E-3.2 Quantification of hydrological processes in tropical forests

Contact Person Makoto Tani
Chief, Forest Meteorology Laboratory
Forest Environment Division
Forestry and Forest Products Research Institute
P.O.Box 16 Tsukuba Norin Kenkyuu Danchi-Nai,
Ibaraki, 305, Japan
Phone +81-298-73-3211(Ext.384), Fax+81-298-74-3720

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Abstract

Field investigations were carried out at a small forested experimental catchment in Peninsular Malaysia to quantify hydrological processes in tropical forests. The following findings were obtained. 1) Rainfall was characterized by the high intensity and the short continuance, and most rainfall events occurred in the afternoon. 2) The structure of soil mantle on a hillslope consisted of a relatively uniform surface layer and weathered rock the thickness of which was widely ranged. 3) The soil permeability within surface layer decreased with depth according to the decrease of soil pore. 4) When the soil moisture condition of hillslope was wet, rain water was infiltrated rapidly into depper soil and the ground water level was found during the storm event at one of the monitoring points. When it was dry, the infiltration was slow and the size of storm hydrograph was very small, but as the soil condition is getting wet, the storm hydrograph was bigger and the gradient of its recession limb became gentler.

Key Words

Tropical Forest, Water Balance, Experimental Watershed,
Hillslope Hydrology, Surface Soil

1. Introduction

The hydrological processes are important to assess the influences of tropical forests on regional and global environments. This study aims at quantifying these processes based on field observations. Investigation and monitoring have been conducted in a small forested catchment at Bukit Tarek, Selangor focusing on hillslope hydrology.

2. Research Method

The runoff processes on hillslope are being monitored in the Catchment C1 of Bukit Tarek Experimental Watershed of FRIM since March, 1992 (see Fig. 1). Basic physical factors necessary for hillslope hydrology have been investigated in a selected hillslope in C1. Two study sites were selected for the investigations both near ridge and near stream on the slope. Samples of soil were collected at each study site using 400cc sample tubes. The saturated hydraulic conductivity (Ks) and the property of water retention were tested for the samples. The soil thickness on the slope was surveyed using a cone penetrometer. The thickness of surface soil and that of weathered rock were estimated from the Nc values as Nc=0-5 and Nc=5-50, respectively, where Nc is defined as the number of hit count necessary for the 10cm penetration of the test cone into the soil. The soil moisture profiles at three points on the lower part of the study slope were monitored by manual tensiometers. The depths are 10, 20, 40 and 80cm at L1, and 10, 20 40 80 and 160cm at L2 and L3 (see Fig. 4).

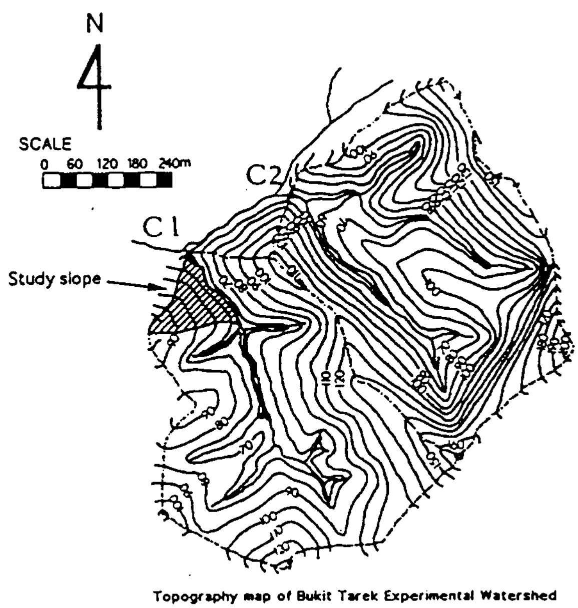

Fig.1 Catchment C1 and study slope

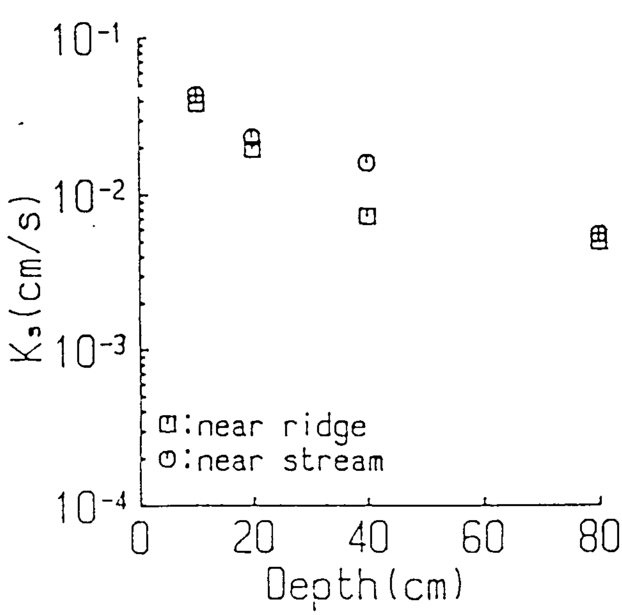

Fig.2 Relation of Ks to depth

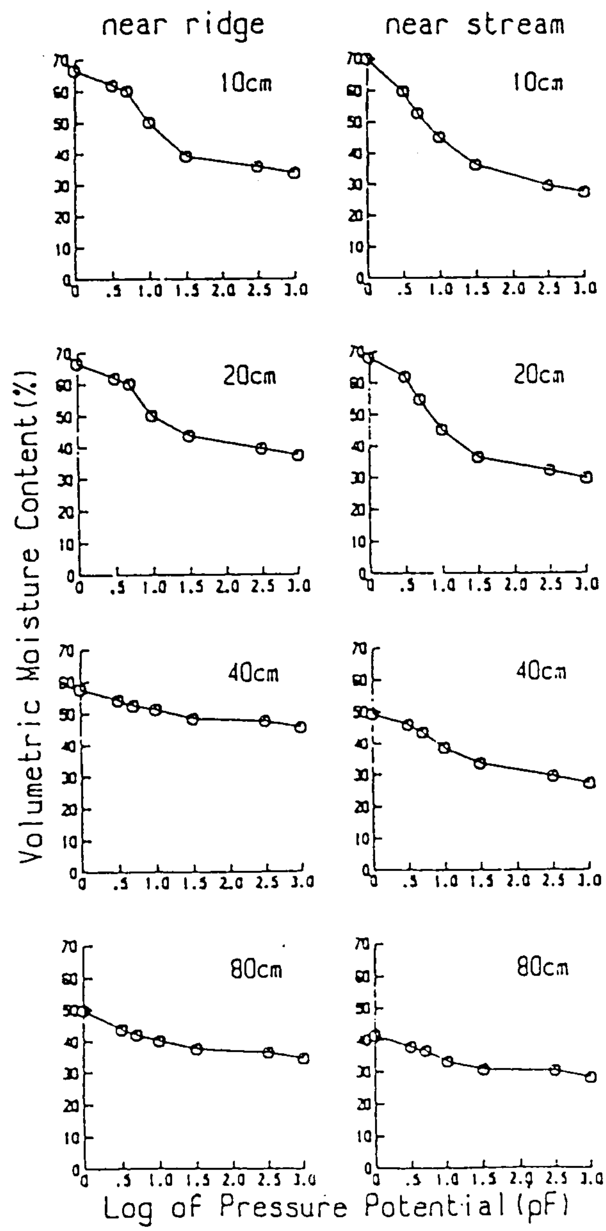

Fig.3 Soil-moisture characteristic curves

3. Result

(1) The rainfall characteristics at Bukit Tarek

The amount of rainfall and the number of rainy day reached their peak values in April and May and in November and December in Bukit Tarek respectively. There were storms even in January which was the driest month.Clear dry seasons are hardly specified.

The frequency analysis of storm events was applied for those generated in one year from February 1992 to January 1993. The frequency of rainfall amount in a storm event shows a J-shape distribution. The beginning of storm event concentrates from 1300 to 1900 in a day and its frequency is 56.5%. The durations of 63.8% storm events were very short, which lasted less than one hour. These characteristics were expected for the tropical weather.

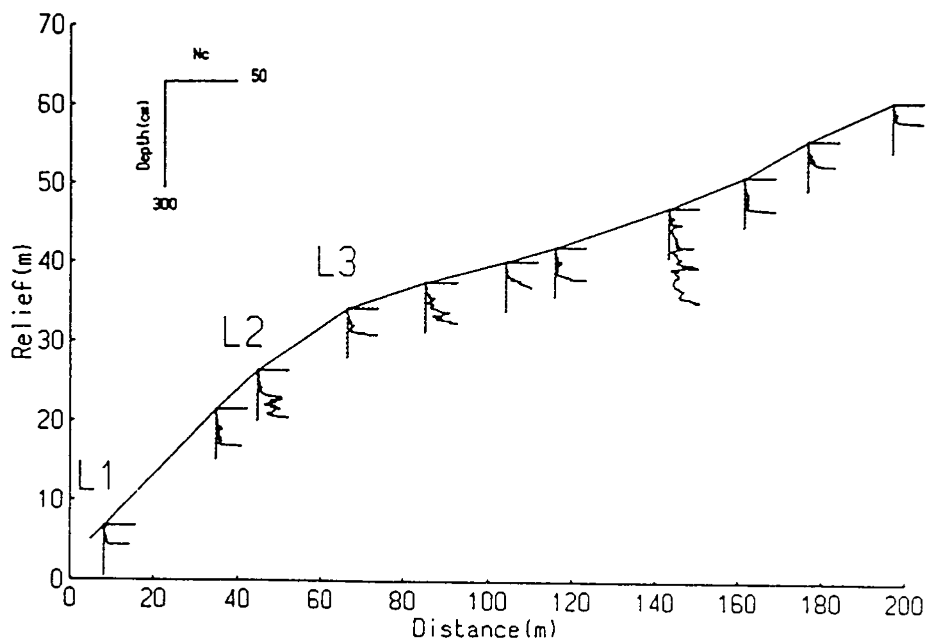

Fig.4 The longitudinal profile of soil layer on the study slope of C1

(2) Soil Physical Properties

The saturated hydraulic conductivity (Ks) measured at the study sites becomes lower as the increasing of depth as shown in Fig.2 and ranges from 1500mm/hr at 10cm to 180mm/hr at 80cm when being converted into the unit of rainfall intensity. This means that storm rainfall must usually infiltrate into the soil at this site. Therefore, water movement within soil is estimated to play more important role in storm-runoff processes than overland flow even though the intensity of rainfall is often very large under the climatic condition there. As for the property of water retention, soil-moisture characteristic curves were obtained (see Fig.3) from the soil samples collected at the study sites. Both the coarse pore (pF0-1.8) and the fine pore (pF1.8-4.2) of the soil tend to decrease with the depth.

(3) The thickness of surface layer

Fig. 4 shows the soil profile of the study slope in C1 Catchment of Bukit Tarek. The thickness of surface layer was comparatively constant and ranged from 65 to 110cm with an average and the standard variability of 91.4cm and 16.0cm. The thickness of weathered rock was widely ranged from 18 to 476cm and the average and the standared variability were 221.8cm and 126.8cm.

(4) Soil moisture change of the study slope

Fig. 5 illustrates temporal changes in soil moisture (as the value of pressure head) on the study slope, rainfall and runoff at the C1 weir of Bukit Tarek for two durations, from November 10 to 26 in 1992 and from January 1 to 31 in 1993. In the former, the pressure head had always low values in response to very wet condition of the rainy season. The response of pressure head to storm rainfall at each depth was similar to each other and was transmitted to the deep soil rapidly.

The response of a storm rainfall on November 21 with the total of 83.0mm and the maximum intensity of 47.0mm/hour was that the head at the depth of 160cm rose to the positive value of 99.1cmH20, that is, the ground-water level appeared, at the point L3. Such a result occurred because of the gentleness of slope and a comparatively shallow (161cm deep) bedrock.

In January 1993, the amount of rainfall from December 31 to January 14 was only 3.5mm, and a drying process was shown in Fig. 5. During such dry conditions, hydrograph responses to rainfall were small and quickly diminished, but the recession became gentler as the soil moisture shown in this figure got wetter due to the cumulative rainwater supply.

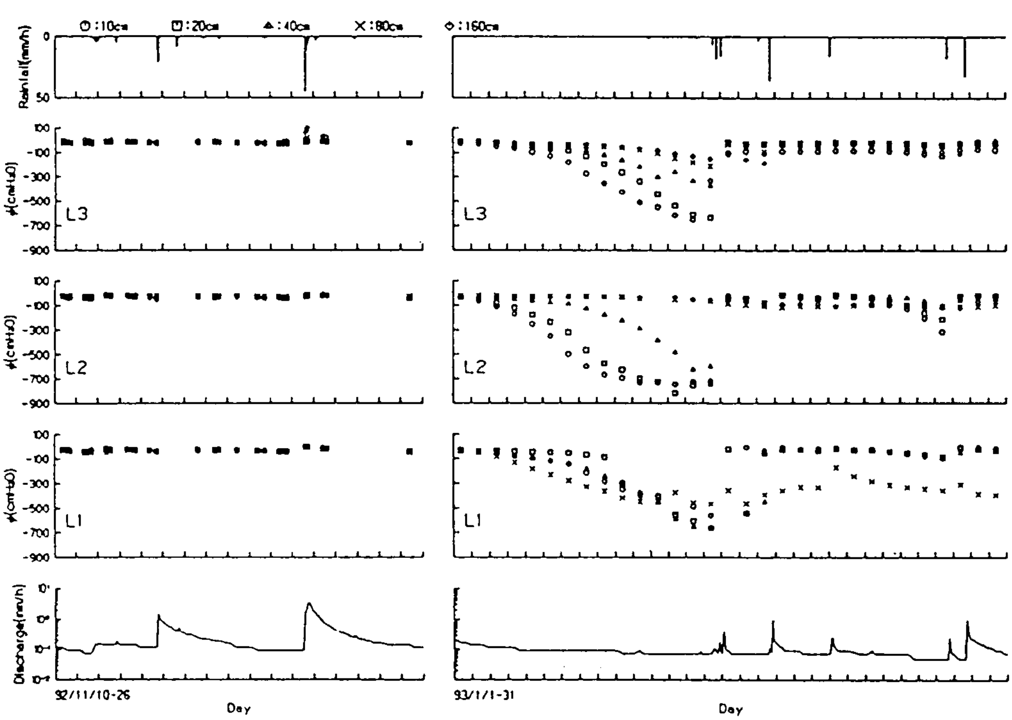

Fig.5 Changes in rainfall, soil moisture and runoff in C1

4. Acknowledgement

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