II -149 Flood Forecasting in Agno River Basin Using a Distributed Hydrologic Model

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1. INTRODUCTION

Forecasting of floods in a catchment in realistic scale depends on the basin characteristics and rainfall patterns. In this study, the usefulness of a distributed hydrologic model for flood prediction in the Agno river basin of the Philippines was analyzed. IISDHM, a physically based distributed hydrologic model *(Jha et. al, 1997)*, is used in this study for the analysis.

2. STUDY AREA

The study area, Agno river basin, which lies in the western portion of the central part of Luzon island of the Philippines with a drainage area of 5,952 km^2, is frequently affected by severe typhoons and consequent floods many times a year. In the catchment, telemetric system is used to obtain the 3-hourly rainfall and water level data in different locations. However, due to technical problems, complete datasets in many gauging stations are not available and depending on the availability of required data, a sub catchment of an area of 1,700 km^2 (Fig. 1) is selected for this study. The annual average rainfall varies from 2,000 mm in the south-eastern part of the study area to more than 4,000 mm in the northern mountainous area. A GIS of the study area has been develop to handle the vast amount of spatial input data layers of the model using spatial data and remotely sensed images *(Dutta and Herath, 1996)*.

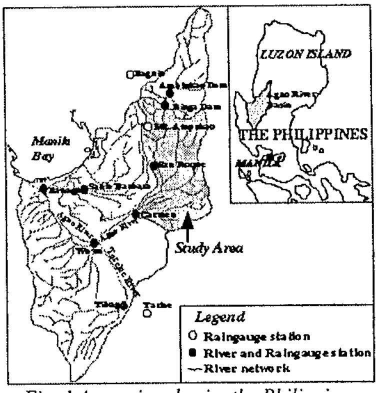

Fig. 1 Agno river basin, the Philippines

3. MODEL DESCRIPTION

IISDHM (Institute of Industrial Science Distributed Hydrologic Model), consists of five major components, they are i) Interception and Evapotranspiration, ii) Overland flow, iii) River flow, iv) Subsurface flow and v) Ground water flow (Fig. 2). The model solves the evapotranspiration component using Kristensen and Jensen model, overland flow by diffusion approximation of 2-D St. Venant equation, river flow by 1-D full dynamic equation, unsaturated zone by 3-D Richard's equation and groundwater flow by 2-D non-linear Boussinesq equation. Spatial distribution of catchment parameters, rainfall input and hydrological response are represented in the horizontal plane by an orthogonal grid network and in the vertical plane by a column of horizontal layers at each grid.

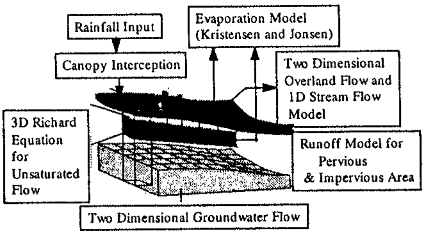

Fig. 2: Schematic diagram of the model

4. FLOOD SIMULATION

In this study, flood events during years 1989-1990 have been selected for model simulation. The model was run continuously for the period of June 1, 1989 to December 31, 1990. Within this period, there are several flood events, out of those, the major flood in the basin occurred during August to October, 1989 caused by typhoon Angela, that passed over the basin. Simulated model outputs were analyzed for two flood events, the first event is from August 1 to October 31, 1989 and the second event is from July 15 to October 31, 1990. Figure 3 shows the daily rainfall of the three stations (Binga Dam, San Roque, and Carmen, Fig. 1) during the 1st selected event of floods. Theissen polygon was used to calculate the distribution of rainfall of these three stations in the basin. 3-hourly time series data of rainfall and other necessary parameters were used in the model simulation.

Figure 4 shows the comparison of observed flood hydrograph with the simulated flood hydrograph of year 1989 from IISHDM. It can be seen that simulated hydrograph of Fig. 4 shows good agreement with the observed hydrographs. In the model simulation, baseflow agrees very well with the observed hydrograph, although it overestimates flood peaks. The flood peaks are very sharp with quick recession and baseflow was less which is due to intense rainfall within a short duration. In the 2nd event also, model simulates the flood with high accuracy.

5. FLOOD PREDICTION

As, the model was successful in simulating flood hydrographs of different past flood events, further analyses have been made to study the applicability of such model for flood forecasting in the basin. Flood prediction mechanism is very much dependent on correct understanding of lag times of upstream rainfall and discharge data with

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downstream river discharge. At present, flood in Agno river basin is forecasted by PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) using pre-defined lag time between upstream rainfall and measured river water levels in the different location of the river. However, this approach does not provide good results due to higher spatial variation of typhoon associated rainfalls in the basin.

In this study, the model was run for several events with and without rainfall to observe the time lags between upstream and downstream hydrographs. Fig. 5 shows hourly simulated hydrographs at San Roque and Carmen due to propagation of Binga dam release during the period from 16:00 hr. of July 26 to 16:00 hr. of July 27, 1989. From the three hydrographs, we can estimate the time of propagation of floods from upstream to down stream of Agno river. A time lag of approximately 3 hours between Binga dam and San Roque and 5 hours between San Roque and Carmen can be observed. Fig. 6 shows the simulated flood hydrographs at Binga, San Roque and Carmen from 12:00 hr. of October 19 to 0:00 hr. of October 21, 1989, with heavy rainfall in the entire basin (80th and 81st days of Fig. 4). From the hydrographs of Fig. 6, no distinct time lag can be estimated among the three river discharge stations. It is due to significant lateral inflow to the river branches from upstream to downstream resulted from the heavy rainfall in the basin. Flood peaks are much higher in Carmen than the upstream two points.

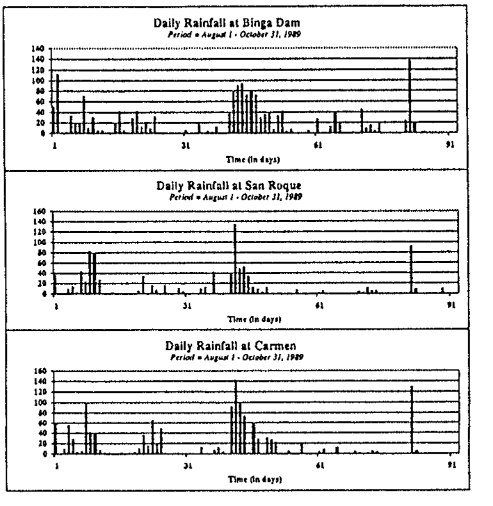

Fig. 3: Daily rainfall (July 1 - Oct. 31, 1989)

6. CONCLUSION

IISDHM is found to be promising for flood simulation in large catchment. Advantage of using such distributed models is that it is possible to obtain the spatial distribution for different components of hydrological cycle and their temporal distribution. However, model results show the difficulties of flood forecasting in the Agno basin using time lag between upstream and downstream river discharges and rainfall at different stations. In the present analysis, 3-hourly rainfall data available for the period were used in the simulation which does not have adequate resolution for flood forecasting in the basin. Recently, the telemetric system has been upgraded to broadcast hourly rainfall and water level data and it may be useful in developing a better framework for operational flood forecasting methodology.

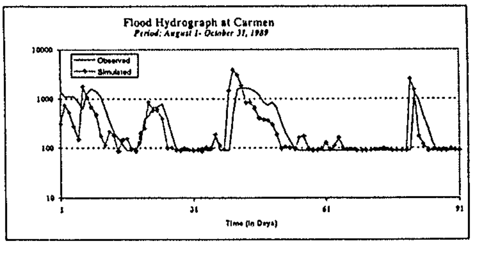

Fig. 4: Observed and simulated hydrographs

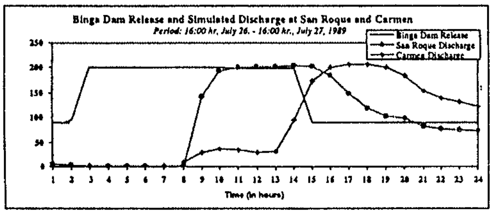

Fig. 5 Hourly simulated discharge hydrograph with hourly dam release data

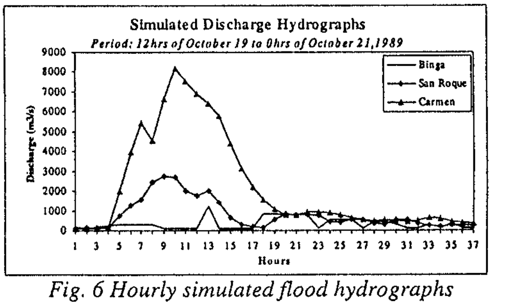

Fig. 6 Hourly simulated flood hydrographs with 3hourly rainfall data

REFERENCES

2) Jha, R., Herath, S. and Musiake, K. (1997): Development of IIS Distributed Hydrological Model (IISDHM) and its Application in Chao Phraya River Basin, Thailand, Annual Journal of Hydraulic Engineering, JSCE, Vol. 41 (1997), pp. 227-232.

2) Dutta, D. and Herath, S. (1996): Development of a GIS For the Hydrologic Analysis of Agno River Basin, Philippines, Proceedings of JSCE Annual Conference, 1996 pp. 334-335.