Call for PhD position: high-order, high-fidelity modeling of tsunamis induced by dynamic earthquake motions

Supervisors

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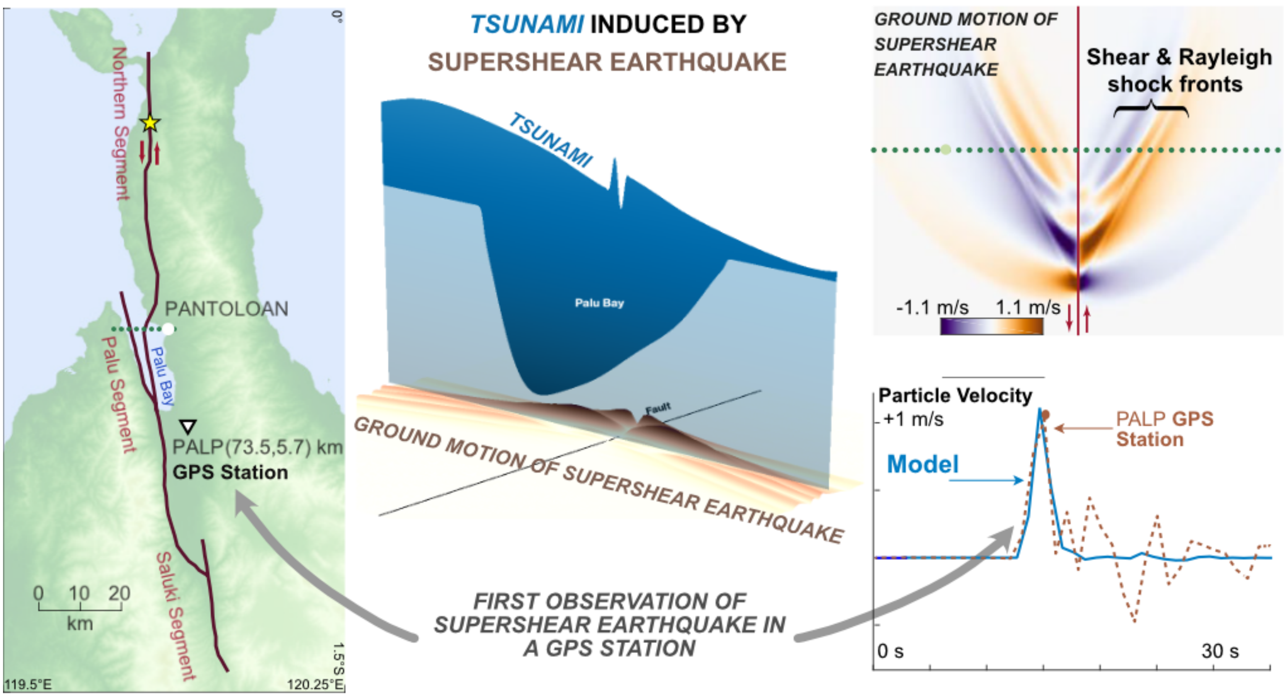
Scientific context

Tsunamis are amongst the most devastating and costly by-products of earthquakes, but how exactly the *dynamics* of earthquake ground motions relate to tsunami generation is not fully understood. Indeed, it was only recently shown (see [1, 2] and references therein) that certain *strike-slip* earthquakes (which have minimal vertical displacement) can create significant water waves, e.g., the deadly 2018 Palu bay, Indonesia tsunami that was mysteriously and unexpectedly generated from such a fault (as opposed to from a *subduction* zone, where vertical ground displacement is non-negligible). This unusual tsunamigenesis was explained in a proof-of-concept work [1] by incorporating the *time-dependent effects* of so-called "supershear" earthquake rupture displacement and velocity into a simplified fluid-structure model solved by a novel, highly-accurate numerical approach. Such a finding has uncovered possible new seismogenic tsunami potential (where there was thought to be little before) in a host of similar fault locations and configurations around the world [1], ultimately implying that there may be an underappreciated risk, yet to be quantified, associated with tsunamigenesis.



Thesis/dissertation objectives

The overarching goals of this project are two-fold:

1. Extension of a proof-of-concept, high-order Fourier-based 1D/2D tsunami solver to 2D/3D (based on the shallow-water wave equations) whilst incorporating dynamic ground motion (where time-dependent displacement/velocities are provided by earthquake rupture simulations). The objective is to faithfully capture the multiscale dynamics that govern the behavior of seismogenic tsunamis in a most generally-applicable sense. This part requires extensive numerical analysis/coding and algorithmic development.
2. Use of the coupled fluid-structure solver for the scientific investigation and possible discovery of new *dynamic* signatures for tsunamigenesis in earthquakes generated on both thrust and strike-slip faults. This part is both pedagogical and exploratory.

Ultimately, such work will be towards rapidly assessing tsunami hazards, identifying new areas of risk, and explaining unexpected behavior or generation of some historical tsunamis—all while characterizing, to the fullest extent possible, various tsunami dynamics and how they relate to the associated earthquake rupture dynamics. At the end of the PhD, the student will potentially have acquired highly multi-disciplinary training with a strong foundation in applied/computational mathematics, theoretical mechanics, and earth sciences.

Position details & how to apply

Profile

The ideal profile is one with a background in numerical/scientific computation (originating from either applied mathematics, engineering or solid/fluid mechanics) with a taste for programming and scientific inquiry. Candidates will have (or about to have) graduated with a Master's degree (or a non-European university degree equivalent) in either applied math, computational mechanics, mechanical/civil engineering, seismology, geophysics, or other related field. Experience in numerical methods and MATLAB simulation (especially in solid or fluid dynamics) is preferred. The project is expected to be conducted mostly in English, hence competency in the French language is not necessary (although language classes are provided by the doctoral schools).

Location

The research will be conducted between two prestigious sites in the greater Paris metropolitan region: the Laboratoire de Mécanique Paris-Saclay (CentraleSupélec, École Normale Supérieure Paris-Saclay, Université Paris-Saclay), located in the "French Silicon Valley", and the Laboratoire de Géologie (École Normale Supérieure Paris, PSL Research University), located in the center of the city.

Salary & project timeline

The position is full-time and financial support is secured for at least three years (the average length of a PhD in France) with an expected gross stipend of around 2135€/month funded by CNRS (the French National Center for Scientific Research) through the MITI interdisciplinary programs. The successful applicant can start as early as September 2023, although this can be negotiated depending on circumstances.

Submission

Interested applicants should send a motivational cover letter and CV to F. Amlani (faisal.amlani@ens-paris-saclay.fr) or H.S. Bhat (harsha.bhat@ens.fr) before May 31, 2023.

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[1] Amlani, Bhat, et al., *Geophysical Journal International* 230, 2022. DOI:10.1093/gji/ggac162

[2] Elbanna, et al., *Proceedings of the National Academy of Sciences* (*PNAS*) 118, 2021. DOI:10.1073/pnas.2025632118