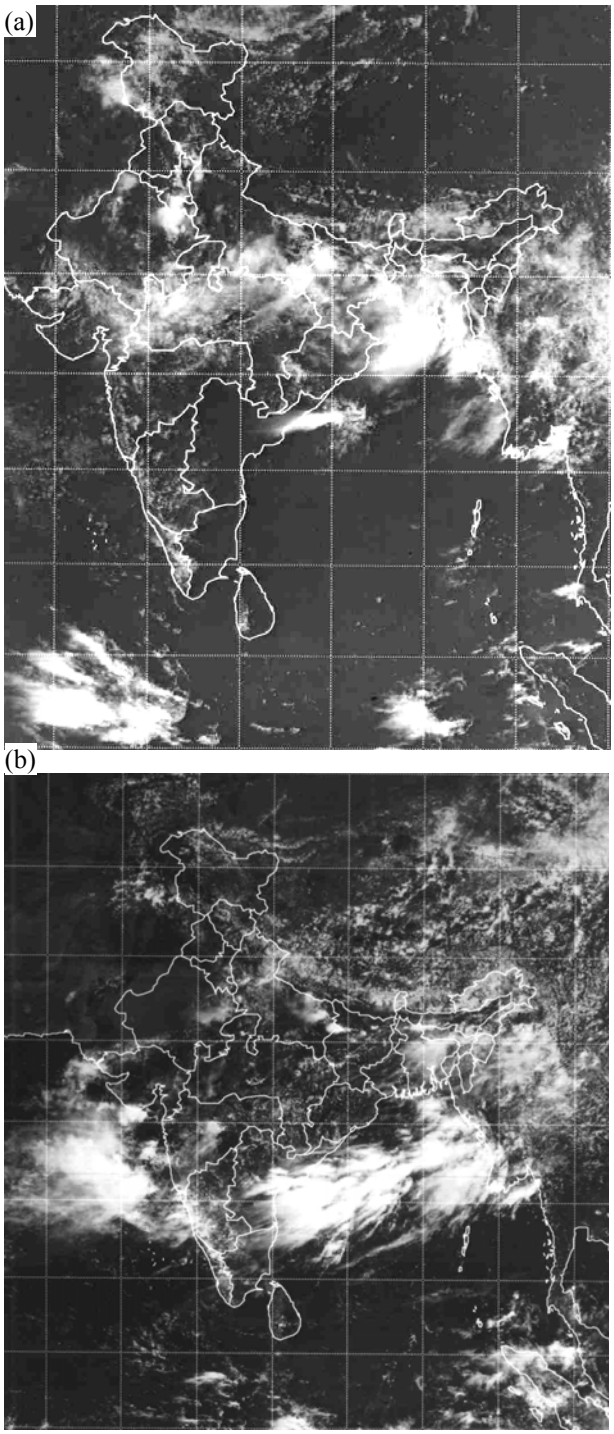


Fig. 4(c). Subdivision wise area weighted rainfall departure from normal in revival of normal monsoon phase (19-25 August)



Figs. 5(a&b). INSAT cloud pictures during (a) a day of pre-break onset phase and (b) a day of revival of normal monsoon phase

compared with active monsoon. The Tropical Easterly Jet is also seen to the north of normal position as westerly anomaly is observed at Trivandrum-Chennai latitude. The

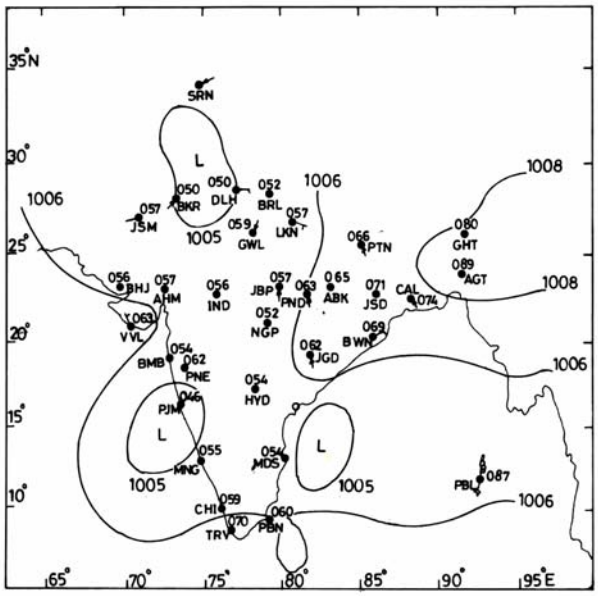


Fig. 6. Monsoon trough on sea level chart during revival of normal monsoon phase (23 August 1998)

composite surface pressure anomalies during the above monsoon condition is shown in Fig. 3. Strong positive pressure anomalies are found over Peninsular India with strong negative pressure anomaly over extreme north India. The rainfall during these days is shown in Fig. 4(a). It shows that most parts of Peninsular India south of 20° N, received deficient rainfall while most of the area north of 20° N received excess rainfall. The associated clouding from INSAT picture during this monsoon condition is shown in Fig. 5(a). It is seen that extreme north India was mostly covered by clouds while Peninsular India was relatively cloud free. This synoptic pattern is totally different from Ramamurthy (1969) active and break monsoon pattern since this period coincides with pre-break period.

4. Revival of normal monsoon phase

This monsoon condition predominantly observed during 19-25 August 1998, in a complete monsoon cycle just before monsoon trough re-established at its normal position after the termination of a weak monsoon over India. In this monsoon condition, the monsoon trough at surface generally shows high day to day fluctuations with respect to normal position. Such fluctuations are dominantly noticed during 19-25 August. Fig. 6 shows monsoon trough at the surface on 23 August when such monsoon conditions prevailed.

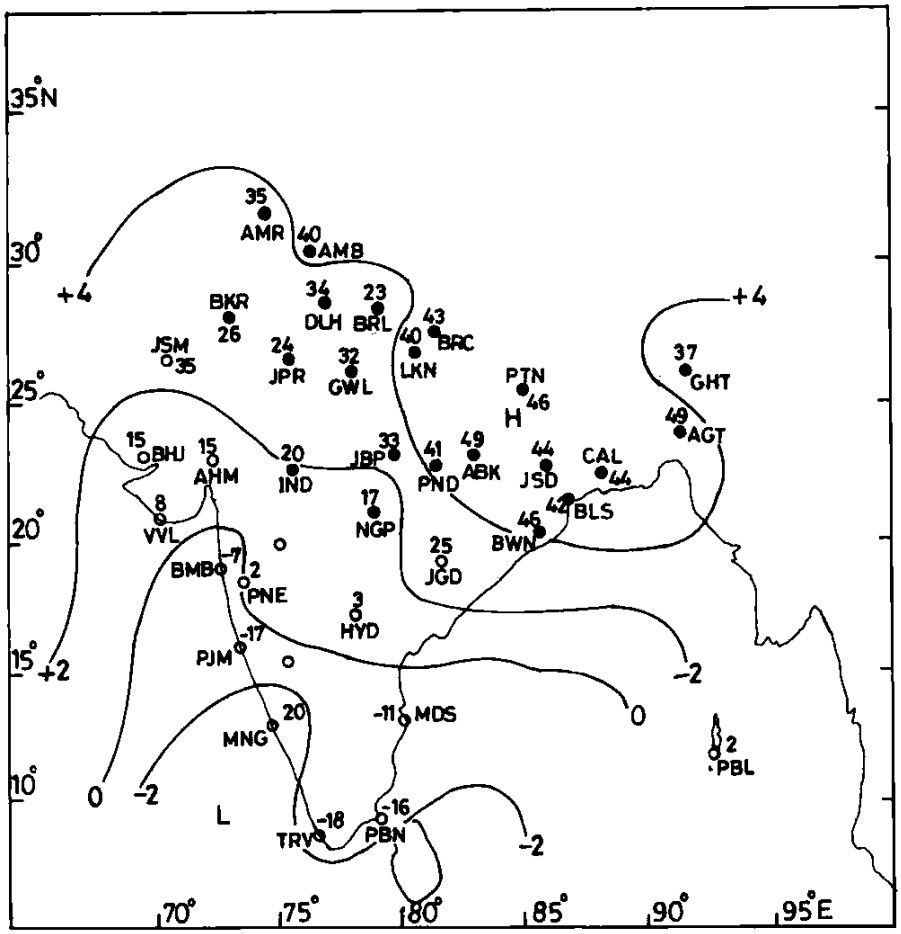


Fig. 7. Composited sea level pressure anomalies during revival of normal monsoon phase (19-25 August)

However, during such monsoon conditions, presence of an east-west trough at mid troposphere is seen in both mean and anomaly circulation over Peninsular India [Fig. 2(b)]. Studies confirm from day to day synoptic analysis shows that movement of this trough to the north revived the break monsoon as concluded in Sikka and Gadgil (1980) studies confirm this observation and re-established the active monsoon by re-establishing sea level monsoon trough to the south of the normal position afterwards.

Due to the presence of above strong east-west trough over Peninsular India at lower and mid-troposphere, low pressure values were observed over Peninsular India and hence the normal pressure gradient over India was partially reversed. As a result, determination of the position of monsoon trough on sea level chart over India during this monsoon condition becomes too difficult (Fig. 6). Tropical easterly jet also shifts to the north of normal position during these days as in case of break monsoon. The surface pressure anomaly shows a distinct spatial pattern with strong negative pressure anomaly is seen over Peninsula India (Fig. 7) and positive anomaly over north India which is differ from pressure anomaly pattern associated with that of active and break monsoon. The week ending on 28 July of 1998 can also be called as revival of normal monsoon phase since just before this phase prolong break monsoon of 15-25 July prevailed (Jenamani and Thapliyal, 1999). But, the revival of such normal monsoon after the break monsoon was so quick, we do not get distinct pattern like the earlier one we have described in the present study. From the rainfall pattern for the week ending on 28 July and 25 August, Peninsula India got excess rainfall Figs. 4(b&c) and most of north India got deficient rainfall. Such condition is just in opposite phase of rainfall distribution during pre-break onset phase monsoon condition as we discussed in Section 3. The above two weeks follow the weeks ending 21 July and 18 August when break monsoon/weak monsoon prevailed over India. Fig. 5(b) shows associated clouding

over India from INSAT 1D during the above monsoon condition. It is seen that most parts of Peninsular India were covered by clouds and north India was relatively cloudless.

One can compare features from these figs. with that of features of active/break monsoon conditions of Ramamurthy (1969) and note that features associated with revival of normal monsoon phase are totally differ from these monsoon conditions and also that from pre-break onset phase that we described earlier.

5. Formation and movement of monsoon disturbances during occurrence of pre-break onset phase and revival of normal monsoon phase

Monsoon disturbances normally form over the head Bay of Bengal and move along monsoon trough. However, formation and movement of monsoon disturbances are found to be different during active and break monsoon conditions as discussed in Jenamani (2001) based on quasi-periodic cycle of monsoon due to significant differences in their associated circulation and pressure patterns. During active monsoon (break monsoon), monsoon disturbances form over north Bay of Bengal (south Bay of Bengal) and move northwest (westwards or persisted). Similarly, as shown earlier since associated circulations and pressure pattern during pre-break onset phase and revival of normal monsoon phase also differ significantly. So it is essential to examine the characteristics of formation and movement of monsoon disturbances during such monsoon conditions.

During pre-break onset phase, monsoon disturbances are found to form over extreme north Bay of Bengal because of presence of monsoon trough north of its normal position during this phase. Since monsoon trough runs very much north of its normal position over India during this phase, these monsoon disturbances are also found to move along north of its normal direction of movement. But during revival of normal monsoon phase, very interesting features associated with the formation and movement of monsoon disturbances is observed. For example, Fig. 1 (indicated by arrow mark) shows the track of the movement of a monsoon disturbance during revival of normal monsoon phase. The monsoon disturbance is seen as a cyclonic circulation over south Andaman Sea on 20 August. Due to the establishment of anticyclone/ridge at 700 hPa over northeast India, along 25° N on 23 August, the above monsoon disturbance moved to southwest Bay of Bengal and under its influence, a low pressure area formed over the same area on 23 August (Fig. 1) and on 24 August, it entered interior Tamil Nadu and neighbourhood. Afterwards, moving westwards it was seen as a cyclonic circulation over north interior Karnataka on 25 August. It moved in a northwesterly direction to Konkan and Goa coast on 26 August and Gulf of Cambay off Saurashtra and Kutch coast on 27 August. The movement of monsoon disturbances during revival of other normal monsoon condition for week ending on 28 July is also seen. However, the anticyclone/ridge was not seen along 25° N or over northeast India during revival of this normal monsoon phase like earlier break monsoon due to which the monsoon disturbances formed over south Bay of Bengal and move in a north northwestward direction (Sikka and Gadgil, 1980) at mid-tropospheric levels and hence monsoon revived quickly. The revival during week ending 28 July was not prominent like the earlier one. So during pre-break onset phase and revival of normal monsoon phase, monsoon disturbances form over north and south Bay of Bengal respectively. However, if monsoon disturbance formed over south Bay of Bengal during revival moves westwards along Peninsular India, then it intensifies break monsoon and on the other hand if it moves northward, it revives the normal monsoon after termination of break features. According to Ramamurthy (1969), monsoon disturbances also move across extreme peninsular India during break monsoon, but it is at the middle and upper levels not at surface as discussed above for their characteristics during revival of normal monsoon phase. Hence this particular pattern show monsoon was reviving during this phase and break was not present in these days.

6. Conclusion

The distinct circulation, rainfall and Pressure distribution associated with “pre-break onset phase” before the occurrence of break monsoon and “revival of normal monsoon phase” after the dissipation of break monsoon features over Indian region are studied and following important conclusions are found.

(*i*) The study shows that strong negative pressure anomaly and excess rainfall over north India and strong positive pressure anomaly and deficient rainfall over Peninsular India are associated with “pre-break onset phase” and *vice-versa* with “revival of normal monsoon phase”.

(*ii*) Monsoon trough runs north of its normal position at the surface during former monsoon conditions while, determination of the position of monsoon trough on sea level chart over India during later monsoon condition becomes too difficult because of presence of low pressure value over Peninsular India in this phase as a result of which pressure gradients over India are partially reversed.

(*iii*) During “pre-break onset phase”, monsoon disturbances are found to form over extreme north Bay of

Bengal and move along north of its normal direction of movement as monsoon trough already runs very much to the north of its normal position at the surface. During "revival of normal monsoon phase", monsoon disturbances form over south Bay of Bengal and move north or northwestwards. However, if monsoon disturbance formed over south Bay of Bengal during break monsoon moves westwards along Peninsular India, then it intensifies break monsoon and on the other hand if it moves northward, it revives the normal monsoon.

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