ENERGY TRANSFER MECHANISMS OF TSUNAMIS GENERATED BY SUBAERIAL LANDSLIDES: A NUMERICAL STUDY IN OPENFOAM®

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INTRODUCTION

Landslide-generated tsunamis are a relevant source of hazard for lakes and coastal areas. As well known, landslide tsunamis are generally characterized by smaller length and time scales than those of tsunamis generated by earthquakes and, when a landslide occurs directly at the water body boundaries, the effects of the impulsive waves (e.g., runup, inundation, edge waves, radiated waves, Bellotti and Romano, 2017) can be magnified by the local features of the coastline and/or the bathymetry, especially for confined geometries (e.g., bays, reservoirs, lakes, and fjords).

Landslide tsunamis risk is dominated by rare but, often, very destructive events causing numerous casualties and consistent socio-economic losses. It is worth citing the event which occurred in 1958 at Lituya Bay (Alaska, Fritz et al., 2009) that caused the largest wave runup recorded in modern times (524 m) killing 5 people, the Vajont Valley event (Italy, Panizzo et al., 2005) in 1963, that destroyed 4 villages causing the loss of nearly 2000 human lives and resulted in severe socio-economic consequences, and, more recently, the Anak Krakatoa event (Indonesia, Grilli et al., 2019) in 2018, when a volcano flank collapse triggered a tsunami that caused several hundreds of casualties. The low frequency/high consequences character of tsunamis in general, and landslide-generated tsunamis in particular, induces considerable uncertainty into hazard assessment of such events. Furthermore, these are highly localized phenomena, both in space and time, and, unlike cyclones and storm surges, the lack (or the incompleteness) of historical records hinders in predicting the future level of hazard.

Due to the complex physical phenomena involved in the tsunami generation, near-field and far-field wave propagation and interaction with the coast, landslide tsunamis are investigated by means of physical, numerical and analytical modelling. Recently, significant efforts have been spent in developing modelling techniques of landslide tsunamis by using computational fluid dynamics (CFD) methods (Ma et al., 2015; Kim et al., 2019; Romano et al., 2020; Clous & Abadie, 2019; Paris et al., 2021; Rauter et al., 2022; Romano et al., 2023). In fact, these methods can be very useful to model in detail the energy transfer mechanisms between the landslide and the water and the complex phenomena that take place during the generation and near-field propagation/interaction with the coast phases. Indeed, the proper understanding and modeling of the energy transfer mechanisms is crucial to improve the landslide-generated tsunamis hazard prediction.

Only a few studies have investigated the energy transfer mechanisms between landslides and tsunamis. These studies, by using both experimental (e.g., Fritz et al., 2004; Heller et al., 2016) and numerical (e.g., Jiand & LeBlond, 1992; Clous & Abadie, 2019) models, aimed at quantifying the conversion rate of energy from the landslide to the impulsive waves. Focusing on subaerial landslides, it was found that this conversion rate is evaluated to be 4−50% (Fritz et al., 2004) and that about 1/3 of the landslide energy conveyed to water during the landslide process is transferred to wave energy (Clous & Abadie, 2019). Important results have been obtained so far, nevertheless, due to the complexity of the physical processes that take place, still large gaps in the knowledge of the involved phenomena have to be filled, especially if 3D configurations and complex shoreline geometries are considered.

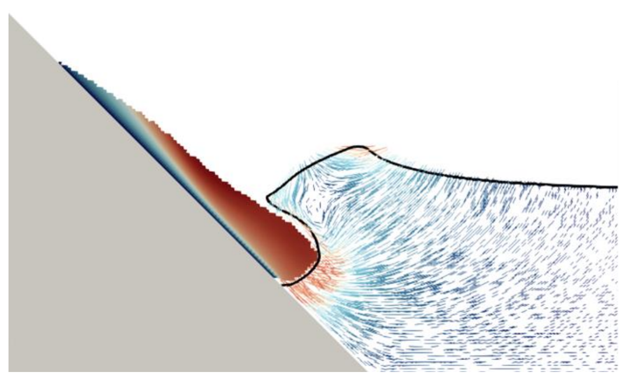

Figure 1 - Snapshot of the interaction between the granular landslide and the water for a subaerial 2D case.

In this paper we present a numerical study of the energy transfer mechanisms related to tsunamis generated by subaerial granular landslides. The study is carried out by using the opensource numerical framework OpenFOAM®, in which the granular material (i.e., the landslide) is modelled by using a Coulomb viscoplastic non-Newtonian rheological model, implemented in the standard solver *multiPhaseInterFoam*, described in the recent work of Romano et al., (2023). Both 2DV and 3D parametric simulations (see Fig. 1 and Fig. 2), by varying both landslide and geometrical parameters, are carried out to explore the importance of energy components and the energy conversion rate from the landslide to the waves. The seminal work of Clous & Abadie (2019) is used as reference for estimating the energy components. New results and physical considerations will be shown at the Conference.

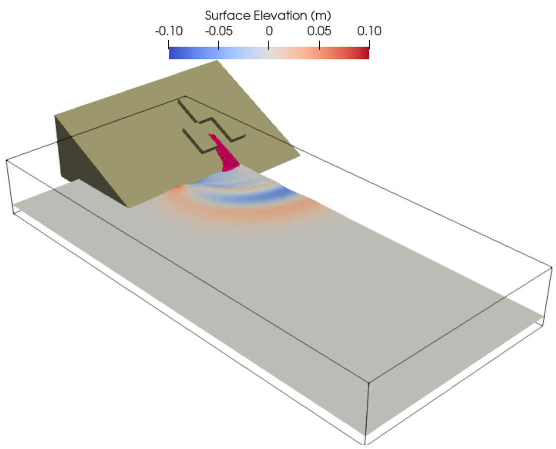

Figure 2 – Snapshot of the interaction between the granular landslide and the water for a subaerial 3D case.

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