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An advanced three-phase physical, experimental and numerical method for tsunami induced boulder transport

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Coasts around the world are affected by high-energy wave events like storm surges or tsunamis depending on their regional climatological and geological settings. By focusing on tsunami impacts, we combine the abilities and experiences of different scientific fields aiming at improved insights of near- and onshore tsunami hydrodynamics. We investigate the transport of coarse clasts – so called boulders – due to tsunami impacts by a multi-methodology approach of numerical modelling, laboratory experiments, and sedimentary field records. Coupled numerical hydrodynamic and boulder transport models (BTM) are widely applied for analysing the impact characteristics of the transport by tsunami, such as wave height and flow velocity. Numerical models able to simulate past tsunami events and the corresponding boulder transport patterns with high accuracy and acceptable computational effort can be utilized as powerful forecasting models predicting the impact of a coast approaching tsunami.

We have conducted small-scale physical experiments in the tilting flume with real shaped boulder models. Utilizing the structure from motion technique (Westoby et al., 2012) we reconstructed real boulders from a field study on the Island of Bonaire (Lesser Antilles, Caribbean Sea, Engel & May, 2012). The obtained three-dimensional boulder meshes are utilized for creating downscaled replica of the real boulder for physical experiments. The results of the irregular shaped boulder are compared to experiments with regular shaped boulder models to achieve a better insight about the shape related influence on transport patterns.

The numerical model is based on the general two-phase mass flow model by Pudasaini (2012) enhanced for boulder transport simulations. The boulder is implemented using the immersed boundary technique (Peskin, 2002) and the direct forcing approach. In this method Cartesian grids (fluid and particle phase) and Lagrangian meshes (boulder) are combined. By applying the immersed boundary method we can compute the interactions between fluid, particles and arbitrary boulder shape. We are able to reproduce the exact physical experiment for calibration and verification of the tsunami boulder transport phenomena. First results of the study will be presented.

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