MAUSAM, 49, 4 (October 1998), 499-502

551.509.319:551.577:556.51

A synoptic analogue model for QPF of river Sabarmati basin

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(Received 17 December 1996, Modified 11 June 1997)

सार — साबरमती नदी के बेसिन क्षेत्र के लिए सिनाप्टिक अनुरूप विधि द्वारा अंशतः मात्रात्मक वर्षण पूर्वानुमान जारी करने के लिए निदर्श तैयार करने का प्रयास किया गया। ये निदर्श 10 वर्षों (1986-95) के आंकड़ों पर आधारित है। वर्ष 1995 और 1996 के भारित माध्य वर्षा के साथ निदर्श द्वारा जारी किए गए मात्रात्मक वर्षण पूर्वानुमान की जांच की गयी है। निदर्श का कार्य-निष्पादन सही था। साबरमती बेसिन के लिए मात्रात्मक वर्षण पूर्वानुमान जारी करने के लिए इस निदर्श का प्रयोग विश्वास के साथ किया जा सकता है।

ABSTRACT . An attempt has been made to prepare a model for issuing semi quantitative precipitation forecast for river Sabarmati by synoptic analogue method. The model is based on 10 years (1986- 95) of data. The QPF issued by the model is verified with the WAR of years 1995 and 1996. The performance of model was good. This model can be used confidently for issue of QPF for Sabarmati basin.

Key words — Quantitative precipitation forecast (QPF), Synoptic analogue model, Weighted average rainfall (WAR).

1. Introduction

River Sabarmati is one of the major west flowing rivers meeting the Arabian Sea in Gulf of Cambay. It rises in the Aravally hills at latitude 20° 40′ N and longitude 73° 20′E in Rajasthan at an elevation of 762 m above msl. The river flows through Rajasthan for about 48 km and through Gujarat for 323 km length and then falls into Gulf of Cambay, as shown in Fig. 1. It has total catchment area of 21674 sq km. The main tributary of river Sabarmati are Sei, Wakas, Harnav, Hathmati and Watrak. Sabarmati basin is bounded on the north and northeast by Aravalli hills, on the east by the ridge separating it from the Mahi basin, on south by the Gulf of Cambay and on the west by ridge separating it from the basins of the rivers draining into Rann of Kutch and the Gulf of Cambay. The average rainfall of the basin is 787.5 mm by the southwest (SW) monsoon which sets in by middle of June withdraws by the last week of September.

In the present paper efforts have been made to identify the various synoptic systems and their locations which are accountable for an weighted average rainfall in ranges 11-25, 26-50, 51-100 and > 100 mm during SW monsoon period in Sabarmati river basin. After conducting the above study for 10 years a synoptic analogue QPF model is prepared. Singh *et al.* (1995) did a similar study for river Pun in Patna. Lal *et al.* (1983) and Abbi *et al.* (1979) also studied QPF by synoptic analogue method for Gomti catchment and Bhagirathi catchment respectively.

2. Method and data

After analysing the synoptic conditions and their location for a period of 10 years, following five meteorological subdivisions are considered influential in causing rain over the basin.

(1) West Madhya Pradesh and adjoining area.

(2) Vidarbha and adjoining area.

(3) East Rajasthan and adjoining area.

(4) Gujarat region and adjoining area.

(5) East Madhya Pradesh and adjoining area.

Sabarmati basin covers the (3) and (4) zones.

Synoptic systems responsible for active/vigorous monsoon conditions over the Sabarmati catchment were identified and are given below:

S1: Cyclonic storm/ deep depression / depression

S2: Low pressure area / well marked low pressure area

S3: Upper air cyclonic circulation

S4: East West trough at mid tropospheric level

According to above classification symbol Sij stands for system Si situated at zone j. For example, S11 stands for cyclonic storm or deep depression over west Madhya Pradesh and adjoining area. Data under study has been used from 15 June to 15 October for a period of 10 years (1986 - 95). Synoptic situation based upon 0300 UTC surface and

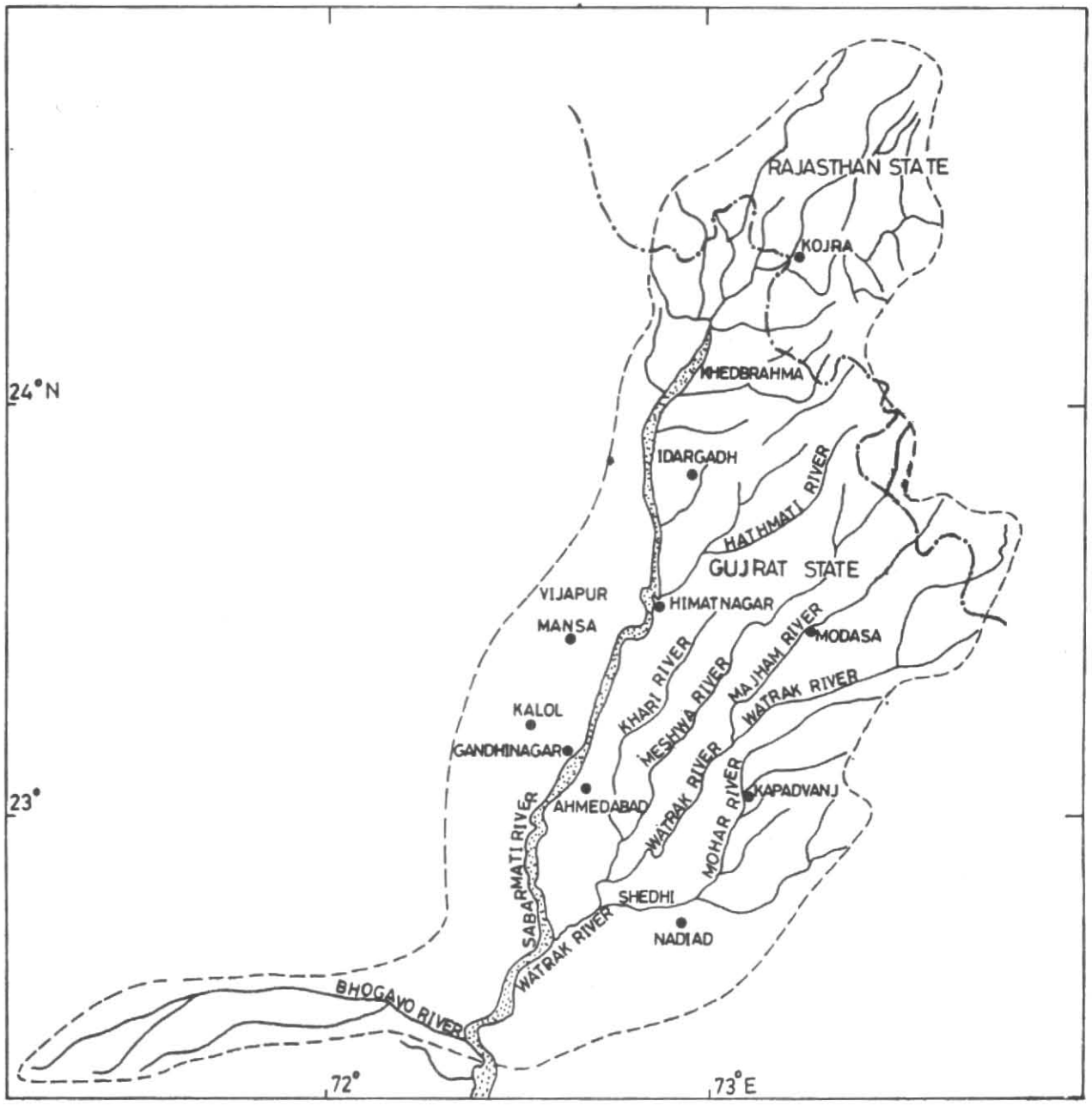

Fig. 1. Catching of river Sabarmati

0000 UTC upper air charts responsible for weighted average rainfall more than 11 mm have been collected data wise.

3. Results and discussion

It is found that out of total 307 occasions of rainfall more than 11 mm, for the given synoptic conditions (S1, S2, S3 and S4), maximum number of occasions of rainfall over the catchment are due to low / well marked low pressure (45 percent) and out of these, 60 percent of the occasions are due to low/well marked low pressure over west Madhya Pradesh and adjoining and 20 percent due to low/well marked low pressure over east Rajasthan (Table 1).

The second most important synoptic condition is the upper air cyclonic circulation, 31 percent of the occasions of rainfall are due to upper air cyclonic circulations (mostly at mid tropospheric level) and of these 57 percent are due to upper air cyclonic circulation over Gujarat region.

East west trough at mid tropospheric levels contributes 18 percent of the total cases and cyclones/deep depression/ depression contributes remaining 6.0 percent. From Table 1

TABLE 1

Frequency of occurrence of WAR more than 11 mm for various synoptic conditions

Symbol	A					B					C					D					G.T.
	11-25	26-50	51-100	>100	Total	11-25	26-50	51-100	>100	Total	11-25	26-50	51-100	>100	Total	11-25	26-50	51-100	>100	Total	
S11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S12	-	-	-	-	-	-	1	-	-	1	-	1	-	-	1	1	-	1	-	2	4
S13	-	-	-	1	1	-	-	-	1	1	-	-	-	1	1	-	-	1	-	1	4
S14	1	1	-	-	2	1	1	-	-	2	-	1	-	-	1	1	-	-	-	1	6
S15	-	-	1	-	1	1	-	-	1	2	-	-	-	1	1	-	-	2	-	2	6
Total	1	1	1	1	4	2	2	-	2	6	-	2	-	2	4	2	-	4	-	6	20
S21	4	7	4	4	19	7	6	7	3	23	6	6	4	2	18	7	6	5	1	19	79
S22	1	-	-	-	1	1	-	-	-	1	-	2	-	-	2	-	2	-	-	2	6
S23	3	1	1	2	7	3	2	-	2	7	2	1	3	-	6	6	1	-	-	7	27
S24	1	1	-	-	2	1	1	1	-	3	1	-	-	-	1	3	-	-	-	3	9
S25	3	1	-	-	4	2	1	1	-	4	1	3	-	-	4	2	3	-	-	5	17
Total	12	10	5	6	33	14	10	9	5	38	10	12	7	2	31	18	12	5	1	36	138
S31	2	3	-	3	8	2	1	-	-	3	3	-	-	-	3	1	1	-	-	2	16
S32	1	1	-	-	2	1	-	-	-	1	1	-	-	-	1	-	1	-	-	1	5
S33	-	1	3	-	4	-	2	2	-	4	1	3	-	-	4	3	-	1	-	4	16
S34	5	5	3	1	14	7	6	1	2	16	6	5	2	1	14	6	2	3	-	11	55
S35	-	1	-	-	1	1	-	-	-	1	-	-	-	-	-	1	-	-	-	1	3
Total	8	11	6	4	29	12	9	3	2	25	12	8	2	1	22	11	4	4	-	19	95
S41	3	-	1	-	4	2	2	-	-	4	2	1	-	-	3	2	-	1	-	3	14
S42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S43	-	-	-	-	-	1	-	-	-	1	-	1	-	-	1	1	-	-	1	2	4
S44	1	5	3	-	9	1	6	2	-	9	2	5	2	-	9	2	5	-	-	7	34
S45	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	1	2
Total	4	5	4	-	13	5	8	2	-	14	5	8	2	-	14	6	6	1	1	13	54
G.T.	25	27	16	11	79	33	29	14	9	85	27	30	11	5	71	37	22	14	2	74	307

TABLE 2
QPF model for Sabarmati basin

Sub Basin	Zone	Met Sub division*	S1	S2	S3	S4
A	1	WMP	Nil	26-50	>50	11-25
	2	V	Nil	Nil	11-25	Nil
	3	ER	>50	26-50	26-50	Nil
	4	Guj	11-25	11-25	26-50	26-50
	5	EMP	>50	11-25	Nil	Nil
B	1	WMP	Nil	>50	11-25	11-25
	2	V	11-25	Nil	Nil	Nil
	3	ER	>50	26-50	11-25	Nil
	4	Guj	11-25	26-50	26-50	26-50
	5	EMP	>50	11-25	Nil	Nil
C	1	WMP	Nil	26-50	11-25	11-25
	2	V	Nil	11-25	Nil	11-25
	3	ER	>50	>50	26-50	Nil
	4	Guj	11-25	Nil	11-25	26-50
	5	EMP	>50	26-50	Nil	Nil
D	1	WMP	Nil	26-50	11-25	26-50
	2	V	>50	11-25	11-25	Nil
	3	ER	>50	26-50	26-50	11-25
	4	Guj	Nil	11-25	11-25	26-50
	5	EMP	26-50	26-50	Nil	11-25

*WMP - West Madhya Pradesh and adjoining area, V-Vidarbha and adjoining area, ER - East Rajasthan and adjoining area, Guj - Gujarat re-

it was also observed that in all the catchment maximum number of cases of rainfall more than 100 mm (40 percent) are due to low/well marked low pressure over west Madhya Pradesh and adjoining and then 2nd maximum due to LOPAR/ well marked LOPAR over subdivisions of each Rajasthan over the Sabarmati basin for all the catchments. The maximum occasions of rainfall > 11mm are due to LOPAR over west Madhya Pradesh and adjoining and the next to maximum due to upper air cyclonic circulation over Gujarat region (generally extending upto mid tropospheric level). Over the period of 10 years a single occasion of deep depression occured over southeast Rajasthan which led to rainfall >10 cm for all catchment except D where it was 77.9 mm (1988).

For all sub basins the frequency of occurrence of various systems preference-wise are as follows, *i.e*, LOPAR > upper air cyclonic circulation > east west trough > deep depression / depression.

The result of model was verified for the year 1995 and 1996 while verifying for 1995 the data for the year were excluded from the model. In the year 1995 the result of model was correct for 70 percent occasions and out by one stage in 25 percent cases, while in 1996 the model was found to be correct for 54 percent of cases, out by one stage in 39 percent and out by 2 stage in 7 percent cases.

4. Conclusions

The Quantitative Precipitation Forecast model is presented in Table 2. It was generally observed from the study that most of the rain occurred over the basin due to following synoptic conditions:

(*i*) LOPAR over west Madhya Pradesh with associated upper air cyclonic circulation upto mid tropospheric level.

(*ii*) Upper air cyclonic circulation (or MTC) over Gujarat region and adjoining.

(*iii*) East-west trough at mid tropospheric levels passing through Gujarat State generally between 1.5 and 4.5 km above msl.

(*iv*) It was observed that frequency of occurrence of rainfall due to LOPAR was maximum over the basin.

From the model it can be concluded that it is possible to give QPF of more than 50 mm under following situations.

(a) Deep depression over east Madhya Pradesh and adjoining and south east Rajasthan.

(b) Upper air cyclonic circulation at mid tropospheric level over Gujarat region.

(c) LOPAR/well marked LOPAR over west Madhya Pradesh and south east Rajasthan with associated upper air cyclonic circulation extending upto mid tropospheric level.

(*v*) It has been seen that two systems are never identical and two almost identical systems give different amount of rainfall over a basin. There is large variation in the amount of rainfall obtained by almost identical system. This factor is main reason for incorrect QPF.

Acknowledgement

The authors are grateful to Shri R.K. Kankane, Director, Meteorological Centre, Ahmedabad for useful suggestions and for providing necessary facilities.

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