Mathematical Modeling and Simulation of:
A Two-phase and Three-dimensional Submarine Landslide and a Fluid Reservoir

Jeevan Kafle[1, 3], Parameshwari Kattel[1], Puskar R. Pokhrel[1], Khim B. Khattri[1], Bhadra Man Tuladhar[1], Shiva P. Pudasaini[1, 2]

[1]School of Science, Kathmandu University, Dhulikhel, Kavre, GPO Box 6260, Kathmandu, Nepal.
[2]Department of Geodynamics and Geophysics, Steinmann Institute, University of Bonn, Meckenheimer Allee 176, D-53115 Bonn, Germany.
[3]Department of Mathematics, Valmiki Campus, Nepal Sanskrit University, Kathmandu, Nepal.
Correspondence to: Jeevan Kafle: jkafle@student.ku.edu.np

Abstract: Gravitational flows like submarine and subaerial landslides and debris avalanches may generate tsunami waves as they hit some water body such as ocean, reservoir, lake or fjord. Here, the general two-phase debris flow model proposed by Pudasaini (2012) is applied to study submarine and subaerial debris flows, and the tsunami generated by the debris impact at reservoirs. The model, which includes three fundamentally new and dominant physical aspects such as enhanced non-Newtonian viscous stress, virtual mass, and generalized drag, constitutes the most generalized two-phase physical-mathematical mass flow model to date. Three-dimensional, high-resolution simulation results are presented in case when a real two-phase debris mass hits a fluid reservoir that consists of different solid concentrations. Simulations are performed for different time slices and different parameter values. An innovative formulation is employed that provides an opportunity, within a single framework, to simultaneously simulate the sliding two-phase debris/landslide, reservoir, debris impact at reservoir, tsunami generation, amplification and propagation, mixing and separation between the solid and fluid phases (Kafle, 2014). The results show formation and propagation of very special solid- and fluid-structures in the reservoir, propagation of the submarine debris mass and turbidity currents, tsunami impacts at coastal lines, and complex interactions between the subaerial, tsunami and submarine debris waves, and reservoir walls. The simulation results show that the amount of grain in the reservoir plays a significant role in controlling the overall dynamics of the tsunami waves, and submarine debris flow. These findings substantially increase our understanding of three-dimensional complex multi-phase systems and flows and allow for the proper modeling of landslide and debris induced tsunami, dynamics of turbidity currents and sediment transports, with associated applications to engineering and hazard mitigation plans.

Keywords: Mathematical modeling, Submarine landslides, Debris flows, Two-phase mass flows, Tsunami, Three-dimensional simulation, High-resolution methods, Hazard mitigations.

References:

Kafle, J., 2014. *Dynamic Interactions Between a Two-Phase Submarine Landslide and a Fluid Reservoir*. MPhil. Dissertation, School of Science, Kathmandu University, Dhulikhel, Kavre, Nepal.

Pudasaini, S. P., 2014. Dynamics of submarine debris flow and tsunami. *Acta Mechanica*, 225, 2423–2434 DOI 10.1007/s00707-014-1126-0

Pudasaini, S. P., 2012. A general two-phase debris flow model. *Journal of Geophysical Research* 117, F03010. http://dx.doi.org/10.1029/2011JF002186.

Pudasaini, S. P. and Miller, S. A., 2012. A real two-phase submarine debris flow and tsunami. *American Institute of Physics Proceedings*, 1479, 197-200.