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A SYNOPTIC ANALOGUE MODEL FOR QUANTITATIVE PRECIPITATION FORECAST OVER DAMODAR VALLEY AREA

1. The forecasting of Quantitative Precipitation (QPF) is crucial for the prediction of floods and water management in real time. Several methods are used for issue of such forecast and the synoptic analogue technique is one of the methods being used conveniently by the meteorologists. For issuing QPF the most important factor is the prevailing synoptic situation and for developing a synoptic analogue model a details analysis of average areal precipitation (AAP) alongwith associated synoptic features for each catchment area is required.

Many scientist during the last few decades have attempted to frame this synoptic analogue model for different river catchments in India. Lal *et al*. (1983) used synoptic analogue model for QPF in Gomti river catchment using five years data. Ray and Sahu (1998) framed a model for Sabarmati basin using ten years data, Ram and Kaur (2004) using eight years data attempted the

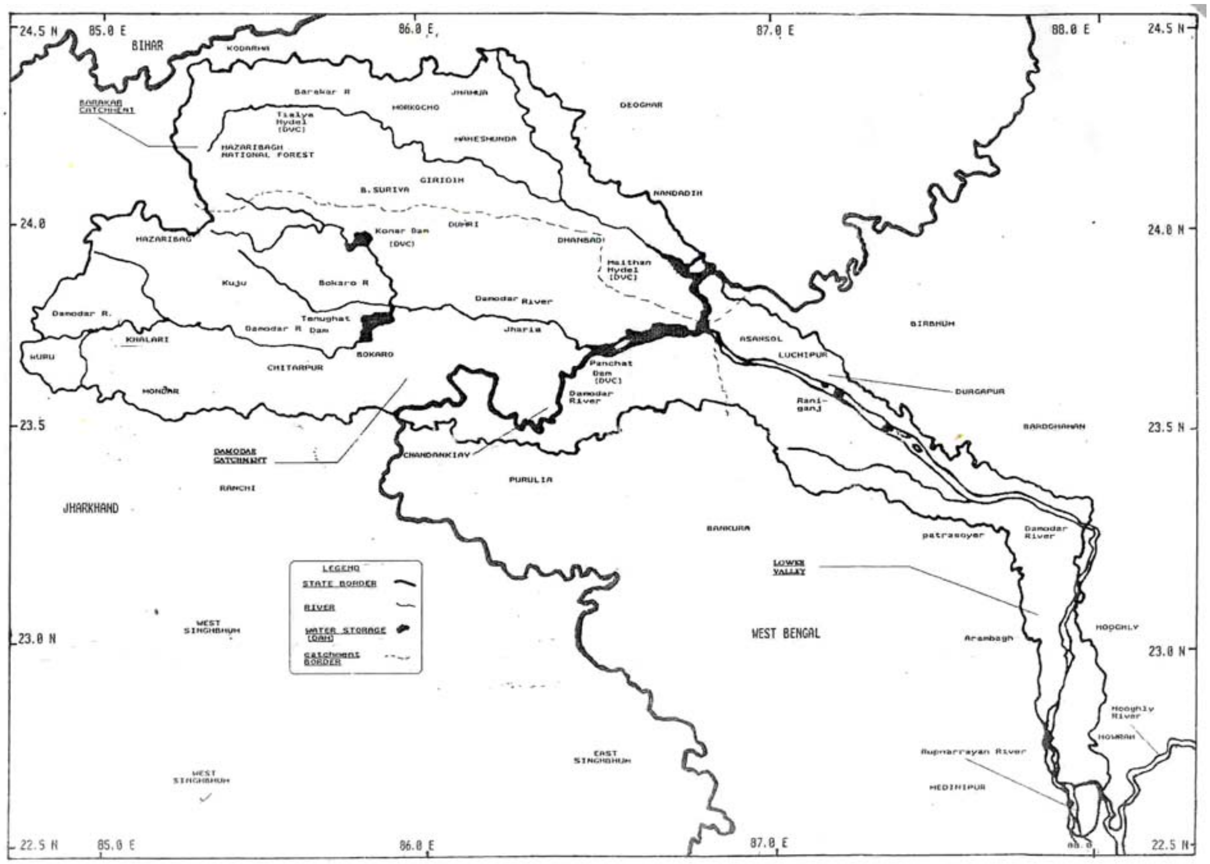

Fig. 1. The Damodar Valley (DV) area

same for upper Yamuna catchment, Raha *et al*. (2009) using ten years data framed a synoptic analogue model for the Teesta Catchment.

In the present study an attempt has been made to frame a synoptic analogue model for the Damodar Valley (DV) area under the meteorological sub-divisions Jharkhand and adjoining Gangetic West Bengal using SW monsoon rainfall data for the 20 years period 1989-2008 and the result has been validated with the realized AAP for the year 2009.

2. The total DV area (22,015 sq km) is constituted with three catchments: the Barakar Catchment (6294 sq km) with 16 part time observatories, the Damodar Valley Catchment (11524 sq km) with 28 part time observatories and the lower valley (4197 sq km) with 3 part time observatories (Fig. 1 and Table 1). The SW Monsoon in this region normally onset around 2nd week of June and withdraw by 2nd week of October. As such in the present analysis rainfall data from 15th June to 15th October have been considered. The AAP have been calculated by analyzing the isohyets drawn over the maps (in 1 cm = 10 km scale) for each day and computed by weighting the average precipitation between the contours by the area between the contours (obtained using Planimeter) and then by dividing their sum by the total area. For isohyetal analysis the rainfall data of some of the neighbouring stations (as available) were also considered in addition to those under the catchment areas.

The synoptic features associated with all the days have been studied from the analysis of different weather charts (surface and upper air) at 0000 / 0300 UTC alongwith relevant satellite pictures (both visible and infrared). The most prominent synoptic feature of the day has been considered and on the basis of its influence over the monsoon rainfall the four most prominent synoptic system, *viz*., (*i*) trough on Sea level chart (T), (*ii*) low pressure area (L), (*iii*) well marked low pressure area (W) and (*iv*) depression/deep depression (D) have been chosen in this study. Also the locations of these systems with respect to the catchment areas have been classified into three categories *viz*., (*i*) system over the catchment,

TABLE 1

List of rain gauge stations in Damodar Valley area

S. No.	Rainguage stations
	Barakar catchment
1.	Maithon
2.	Jamua
3.	Tuladih
4.	Nandadih
5.	Maheshmunda
6	Barkatha
7.	Palganj
8.	Dhanwar
9.	Suriya
10.	B. Suriya
11.	Parsabad
12.	Hirodih
13.	Kodarma
14.	Tilaiya
15	Barhi
16.	Padma
	Damodar catchment
17.	Panchet
18.	Nawadih
19.	Phusro
20	Dhanbad
21.	Putki
22.	Gansadih
23.	Dumri
24.	Bokaro
25.	Chandrapura
26	Peterber
27.	Mandu
28.	Konar
29.	Hazaribagh
30.	Ramgarh
31.	Bhurkunda
32	Barkagaon
33.	Hendegir
34.	Khalari
35.	Mandar
36	Sindri
37.	Chandwa
38.	Raiganj
39.	Rajdah
40.	Bishungarh
41.	Daroo
42	Chandankiay
43.	Burmu
44.	Shillaichak
	Lower Valley
45.	Asansol
46.	Luchipur
47	Durgapur

(*ii*) system in the neighbourhood (*i.e.*, within approximately 200 km from the boundary) of the catchment and (*iii*) system outside (*i.e.*, beyond 200 km) of the catchment. Thus in total 12 (= 4*3) categories of the synoptic system have been considered. Accordingly in the following symbols suffixing numbers have been used to denote different synoptic situations, *e.g.*, T_1 represents trough over the catchment, L_2 represents low pressure area in the neighbourhood of the catchment etc.

Also in this analysis the AAP in the ranges 11-25, 26-50 and >50 mm have been considered. The effect of rainfall less than 11 mm is negligible in changing the river gauge and hence not considered. It is found that out of total 7380 cases (3 catchments *123 days * 20 years) the AAP was ≥ 11 mm in 2662 cases, which were actually studied.

3. Table 2 depicts the number of occurrence of AAP under different rainfall ranges associated with different synoptic situation during SW monsoon months of 1989 to 2008. It is observed that for the DV area out of total no. 2662 of AAP ≥ 11 mm the maximum number of occurrence (70.1%) was in the range 11-25 mm. and the minimum occurrence (2.2%) was for AAP > 50 mm. Also for the synoptic situations T_1, T_2, T_3, L_2, L_3, W_3 and D_3 the probability of occurrence of AAP is more for the range 11-25 mm and for the synoptic situations L_1, W_1, W_2, D_1 and D_2 the probability of occurrence of AAP is more for the range 26-50 mm. However, no specific situation could be identified which attributes to AAP > 50 mm as only in 2.2 % occasions in the 20 years period of the present analysis the observed AAP was > 50 mm.

The most probable range as stated above and depicted in the Table 2 may be used for issuing QPF for the DV area. However, it is observed that for the synoptic situation L_1 (*i.e.*, low pressure area over the region) the difference of probability of occurrence of AAP for the range 11-25 mm. and 26-50 mm is not very significant. Also as all the different systems under the same synoptic situation are not identical the AAP varies even if it is within the range. Further though a few in number some AAP > 50 mm have been observed to be associated with different synoptic situations (T_1, L_1, L_2, L_3, W_1, D_1 and D_2). As such detail study is required for issuing QPF more accurately. In the present analysis only 12 no. of significant synoptic situations have been considered. A forecaster may consider the other details, *e.g.*, depth of upper air circulations associated with different systems and also their movements and positions (*i.e.*, north and south of the catchment) before issuing the QPF after broadly categorizing the situation as per Table 2, which will definitely increase the accuracy of QPF.

TABLE 2

Number of AAP occurrence and their percentage (within bracket) for different rainfall ranges under different synoptic situations

Synoptic situation	Total no. of AAP occurrence	No. of AAP occurrence under different ranges (figs. within bracket represents percentage of total)		
		11-25 mm	26-50 mm	> 50 mm
T_1	821	694 (84.5)	120 (14.6)	7 (0.9)
T_2	192	173 (90.1)	19 (9.9)	0 (0)
T_3	131	126 (96.2)	5 (3.8)	0 (0)
L_1	425	194 (45.6)	209 (49.2)	22 (5.2)
L_2	365	287 (78.6)	75 (20.5)	3 (0.9)
L_3	115	109 (94.8)	5 (4.3)	1 (0.9)
W_1	156	57 (36.5)	89 (57.1)	10 (6.4)
W_2	160	73 (45.6)	87 (57.4)	0 (0)
W_3	45	39 (86.7)	6 (13.3)	0 (0)
D_1	49	15 (30.6)	30 (61.2)	4 (8.2)
D_2	153	59 (38.6)	83 (54.2)	11 (7.2)
D_3	50	40 (80.0)	10 (20.0)	0(0)
Total	2662	1866 (70.1)	738 (27.7)	58 (2.2)

TABLE 3

Testing of synoptic analogue model (for the year 2009)

Synoptic situation	QPF (mm) as per model	No. of realized AAP in next 24 hrs	
		Correct	Incorrect
T_1	11-25	11	2
T_2	11-25	20	7
T_3	11-25	18	4
L_1	26-50	2	0
L_2	11-25	2	2
L_3	11-25	9	2
D_2	26-50	1	1
D_3	11-25	5	4
Total no. of cases verified = 90		68 (75.5%)	22 (24.5%)

(No case was under the synoptic situations W_1, W_2, W_3 and D_1 in 2009)

4. The synoptic analogue model so derived has been tested for issue of QPF for the year 2009. It may be mentioned here that over the DV area in 2009 the SW monsoon onset was on 29th June and before that there was no strong synoptic situation and the area was mainly dry. As such the model was tested from 29th June to 15th October 2009 with actual AAP ≥ 11 mm. The result is given in Table 3. It may be observed that as per this analogue model only 75.5% of QPF has been found correct for the year 2009.

5. The QPF model for the DV area as presented in Table 2 reveals the following:

(*i*) For the synoptic situations trough (over the region, in the neighbourhood or outside the region), low pressure area (in the neighbourhood or outside the region), well marked low pressure area (outside the region) and depression / deep depression (outside the region) the maximum probability of AAP is in the range 11-25 mm.

(*ii*) For the synoptic situations low pressure area (over the region), well marked low pressure area (over and in the neighbourhood of the region) and depression / deep depression (over and in the neighbourhood of the region) the maximum probability of AAP is in the range 26-50 mm.

(*iii*) The coarse classification of synoptic situations as done in this study could not identify any specific situation(s) favorable for occurrence of AAP > 50 mm. In fact such type of rainstorms, which contributes to more than 50 mm of AAP, is possibly associated with finer synoptic situations like depth of the associated upper air circulation etc. Thus, particularly for such rainstorms details study is required keeping in mind the finer aspects of the synoptic situations.

(*iv*) For day-to-day work if the synoptic systems are assessed properly as per classification of the present analysis a fairly accurate QPF (about 75%) for next 24 hrs can be issued for the DV area and further detail analysis may increase the accuracy.

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