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Case studies of westerly waves in the development of monsoon depressions

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ABSTRACT. Development of monsoon depressions forming on 3 and 12 August 1972 in the north Bay of Bengal was found to be linked with changes in mid-latitude upper tropospheric flow patterns over China and adjoining areas. Development took place in association with upper tropospheric cut-off lows which formed over China, retrograded and induced perturbations in the easterlies over the head Bay of Bengal.

1. Introduction

1.1. The role of westerly waves in producing weather over India during different seasons has been the subject of numerous studies by Indian meteorologists. The eastward moving troughs in the zonal westerlies affect weather over the country throughout the year, either directly or by inducing low pressure systems over the area. Pisharoty and Desai (1956) surveyed in an article some of the salient features of interaction between the tropics and the extra tropics.

Influence of westerly waves during the monsoon period is varied. The advance of the monsoon along the Konkan coast is often precluded by the westerly troughs extending to Bombay latitude. The eastward movement of westerly troughs along the Gangetic valley during the early part of June prevents the extension of monsoon into Bihar and Uttar Pradesh. Ramaswamy (1958) related the 'break' monsoon situations in 1954 to the extension of a large amplitude trough at 500 mb. Koteswaram and Bhaskara Rao (1963) on the other hand pointed out the activities of the monsoon along the west coast of India due to the increase in amplitude of a 500 mb trough in July 1958. It is thus well known that the fluctuations in the activity of the monsoon over north India are associated with the movement of the westerly troughs.

Westerly troughs extending into Indian latitudes are also responsible for the recurvature of monsoon depressions and tropical cyclonic storms.

There has, however, been no case study made so far of westerly troughs having induced monsoon depression in the Bay. In he present study two cases are presented where 'cut off' lows of westerly troughs retrograded and induced monsoon depressions over the north Bay.

1.2. As is well known, the upper tropospheric flow pattern over south Asia is easterly in SW monsoon period with a huge anticyclone over the Tibetan Plateau and with an easterly jet stream between 150-100 mb at its southern rim. In a study of vertical time-sections of Calcutta of August-September 1955 Koteswaram and George (1958) noticed that the easterly jet stream is of a pulsating character shifting its position both laterally and longitudinally. The easterlies are also subjected to frequent perturbations due to wave like disturbances moving from east to west between 500 and 300 mb. From an examination of hemispherical charts of 1955 they found that most of these waves had their origin in the southwest Pacific and some of them could be traced from even longitude 140°E. These upper tropospheric perturbations when superposed over a pre-existing sea level disturbance result in development of monsoon depressions. This pattern is now well established from synoptic practice.

1.3. From an examination of upper air charts of July-August 1972 over Asia it was found that the two upper tropospheric easterly troughs which caused the development of depressions over north Bay on 2 August and 12 August respectively had resulted from upper tropospheric lows which got cut-off from westerly troughs over the Chinese area. They retrograded along the periphery of subtropical anticyclone over Tibet, the westward motion being as much as 15° longitude in 6 days in the first case and 11° longitude in 4 days in the second. These retrograded lows induced perturbations in the upper tropospheric easterlies over north

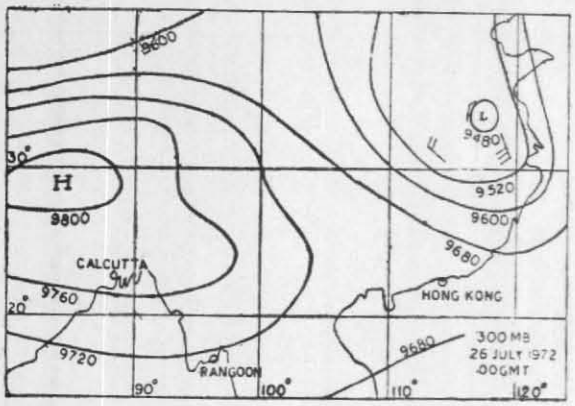


Fig. 1

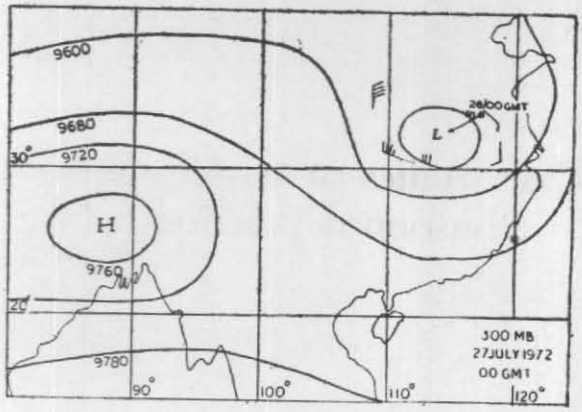
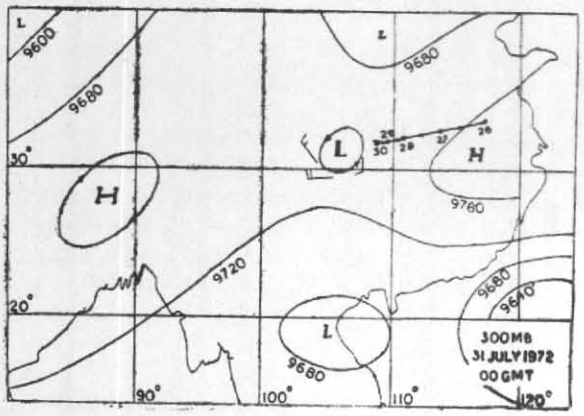


Fig. 2



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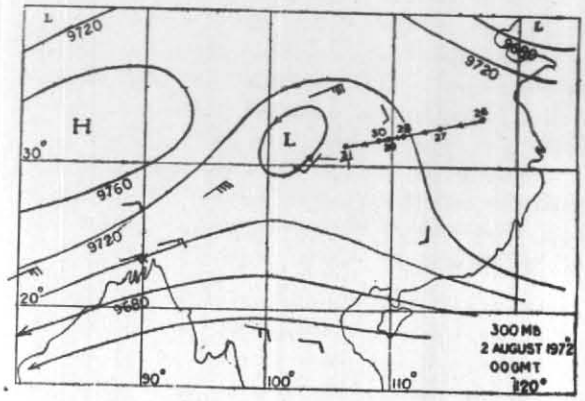

Fig. 4

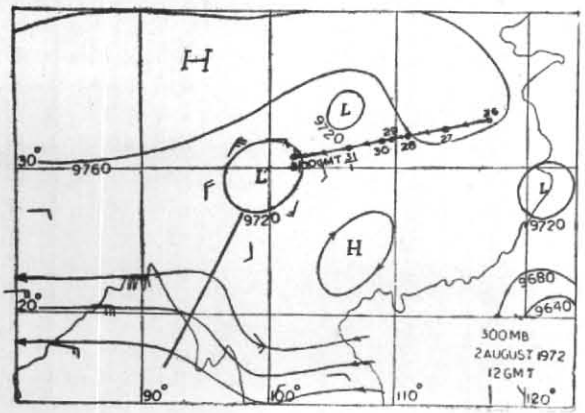

Fig. 5

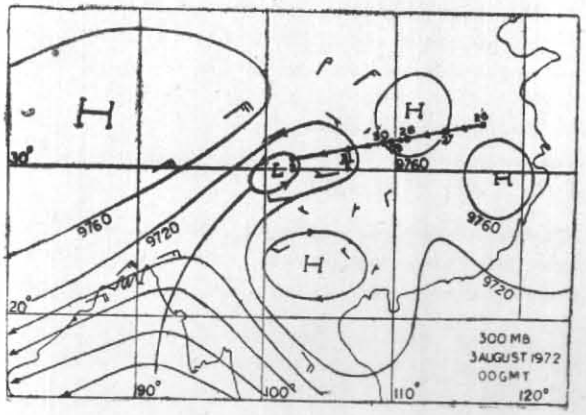

Fig. 6

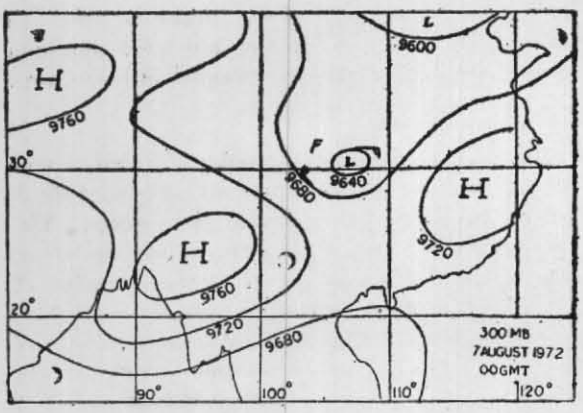

Fig. 7

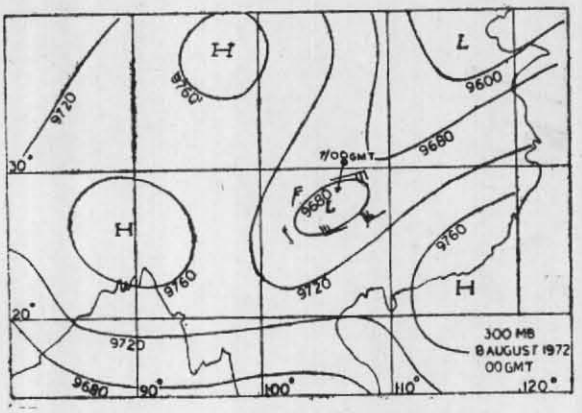

Fig. 8

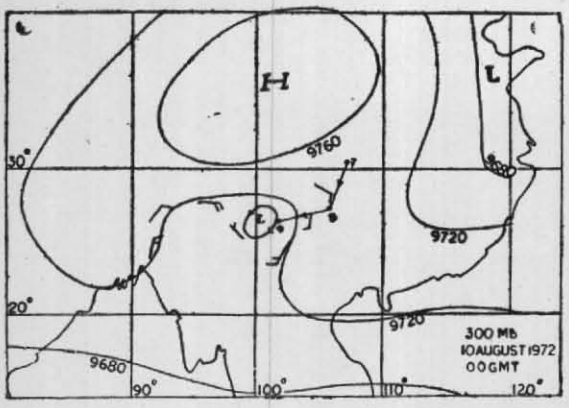

Fig. 9

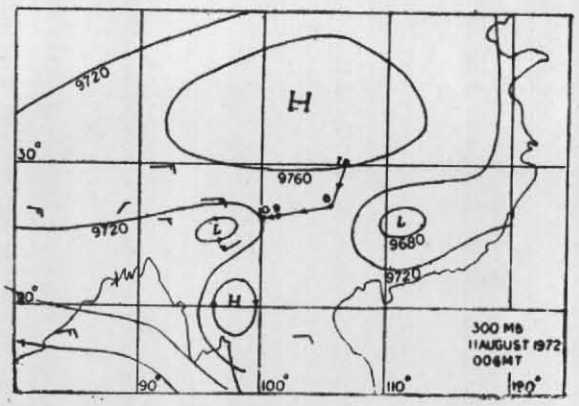

Fig. 10

Bay. There was no easterly wave that moved from east to west in either of the two cases.

2. Synoptic situation at 300 mb

2.1. *25 July-3 August 1972* — A deep trough over east China extended from about 40°N, 120°E to 28°N, 118°E on 25 July. A cut-off low formed in this trough which lay centred near 34°N, 117°E on 26 July (Fig. 1). Coming under the influence of the easterlies south of the sub-tropical ridge line, it moved WSW and was centred near 33°N, 114°E on 27 July (Fig. 2). It moved further west and the position was near 32°N, 111°E on 28 July. Continuing to move slowly westwards along the shear line, the cut-off low lay centred near 32°N, 106°E on 31 July, and near 32°N, 102°E on 2 August (track in Fig. 6). The readjustment of the anticyclones on either side led to the formation of a well marked trough in the easterlies extending from Burma to east central Bay at 12 GMT of 2nd. The trough persisted till 00 GMT of 3 August (Fig. 6).

2.2. *7-12 August 1972*—A low centred near 30°N, 107°E over central China formed in a trough extending from about 40°N, 114°E to 32°N, 108°E on 7 August (Fig. 7). The low moving SSW on 8th and WSW later was located over north Burma on 11th centred near 26°N, 96°E (track in Fig. 11). Here again a change in the flow pattern exactly similar to one described in the previous case occurred over the area. A well marked trough is seen extending from north Burma to central Bay (Fig. 11) at 12 GMT of 11 August.

2.3. *Thermal characteristics* — In both the cases the cut-off lows extended between 500 and 300 mb and had the usual cold pool characteristics. The cold pool was distinctly maintained either in the form of a closed isotherm or a cold thermal trough till a few days prior to its complete dissipation.

3. Discussion

In both these cases, a noticeable modification of easterlies flow pattern over China and Burma areas followed the arrival of these systems over east

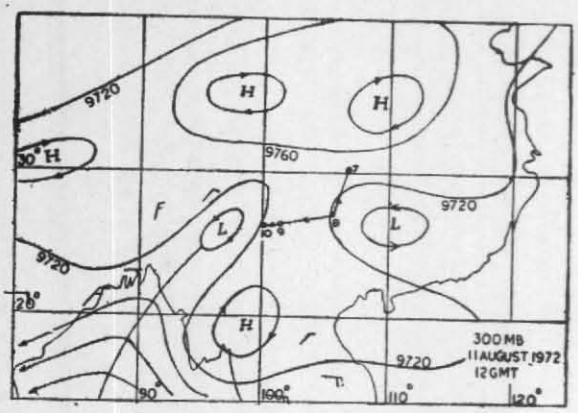

Fig. 11

Tibet and north Burma. This resulted in the formation of troughs in the high level easterlies over the Bay of Bengal. When the areas of upper air divergence in advance of the upper trough were superposed on the pre-existing low level monsoon trough, monsoon depressions formed in both cases.

4. Concluding remarks

The above study has brought out that extra-tropical systems in the upper air also contribute in the formation of monsoon depressions. The upper easterlies seem to be perturbed by the imposition of easterly waves as well as the migration of cut-off lows of westerly troughs into the easterlies. A statistical study of a sufficiently large number of cases is necessary to determine which of the effects is predominant in the monsoon season.

Acknowledgement

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