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The floods in north India in 1988 — Forecasting aspects

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सार — (1) जुलाई 1988 के दूसरे सप्ताह और अगस्त 1988 के अन्तिम सप्ताह, तथा (2) सितम्बर 1988 के चौथे सप्ताह के दौरान जम्मू एवं कश्मीर, हरियाणा, हिमाचल प्रदेश और पंजाब के राज्यों में आई भीषण/आकस्मिक बाढ़ों में क्षति पहुंचाई थी। ये बाढ़ें तब आई जब इन राज्यों में 20° उ० के दक्षिण स्थित अधिकतम मेघनयता वाले विषुवतीय क्षेत्रों के रूप में मानसून स्पंद सहित मध्य अक्षांश पश्चिमी हवा द्रोणिकों की अन्योन्य क्रिया के कारण भारी वर्षा हुई। उपग्रह से प्राप्त चित्र और सिनॉप्टिक चार्ट यह बताते हैं कि –

(क) जुलाई-अगस्त 1988 में बने सिस्टम मुख्यतः अरब सागर की आर्द्रता से बने थे और उनकी उष्ण कटिबंधीय विशिष्टताएं थीं।

(ख) सितम्बर 1988 में बने सिस्टम में आर्द्रता अरब सागर और बंगाल की खाड़ी से आई और ये अतिविशिष्ट उष्णकटिबंधीय थे।

इस शोध-पत्र में इन दोनों घटनाओं की विस्तृत रूप से चर्चा की गई है। उपग्रह से प्राप्त चित्र भारी वर्षा में परिणत होने वाली मेघ रचना दर्शाते हैं।

ABSTRACT. Severe floods/flash floods ravaged the States of Jammu & Kashmir, Haryana, Himachal Pradesh and Punjab during, (*i*) 2nd half of July and last half of August 1988, and (*ii*) 4th week of September 1988. They took place when heavy rains occurred in these States due to the interaction of mid-latitude westerly troughs with the monsoon pulses in the form of equatorial zones of maximum cloudiness (EZMC), located south of 20° N. Satellite pictures and synoptic charts suggest that :

(a) The systems which formed in July-August 1988 were fed by moisture mainly from the Arabian Sea and had tropical characteristic, and

(b) The systems which formed in September 1988 had their moisture supply both from the Arabian Sea and the Bay of Bengal and were extra-tropical in character.

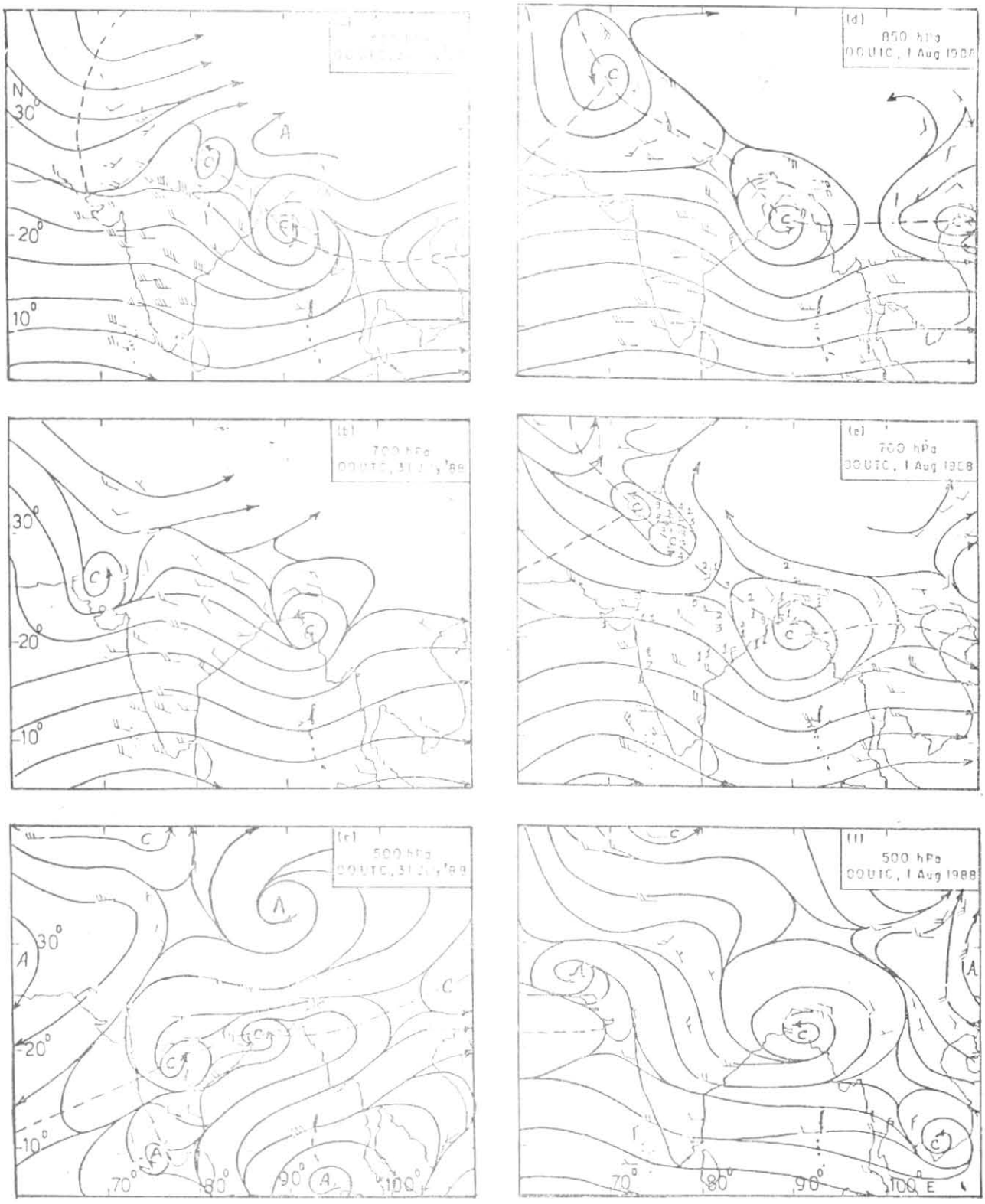
The paper describes two of these events in detail. The satellite pictures show cloud formation resulting in heavy rains.

Key words —Flash flood, Equatorial zones of maximum cloudiness.

1. Introduction

Floods have occurred in Jammu & Kashmir and neighbouring States due to depressions recurving over Rajasthan towards north or northeast and reaching the State (Ananthakrishnan and Bhatia 1960). Deep penetration of moisture over this area occurs even in the absence of depressions due to the presence of lows in the lower tropospheric levels associated with the trough in upper level westerlies with an embedded jet stream (Ghosh and Veeraraghavan 1975). The severe floods that occurred in quick succession in Jummu & Kashmir State and neighbourhood in the first two weeks of August 1976, were the results of the formation of two independent circulations over the J & K State. Satellite pictures suggested that the first of these two vortices had infact intensified into monsoon depression over J & K on 1 August and the other system close to a cyclonic storm over Punjab, J & K and adjoining hills of Uttar Pradesh and Himachal Pradesh on 6 August 1976 [Ranjit Singh 1987 (a)].

The recent floods/flash floods in J & K State, Punjab, Haryana and Himachal Pradesh during July-August 1988 and the severe floods in Haryana, Himachal Pradesh and Punjab in September 1988 have, however, occurred under different settings. These took place when heavy rains occurred in these States due to the interaction of mid-latitude westerly troughs with the monsoon pulses, that can be identified in the form of equatorial zones of maximum cloudiness



Figs. 1 (a-f). Interaction between the mid-latitude and equatorial troughs on 31 July 1988 at : (a) 850 hPa, (b) 700 hPa, (c) 500 hPa 00 UTC, and on 1 August 1988 at (d) 850 hPa, (e) 700 hPa, and (f) 500 hPa 00 UTC

(Ranjit Singh *et al.* 1988), when they were still south of 20° N. Under this interaction, independent weather systems formed over the latitudes of these States. Satellite pictures and synoptic charts suggest that the systems that formed in July-August 1988 were fed by moisture mainly from the Arabian Sea and had tropical characteristics while the systems that formed in September 1988, had their moisture supply both from the Arabian Sea and the Bay of Bengal and were extra-tropical in nature.

2. Methodology

During the monsoon season, the equatorial zone with westerlies in the lower troposphere and easterlies in the middle and upper troposphere, advances northward. Embedded in this feature we observe a sequence of northward propagating pairs of zonally oriented equatorial trough (ET) and ridges (ER) at 500 hPa level between equator and the Tibetan region. This occurs with a periodicity of 30-50 days, in response to the northward propagating "equatorial zones of mixiumum cloudiness (EZMC)". The EZMC coincides with ET at 500 hPa in a strong monsoon current. It coincides with ET at 700 hPa in a week or withdrawing monsoon current. Monsoon is active when the ET is located between 17-23° N. Break monsoon (cessation of rainfall over central India) occurs when a ridge is located between these latitudes [Ranjit Singh 1987 (c)].

In the present study, INSAT-1B satellite cloud imageries have been used alongwith the daily weather charts to identify the systems responsible for the rainfall causing floods.

3. Floods of July-August 1988

According to press reports, Kashmir valley was cut-off from the rest of the country due to heavy rains, floods and landslides. 22 persons died in heavy rains and severe floods in *Chenab* and *Jhelum* rivers between 14 and 20 July. 17 persons lost their lives in flash floods near Kargil in the early part of August 1988 and 34 persons were washed away in yet another flash flood near Poonch in Jammu on 8 August. 38 persons died in severe floods in *Ravi* and *Sutlej* in Punjab between 2nd week of July and 2nd week of August. 7 persons died in flash flood in *Markanda* (20-31 July) and 15 in severe floods in *Ghaghra* (9-10 August) in Haryana 38 persons died in HP in severe flood in *Beas* and *Sutlej* from 1st week of July to 2nd week of August. Thousands of cattle heads were lost. Thousands of houses were damaged and washed away. Crops worth several of crores in thousands of acres of land were washed away. Heavy damage was reported to roads and railways. Some of the important amount of rainfall (in cm) between 13 July and 8 August are given below:

13 July : Jammu 14, Karnal 12, Katra 4.

16 July : Katra 9, Batote 7, Banihal 6, Gulmarg 6, Qazigund 6.

22 July : Katra 17.

31 July : Jammu 10, Katra 5.

1 August : Jagadhari (Har.) 23, Patiala (Punjab) 20, Kukernag 4, Jammu 4.

2 August : Dharamsala (HP) 19, Palwal (Har.) 10, Batote 4.

3 August : Jogindernagar (HP) 11, Katra 4.

7 August : Katra (J & K) 17.

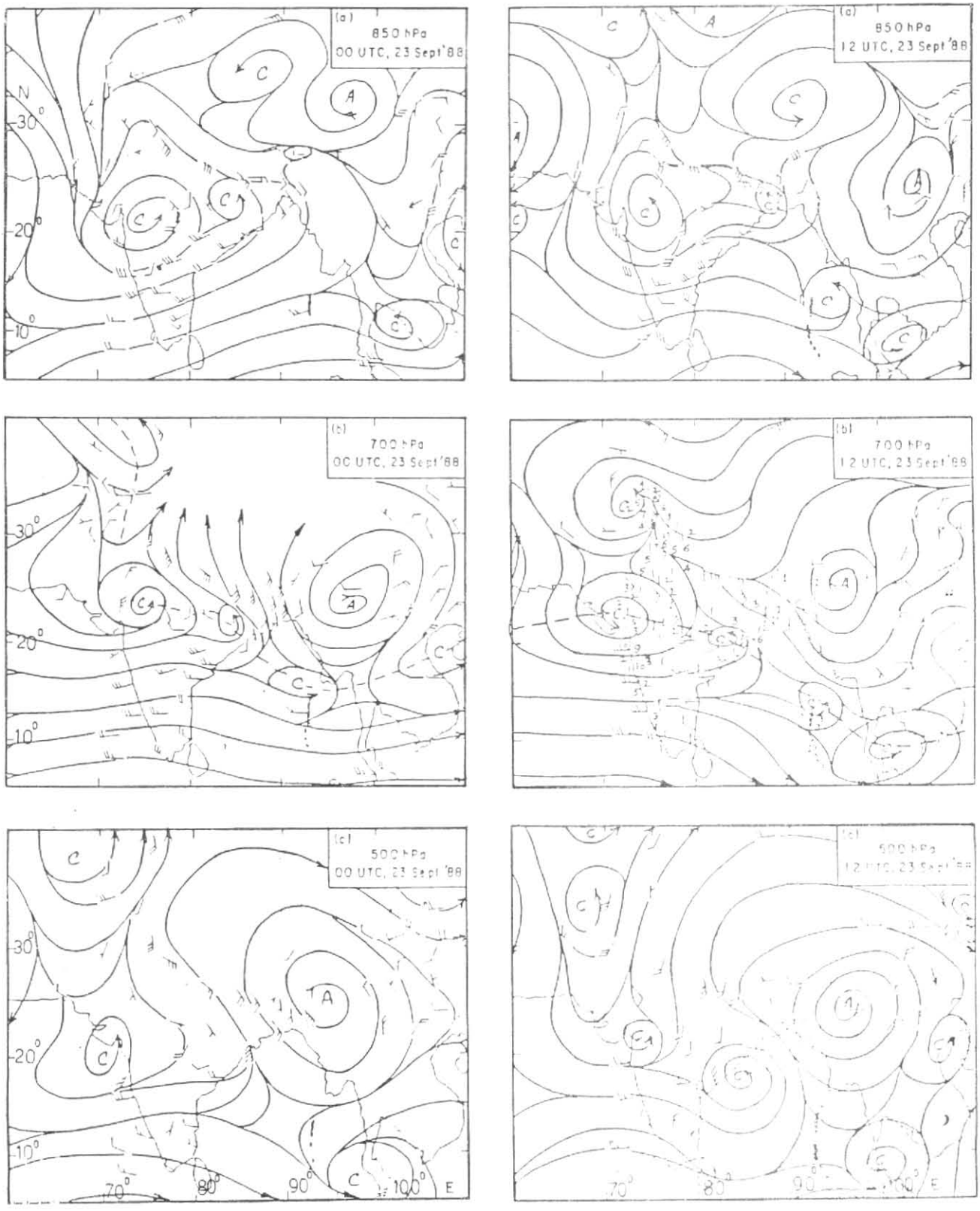
8 August : Jagadhari (Har.) 24, Ropar (Punjab) 13, Katra (J & K) 9.

9 August : Jogindernagar (HP) 15, Katra (J & K) 9.

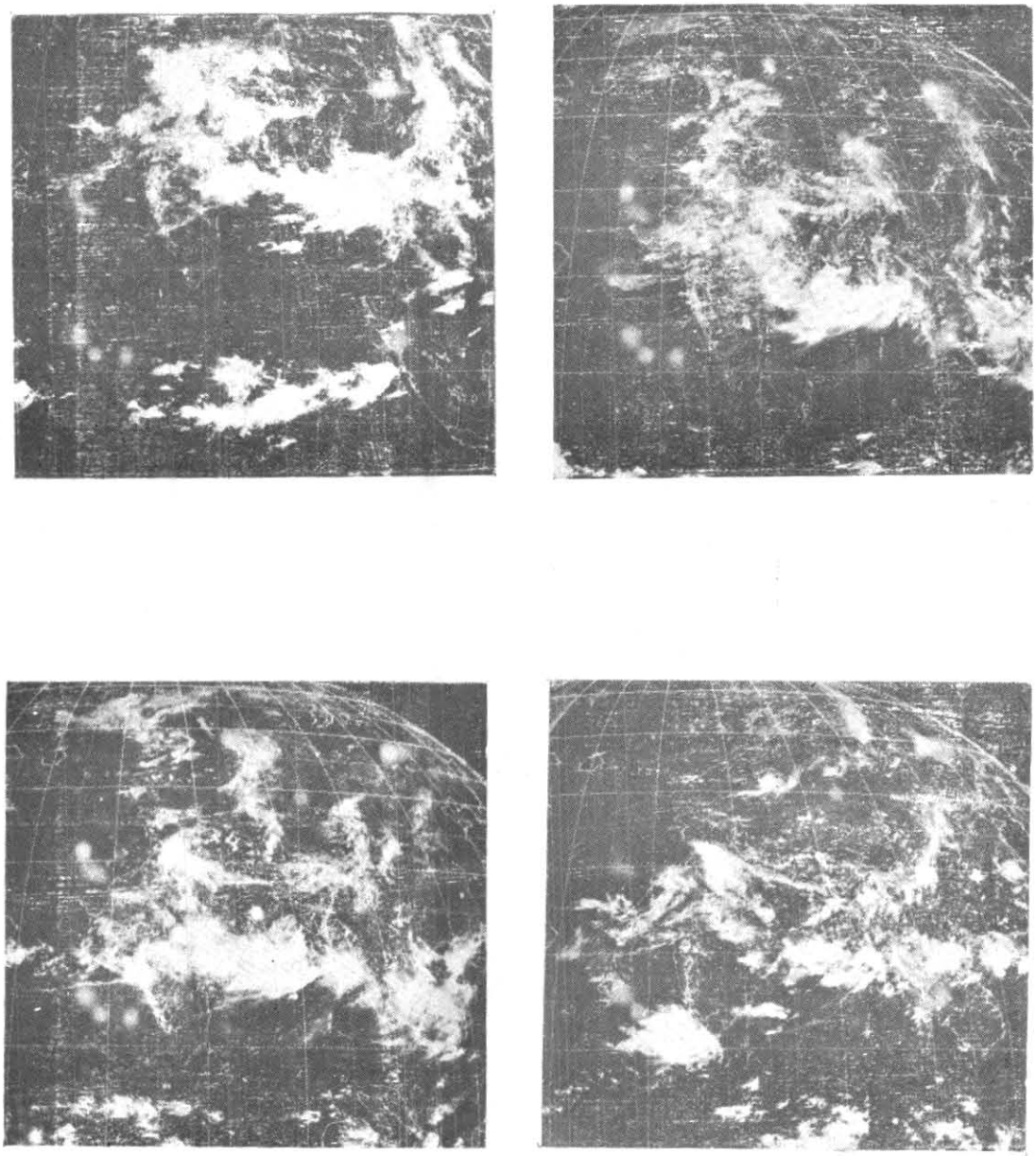
The devastating heavy rainfall occurred in the northern States of India in two spells, *viz.*, 31 July-3 August and 7-9 August.

3.1. *Synoptic situations*

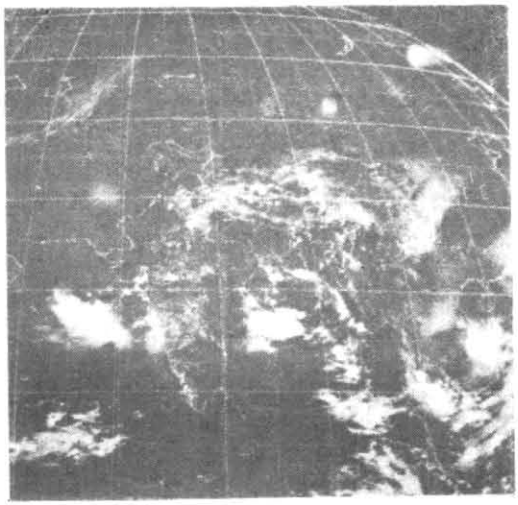
In Figs. 1 (a-f) the 850, 700 & 500 hPa charts of 31 July and 1 August 1988 are presented. The east-west equatorial trough (ET) at 500 hPa is roughly aligned along 20° N. A mid-tropospheric cyclonic circulation lies over north Rajasthan at 700 hPa. Under their influence the lower tropospheric southwesterlies over east Rajasthan, west Uttar Pradesh, Haryana and Punjab have intensified between 850 & 700 hPa. On the satellite imagery the southwest to northeast oriented streaks of low clouds from the Arabian Sea indicate a lower tropospheric moisture feed from the Arabian Sea. This had led to the build up of large scale convective activity over Jammu & Kashmir, Punjab, Haryana, Himachal Pradesh and west Uttar Pradesh on 31 July [Figs.3(a & b]. A new cyclonic circulation developed within the recurving westerlies in the lower tropospheric levels of 850 and 700 hPa on 1 August. With this the western sector of the equatorial trough shifted towards north. This is also supported by the rainfall distribution recorded at 03 UTC of 1 August. An important feature of the monsoon field is noticed here. The

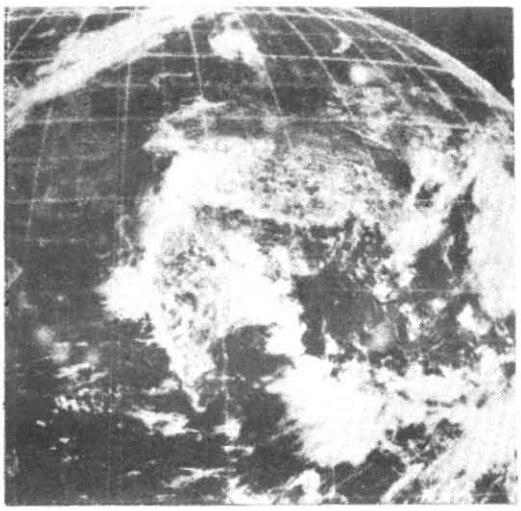


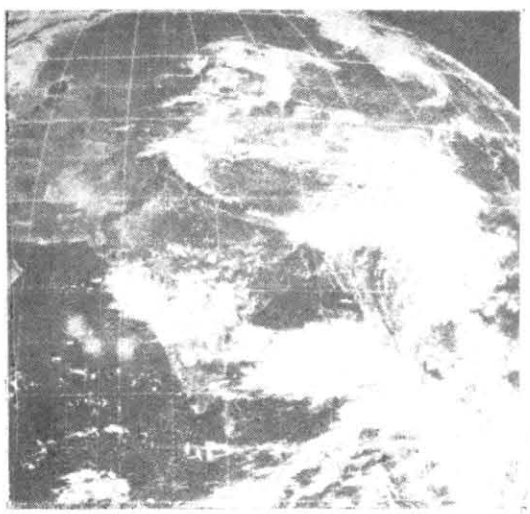
Figs. 2 (a-c). Interaction between mid-latitude and equatorial troughs on 23 September1988: (a) 850 hPa at 00 & 12 UTC, (b)700 hPa at 00 & 12 UTC, & (c) 500 hPa at 00 & 12 UTC



Figs. 3(a-d). INSAT-1B visible cloud pictures at 06 UTC: (a) 31 July 1988, (b) 1 August 1988, (c) 2 August 1988, and (d) 8 August 1988







Figs. 4 (a–c). INSAT-1B visible cloud pictures at 06 UTC on : (a) 21 Sep. (b) 23 Sep, & (c) 28 Sep 1988

cloudiness developed over an area first and it was followed later by the formation of a cyclonic circulation. The entire development took place under an interaction of the ET with the middle latitude westerly trough. This interaction is supported by the satellite observation on 2 August [Fig.3 (c)]. On this day the equatorial trough has again intensified over India along 20° N after the westerly trough has moved away eastward.

A Bay depression had moved in a northwesterly direction and lay centred over west Rajasthan in the morning of 6 August. It weakened and merged with the seasonal low on 7 August. The second spell of heavy rainfall occurred when the monsoon trough moved northward and interacted with the mid-latitude westerly trough. The satellite imagery of 8 August depicts this development [Fig.3 (d)].

4. Floods of September 1988

According to press reports the States of J & K, Haryana, Himachal Pradesh and Punjab were affected by unprecedented floods in the 4th week of September. 50 persons died in J & K State due to heavy rains and severe floods in *Chenab*. Srinagar-Jammu National Highway was closed for traffic. 57 people died in Punjab between 4th week of September and 2nd week of October due to floods in *Beas*, *Ravi* and *Sutlej*. 5 persons died in Haryana in severe floods in *Ghaghra*. 32 persons died in HP in severe floods in *Beas* and *Sutlej*. Besides Lakhs of people were rendered homeless in these States. Standing crops worth several of crores were damaged. The rainfall recorded were:

22 September : Katra (Jammu) 6.

23 September : Batala (Punjab) 10, Gohana (Har.) 9.

24 September : Uria (HP) 32, Kapurthala (Punjab) 28, Chandigarh AP 19, Bhadarwah 16, Batote 15, Katra 9, Banihal 8, Kukernag 8, Jammu 7, Qazigund 5.

25 September : Batote 32, Katra 29, Jammu 27, Kathua 25, Kandaghat (HP) 18, Raya (Punjab) 17, Bhadarwah 16, Qazigund 15, Banihal 15, Pahalgam 9, Gulmarg 5, Srinagar 5.

26 September : Tibri (Punjab) 22, Bhadarwah 16, Batote (J & K) 12, Kukernag 6, Banihal 6, Qazigund 5, Jammu 4.

27 September : Uria (HP) 26, Chandigarh AP 10.

4.1. *Synoptic situations*

In Figs. 2 (a-c) the stream line analysis of 850, 700 and 500 hPa charts of 00 UTC and 12 UTC of 23 September 1988 are presented. The satellite cloud imageries of 21, 23 and 28 September are presented in Figs. 4 (a-c). Both the satellite imageries and the charts are suggestive that the EZMC and the ET at 700 hPa have moved northward and are aligned along 20° N over India on 23 September. They slope southeastward to Andaman Sea along 10° N and thence aligned eastward. An interaction takes place between this ET and the mid-latitude westerly trough along 67° E. As a result moisture is advected by the Arabian Sea current over north Indian States of J & K, Punjab, Haryana and Himachal Pradesh where large scale convective build up has taken place. The development in cloud field is followed by the formation of a mid-latitude cyclonic circulation at 700 hPa. This, however, is not observed at 850 hPa and lower levels. Here the monsoon current from the Bay of Bengal extends northwestward and feeds moisture into the region. The EZMC/ET and the extra-tropical systems over northwest India have maintained their distinct identifies. This is also observed in the 24-hour rainfall distribution recorded at 03 UTC of 24 September and plotted on 700 hPa chart of 12 UTC of 23 September. The cyclonic circulation persisted till 28 September. It was, thereafter driven northeastward by the westerly trough at 500 hPa leaving the EZMC/ET in its former place. As a result of this interaction heavy rainfall occurred for 3 to 5 days in J & K, Haryana, Punjab & Himachal Pradesh leading to devastating floods what were termed as the century's worst.

This spell of heavy rainfall occurred after a long monsoon break over central and north India, which had lasted almost over a month from the middle of August. The withdrawal of monsoon from northwest India had started. It was observed that though a fresh pulse of monsoon had arrived from equator over India, it was held up along 15° N without further progress. Observations showed that this happened due to two main reasons : (*i*) the pulse was not being augmented by fresh moisture supply from the southern hemisphere, satellite observation, & (*ii*) the mid-latitude westerlies of the northern hemisphere had pushed southward anomalously.

5. Discussion and conclusion

From the two case studies presented in this paper, a perspective has emerged on the development of systems which can lead to heavy rainfall and floods in

the region comprising of J & K and the other northern States of Punjab, Haryana and Himachal Pradesh. The development of these systems is related to the interaction of the mid-latitude westerly troughs located west of 70° E with the equatorial troughs in the mid-tropospheric levels [Ranjit Singh 1987(c)]. These interactions lead to the activation of the Arabian Sea current and enhanced supply of moisture over the region. During the peak monsoon season of July and August months, this will lead to the accentuation of monsoon trough and development of new cyclonic disturbances in it. During the onset and withdrawal phases of monsoon, the same may lead to the formation of extra-tropical systems of the type similar to western disturbances over the region. Heavy rains and floods also occur in this region when the western end of the monsoon trough reaches the foot-hills of Himalayas.

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