556.5.072 : 556.51

SEMI-QUANTITATIVE PRECIPITATION FORECAST MODEL FOR SUBARNAREKHA CATCHMENT BY SYNOPTIC ANALOGUE TECHNIQUE

1. Qualitative precipitation forecast do not serve the real purpose in hydrological forecasting. Hence, a method to issue the quantitative precipitation forecast is required to serve the real purpose of hydrological forecasting. During South-West monsoon season when country experiences almost daily and substantial rainfall activities, the various rivers in the country reel under flood situation, causing a lot of damage to life and property. Quantitative precipitation forecast (QPF) being one of the important parameters required for calculating the rainfall run-off value, which subsequently helps in issuing the run-off forecast for a river, requires to be forecasted more accurately.

During last three decades, attempts were made by a few workers to evolve semi-quantitative precipitation forecast models based on simpler synoptic analogue methods feasible for small catchment areas. Abbi *et al*. (1979) identified the movement of cyclonic storms/ depressions with respect to Bhagirathi Catchment and prepared the basin maps depicting the associated rainfall distribution. Lal *et al*. (1983) identified the rainstorms in three different rainfall ranges for Gomti catchment and grouped the analogous systems accordingly. In this paper an attempt has been made to evolve the synoptic analogues for specified ranges of QPF (being used operationally by India Meteorological Department) in respect of Subarnarekha Catchment.

2. Subarnarekha river originates near Nagari village of Ranchi district in Jharkhand. During its course, it travels a distance of 270 km in Jharkhand, 70 km in West Bengal and 60 km in Orissa before it merges into Bay of Bengal. It flows with very strong current due to which monsoonal heavy rains cause frequent floods in this river. The floods cause a lot of damage to lives and property in Orissa and West Bengal.

Subarnarekha river drains the water of 18,951 square kilometer catchment area. The major portion of the river catchment falls in Jharkhand and minor portion in West Bengal and Orissa. The position of river and its catchment has been shown in Fig. 1.

3. The rainfall data of raingauge stations belonging to IMD, Central Water Commission (CWC) and Orissa state for a period of 20 years from 1978 to 1997 of the flood season (June to October) were used in respect of important synoptic systems, *viz*., low pressure area (L), depression (D), deep depression (DD) and the cyclonic storms (C) of varying intensity. The daily average areal rainfall over the catchment was calculated by the method of arithmetic mean by using the above data.

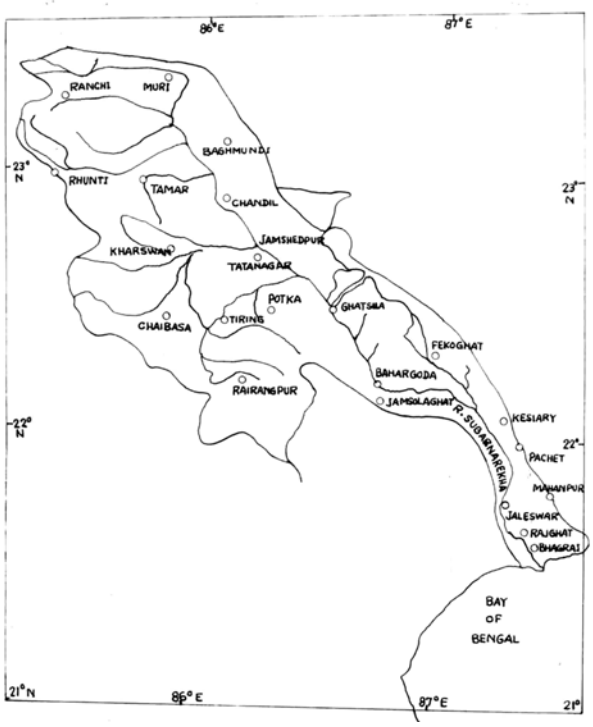

Fig. 1. Subarnarekha catchment

To find out the location, movement and intensity of the above described synoptic systems the documented information and the charts available at Meteorological Centre (M.C.), Bhubaneswar, were used and it is observed that the synoptic systems having their centre within a range of 400 km from the central region of the river catchment have maximum contribution in average areal rainfall over the catchment while the systems beyond the above range contribute very little. As such, the synoptic systems were identified.

4. To develop the Semi-QPF model for Subarnarekha catchment the effective area (within 400 km from the central region of the catchment) in and around the catchment was divided into 8 parts with location indicators S1, S2, ... , S8. The description of the locations represented by S1, S2,... ... ..., S8 are given below:

S1 - North West Bay (NW Bay) of Bengal,

S2 - Adjoining parts of North West and West Central Bay of Bengal,

S3 - Orissa,

S4 - Gangetic West Bengal (GWB) and neighbourhood,

S5 - Parts of North Orissa, Gangetic West Bengal and North West Bay of Bengal,

S6 - Jharkhand,

S7 - Parts of Bihar, Jharkhand, Chattisgarh and East Uttar Pradesh,

S8 - Parts of North Orissa, Chattisgarh & Jharkhand.

Now the important analogous synoptic systems such as low pressure area (L), depression (D), deep depression (DD) and the cyclonic storms(C) were grouped at these defined positions and subjected to the following criteria during next 24 hours period:

A - Synoptic system which moved towards the catchment,

B - Synoptic system which moved away from the catchment

C - Synoptic system which remained stationary with respect to the catchment or moved in such a way that its distance remained same from the catchment.

The systems grouped on the basis of above criteria were further subjected to the following conditions:

(a) Synoptic system intensified during the next 24 hours period,

(b) Intensity of synoptic system remained same during next 24 hours period,

(c) Synoptic system weakened during next 24 hours and then final groupings were done by giving system code to each type of system. For example, the system code, DDS3A(a) in table-1 stands for deep depression over Orissa which moved towards the catchment during next 24 hours and intensified.

Table 1 shows the number of synoptic systems identified on the basis of above criteria in coded forms, their numbers in different QPF ranges and percentage probability and the proposed optimum QPF ranges. The QPF ranges are as according to Flood Meteorological Office (FMO) of the IMD.

The optimum proposed QPF ranges were selected by keeping the following points into consideration:

(*i*) The maximum probability of occurrence,

(*ii*) Its significance compared to the adjacent QPF ranges,

(*iii*) Giving due importance to the synoptic system.

5. The results of the study are discussed below:

(*i*) It is seen from Table 1 that in case of the low-pressure area located over Sl. S2, S3, and S6; the maximum realized AAP has been less or equal to 50 mm while in case of low pressure area located over S7 & S8; the maximum realized AAP has been less or equal to 25 mm except one case in each over S7 & S8, where it is between 26-50 mm. The realised AAP in case of low-pressure area located over S4 & S5 has reached in the range of 51 to 100 mm in some cases and more than 100 mm in one case over S4.

It is also evident from Table 1 that the low pressure area located over S1, S4 and S5 has given rainfall in the range of 11-25 mm in maximum number of cases while in case of low pressure area at other locations, *viz*., S2, S3, S6, S7 & S8 the rainfall has been in the range of 01-10 mm in maximum number of cases. This reflects that a low pressure located over sea or in the close vicinity of sea (*i.e*., over S1, S4 & S5) produce more rainfall than that a low pressure over land area (*i.e*., over S2, S3, S6, S7 & S8). The low pressure area over S1, S4 & S5 should be given due importance.

(*ii*) It is also revealed from Table 1 that in case of depressions located over S2, S3, S6, & S7 the maximum AAP has been less or equal to 25 mm; while in case of depressions located over S4 and S8, which are north of the catchment, the AAP has been in the range of 25-50 mm in one and two case.

The depressions located over S1 and S5, *i.e*., over North West Bay of Bengal and the parts of North Orissa, GWB and North West Bay, the AAP has reached upto 100 mm or so. Thus the system at these positions should be given due weightage while issuing QPF. In case of depression, its position is important for forecasting QPF as its southwest sector gets the maximum rainfall.

(*iii*) In case of the Deep depressions located over S1, *i.e*., NW-Bay, AAP has been up to 100 mm or more in some cases while at other locations, *viz*., S2, S3, S4, S5, S7 &

TABLE 1

Code of synoptic system	No. of systems in different Q.P.F. Ranges (in mm)/their probability of occurrence (%)					Optimum QPF range as per analogue (mm)
	1-10	11-25	26-50	51-100	Above 100	
LS1A (a)	11/44	9/36	5/20	-	-	11-25
LS1A (b)	11/31	19/45	5/14	-	-	11-25
LS1A (a)	7/54	4/31	2/15	-	-	01-10
LS1B (a)	-	-	1/100	-	-	26-50
LS1B (b)	1/50	1/50	-	-	-	11-25
LS1B (c)	2/50	2/50	-	-	-	11-25
LS1C (c)	6/75	2/25	-	-	-	01-10
LS2A (a)	8/57	5/36	1/7	-	-	01-10
LS2A (b)	8/42	8/42	3/16	-	-	11-25
LS2A (c)	8/67	2/16.5	2/16.5	-	-	01-10
LS2B (a)	2/100	-	-	-	-	01-10
LS2B (b)	6/86	1/14	-	-	-	01-10
LS2B (c)	1/100	-	-	-	-	01-10
LS2C (a)	-	1/100	-	-	-	11-25
LS2C (b)	3/60	1/20	1/20	-	-	01-10
LS3A (a)	1/100	-	-	-	-	01-10
LS3A (b)	9/60	4/27	2/13	-	-	01-10
LS3A (c)	6/60	2/20	2/20	-	-	01-10
LS3B (a)	1/100	-	-	-	-	01-10
LS3B (b)	2/67	1/33	-	-	-	01-10
LS3B (c)	2/100	-	-	-	-	01-10
LS4A (a)	1/17	2/33	1/17	2/33	-	51-100
LS4A (b)	6/31	8/42	3/16	2/11	-	11-25
LS4A (c)	5/42	7/58	-	-	-	11-25
LS4B (a)	-	2/100	-	-	-	11-25
LS4B (b)	4/17	13/54	6/25	-	1/4.	11-25
LS4B (c)	4/36	4/36	3/28	-	-	11-25
LS4C (b)	7/70	2/20	1/10	-	-	01-10
LS4C (c)	1/333	1/33.3	1/33.3	-	-	11-25
LS5A (a)	1/8	5/43	4/33	2/16	-	11-25
LS5A (b)	10/26	21/55	2/5	5/13	-	11-25
LS5A (c)	13/54	9/38	1/4	1/4	-	01-10
LS5B (b)	4/22	8/44	6/34	-	-	11-25
LS5B (c)	1/33.3	1/33.3	1/33.3	-	-	11-25
LS5C (a)	-	3/75	1/25	-	-	11/25
LS5C (b)	3/19	7/43	3/19	3/19	-	11-25
LS5C (c)	3/50	3/50	-	-	-	11-25
LS6A (b)	2/40	1/20	2/40	-	-	26-50
LS6A (c)	9/69	3/23	1/08	-	-	01-10
LS6B (b)	8/80	2/20	-	-	-	01-10
LS6B (c)	5/100	-	-	-	-	01-10
LS6C (b)	3/75	1/25	-	-	-	01-10
LS6C (c)	1/100	-	-	-	-	01-10
LS7A (b)	12/86	2/14	-	-	-	01-10

TABLE 1 (*Contd.*)

Code of synoptic system	No. of systems in different Q.P.F. Ranges (in mm)/their probability of occurrence (%)					Optimum QPF range as per analogue (mm)
	1-10	11-25	26-50	51-100	Above 100	
LS7A (c)	8/62	5/38	-	-	-	01-10
LS7B (b)	24/80	6/20	-	-	-	01-10
LS7B (c)	19/83	3/13	1/4	-	-	01-10
LS7C (b)	10/71	4/29	-	-	-	01-10
LS7C (c)	9/75	2/17	-	1/08	-	01-10
LS8A (a)	1/33	2/67	-	-	-	11-25
LS8A (b)	15/63	9/37	-	-	-	01-10
LS8A (c)	7/58	5/42	-	-	-	01-10
LS8B (a)	1/100	-	-	-	-	01-10
LS8B (b)	15/56	12/44	-	-	-	01/10
LS8B (c)	19/83	3/13	1/4	-	-	01/10
LS8C (a)	1/100	-	-	-	-	01-10
LS8C (b)	12/80	3/20	-	-	-	01-10
LS8C (c)	8/100	-	-	-	-	01-10
DS1A(a)	5/31	6/38	4/24	1/06	-	11-25
DS1A(b)	2/18	6/55	2/18	1/09	-	11-25
DS1A (c)	1/08	5/42	4/33	2/17	-	11-25
DS1B (a)	1/33.3	-	1/33.3	1/33.3	-	51-100
DS1B (b)	-	3/75	1/25	-	-	11-25
DS1B (c)	1/100	-	-	-	-	01-10
DS1C (a)	-	1/50	1/50	-	-	26-50
DS1C (b)	1/100	-	-	-	-	01-10
DS2A (a)	1/25	3/75	-	-	-	11-25
DS2A (b)	1/50	1/50	-	-	-	11-25
DS2A (c)	-	1/100	-	-	-	11-25
DS2C (b)	1/100	-	-	-	-	01-10
DS2C (c)	-	1/100	-	-	-	11-25
DS3B (b)	-	1/100	-	-	-	11-25
DS3C (b)	1/100	-	-	-	-	01-10
DS4A (b)	-	4/80	1/20	-	-	11-25
DS4A (c)	1/20	4/80	-	-	-	11-25
DS4B (b)	-	2/100	-	-	-	11-25
DS5A (b)	-	2/100	-	-	-	11-25
DS5B (b)	-	-	-	-	1/100	>100
DS5C (b)	-	-	1/100	-	-	26-50
DS5C (c)	1/100	-	-	-	-	01-10
DS6A (b)	3/100	-	-	-	-	01-10
DS6A (c)	2/100	-	-	-	-	01-10
DS6B (b)	2/100	-	-	-	-	01-10
DS7A (b)	-	1/100	-	-	-	11-25
DS7A (c)	1/100	-	-	-	-	01-10
DS7B (b)	1/50	1/50	-	-	-	11-25
DS7B (c)	2/67	1/33	-	-	-	01/10
DS8A (a)	-	1/100	-	-	-	01-10
DS8A (b)	1/100	-	-	-	-	01-10

TABLE 1 (*Contd.*)

Code of synoptic system	No. of systems in different Q.P.F. Ranges (in mm)/their probability of occurrence (%)					Optimum QPF range as per analogue (mm)
	1-10	11-25	26-50	51-100	Above 100	
DS8A (c)	1/33.3	1/33.3	1/33.3	-	-	26-50
DS8B (c)	3/100	-	-	-	-	01-10
DS8C (b)	1/100	-	-	-	-	01-10
DS8C (c)	1/100	-	-	-	-	01-10
DDS1A(a)	3/60	1/20	-	-	1/20	01-10
DDS1A(b)	1/50	1/50	-	-	-	11-25
DDS1A(c)	3/30	4/40	2/20	1/10	-	11-25`
DDS1B(b)	-	-	1/100	-	-	26-50
DDS1B(c)	1/33.3	1/33.3	1/33.3	-	-	26-50
DDSC(a)	-	1/100	-	-	-	11-25
DDS1C(c)	1/100	-	-	-	-	01-10
DDS2A(a)	1/100	-	-	-	-	01-10
DDS2C(a)	-	1/100	-	-	-	11-25
DDS3A(a)	1/100	-	-	-	-	01-10
DDS3A(b)	4/18	1/20	-	-	-	01-10
DDS3A(c)	2/15	2/15	-	-	-	11-25
DDS3B(b)	2/100	-	-	-	-	01-10
DDS3B(c)	1/100	-	-	-	-	01-10
DDS4B(b)	2/67	1/33	-	-	-	01-10
DDS4B(c)	-	1/100	-	-	-	11-25
DDS4C(b)	-	1/100	-	-	-	11-25
DDS5A(b)	-	1/00	-	-	-	11-25
DDS5A(c)	2/100	-	-	-	-	01-10
DDS6A(c)	2/100	-	-	-	-	01-10
DDS6C(a)	-	1/100	-	-	-	11-25
DDS7B(b)	2/100	-	-	-	-	01-10
DDS7B(c)	1/100	-	-	-	-	01-10
DDS7C(b)	1/100	-	-	-	-	01-10
DDS8A(b)	2/100	-	-	-	-	01-10
DDS8A(c)	2/66	-	1/33	-	-	01-10
DDS8B(a)	1/100	-	-	-	-	01-10
DDS8B(c)	1/100	-	-	-	-	01-10
DDS8C(c)	2/66	1/33	-	-	-	01-10
CS1A (a)	-	1/25	2/50	1/25	-	26-50
CS1A (b)	-	2/66	1/33	-	-	11-25
CS1A (c)	-	2/100	-	-	-	11-25
CS3A (c)	-	1/50	1/50	-	-	26-50
CS5A (c)	1/100	-	-	-	-	01-10
CS8A (c)	1/100	-	-	-	-	01-10

S8, the upper limit of AAP is upto 25 mm. This shows that the AAP reduces drastically in case of land deep depression.

(*iv*) The statistics in case of cyclones is very poor because the formation of cyclonic storms during monsoon season is rare.

(*v*) In General, the higher rainfall amounts than the optimum QPF ranges as suggested in Table 1, were associated with the systems formed during the months of July and August, *i.e*., during the full prevalence of South West monsoon season/Active monsoon condition.

6. From the above study following conclusions are drawn:

(*i*) The study at once reveals that the variation of AAP is large in case of low pressure area while the variability reduces very much in depression and in deep depression, *i.e*., the depressions or deep depression are giving rainfall in a very limited area or in other words they are more concentrated.

(*ii*) The optimum ranges given in Table 1 should be used for issuing QPF on identifying the analogues system.

(*iii*) The model should be used as an additional important tool for forecasting the QPF over the Subarnarekha catchment.

(*iv*) The model can be updated by adding more data or by inserting the new analogues system at these positions which are not already covered in the model.

References

Abbi, S. D. S., Singh, Rajinder Khanna, B. S. and Katyal, K. N., 1979, "Forecasting of (semi) quantitative precipitation over Bhagirathi catchment by synoptic analogue method", *Vayu Mandal*, **9**, 1 & 2, 16-22.

Lal, J., Day, J. S. and Kapoor, K. K., 1983, "Semi-quantitative precipitation forecast for Gomti catchment by synoptic analogue method", *Mausam*, **34**, 3, 313-316.

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