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Weather radar distributed hydrological modelling: a case study in the Indus Basin

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Abstract Radar rainfall estimation through echo reflectivity detects heavy precipitation areas. The intensity of rainfall depicted quantitatively through radar echo variations with pseudo colouring technique and CAPPI (Constant Altitude Plain Position Indicator) representation can pinpoint the areas of intense rainfall. The weather radar equipment plays an extremely vital role for flood monitoring/forecasting and its assessment for subsequent mitigation measures applied to the Pakistan river basins on a real-time basis. An application of radar rainfall estimation and runoff prediction, which was studied in the Jhelum River basin, a tributary of the Indus River in Pakistan, is presented here.

Key words flash flood prediction; radar rainfall estimation

INTRODUCTION

Rainfall measurement in drainage basins, particularly in the mountainous region, poses a great problem, though some mitigation of the situation is made by the installation of manual and telemetric rainfall stations. Still, uncertainty persists in areal precipitation measurement because the ground gauged rainfall stations give only the point rainfall estimation. To solve this problem and predict river runoff, a simple two-dimensional hydrological model with quantitative precipitation measurement radar (QPM radar) is utilized. It covers spatio-temporal rainfall distributions for river runoff estimations, particularly with regard to integrated streamflow in a main river channel. The system was applied to the Jhelum River basin, a tributary of the River Indus in Pakistan, for the flood season from 15 June to 15 October 2002.

Figure 1 shows the location of the ground gauged telemetric rainfall stations and the study catchment area. The telemetric stations reported almost no significant rainfall, therefore it was difficult to estimate the inflow into the Mangla Dam due to rainfall during this period in the upper drainage basin. Table 1 shows the hourly ground gauged rainfall intensity and inflow to the Mangla Dam.

The C-band QPM radar during the period showed a sequential growth and decay of the clouds, which was a clue for prediction of the increase of inflow into the reservoir. To utilize the suitability of QPM radar for reservoir management, a two-dimensional hydrological model has been developed and applied to the Jhelum River basin.

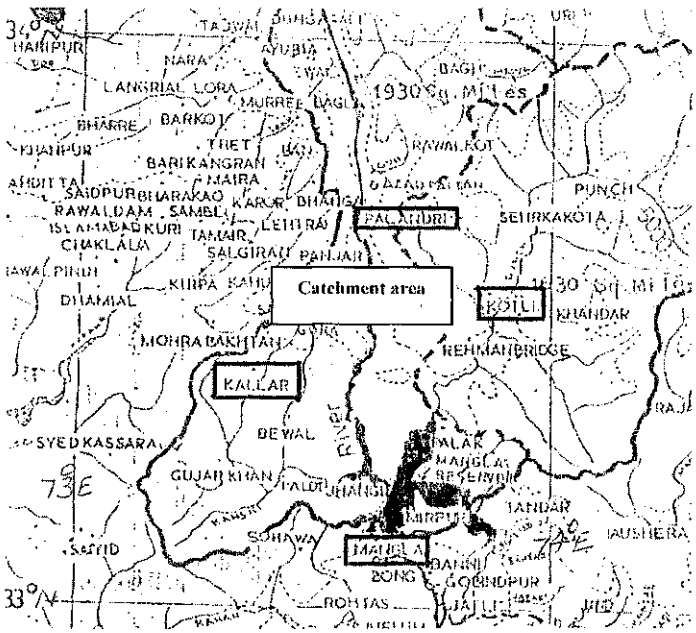

Fig. 1 Location of telemetric station and study area.

Table 1 Ground gauged telemetric rainfall and inflow on 26 August 2002.

Time (h GMT)	Telemetric rainfall (mm h^{-1}):			Inflow (m^3)
	Kotli	Kallar	Plandari	Mangla Dam
00:00	0.0	0.0	0.0	753.0
01:00	0.0	0.0	0.0	755.6
02:00	14.5	6.3	0.0	713.0
03:00	26.2	10.7	0.0	906.0
04:00	1.3	2.5	2.5	906.0
05:00	0.5	0.0	0.0	3197.9

FLOOD OF AUGUST 2002

The C-band QPF image obtained on 26 August 2002 at 04:00 PST (Pakistan Standard Time) showed hardly any rainfall activity over the upper catchment of the Jhelum River. Between 04:30 and 05:00 h (Figs 2 and 3) the rainfall at the rate of 2.5 mm h^{-1} started over the reservoir, while the telemetric rainfall measuring stations located at Plandri (PLI), Kotli (KTI) and Mangla (MAG) indicated no rainfall in 2 h from 04:00 to 06:00 h. The whole catchment area (250 km^2) of the reservoir was covered with rainfall intensity up to 5 mm h^{-1} until this time while no ground verification could be made as the telemetric station reported no rainfall. The heavy rain band approached after 07:00 h (Fig. 4). The rainfall considerably decreased over the reservoir at 08:30 h PST, as indicated through radar echoes (Fig. 5). The rainfall generated runoff into the Mangla Dam, which is the second largest reservoir in the country. The inflow jumped from 755.6 m^3 at 06:00 h to 3197.9 m^3 at 10:00 h (PST).

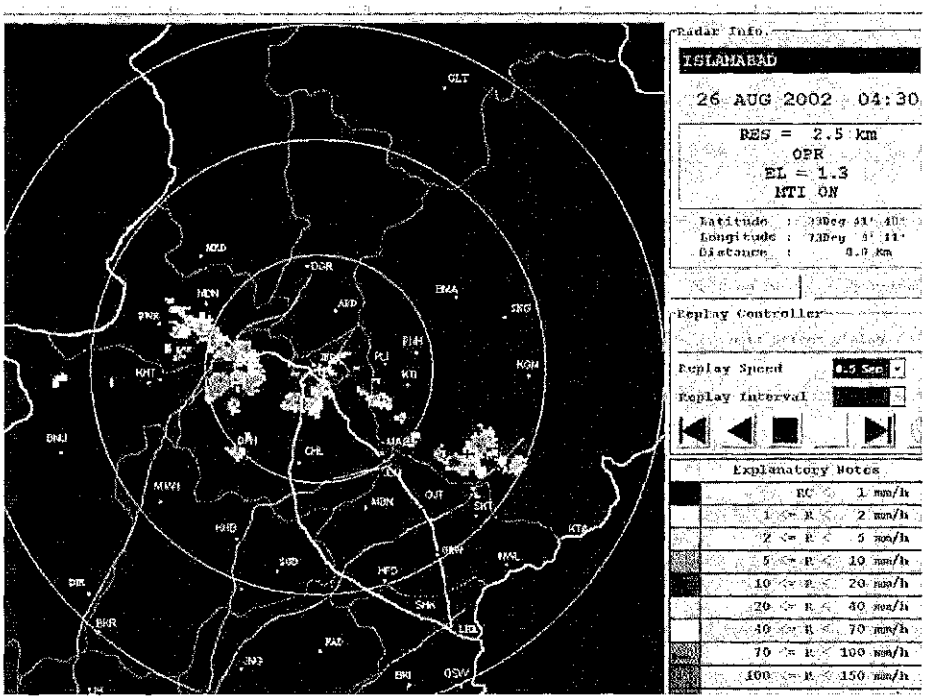

Fig. 2 C-band radar image showing amount of precipitation at 04:30 h on 26 August 2002.

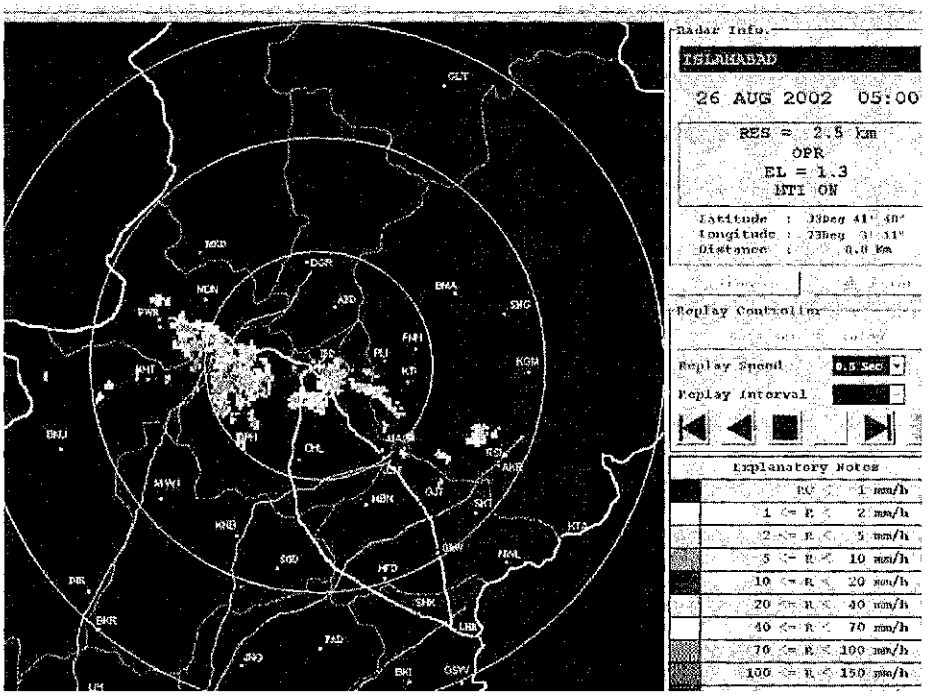

Fig. 3 C-band radar image showing amount of precipitation at 05:00 h on 26 August 2002.

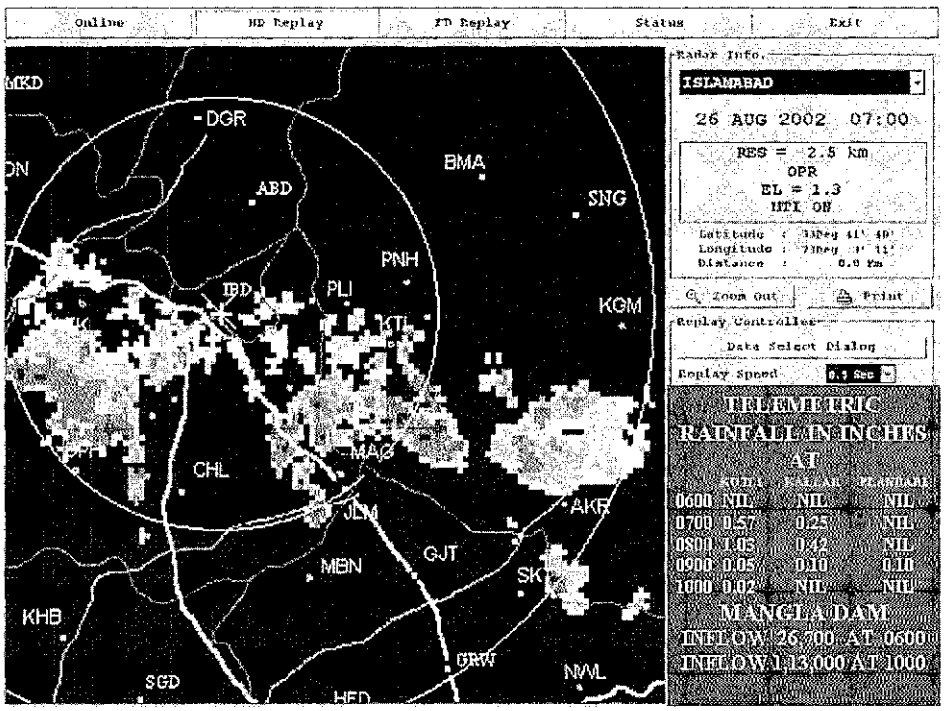

Fig. 4 C-band radar image showing amount of precipitation at 07:00 h on 26 August 2002.

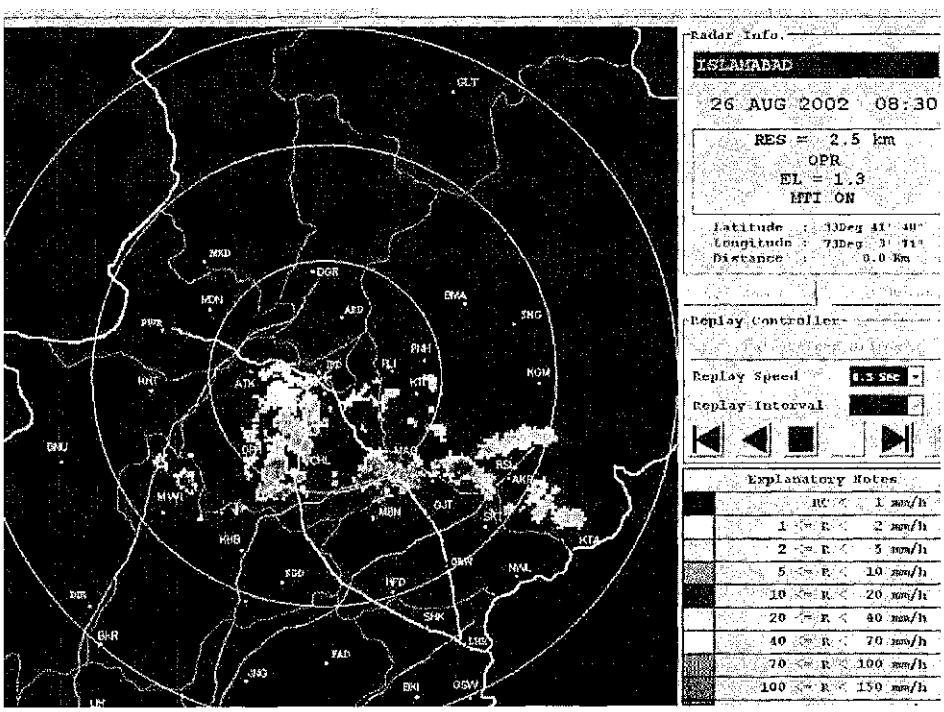

Fig. 5 C-band radar image showing amount of precipitation at 08:30 h on 26 August 2002.

RESULTS

Though there was a sudden increase of inflow into the Mangla Dam from 755.6 m^3 to 3197.9 m^3 in almost 3 h, the inflow could be effectively predicted in the distributed hydrological modelling. From the viewpoint of the reservoir operation, the prediction resulted in effective reservoir operation to treat additional inflow without causing any flood peak or danger of spillover.