



## Numerical Simulation of Impulse Waves using Primitive Flow Models

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Three-dimensional multiphase Navier-Stokes (NS) Equations are used here to simulate landslide tsunamis numerically. This type of model provides some significant advantages over their depth-integrated counterparts, as they in principle allow us to model landslide dynamics coupled with tsunami generation with very few simplifications. For instance, NS models can capture non-shallow flow structures, such as breaking waves, eddies and impact craters. Still, they are rarely used and little information about their capabilities and shortcomings are available.

We conducted simulations of landslide tsunamis with the CFD-toolkit OpenFOAM [1]. We simulate the experiments by Viroulet et al. [2], in which the impact of a granular slide into water reservoir is studied. This is also benchmark 5 suggested by the National Tsunami Hazard Mitigation Program (NTHMP) for testing landslide tsunami models. The landslide was simulated as a viscous fluid and two additional phases, water and air, allowed the simulation of the tsunami wave.

We investigate and quantify uncertainties due to numerics and rheology and give recommendations for practical applications. Finally, we compare the empirical scaling laws for the wave height as reported by Fritz [3] with simulation results.

## References

- [1] OpenCFD, “Openfoam user guide,” *OpenFOAM Foundation*, vol. 2, no. 1, 2017.
- [2] S. Viroulet, A. Sauret, O. Kimmoun, and C. Kharif, “Granular collapse into water: toward tsunami landslides,” *Journal of visualization*, vol. 16, no. 3, pp. 189–191, 2013.
- [3] H. M. Fritz, *Initial phase of landslide generated impulse waves*. PhD thesis, ETH Zurich, 2002.