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Comparison of long-term fluctuations in sediment discharge between two mountain basins after huge landslides

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Earthquakes and heavy rainstorms can lead to huge landslides and many shallow landslides in mountainous areas. The large amounts of unstable sediment supplied to mountain basins by landslides are partially removed by various transport processes, including debris flows, bed load sediment, and suspended sediment. In some cases, subsequent heavy rainfall events eventually flush the deposited sediment out of the basin through repeated transport and deposition processes. Thus, landslides may affect the sediment discharge from mountain basins over a long period. Long-term assessment is needed to understand the sediment dynamics, since sediment discharge often shows large temporal fluctuation. This study compared two mountain basins that had experienced huge landslides and showed different characteristics of sediment discharge. Long-term fluctuations in sediment discharge were examined with the aim of revealing the factors affecting sediment dynamics at the basin scale.

The study sites were the Nakagawa River basin (NRB, 39 km^2), Kanagawa Prefecture, and the Dogawa River basin (DRB, 81 km^2), Miyazaki Prefecture, Japan. In the NRB, the 1923 Kanto Earthquake induced many shallow landslides, and heavy rainfall events in 1972 caused substantial numbers of shallow landslides. In the DRB, a typhoon induced numerous shallow landslides in 1954, and landslides were also recorded in 1968, 1997, 2004, and 2005. First, we examined the relationship between the landslide history and time series of sediment discharge for both basins to identify differences in the sediment transport processes between the two basins. Then, we compared the range and convergence of the sediment discharge fluctuations.

Reservoir sedimentation data indicate that, for the whole basins over the total period, average sediment yields were comparable at 2897 $m^3/km^2/yr$ in the NRB and 1962 $m^3/km^2/yr$ in the DRB. Comparison of landslide histories and time series of sediment discharge revealed that the Kanto earthquake still affects discharge, even though almost 80 years have passed, because the earthquake supplied an extremely large volume of sediment in the NRB. The fluctuations in sediment discharge were slight and showed good agreement with annual precipitation, indicating a transport-limited condition for sediment discharge in the NRB. On the other hand, massive sediment discharge was detected only in the year of landslide occurrence and a few years after in the DRB. Since the DRB has sufficient sediment transport capacity, with frequent heavy rainstorms caused by typhoons, shortage of unstable sediment was considered to occur in periods without landslides, resulting in supply-limited conditions for sediment discharge.

To determine the range and convergence of the sediment discharge fluctuations, we calculated moving averages for N continuous years from N=1 to the total period and compared the maximum and minimum values. In the NRB, the maximum and minimum values converged to the total average in a short period (N of 5?10 years). However, in the DRB, these values did not converge until the end of the period, and there was a significant difference between the maximum of 2552 $m^3/km^2/yr$ and the minimum of 325 $m^3/km^2/yr$ at N=25. This result suggests that sediment discharge fluctuates significantly in a watershed with a supply-limited condition, where infrequent landslides have strong effects. It can be concluded that differences in sediment transport conditions result in different sediment dynamics among basins.

Keywords: Shallow landslide, Sediment discharge, Dam sedimentation, supply-limited, transport-limited