

Very heavy rainfall over Punjab, Himachal Pradesh and Haryana during 24-27 September 1988 — case study

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(Received 1 November 1989, Modified 1 December 1995)

सारांश — ऊपरी सतह पर चारों ओर से पश्चिमी घेरी से आच्छादित निम्न स्तर पूर्वी घेरी के प्रभाव से हरियाणा, पंजाब और हिमाचल प्रदेश में 24 से 27 सितम्बर 1988 के दौरान भारी और अत्यधिक रूप से अधिक भारी वर्षा हुई। इस परिघटना से संबंधित विषय का यहाँ अध्ययन किया गया है।

ABSTRACT. Heavy to exceptionally very heavy rainfall over Haryana, Punjab and Himachal Pradesh during 24-27 September 1988 was associated with the low level easterly trough which was overlain by upper level diffluent westerly trough. The case study of this phenomenon is reported here.

Key words — Rainfall, Trough, Blocking High, Mid and upper troposphere.

1. Introduction

Over northwest India, particularly in the months of August and September, widespread rainfall sometimes with heavy to very heavy falls occurs in association with low level easterly systems and upper level westerly systems. This is more so when the low level easterly systems are in phase and are overlain by upper level westerly systems. When a westerly trough aloft moves slowly across northwest India or remains stationary for 2 to 3 days and if there is a low level easterly system, then because of interaction of these two systems heavy to very heavy falls occur over northwest India which cause floods. Presence of blocking high in the mid and upper troposphere over western Tibet will help the slow movement of upper tropospheric westerly trough and cause increased rainfall activity.

An interesting synoptic situation is reported here where the low level easterly trough and upper level westerly trough overlaid one over the other and caused very heavy to exceptionally heavy rainfall during 24-27 September 1988 over Haryana, Punjab and Himachal Pradesh leading to floods. The synoptic and dynamic aspects of the case are reported here as a case study.

2. Rainfall

During 24 to 27 September 1988 heavy to exceptionally heavy rainfall causing floods occurred over Haryana, Punjab and Himachal Pradesh and also in some parts of Jammu & Kashmir.

Figs. 1 (a & b) show the significant amounts of rainfall on 24 and 25 September 1988.

Fig. 2 gives percentage departure from normal of districtwise weekly rainfall for the period 22-28 September 1988 over northwest India and adjoining Jammu & Kashmir. Very high values of positive percentage departures from normal, some even exceeding 4000, are noteworthy.

Figs. 1 & 2 show that very heavy rainfall of the order of more than 20 cm occurred at many places which caused floods.

3. INSAT-1B cloud imagery

INSAT-1B cloud imageries from 0000 UTC of 22 to 1200 UTC of 26 September were examined. It is observed that there was intense to very intense convection with broken multi-layered clouds prevailing over Haryana, Punjab, Himachal Pradesh and Jammu & Kashmir. INSAT-1B bulletin of 24 September at 0600 UTC is as follows:

Broken multi-layered clouds with embedded intense convection over northern parts of west Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Punjab and north Rajasthan. Scattered low/medium clouds with embedded moderate convection over rest Haryana, south and east Rajasthan and adjoining east Uttar Pradesh.

4. Synoptic situation

Synoptic situation which caused heavy rainfall over Haryana, Punjab and Himachal Pradesh during 23-26 September 1988 is as follows:

A trough in the easterly from southwest Madhya Pradesh to Haryana extending upto 500 hPa level

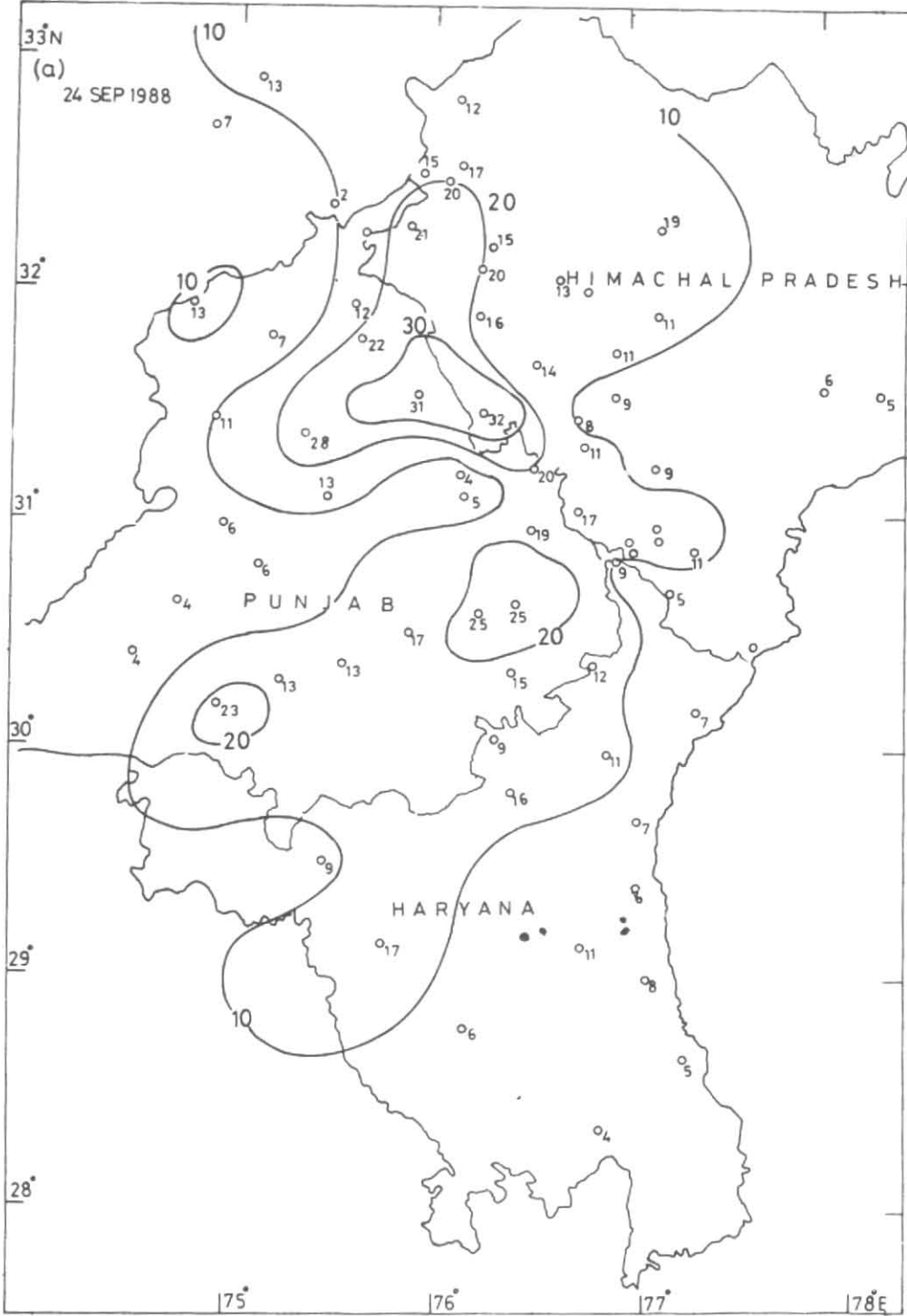


Fig. 1 (a). Significant amounts of rainfall (cm) on 24 September 1988

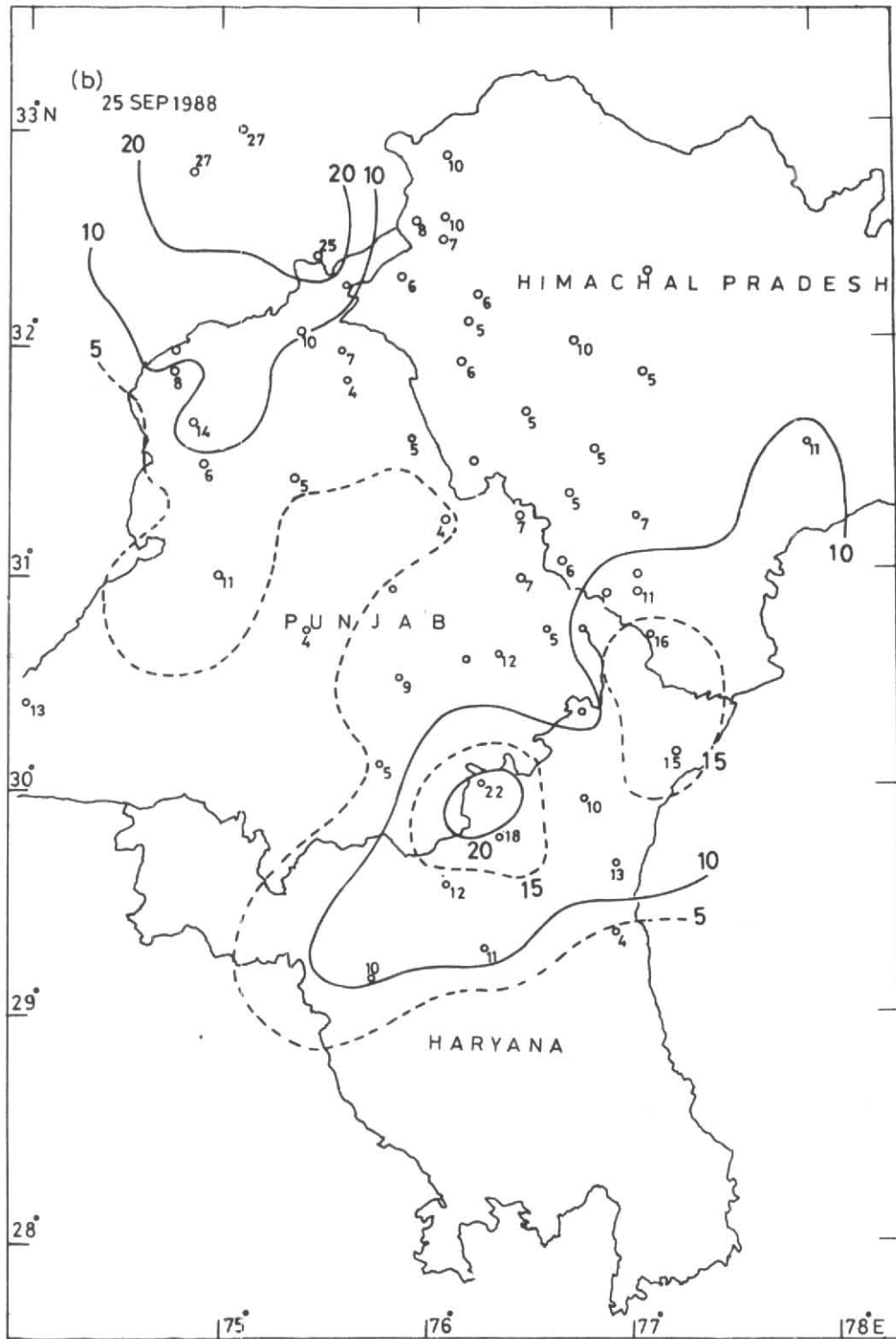


Fig. 1 (b). Significant amounts of rainfall (cm) on 25 September 1988

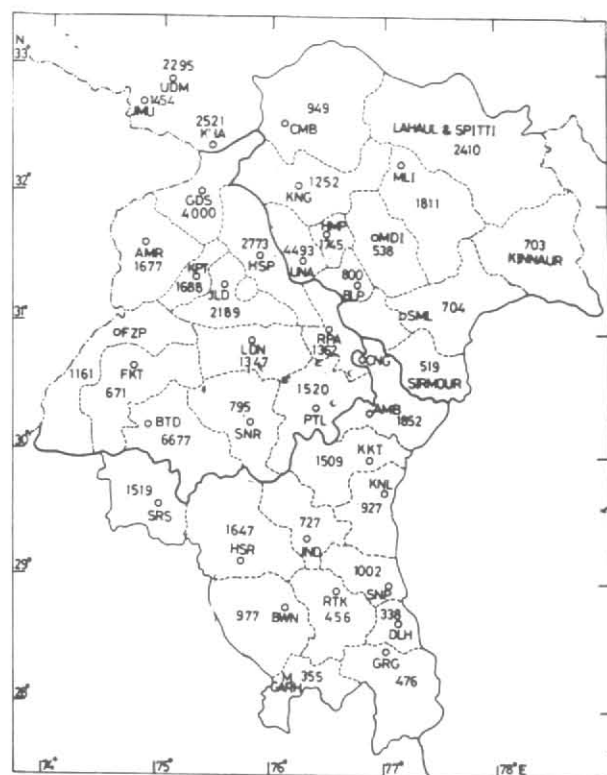


Fig. 2. Percentage departure of districtwise rainfall during 22-28 September 1988

persisted from 22nd-26th. This trough did not have any tilt with height. In the mid and upper troposphere, there was a diffluent westerly trough along Long. 68°E, north of Lat. 22°N between 23rd to 26th. This trough remained practically stationary during the above period. In addition, there was a blocking high over western Tibet between 400 to 200 hPa level, which inhibited the movement of the westerly trough aloft. The forward sector of the westerly trough was superimposed over the low level easterly trough. The divergence field in the forward sector of the westerly trough was overlain over the convergent field of the rear sector of the low level easterly trough and gave rise to strong vertical motion. The feed of moisture from Bay of Bengal through the low level southeasterly flow was equally significant. As a result Punjab, Haryana, Himachal Pradesh and also parts of Jammu & Kashmir received exceptionally heavy rainfall on 24 and 25. The details of which are given under section 2.

The upper wind chart of 22 September for 850 hPa level shows a cyclonic circulation over north Madhya Maharashtra and neighbourhood. A trough in easterlies from this system extends to Haryana and Punjab. The same synoptic situation

is seen at 700 to 500 hPa level. At 300 to 200 hPa level a westerly diffluent trough is seen around Long. 65°E, roughly north of Lat. 25°N.

Fig. 3 shows the charts of rainfall for 23 to 26 September 1988 from observatory stations. In these charts, low level easterly and upper level westerly troughs are marked for the previous day as given in the legend. It could be seen from these charts that heavy to very heavy rainfall occurred in the rear sector of the low level easterly trough. In the forward sector of the low level easterly trough the rainfall is almost absent. It is worth noting that on 24 and 25 September, exceptionally heavy rainfall occurred when the low level easterly trough did not have tilt upto 700 hPa level and upper level westerly trough did not have any tilt between 500 and 200 hPa levels. Further, the low level easterly and the upper level westerly troughs were very close separated by 5° to 6° Long.

5. Vorticity, divergence and vertical velocity

Fields of vorticity, divergence and vertical velocity of 700 and 300 hPa level on 23 and 24 September were calculated. A few diagrams of

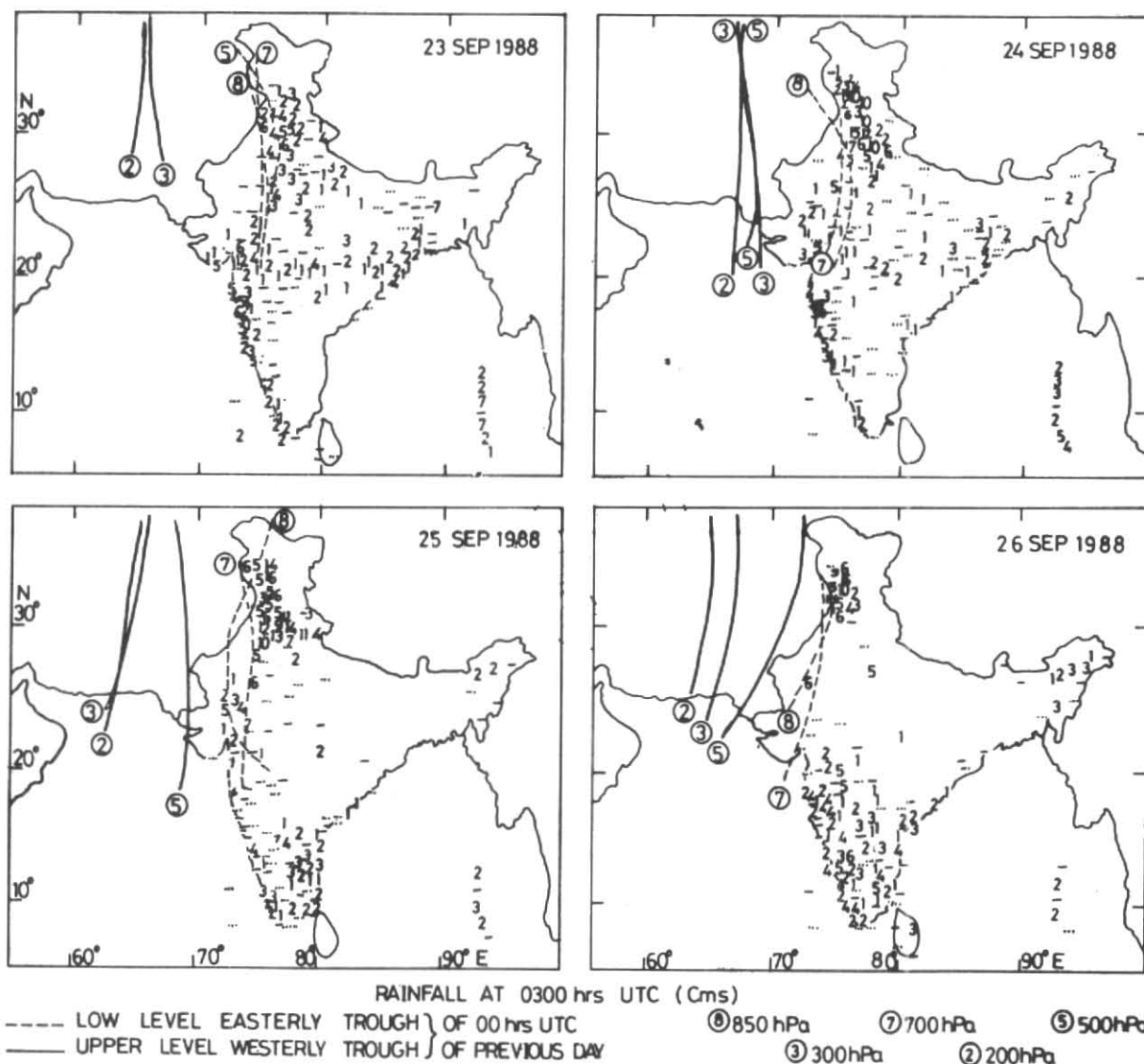


Fig. 3. Rainfall (cm) at 0300 UTC

divergence and vertical velocity are given in Figs. 4 (a-f). Vorticity and divergence are calculated by finite difference method and vertical velocities are calculated from equation of continuity in pressure co-ordinate system. Horizontal divergence (henceforth called divergence, D) and relative vorticity (henceforth called vorticity, ξ) are expressed in local co-ordinate system as below :

$$D = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}$$

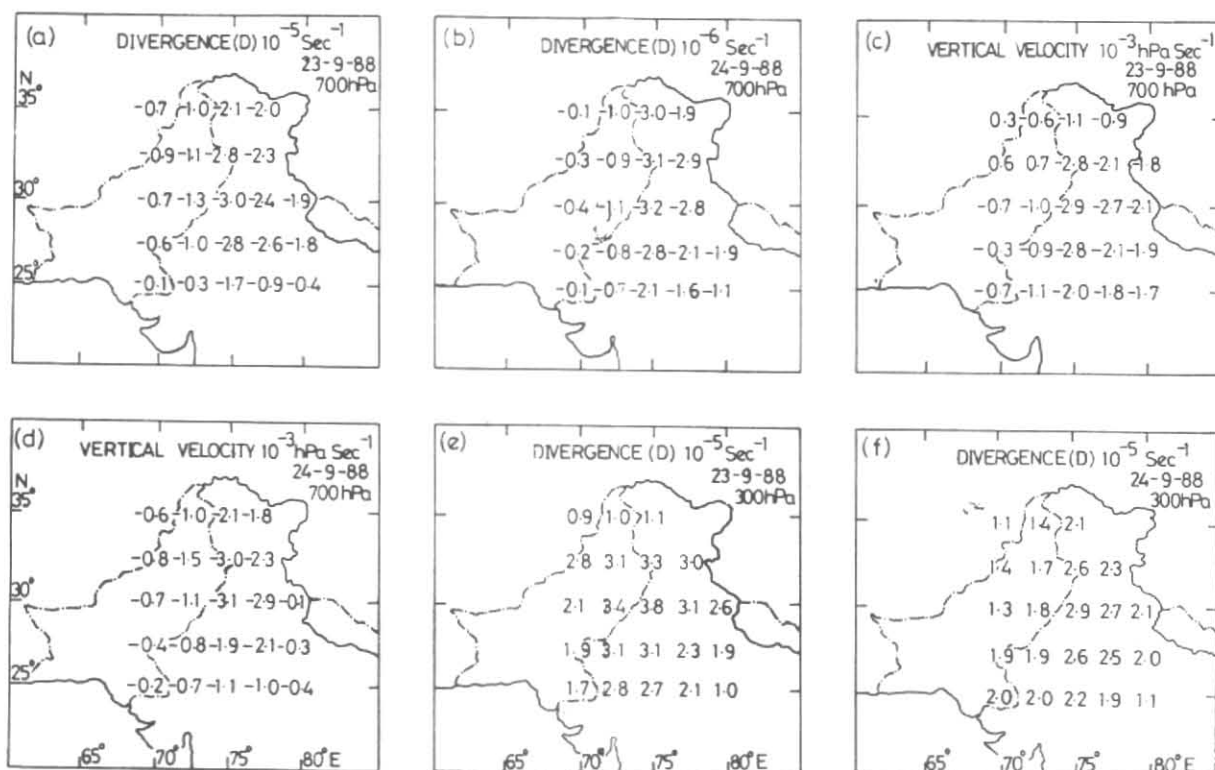
$$= \frac{u(x_0+d) - u(x_0-d)}{2d} + \frac{v(y_0+d) - v(y_0-d)}{2d} \quad (1)$$

$$\xi = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$$

$$= \frac{v(y_0+d) - v(y_0-d)}{2d} - \frac{u(x_0+d) - u(x_0-d)}{2d} \quad (2)$$

D and ξ are calculated by using finite difference method and expressed in the units of 10^{-5} sec^{-1} .

Vertical velocity is calculated by using equation of continuity in pressure co-ordinate system between two pressure surfaces p_0 and



Figs. 4(a-f). Divergence and convergence on 23 and 24 September 1988 respectively

p_1 separated by ∂p . The equation used is

$$w(p_1) = w(p_0) + (p_0 - p_1) \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right)_p \quad (3)$$

and expressed in units of 10^{-3} hPa sec^{-1} . The details are given in any standard text book (Holton 1973).

At 700 hPa level on 23rd and 24th, it may be noted that there is a very strong field of convergence [Figs. 4 (a & b)], positive relative vorticity and vertical velocity [Figs. 4 (c & d)] in the rear sector of the low level easterly trough. At 300 hPa level on 23rd and 24th there is strong field of divergence [Figs. 4 (e & f)] and negative relative vorticity (Fig. not given) in the forward sector of the upper level diffluent westerly trough.

6. Conclusions

Heavy to exceptionally very heavy rainfall over Haryana, Punjab and Himachal Pradesh occurred in association with the following synoptic situations.

When the rear sector of the low level easterly trough is overlain by the forward sector of the

diffluent, slow moving or nearly stationary upper level westerly trough, the area in the rear sector of the easterly trough gets exceptionally very heavy rainfall. The above situation caused heavy to exceptionally very heavy rainfall over Punjab, Haryana and Himachal Pradesh during 24th-25th September 1988 and is reported here as a case study.

Acknowledgement

We thank Shri M. V. Mande, who assisted in writing this paper.

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