PostDoc position Offer

Duration: 18 months

Starting date: Flexible, ideally between June and September 2022

Location: Paris, France

Pre-requisites: PhD - experience in numerical simulations of wave propagation or rupture dynamics in 3D models

Our offer: Opportunity to model the seismic ground motion taking into account source rupture complexity and wave propagation in a 3D sedimentary basin. True integration of the ground motion models in a knowledge chain spanning between geology (build 3D model from inputs) and the damaged structures (outputs will be used to shake numerical models of historical buildings). Collaborate with a multidisciplinary team (historians, archeologists, petrologists, civil engineers, geologists, seismologists, mathematicians) from Italy and France. Learn to solve complex problems using high performance computing facilities.

Project : ACROSS project (https://across-project.github.io) founded by the French national research agency, ANR

Title: Modelling seismic ground motion including source and site complexity for better knowledge of past earthquakes

Supervisors: C. Gélis, S.Hok and H. Jomard (IRSN-Fontenay aux Roses), H. Lyon-Caen (ENS-Paris)

Context: Historical earthquake catalogues are one of the building blocks for the assessment of seismic hazard. In spite of many years of research in the archives, many earthquakes remain poorly known. New sources of information are hence required. Among these, historical buildings are witnesses of natural catastrophes recorded in their walls as structural disorders, repairs, restorations. The ambition of the "ArChaeology, inventory of RecOnstruction, Seismology and Structural engineering" (ACROSS) ANR Project is to study past earthquakes using buildings as "stone seismometers", analysing the seismic ground motions required to explain building repairs/disorders, or their absence. The ACROSS project aims at developing a methodology to demonstrate that archaeological characterization of post-seismic repairs on buildings can be successfully used to infer key ground motion and earthquake source characteristics of historical earthquakes.

The site under study is located in Tuscany, Italy. Mugello is an intramontane basin bordered by two large antithetic normal fault systems ("Ronta" and "Sieve") characterized by the same extensional regime causing the recent strong Italian earthquakes (i.e. Norcia - Amatrice 2016 Mw 6,5 ~200 km south along the Apennine chain), but with a lower seismicity rate. The strongest known events in Mugello occurred in 1542 (Mw~6) and in 1919 (Mw~6.3). Both earthquakes induced extensive damages over the whole region. On the basis of historical macroseismic intensities, the 1542 event is located in the north-western part of the basin, while the 1919 one is in the south-west. However, the fault system on which these earthquakes occurred is still a matter of debate. These two events led to disorders, repairs, restorations to five bell-towers located in the area, that will be studied by historians, archeologists, petrologists and civil engineers in the framework of the project.

Objectives: The candidate PostDoc will be involved in the numerical modelling of ground motion generated by these two past earthquakes, especially at the location of the five bell-towers. A

representative model (geometry and mechanical properties) of the Mugello area will be defined on the basis of data on faults and basin properties coming from scientific publications, reports, and national/regional databases. Eventually, additional data will be acquired in the field to complement basin characterization. Uncertainties related to this model will be defined as well.

The main challenges and tasks of the candidate PostDoc will be the following:

Building the rupture scenario

This task is focused on the exploration of the physical parameters of the fault model that could have led to the 1542 and 1919 earthquakes, such as 1) the fault geometry (based on different geometries at depth for the two fault systems), 2) the fault kinematic model parameters (spatio-temporal slip evolution, stress drop & rupture velocity). At the end of this phase, a set of plausible scenarios of the 1542 and 1919 earthquakes will be chosen in accordance to the seismotectonic context of the area and other information, such as macroseismic intensity of past earthquakes.

Basin model validation

This step aims at determining the capacity of the basin model to reproduce observed seismic ground motion, by comparing available seismic ground motions recorded in the area (e.g., local sequences, teleseismic events) with seismic ground motions computed in the model, especially inside the basin. Depending on these comparisons, the model of the basin could be updated.

Computing broadband 3D ground motions

The last task is the computation broadband 3D ground motions emitted by the chosen fault rupture scenarios and propagating inside the area including the basin, especially at the 5 bell-towers studied within the project. If needed, the high frequency part of the signal will be generated using a different technique and combined with the low frequency part coming from the wave propagation 3D numerical model.

Tools : Different 3D codes implementing different numerical methods (Spectral element method, Finite difference method, Discontinuous Galerkin method) can be used for this purpose, provided that: (1) they are submitted to a verification phase demonstrating their accuracy and computational efficiency for both the kinematic source rupture and seismic wave propagation modelling, (2) they are open-source. Among others, user-friendly codes such as SeisSol or SPECFEM3D fulfill these criteria. Previous experience with using those codes will be a plus for the candidate, and will guide the choice of the code.

Expected Results:

Identification of the seismogenic sources that ruptured in 1542 and 1919 together with possible rupture scenarios

Determination of a series of 3D broadband ground motions for each bell-tower

Post-doc position application

Applications including cover letter (explaining background and motivation), CV, publication record and contact information for 2 references must be sent to Sebastien.hok@irsn.fr, herve.jomard@irsn.fr, celine.gelis@irsn.fr, lyoncaen@ens.fr and maria.lancieri@irsn.fr. Application is open until the position has been filled.