Characteristics of water and sediment discharge in Tansan-dani gully of Mt. Unzen

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Introduction

To prevent sediment hazards and manage sediment, it is essential to be able to predict the occurrence of debris flow from rainfall data. Although several prediction indexes have been proposed, their efficiency depends on the areas. Recently, Kosugi (2015) proposed a method for distinguishing rainfall events triggering landslides from those without, using the concept of effective rainfall with various half-life times (HLTs), as increased pore-water pressure is one of the main cause of landslides. This method assumes that rainfall is directly connected to groundwater level change, but this assumption should be further examined in different environments.

At Mt. Unzen, sediment discharge has been continued for >20 years after the cessation of volcanic activity. Although several studies have been conducted to predict the occurrence of debris flow in Mizunashi-gawa river, there hasn't been a comprehensive answer to those issues. The objective of this study has been to verify the role of effective rainfall in the Tansan-dani gully in feeding the main Mizunashigawa valley (Fig. 1) in sediment.

Material and method

The present study was conducted in the Tansan-dani gully, at Mt.Unzen (Fig. 1). We first installed five time-lapse cameras (TLC) and recorded sediment discharge and surface runoff at an interval of 1-min for the period 2016-2019. We set two monitoring points to be able to view the thalwegs as well as the talus for each TLC (T1-T10).

The rainfall data come from the JMA (Japan Meteorological Agency) Unzen-dake station, 4km away to the West of the Tansan-dani gully. The 10-minute rainfall data were used for analysis using TLC, and for the longer time-span (2000 to 2019) 1-hour rainfall data were used for the analysis of effective rainfall.

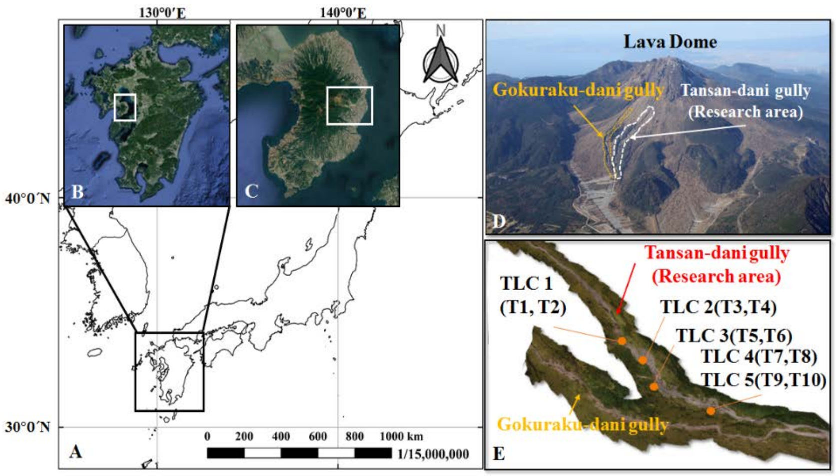

Figure 1. Location of Mt. Unzen and Tansan-dani gully

From this dataset, we calculated the effective rainfall $X(M,t)$[mm] of various HLTs (M[h]) using the following equation:

$$\boldsymbol{X(M,t) = X(M,t-1)e^{\alpha} + R(t)e^{\alpha/2}} \quad (1)$$

where $R(t)$[mm] is rainfall between t-1 and t and α [h^{-1}]is the reduction coefficient, which is calculated as follows.

$$\boldsymbol{\alpha = ln(0.5)/M} \quad (2)$$

We calculated 401 HLTs between 0.1h and 2784h (Kosugi, 2015) for all events from 2000 to 2019. In addition, $E(M,t)$, which is the ratio of $X(M,t)$ to the historical maximum $X(M,t)$, was calculated for three events with debris flow from 2016 to 2018.

Results and discussion

For the period 2016-2019 a total of 3 debris flows and 32 surface runoff were recorded (Table 1), with the first debris flow of 2016 being prior to the TLC installation. On June 29th 2018, a debris flow was observed at both the mid-stream and down-stream survey sites (Fig. 2), providing an idea of the timing of the debris flow.

Fig. 3 shows $E(M,t)$ for three events with debris flow for 2016-2018. For the event in 2016, heavy rainfall continued for only two hours. Rainfall intensity in the two hours (i,e, from 21:00 to 22:00 and from 22:00 to 23:00 on June 20 were 97.0 and 96.5, respectively. Therefore, $E(M,t)$ for short M[h] was larger than that for large M[h]. $E(M,t)$ was 1 in the range of $1.0 < M < 2.45$. On the other hands, for the events in 2017 and 2018, $E(M,t)$ was less than 60% for any M[h]. Although M[h] with peak of $E(M,t)$ was different in the three periods, the maximum $E(M,t)$ over the three periods was almost constant in each M[h].

At this stage, specific M [h] for distinguishing between events with debris flow and those without debris low. Further studies required to find $E(M,t)$, which is possible to distinguish between them clearly. For that, the maximum $E(M,t)$ should be calculated not only for events with debris flow but also for events without debris flow.

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Table 1. The number of events with debris flow and with surface runoff in each year

Type of discharge \ Year	2016	2017	2018	2019
Debris flow	1	1	1	-
Surface runoff	2	10	9	11

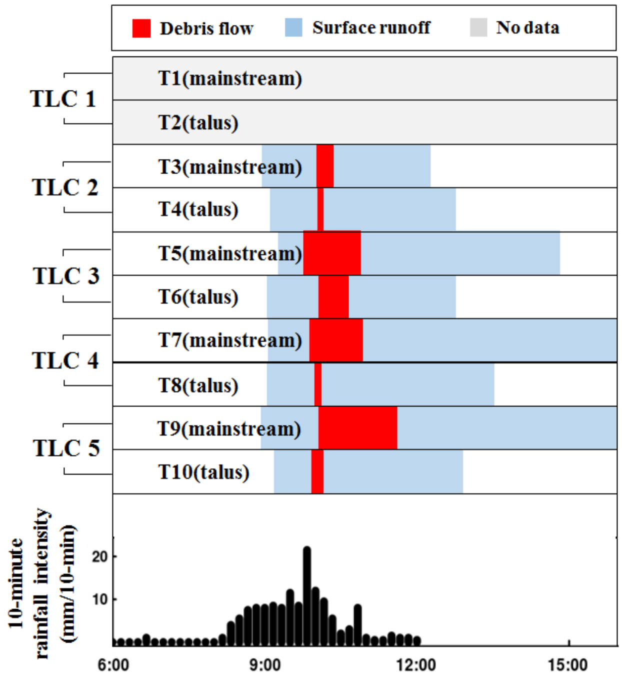

Figure 2. Timing and duration of surface runoff and debris flow: rainfall on 29 June 2018

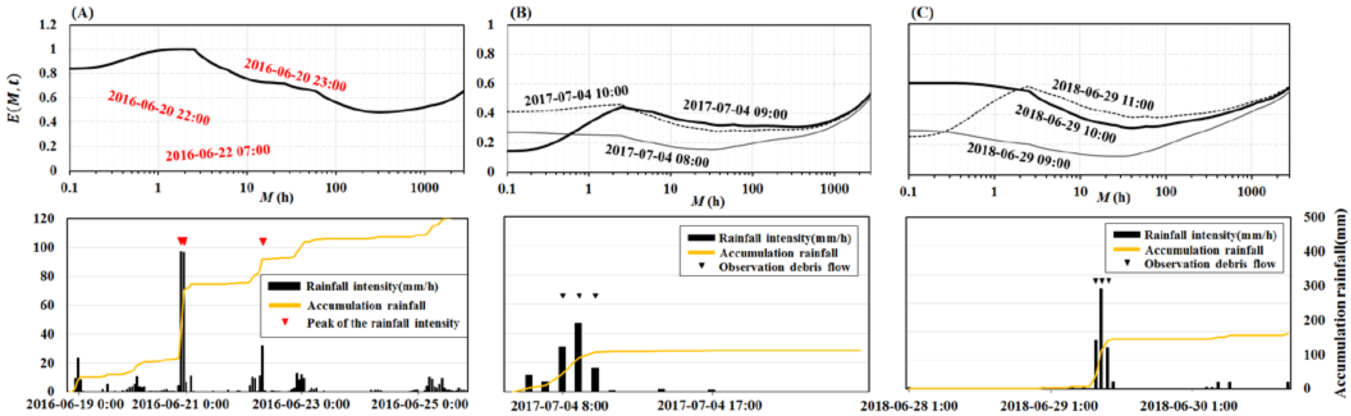

Figure 3. Hyetograph and M[h]-E(M,t) plots of debris flows from 2016 to 2018

References

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