

HYDROLOGICAL MODEL DEVELOPMENT USING GEOINFORMATICS FOR PALERU RIVER, ANDHRA PRADESH, INDIA

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KEY WORDS: Rainfall, discharge, DEM, Hydrological parameters, Paleru catchment.

ABSTRACT:

In the present study, an attempt has been made to generate runoff using Up-scaled Physically based (UP), rainfall – runoff model in the Paleru catchment covered in Andhra Pradesh state. Hourly and daily rainfall, global data sets of Digital Elevation model (DEM), landuse/landcover with 1km resolution, 9km gridsize of soil and 55km gridsize of potential evaporation were used in the study. Runoff was simulated using a semi-distributed rainfall–runoff model - UP. The daily observed flows were compared against hourly simulated flows of 3 selected flood events - Nov 1992, Nov 1993, and Dec 1993 at Bitragunta gauge, Prakasam district, A.P. It is observed that the deviations of modelled against observed flow are +5.9%, -0.7%, and +8.0% for Nov 1992, Nov 1993, and Dec 1993 events respectively. The match between the modelled and observed hydrographs is good, with maximum deviation of +8.0% in peak discharge for Dec 1993.

INTRODUCTION

The UP model is a semi-distributed model consists of two components, one representing the rainfall-runoff generation system and another to transport the runoff from the hill slopes through the channel system to the catchment outlet. The UP model is an Explicit Soil Moisture Accounting Scheme (ESMA) consisting of a number of elements that are conceptual representations of hydrological storages (figure-1). One of the advantages of the distribution function approach is that some important non-linearities of the runoff generation process can be reflected in the distribution function but without

introducing the large number of parameter values needed for fully distributed models. It is assumed that each grid cell is composed of an infinite number of elemental areas, each having different soil moisture capacities and soil moisture contents. Precipitation, which is assumed to fall uniformly over a grid cell, infiltrates unless the soil is either saturated or impervious. A special probability function describes both the dynamics of the catchment areas that contribute to runoff, and the proportion of elementary areas saturated.

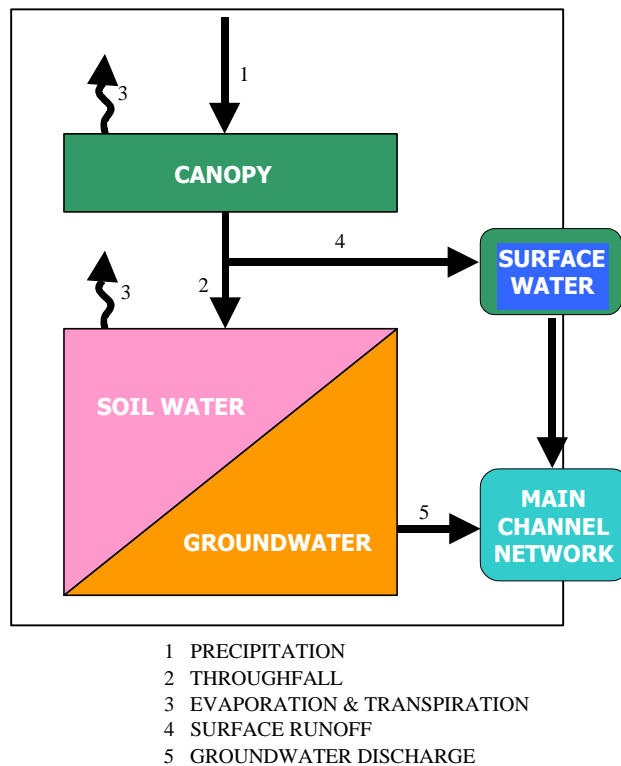


Figure 1: UP Model Schematic

The flow routing in the model is performed using a transfer function and St.Venant equations. The function is derived from a digital elevation model (DEM). The UP model conserves mass, such that

$$P - (Q + ET) = \Delta S$$

Where **P** is precipitation,
Q is stream discharge,
ET is evapotranspiration
 and **ΔS** is the change in all forms of storage.

The UP model can run as a stand alone hydrological model simulating surface and subsurface water storages and transfers, and as the hydrology component of a linked atmosphere and land surface hydrology model (Ewen, 1999). Kilsby et. al.,(1999) concluded that the model could be successfully applied to modeling the water budget and hydrological processes and was tested to simulation of the Arkansas-Red River basin. Similar study has been carried out for the Nagavali catchment, Andhra Pradesh (Prasada Rao et.al., 2005).

**DATA USED AND
METHODOLOGY**

A summary of the data sources used in the characterization of the catchments is shown in Table below.

Data	Source
Topography	USGS GTOPO30 DEM
Soil	IGBP (Global Soil Data Task Group, 2000)
Land cover	IGBP
Rainfall	India Meteorological Department
Potential evapotranspiration	Ahn and Tateishi (1994)
Stage/Discharge	Central Water Commission

Model setup

The Paleru river catchment was demarcated as 6 sub-catchments in the UP model (figure-2), each of which was composed of a number of 5X5 km grid cells. The model-generated runoff was routed within each sub-catchment. The drainage parameters - Maximum linear base flow(Q_c), Soil moisture content at which nonlinear base flow occurs (W_c), Maximum base flow (Q_m) and Maximum soil moisture (W_m) were initialized to

reproduce the hydrograph recession limbs of the hydrographs after a few initial runs.

The USGS GTOPO 30 arc second DEM (approximately 1 km) (Gesch et al., 1996) was used to provide the necessary topographic information for the UP2 model (Figure-3). The DEM was used to delineate the basin boundaries and to identify the major river courses.

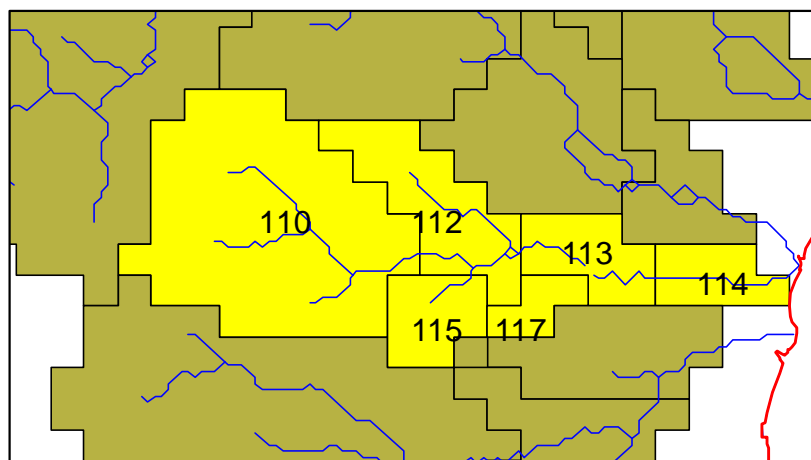


Figure 2: UP model grid representation – Paleru river catchment

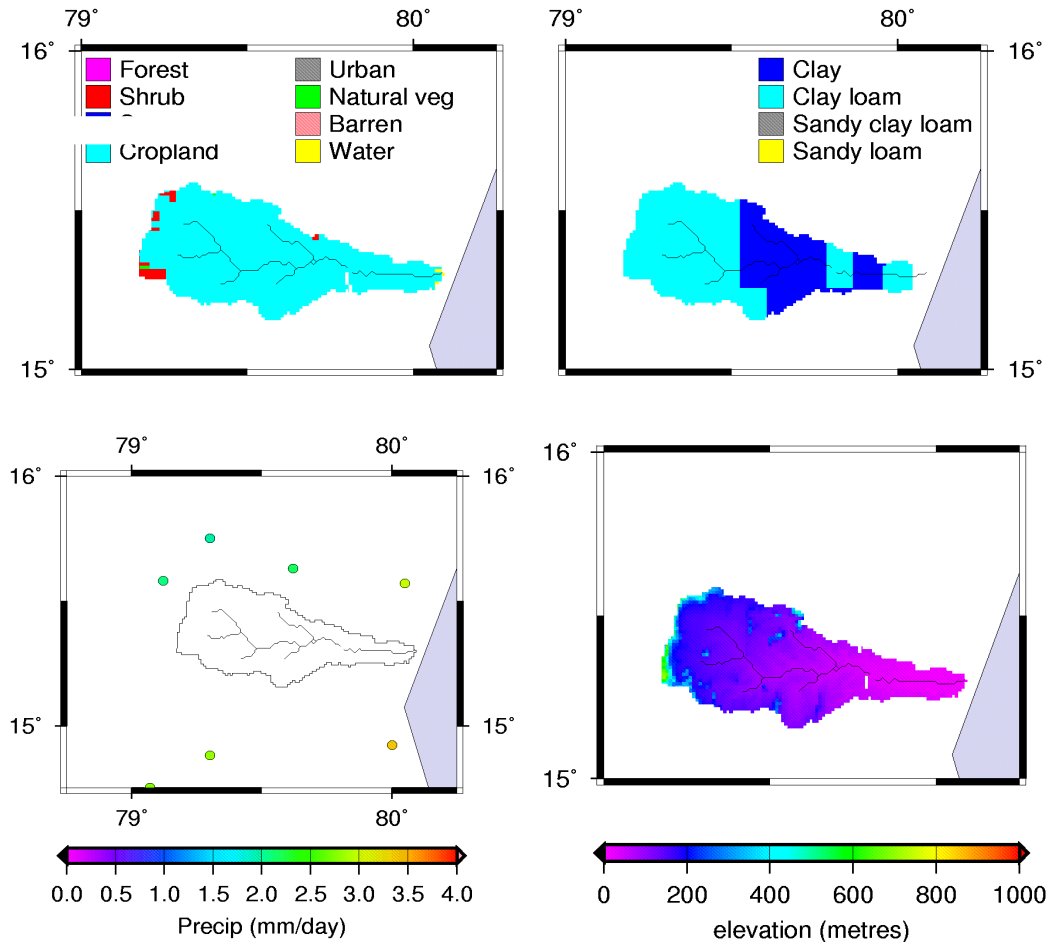


Figure 3: Distributions of Vegetation (Top left) and Soil (top right) types, and Rain gauges (bottom left) and Elevation (bottom right) for the Paleru catchment

Based on 1 km resolution land use data of USGS IGBP (Belward, 1996), seven classes of land use / land cover were identified (Figure-3). The catchment is mostly covered by agriculture cropland, with small extent of shrub in the elevated areas. In the absence of spatial distributed potential evapotranspiration (PE) data, the 30 minute (approx. 55km) mean monthly PE global data set of Ahn and Tateishi(1994) was used for calculation of the actual evapotranspiration (AE). PE factor is the ratio of the potential evapotranspiration of a given to that of a reference crop. The mean annual PE was

approximately 1400 mm in the catchment, exhibiting little spatial and temporal variation. The PE is highest during the months of February, March and April, and at its lowest in June, July and August.

The prominent soil types within the catchment, identified from the USGS IGBP 5 arc minute data set (Belward, 1996), approximately 9km resolution, are clays and clay loams (figure-3). Soils with a large clay fraction have high plasticity and stickiness.

As there is no gauges were located in the catchment, the hourly precipitation values were assigned to the UP model grid cells using a nearest neighbor (Thiessen polygon) approach using 6 gauges nearest to the catchment (Figure 3). The disaggregating scheme used to allocate the recorded daily rainfall values to hourly intensities was based on statistical and deterministic measures, derived from observations at hourly gauges. The daily rainfall was distributed into hourly quantities according to the relative distribution at the hourly gauge.

MODEL RESULTS AND DISCUSSION

The main modeling emphasis was to reproducing the flood peaks by considering the antecedent soil moisture conditions. Precipitation is highest during the northeast monsoon in the months of October and November, which is also the period of largest runoff. Actual evaporation is reasonably constant all the year round, with the slightly higher rates in the months October to December, when water availability is high during and after

the monsoon. It is observed that about 72% of the precipitation is evaporated, of the remaining 26% forms runoff, with the net change in storage accounting for the discrepancy between these two values. After the monsoon rains the soil moisture storage is diminished until rains increase in July. The daily observations are compared against hourly simulated values at Bitragunta gauge (figure- 4a & b).

It can be observed in all events that during the period of the peaks of rainfall and modeled run-off are showing relative peaks. It is also noticed that the simulated flow is 394 m³s against 372 m³s observed flow, 272 m³s against 274 m³s and 537 against 497 m³s for Nov 1992, Nov 1993, and Dec 1993 events respectively at the Bitragunta gauge gauge. It is perceived that the deviations of simulated flow against observed are +5.9%, -0.7%, and +8.0%, for Nov 1992, Nov 1993, and Dec 1993, events respectively. The good fit is observed for these events between the simulated and observed hydrographs, with maximum deviation of +8% in peak discharge for Dec 1993.

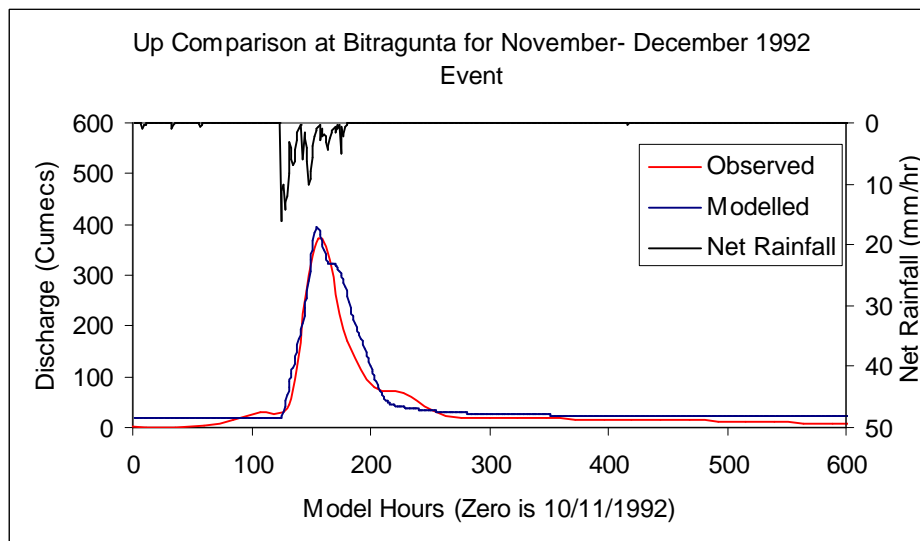


Figure 4a : Comparison of observed and simulated peak discharges for 1992

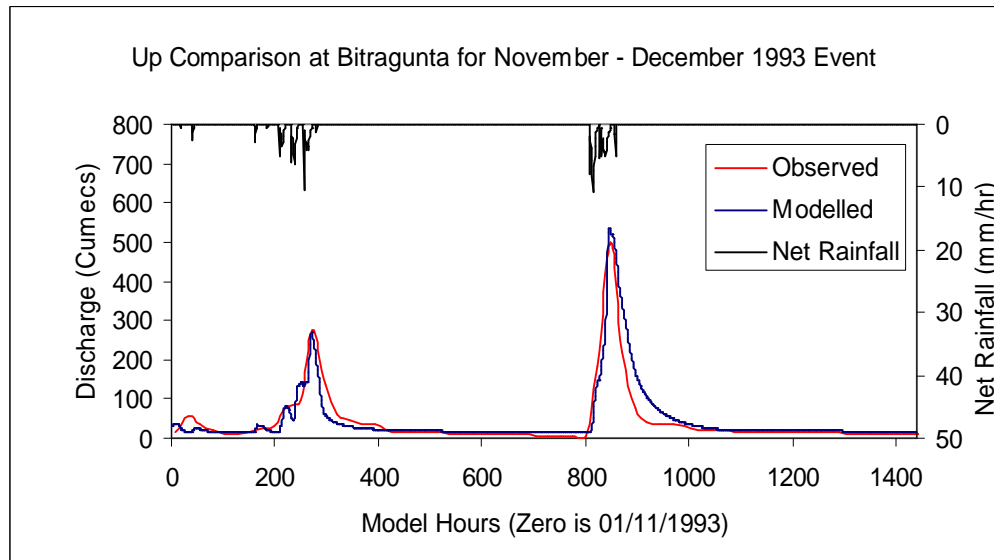


Figure 4b : Comparison of observed and simulated peak discharges for 1993

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