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Hydrometeorological Aspects of September 1988 Storm Over Western Himalayas

K.S. Ramasastri
Western Himalayan Regional Centre
National Institute of Hydrology,
Jammu (INDIA)

SYNOPSIS

The western Himalayan region covers the hilly areas in the states of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh in India. The rivers in the region namely Jhelum, Chenab, Ravi, Beas, Sutlej, upper Yamuna and upper Ganga occasionally experience floods caused by intense storms. These storms occur as a result of an interplay of tropical and extratropical weather systems both at surface as well as in the lower and middle troposphere.

The severe floods in the past such as Sept 1947 and Oct 1955 in Punjab and August 1957 in Jammu and Kashmir are noteworthy. One storm which has caused flooding over vast areas in the western Himalayan region is the Sept 1988 storm. The storm was identical to the Oct 1955 storm in respect of rain depths as well as areal extent. Some of the hydrometeorological aspects of the Sept 1988 storm including its temporal distribution at different locations are presented and discussed.

Introduction :

The western Himalayas cover the hilly areas in the states of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh in northern India. The rivers originating from this region are the Indus, Jhelum, Chenab, Ravi, Beas and Sutlej of the Indus system and Yamuna, Ganga, Ramganga, Sarada and Karnali of the Ganga basin. The rivers are fed by snowmelt and rainfall in the summer and baseflow from springs in the winter. In the hills precipitation (rainfall and snowfall) is evenly distributed in summer and winter. The mean annual precipitation is in the range of 100 to 150 cm.

Floods :

Floods in the Indus system are occasional though they are frequent in the Ganga basin. Floods do not occur due to snowmelt. High intensity rainstorms coupled with wet antecedent conditions are generally responsible for the floods in rivers originating from this region.

In September 1988, a combination of weather systems during the period 20th to 26th September led to very heavy rainfall and floods during the period 23rd to 27th September in the rivers Jhelum, Chenab, Ravi, Beas, Sutlej. Floods were also reported in the catchment of Yamuna above Delhi (Basandra et al, 1990).

The Tawi at Jammu bridge recorded a maximum flood discharge of 6400 cumecs at 1300 hrs on 25th September 1988. Rao and Madan (1989) reviewed the design flood for Salal on Chenab based on the Sept 1988 storm. In Ravi the discharge at Ranjit Sagar dam was observed to be 24069.5 cumecs at 1330 hrs on 25th September. The previous highest discharge in Ravi was observed in Otober 1955 which was less than that observed in Sept 1988.

In Beas an outflow of 7702.2 cumec from Pong dam was joined by a peak flood of 4247.5 cumecs from Swan nadi on 25th September In Sutlej a maximum flood discharge of 13535.5 cumecs was observed at Ropar on 26th Sept. This is very close to the highest ever discharge of 13875.3 cumec observed at Ropar in 1947 (Avtar Singh, 1989).

The Yamuna crossed the danger level of 204.83 m at Delhi Railway bridge at 0230 hrs on 26th Sept and attained a maximum level of 206.9 m at 1300 hr on 27th September.

Weather Systems :

The main systems responsible for heavy to very heavy rainfall in the western Himalayas were a low pressure system over central Arabian sea and adjoining north Maharashtra, south Gujarat coast and another well marked low pressure area over west Madhya Pradesh and neighbourhood which formed during 17th to 20th September 1988. They merged together and the system was lying as a low pressure area over north Gujarat and south Rajasthan on 24th Sept. In association with this system there was also an upper air cyclonic circulation extending upto mid tropospheric levels moving across Himachal Pradesh.

The other system which helped the above mentioned cyclonic circulation in drawing up copious moisture resulting in heavy to very heavy rainfall was a westerly trough in mid and upper troposphere with its axis at 500 mb fluctuating between 67 E and 75 E and north of 25 N during the period from 22nd to 26th September.

A third system which influenced the rainfall occurrence on 26th and 27th was an upper air cyclonic circulation extending upto mid tropspheric levels over north Rajasthan and adjoining Haryana on 25th and 26th September.

Interpretation of satellite pictures alongwith synoptic charts suggested that the systems that formed over hills of Himachal Pradesh and Jammu and Kashmir were extra tropical in nature (Gupta, 1989)

Rainstorm Analysis :

The analysis of the rainstorm has been carried out on the basis of daily (Ø83Ø to Ø83Ø) rainfall recorded at non recording raingauge stations maintained by a number of organisations such as India Meteorological Department, Central Water Commission (CWC), Bhakra Beas Management Board (BBMB) and other State organisations. Also hourly rainfall data recorded through self recording raingauge stations of CWC, BBMB and National Institute of Hydrology have been used for studying the temporal distribution.

For the purpose of determining the flood potential of the storms, not only the study of the areal depths over different durations but also the depth of rainfall in the different catchments on each day during the storm would be required. This is necessary in view of the movement of the storm centre each day as guided by the weather systems controlling the rainfall.

Depth area duration analysis for highest 1 day, 2 day and 3 day total storm values during the period 23rd to 27th September have been carried out. Average catchment depths for each day on 24th, 25th and 26th Sept were computed for Chenab, Ravi, Beas, Sutlej and Yamuna. There was some significant rainfall over some catchments on 23rd and 27th Sept. The results are presented in tables 1 and 2 respectively. The isohyetal pattern of the highest one day storm of 24th Sept is shown in Figure 1.

The isohyetal pattern indicated that the storm intensities were more in the foot hills than over the higher mountains. There are more than three storm centres indicating the presence of a number of storm cells imbedded in the larger synoptic system.

It may be seen from Table 1 that the rainfall depths of the Sept 1988 storm are high even over larger areas for all durations. A comparison of the rainfall depths of this storm with those of October 1955 storm given by Dhar and Rakhecha (1976) indicated that the depths of September 1988 are higher over all areas and all durations. Unlike the October 1955 storm, the September 1988 storm extended into the interior of Himalayas covering the Pir panjal range.

Table 1 : Rainfall Depths (cm) for different durations 24 - 26 September 1988

Area in Sq. Km	1 day 24 Sept	2 day 24-25 Sept	3 day 24-26 Sept
Principal Centre	Nawanshahar	Nawanshahar	Basholi
value	51.4	64.9	81.1
500	51.0	61.0	80.7
1000	49.0	59.5	77.5
2000	47.0	56.3	73.5
5000	41.7	50.0	66.0
10000	38.0	46.2	58.5
20000	33.5	42.2	51.5
30000	30.0	40.5	48.0
50000	24.0	38.2	44.0
75000	21.5	36.0	40.8
100000	20.5	33.3	38.3
150000	-	29.5	33.5
200000	-	25.0	-

Table 2 : Average daily Raindepth (mm) over different catchments

S.No	River	Site	24thSept	25th Sept	26th Sept
1.	Chenab	Akhnoor	95.3	135.6	67.5
2.	Ravi	Madhopur	159.4	137.1	154.6
3.	Beas	Mukerian	79.9	76.0	116.8
4.	Sutlej	Bhakra Dam	87.3	49.1	34.4
5.	Yamuna	Paonta Sahib	58.5	100.2	25.5

Rao and Madan (1989) found that the Sept 1988 storm yielded highest raindepths in Chenab basin as compared to the previous storms.

Rainfall distribution in time :

Unlike the storms which occurred in the past hourly rainfall data recorded at a number of recording raingauges is available for the September 1988 storm. This facilitated the study of distribution of rainfall in time during the period 23rd to 26th September. The rainfall hyetograph of Roorkee (Upper Ganga), Bhakra Dam (Sutlej) and Bhadarwah (Chenab) are given in figures 2 (a) to 2 (c).

An examination of the the hyetographs revealed that the storm has occurred as a single intense spell in the foothills of Uttar Pradesh as indicated by Roorkee whereas in Sutlej and neighbouring upper Yamuna, the rainfall occurred continuously over a longer duration as seen from hyetograph at Bhakra Dam. Rainfall was also continuous though comparatively less intense over Chenab basin as indicated by hyetograph at Bhadarwah.

The highest rainfall recorded was 7.2 cm in 1 hr during 1300 hr to 1400 hr and 10.5 cm in 2 hr during 1200 to 1400 hr on 26th Sept. at Bhakra Dam. The time distribution of the two important spells on 23-24 Sept and 25-26 Sept 1988 at Bhakra Dam are given below.

BHAKRA DAM

Date : 23 - 24 Sept (Total 24 hr rainfall : 297.5 mm)

Time :	1	2	3	6	12	24 hours
%	10	20	25	35	61	100

Date : 25 - 26 Sept (Total 24 hr rainfall : 267.0 mm)

Time :	1	2	3	6	12	24 hours
%	27	39	43	50	65	100

The time distribution of 23 - 24 Sept compares with the time distribution adopted by Rao and Madan (1989) for PMF of Salal Dam.

Conclusions

From the results it could be concluded that

(i) The rainstorm of September 1988 was widespread on all the three days during 24th to 26th September covering the mountainous and sub mountainous areas in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and plains of Punjab and Haryana.

(ii) The storm intensities were more in the foot hills than over the higher mountains.

(iii) The floods in the different rivers were the result of heavy and continuous rainfall on 5 days starting with 23rd Sept and ending on 27th Sept. 1988

(iv) Storm intensities were especially heavy and continuous over the catchment of Sutlej above and below Bhakra dam. The 6 hour total rainfall was 50 % of the total 24 hours rainfall on 25 - 26 Sept 1988 at Bhakra Dam.

(v) The three storm centres were located in the three basins namely Chenab, Ravi, and Sutlej

(vi) The storm depths were higher than the depths of October 1955, the severest storm recorded in the past

References

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Figure 1 : One Day (24 Sept 1988) Storm Isohyetal Pattern
Isohyet in Cm

Figure 2 a : ROORKEE

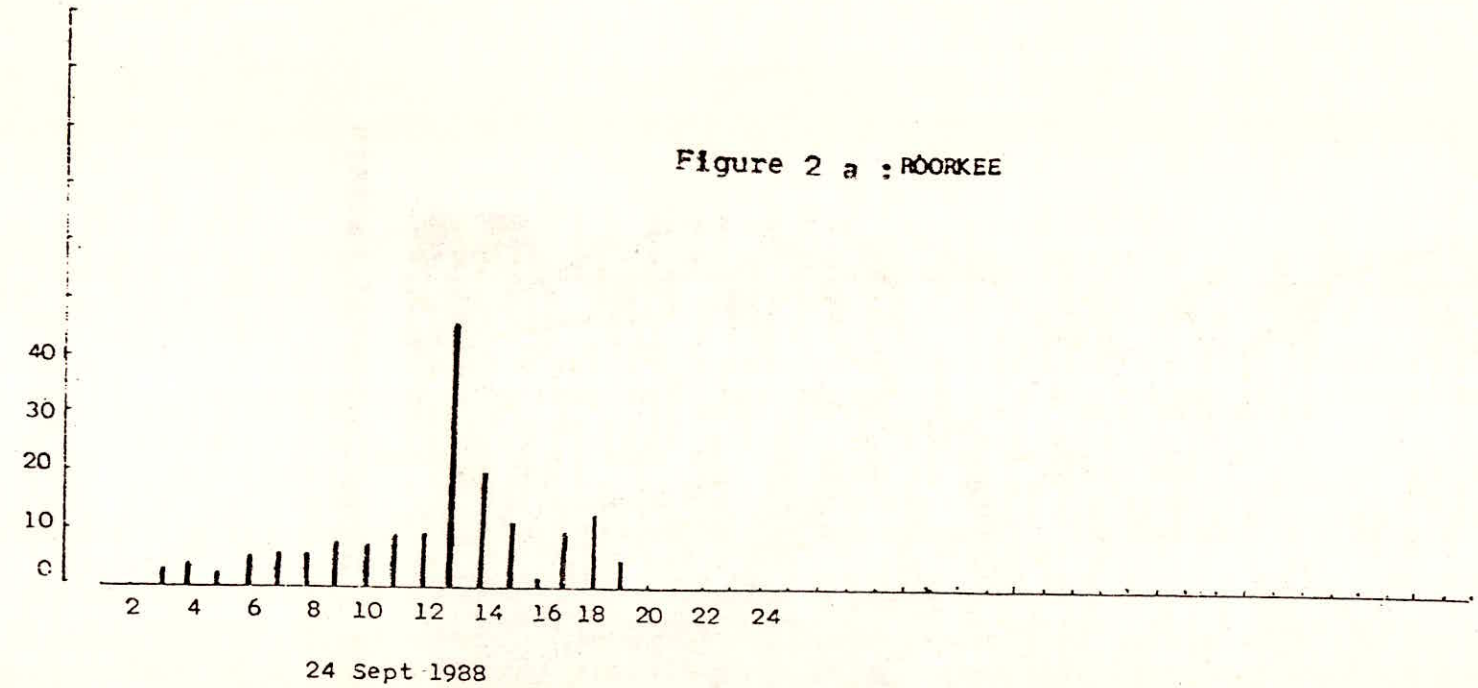


Figure 2b: BHAKRA DAM

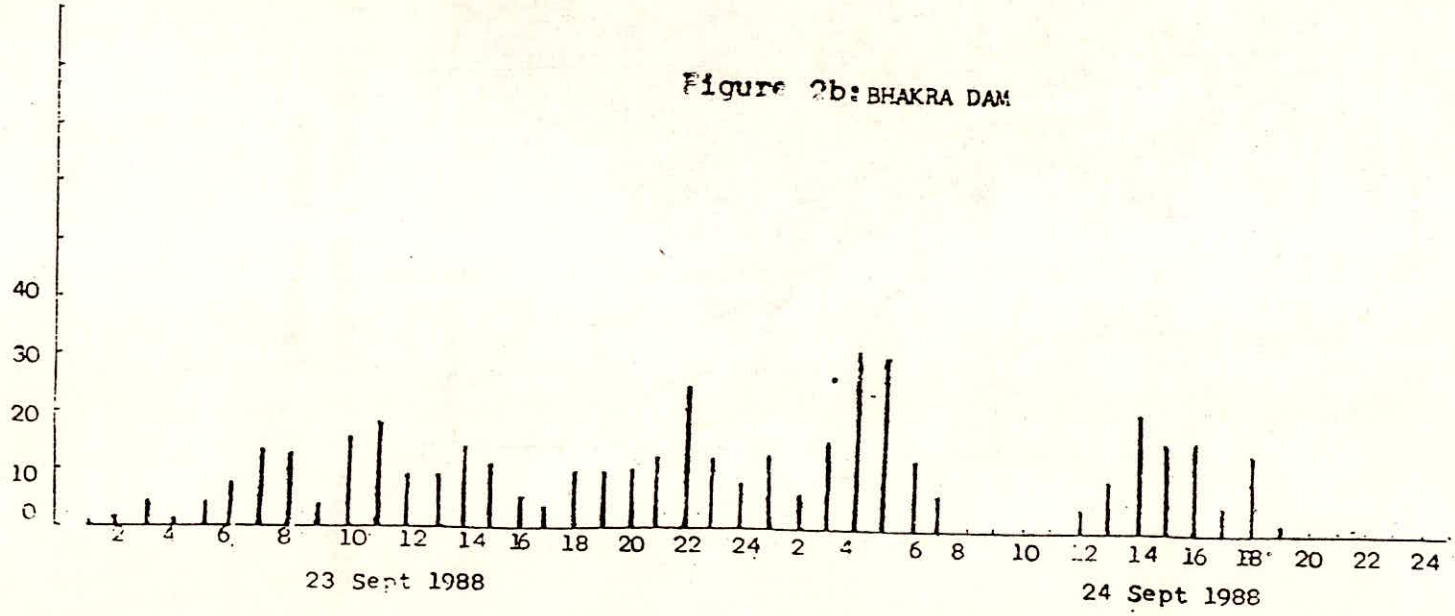
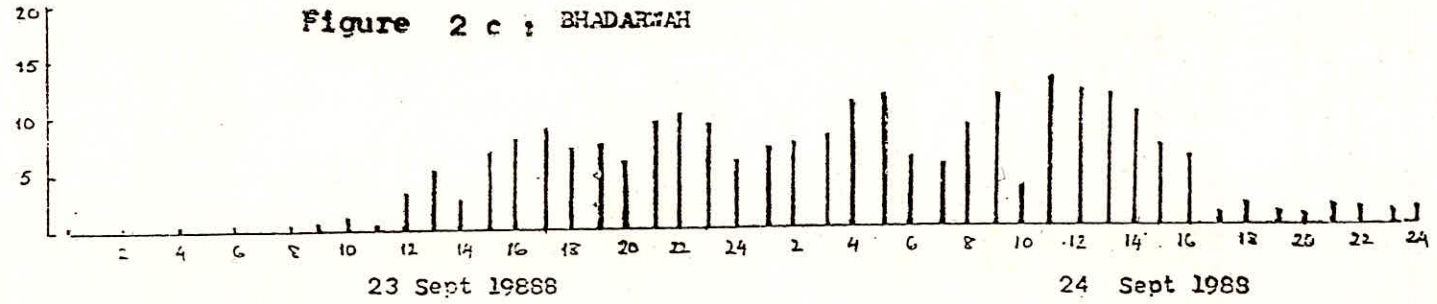
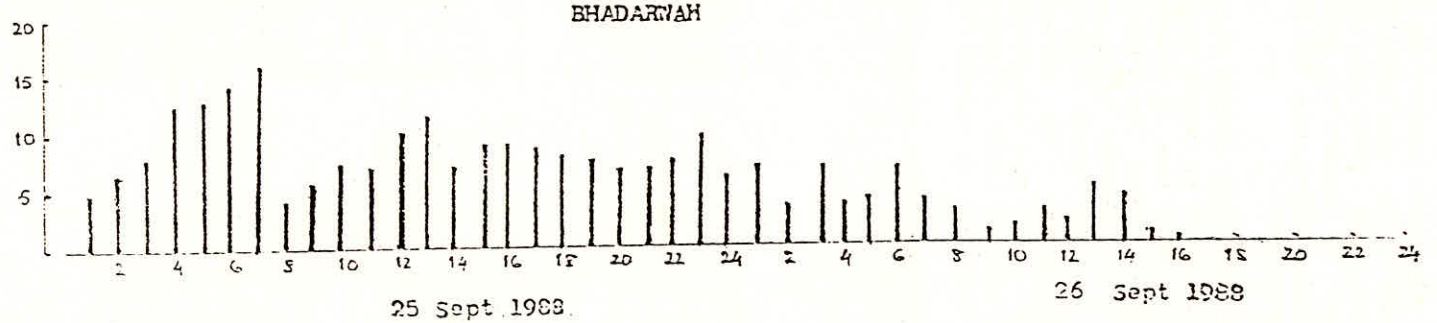


Figure 2 c : BHADARWAH



23 Sept 19888 24 Sept 1988

BHADARWAH



25 Sept 1988 26 Sept 1988

DISCUSSION

S. M. SETH : How the precipitation and temperature conditions vary with elevation ? Whether Sept.'88 storm represented similar pattern with respect to elevation ?

AUTHOR(S) : Studies in the Himalayas by several authors have shown that the precipitation increases approximately upto 2500 m and decreases thereafter. However, not many studies have been reported on the precipitation pattern during storm periods. Temperature is known to decrease with elevation. However,the environmental lapse rate differs from the lapse rate found in the free atmosphere.

In the present study only precipitation distribution during storm period 24th to 26th September 1988 has been studied. Except in the case of the catchment of Yamuna where the heavy rain centre was located in the mountains,in the case of other principal rain centre they were located in the foothills of the Himalayas. A few heavy rain centres were also noted in hills in Chenab catchment. The reasons for this could be due to the presence of the mid tropospheric circulation which caused the precipitation and lack of any clear surface weather system which could have moved over the hills.

No studies have been done on the temperature distribution during the storm.