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THE BAY OF BENGAL DEPRESSION OF SEPTEMBER 1986 THAT CAUSED DELUGE IN WEST BENGAL—A CASE STUDY

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SYNOPSIS

In India floods mainly occur during the monsoon season. They are caused by the heavy rainfall that occur along the track of monsoon depressions. The Bay depression of 25 September 1986 which caused devastation in the West Bengal forms the subject matter of this study. New processes which led to the development of this depression have been identified and presented.

A cyclonic circulation first formed in the lower tropospheric levels over Bangladesh and adjoining West Bengal. It interacted with the environmental cloudiness (i) a cloud cluster over the Bay of Bengal and Burma (ii) a fresh northward propagating monsoon pulse, identified in the form of an east-west trough at 500 hPa and the associated cloudiness on cloud imagery. We observe a sequence of events in which (i) the cyclonic circulation moves southward and organises itself into a low pressure area on the sea surface under interaction with the cloud cluster moving from east (ii) the low pressure area concentrates itself into a depression when it merges with the northward propagating monsoon pulse. The depression had a cold core at the time of formation. Subsequently it developed a warm core as a result of heavy rainfall and release of latent heat.

1. INTRODUCTION

It has been shown earlier by the first author that during the SW monsoon season, a sequence of east-west oriented troughs and ridges in the geopotential and wind field is observed to propagate northward from the equator at 500 hPa (3). The distribution of convection as observed

in the satellite imageries is such that the zones of maximum cloudiness coincide with these troughs. These may be termed as monsoon pulses. When such a trough arrives or is situated along 21°N, monsoon is active over India. It is at this time that the depressions and cyclonic storms form over the Bay of Bengal.

2. FORMATION OF THE BAY DEPRESSION OF SEPTEMBER 1986

On 20 September 1986, a cyclonic circulation developed in the lower tropospheric levels of 850 hPa and 700 hPa over Bangla Desh and adjoining Gangetic West Bengal. It was overlain by a mid-latitude westerly trough. At 500 hPa an east-west trough was aligned along 10°N, south of the sub-tropical ridge along 20°N. This formed a northward propagating pulse. This trough could also be seen at the lower tropospheric levels of 850 hPa and 700 hPa, with embedded cyclonic circulations in Bay of Bengal and the Arabian Sea (Fig.1). Under interaction with this equatorial trough, the northern circulation was displaced southward on 22 September. On 23 September it was located further south and a low pressure area developed over west central and adjoining northwest Bay off north Andhra and South Orissa coast. The associated cyclonic circulation extended upto 500 hPa. The e-w equatorial trough was clearly seen as a separate entity at 700 hPa and 500 hPa at this time. On 24 September the equatorial e-w trough showed a significant northward progress, its Bay circulation merged with the northern system. At this time the mid-latitude westerly trough at 500 hPa had also deepened significantly. On 25 September the merged system concentrated into a depression and lay at 0830 hrs. IST close to Balasore. Moving north-westward it crossed north Orissa coast near Balasore in the afternoon. Thereafter it moved slowly in the northeasterly/northerly direction and weakened into a low pressure area on 27th over Gangetic West Bengal and adjoining Bihar where it became less marked by next day.

3. SATELLITE VIEW

On the INSAT-1B satellite imageries (Figs.2) a cloud cluster lay over northeast Bay and Burma between 20 and 21 September. But the northern circulation itself was a cloud free area on both these days. On 23 September the circulation and the cloud blob coincided. It was only on 24 September when the equatorial pulse merged with the northern circulation that cloud organisation became significant, with Arabian Sea current feeding the Bay of Bengal disturbance. This led to the northward movement of the Bay system embedded in the e-w trough. Subsequently it intensified into a depression on the morning of 25 September. The cloud band over the Peninsular India represents the Arabian Sea feed.

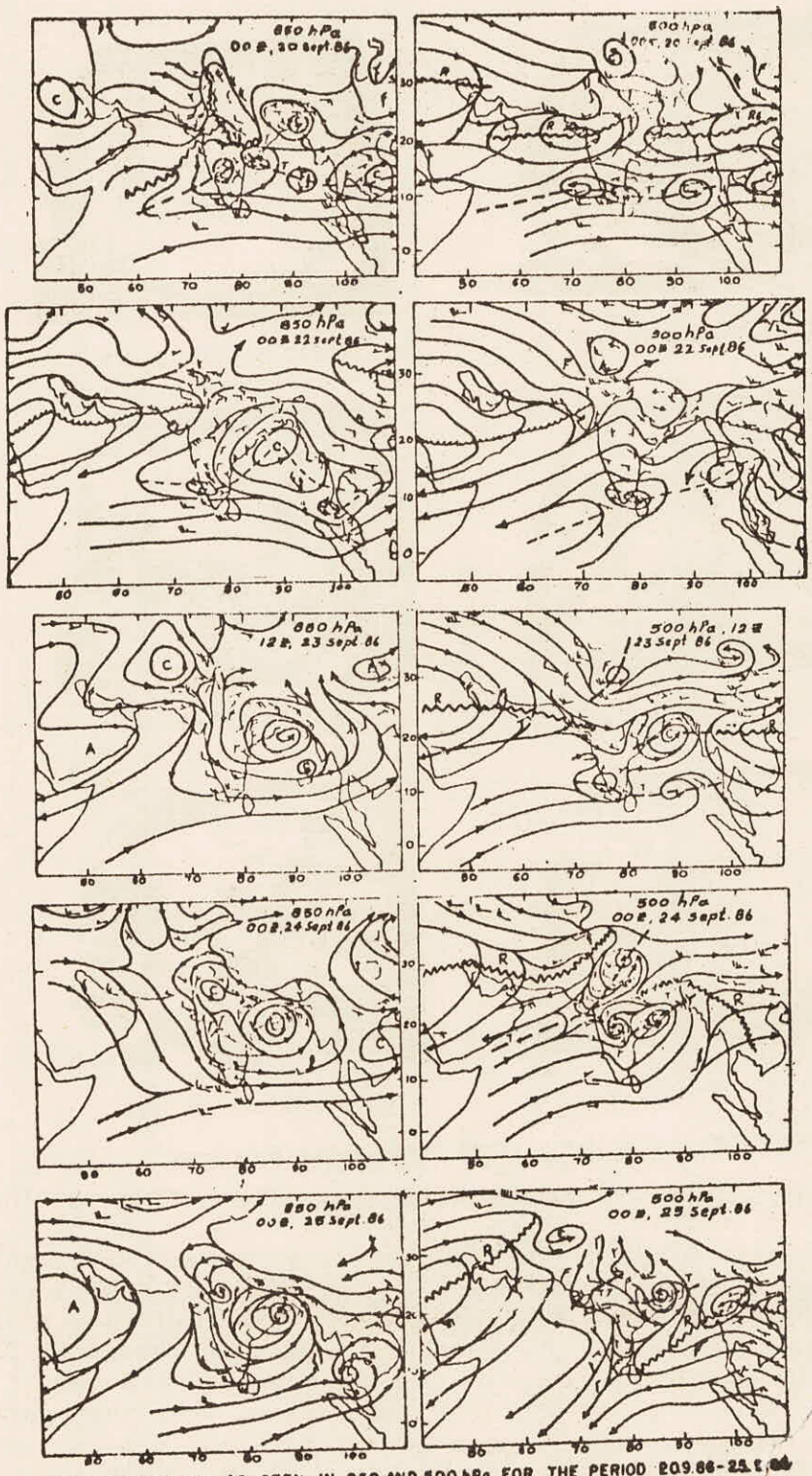
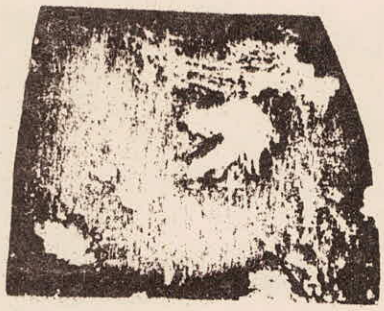


FIG. 1. INTERACTION AS SEEN IN 850 AND 500 hPa FOR THE PERIOD 20.9.86-25.9.86

06 UTC 20 SEP 86 VIS



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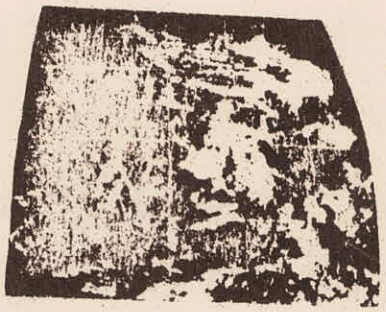

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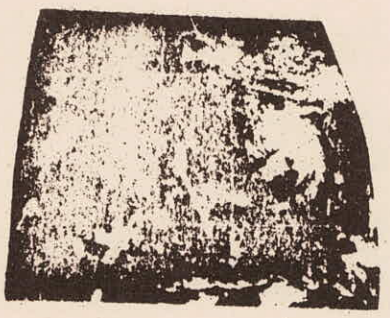

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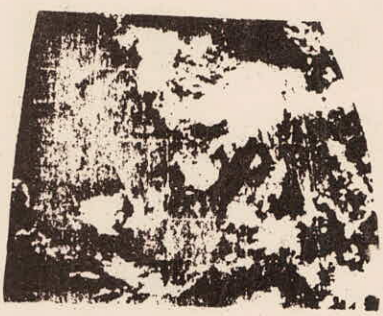

06 UTC 27 SEP 86 VIS

FIG. 2. DEVELOPMENT OF A DEPRESSION - INSAT PICTURES

4. GEOPOTENTIAL HEIGHT AND TEMPERATURE ANOMALIES - TIME SECTION

Fig.3 shows the vertical time section of geopotential height and temperature anomalies over Calcutta from 00 UTC of 23 September to 12 UTC of 27 September obtained by subtracting the normal values of standard pressure levels for the month of September (based on 20 years 1951-1970 data). A fall in geopotential increasing with height was observed at all levels at 00 UTC of 25 September, when the system developed into a depression. The system was cold cored in lower tropospheric levels. The winds between 250 and 150 hPa were southerly and moderately

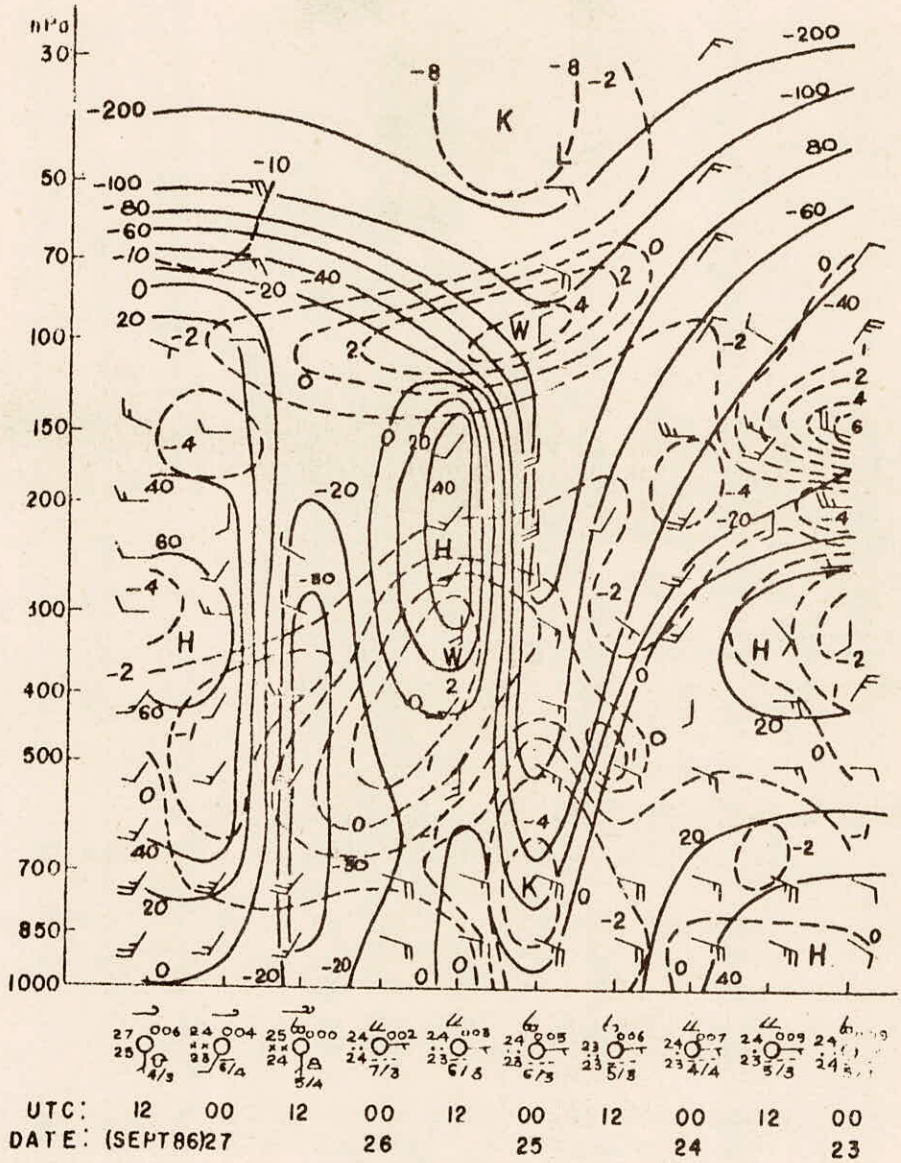

FIG. 3 VERTICAL TIME SECTION FOR CALCUTTA-GEOPOTENTIAL (FULL LINES) AND TEMPERATURE (DASH LINES) ANOMALIES.

strong, suggestive of an interaction between system and an upper air westerly trough. The mixing ratios had increased substantially at all levels indicating increasing of water vapour in the column. It rained heavily over Calcutta on 25 September. The important 24 hours rainfall amounts for Calcutta and some neighbouring stations recorded at 03 UTC of the day during the period of depression are given below :

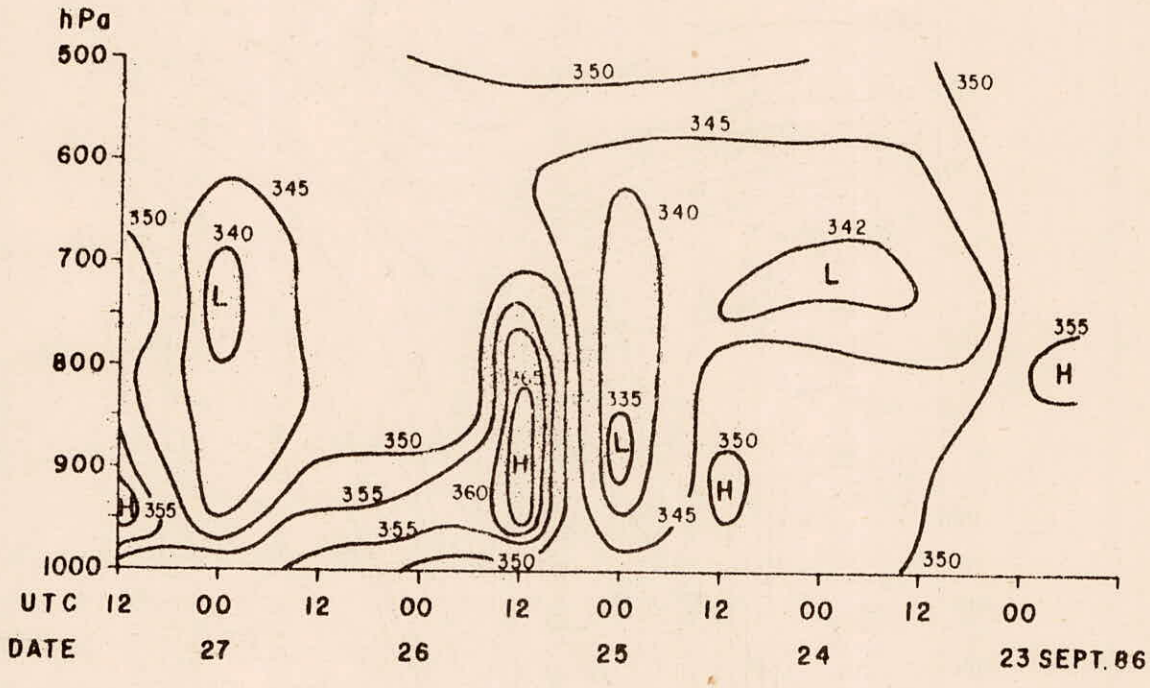

FIG. 4. VERTICAL TIME SECTION OF CALCUTTA EQUIVALENT POTENTIAL TEMPERATURE Θ_e(°K)

24 Sep'86 — Balasore (Orissa) 25.4, Sandheads 16.1, Chandbali (Orissa) 12.8)

25 Sep'86 — Sandheads 59.4, Sagar Island 18.3, Contai 22.5, Calcutta 15.1

26 Sep'86 — Sandheads 31.7, Calcutta* 25.9, Contai 18.7, Sagar Island 15.6, Midnapore 15.1.

As per press report the heavy rain over Gangetic West Bengal claimed 18 lives and rendered 6.15 lakh people homeless following deluge in Calcutta and in the districts of Howrah, Hoogly, Midnapore and 24 - Parganas:

As a result of the release of latent heat during heavy precipitation the temperature rise at different heights at 12 UTC of 25 September w.r.t. 00 UTC are given below :

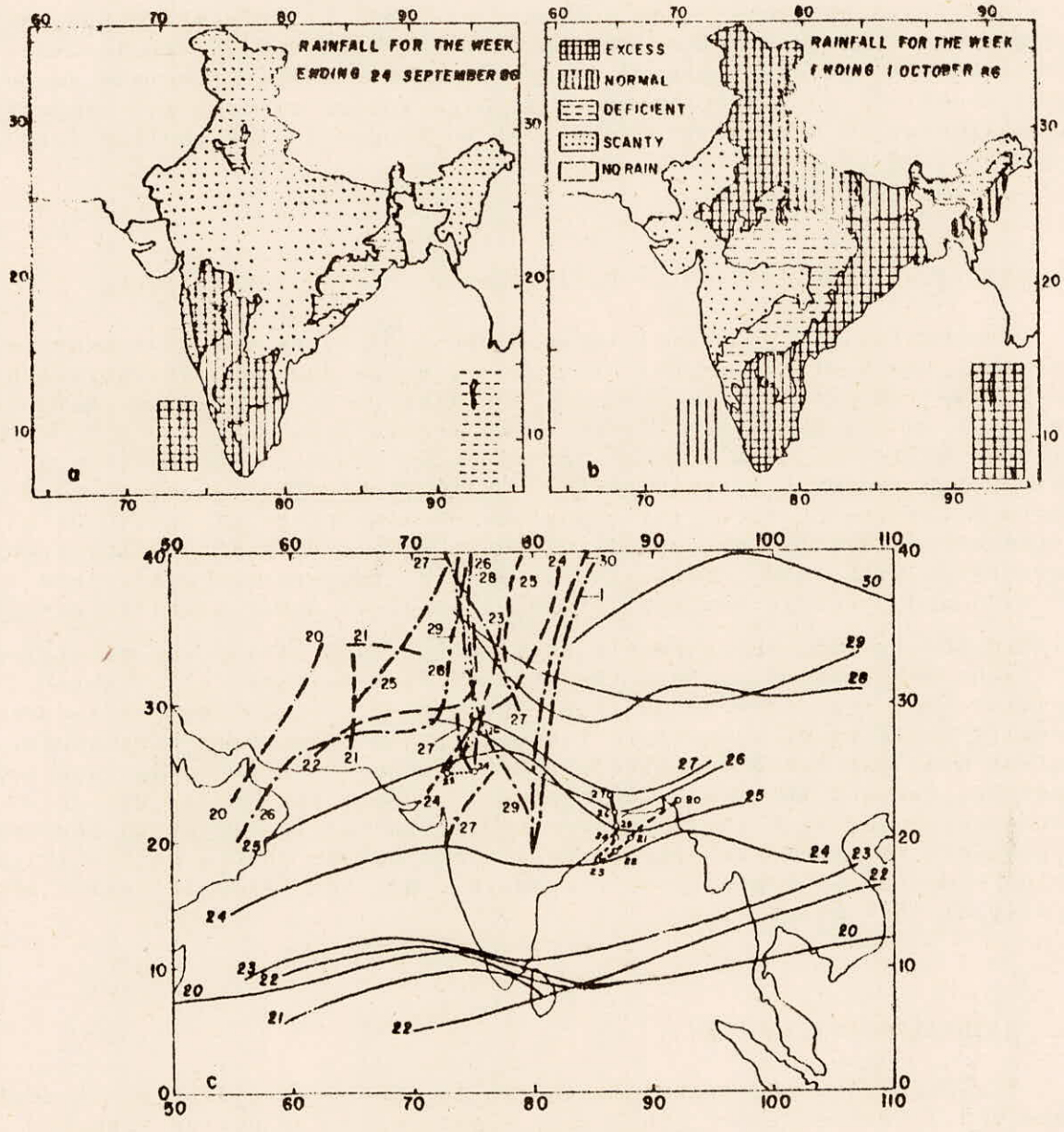

FIG. 5. PROPAGATION OF TROUGHS AND RAINFALL.

Level (hPa)	950	900	850	800	750	700	650	600	550
Rise in temperature (°C)	6	7	7	5	4	3	3	3	3
Level (hPa)	500	450	400	350	300	250			
Rise in temperature (°)	3	3	3	4	1	1			

The mid-tropospheric warming was overlain by a high in the geopotential anomalies. This was a temporary phenomenon observed due to the excessive rainfall and was replaced soon by negative temperature and geopotential anomalies on 26 September. The high values of negative temperature anomalies at 70 hPa and 50 hPa appear to be due to the cooling from the overshooting CB clouds (2).

5. VERTICAL TIME SECTION OF EQUIVALENT POTENTIAL TEMPERATURES

The equivalent potential temperature (θ_e) serves as a measure of the heat stock of the parcel of air. Also the decrease of equivalent potential temperature with height is a measure of convective instability inherent in the atmosphere. Therefore the vertical time section of θ_e from 00 UTC of 23 to 12 UTC of 27 September was constructed (Fig.4). A low energy region L (trough in θ_e) with steep θ_e gradient near the surface was the characteristic feature of atmosphere at 00 UTC of 25 September. This feature appears to have been generated by the strong downdrafts with rain. Thereafter, sea-air temperature difference ($T_s - T_a$) and Specific humidity ($q_s - q_a$) gradient substantially increased within the system. As a result substantial evaporation was maintained over the Sea-surface, within the body of system itself (3). This moisture was transported upward by the strong vertical currents dueto the locally built up of convective instability and the converging winds. The latent heat was again released in the subsequent condensation and rainfall process and the system developed a warm core at 12 UTC of 25 September. The high in θ_e over the station at 12 UTC of 25 September, represents the state of atmosphere at this hour. Thus a self - intensifying - mechanism seems to be responsible for the intensification of the system at this stage.

6. RAINFALL DISTRIBUTION

Fig.5a,b shows the rainfall charts for the week ending on 24 September and 1 October 1986. These two weeks cover the period when the monsoon pulse moved from south to north and the depression formed in the Bay (Fig.5c). Two western disturbances also moved across India during this period. The full lines in Fig(5c) represent the northward propagation of (i) the e-w equatorial trough till 24 September (ii) thereafter this trough line is embedded in the westerlies. The rainfall distribution of these two weeks suggests that the short or medium range forecast of the heavy rainfall should take into account the interaction between the northward propagating monsoon pulse and the tropical and extratropical systems.

7. DISCUSSION AND CONCLUSION

Over Indian region the monsoon depressions and the tropical storms form in a vigorous monsoon type circulation, that is when the equatorial trough is located in its active phase. The northward movement of the equatorial trough is observed in all the seasons, though in different levels. During the monsoon season this is seen at 500 hPa. In pre - and post-monsoon seasons this is noticed at 700 hPa. During the winter season the level is 850 hPa. The latitude of the active phase of the e-w trough is determined by the general circulation of the season, especially the location of subtropical anticyclone. During monsoon (particularly during July and August) it is 21°N. This latitude begins shifting southward from September onwards.

The depressions and cyclones form from the reorganisation and intensification of the embedded disturbances in the equatorial trough when it is located in its active phase. Interaction with the mid-latitude westerly trough provides the favourable settings for such reorganisation and intensification e.g. merging of the two existing embedded circulations or the development of a new circulation in a cloud cluster (4).

In this study it is observed that the development of a cyclonic circulation in the lower tropospheric levels was not necessarily associated with any cloudiness over the region itself, Once developed, this circulation interacts with a cloud cluster. This interaction leads to the southward displacement of the circulation and subsequent development of a low pressure area on the sea level. The circulation extends upto 500 hPa and is vertically aligned on 23 September. Its further deepening /concentration into a depression and subsequent northward movement are the result of its merger with the northward propagating monsoon pulse. As a result of this merger the cyclonic system appears to be displaced further south on 24 September. The circulation at 500 hPa is now embedded in the e-w trough. Both these interactions are distinctly separate and independent of each other.

Once the depression has formed, it moves northward faster than the equatorial trough developing a configuration of the type of easterly trough. And the equatorial cloudiness takes the form of feeder bands on the satellite imageries. It gets finally detached and its further movement is controlled in relation to the subtropical ridge. The depression had a cold core at the time of its development. Subsequently the core warmed up to 300 hPa due to the release of latent heat in heavy rainfall.

ACKNOWLEDGEMENT

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