PhD call on **FAULT DISPLACEMENT HAZARD ANALYSIS**, 2022-2025, **Italy – France** collaboration

Fault displacement hazard (FDH) is a localized hazard due to rupture of the ground surface from slip along an earthquake fault. This can be a significant source of danger for infrastructure, industrial facilities, or even housing. There is a growing interest from the scientific community, the geoscience practitioners' world and from stakeholders for methods aimed at quantifying FDH. This is required also by the need of updating the current methodologies of FDH Analysis with approaches in step with the most modern engineering mitigation solutions developed in the past decades. Probabilistic fault displacement hazard analysis (PFDHA) is one methodology, though with limitations that need to be overcome.

The PhD project is aimed at developing the methodology of PFDHA. It will be in continuity with promising results obtained in the past few years. The project will be developed within an international collaboration between Italy (University of Chieti – UdA and INGV) and France (IRSN, IsTERRE).

PhD title: Fault Displacement Hazard on Principal Fault rupture: probability of occurrence, slip distribution and role of surface geology

Supervising team: Paolo Boncio (UdA), Francesco Visini (INGV), Stéphane Baize (IRSN)

Collaboration team: Céline Beauval (IsTERRE), Oona Scotti (IRSN), Bruno Pace (UdA)

UdA: University "G. d'Annunzio" of Chieti-Pescara (Italy); INGV: Istituto Nazionale di Geofisica e Vulcanologia (Italy); IRSN: Institut de Radioprotection et de Sûreté Nucléaire (Fontenay-aux-Roses, France); IsTERRE: Institut des Sciences de la Terre (Grenoble, France)

Expected results: probabilistic models to forecast the distribution of slip along capable faults; specific relationships depending on surface geology conditions to be used with the aim of providing a complete model (principal + distributed faulting) for PFDHA.

Methods: analysis of geological data from historical earthquake surface ruptures occurred globally; statistical analysis; coding by Python and/or Matlab; application of models to real cases.

Who: we encourage the application of students who love combining knowledge in geosciences with numerical quantification methods (statistical analyses, Python and/or Matlab coding).

Where: The student will be based in the University of Chieti (UdA, Italy), with tight cooperation with INGV team. Long duration stays in France (ideally 2 of 3 months each) in Paris (IRSN) and Grenoble (IsTERRE) are planned.

How to apply (deadline for application: August 3rd 2022): The student will be recruited following the UdA procedure at (look for Call for PhD positions Doctoral Programme 38th cycle (*BANDI DI CONCORSO* in Italian), PhD program in GEOSCIENCES):

https://www.scuolasuperiore.unich.it/sites/sc03/files/bando_inglese_xxxviii.pdf

https://www.scuolasuperiore.unich.it/sites/sc03/files/schede_inglese_xxxviii.pdf

https://en.unich.it/teaching/postgraduate-courses/scuola-superiore-g-dannunzio-school-advanced-studies

If you need help with the procedure, please ask: paolo.boncio@unich.it.

Ask for info, or send your CV @

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Scientific details for the PhD project:

Fault Displacement Hazard on Principal Fault rupture: probability of occurrence, slip distribution and role of surface geology

Surface slip on faults during an earthquake is a potential hazard to surface infrastructure. Probabilistic methods for estimating this surface rupture hazard (PFDHA) are developed, based on empirical regressions. The improvement of probabilistic methods for PFDHA mostly aims at proposing more robust such regressions, based on dense populations of well-documented earthquake surface ruptures. The empirical dataset has been enriched in recent years with the constitution of worldwide, unified and up-to-date databases of well-documented case studies (SURE: Baize et al., 2019; SURE v. 2: Nurminen et al., in publication; FDHI: Sarmiento et al., 2021). The goal of the new PhD thesis is to provide those new statistical tools to obtain a complete, updated method for assessing the PFDHA, including principal and distributed faulting, during earthquakes.

A first result in the process of improving the PFDHA method was achieved with the PhD thesis of Fiia Nurminen (2018-2022), who defined new empirical regressions for estimating the likelihood of distributed surface ruptures, and the probability of exceeding a certain level of displacement in sites located distant from the Principal Fault (PF) (i.e., Distributed Ruptures, DR). The regressions were obtained for dip-slip earthquakes, and account for kinematics (reverse and normal faults), earthquake magnitude, displacement on PF, distance from PF, and size of the site exposed to the fault displacement hazard (Nurminen et al., 2020; Visini et al., in prep.). These results complement the regressions already available in the literature for strike-slip DR (Petersen et al., 2011). The new obtained regressions have been tested in 2021 within the Benchmarking study “Current Practices in Probabilistic Fault Displacement Hazard Assessment for Existing Nuclear Installations”, led by IAEA (Valentini et al., 2021).

Today it is important to improve the regressions of estimating the hazard for PF, in order to have an updated and complete model for PFDHA. The first fundamental question is to predict how often an earthquake will break the surface given its magnitude: there are existing regressions, but today they deserve to be revisited by using the enlarged databases, including the satellite-based ones (InSAR) and especially for dip-slip earthquakes. Next, how to predict the distribution of slip along the PF rupture? The existing regressions are based on old datasets and an update is needed, in particular to statistically constrain the evolution of slip at the rupture tips. Finally, what are the impacts of local geological conditions on the distribution and characteristics of both PF and DR surface ruptures? Local geologic conditions include geometric/structural complexities of the PF (e.g., stepovers, bends, gaps), kinematics of PF (e.g., slip partitioning in oblique-slip earthquakes), and rheology and thickness of near-surface rocks/soils. Historical examples (2010 M7 El Mayor, Mexico City: Teran et al., 2015), empirical datasets and modelling (e.g., Loukidis et al., 2009; Moss et al., 2013) show that these conditions are important but their role remains to be constrained statistically, and possibly converted into regressions applicable to FDHA.

The PhD will address these issues in order to define a complete model for PSHA.

Cited References

Baize S., et al. (2020). A Worldwide and Unified Database of Surface Ruptures (SURE) for Fault Displacement Hazard Analyses. Seismological Research Letters, Data mine. DOI: 10.1785/0220190144

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Moss, R. E. S., et al. (2018). Physical, analytical, and numerical modeling of reverse-fault displacement through nearsurface soils, Bull. Seismol. Soc. Am. 108, 3149–3159, doi: 10.1785/0120180067.

Nurminen, F., et al. (2020). Probability of occurrence and displacement regression of distributed surface rupturing for reverse earthquakes, Front. Earth Sci. 8, doi: 10.3389/feart.2020.581605.

Nurminen, F., et al. (in publication). SURE 2.0: the new release of the worldwide and unified database of surface ruptures (SURE) for fault displacement hazard analysis, in preparation for Scientific Data - Nature.

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Petersen, M. D., et al. (2011). Fault displacement hazard for strike-slip faults, Bull. Seismol. Soc. Am. 101, no. 2, 805–825, doi: 10.1785/0120100035.

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Valentini, A., et al. (2021). Probabilistic Fault Displacement Hazard Assessment (PFDHA) for Nuclear Installations According to IAEA Safety Standards, Bull. Seismol. Soc. Am. XX, 1–12, doi: 10.1785/0120210083