Conditions for Developing Debris Flows at Mt. Unzen

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INTRODUCTION

Mt. Unzen Fugen-dake had erupted from 1991 to 1996. Volcanic ash accumulated on the ground and it reduced the infiltration rate dramatically. Large debris flows were often observed in Mizunashi-gawa basin. These debris flows caused serious damage to the surrounding people. After finishing the sequential eruptions, the infiltration rate had gradually recovered, and Unzen Restoration Project Office of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan has constructed many check dams. Although they have reduced the risk of sediment disasters, debris flows have been observed almost every year even recently. For the mitigation of sediment disaster, it is still important to predict debris flow occurrence. The objective of this study was to clarify development conditions of debris flows using rainfall data in Mizunashi-gawa basin.

MATERIAL AND METHODS

In Mizunashi-gawa basin, debris flows recently occur only in the two valleys such as Gokuraku-dani and Tansan-dani valleys. Occurrences of the debris flows have been identified based on sediment accumulation, a video camera in Gokuraku-dani valley, and seismometers at several points of the basin by Unzen Restoration Project Office. When a large accumulation of sediment was observed in the downstream of the exit of Gokuraku-dani and Tansan-dani valleys, we defined an occurrence of debris flows. When debris flows were identified only by the seismometers, we did not define an occurrence of debris flows. Rainfall has been observed at Unzen-dake station, which is 4 km away from the two valleys to the west, by Japan Meteorological Agency (JMA).

We firstly examined if the occurrence of debris flows was clearly separated by the maximum hourly rainfall (P_{hmax}) and the maximum 10-min. rainfall (P_{10max}). We secondly calculated antecedent precipitation indices (APIs) with 401 half-life times (HLTs) between 0.1h and 2784 h, and also examined if the occurrence of debris flows was clearly separated by APIs with various HLTs. We thirdly developed a logistic regression model. We used three explanatory variables such as P_{hmax}, the number of days from the first day of the experimental period (D_{total}), and the number of days from the last rainfall event with occurrence of debris flows (D_{interval}). Significant of these variables was verified stepwise using Akaike Information Criterion (AIC). A debris flow was observed on September 6, 2005 after an interval of 5 years. The period for the analysis was from just after the event to the last event in 2016.

RESULTS

Fig. 1 and **Fig. 2** show P_{hmax} and P_{10max} for all events, respectively. Debris flows were observed for eight events. Although P_{hmax} and P_{10max} for events with debris flows tended to be larger than those without debris flows, the occurrence of debris flows was not clearly separated by P_{hmax} and P_{10max}. This result was not altered even if we used APIs with different 401 HLTs instead of P_{hmax} and P_{10max}.

In the logistic regression analysis, P_{hmax} and $D_{interval}$ were selected as significant explanatory variables (Tab. 1). Obviously, the coefficient for P_{hmax} was positive. The coefficient for $D_{interval}$ was negative. D_{total} was not selected as a significant explanatory variables and the coefficient for D_{total} was about 0.

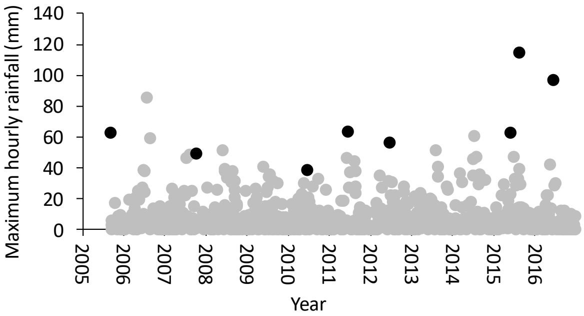

Fig. 1 The maximum hourly rainfall for rainfall events with debris flow (black) and those without debris flow (gray)

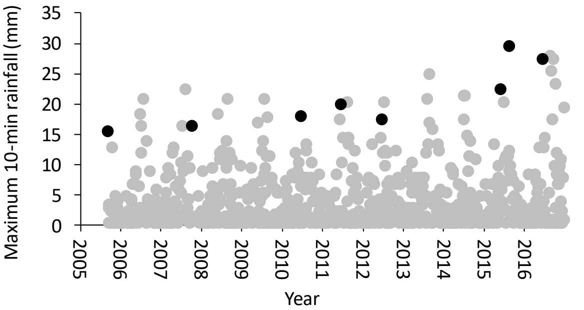

Fig. 2 The maximum 10-min rainfall for rainfall events with debris flow (black) and those without debris flow (gray)

Tab. 1 Summary of the logistic regression model (P_{hmax}, the maximum hourly rainfall; D_{total}, the number of days from the first day of the experimental period; $D_{interval}$, the number of days from the last rainfall event with occurrence of debris flows)

Experimentory variable	Coefficient
P_{hmax}	0.142
D_{total}	-0.000
$D_{interval}$	0.005
Intercept	-12.24

DISCUSSION AND CONCLUSIONS

Although rainfall conditions strongly affected the occurrence of debris flows, there was not a specific rainfall index to separate events with and without the occurrence of debris flows. This suggests it is difficult to find the conditions determining the occurrence of debris flows from rainfall characteristics only. In the logistic regression model, D_{total} of about 0 suggests possibility of debris flows does not continuously change recently. The positive $D_{interval}$ suggests possibility of debris flows gradually increases after the last debris flow. In Gokuraku-dani and Tansan-dani valleys, fine sediment has been constantly supplied from sidewall, and accumulated in the valley as taluses. In general, debris flows would develop due to involving the fine sediment. Developing processes of debris flows are still unknown in the two valleys. To clarify conditions determining the occurrence of debris flows in more details, we should understand these processes.

Keywords: Debris flow, Rainfall, Topographic change, Logistic regression analysis