551.501.8 : 551.526.6

ARABIAN SEA DRY AIR MASS AND MONSOON BEHAVIOUR AS SHOWN BY INSAT SEA SURFACE TEMPERATURE ANALYSIS

1. Indian economy depends mostly on monsoon rains which generally get established over the Indian sub-continent around the normal dates and continue thereafter with some breaks of very short duration during July and August. Many authors have studied the monsoon behaviour from different angles. Pisharoty (1965) studied monsoon considering water vapour flux and concluded that evaporation over Arabian Sea is an important source of moisture that crosses the west coast of India and is available for precipitation. Ghosh *et al.* (1978) studied the water vapour budget over Arabian Sea and found that Arabian Sea plays a dominant role in the monsoon activity over the west coast of India. Agnihotri (1986) studied INSAT sea surface temperature data over Arabian Sea and from attenuation caused by vertical column of moist air, inferred the movement of moist air mass (monsoon air mass) from south to north over the Arabian Sea. The attenuation increased as the moisture tongue moved northward and followed its northward movement with time during the onset phase of southwest monsoon by analysing SST anomaly on daily and weekly basis. Agnihotri (1987) studies the unusual behaviour of 1987 monsoon and observed that dry air mass (DAM) over Arabian Sea has some effect on the monsoon activity. In this study author has tried to investigate in detail how the monsoon activity in 1984, 1986 and 1987 has been affected by the presence of dry air mass over the Arabian Sea area. 1985 monsoon season could not be studied due to non-availability of SST data.

2. *Data and analysis*—In this study INSAT derived uncorrected SST data of 0600 GMT over Arabian Sea, between 10° and 25° N latitude and 59° & 73° E longitude have been made use of. To analyse SST data, the area under study (10-25° N, 59-73° E) has been divided into 49 sub-grid areas of 2°×2° latitude/longitude. SST data over each sub-grid area have been averaged both in space and time to find out deviation from corrected SST data for each sub-grid area. The deviation so computed have been made use of to monitor the movement of monsoon air mass (MAM) or the presence of dry air mass (DAM) over the Arabian Sea. The area having positive deviation corresponds to more moist air mass as compared to an area having negative deviation. The sub-grid area having no deviation corresponds to no relative change in the moisture content. Thus to monitor the movement of monsoon air mass over Arabian Sea SST deviation have been used as an indirect indicator. In this study three years monsoon activity over Arabian Sea have been monitored on a weekly basis in both space and time. Weekly averaged position of the moisture tongue in the area of study has been worked out from the various sub-region of 4°×4° along 61°, 65°, 69° and 73° E position to find out the most suitable northerly movement with time. During the analysis it has been observed that moisture tongue first appears in the southwest sector of Arabian Sea and shows northeastward orientation with northerly movement.

3. *Results and discussion*—The northward movement of monsoon air mass for three monsoon seasons 1984, 1986, 1987 have been shown in Fig. 1. From the analysis of these curves it is seen, that during 1984 and 1986 monsoon seasons moist air mass showed steadily northward progress with time, although movement was faster in 1986 as compared to that of 1984 monsoon season.

From this figure it is seen that during 1984 (the movement of mosoon air mass was rather slow) weak current entered into Arabian Sea in the first week of May and reached 17.5° N latitude on 3 June. The onset of monsoon over south Kerala coast (8.5° N latitude) also occurred on this day. The northward movement of MAM along west coast was gradual but became slow after 3 June and reached 21°N latitude by last week of June, causing onset of monsoon over whole of Arabian Sea and west coast of India. Over Peninsula MAM arrived by 18 June. After 18 June the movement of MAM continued steadily but slowly up to 2nd week of August and thereafter dry air mass (DAM) from the north started moving southward pushing MAM backward and thus establishing a reverse circulation. DAM moved very fast between 22° and 17°N latitude causing rapid withdrawal of monsoon.

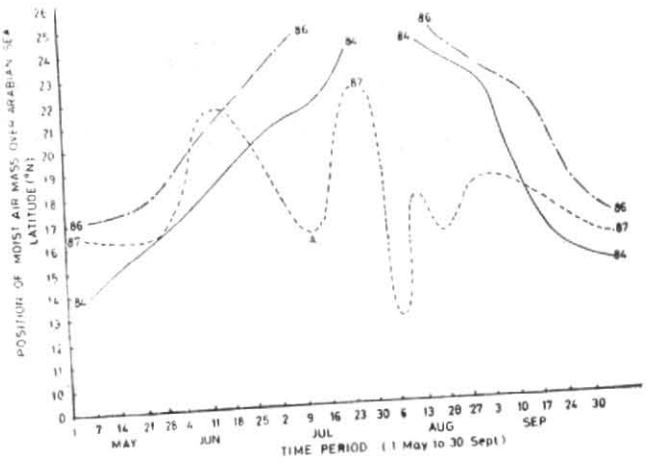

Fig. 1. Position of northward movement of monsoon air mass (MAM) during onset phase and southward movement during withdrawal phase of 1984, 1986 and 1987 southwest monsoon seasons over Arabian Sea area

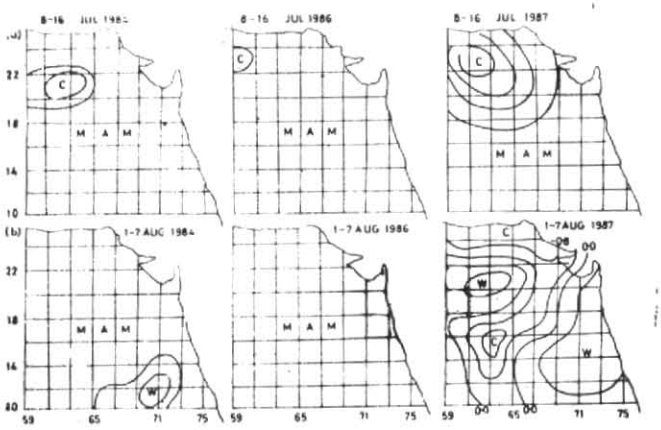

Fig. 2. Position of dry air mass (DAM) over Arabian Sea area: (a) Situation between 8 and 16 July and (b) 1 and 7 August DAM entering Arabian Sea from northeast direction

The curve for 1986 shows that monsoon current persisted at 17.0° N latitude up to 14 May and thereafter it showed northward movement and reached 22° N by 18 June, establishing monsoon over whole of Arabian Sea and west coast of India. MAM maintained its northward progress which continued up to 2nd week of August. Thereafter monsoon activity gradually started decreasing as the continental DAM entered Arabian Sea around 21° N by 2nd week of September and gradually moved further southward and causing thereby withdrawal of monsoon activity.

During the 1987 monsoon season, the movement of MAM was quite different to that of 1984 and 1986 seasons. 1987 season was marked by frequent appearances of dry continental air mass over Arabian Sea thus not allowing a normal northward movement of MAM to be established during onset phase of monsoon season. Fig. 1 shows a stagnating type of MAM around 16° N latitude up to 28 May, thereby blocking the northward movement of monsoon and its setting in over Kerala. After 28 May MAM showed further northward movement and reached 17.5°N latitude on 1 June and the monsoon advanced Kerala coast (8.5°N). Thereafter it continued to move faster and reached 21°N latitude, on 8 June, causing, onset of monsoon over whole of the Arabian Sea and west coast of India. From 13 June MAM started receding backward due to entrance of continental dry air mass into Arabian Sea, and halting the progress of monsoon. This situation continued up to 11 July, from 12 July onward MAM again moved northward and continued its northward progress up to 27 July. From 28 July suddenly MAM was pushed back to south Arabian Sea and reached southern part by 7 August showing thereby a total withdrawal type of situation.

From 8 August, monsoon current showed revival and northward movement which continued with some reversal up to 1st week of September. Thereafter monsoon current showed southward movement and finally resulted in a complete withdrawal of southwest monsoon season.

Fig. 2 shows the contour analysis of SST deviation over the monitoring zone. Positive deviation shown as warm (W) while negative deviation correspond to DAM as (C). Fig. 2 (a) corresponds to the weak monsoon situation between 8-16 July in all the three seasons. This analysis shows a small DAM cell between 20° and 22° N and west of 65° E during 1984, but in 1986 this has shown shift to very much westward, while in 1987, DAM has been seen very much deep in Arabian Sea (18°N), thereby pushing MAM to south of 18° N latitude and thus affecting the monsoon activity. Fig. 2 (b) corresponds to the situation between 1 and 7 August during all the three seasons. This shows MAM occupying a whole of Arabian Sea during 1984 and 1986 seasons but in 1987 a continental DAM northeast has entered into Arabian Sea right up to 18°N latitude position thereby completely affecting the monsoon activity and causing a situation similar to that of normal withdrawal type which generally occurs in 3rd week of September.

4. *Conclusions* —The following broad conclusions may be arrived at from the above study:

(*i*) During onset phase of monsoon, MAM moved about 9° ahead of normal onset data. Over Kerala, condition becomes favourable for onset when MAM reaches 17.5° N latitude position over the Arabian Sea.

(*ii*) Condition becomes favourable for onset of monsoon over whole of Arabian Sea and west coast of India when MAM reached 21° N latitude position in Arabian Sea.

(*iii*) Stagnation of DAM over Arabian Sea is likely to affect adversely the onset phase.

(*iv*) Entrance of continental DAM from north over Arabian Sea during active phase of monsoon may lead to break condition or sometime withdrawal type of situation.

(*v*) During withdrawal phase continental DAM sets the reverse circulation over Arabian Sea thus pushing MAM further south.

References

Agnihotri, C.L., 1986, "Inference of the moisture field over Arabian Sea during the monsoon of 1984 using INSAT-1B sea surface temperature data, *Mausam*, **37**, 4, pp. 521-524.

Agnihotri, C.L., 1987, "Analysis of INSAT sea surface temperature over Arabian Sea during May to August 1987", Proc. of National Space Science Symp., Dec. 1987, PRL, Ahmedabad, India, pp. 383-386.

Ghosh, S.K., Dewan, B.N., Pant, M.C., 1978, "Influence of the Arabian Sea on the Indian Summer Season", *Tellus*, **38**, 88, 117-125.

Pisharoty, P.R., 1965, "Evaporation from the Arabian Sea and the Indian Southwest monsoon," Proc. of the Internal symp. on Met. Results of International Indian Ocean Expedition, Bombay, India, 22-26 July 1965.

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