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Observations of shear and normal forces in debris flows at the Illgraben observation station

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Understanding the frictional behavior of debris flows is important to help explain their flow patterns and also to determine the appropriate rheology for use in e.g. models to predict their runout. Here we examine the flow properties of debris flows and debris floods at the Illgraben debris-flow observation station to examine their frictional properties. The force plate is a 4m wide, 2m long steel structure installed in a check dam flush with the channel bed. This structure contains sensors to measure both normal and shear forces at the channel bed. Accelerometer and geophone sensors provide additional information on the flow that passes over the plate. A laser sensor is used to determine the flow depth near the center of the force plate, and a radar stage sensor provides an estimate of the average flow depth over the force plate. After 2012, data are sampled and stored at 2 kHz to permit analysis of force fluctuations at the base of the flow. Here we compare friction coefficients–the ratio of shear to normal force–among several different types of flow typically observed at the Illgraben. For a debris flood, the friction coefficient reaches a stable value which is about the same as the slope of the channel itself, indicating uniform flow after the passage of the leading edge of the debris flow. In contrast, debris flows tend to have friction coefficients which are approximately 20% larger than the slope of the channel. In all cases, the friction coefficient is largest near the front of the flow or within the first few hundred seconds of the flow, and decreases towards the tail of the flow. These observations are compared with other data such as the force fluctuations within the flow, front velocity, as well as video observations, when available, to help corroborate the quality of the data and to account for effects such as deposition of sediment on the force plate after the passage of the flow front.