ESR 2.2 : Seismic swarms: comparing natural and induced earthquakes
A Research PhD position in the URBASIS ITN funded by the EC

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Recent devastating earthquakes and induced seismicity near infrastructures must become the centrepiece of analysis in reducing risk and increasing resilience, facing up to global urban population growth in the coming decades and the concentration of wealth in cities. The prediction of seismic ground motion and response of structures are key issues in reduction of seismic urban risk. There is therefore a demand for highly trained scientists with a broad understanding of engineering seismology and earthquake engineering, skills being essential in academic research, in private companies with activities related to risk mitigation and energy facilities and for policy makers. The URBASIS-EU project aims to provide a multi-disciplinary training platform for young scientists in order to develop their individual project and to promote their entrepreneurship and their employability toward the academic, private and insurance or decision-making sector. High-quality supervision of the young scientists will be ensured through the international recognition of the URBASIS-EU partners. A comprehensive set of transferable skills will be developed through innovative and interdisciplinary joint research projects between academic and non-academic partners on the prediction of seismic hazard in urban areas considering low-probability/high-consequences events and induced seismicity related to the exploitation of energy resources; the seismic ground motion prediction within the non-free-field urban area; the coupling between ground motion and structures/infrastructures responses for natural and induced seismicity including time dependent vulnerability; and the systemic risk of interconnected urban systems. URBASIS-EU will create a lasting collaboration for the establishment of a European network of academic and non-academic experts, improving the interface with decision-makers.

More information: https://urbasis-eu.osug.fr/?lang=en

Job Description

The topic of the PhD is the study of seismic swarms, both natural and induced. Swarms are bursts of seismicity that can last for days to years, with a rate of activity much larger than the long-term rate. Unlike regular aftershock sequences, the rate of seismicity increases progressively and decays slowly with time, and the largest earthquake does not often occur at the beginning of the sequence. In space, the size of the cluster is usually much larger than the rupture length of the largest earthquake. This suggests that swarms are not only triggered by tectonic stress or earthquake interactions, but that another loading process is active. In many cases, the size of the swarm extends with time. This diffusion of activity is also observed for seismicity induced by fluid injections (geothermal fields, reservoir dams, oil fields, etc.), suggesting that fluid flow is also responsible for the triggering of natural swarms. In addition to fluid diffusion, aseismic slow slip events have also been proposed as a triggering process, both for natural and induced swarms. Swarms are also particularly interesting because they have been observed several times prior to large earthquakes (2009 L'Aquila earthquake

in Italy, 2011 Tohoku-oki earthquake in Japan). However, we cannot predict yet how a swarm sequence will evolve and if it may lead to a large event.

The goal of this project is to compare the properties of natural and induced swarms. Analyzing induced seismicity offers the opportunity to know the loading process (injection rate), and thus to better understand how fluids can trigger earthquakes. We will search for signatures of fluids in the properties of swarms. Beside diffusion of seismicity, swarms are often characterized by anomalies in the magnitude distribution (low or high b-value, deviations from Gutenberg-Richter law) or in the Omori law (slow temporal decay of seismicity rate, unusual scaling of aftershock productivity with mainshock magnitude).

The first step of the project will be to obtain large datasets of earthquakes both for natural swarms (e.g. Ubaye, Maurienne and Vallorcine in the French Alps) and induced seismicity (e.g., Soultz (France), Basel (Switzerland), Otaniemi (Finland)). Template-matching methods are useful to improve the detection threshold down to M=0 and therefore to increase considerably the number of detected earthquakes. Relocation by double-differences can further be applied to obtain much more accurate relative locations. These methods have already been applied successfully to analyze swarms in Ubaye and Maurienne. One goal of this project will be to extend this analysis to longer time periods in Ubaye and Maurienne and to apply them to the Vallorcine area. This last study site is particularly interesting as it has been regularly affected by swarms, with magnitude reaching M=4.5 in 2005, and because these earthquakes are suspected to be triggered by the nearby dam reservoir.

In a second step, the PhD student will analyse statistical and physical properties of swarms and compare them with “regular” tectonic earthquakes, to look for markers of swarms and identify triggering mechanisms (fluid flow? aseismic slip?).

The ultimate test of a model is to have it generate a forecast of some or all of its properties and to test these forecasts against future observations. Therefore, within this PhD, the candidate will develop for each property a targeted experiment to test it against future observation. This work is supposed to be conducted in the framework of the Collaboratory for the study of Earthquake Predictability (CSEP). The goal is to ensure that findings based on retrospective analysis of data do not stem from overinterpreting or overfitting data but are describing a characteristic of a physical phenomenon and should become part of a describing model..

The URBASIS consortium is funded by European Commission’s Innovative Training Network (ITN) program. This research project will take place at the University Grenoble Alpes, France, within the Institute of Earth Science (ISTerre). This project will involve close collaboration with GFZ Potsdam, where the researcher will spend several months. The project will also involve secondments with University of Liverpool (UK) and AXA (France)

Requirements and Application

The successful applicant must have a Master degree in seismology or geophysics. The applicant is expected to have a strong background in seismology and a good expertise of programming languages (matlab and python, but also fortran or C and use of linux and shell scripting). The PhD student should be able to work with large datasets and be good at software development. Furthermore, knowledge of statistics is an advantage. Excellent undergraduate and master degree grades are

expected. A high level of written and spoken English is also expected.

PhD stipends are allocated to individuals who hold a Master's degree. PhD stipends are normally for a period of 3 years. It is a prerequisite for allocation of the stipend that the candidate is to be enrolled as a PhD student at the Earth Sciences Doctoral School of the UGA. According to the URBASIS-EU, the progress of the PhD student shall be assessed every 12 months. It is a prerequisite for continuation of salary payment that the previous progress is approved at the time of the evaluation.

The qualifications of the applicant will be assessed by the **Selection committee**. On the basis of the recommendation of the **Selection** committee, the Administration of University Grenoble Alpes will make the final decision for allocating the stipend.

URBASIS-EU wishes to reflect the diversity of society and welcomes applications from all qualified candidates regardless of personal background or belief. We encourage applications from everyone irrespective of gender and ethnic group but, as women and members of ethnic minority groups are currently under-represented at this level of post, we would encourage applications from members of these groups. Appointment will be based on merit alone.

Application must be in a form of a single PDF file including a CV, a cover letter, academic transcripts, and the names and complete contact information and letter of two referees sent through :

- **the consortium web-page https://urbasis-eu.osug.fr/?lang=en**
- **the EU EURAXESS portal https://euraxess.ec.europa.eu/**

Vacancy number : URBASIS-EU ESR2.2 (to be reminded in the application form)
Deadline : February, 23rd 2019
Salary : According to the European Commission and local standards ; minimum gross wage is 3500 euros before local taxes

Contact Information
You may obtain further information from :

- **Philippe Guéguen**, URBASIS project coordinator : philippe.gueguen@univ-grenoble-alpes.fr (Earth Science Institute, Université Grenoble Alpes) for general questions regarding the URBASIS consortium or concerning the scientific and training aspects of the ITN program
- **Agnes Helmstetter** (ISTerre, UGA) : agnes.helmstetter@univ-grenoble-alpes.fr concerning the scientific aspects of the stipend
- **Florence Cataye**, URBASIS project manager : florence.cataye@univ-grenoble-alpes.fr for administrative questions

For more information of Earth Sciences Doctoral School of UGA: *https://ed-tue.osug.fr/*