



Debris flows modeling using reproducible initial and boundary conditions

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Predicting debris flows and designing countermeasures against these hazardous streams requires a fundamental understanding and a quantitative assessment of the process. For this, hybrid modeling as a combination of CFD simulations and physical model tests is particularly suitable, as among others, it is not necessarily site specific, it is not depending on weather and event conditions as well as the initial and boundary conditions are variable and can be specified, in contrast to field measurements. But these advantages are at the same a major challenge of the fundamental and valuable debris flow modeling. As debris flows are unique mixtures of water, sediments and debris, which rapidly run down a specific confined channel, they are hardly repeatable in the physical models, therefore the settings of the numerical modeling are hard to define.

To meet these challenges, we built up a physical model, constructed like a seesaw. The model consists of a 4 m long, 0.3 m wide and 0.3 m high Plexiglas flume with 0.5 m long sediment reservoirs at both ends, hinged in the middle. Due to the hinge, the flume can be turned, so the slope is variable and each of the sediment reservoirs can represent the initial condition. To obtain reproducible initial conditions we used in this case material from the Swiss Illgraben, first determined its exact properties, second composed it in a specific mixture, third mixed it in the sediment reservoir and fourth started the experiments through opening the removable reservoir gates. After the gate opening, the material flows through the Plexiglas flume, with a modifiable roughness made of fixed Illgraben material, and four ultrasonic probes to measure the water level. In addition to the water level, the velocity distribution was measured with the Large-Scale Particle Image Velocimetry (LSPIV)-method, using several cameras with frame rates of at least 150 photos per second. After passing the channel, the material flows into the second reservoir, which is reused as the initial condition in the next experiment. Therefore, this is the first physical debris flows model, that enables reproducible initial and boundary conditions.

The measurement results and the analysis of water levels and flow velocities with different initial and boundary conditions show a major effect of the slope and the solid content on both values. Obviously, with steeper slopes flow velocities increase, however, this correlation is nonlinear. Furthermore, the flow velocities decrease with an increasing solid content in the composition up to a certain critical value, which depends on the flume slope, and increase after that value due to the stronger effect of gravity. Despite the repeatable initial and boundary conditions, the results show measurable differences in water levels and velocity profiles within the repetition of the experiments. In order to identify the cause and to analyze fundamentally the process of debris flows, we use these results as basis for the CFD modeling, with the objective of hybrid modeling.