3D simulation of landslide generated waves with OpenFoam

Contract

Post-doctoral contract **(2 years) ≥ 1 sept 2023**

Job location

CEA DAM – Île-de-France : Bruyères-le-Châtel, 91297 Arpajon Cedex

Job description

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas : defense and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences. Within the framework of the monitoring missions of the Department of Environmental Analysis and Monitoring (DASE), CEA operates the Tsunami Warning Centre (CENALT, CENtre Alerte Tsunami) and contributes to the international effort in tsunami research.

The present post doc proposition deals with tsunami generated by landslides. Many tsunamis, consecutive or not to strong earthquakes, are generated or accentuated by the triggering of sub-aerial or submarine land collapses. This is the case of several historical tsunamis (Nice, 1564, 1979; Mer Ligure, 1887; Polynesia 1979; Papua, 1998; Java, 2012; Greenland, 2017; Anak Krakatau, 2018) that have impacted several kilometers of near or distant coasts. In this context, the DASE department faces the challenge of accurately simulating potential gravity tsunamis to estimate the inundation heights at the coast. A first PhD, defended in 2021, worked on the comparison between shallow water modeling and multiphase Navier-Stokes simulations (OpenFoam) on this problematic (see for instance Paris et al., 2021). In this work the collapse was modeled as a viscous flow which viscosity has to be tuned depending on the case considered. This approach, while pragmatic, neglects important phenomena such as the penetration of water within the slide grains. Additionally, in real 3D cases, non negligible parasitic flows were generated at the initiation of the computation, likely due to numerical errors generated by the complexity of the mesh.

Therefore, the purpose of the 2-year post-doctoral fellowship is to go beyond this first study limitations, and propose a truly efficient and robust procedure to simulate real 3D landslide tsunami cases using the multiphase solvers of OpenFoam.

The following stages would have to be completed :

1. The development of an optimized protocol to define the domain mesh and volume fractions (i.e., water and slide) initiation for 3D real cases. Specifically, the finite volume construction procedure should match the bathymetry and be as simple and quick as possible. The volume fractions initiation should allow an accurate description of the slide volume and the water surface à t=0, and allow a smooth computation start without parasitic currents. The whole procedure should be repeatable through the use of a python script,

2. The use or development of a rheological model within OpenFoam drawing on recent papers in the literature (Si et al., 2018; Yu and Lee, 2019; Lee and Huang, 2021, Rauter et al., 2022). Particular at-

tention will be paid to granular-type models that approximate the physical behavior of collapsing rock masses. This model will be tested against controlled experimental data and finally compared to the previous approach (i.e., viscous flow) to assess its reliability and efficiency in addressing real cases taking into account the geotechnical uncertainties,

3. The development of a robust procedure for transferring the results from the 3D OpenFoam simulations in a 2D "tsunami" code as initial or boundary condition in order to propagate the tsunami over long distances and simulate the impact on distant coasts. The procedure could formalize the one described in Abadie et al., 2012,

4. Finally, applications of the whole procedure to one or two well-documented historical events with the aim of publishing. Applications will also include simulation of potential slide tsunamis in French Polynesia, for which sensitivity studies on slide volume and rheology will be performed. Comparisons with the results of depth-integrated models will also be carried out to precisely evaluate the contribution of the 3D resolution according to the case studied.

The supervision and host of the post doc will be provided by the LEGA laboratory (Geophysical Studies and Hazards Laboratory) of the CEA, supported by the Wave-Structure Interactions team of the SIAME laboratory (University of Pau and the Pays de l'Adour - Basque Coast Campus). The two teams have been involved for many years in the analysis and simulation of tsunamis generated by gravity instabilities and have recently collaborated on this subject through a thesis to be defended in 2021.

Spécificité du post-doctorant au CEA

Le CEA, avec plus de 16,000 salariés et plus de 1500 doctorants, fait partie des entreprises françaises les plus innovantes. De même que les salariés en CDI, les doctorants et post-doctorants au CEA bénéficient de jours de télétravail, de JRTT, d'un restaurant d'entreprise, d'infrastructures sportives, de prestations vacances et loisirs et d'un système de transport gratuit en région parisienne. Si votre candidature est retenue, nous vous contacterons pour un entretien avec les deux contacts ci-dessous.

Seeked candidates profile :

PhD thesis completed.

Strong skills in :

- OpenFoam (use and programming) : multiphase solvers, granular-type flows

- python script programming

Experience in simulation of water waves or landslides appreciated.

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References :
Abadie, S. M., et al. "Numerical modeling of tsunami waves generated by the flank collapse of the Cumbre Vieja Volcano (La Palma, Canary Islands): Tsunami source and near field effects." *Journal of Geophysical Research: Oceans* 117.C5 (2012).
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Paris, Alexandre, Philippe Heinrich, and Stéphane Abadie. "Landslide tsunamis: Comparison between depth-averaged and Navier–Stokes models." *Coastal Engineering* 170 (2021): 104022.
Rauter, Matthias, et al. "Granular porous landslide tsunami modelling–the 2014 Lake Askja flank collapse." *Nature communications* 13.1 (2022): 678.
Si, P., Shi, H. & Yu, X. A general numerical model for surface waves generated by granular material intruding into a water body. *Coast. Eng.* **142**, 42–51 (2018).
Yu, Ming-Lan, and Cheng-Hsien Lee. "Multi-phase-flow modeling of underwater landslides on an inclined plane and consequently generated waves." *Advances in Water Resources* 133 (2019): 103421.