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Tsunami generation and propagation by 3D deformable granular landslides

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Landslides can trigger tsunamis with locally high amplitudes and runup, which can cause devastating effects in the near field region. The events of 1958 Lituya Bay, 1998 Papua New Guinea and 2006 Java tsunamis are reminders of the hazards associated with impulse waves. Tsunamis generated by granular landslides were studied in the three dimensional NEES tsunami wave basin (TWB) at Oregon State University (OSU) based on the generalized Froude similarity. A novel pneumatic landslide generator was deployed to simulate landslides with varying geometry and kinematics. Granular materials were used to model deformable landslides. Measurement techniques such as particle image velocimetry (PIV), multiple above and underwater video cameras, multiple acoustic transducer arrays (MTA), as well as resistance wave and runup gauges were applied. Tsunami wave generation and propagation is studied off a hill slope, in fjords and around curved headlands. The wave generation was characterized by an extremely unsteady three phase flow consisting of the slide granulate, water and air entrained into the flow. Landslide deformation is quantified and the slide kinematics with reference to slide surface velocity distribution and slide front velocity is obtained. Empirical equations for predicting the wave amplitude, period and wavelength are obtained. The generated waves depend on determined non-dimensional landslide and water body parameters such as the slide Froude number and relative slide shape at impact, among others. Attenuation functions of the leading wave crest amplitude, the lateral wave runup on the hill slope, the wave length and the time period were obtained to describe the wave behavior in the near field and to quantify the wave amplitude decay away from the landslide source. The measured wave celerity of the leading wave corresponds well to the solitary wave speed while the trailing waves are considerably slower in propagation. The individual waves in the wave train span from shallow to deep water depth regime. The energy conversion between landslide and waves is lower compared with 2D and solid block landslides due to radial spread of unidirectional landslide energy by the wave front. The slide characteristics measured in the experiment provide the landslide source for numerical landslide tsunami modeling. The measured landslide and tsunami data serve the validation and advancement of 3-dimensional numerical landslide tsunami and prediction models.