Report of Transnational Access Projects

Project ID: C4-TA-542-1-2

Principal investigator:

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Project team (if applicable):

Josep de la Puente, Barcelona Supercomputing Center (BSC); Laurentiu Danciu, Swiss Seismological Service (SED), ETH Zürich; Scott Callaghan, SCEC/USC.

Project title:

Physics-Based Probabilistic Seismic Hazard and Risk Assessment for Istanbul Integrating OpenQuake and CyberShake Using Rupture, Exposure, and Vulnerability Data from the European ESHM20 Model.

Project acronym:

QUAKERISK-EU

Hosting installation:

EF-PSHA – Probabilistic Seismic Hazard Analysis (TA2-542-1), Swiss Seismological Service (SED), ETH Zürich – combined with computational access to MareNostrum 5, Barcelona Supercomputing Center (BSC).

Hosting team:

Laurentiu Danciu, ETH Zürich (SED).

Period of access:

Two in-person weeks at ETH Zürich (Week 1: 18/01/2026 to 24/01/2026; Week 2: 07/06/2026 to 13/06/2026), complemented by remote meetings with the host.

Report of activities:

The QUAKERISK-EU project adapted CyberShake, a physics-based probabilistic seismic hazard platform originally developed for California, for application in Europe, using Istanbul as a pilot city. This is the first physics-based seismic hazard pipeline developed for a European urban center, carried out through a collaboration between BSC, ETH Zürich (SED), and SCEC/USC. The core activity of the access was translating the probabilistic source model of the European Seismic Hazard Model 2020 (ESHM20) into a CyberShake-compatible Earthquake Rupture Forecast (ERF) via OpenQuake. This involved generating a first Istanbul ERF spanning Mw 6–8 with 83,823 ruptures (see Figure 1); the full event-based PSHA run, producing approximately 2.9 million events, is planned for the coming months. A key result was demonstrating that hazard curves converge at a Stochastic Event Set (SES) size of 10,000–50,000 realizations (see Figure 2), and

that the ERF was successfully converted into CyberShake-compatible format, bridging the European probabilistic hazard model with the physics-based simulation framework.

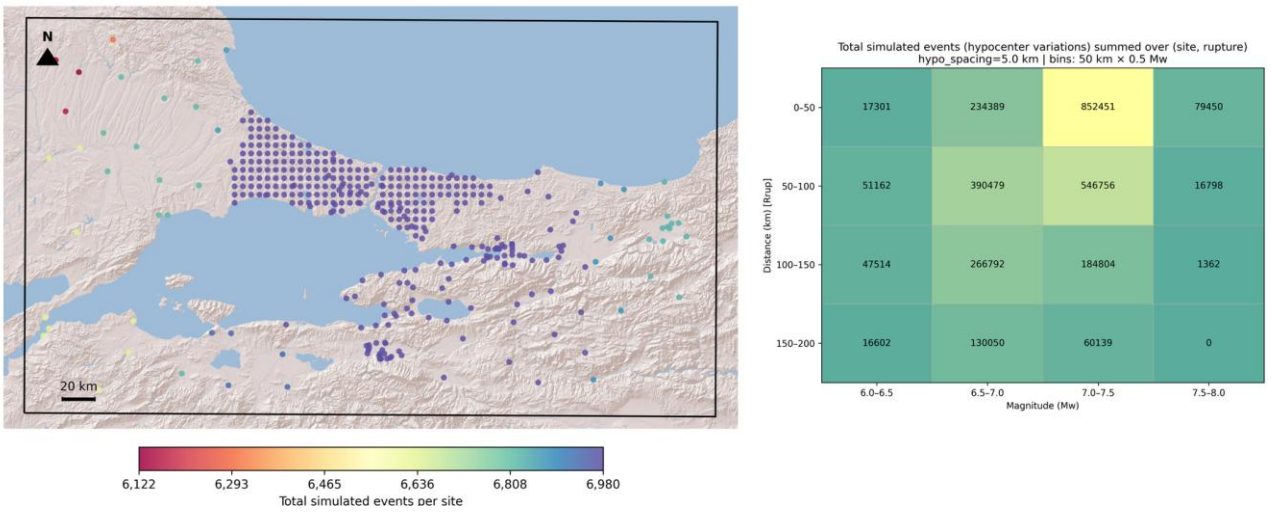

Figure 1. Dataset: Istanbul ERF (Mw 6–7.5, 83,823 ruptures) + ~2.9M simulated events that will be uploaded to SDL once simulations are completed.

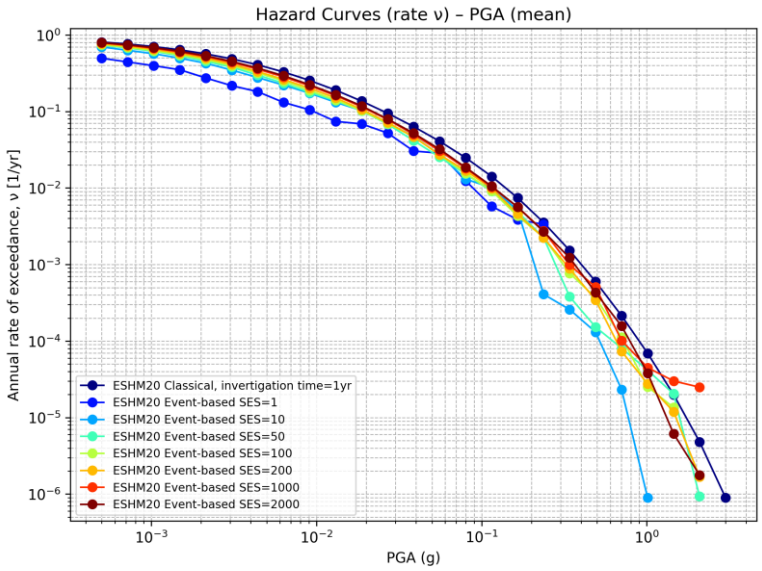

Figure 2. ERF convergence. Sufficient event sampling is essential to ensure statistical stability before transferring ruptures into CyberShake.

In parallel, work was carried out on the physics-based simulation side using AWP-ODC on MareNostrum 5 (BSC) GPU partitions: debugging source parameterization, velocity model file handling, attenuation (Q) parameters, and boundary-reflection artifacts. This included building and validating 1D seismic velocity models (combining Pulido et al. 2009 with a continuous gradient background from a 3D velocity model). Enabling these simulations has also required substantial software development: a dedicated BSC branch of

CyberShake, adapted to run on MareNostrum 5 and applicable to regions beyond California, plus a new workflow, ShakeFlow, connecting all CyberShake components and scheduling GPU/CPU tasks on MareNostrum 5. Both are maintained in BSC GitLab repositories (see Figure 3) and will be made fully public once tested and validated, expected in the coming months.

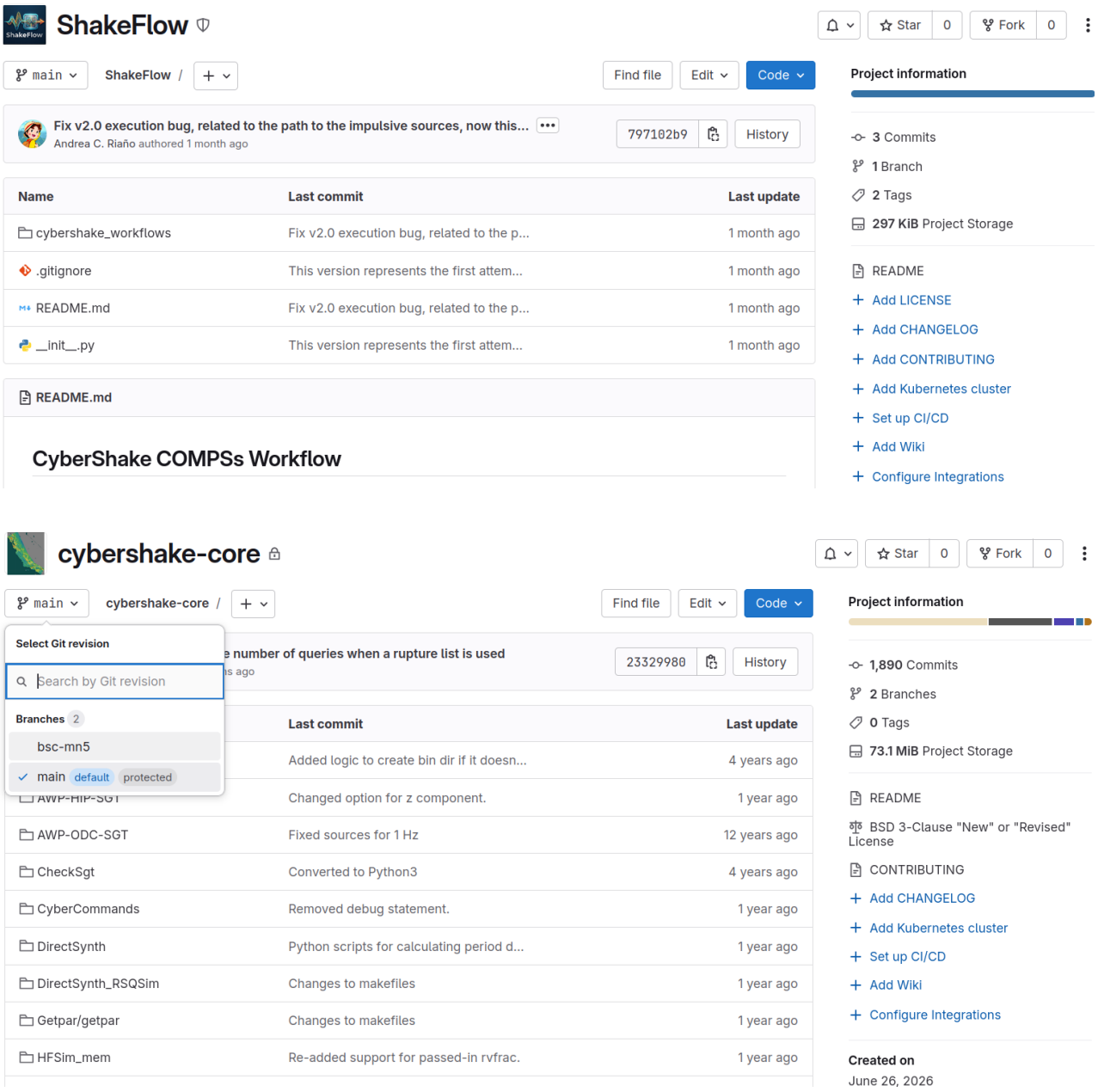

Figure 3. ShakeFlow and CyberShake repository snapshots. Currently private; to be made publicly available upon completion and validation of the full implementation.

The computational access (WP5) combined MareNostrum 5 HPC runs at BSC with ETH Zürich's expertise, the two environments needed for this hybrid OpenQuake–CyberShake workflow. Much of the project remains under active development: rather than building on an already-available software stack, the workflow, tools, and input datasets have had to be developed and validated from the ground up, and completing production simulations depends on this development finishing. Results to date are therefore those presented at conferences and workshops (EPOS Seismology 2025, EGU 2026, Messina 2026, Geo-INQUIRE Final Annual

Geo-INQUIRE is funded by the European Commission under project number 101058518 within the HORIZON-INFRA-2021-SERV-01 call

Meeting, Potsdam); as production runs become available they will be uploaded progressively to the Simulation Data Lake, and the code repositories made public. Four publications are planned and already structured, with the first in preparation and submission expected around October 2026.

Project outcomes:

QUAKERISK-EU is a long-term project: several outcomes below remain under active development beyond the end of this TA period and will be made publicly available progressively as each component is completed and validated.

Outcome	Details	Weblink / Status
Data & software	Istanbul Earthquake Rupture Forecast (Mw 6–8, 83,823 ruptures) and ~2.9M simulated events, to be openly contributed to the Geo-INQUIRE Simulation Data Lake (VA product). Workflow code: ShakeFlow repository. Cybershake: BSC branch repository.	*In development, currently private on BSC GitLab; will be made public and deposited in the Geo-INQUIRE Simulation Data Lake once testing and validation are complete.*
Publications	Four publications are envisaged from this project. Work is currently underway on the first, a CyberShake workflow development paper covering California and Istanbul/Turkey test cases, with an Istanbul PSHA application paper and two further publications planned to follow.	*First manuscript in preparation, submission expected around October 2026; weblinks will be added upon submission/acceptance for this and the three remaining planned publications.*
Presentations & events	QUAKERISK-EU has been presented at EPOS Seismology 2025, EGU 2026, From Data to Hazard Modelling (Hackathon), Earthquake and Tsunami Cascades", Messina, 2026, and the Geo-INQUIRE Final Annual Meeting (16–18 June 2026, Potsdam, "QUAKERISK-EU / EF-PSHA").	*Completed; weblinks to events and abstracts (if available) are listed below.*

EPOS Seismology 2025
https://www.geo-inquire.eu/dissemination/workshops/epos-seismology-and-geo-inquire-workshop-2025
Program and presentations:
https://polybox.ethz.ch/index.php/s/zcJDTrTqyfHBYER?dir=/presentations&editing=false&openfile=true

EGU2026
https://www.egu26.eu/
https://meetingorganizer.copernicus.org/EGU26/EGU26-540.html
Cite: Riaño Escandon, A. C., de la Puente, J., Danciu, L., and Callaghan, S.: Adapting CyberShake for Europe using OpenQuake-Derived Earthquake Rupture Forecasts, EGU General Assembly 2026, Vienna, Austria, 3–8 May 2026, EGU26-540, https://doi.org/10.5194/egusphere-egu26-540, 2026.

From Data to Hazard Modelling (hackathon) + Earthquake and Tsunami Cascades, Messina 2026
https://www.geo-inquire.eu/dissemination/workshops/hazard-modelling
Program: https://docs.google.com/spreadsheets/d/1eWI-PoNHuoUH8FbxqsBbCi7e4Y7i1ZAjBYuuRiH9svo/edit?gid=0#gid=0

Presentation: https://drive.google.com/drive/folders/1ZwbnSE8stvuu6s_m5unSBxtwimEUXRo3

Geo-INQUIRE Final Annual Meeting (16–18 June 2026), Potsdam:
https://www.geo-inquire.eu/communication/news/details/geo-inquire-final-annual-meeting-2026
Presentation:https://docs.google.com/presentation/d/1SygfuGN2MPsfozs_P-4GOCeEsFew-a026L9gCZyuf20/edit?slide=id.p1#slide=id.p1