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Rajasthan flood as viewed by SAMIR onboard Bhaskara

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ABSTRACT. Data from Satellite Microwave Radiometer (SAMIR) onboard India's second satellite Bhaskara have been analysed for orbit Nos. 473 (8 July 1979), 607 (17 July 1979) and 890 (5 August 1979). These data correspond to the pre and post flood period over *Luni* river basin in Rajasthan. The limited observations show the separability of dry land from flooded area using SAMIR.

1. Introduction

The Indian satellite Bhaskara was launched on 7 June 1979. The satellite microwave radiometer (SAMIR) onboard this satellite has been collecting data on an operational basis since 4 July 1979. This paper describes the preliminary results of the analysis of data from SAMIR at 19.35 GHz frequency for orbit Nos. 473 (8 July 1979), 607 (17 July 1979) and 890 (5 August 1979).

The above passes cover the region of Rajasthan where flooding occurred in the *Luni* river basin. They also cover the nearby region before, during and after the flood. A map based on ground data showing the area flooded due to *Luni* river in July 1979 is shown in Fig. 1.

2. Satellite Microwave Radiometer (SAMIR)

There are two radiometers onboard Bhaskara, operating at frequencies 19 GHz and 22.235 GHz respectively. The spatial resolution of the former corresponds to a circle of 125 km diameter at the subsatellite point while that of the latter corresponds to 200 km. The brightness temperature resolution of each is about 1 deg. K.

During each spin the radiometers look at the scene at different angles from nadir. In the present analysis only the data from the 19 GHz radiometer at the look angle of 2.8 deg. have been used.

3. Description of the *Luni* river flood and weather condition for Bhaskara passes over Rajasthan

Fig. 1 shows the flooded region in the *Luni* river basin. Heavy rainfall occurred during the period 14 to 19 July 1979 and the river *Luni* and its tributaries flooded the vast areas in the districts of Barmer, Jalore and Pali. The flood subsided towards the end of July.

According to the *Indian Daily Weather Report*, on 17 July 1979 fairly widespread rain has been reported in Rajasthan. The chief amounts of rainfall are: Abu 134 mm, Jodhpur AP 11.7 mm, Ajmer 33 mm, Alwar 10 mm and Barmer 9 mm. Significant amounts of rainfall are given in Table 1.

On 8 July mainly dry weather with clear sky occurred in most parts of Rajasthan. This corresponds to the Bhaskara orbit No. 473.

On 5 August 1979, scattered rainfall occurred with significant rainfall rate reported only at Abu (28 mm), with five to seven octas of clouds reported in most of the area. The Bhaskara's orbit No. 890 on 5 August covers almost the same region as also orbit No. 607 on 17 July 1979.

4. Theoretical basis for relating brightness temperature with water, land and wet surface

The brightness temperature of a satellite microwave radiometer is given by:

TABLE 1

Significant rainfall over Rajasthan for the period 1 June to 31 July 1979

(*Courtesy* : Central Water Commission, New Delhi)

S. No.	Station	Normal rainfall (mm)	Actual rainfall (mm)
	Western Rajasthan		
1	Barmer	112.5	59.0
2	Bikaner	120.4	35.4
3	Churu	157.5	129.3
4	Sri Ganganagar	112.0	22.0
5	Jaisalmer	64.0	33.6
6	Jalore	146.6	171.0
7	Jodhpur	138.9	278.4
8	Nagaur	122.2	128.0
	Eastern Rajasthan		
9	Alwar	299.5	233.1
10	Ajmer	218.4	589.9
11	Banswara	421.4	183.6
12	Bharatpur	258.1	85.9
13	Bhilwara	314.4	277.2
14	Bundi	338	378.5
15	Chittorgarh	447.2	358.5
16	Dungarpur	366.5	311.5
17	Jaipur	239.1	248.3
18	Jhunjhunu	164.8	25.0
19	Jhalawar	498.3	127.0
20	Kota	342.1	464.0
21	Pali	160.2	712.5
22	S. Madhopur	413.5	529.5
23	Sikar	188.2	65.9
24	Sirohi	237.5	162.0
25	Tonk	306.0	415.9
26	Udaipur	292.6	165.8

$$T_B=[\epsilon.\ T_S+(1-\epsilon).\ T_{sky}]\ \tau+T_{atm} \qquad (1)$$

where,

ϵ = Emissivity of the surface

T_S = Physical temperature of the surface

T_{sky} = Sky brightness temperature

T_{atm} = Atmospheric brightness temperature

τ = Transmittance of the atmosphere

For a 19.35 GHz radiometer, at satellite altitude $T_{atm}=T_{sky}\approx 30°$ K. As can be seen from Eqn. (1) the maximum contribution to T_B is from surface. This contribution differs depending upon the type of surface, where emissivity will be different. The emissivity of water is $\sim$0.4 at 19.35 GHz and that of land varies from 0.8-1 depending upon the soil type and vegetation cover. A moist or wet soil will have emissivity between that of water and dry land depending upon the moisture content. This provides the physical basis for classification of water, dryland and wet surfaces.

5. Data analysis and interpretations

The Bhaskara passes for the orbit Nos. 473, 607 and 890 are shown in Figs. 2, 3, 4. The circle on the subsatellite track represents the area covered by 19.35 GHz radiometer. The different circles on the subsatellite track denote the numbers of data points used in the interpretation, each circle representing one data point. The passes for orbit Nos. 607 and 890 are almost covering the same area. The orbit No. 473 passes within about 100 km of the above passes and, therefore, it can be taken for comparison before the flood occurred in the *Luni* river.

The plots of the brightness temperature T_B *versus* ground trace (in the form of spin No.) are given in Figs. 5, 6 and 7 for orbit Nos. 473, 607 and 890. Fig. 5 shows the initial brightness temperature of 254 deg. for spin No. 2 on 8 July 1979 which appears from Fig. 2 to be partly covering the adjoining coast, considering the ground resolution of 125 km. Thus this value of brightness temperature (254 deg. K) could be attributed to water and land. The value of brightness temperature reaches a maximum of about 290 deg. around spin Nos. 11, 12 (25.52 deg. N, 71.59 deg. E) indicating terrain type with emissivity reaching that of land surfaces. After that the brightness temperature decreases until it reaches a constant value of 254 deg. K again indicative of a different types of surface. The values of the brightness temperatures in the region of interest are given below:

Spin No.	Position Lat. (°N)	Long. (°E)	T_B(19.35GHz) (°K)
12	25.18	72.23	294
13	25.44	72.49	290
14	26.10	73.14	291
15	26.35	73.40	289

Average T_B = 291±1 before the flood

The values of the brightness temperatures indicate uniform terrain and hence the average of brightness temperature has been extended to larger area which will also take into account the uncertainties in the subsatellite point ($\sim$ 0.5 deg.).

Fig. 6 shows the variation of brightness temperature for orbit Nos. 607 dated 17 July 1979. The initial value of 150 deg. K corresponds to the radiometer looking over the sea (Fig. 3). The brightness temperature reaches a maximum value of about 260 deg. K between spin No.

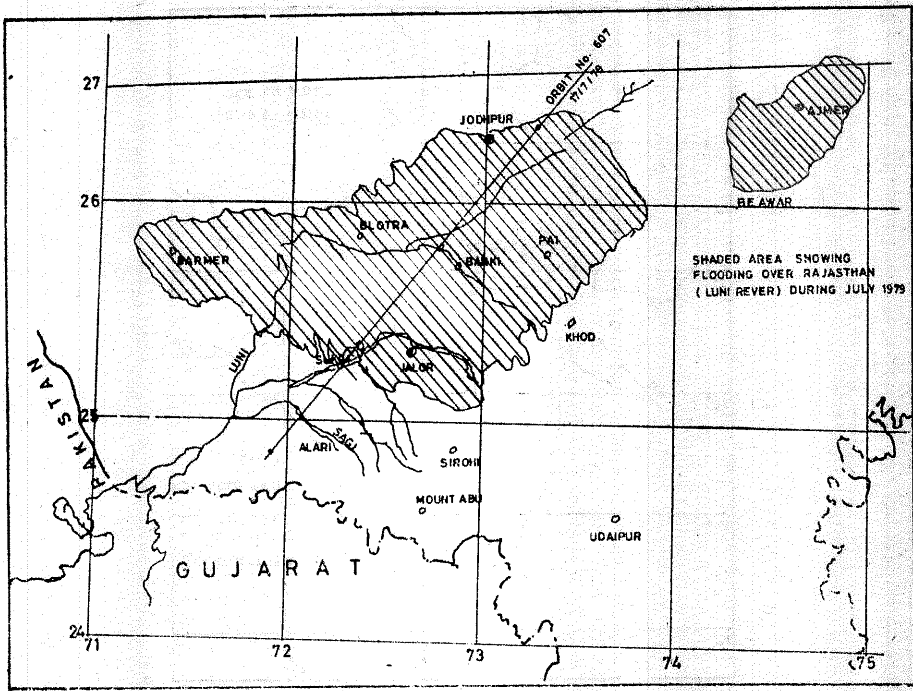

Fig. 1. Map showing the flood in the *Luni* river basin

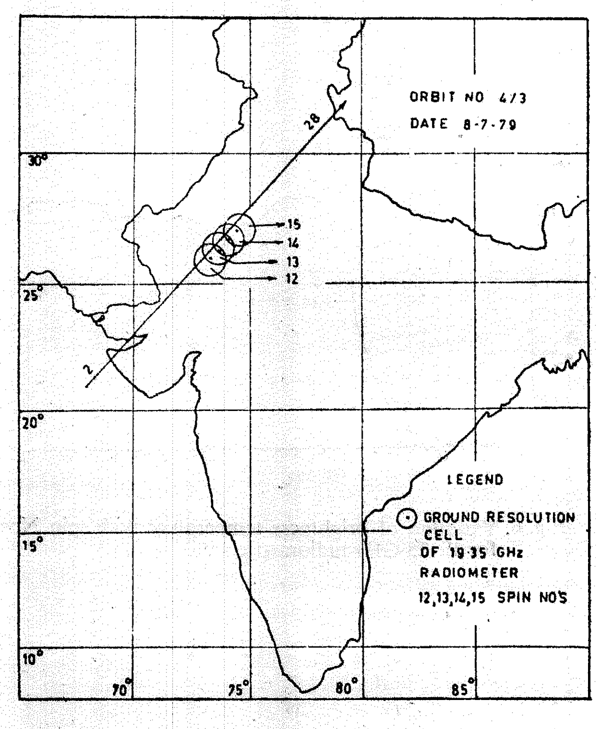

Fig. 2. Subsatellite points for Bhaskara pass No. 473 dated 8 July 1979. The circle indicates the ground resolutions and spin Nos, used in the analysis

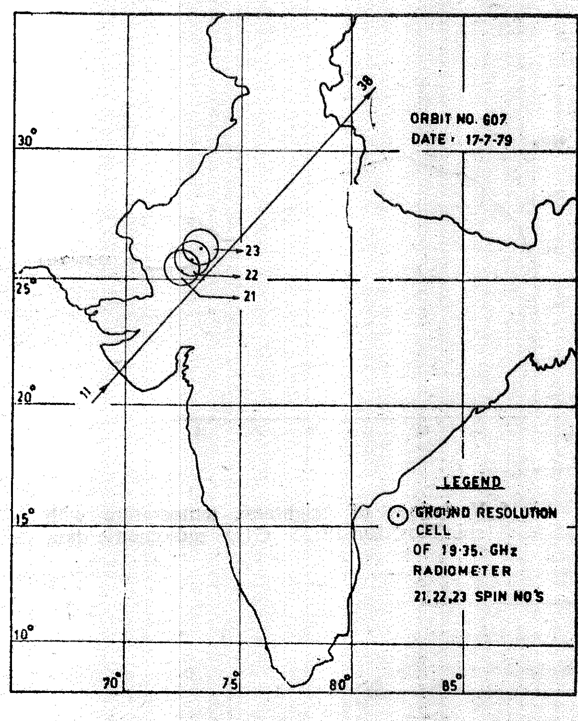

Fig 3. Subsatellite points for Bhaskara pass No. 607 dated 17 July 1979. The circle indicates the ground resolutions and spin Nos. used in the analysis

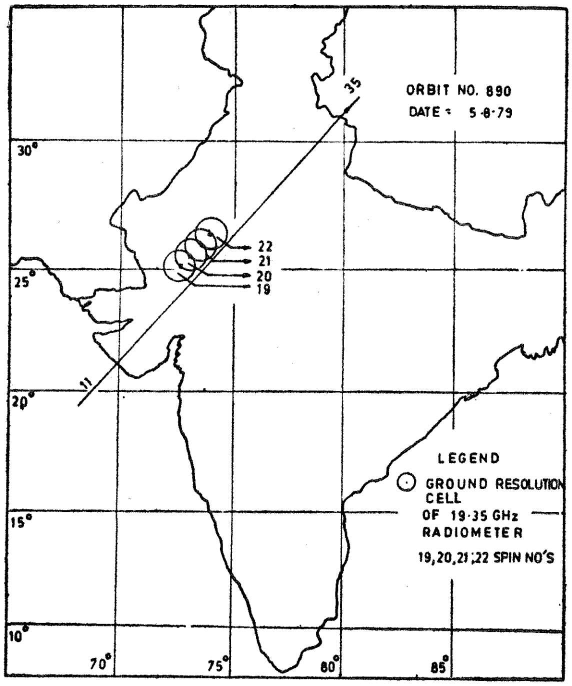

Fig. 4. Subsatellite points for Bhaskara pass 890 dated 15 August 1979. The circle indicates the ground resolutions and spin Nos. used in the analysis

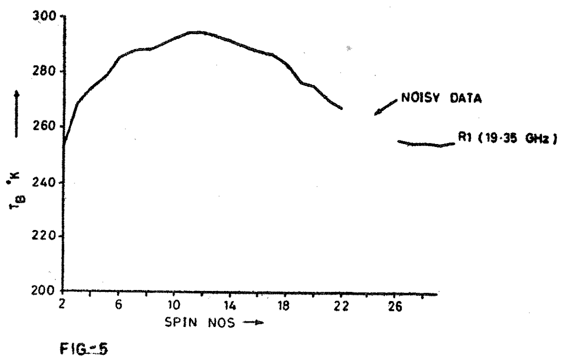

Fig. 5. Variations of brightness temperature with spin Nos. for 19.35 GHz radiometric data

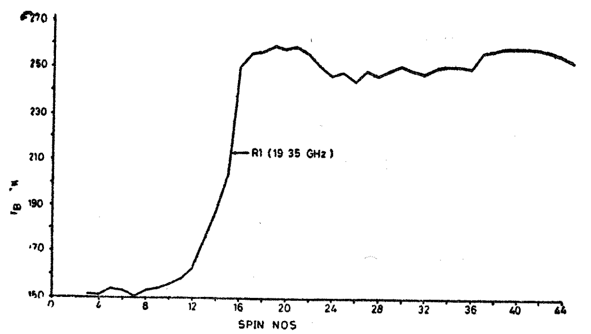

Fig. 6. Variation of brightness temperature with spin Nos. for 19.35 GHz radiometric data

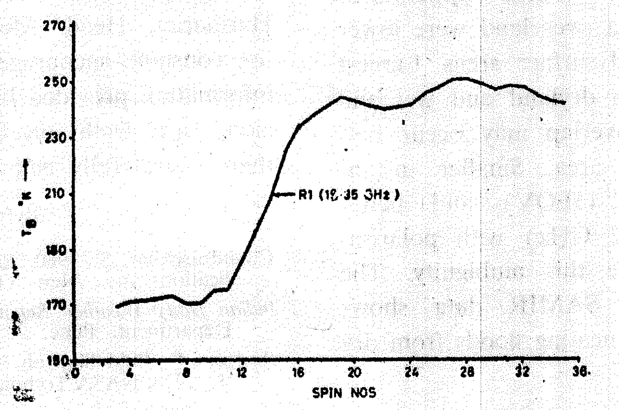

Fig. 7. Variation of brightness temperature with spin Nos. for 19.35 GHz radiometric data

17-22, after which it fluctuates with an amplitude of 5 deg. K. The values of brightness temperature within the region of interest is given below:

Spin No.	Position		T_B (19.35 GHz) (°K)
	Lat. (°N)	Long. (°E)	
21	25.26	72.20	259
22	25.53	72.48	256
23	26.20	73.15	251

Average T_B = 255·3±3.3 during flood

The three locations are also shown in the map showing the flooded region in *Luni* river. The circle in the map indicates the ground resolution of 125 km. Again an average has been taken keeping in view the uncertainty of subsatellite points.

Fig. 7 shows the variation of brightness temperature for orbit No. 890 dated 5 August 1979. This orbit corresponds to the date when the flood subsided. This pass nearly coincides with the pass of 17 July when there was floods. The brightness temperature in the region of interest is:

Spin No.	Position		T_B (19.35 GHz (°K)
	Lat. (°N)	Long. (°E)	
19	25.18	72.38	244
20	25.42	73.20	242
21	26.08	73.27	241
22	26.32	73.51	240

Average T_B = 242±0·09 after flood

Thus based on ground truth in the form of maps showing the flooded region and coincident Bhaskara passes, the following three classifications could be suggested.

TABLE 2

T_B =291±1	Dry land
T_B =255.3±3.3	Flood
T_B =242±0.9	Wet land

The reason of larger T_B for flooded region than that for wet region may lie in the poor ground resolution of 19.35 GHz radiometer. This may be particularly true because of the dimension of the flooded area being comparable to the instantaneous field of view of microwave radiometer.

6. Conclusions

Table 2 shows that brightness temperatures from rain or flooded area over land were lower than those from dry land surface areas. Largest contrast appears between dryland and wet and flooded areas whereas overlap may occur between wet and flooded area. Smaller instantaneous field of view (IFOV) and better frequencies (probably 37 GHz) with polarisation change may resolve this ambiguity. The preliminary analysis of SAMIR data shows reasonable results for delineating floods from dry land.

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