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THE NORTHWARD MOVING LOW FREQUENCY MODE : A CASE STUDY OF 2001 MONSOON SEASON

1. The tropical intra-seasonal oscillation is one of the most intensively studied large-scale low frequency phenomenon in recent times. After the first observation of this low frequency oscillation by Madden and Julian (1971), many more authors have studied different aspects of this oscillation for the Indian summer monsoon season (Sikka and Gadgil 1980; Yasunari 1979, 1980, 1981; Gadgil & Srinivasan 1990; Madden and Julian 1994). The periodicity of this northward moving low frequency mode is 4 to 6 weeks. The northward movement of low frequency mode from the equator to the northern hemisphere subtropics is prominent in two sectors with one over Indian Ocean and other over western Pacific region during the monsoon season. Krishnamurti and Subramanyam (1982) have shown that there exists a close association between the northward migration of anomalous troughs and ridges and the wet and dry spells of the monsoon. They have also shown that the mean phase speed of northward propagating mode is about one degree of latitude per day. Wang and Rui (1990) used the pentad mean anomaly maps to investigate climatological features of Tropical Intraseasonal Convection Anomalies

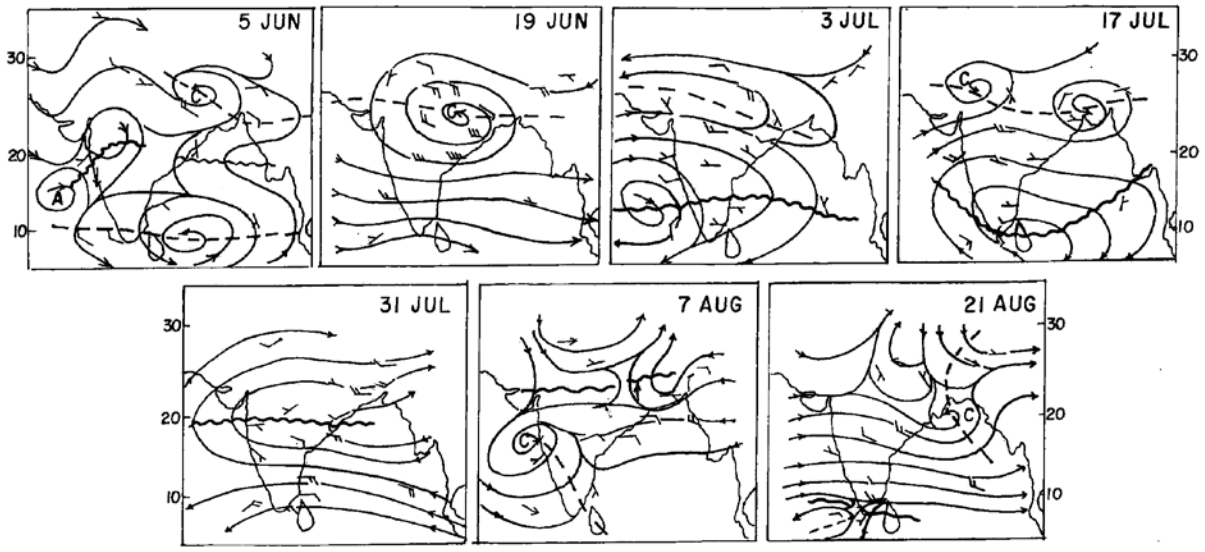


Fig. 1. Weekly anomaly wind at 700 hPa for week ending on different dates during 2001 monsoon season

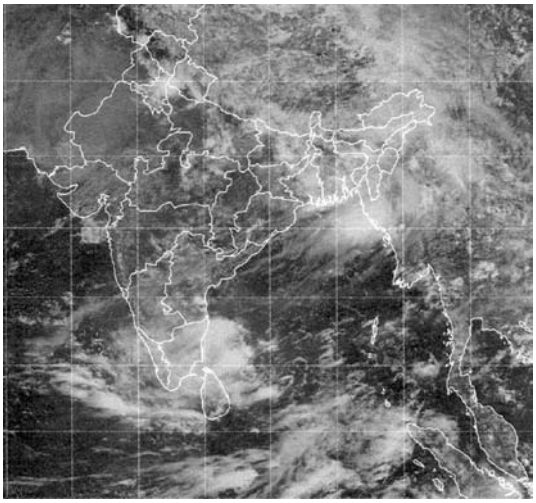
(TICA) on global tropical basins for the whole year. Thus, these results show that the eastward moving TICAs are dominant tropical low frequency mode while independent northward and westward moving TICAs are regional modes confined to summer season. The results also indicate that all the independent northward moving TICAs occur in northern summer from May to October. Our interest in the present article is to study the synoptic perspective of the northward moving low frequency oscillation over the Indian longitude during the southwest monsoon season of 2001 and it's association with wet and dry spells of monsoon.

2. *Data* - The data used for the study of northward movement of low frequency oscillation are unfiltered weekly wind anomalies at 700 hPa during the entire season from June to September prepared by the office of Deputy Director General of Meteorology (Weather Forecasting) [DDGM (WF)] Pune. The satellite pictures obtained from INSAT were also used to see the northward movement of cloudy zones. The weekly area weighted rainfall over the country is used to study the association of wet and dry spells of monsoon with that of northward movement of troughs and ridges. The analysed wind field obtained from the National Centre for Medium Range Weather Forecasting (NCMRWF) is also referred for this purpose.

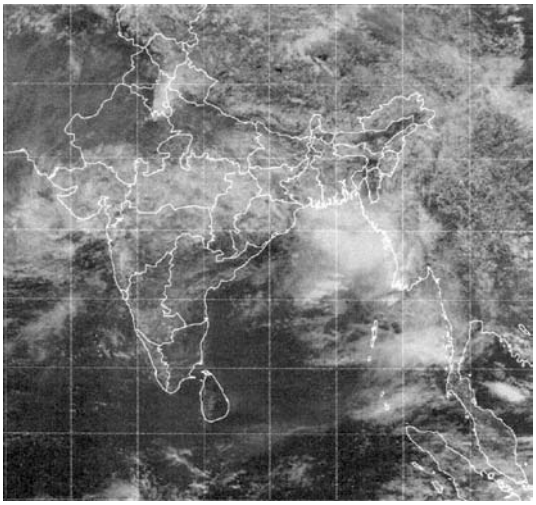
3. *Results and discussion* – (a) In order to see the meridional propagation of 30-50 day low frequency mode, the weekly wind anomalies at 700 hPa during the monsoon season for selected weeks till week ending 21 August is shown in Fig. 1. It is seen that during the first week of June (week ending 5 June) the east-west oriented anomalous trough was lying over the southern tip of India around 10° N and subsequently this trough moved northward and its position coincided with monsoon trough position on sea level chart around 24° N during the week ending 19 June. Thus a phase speed of about 1° latitude per day was observed during the monsoon season, which agrees with the results obtained in many previous studies (Sikka and Gadgil 1980; Krishnamurty and Subramanyam 1982; Wang and Rui 1990). Thus the first northward mode from 5 June to 19 June was associated with movement of anomalous trough over the country. Hence, it is clear from Fig. 1 that there is rapid progress of the anomalous trough northward from 5 June to 19 June followed by northward movement of anomalous ridge from 3 July to 7 August with a prominent anomalous ridge over central India during week ending 31 July. Simultaneously a trough was reestablished towards the southern part of the country as seen from the weekly anomalies of wind for week ending 7 August and for week ending 21 August. During the remaining part of the season the northward movement of trough was not clearly observed in weekly anomalies charts (remaining weekly maps till end of September are not shown in Fig. 1. The northward movement of anomalous trough is also associated with northward movement of cloudy zone as seen from the satellite pictures (Fig. 2).

(b) Comparing the wet spell (rainfall area weighted) of monsoon with that of northward movement of trough

4 June



16 June



7 August

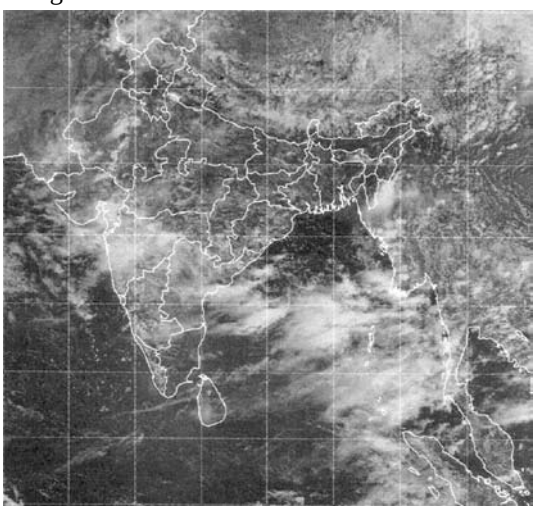


Fig. 2. INSAT visible pictures at 0600 UTC for the selected dates during 2001 monsoon season

over the Indian region it is very clear that the first northward mode from 5 June to 19 June, which was associated with northward movement of anomalous trough over the central India contributed widespread rainfall over the country. However, with the establishment of ridge over the central India, the all India rainfall departure became negative with a weekly departure of about –32% and –24% for week ending 25 July and week ending 1 August respectively. Thus during the period of northward movement of ridge the rainfall activity over the country was subdued. It may be mentioned here that during the propagation of anomalous trough during 5 June to 19 June, there was a monsoon depression, which crossed Orissa coast on 13 June and contributed very good rainfall over the country for many days. It is also observed that during most of the days for the week ending on 31 July, when the anomalous ridge was prominent (Fig. 1), the monsoon trough position on sea level chart was either at foothills of Himalayas or north of the normal position, a situation commonly known as break in monsoon. The large-scale monsoon flow (Fig. not shown) as seen from NCMRWF analysis also show active and weak monsoon condition during the two weeks when the anomalous trough and anomalous ridge were prominent around 20° N (for week ending 19 June and week ending 31 July respectively). The large scale flow at 850 hPa and 500 hPa levels obtained from NCMRWF analysis indicate very active monsoon condition during 15 June (representative date for week ending 19 June) as seen by active monsoon trough extending upto 500 hPa and accompanied with a low pressure area over northwest Madhya Pradesh. On the other hand the circulation feature during 30 July is almost identical to the situation of break monsoon condition with westerly lies over entire India and the monsoon trough was not observed on sea level chart. As there was no prominent northward moving trough over the country during the latter part of the season (August and September), the rainfall activity was subdued over the country during this period. Thus the analysis shows that the active (weak) spells of monsoon is associated with northward movement of anomalous trough (ridge) at low level during the monsoon season of 2001.

4. *Conclusions* – (*i*) There was a clear progress of northward propagating low frequency mode during the southwest monsoon season of 2001 associated with onset and progress of monsoon.

(*ii*) The northward movement of anomalous trough was very prominently observed even in unfiltered data during the monsoon season of 2001.

(*iii*) The horizontal phase speed of this northward propagating mode was about 1 degree of latitude per day.

(*iv*) The active rainfall activity of monsoon during initial period of the season (during June) was in association with propagation of anomalous trough to the central India and subsequent absence of any northward propagating troughs are associated with subdued rainfall activity over the country.

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