

## Letters to the Editor

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### HEAVY RAINS AND LANDSLIDES IN PAURI GARHWAL AND NAINITAL DISTRICTS (UTTAR PRADESH) DURING 9-10 JULY 1990 — A CASE STUDY

1. Synoptic situation causing heavy rain, which occurred in Pauri Garhwal and Nainital districts of hills of Uttar Pradesh during the period 9 to 10 July 1990, has been studied. The heavy rains occurred due to a cyclonic circulation over Haryana, Punjab and northwest U. P. embedded in the monsoon trough and extending up to 3.1 km asl with a trough aloft. The lower level convergence area was overlain by upper air divergence. Under the influence of these systems torrential rains occurred causing massive landslides, at Talai village in Pauri Garhwal. According to press reports as many as sixty three persons were killed and Kumaon hills region was practically cut off due to landslides. Many tourists were stranded in Nainital owing to disruption of rail and road traffic.

1.1. During the monsoon season hills of west U. P. get heavy to very heavy rainfall when depressions and low pressure areas forming over Bay of Bengal reach northwest U.P. In such situations incursion of moisture takes place predominantly from north Arabian Sea. Rainfall over hills of west U. P. is also accentuated due to orographic influence and favourable flow pattern in the lower troposphere. In the case under study some parts of northwest U.P. received exceptionally heavy rainfall during the period 9-10 July 1990. Kathgodam recorded 37 cm, Pithoragarh 34 cm, Dataganj and Paliakalan 30 cm each, Moradabad 28 cm during the two day period. The heaviest 24 hrs rainfall amounts of 23 cm at Hardwar, 22 cm at Haldwani were recorded on 9 July and of amounts 22 cm at Dhampur, 21 cm at Haldwani were reported on 10 July 1990. These concentrated exceptionally heavy rains completely paralysed life in Pauri Garhwal, Nainital, Moradabad and Lakhimpur Kheri. The synoptic situations leading to interaction of troughs in easterlies and westerlies causing very heavy to exceptionally heavy rainfall have been discussed in this paper.

2. A cyclonic circulation which was seen over southwest U.P. from 1 July to 3 July developed into a

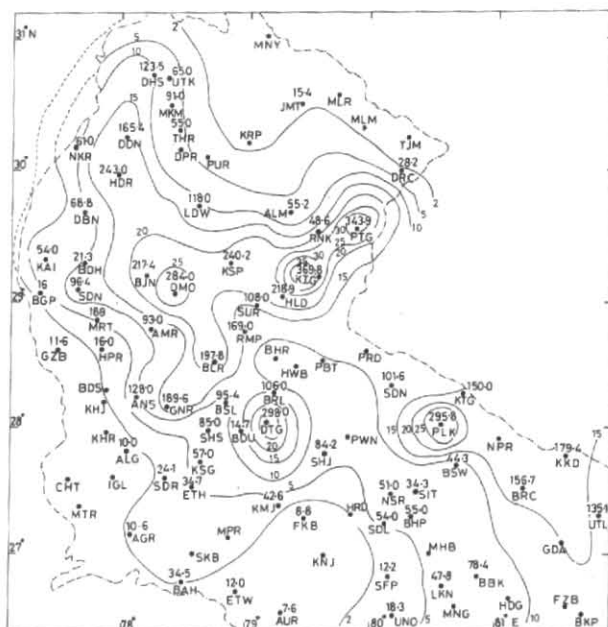


Fig. 1. Isohyetal pattern of rainstorm on 9-10 July 1990

low pressure area and moved in a westerly direction. It persisted over Rajasthan and adjoining areas from 4 to 6 July. While moving in northwesterly direction it lay over north Rajasthan and adjoining areas on 7 July. It was seen as a cyclonic circulation on 8 July over Punjab, Haryana and adjoining northwest U.P. From Fig. 2, in which movement of troughs in westerlies and easterlies have been shown, it is seen that between 0000 UTC and 1200 UTC of 8 July trough in westerlies shifted eastward by 10 degrees but retrogradation has been noticed from 1200 UTC of 8 July to 0000 UTC of 10 July and on 10 July at 0000 UTC it was seen roughly along 75°E. By 1200 UTC of 10 July troughs in westerlies and easterlies both moved eastward and were no longer seen in phase.

3. Isohyetal pattern of rain storm on 9 and 10 July, combined, has been shown in Fig. 1. The cyclonic circulation over Haryana, Punjab and adjoining northwest U.P. between 8 July and 10 July in

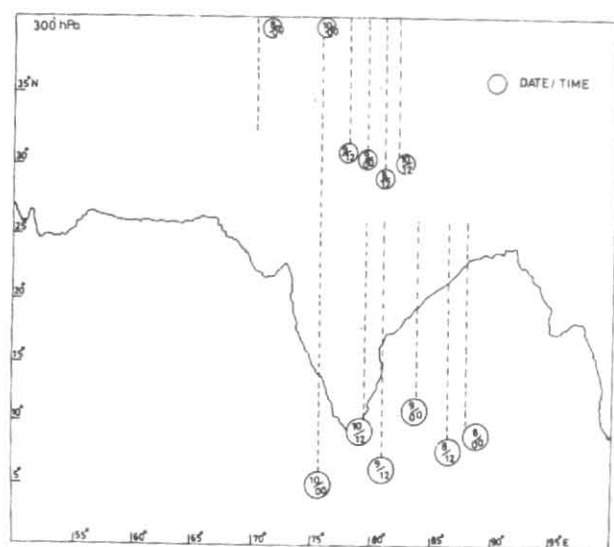


Fig. 2. Movement of trough in westerlies and easterlies

association with interacting troughs in westerlies and easterlies caused very heavy and exceptionally heavy rainfall in Pauri Garhwal, Meerut, Nainital, Rampur, Moradabad and Bahraich districts.

4. Precipitable water content is another criteria which is given considerable weightage in forecasting day-to-day rainfall. Mukherjee (1969) has emphasised the role of mixing ratio value at 700 hPa in forecasting rainfall in the absence of prominent synoptic situation like depression or cyclonic storm affecting the region. The variation of precipitable water contents from surface to 700 and 500 hPa levels from the period 8 to 10 July 1990 has been shown in Fig. 3. The values of mixing ratio were calculated from the tephigrams and precipitable water content was calculated by using the formulae :

$$W = 0.0005 (q_1 + q_2) P$$

where,

$W$  = Precipitable water content,

$P = P_2 - P_1$ ,

$P_1$  = Pressure at level 1,

$P_2$  = Pressure at level 2,

$q_1$  = Specific humidity at pressure  $P_1$ ,

$q_2$  = Specific humidity at pressure  $P_2$ .

The unit of precipitable water is cubic centimetre and as the density of water is unity, the unit of precipitable water may be taken as gram.

From Fig. 3, it is seen that there is a gradual fall in precipitable water content at Lucknow from 8 July 1990. From the curve indicating the variation in

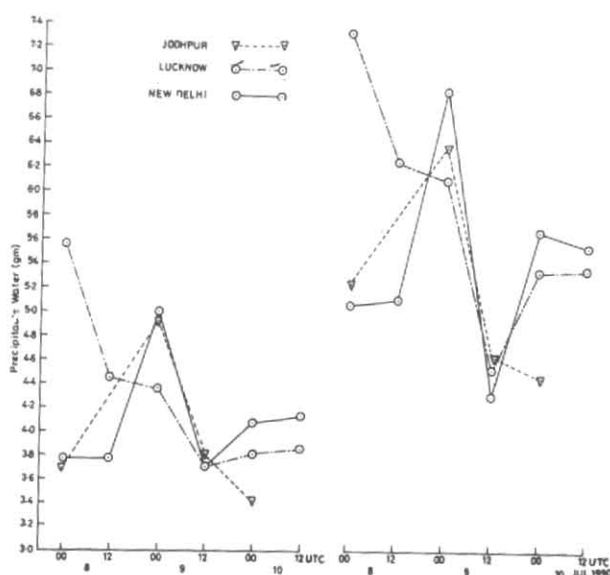


Fig. 3. Precipitable water from surface to 700 hPa and 500 hPa

precipitable water at Jodhpur it is seen that between 0000 UTC of 8 July and 0000 UTC of 9 July there is an appreciable rise followed by fall in precipitable water content. In case of Delhi between 8 July and 9 July rise is observed followed by fall up to 1200 UTC and then steady rise. Looking at the precipitable water content curve at 500 hPa it is seen that in respect of Lucknow, there is steep fall between 8 and 9 July followed by a rising trend, whereas in case of Delhi initially steady and then rising trend has been noticed upto 9 July followed by sharp fall and rise later on. The curve for Jodhpur is similar, to that of Delhi. Variations in precipitable water content over Jodhpur and Delhi suggest considerable moisture incursion over west U.P. from northeast Arabian Sea between 8 and 9 July. Rainfall recorded at 0830 IST of July 9 and 10 indicates increased activity of precipitation in west U.P. in general and northwest U.P. in particular on 10 July whereas increased rainfall activity was noticed in east U.P. on 9 July, a day after the precipitable water content at Delhi, Jodhpur (representing west U.P.) and Lucknow (representing east U.P.) was maximum.

5. Ghosh and Veeraraghavan (1974) have highlighted the role of troughs in westerlies at 300 hPa in enhancing the precipitation during monsoon season. The convergence associated with vertical lift of moisture laden air on 9 July around the cyclonic circulation region in lower level was superimposed by high level divergence provided by trough in westerly coupled with orographic influence of the region

yielded torrential precipitation causing landslide in Pauri Garhwal and Kumaon hill areas. The value of convergence at 900 m asl for the area Patiala, Lucknow and Jodhpur on 9 July 1990 at 1200 UTC was found to be  $0.21 \times 10^{-5}/\text{sec}$  and divergence at 300 hPa on same area at same time was found to be  $0.41 \times 10^{-5}/\text{sec}$ . It was calculated by Bellamy's method.

6. The vertical motion provided by the orographic influence and convergence/divergence superimposed over the moisture laden area in northwest U.P. and interaction of westerly and easterly trough due to retrogradation of troughs in westerlies gave rise to exceptionally heavy precipitation.

7. Authors are thankful to Shri S. R. Puri, Dy. Director General of Meteorology and Shri Bhukan Lal, Director (Research), Regional Meteorological Centre, New Delhi for offering valuable suggestions and to Miss Kalpana Srivastava for typing the script.

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