

## Meteorological factors associated with July 2005 floods in river Jhelum

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**सार** – इस शोध पत्र में जम्मू कश्मीर राज्य में जुलाई 2005 में झेलम नदी में आई बाढ़ की मौसम वैज्ञानिक स्थितियों का विश्लेषण किया गया है। उत्तरी पश्चिमी भारत के मैदानी भागों में मानसून विक्षोभ के पश्चिम की ओर बढ़ने तथा उत्तरी पाकिस्तान के मध्य क्षोभमंडल में द्रोणी के पूर्व की ओर बढ़ने के बीच अन्योन्य क्रिया के कारण जुलाई 2005 के दूसरे सप्ताह के दौरान बाढ़ के साथ-साथ राज्य में भारी वर्षा का दौर रहा। राज्य में वर्षा के और विश्लेषण करने से इससे पहले की शीत ऋतु के दौरान राज्य के अनेक केन्द्रों में काफी हिमपात के होने का पता चला है। कल्पना-1 उपग्रह से प्राप्त हुए आकलन से 1998 के बाद इस क्षेत्र में सबसे बड़े हिमाच्छादित क्षेत्र का भी पता चला है। हिमाच्छादित क्षेत्र में बढ़ती के कारण हिम के अधिक मात्रा में पिघलने के कारण भारी बाढ़ आई।

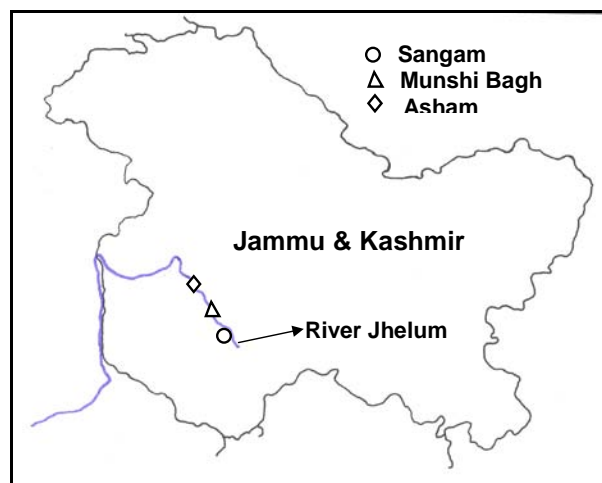
**ABSTRACT.** The meteorological conditions leading to the July, 2005 floods in river Jhelum in the state of Jammu & Kashmir have been analyzed in the present study. The floods coincided with a spell of heavy rains over the state during second week of July 2005 caused by the interaction of a westward moving monsoon disturbance over the plains of northwest India and an eastward moving trough in middle troposphere over north Pakistan. Further analysis of precipitation over the state during the preceding winter season shows that there was record snowfall at many stations over the state. The estimate from KALPANA-1 satellite also revealed the highest snow cover area over the region since 1998. The higher volume of snowmelt because of the increased snow cover area seems to have significantly contributed towards the floods.

**Key words** – Jhelum, Jammu and Kashmir, Floods, Monsoon, Western disturbance.

### 1. Introduction

Jammu and Kashmir has a long history of floods from the tributaries of Indus river mainly the rivers Jhelum, Chenab and Tawi. Rising from a deep spring at Vernag, the Jhelum meanders northwest from the northern slope of the Pir Panjal Range through the Vale of Kashmir to Wular Lake, which controls its flow. Emerging from the lake, it crosses the Pir Panjal in a 7,000 ft (2,100 metre) gorge en route to the Indus River. The total length of the river is about 725 km. Jhelum is mainly a snowfed perennial river. However, the monsoon precipitation also contributes significantly towards the discharge. The amount of runoff is important for filling the reservoirs and hence for the amount of water available for irrigation, power generation, municipal use and recreation (Dunne and Leopold, 1978).

Floods in Jammu and Kashmir are mainly caused by heavy rainfall in the catchments during the summer monsoon season (July-September) which is augmented by snowmelt flows. De Scally (1994) studied the relative importance of winter snow accumulation and monsoon



**Fig. 1.** Flood monitoring sites on river Jhelum

rainfall for estimating the runoff in the Jhelum river basin. Annual maximum snowpack and the total winter precipitation were found to be strongly correlated with the

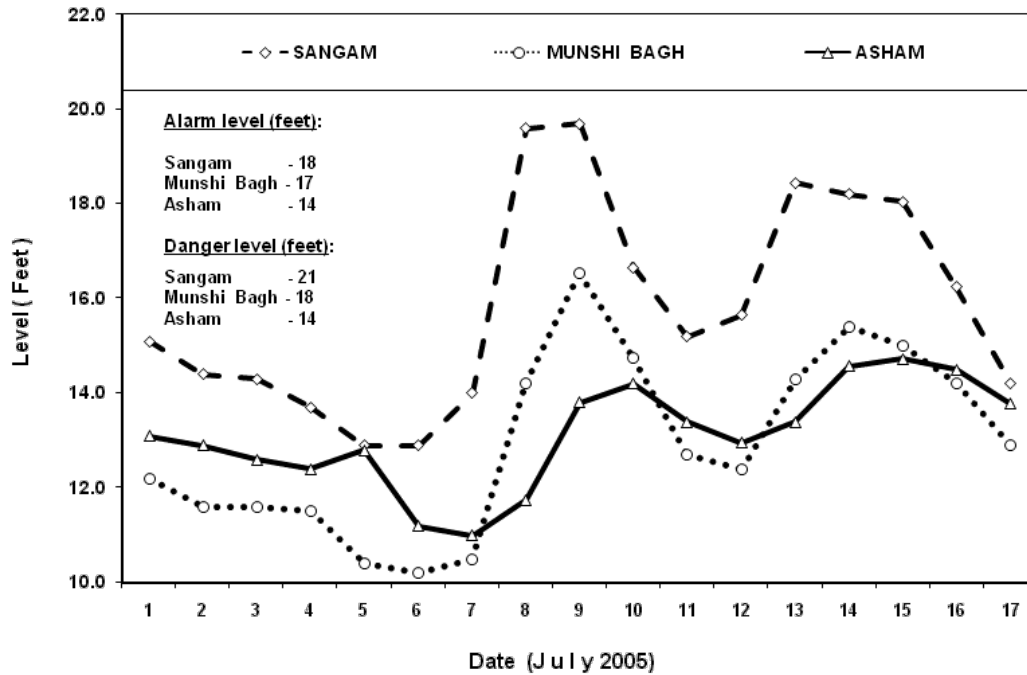


Fig. 2. Water level (feet) in river Jhelum at three monitoring sites – Snagam, Munshi Bagh and Asham

discharge. Rainfall during the period occurs due to the monsoonal systems (lows or depressions) coming from the Bay of Bengal. The frequency of monsoon depressions formed in Bay of Bengal is about 80% of the total number of depressions formed in the South Asia monsoon region (Pant & Kolli, 1997). One third of the depressions fill up on crossing  $85^{\circ}$  E and nearly half on crossing  $80^{\circ}$  E. When the depressions are fed by fresh moisture supply from the Arabian Sea branch of the monsoon, they may retain their intensity and take a westerly course to reach Gujarat state of India, causing very heavy rains in the region. On some occasions a westerly wave passing over the north Pakistan may take the depression under its grip and cause it to recurve initially in a northerly direction and then northeastwards, causing heavy rains in the upper areas of Punjab and adjoining areas of Jammu and Kashmir. The structure, track and movement of monsoon depressions and associated rainfall patterns have been studied and reviewed in detail (Sikka, 1977 and Pant and Kolli, 1997). Similar situation occurred in July 2005 when floods were reported in river Jhelum. The weather conditions which contributed towards these floods are described in this paper. Contribution of increased snow melt discharge towards these floods has also been examined. Not many studies are available on floods in

TABLE 1

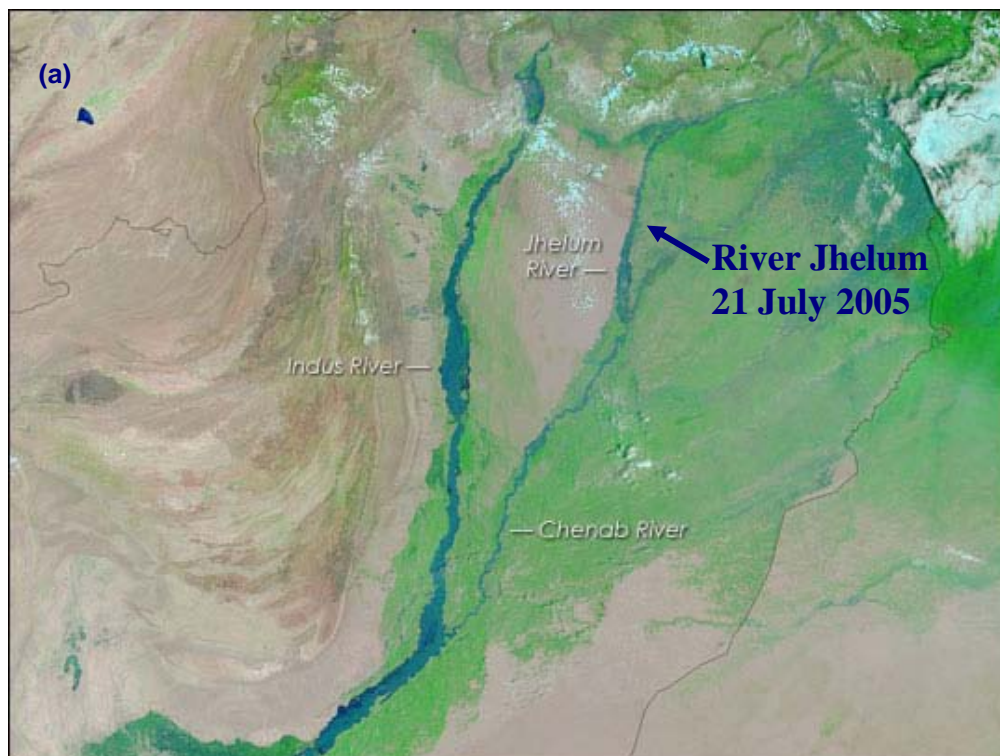
Rainfall (mm) during June & July 2005 over Jammu & Kashmir

Period	Actual	Normal	Departure (%)
June	28.6	58.5	-51
July	251.7	186.0	35
1 <sup>st</sup> week, July	43.0	29.0	47
2 <sup>nd</sup> week, July	130.0	34.0	284

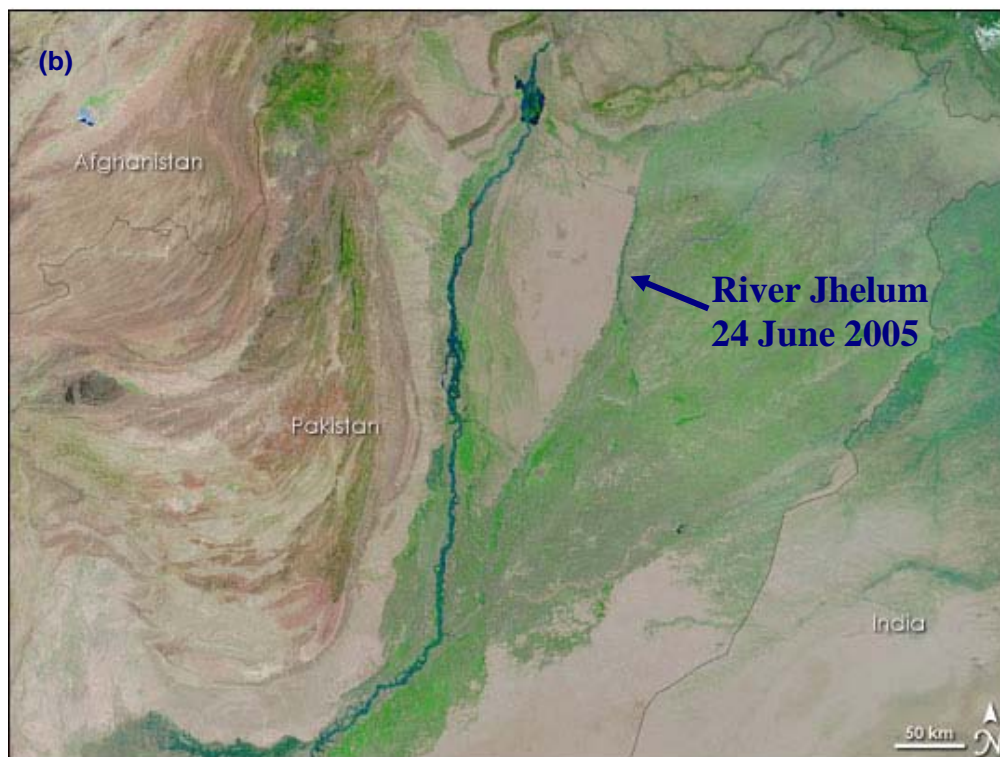
Jhelum in India. However, some studies are available on floods in Jhelum in Pakistan (Majeed, 1992 and Siddiqui *et al.*, 2003).

## 2. Data

Observed climatic variables – weekly, monthly and seasonal precipitation and temperature - from meteorological stations of India Meteorological Department, the precipitation data from the newly established automatic weather stations under multi-agency national project PARWAT and estimates of snow cover area from Kalpana-1 satellite have been used to study



July 21, 2005



June 24, 2005

**Figs. 3 (a&b).** Satellite imageries from NOAA dated (a) July 21 and (b) June 24, 2005 ([http://veimages.gsfc.nasa.gov/20122/Pakistan\\_TMO\\_2005202.jpg](http://veimages.gsfc.nasa.gov/20122/Pakistan_TMO_2005202.jpg))

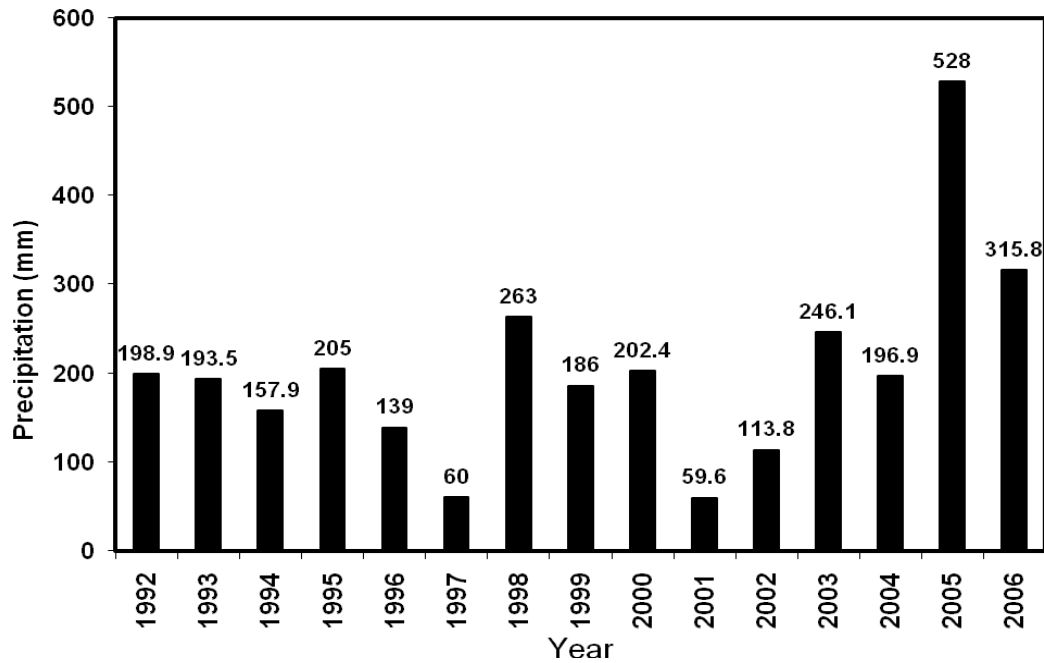


Fig. 4. Precipitation (equivalent to mm of liquid water) over J & K during winter season

these floods. The Government of Jammu & Kashmir monitors the flood levels at three sites - Sangam, Asham and Munshi Bagh on river Jhelum (Fig. 1). The gauge data of these three monitoring sites at river Jhelum have also been utilized in this study.

### 3. An overview of 2005 floods in Jhelum

Floods were reported in river Jhelum during July 2005 and flood alerts were issued by the Government of J & K. Though the floods were not very damaging in India, severe floods were reported in river Jhelum downstream in Pakistan. The leading Pakistani daily - The Dawn (14 July, 2005) published a report about high floods in river Jhelum with a total discharge of 93,600 cusecs at Mangla Dam. This daily reported decline in the flow in river Jhelum on 17 July, 2005 attributing it to the reduction in temperatures over northern areas. Analysis of flood data for the month of July 2005 as received from the office of Executive Engineer Floods (P & D) Division, Srinagar reveal that there were no floods during July 2005 in river Jhelum, although the water level in the river had reached alarm level at the gauge site Sangam and at danger level at gauge site Asham during the period 8<sup>th</sup> to 17<sup>th</sup> of July. The flood levels at three monitoring sites are given in Fig. 2. The satellite imageries from NOAA dated June 24 and July 21, 2005 (Fig. 3) also indicate swelling of river Jhelum in Pakistan territory around third week of July.

### 4. Weather over Jammu & Kashmir during June and July 2005

Jammu and Kashmir received heavy rainfall during July 2005, particularly in the second week when the state received heavy to very heavy rains. The state as a whole received 252 mm rainfall during the month against a normal of 186 mm which was 35 % above normal. More than 50 % of this rainfall was received in the second week only (130 mm against a normal of 34 mm). Rainfall over the state during June and July 2005, are given in Table 1. This heavy rainfall was caused by a monsoon depression moving west-northwestwards across Jharkhand, north Madhya Pradesh, and south Uttar Pradesh till 5<sup>th</sup> of July. This system was seen over southwest Uttar Pradesh & adjoining east Rajasthan on 6<sup>th</sup> as a well marked low pressure area. Subsequently it was seen as low pressure area over Haryana on 7<sup>th</sup>. It persisted as an upper air cyclonic circulation over northwest Rajasthan till 13<sup>th</sup>. A westerly trough in the middle troposphere moved concurrently across western Himalayan region. Typical interaction of tropical and extra tropical systems took place which resulted in enhanced rainfall over entire northwest India and Western Himalayan region.

This heavy rainfall in the state seems to be one of the factors contributing towards these floods. Snowmelt also has a significant contribution towards river water inflow in the Himalayan Rivers, particularly during summer.

TABLE 2

Precipitation during winter season 2001-2005 for the stations under project PARWAT

Station	Year				
	2001	2002	2003	2004	2005
Banihal Top	21	172	147	313	<b>738</b>
Gulmarg	165	376	148	255	<b>570</b>
Hiddan Taj	85	360	354	531	<b>677</b>
Stage-ii	33	611	477	474	<b>822</b>
Pharkian	77	537	455	322	<b>587</b>
Kanzalwan	51	451	459	374	<b>814</b>
Z-gali	84	397	490	280	<b>668</b>
Drass	56	138	167	120	<b>258</b>
Puttakhan	45	228	255	184	39
N.c.pass	81	462	430	581	146
Ragni	92	300	459	DNA*	DNA*
Himmat	72	62	137	334	<b>1129</b>
Sonapindi	83	343	159	399	<b>400</b>
Niru	71	290	102	179	<b>625</b>
Dawar	46	193	192	191	<b>296</b>
Pant	110	271	391	288	<b>786</b>
Sonamarg	102	250	243	190	<b>587</b>
Bim lc	106	106	224	234	<b>389</b>
Firm base	105	DNA*	60	146	<b>372</b>
Kaksar	18	52	67	115	<b>210</b>
Mop	128	426	356	272	DNA*
Gogaldhar	84	301	139	235	<b>542</b>
Bhang	42	204	222	186	<b>340</b>
Solang	24	199	343	244	<b>398</b>
Dhundi	108	366	551	573	<b>717</b>
Patseo	39	162	172	211	154

\* DNA : Data not available

Severe floods can be experienced when copious rain in a short span is associated with high temperatures (Upadhyay, 1995). In view of above, it is pertinent to analyze the snowfall in the state (catchments of river) during the preceding winter and temperature condition in the state during the period just before the floods. The same is described below.

#### 4.1. Winter snowfall in J & K during 2005

The winter season (January-February), 2005 experienced high western disturbance activity with as

many as 15 systems (1 western depression, 4 low pressure areas and 10 upper air cyclonic circulations) affecting the western Himalayan region. The analysis of snowfall pattern over the region during winter season 2005 shows that Jammu & Kashmir received 528 mm precipitation (equivalent water) against a normal of 234 mm (126% above normal). It was a record snowfall for the last many years in Jammu & Kashmir (Fig. 4). Similar pattern was also found from the data collected under project 'PARWAT' where snowfall amounts in winter season 2005 at a number of stations were much higher than the previous years for which data are available (Table 2).

TABLE 3

All time precipitation records (mm) in Jammu & Kashmir during February

Station	Data period	All time record	
		Precipitation	Year
Srinagar	1891-2005	211.6	1996
Kukernag	1978-2005	<b>320.7</b>	<b>2005</b>
Qazigund	1974-2005	1413.0	1975
Gulmarg	1974-2005	<b>661.3</b>	<b>2005</b>
Pehalgaum	1979-2005	383.0	1984
Kupwara	1983-2005	<b>337.7</b>	<b>2005</b>
Jammu	1983-2005	186.1	1991
Katra	1981-2005	344.5	2003
Banihal	1974-2005	<b>733.4</b>	<b>2005</b>
Batote	1978-2005	<b>641.5</b>	<b>2005</b>
Bhaderwah	1978-2005	<b>410.0</b>	<b>2005</b>

Further analysis of winter precipitation over Jammu & Kashmir revealed that monthly snowfall was an all time record at many stations during February, 2005 (Table 3).

Estimates of snow cover area over Western Himalayas (31-35.5° North and 73-79.0° East) from KALPANA-I satellite also indicated highest snow cover area of 1, 01,828 sq km in winter 2005 as compared to previous 7 years for which estimates are available (Table 4).

#### 4.2. Temperatures in J & K during summer 2005

The maximum and minimum temperatures over the state during first and second week of July are given in Table 5. The Minimum temperatures during the second week (when the floods were reported) were higher than those in the first week. However they were not abnormally high. The maximum temperatures, however, recorded a general fall in the second week, which may primarily be attributed to high rainfall activity.

## 5. Discussion and summary

Blockage of rivers due to landslide/ rockslide and glaciation are known to cause artificial lakes at high altitude glaciated area. Sudden release of water from such lakes can sometimes generate severe floods downstream. However, no such evidence has been noticed in the satellite imageries in present case. It is, therefore, assumed that the July 2005 floods in river Jhelum were because of meteorological factors.

TABLE 4

Kalpna-I estimates of snow cover area over western Himalayas

Date & year	Snow cover area (sq km)
01 Jan 1998	58,640
26 Jan 1998	69,300
06 Feb 1998	77,000
20 Feb 1998	82,620
10 Mar 1998	85,390
25 Mar 1998	77,850
01 Jan 1999	42,170
27 Feb 1999	68,650
12 Mar 1999	74,270
06 Jan 2000	55,021
14 Feb 2000	81,580
25 Feb 2000	65,899
08 Mar 2000	64,308
25 Mar 2000	64,222
15 Jan 2001	60,741
27 Jan 2001	61,010
08 Feb 2001	68,944
27 Feb 2001	69,311
15 Mar 2001	69,585
24 Mar 2001	59,261
03 Jan 2002	68,032
24 Jan 2002	70,701
14 Feb 2002	75,417
19 Feb 2002	77,316
05 Mar 2002	77,335
27 Mar 2002	73,660
20 Jan 2003	38,607
08 Feb 2003	67,880
24 Feb 2003	93,100
07 Mar 2003	86,584
20 Mar 2003	83,315
09 Jan 2004	55,915
27 Jan 2004	67,144
06 Feb 2004	80,027
07 Mar 2004	63,575
26 Mar 2004	60,737
14 Jan 2005	72,524
01 Feb 2005	90,232
<b>21 Feb 2005</b>	<b>1,01,828</b>
06 Mar 2005	89,729
24 Mar 2005	90,216
11 Apr 2005	80,738

**TABLE 5**  
**Temperatures (°C) during 1<sup>st</sup> and 2<sup>nd</sup> week of July 2005**

Station	Maximum temperature				Minimum temperature			
	1-7 July		8-14 July		1-7 July		8-14 July	
	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal
Srinagar	25.8	30.0	27.0	30.7	16.4	17.4	18.5	18.0
Gulmarg	18.7	21.0	18.3	21.0	9.9	9.4	12.3	10.0
Kupwara	31.6	-	28.5	-	14.6	-	15.2	-
Qazigund	25.7	28.0	25.0	28.0	15.0	16.4	17.1	17.0
Kukernag	27.6	-	23.5	-	15.9	-	16.4	-
Pahalgaum	22.3	-	23.3	-	11.8	-	13.6	-

Analysis of the temperatures over the state did not indicate any abnormally higher temperature conditions which could have caused unusually high snowmelt discharge leading to floods. However, there was excess rainfall during July 2005 (Table 1), especially during second week, which coincided with the period of alarm/danger level of floods in the river Jhelum. Considering the quantum of rainfall, it may be assumed that the rainfall alone could not have raised water upto alarm/danger levels, unless it was supplemented by other causes.

The snowmelt discharge is also a significant factor contributing towards discharge in the Himalayan rivers during summers. Siddiqui *et al.* (2003) concluded that more than two third of the annual flow in the Jhelum river basin is derived from the melting of snow in the catchments areas.

Jammu & Kashmir had received exceptionally high precipitation during the preceding winter (Table 2, 3 and Fig 4). The examination of satellite snow cover area estimates (Table 4) also shows higher snow cover during winter, 2005 as compared to many previous years. This high snowfall in the preceding winter season might have caused higher snow melt discharge during the following summer even with near normal temperatures. These results are in conformity with the studies in the past. Ramamoorthi (1987), based on his studies carried out for Sutlej basin, concluded that in the absence of significant temperature variations at high elevations in the snow melt season (April-July), the snow cover area was the main factor contributing to snow melt run-off from major Himalayan river basins. Also Archer and Fowler (2008) have reported that in the mountainous region, runoff from snowmelt and glacier-melt provides the dominant contribution to river flows during the spring and summer

seasons although monsoon rainfall may also influence peak flow.

## 6. Concluding remarks

The study reveals that the prevailing temperatures over Jammu & Kashmir during July 2005 were not too high (when compared with normal/previous records). There was exceptionally high rainfall in Jammu & Kashmir during July 2005, particularly during the 2<sup>nd</sup> week. Precipitation during preceding winter was an all time record at many stations as per conventional & 'PROJECT' Parwat observations and satellite estimates.

In view of above, it can be inferred that exceptionally heavy snowfall in the preceding winter combined with heavy summer monsoon rains even with normal summer temperatures led to floods/ flood like situation in river Jhelum.

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