551.577.3 (540.11)

PRECIPITATION VARIABILITY AND ITS TREND ANALYSIS OVER KASHMIR REGION

1. The region of Kashmir valley surrounded by all sides by high mountain ranges having different altitudes and orientations. The Kashmir valley is basin shaped and has a length of about 140 kms and width varying 50-55 kms. The peculiarity of Kashmir climate is mainly due to Pirpanjal range to the south, Zanskar range to the north, Ladakh range to the east and in west Pakistan. The mountain areas lead to various mesoscale circulations like catabatic /anabatic winds, valley/gorge winds etc. these have profound influence on local weather associated with the latter. Actually, in Kashmir the precipitation during winter is mostly in the form of rain and snow. It occurs in association with the passage of western disturbances (Hatwar *et al*. 2001).

2. Since precipitation is the primary and major source of fresh water, a clear understanding of precipitation for climate of a place is highly essential. Earlier climatological studies (Ramakrishnan, 1953; Bhadram & Narayanaswamy, 2000) of Madras (presently known as Chennai) and Hyderabad city presented a critical climatological analysis. Studies of Mumbai rainfall, for Colaba as well as Santacruz, were carried out in respect of spatial variability and trend analysis for different periods, by (Apte, 1979; Saxena & Agarwal, 1989; Suresh *et al*., 1998). An attempt has been made in this paper, to study the precipitation variability and its trend over Kashmir during the 16 years period. The Jammu & Kashmir state lies roughly between Latitudes 32° 17′ N and 36° 50′ N and Longitudes 73° 27′ and 80° 29′ E. The Kashmir regions lie in extratropical region and enjoy extra tropical (ET) type of climate. Southwest monsoon season affect feebly in Kashmir region and rain occurs due to penetration of monsoon currents through the

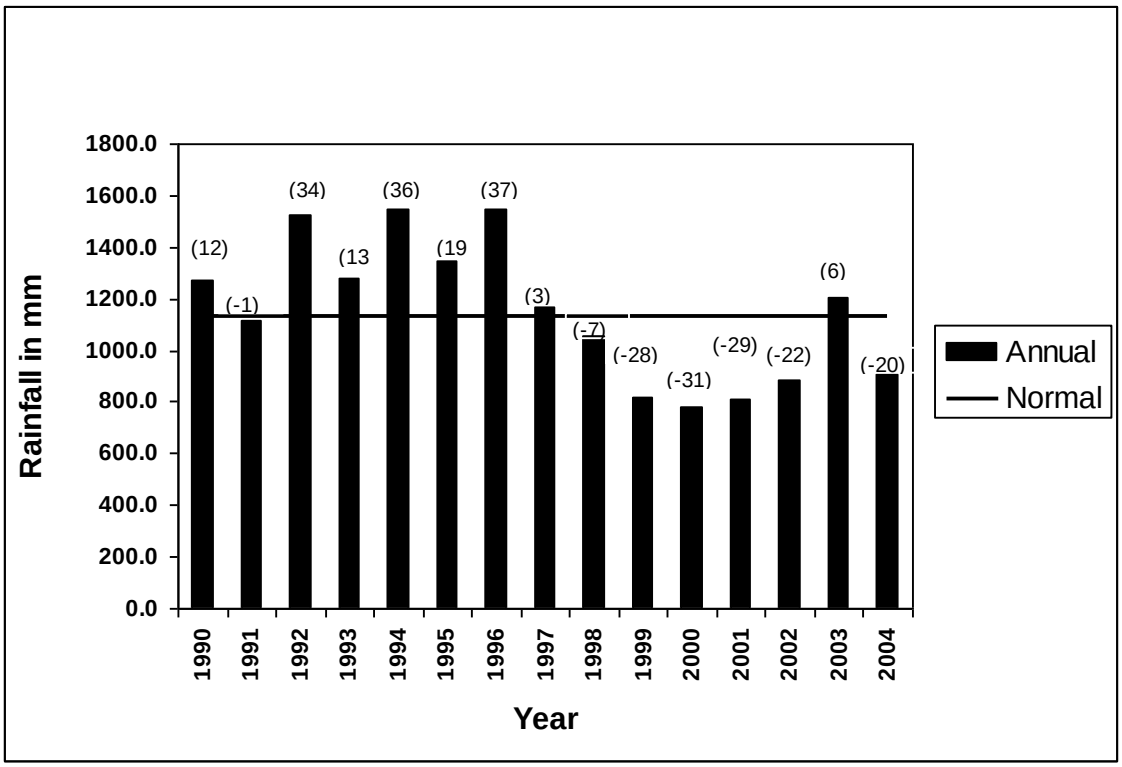

Fig. 1. Annual precipitation (rainfall/snowfall) and departure from normal of Kashmir during the years (1990-2004)

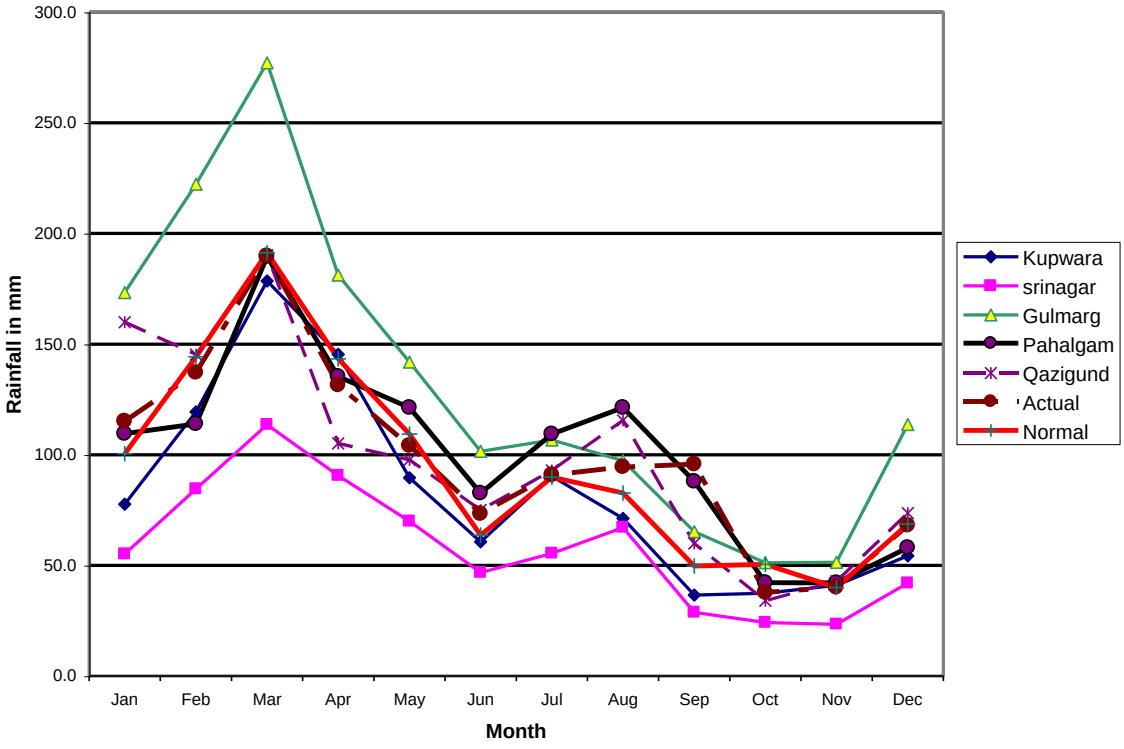

Fig. 2. Monthly distribution of precipitation over Kashmir division with individual stations during the years (1990-2004)

TABLE 1

Number of excessive precipitation (monthly departure from normal > 50 %) and highest fall in a month and flood events during years (1990 - February, 2005)

Months	Number of excessive rainfall	Years	Highest rainfall (% Departure from normal) with years	Flood years
January	7	1992, 1993, 1994, 1998, 1999, 2004, 2005	230.1 mm (135) in 2005	
February	3	1992, 2003, 2005	392.5 mm (176) in 2005	
March	1	1992	391.6 mm (66) in 1992	
April	1	1991	235.1 mm (57) in 1994	
May	1	1996	208.1 mm (93) in 1996	
June	4	1993, 1996, 2001, 2002	204.5 mm (222) in 1996	1996
July	2	1993, 1995	233.7 mm (157) in 1997	1993, 1995
August	2	1996, 1997	211.2 mm (145) in 1997	1997
September	3	1992, 2002, 2003	197.5 mm (277) in 1992	1992
October	3	1994, 1996, 2004	127.9 mm (108) in 1997	
November	4	1993, 1997, 1999, 2001	93.7 mm (108) in 1997	
December	2	1990, 1994	297.3 (108) in 1994	
Total	33			

TABLE 2

Highest recorded monthly snowfall at selected stations in Kashmir division during the period years (1995 – February, 2005)

Stations	Depth of snowfall in cms				
	Kupwara	Srinagar	Gulmarg	Pahalgam	Qazigund
	Highest (Year)	Highest (Year)	Highest (Year)	Highest (Year)	Highest (Year)
January	105.6 (2004)	73.2 (1999)	290.6 (1999)	224.6 (2005)	268.9 (1999)
February	329.5 (2005)	151.6 (2005)	661.3 (2005)	352.4 (2005)	319.3 (2005)
March	11.3 (1998)	81.7 (2002)	416 (1998)	144 (1999)	37.5 (2000)
	30.9 (2000)	----	---	---	81.7 (2002)
April	1.5 (2000)	----	242.4 (1995)	57.8 (1997)	---
	--	--	---	19.2 (1999)	
May	--	---	229.2 (1995)	42.6 (1997)	---
	---	---	18.6 (1998)	---	--
June	--	---	69.2 (1995)	--	---
July	---	---	297.8 (1995)	--	---
August	--	--	---	---	---
September	--	--	28.4 (1995)	--	--
October	--	---	79.7 (1995)	31.8 (1996)	53.4 (1996)
November	38.7 (1997)	39.8 (1996)	136.6 (1997)	76.2 (1997)	87.6 (1997)
December	108.4 (2003)	41.2 (2003)	116.4 (1997)	101.5 (2003)	13.7 (1996)
	--	--	---	--	101.5 (2003)

trenched valleys. This occurs either in association with monsoon lows/depression which forming over Bay of Bengal and moving in north westerly direction across North India & affect Jammu & Kashmir state or as a result of the shift of the axis of monsoon trough to the north of its normal position. The variability of the precipitation is due to complexity of the relief and their orientations.

3. The precipitation (rainfall /snowfall) data used in the present study is taken from meteorological centre

Srinagar. The selected stations for the study are Srinagar (34° 05′ N, 74° 50′ E; 1585 m), Kupwara (34° 25′ N, 74° 18′ E; 1609 m), Gulmarg (34° 03′ N, 74° 24′ E; 2705 m), Pahalgam (34° 02′ N, 75° 50′ E; 2310 m) and Quazigund (33° 35′ N, 75° 05′ E; 1690 m). All the five stations constitute the Kashmir division for the present study. The mean annual rainfall of Kashmir division during 15 years (1990-2004) and their departures from normal are shown in Fig. 1. It is noticed that the years 1992, 1994 and 1996 have excess precipitation (departure from normal > 20 %) and the years 1998 to 2002 have deficient precipitation (departure from normal < 20 %). Monthly distribution of precipitation for 15 years (1990-2004) is shown in Fig. 2. It has been observed from Fig. 2 that the precipitation over Kashmir region is increasing from November to March and decreasing from March to June. The minor fluctuations will also be present due to sampling. Fig. 1 and Fig. 2 show intra-annual and inter annual variations of the precipitation over the region. The intra-annual variability of precipitation is frequently affected by western disturbances over the region. It is seen that the annual precipitation distribution during the 15 years lies between 78.29 cm (in the year 2000) to 154.96 cm (in the year 1996) (Fig. 1). The annual normal is 113.35 cm, which shows large, inter annual variability. It is clear from the analysis that the lowest precipitation is observed at Srinagar and the highest at Gulmarg.

4. If the precipitation departure from normal is 50 % or more in any month then it is considered as excessive rainfall. Table 1 shows the number of excessive precipitation and highest fall in a month and flood events during 1990 – February, 2005. It is clear from Table 1 that there is a total 33 excessive rainfall months during last 15 years. Maximum occurrences of precipitations are in January month (7 events) followed by June and November month (4 events in each months). It is interesting to note that about 11 (33 %) excessive rainfall occurred during monsoon season in last 15 years. The highest recorded snowfall depths in cm during 11 years (1995 - February, 2005) are given in Table 2. It can be seen that Gulmarg being at higher altitude 2705 m receives snowfall all through the year except August whereas Srinagar at 1585 m receives the snowfall only during winter season. It has also been noticed from Table 2 that the February, 2005 shows highest average snow depth during the last 11 years. These events disrupt the normal life and causes disastrous situation in Kashmir. The reason for highest snow depth in February 2005 was in association with the western disturbance that affected Jammu and Kashmir region badly.

5. The major floods that affected Kashmir valley in last 15 years are in the monsoon season and which is caused due to heavy precipitation in association with active monsoon conditions in the region. In many occasions heavy precipitation leads to avalanches at mountain slopes and disrupts the normal life, communication, loss of life and socio-economic development of the state. Sixteen years precipitation analysis of Kashmir region show that the years 1992, 1994 & 1996 have recorded excessive whereas the years 1998 to 2002 deficient precipitation. Gulmarg and its nearby areas record highest precipitation in the form of rain and snow. The monthly precipitation increases from October to March and thereafter decreases upto June again increases in July and thereafter decreases and minimum is attained in the month of September when the SW monsoon withdraws from Kashmir region. The months December to March have maximum number of heavy rainfall events in association with eastward moving systems. The India Meteorological Department (IMD) is giving weather forecast based on the daily observations to ensure the safety and welfare of the people. The short-range forecasts (validity up 3 days) are also issued by IMD, which is very useful in managing and mitigating meteorological disasters.

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R. K. GIRI
B. R. LOE
RAJVEER SINGH
S. BALI

India Meteorological Department, New Delhi, India
(*5 January 2006, Modified 22 January 2008*)
email : rkgiri_ccs@rediffmail.com