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Field observations of pressure fluctuations in debris flows and debris floods at the Illgraben torrent channel with implications for channel-bed erosion

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The Illgraben catchment in southwestern Switzerland experiences frequent debris flows and debris floods, providing an ideal location to study the properties of debris flows. A large (2m long, 4m wide) force plate in the channel bed is outfitted with normal and shear force sensors as well as a geophone and an accelerometer. A vertical flow-parallel concrete wall immediately upstream of the large force plate is instrumented with 18 geophones and 6 force plates, each mounted on a 0.3m by 0.3m square steel plate. The flow height near the wall and over the force plate are measured using laser sensors. Three video cameras have been installed to record the passage of debris flows. While the measurement system was designed for observing debris flows, large debris floods also trigger the observation station, providing an opportunity to compare their flow properties. Debris flows tend to have steep flow fronts, with flow depths increasing from 0 to several meters over about 10 seconds; the flow front generally appears to be granular with little turbulent water visible on the surface. Debris floods tend to have undular fronts which visibly resemble flash floods, increasing from flow depths on the order of a few cm to several meters typically over several 100's of seconds. Both types of flow produce strong fluctuations in normal force on the channel bed, however the magnitude of fluctuations at the base of debris flows tend to be substantially larger than in debris floods. In debris flows the pressure fluctuations are largest at the bed and decrease in amplitude with height above the channel bed, which is consistent with the idea that the pressure fluctuations in the flow are generated at the contact between the debris flow and channel bed. Pressure fluctuations in debris floods (when the measuring system at the wall is triggered) are much smaller. Mean shear stresses on the channel bed are similar in both types of flow, however the pressure fluctuations at the base of debris flows are at least an order of magnitude larger than in debris floods. Previous investigations of channel-bed erosion suggest that debris flows tend to erode the channel more rapidly than debris floods, suggesting that pressure fluctuations at the base of debris flows should be considered when developing e.g. models of channel-bed erosion.