

**CONSIDERATION OF ANTECEDENT SOIL MOISTURE FOR PREDICTING FLOOD CHARACTERISTICS**

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**Abstract**

Antecedent soil moisture is a key factor to determine flood characteristics following hydrological cycle's processes. The aim of this study is to quantify the relationships of the antecedent soil moisture to flood volume, peak discharge and its duration. River discharge and soil moisture were simulated by a distributed hydrological model. Then, multiple linear models were employed for the quantification of the relationships. Forty-three single flood events were analyzed during the rainy seasons of 2005-12 in Huong River, Vietnam. As a result, soil moisture before flooding strengthened the relationships not only of total precipitation volume for flood volume and duration but also of peak rainfall amount for peak discharge. It was found that the flood characteristics change by reflecting the wet/dry condition at top soil. We expect that consideration of antecedent soil moisture to predict the flood characteristics accurately has a potential to provide benefits not only for flood mitigation but also for conservation of ecological system.

**Keywords:** Flood characteristics, Antecedent soil moisture, Multiple Linear Regression, Hydrological Model



**Fig. 1** Huong River basin with the location

of rain gauges and dams Rain gauge location Dam location Ta Trach river Huu Trach river Kim Long Binh Dien Thuong Nhat Nam Dong Binh Dien Dam Ta Trach Dam Rain gauge location Dam location Ta Trach river Huu Trach river Kim Long Binh Dien Thuong Nhat Nam Dong Binh Dien Dam Ta Trach Dam [m] 1399 1050 701 352 3

**Table 1** Summary of flood characteristics:

simulated flood volume, peak discharge and duration unit average  $\pm$  standard deviation volume  $\times 10^8$  m<sup>3</sup> 3.48 $\pm$ 3.56 peak discharge  $\times 10^3$  m<sup>3</sup> s<sup>-1</sup> 1.93 $\pm$ 1.71 duration hrs 87 $\pm$ 69

**Fig. 2** Discharge and soil moisture simulation in 2009 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0 1000 2000 3000 4000 5000 6000 7000 1 727 1453 2179 soil moisture [%] discharge [m<sup>3</sup>s<sup>-1</sup>] Soil moisture Simulation Observation 0 10 20 30 precipitation [mm] September October November 2009 discharge and soil moisture simulation time [hrs]

flooding with the flood characteristics quantitatively. Here we attempted to answer how strongly antecedent soil moisture affects variability of the flood characteristics such as magnitude (volume and peak discharge) and its duration. Quantifying these characteristics could be a potential strategy for increasing chance for evacuation and mitigation against the disaster as well as for the conservation of ecological system.

The aim of this study is to quantify the relationship of the antecedent degree of saturation in the topsoil to flood volume, peak discharge, and its duration.

## 2. STUDY AREA

We targeted a watershed where floods occur frequently, and the characteristics are not altered strongly by water control facilities. Huong River basin was selected, which is located in Thua Thien Hue Province of the central Vietnam, between 16°00' to 17°45' of the north latitude and from 107°00' to 108°15' of the east longitude (**Fig. 1**). The total catchment area is 1,500 km<sup>2</sup>, the topography changes from 1 m to 1,708 m above sea level, and the mean basin slope is 28.5%. The terrain is classified as hilly mountainous region. The basin captures the heaviest precipitation during the monsoon season. Flood characteristics are not controlled by two dams existing in the region (**Fig. 1**). Binh Dien dam purposes to generate hydropower, whereas Ta Trach dam has not been operated yet.

In total 43 single-pulse flood events during the target period from September to November in 2005–2012 were selected for this study. The characteristic of total volume, peak discharge, and its duration are summarized in **Table 1** (for the definition, see method **3.2**).

## 3. METHODS

### (1) Discharge and soil moisture simulation

A physically-based semi-distributed hydrological model was applied to simulate soil moisture and streamflow. In this study, the Geomorphology-Based Hydrological Model (GBHM) was employed<sup>15</sup>. The main modules are for hillslope and river routing. The spatial and temporal resolutions were set to 500 m and hourly, respectively. The river network was delineated from a 90 m digital elevation model (the Shuttle Radar Topography Mission: <http://srtm.usgs.gov/>). The whole basin was divided into sub-basins, and sub-basins are further decomposed into a set of computational units namely flow interval. The hydrological processes in each flow interval were simulated sequentially from the uppermost section to downward.

The hillslope module simulates the hydrological processes such as evapo-transpiration, the movement of groundwater, and overland flow at each grid within the flow interval. Then, the accumulated lateral inflow from flow intervals becomes the later inflow to the main stream in the sub-basin. At last, the outflow from each sub-basin is routed downstream sequentially.

The topsoil with average depth of 1.5 m was horizontally subdivided into 12 thin layers. For each layer, the amount of the soil moisture was estimated and taken their vertical mean

(1)

per grid. The soil  
moisture was  
simulated by one-  
dimensional  
Richard's Equation  
(1).  $\theta(z,t) = \theta_0 + \frac{\theta_s - \theta_0}{2} \left[ 1 - \operatorname{erf} \left( \frac{z}{2\sqrt{D t}} \right) \right]$