RUNOFF PROPERTIES FROM SOIL AND ROCK LAYERS IN FORESTED MOUNTAINOUS WATERSHEDS

Gifu University, Student Member, Fereshteh Ghiami-Shomami, Kohzo Kawasaki
Gifu University, Takumi Kamiya, Arif Nurman, Tatsuo Nishino
Gifu University, JSCE Member, Seirou Shinoda, Toshiharu Kojima,Keisuke Ohashi

1. Introduction

The term, runoff ratio, is the proportion of rainfall that does not infiltrate and is not taken up by evapotranspiration, and thus ends up as runoff. It is a function of the interactions among precipitation, evapotranspiration, slope, soil characteristics and land use/land cover. High runoff ratio indicates low infiltration capacity [1]. As infiltration refers to water entry into the soil, it is largely determined by the condition of the soil like type, structure and moisture content at the start of the rain. Recent studies have found that bedrock groundwater is a dominate source of runoff from headwater catchments [2]. Hosoda and Tani examined the influence of moisture fluctuation in bedrock layer on rainfall-runoff response in a forested catchment and concluded that thick, weathered bedrock layers are functional on rainfall-runoff during significant storm event [3]. To increase our understating about soil and rock interaction in runoff process, this paper aims to gain insight to the runoff properties of soil and rock layers in two mountainous forested watersheds through estimating runoff ratio for each soil horizons.

2. Field observation:

Our study area covers Enbara and Futatsumori watersheds located respectively in Yamagata city and Nakatsugawa city of Gifu Prefecture, represented by 5 stream gauging stations measuring discharge of drainage areas in Enbara and Futatsumori using pressure type water level gauge and V-notch (triangular) weir discharge calculator respectively. Rainfall were measured by tipping bucket rain gauge in each watersheds. The catchments location, area and available period of record are presented in figure 1. Due to the type and bad location of measuring instruments in Morigahora (FU), autumn and winter records were affected by fallen leaves and frozen rainfall. Therefore, to avoid using uncertain records, only spring and summer data were used for this site.

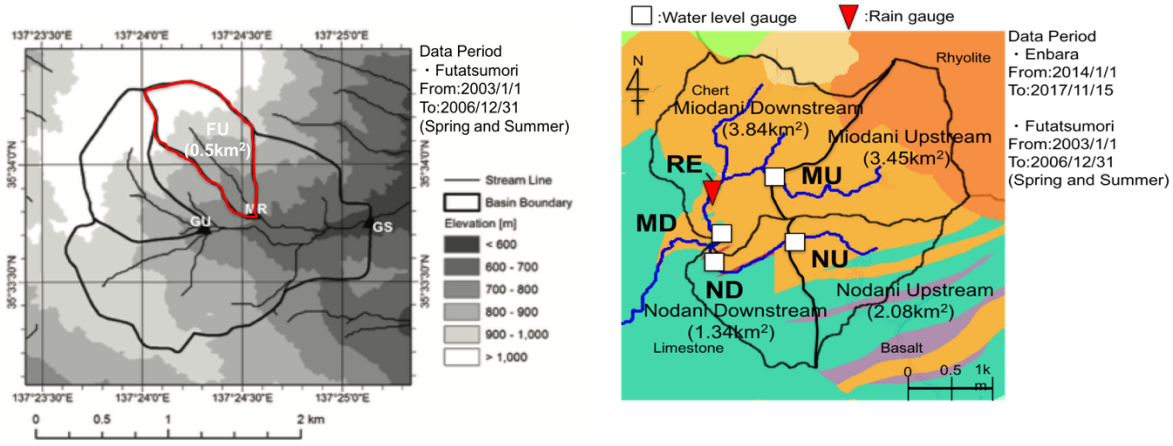

Figure1.Location of watersheds (Left: Futatsumori[4], Right: Enbara)

3. Runoff simulation

The Storage Function Method (SFM) as a conceptual rainfall-runoff model, consists of two components: tanks and channels connected to them. The relationships between the inflow and the outflow at each tank is expressed by the storage equation and the balance equation. We structured SFM vertically into three tanks corresponding to humus soil layer (A), inorganic soil layer (B) and bedrock layer (C) to simulate runoff process. It considers rainfall as the input and generates the output as horizontal discharge(Q_H) and vertical discharge (Q_v) from three distinct layers of soil. Figure 2 shows the SFM model.

4. Runoff ratio

The watershed areas shown in Figure 1 are so small that the response period of rainfall-runoff is less than several hours. The runoff ratio can be evaluated with a rate of runoff height from a watershed or a soil/rock layer against an amount of rainfall in a rain event. Figure 2 shows the relationships between rainfall and runoff height in each event.

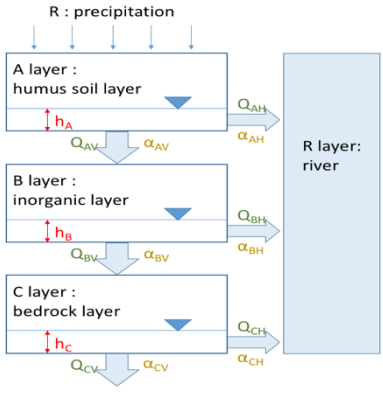

Figure2. Storage function model

We extracted rainfall events based on the weather characteristics of our study area which considers two rainfalls as separate events if it takes more than 24 hours after finishing a rainfall to start the next rainfall.

5. Result and Discussion:

Simulated runoff heights from the A, B and C layers correspond to a direct, intermediate and base flows in a runoff phenomenon. The runoff ratio of the C layer is on the same level with the A layer and the base flow component is significant in the watersheds MD, MU and NU, where the loss of water due to vertically move through a bed rock can be small. Figure 4 shows relationships of runoff ratio at A+B layer and C layer. As plots of MD, MU and NU are proportional, the base flow from the rock layer is influenced on a storage volume in the soil layer and runoff height from the layer. In the case of FU and ND, the bed rock is mainly composed of weathering rhyolite and limestone, respectively. The loss of water become remarkable in these types of rock because of vertical infiltration. Although the base flow may be related with storage properties in the soil layer, water storage abilities and runoff characteristics in the soil layer have to be investigated with the detail observed data and their analysis.

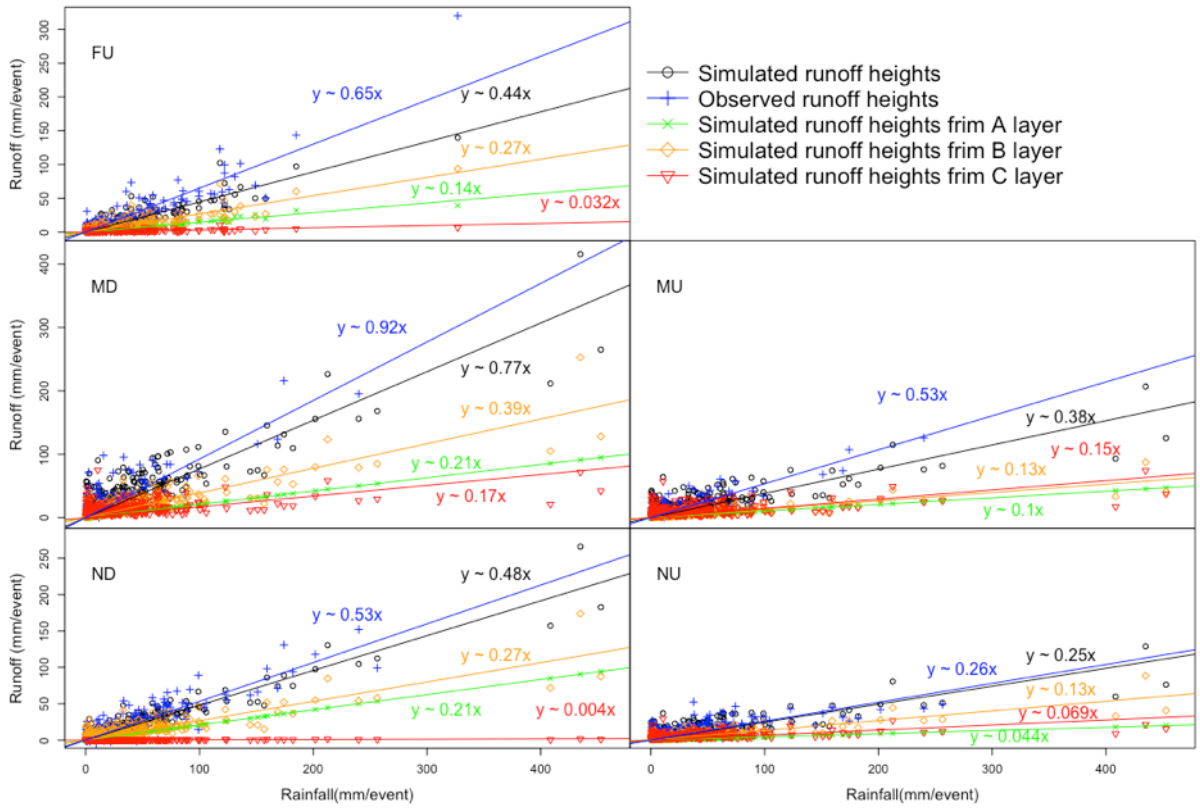

Figure 3. Relationships between rainfall and runoff height in a rain event

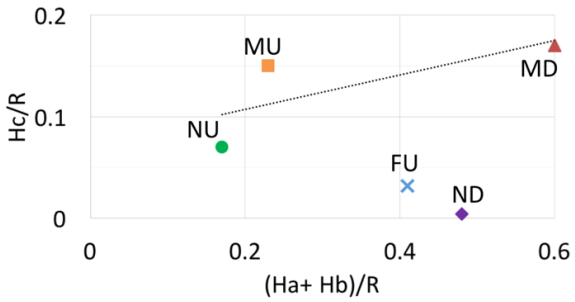

Figure 4. Runoff ratio of soil and bedrock layers

References:

1. Applied morphometry and watershed management Using RS, GIS and multivariate statistics (Case Studies), Yahya Farhan, 2017, Scientific Research Publishing, Inc. USA, 2017, 488p.
2. Effects of bedrock groundwater on spatial variability of baseflow in a small granite catchment, Fujimoto et.al, 2016, Japanese Geomorphological Union, 37-4, p493-510.
3.Influence of moisture fluctuation in thick, weathered bedrock layers on rainfall-runoff response in a small, forested catchment underlain by Paleozoic sedimentary rocks in japan, 2016, Japanese Geomorphological Union, 37-4, p465-492.
4. Long term variable properties of runoff process in a mountainous forested catchment, Edwina Zainal et al, 2012. Advances in River Engineering, JSCE, vol.18.