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Time-series Characteristics of Bedload in Mountain River

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Introduction

The observation of sediment transport is highly essential to determine the reasonable Sabo works[1)]. However, continuous bedload discharge data was still limited in mountain rivers. The objective of this study was to present a result of continuous bedload measurements in the Fuji River of Southern Alps of Japan. Moreover, we examined roles of relatively large event on bedload characteristics in following periods.

Method of Data Collection

This study was carried out in the Kamanashi River, Nigori River, and the Omu River which are tributaries of the upstream of Fuji river (Fig. 1). In the Fuji River, bedload observation has been carried out since 2010. We analyzed bedload data (e.g., bedload discharge, particle size, and water level), which were taken in 5 or 15 minutes intervals in the field using pipe hydrophone. The dataset simplified to average values of one-hour intervals for the analysis. Rainfall data used the dataset, which was taken in one-hour intervals by AMeDAS network (Automated Meteorological Data Acquisition System).

Bedload events were extracted based on the single rainfall event which occurred the bedload transport (Fig. 2). Table 1 shows the number of bedload events. In the Nigori and Kamanashi Rivers, 67 and 111 bedload events have been observed from 2010 to 2016, respectively. For the Omu River, 62 bedload events have been observed from 2011 to 2016.

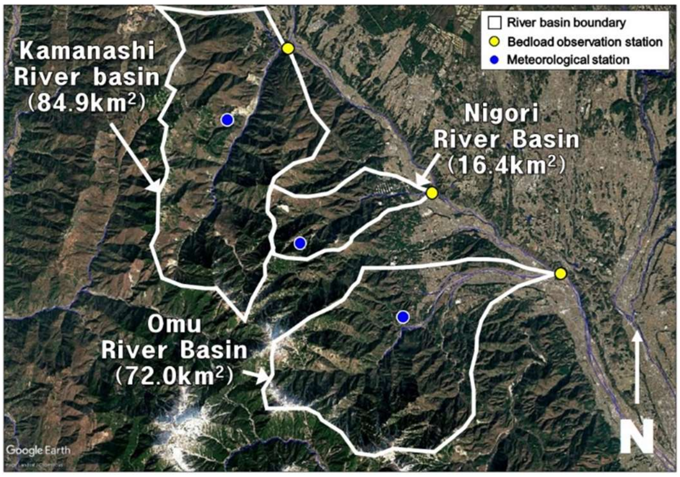

Figure 1. Location of study sites

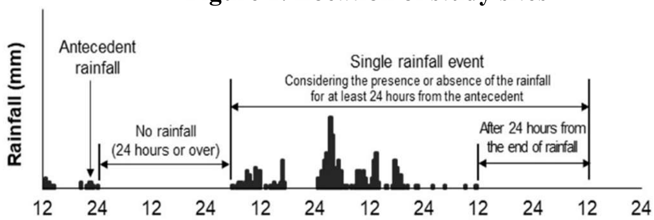

Figure 2. Definition of single rainfall event

Table 1. Number of bedload events

	2010	2011	2012	2013	2014	2015	2016
Kamanashi River	12	16	13	17	12	15	26
Nigori River	8	19	12	9	9	3	7
Omu River	-	13	14	9	6	10	10

Results and Discussion

In 31 August 2011, a typhoon with heavy rainfall occurred in Fuji River. Total rainfall amounts of typhoon were recorded at 350mm, 306mm, and 220mm in the Kamanashi, Nigori, and Omu Rivers, respectively. Typhoon led to a large-scale sediment transport (hereafter episodic event) at the study sites. Thus, annual bedload discharges were the largest in 2011 during the observation periods (Fig. 3). After this episodic event, annual bedload discharge was elevated in the Nigori and Omu Rivers, while the change of annual bedload discharge was not clear in the Kamanashi River.

Fig. 4 shows the correlation between total rainfall amount, R_T, and bedload discharge, Q_B. Overall, Q_B occurred in R_T larger than 10mm, and it was increased two and four orders of magnitude when R_T increased by one order of magnitude. The data of Kamanashi River displays a relatively good correlation between R_T and Q_B, While the plots of the Nigori and Omu Rivers for the relationship between R_T and Q_B were scattered. Q_B of the Nigori and Omu Rivers in 2012 were one and two orders of magnitude higher than 2011 in the similar rainfall conditions. We assumed that because the episodic event led to an increased bedload transport capacity of the Nigori and Omu Rivers, it caused the difference as shown in Fig. 4.

Yager et al. (2012) proposed Equation (1) to describe temporal change of bedload discharge after episodic event.

$$Q_{SW} = aT^b$$

where Q_{SW} is the bedload discharge per water volume, T is the elapsed time (month) after episodic event. We used same equation, but we used Q_B instead of Q_{SW} (Fig. 5). Fig. 5 displays a clear difference in bedload transport capacity between the mountain rivers largely affected by episodic event (Nigori River and Omu Rivers) and little affected (Kamanashi River). The variability of Q_B indicated one order of magnitude more substantial in the Nigori and Omu Rivers than in the Kamanashi River. Further, Q_B of the Nigori and Omu Rivers tends to be greater in 2011 and 2013 than in 2014 and 2016.

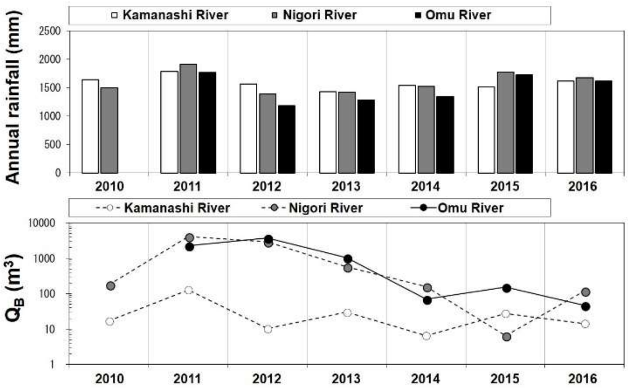

Figure 3. Annual changes of Q_B

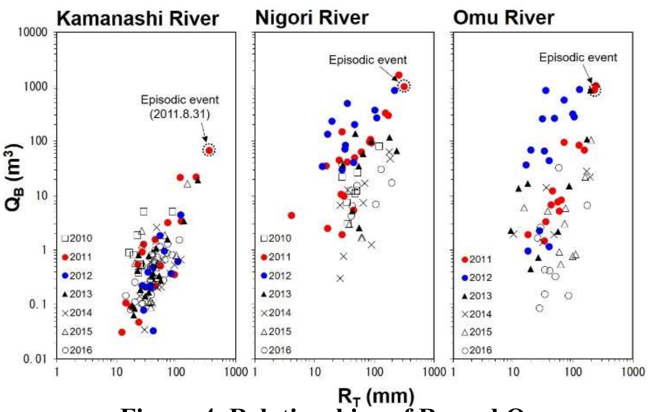

Figure 4. Relationships of R_T and Q_B

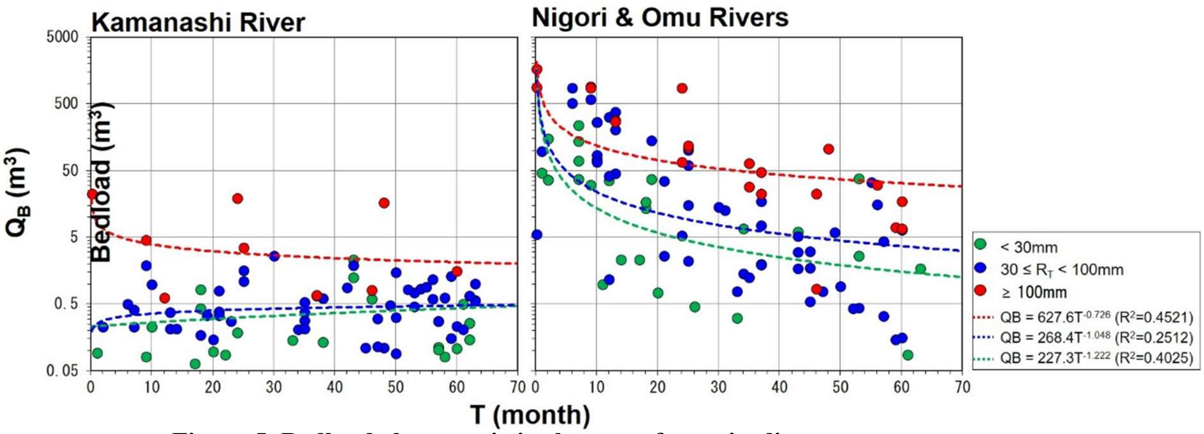

Figure 5. Bedload characteristic changes after episodic event

Reference

1) T., Mizuyama, M., Fujita, and M., Nonaka (2003): Measurement of bed load with the use of hydrophone in mountain torrents. Erosion and Sediment Transport Measurement in Rivers: Technological and Methodological Advance, 283, 227-227
2) E. M., Yager, J. M., Turowski, D., Rickenmann, B. W., McArdell (2012): Sediment supply, grain protrusion, and bedload transport in mountain streams. Geophysical Research Letters, 29, 1-5