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Direct Runoff Hydrograph for Ungauged Basins Using a Cell Based Model

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Stream flow prediction in ungauged basins is recognized as one of the urgent issues to be addressed for sustainable water resources development of the world. In particular, most of the river basins in developing countries are ungauged though the water resources development potentials greatly exist in these river basins today. This paper describes a distributed model to derive direct runoff hydrographs for ungauged basins based on the spatially heterogeneous basin physical properties. The basin is divided in to several grid cells and the physical properties are derived for each cell using GIS data. Flow paths to the basin outlet and the stream network are derived from the DEM of the basin. Overland flow is generated from each grid cell of the basin by the application of continuous effective rainfall of 1mm/hr to the basin. The flow velocity through each grid cell is calculated using the kinematic wave approach and travel time of flow through each cell is obtained considering flow travel distance in the flow direction of the cell. The collated overland flow at a cell with a flow accumulation number above a specified value is considered to flow as a canal flow. The travel times for direct runoff from each grid cell to the basin outlet is calculated by using the flow direction grid and the flow travel time through each cell. The S-curve for the basin so obtained is then used to derive the unit hydrograph of a given duration for the basin. Direct runoff hydrograph for a given rainfall hyetograph is obtained by using the basin unit hydrograph with a flow travel time based constant rate loss model. The model is tested using hourly data collected from the mountainous Upper Kotmale basin, which is the upper most sub basin of the Mahaweli River in Sri Lanka. The area of the basin is 304 km2 and the elevation varies from 1200 m to 2500 m above mean sea level. The basin is situated in the wet zone of the country and the average annual rainfall varies from 2200 mm to 2600 mm. The basin is under varying land use and land cover types comprise of tea (44%), forest (36%), build up land (7%), grass (5%), water bodies (1%) and other crops. The direct runoff hydrographs for rainfall events obtained by the application of the model reasonably agree with the observed hydrographs. The unit hydrograph obtained from the model was compared with the conventional Snyder's synthetic unit hydrograph obtained using regionalized parameters assuming the basin as an ungauged basin. It is found that the new model predictions are more accurate than the Snyder's unit hydrograph predictions and thus, the developed model is a useful tool to derive the direct runoff hydrograph for ungauged basins.