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Evolution of vertical velocity profiles along a sequence of debris flow surges

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Surges are a characteristic phenomenon of debris flows and of particular interest for designing defense structures or estimating the runout. However, details on the internal dynamics of surges are rare and difficult to re-produce in laboratory experiments. The unpredictable appearance and tremendous energy make direct measurements of field-scale debris flows challenging, but would avoid scaling problems that may bias the mechanisms and bulk flow behavior. Making use of a monitoring barrier at the Gadria creek in South Tyrol, Italy, we developed a monitoring technique based on paired conductivity sensors that enable to quantitatively assess the vertical velocity distribution of the passing debris. Additional bulk flow parameter like flow depth, normal force, shear force and basal pore liquid pressure were measured with two force plates equipped with pressure transducer. Since 2016, three debris flows, triggered by intense rainfall, were recorded. Two debris flows exhibited several surges and one was characterized by only a single surge, moving relatively slowly with 1m/s and 1m flow height. The back-calculated densities ranged between 2,000 and 1,600 kg/m^3 and liquefaction ratios close to unity were in some sections of the flows. We observe changing velocity profiles along the surges, varying from a plug-flow like profile at the front to concave profiles in the main body to convex profiles, which were especially pronounced when surge fronts arrived and reactivated deposited material at the basal layer.