Application of a Combined Model of Sediment Production, Supply and Runoff

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INTRODUCTION

To aid sediment management planning in rivers (particularly after huge sediment disasters), several numerical calculation models for sediment runoff have been previously proposed. However, the numerical model is only able to output limited results to enable synthetic sediment management, because the model is designed to mainly focus on the movement of sediment in rivers. It is also note that when using these models it is difficult to obtain results relating to important information within a mountainous watershed, such as the deposited sediment around a channel and the fresh sediment produced on a mountain slope. To ameliorate such issues pertaining to past models, we have developed a new sediment runoff model, which the sediment runoff process is perceived as a combination of three sub-processes: sediment production, supply, and transport [*Yamanoi & Fujita*, 2014]. In this paper, we examined the performance of this model and verified its advantages by applying it to an actual watershed.

GENERAL DESCRIPTION OF THE INTEGRATED MODEL

The model was developed by integrating sub-process models of sediment production, sediment supply, and sediment transport using a basin model composed of unit channels and unit slopes. We have employed a sediment production model due to freeze-thaw action initially proposed by *Izumiyama* (2012) and existing sediment transport model proposed by *Egashira* & *Matsuki* (2000). Sediment supply model was developed in relation to talus erosion considering stream width and valley width.

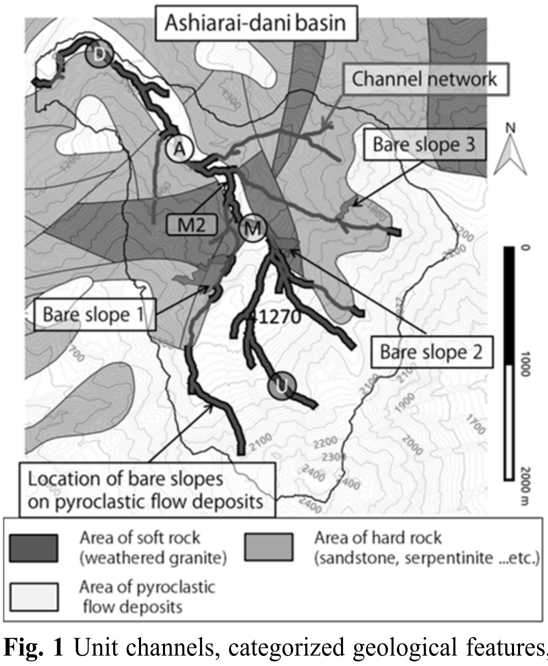

Fig. 1 Unit channels, categorized geological features, and sediment sources in the basin. Locations used for calculation results are denoted by circles

APPLICATION OF THE INTEGRATED MODEL

The integrated model was applied to the Ashiarai-dani river basin at Gifu prefecture, Japan (Fig. 1 shows a map of the area) using meteorological data from April to November in 2012. As a result, the sediment runoff process in a mountainous watershed was simulated in detail. Sediment was initially produced by weathering due to freeze-thaw action, and it then formed taluses at the bottom of the valley. Secondly, the taluses were eroded by stream flow that occurred mainly during two floods in July, which enabled sediment to be supplied to the stream channel. Thereafter, the sediment was transported downstream. In this type of sediment runoff routing, sediment supply caused a reduction in the mean diameter of riverbed material, which subsequently increased in the upstream reach, although the mean diameter variation in the downstream reach appeared to be dependent on sediment transport from upstream (Fig.2).

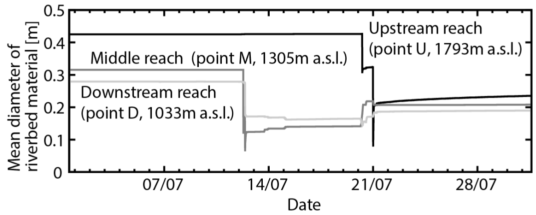

Fig. 2 Change of mean diameter of exchange layer during the flood season

Additionally, spatial and temporal variation in sediment deposition ware calculated and discussed. Fig. 3 shows a comparison of the relationship between deposited sediment, water discharge, and sediment discharge at points U, M, and M2 shown in Fig. 1. In the upper part of each of the three graphs, the volume of deposited sediment as taluses is seen. The decrease in sediment deposition implied that sediment supply occurred at the time. At point U, sediment runoff happened only by a second large flood of July 20 because the sediment was supplied only in the second flood. At point M, the amount of sediment supply on first flood of July 12 was large enough to enable sediment runoff. The scales of both sediment runoff events were large and almost the same. However, no sediment runoff occurred after August in this year, which indicated that almost of the sediment had already run off by the end of July. In contrast, sediment runoff occurred twice on large scale and also during the small floods in August at point M2, despite the low rate of sediment supply, because sediment was transported from point M. These results showed that the relationship between water discharge and sediment discharge was influenced by the amount and timing of sediment supply, the spatial distribution of sediment sources, and the time variation in the volume of sediment deposited.

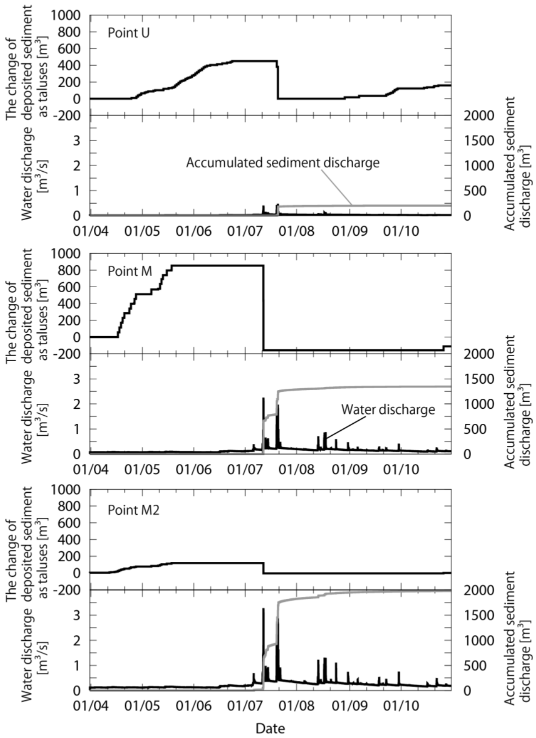

Fig. 3 Comparison of the relation between deposited sediment, water discharge, and sediment discharge

CONCLUSIONS

These calculation results show that the integrated model has ability to trace the entire process of sediment runoff. Also the results imply that the integrated model can provide a greater amount of detailed information, and it can therefore contribute to advancements in synthetic sediment management.

REFERENCE

Izumiyama, H. *et. al.* (2012) Effect of freeze-thaw action on porosity change and destruction of weathered bedrock in different lithology and development of destruction model, International Journal of JECE Vol. 5, No.1, 103–112, Egashira, S. and Matsuki, T. (2000) A method of predicting sediment runoff caused by erosion of stream channel bed, Annual Journal of Hydraulics Engineering, JSCE, Vol. 44, 735–740, Yamanoi, K. and Fujita, M., (2014) Development of a combined model of sediment production, supply and transport and its application to a mountainous basin, Journal of the JSCE B1, Vol. 70, I_925–I_930

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