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Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: Spatiotemporal Imaging of Earthquake Rupture process in High Frequencies using Backprojection methods (SIREN)

Principal Investigator: Dr. Christos P. Evangelidis

Reader-friendly title: SIREN

Scientific Area: Natural Sciences

Institution and Country: National Observatory of Athens, Greece

Host Institution: National Observatory of Athens

Collaborating Institution(s): University of Patras, Disaster Prevention Research Institute (DPRI), Kyoto University, Japan, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Milan, Italy








Budget: 199,888.00 €

Duration: 36 months

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Research Project Synopsis

The main goal of SIREN is to map accurately and timely the high frequency (HF) energy emitted at the earthquake source region during large events. For this study we will perform backprojection analyses on well recorded earthquakes in Japan, Italy, Greece, Turkey, New Zealand and elsewhere. Our approach will require the removal of the site-effects part from all available records or at least to distinguish quantitatively good reference stations. As site effects at the recording stations have never been removed in similar studies so far, SIREN aims to develop such practices and test them with a fast and robust new software tool that will provide rapid calculations in parallel mode using multiple threads in CPUs and GPUs. The implementation of the project plan will lead towards an improved understanding of the earthquake rupture process. The high-frequency energy emitted during an earthquake is of great importance in seismic hazard assessment for certain critical infrastructures of the energy sector. In practice, the methods, tools, knowhow and experience will be directly exploited by consulting companies specialized on designing safety measures of critical infrastructures (e.g. nuclear power plants, dams).

Project originality

The conventional way to explore the rupture process of large earthquakes and, consequently, the nature of faulting is finite source inversion. The application of the method is feasible considering a good station coverage, but it would be performed at relatively long periods (<1 Hz) with various assumptions on fault geometry, rupture directivity, and speed. Backprojection methods provide the alternative novel approach to image the spatiotemporal earthquake rupture. The greatest advantage of backprojection methods is that processing is done without any a-priori constraints on the geometry, dimension and size of the source. Thus, the spatio-temporal imaging of the rupture is feasible in much higher frequencies (> 1Hz) than conventional source inversion methods. There are also cases where the examined fault geometry is complex and not easily represented as a 2-D planar fault as a kinematic source inversion study requires.

For backprojection analyses, the site component needs to be removed first from the records in order for the source to be studied. In the case of hard-soil or rock sites, their response is sometimes considered negligible and thus this correction was omitted. This, however, may be a significant oversight given the variability in the response of hard sites, including sites often considered as reference stations

Any trial and error backprojection analysis that make use of different and variable in quality and frequency content records require very fast algorithm implementations. SIREN plan will lead towards an improved understanding of the earthquake rupture process especially at higher frequencies where critical large infrastructures are more sensitive.

Expected results & Research Project Impact

Fast and accurate images of the earthquake rupture process at high frequencies (HF) is of great importance for many scientific, industry and society stakeholders. In SIREN, we aim to develop a new software tool that will perform a very fast and robust determination of the HF spatio-temporal rupture process. Attached to a near-realtime earthquake seismic system it will provide a fast service.

Site effects at the recording stations have never been removed so-far in backprojection studies. Thus any spatio-temporal images of the source rupture area may have been blurred. The resolvability of the method will improve considerably allowing the use of even higher frequency bands (>10Hz) by removing the site effects before processing or selecting the appropriate reference data by accounting for κ values will improve .

The high frequency (HF) energy emitted during an earthquake rupture process is of great importance in seismic hazard assessment for certain critical infrastructures of the energy sector sensitive to those frequencies, e.g. concrete dams and the safe shut-down equipment of nuclear facilities. In practice, mapping accurately and timely the earthquake rupture using backprojections methods can have significant implications on seismic risk for these critical infrastructures that are located near active fault zones (eg. Japan nuclear plants).

The importance of this funding

SIREN project is a great opportunity to explore a novel emerging idea on the field of seismology.

Studying the high frequency (HF) energy emitted during an earthquake rupture process is of great importance in seismic hazard assessment for certain critical infrastructures of the energy sector sensitive to those frequencies.

H.F.R.I funding of SIREN research project provides the means and funds to perform novel research, develop new software and train postgraduate students in Greece in collaboration with well respected international research institutions.

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