Application of Rainfall–Runoff Model to Study Flash Floods in Volcanic Mountain Catchments

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In active volcanic mountain areas, prediction of occurrences of flash flood is essential for disaster prevention. The study area is located in Sakurajima Island, an active volcanic island with deeply incised gully and creeks in Southern Japan. Because there were more than 1000 eruptions in 2012, source areas of the study creeks were expected to be covered by thick volcanic ash layers. Volcanic ash often generates surface flow on hillslopes as it decreases the infiltration rate of surface soil. Volcanic ash itself has a grain size of sand and has non-cohesive properties so it commonly has a high rate of water infiltration in laboratory tests. In spite of this, hillslopes covered by volcanic ash often generate surface flow, which results from the low infiltration rate of surface soil. Ordinarily, one of the reasons given for this low infiltration rate is the soil crust which develops on the surface of soil as a result of compression by drops of rainfall.

In this study, a numerical simulation model was used for examining occurrences of flash flood and hydrological processes in volcanic mountain watershed (Arimura catchment, Figure 1). For the simulation, the study catchment was divided into slope and channel segments. Slope segment was divided into 10 x 10 m elements using a GIS software and each element consisted of a surface volcanic ash layer and subsurface soil layers. Lateral discharge in the slope segment was calculated using the Darcy equation. Discharges from elements adjacent to channel segment were used as inputs in streamflow simulation in the channel segment. Unsteady 1-D flow analysis was applied for simulating streamflow.

Simulations were conducted under three rainfall events (small, medium, and large). The large event itself was divided into three sub-events to focus on the rainfall peaks. Initial conditions from the previous sub-event were considered as the output from the previous event. Figure 2 shows spatial distribution of runoff heights on hill-slope during the second sub-event of the large event (from 21 June 2012 to 26 June 2012). The simulation results of the second sub-event were compared to field observations of stream water height at the outlets of the catchment (Figure 3). Differences between the observed and simulated results suggest the effects of spatial rainfall distribution on flash flood generations. In the presentation, impacts of the spatial distribution of rainfall on flash floods and change of infiltration characteristics of the surface volcanic layer will be discussed.

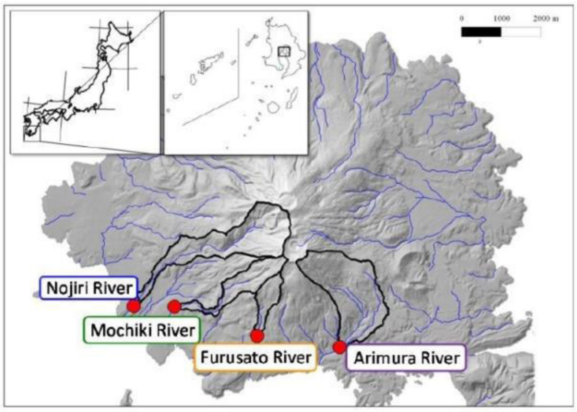

Figure 1 Map of Sakurajima Island and locations of study watersheds.
Red circles indicate monitoring stations of stream water height. (After Miyata et al, 2013)

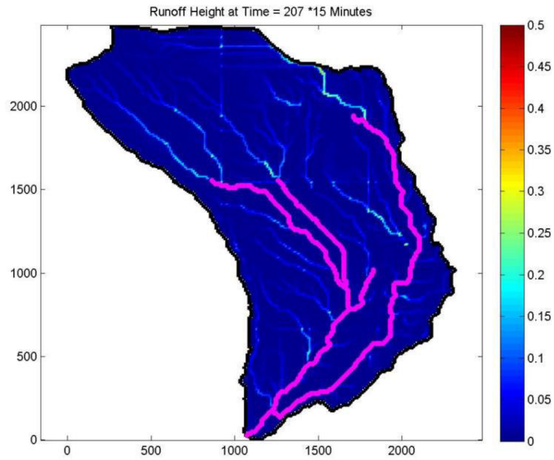

Figure 2 Runoff heights on hills lopes for the big event.

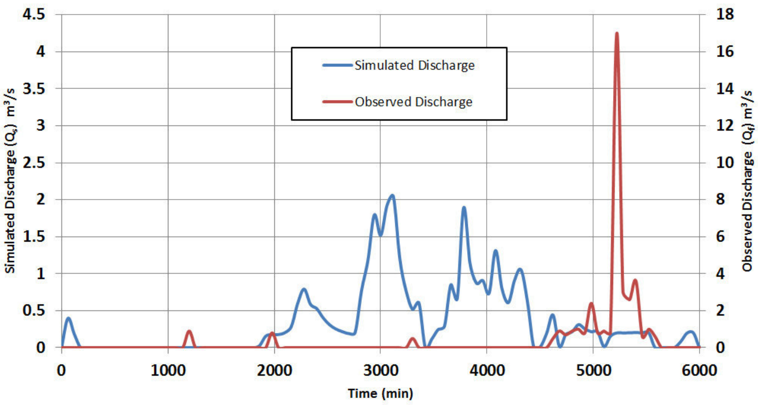

Figure 3 Simulated discharges compared to field observations.