PostDoc opportunity: Exploring physics-based earthquake rupture approaches in fault networks for seismic hazard assessment (French ANR project EQTIME in collaboration with LMU Munich)

Supervisors: A.-A. Gabriel (LMU Munich), S. Hok and O. Scotti (IRSN)

Contact: oona.scotti@irsn.fr

Duration: 2 years

Starting date: Flexible, between Sept 2020 and Sept 2021

Location: Paris, France and Munich, Germany

Pre-requisites: PhD; experience in dynamic earthquake rupture (laboratory or numerical)

Our offer: Opportunity to develop a new approach in seismic hazard modeling; collaborate with a well-established European network of fault modelers internationally renowned and top-level scientists in a multidisciplinary team (geologists, seismologists, geodesists and hazard modelers); learn to solve complex problems using high performance computing facilities.

Objectives:Probabilistic Seismic hazard modeling aims to forecast earthquake occurrence and its resultant ground shaking. One of the main challenges relies in an adequate quantification of uncertainty involved in seismic-source and ground-motion models. Seismic source models are today evolving towards considering multi-segment ruptures in complex fault systems as observed in recent events (i.e. the 2016 Mw7.8 Kaikoura, New Zealand earthquake with more than 20 individual faults involved). However, evaluating the possibility of future complex earthquake ruptures in any given fault system remains a major challenge. Physics-based computer models allow to simulate how fault interact with each other during their rupture and cause shaking at the surface of the earth. As such they provide a framework for the exploration of the space of viable rupture scenarios.
The candidate PostDoc will develop 3D dynamic earthquake rupture scenarios across complex fault systems combining nonlinear frictional failure and seismic wave propagation by exploring a range of viable physical parameters. Empowered by supercomputing, such models will produce physics-based forecasts of ground motions and fault interaction as well as providing insight into fundamental processes of earthquake physics.

Challenge: The main challenge and task of the candidate PostDoc will be to first construct the fault model(s) based on the integration of the rich amount of data available in the Central Appenines, Italy. For this part, the PostDoc will interact with the ANR-EQTIME partners. In a second phase, the candidate will focus on the exploration of the physical parameters of the fault model (3D fault geometry, regional stress orientation and amplitude, fluid pore pressure, anelastic behavior parameters, faults' frictional parameters). For setting these parameters and their variability in such a blind prediction exercise, a puzzling challenge consists in bridging the apparent gaps between the large range of variations implied by Bayesian inversions on simple faults (e.g. Gallovic et al. 2019) and the tighter variability allowed for the reproduction of multi-fault rupture scenarios of past earthquakes (e.g. Wollherr et al., 2019, Ulrich et al., 2019).

Expected Results: The final purpose of the PostDoc is to devise an efficient strategy to compute viable rupture scenarios in a probabilistic framework. The physically viable earthquake rupture scenarios and their associated probabilities will be used to compute fault-based seismic hazard in the region.
Depending on progress the candidate PostDoc may also tackle the delicate issue of computing physics-based GMPE's accounting for source/site and path effects, as a first step towards a comprehensive physics-based approach for seismic hazard estimates.

Tools: The candidate will use mainly three open-source, user-friendly codes: SeisSol, a code used to study complex earthquakes such as Landers or Kaikoura to model multi-fault rupture propagation; SHERIFS to explore epistemic uncertainties in multi-rupture scenarios and OPENQUAKE to compute seismic hazard at selected sites.

References:
Wollherr, Stephanie, Alice-Agnes Gabriel, and Paul Martin Mai (2019), Landers 1992 "reloaded": an integrative dynamic earthquake rupture model, Journal of Geophysical Research – Solid Earth, 124, doi:10.1029/2018JB016355, open-access available at https://eartharxiv.org/kh6j9/

Ulrich, Thomas, Alice-Agnes Gabriel, Jean-Paul Ampuero, and Wenbin Xu (2019), Dynamic viability of the 2016 Mw 7.8 Kaikōura earthquake cascade on weak crustal faults, Nature Communications, 10(1213), doi:10.1038/s41467-019-09125-w