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Submarine Landslide and Tsunami Impact on Submarine Obstacles

by
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Gravitational mass flows like submarine and subaerial landslides, and debris avalanches may generate super tsunami waves as they are triggered and impact water bodies such as ocean, sea, bays, hydraulic reservoirs or mountain lakes. On the one hand, these water bodies may contain icebergs, big boulders, islands, fiber-optics, oil-drilling platforms, oil pipe lines, and wind farms as different obstacles. These objects substantially alter the mass flow dynamics. In response, these objects may be severely damaged by the tsunami and submarine landslide impacts. On the other hand, the devastating effect of a submarine landslide and tsunami can be greatly reduced by submarine obstacles such as wave-breaking barriers installed in bay-mouths. As the tsunami enters the shallow regions the propagation speed decreases, and the amplitude grows drastically. Placing obstacles in the flow path controls the flow dynamics by reducing the destructive wave impact, runup and the resulting damages. Constructing appropriate protective object against tsunamis and submarine landslide is thus an engineering solution to the population and infrastructure. So, in order to substantially mitigate mountain and coastal hazards and integrity of hydraulic power plants it is very important to properly understand submarine landslide and tsunami interactions with submarine obstacles.

Here, we apply a comprehensive and general two-phase, physics-based, mathematical mass flow model (Pudasaini, 2012), and present first-ever three-dimensional, high-resolution novel simulation results for a real two-phase debris mass impacting a fluid reservoir containing obstacles of different shapes, sizes and dimensions, installed at different bathymetric positions. The simulations clearly demonstrate that due to the presence of obstacles in the submarine environment, the intense submarine-flow-obstacle-interaction dramatically reduces the flow momentum resulting in the rapid energy dissipation around the obstacles. This results in completely different tsunami and submarine flow dynamics around the obstacle, and in the flow influence region, tsunami wave impact, and the depositional behaviour of the submarine landslide with obstacles as compared to the reservoirs without obstacles. These novel findings help for the proper understanding of landslide and debris induced tsunamis in fluid reservoirs in high mountain slopes, channels, and reservoirs containing different types of obstacles in submarine environment, the associated dynamics of turbidity currents and highly-concentrated sediment transports, and submarine landslides in abyssal plains. These results may be extended and applied to hazard mitigation, prevention and solving relevant engineering

or environmental problems.

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

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