Timing, magnitude and origin of seasonal rockfall activity in the Southern Japanese Alps: A multi-method approach

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Recent technological advances have enabled us to monitor bedrock micro-cracking at high time resolution and succeeding rockfall activity at high spatial resolution. Precise evaluation of the trigger of each rockfall event, however, requires a combination of multiple methods that detect cracking and falling activities and provide data on their controlling environmental parameters. Long-term monitoring is also necessary to evaluate the contribution of each trigger to the rockwall erosion.
Multi-method monitoring has been conducted to detect the timing and trigger of rockfall activity on an alpine rockslide cliff composed of Cretaceous sandstone and shale in the southern Japanese Alps (Aresawa rockslide, 2900 m ASL). The monitoring programme includes manual measurements of peeling from painted rockface and collection of fallen debris (4-5 times per year) and thermography of rockface (yearly), and data logging of time-lapse photography of rockface (daily), crack opening, rock temperature and moisture (3-4 hr intervals) and meteorological elements (air temperature and precipitation at 10-min intervals). A stereographic pair of sequential photographs allow us to visually identify the location of new erosion at daily resolution. Combined with precipitation data, the photographs also indicate the type of precipitation (rain or snow).
Five years (2010-2015) of debris trapping show major rockfall activity in winter (between November and May) and occasional activity associated with heavy rains in summer. Highly active areas of the rockwall experience retreat by >1 mm per year. Time-lapse photography displayed at least eight rockfall events within the shot area in the 2014-2015 period. The integration of multiple data enables understanding of a sequence of natural processes towards rockfalls, suggesting that at least three types of rockfall processes recur annually (Fig. 1A). (1) In summer and early autumn, heavy rainfalls (>100 mm/day) raise the rock moisture content close to the saturation level, often triggering significant rockfalls, probably due to raised water pressure in rock joints or lubrication of joints. (2) In late autumn and late spring, light or intermediate rainfalls are sometimes followed by high moisture, shallow freezing, rapid thawing and eventually by small-scale rock peeling. (3) In early winter and early spring, the same process occurs as in the second case but rainfall is replaced by snowfall (Fig. 1B).

Keywords: Rockfall , Monitoring, Time-lapse photography, Freeze-thaw, Japanese Alps

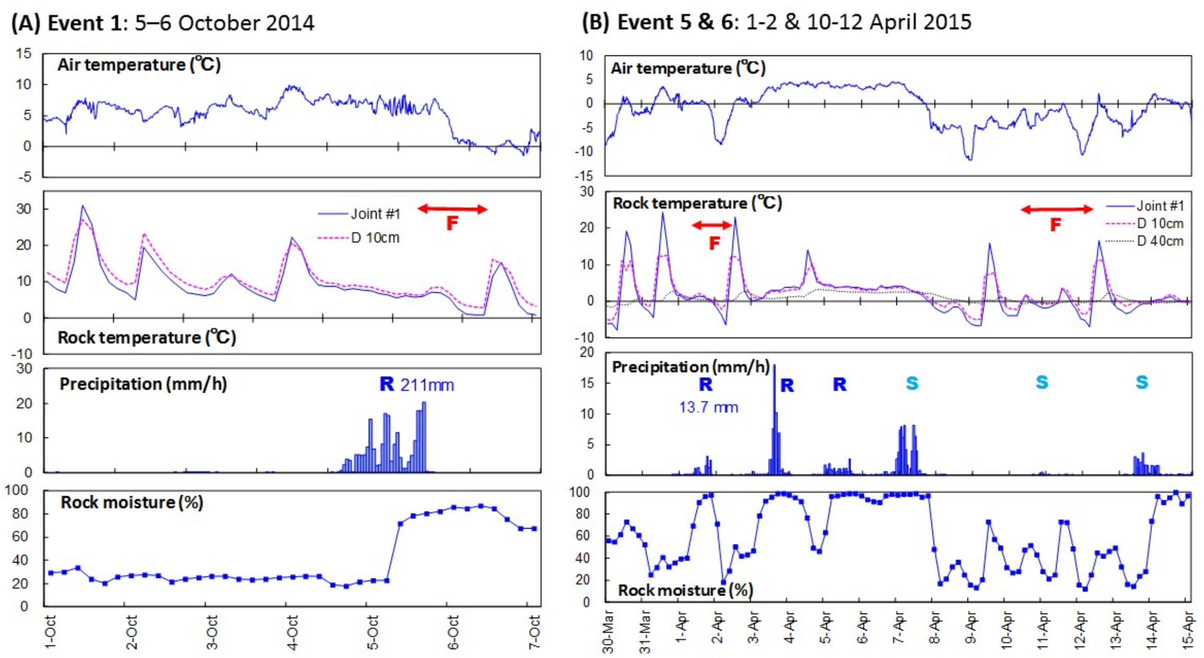

Fig. 1. Examples of rockfall events (F) and corresponding environmental conditions in the 2014-2015 period. Symbols: R=Rain, S=Snow, D=Depth.