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Seismic precursory signals from a rockfall at Rappenlochschlucht, Vorarlberg, Austria

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On May 10, 2011 at 10:48 UTC a rockfall happened at Rappenlochschlucht, Vorarlberg, Austria. The rockfall with 15.000 m3 volume destroyed a massive bridge but luckily did not cause any fatalities in this famous, heavily frequented touristic spot. Our institute operated a seismic network in 5 km distance at the Heumös slope dedicated to record very small slide quakes caused by the creeping slope. The network was tuned to extreme sensitivity, and thus monitored the rockfall as well.
We found two types of seismic signals shortly before and during the rockfall that we could not observe at that region in the remaining two and half years of network operation. Type one was a minute-lasting sequence of broadband pulses caused by the stochastic hits of single rockfall blocks against subsurface during the entire period of sliding. This signal resembles the audible, acoustic noise of avalanches in our lower-frequent passband of measured mechanical vibrations. Thus we called this type 'avalanche'. Two small avalanche events were identified in the last five hours before the final rockfall.
The second type exhibits an impulsive onset and a subsequent decay to lower frequencies. This signature is caused by a single fracture process where the instantaneously released energy reaches the observation site in a well-defined sequence of different wave types and travel paths with decreasing propagation speed. These fracture processes or nano-earthquakes could be located close to the rockfall, and the energy release could be described by a local magnitude –0.5 to 0.4 indicating an activated fault length of some ten meter in rock. We thus called this type 'fracture', and could identify twelve fracture signals before final failure.
Further hints for the precursory character of these signals will be discussed, as well as a search for potential trigger indications.