

15 Years of the OpenQuake Engine

From Earthquake Models to Risk-Informed Policy and Investment Decisions

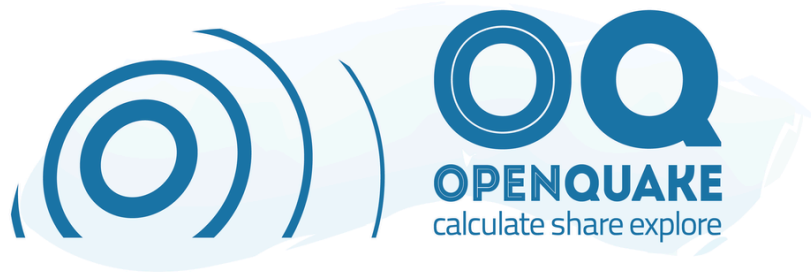
Anirudh Rao, GEM Foundation

13th October 2025

2025 IDDRR calls to action and target stakeholders

Calls to action

- Increase funding for DRR
- Ensure risk-informed decision making



Target stakeholders

- National governments
- Private sector leaders
- Multilateral development agencies
- Civil society and academia



INTERNATIONAL DAY FOR
**DISASTER RISK
REDUCTION**

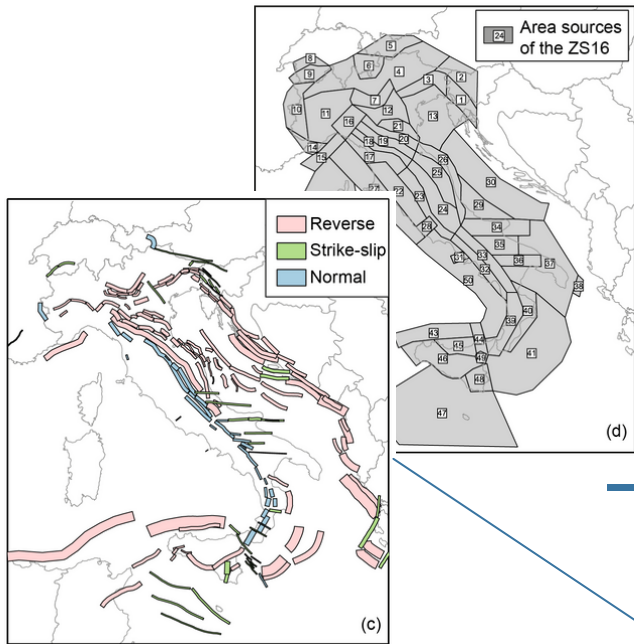
**Fund resilience,
not disasters**

#ResiliencePays

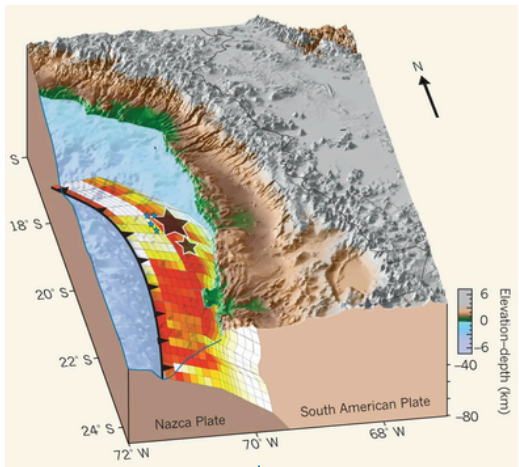
#DRRday

What is the OpenQuake Engine?

Seismic source
characterization

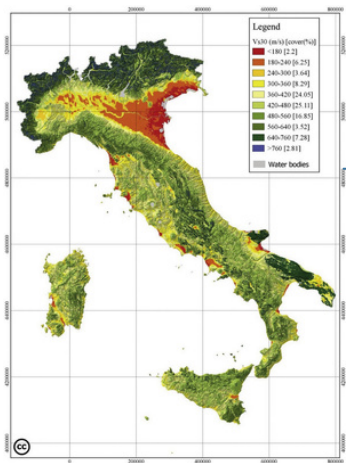


Earthquake
rupture model



— or —

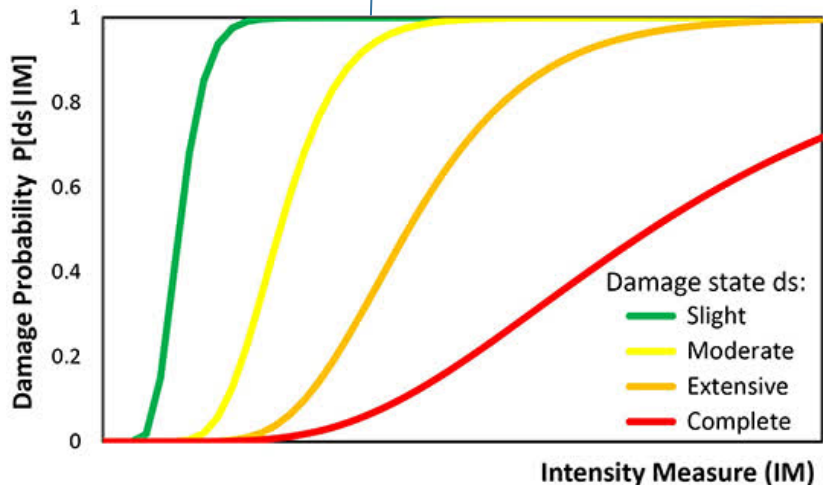
Site model



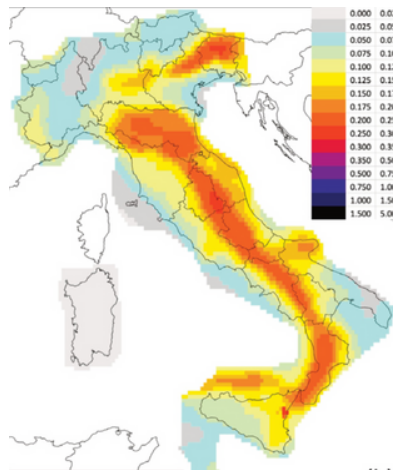
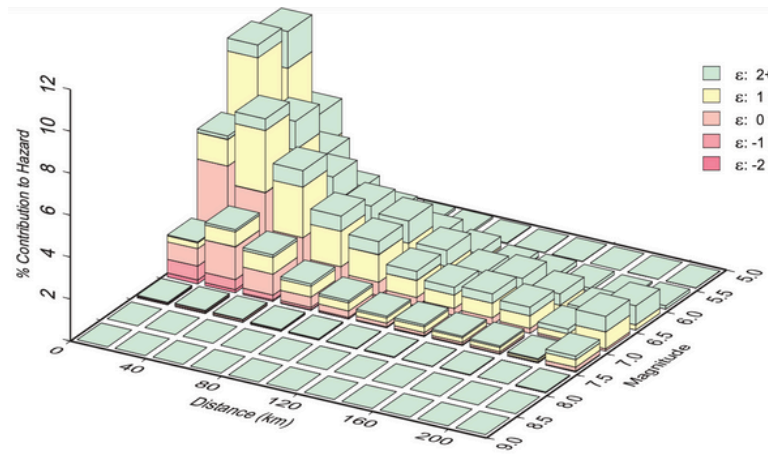
Exposure model



Fragility or
vulnerability
model

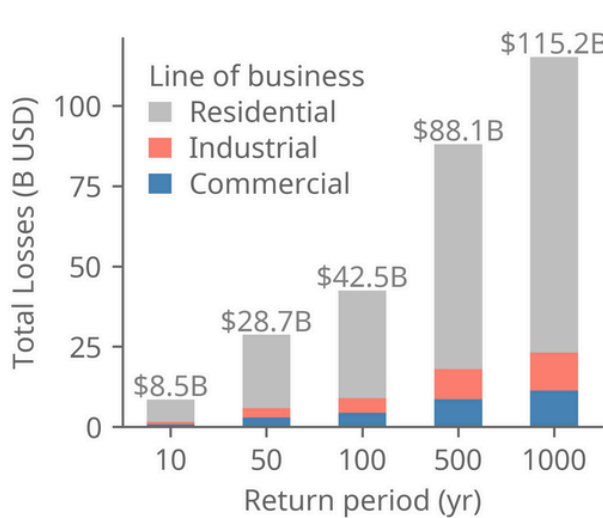


Seismic hazard curves Uniform hazard spectra

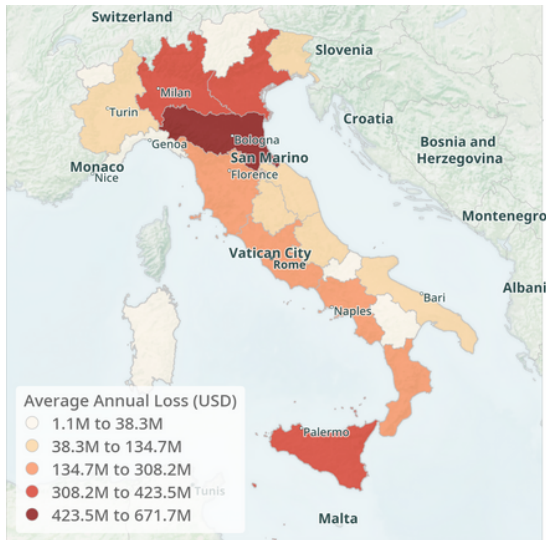


Hazard disaggregation

Hazard maps

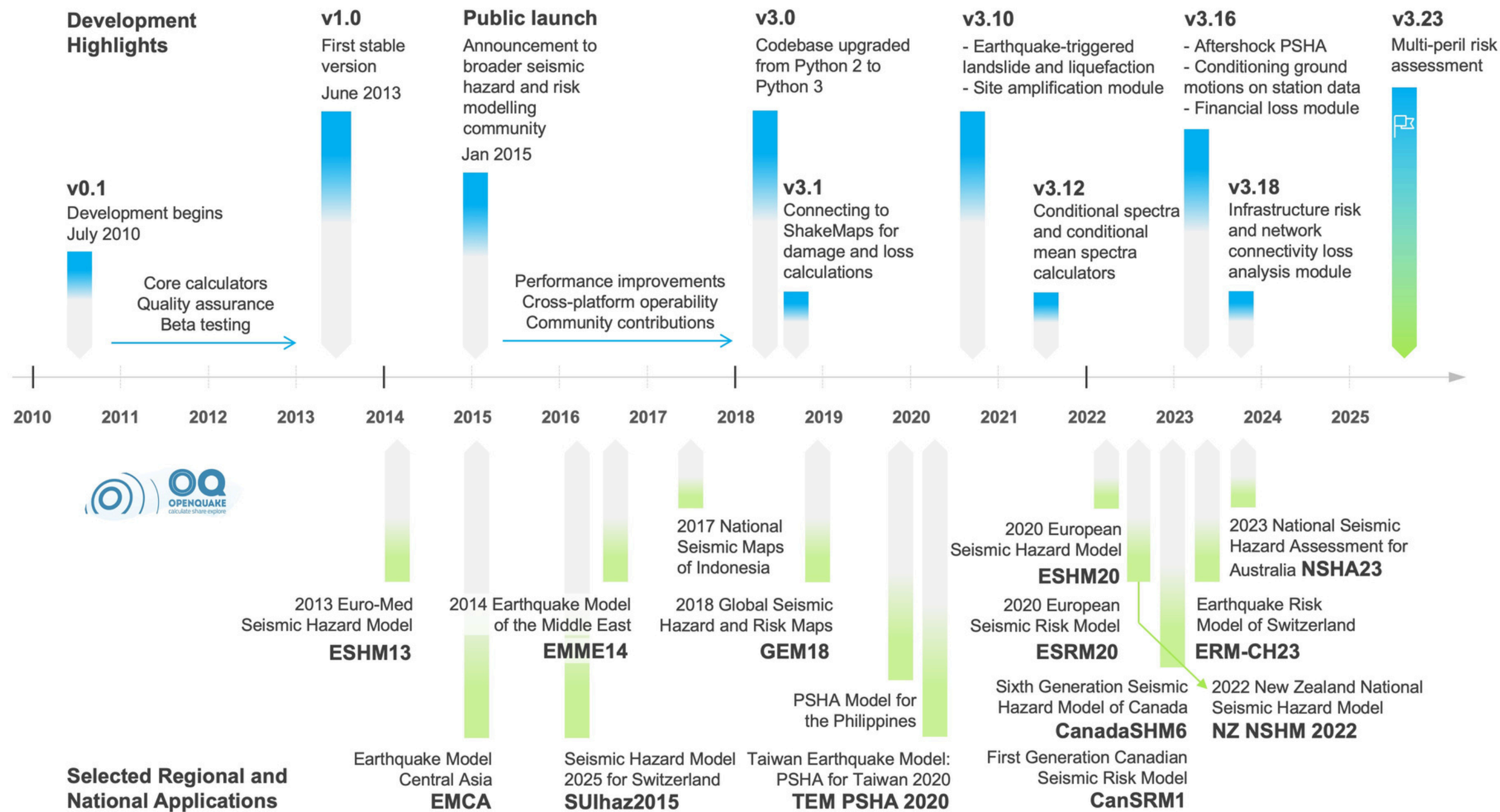


Probable maximum
losses

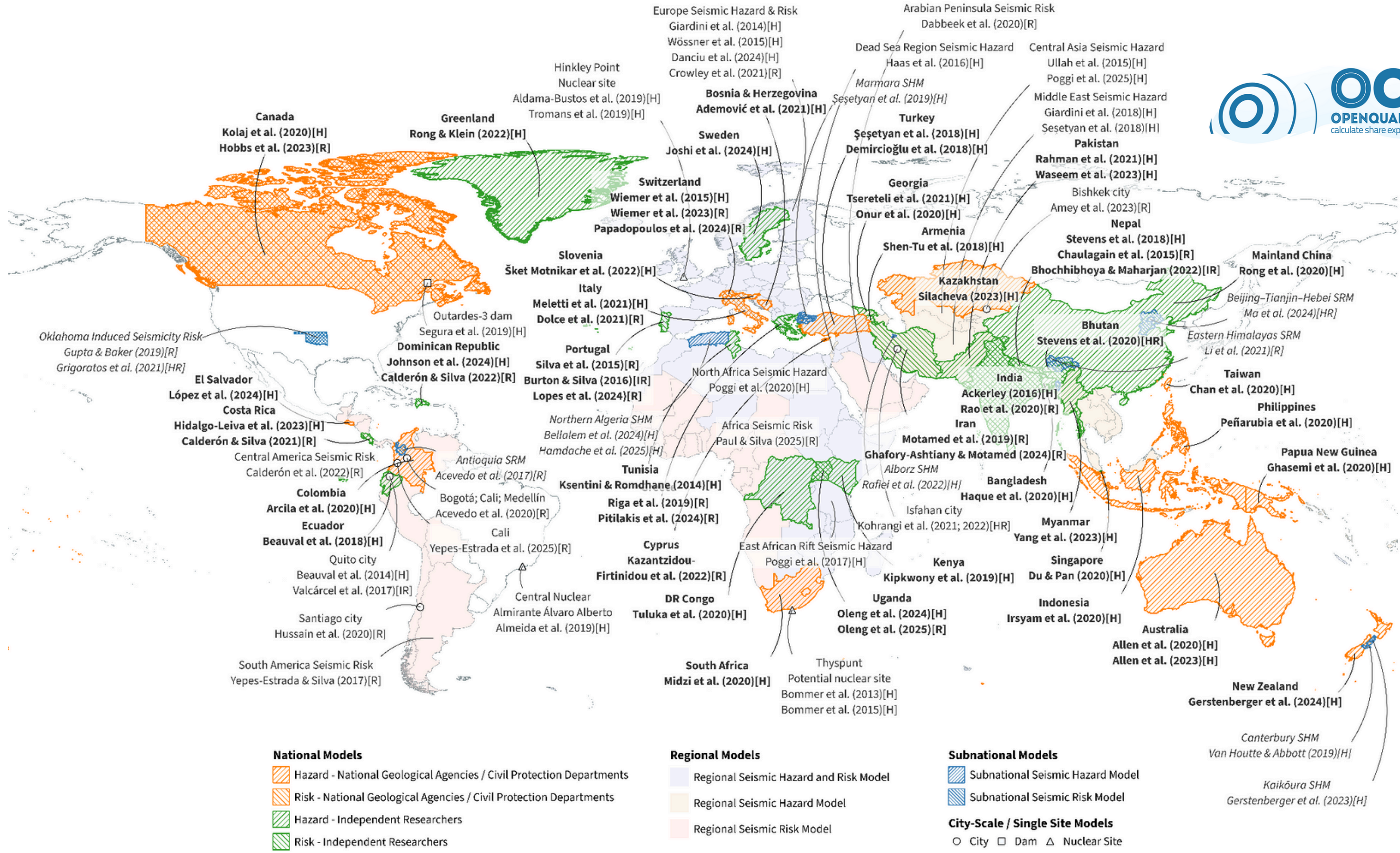


Average annual
losses

Evolution of the OpenQuake Engine

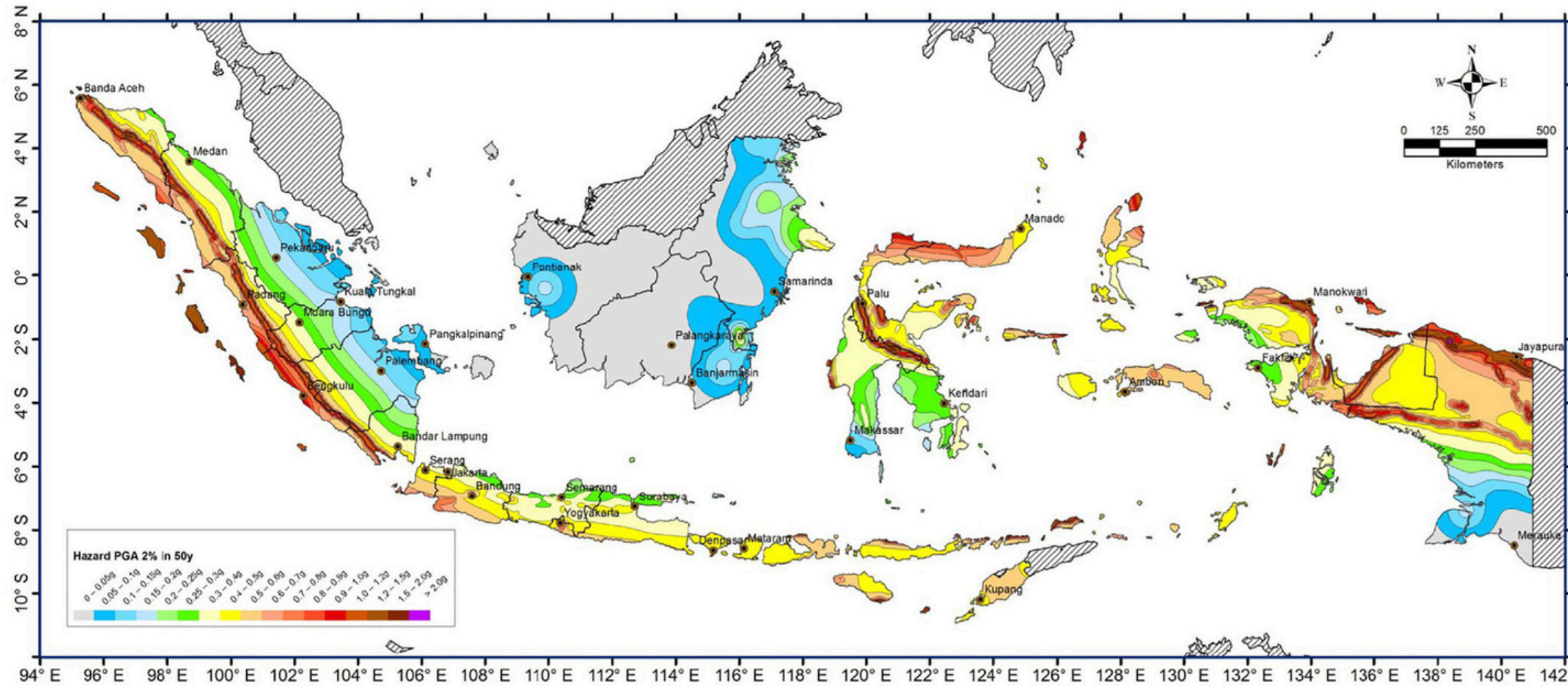


Global adoption of the OpenQuake Engine



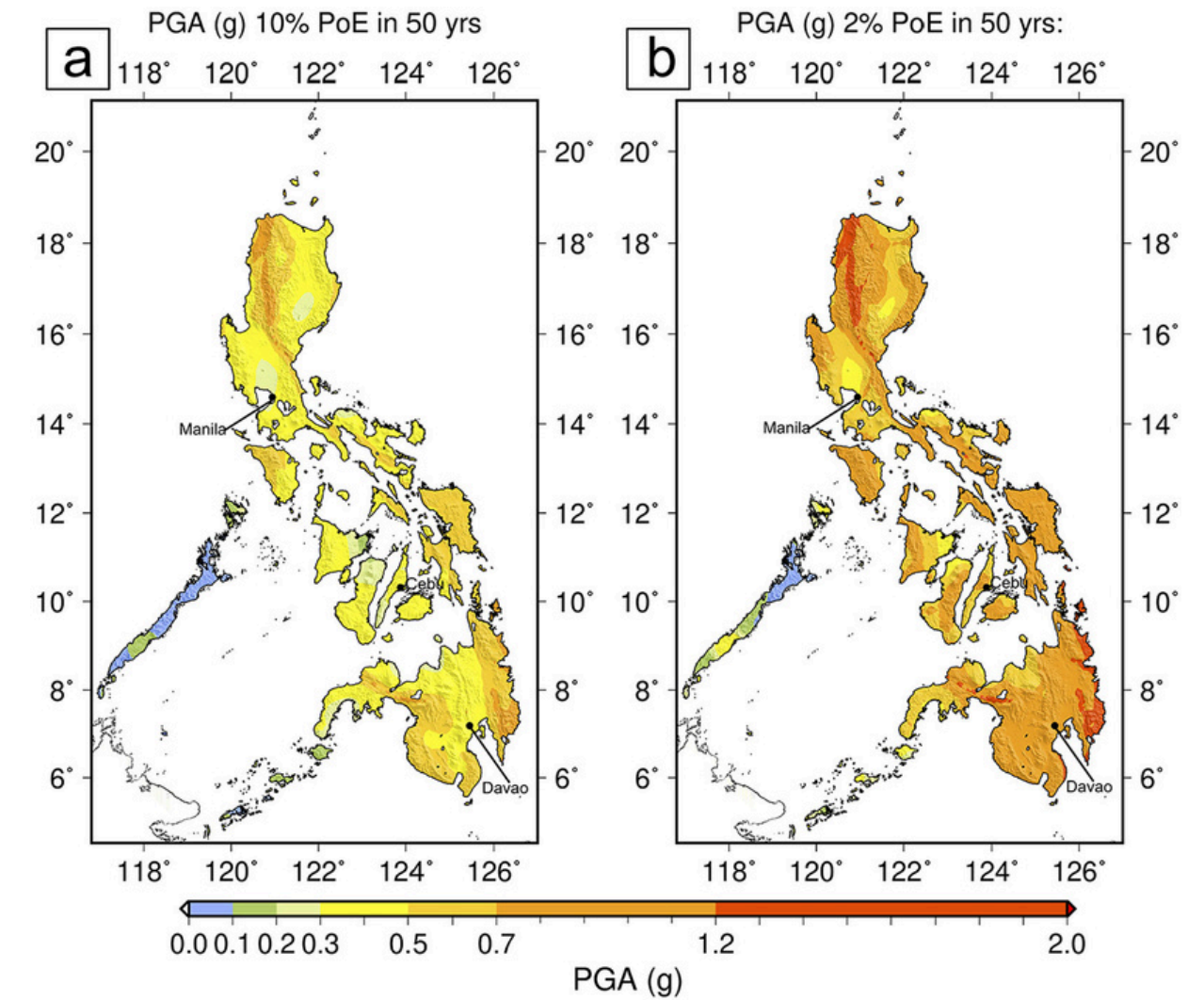
National seismic hazard maps

Indonesia



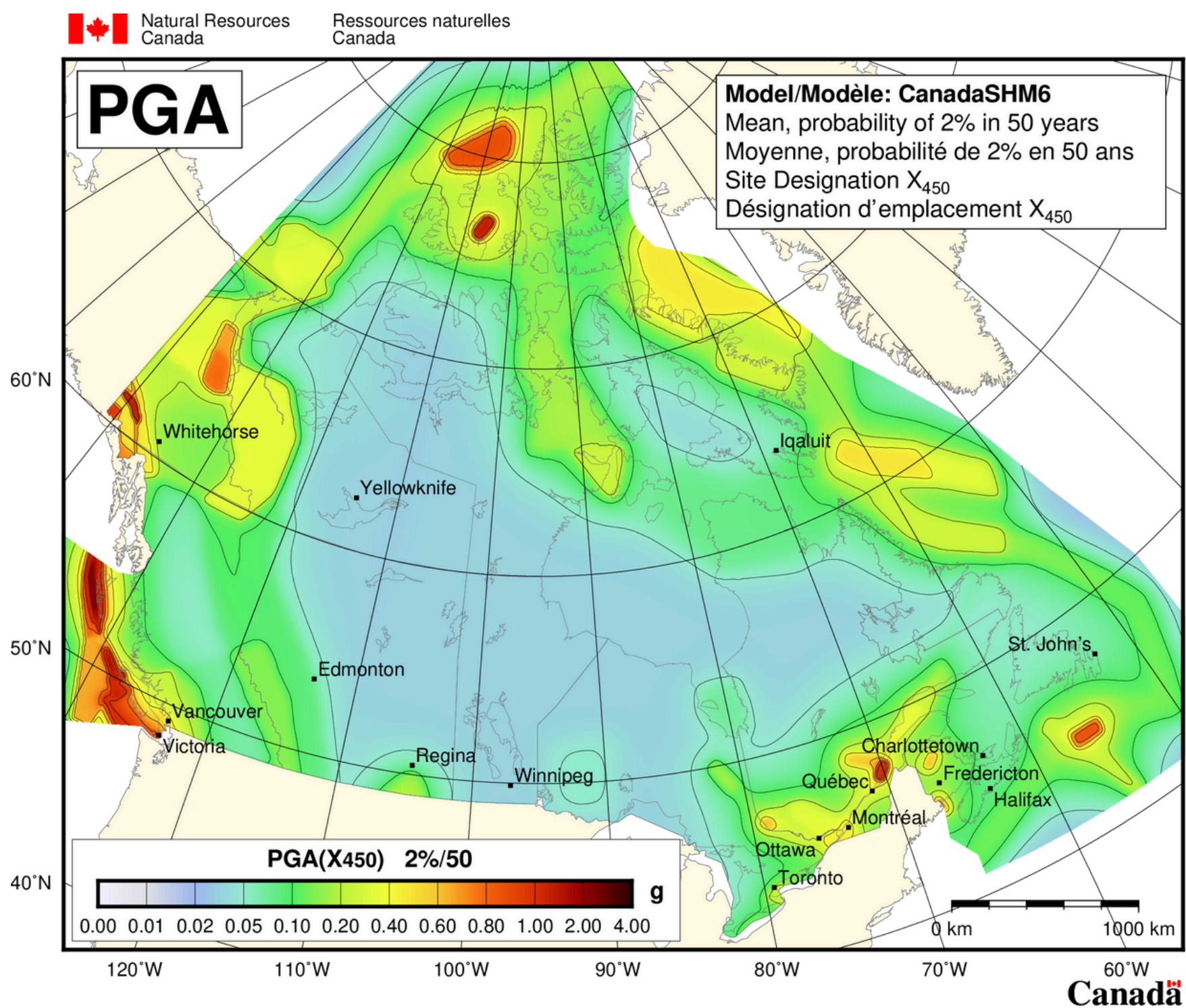
Irsyam et al. (2020). Development of the 2017 national seismic hazard maps of Indonesia. *Earthquake Spectra*, 36(1_suppl), 112–136. <https://doi.org/10.1177/8755293020951206>

Philippines



Peñarubia et al. (2020). Probabilistic seismic hazard analysis model for the Philippines. *Earthquake Spectra*, 36(1_suppl), 44–68. <https://doi.org/10.1177/8755293019900521>

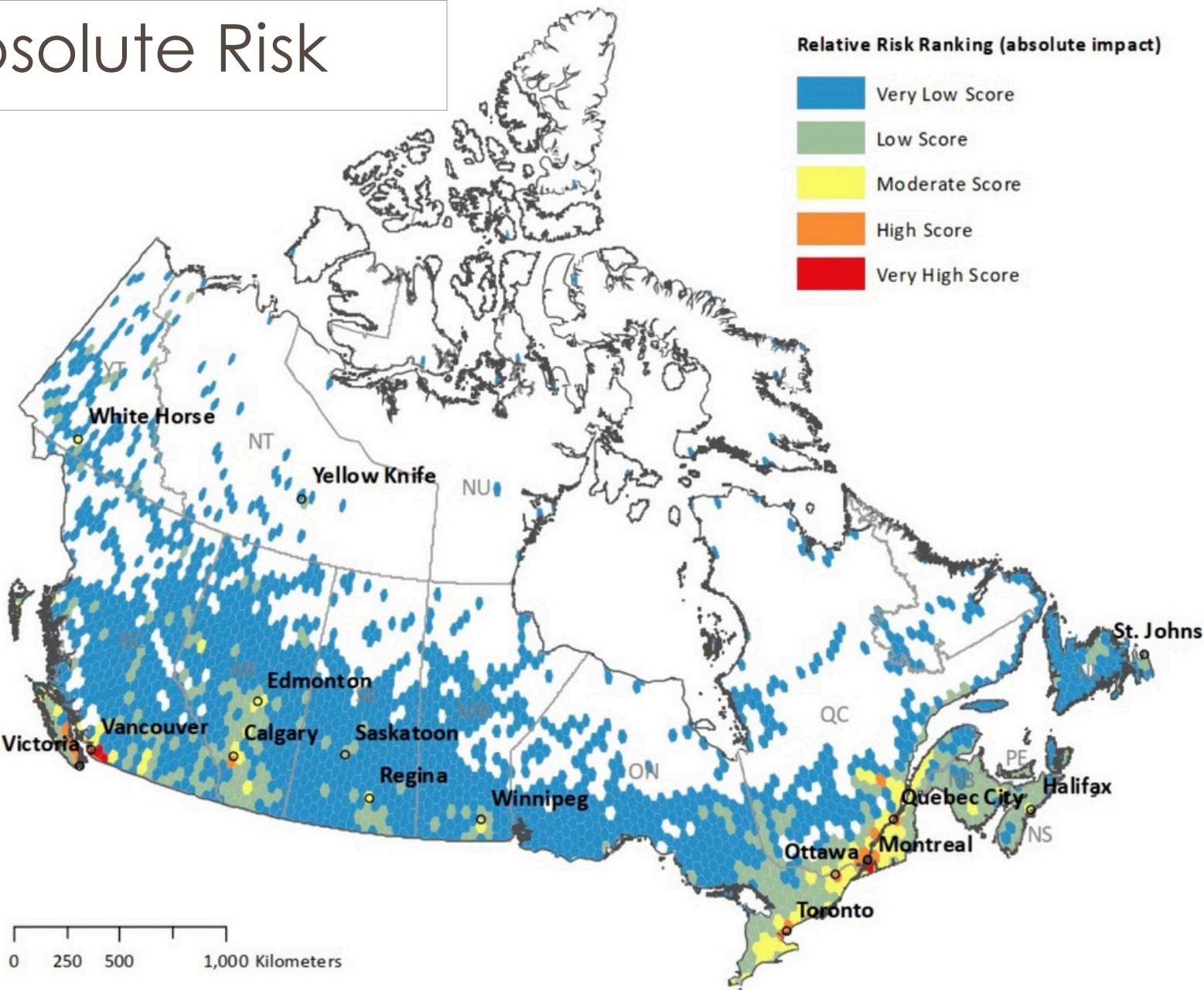
National seismic risk maps



Kolaj, M., Halchuk, S. C. & Adams, J. (2023). Sixth-generation seismic hazard model of Canada: grid values of mean hazard to be used with the 2020 National Building Code of Canada. version 1.0, Geological Survey of Canada, Open File, 8950. <https://doi.org/10.4095/331497>

Canada

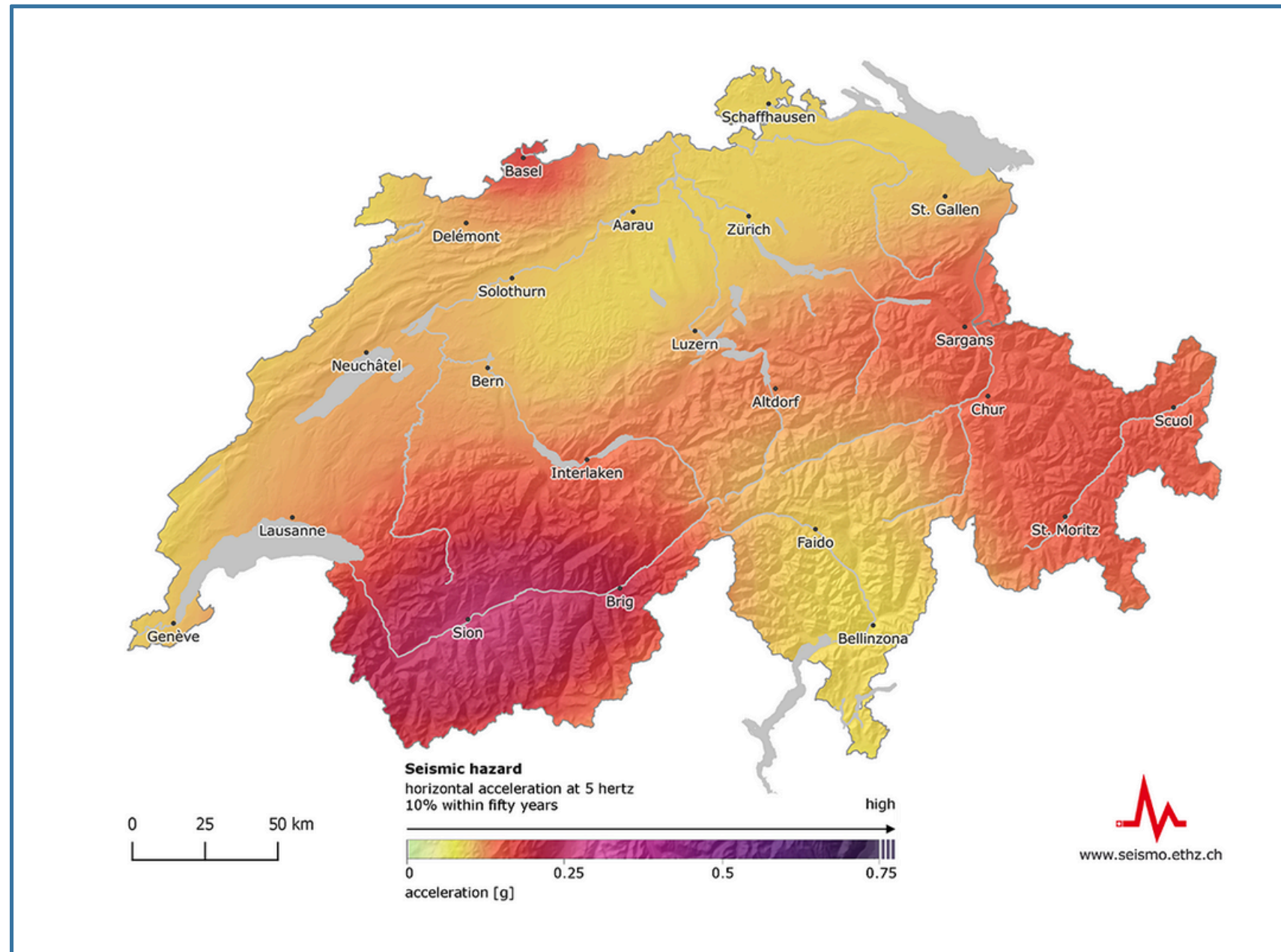
Absolute Risk



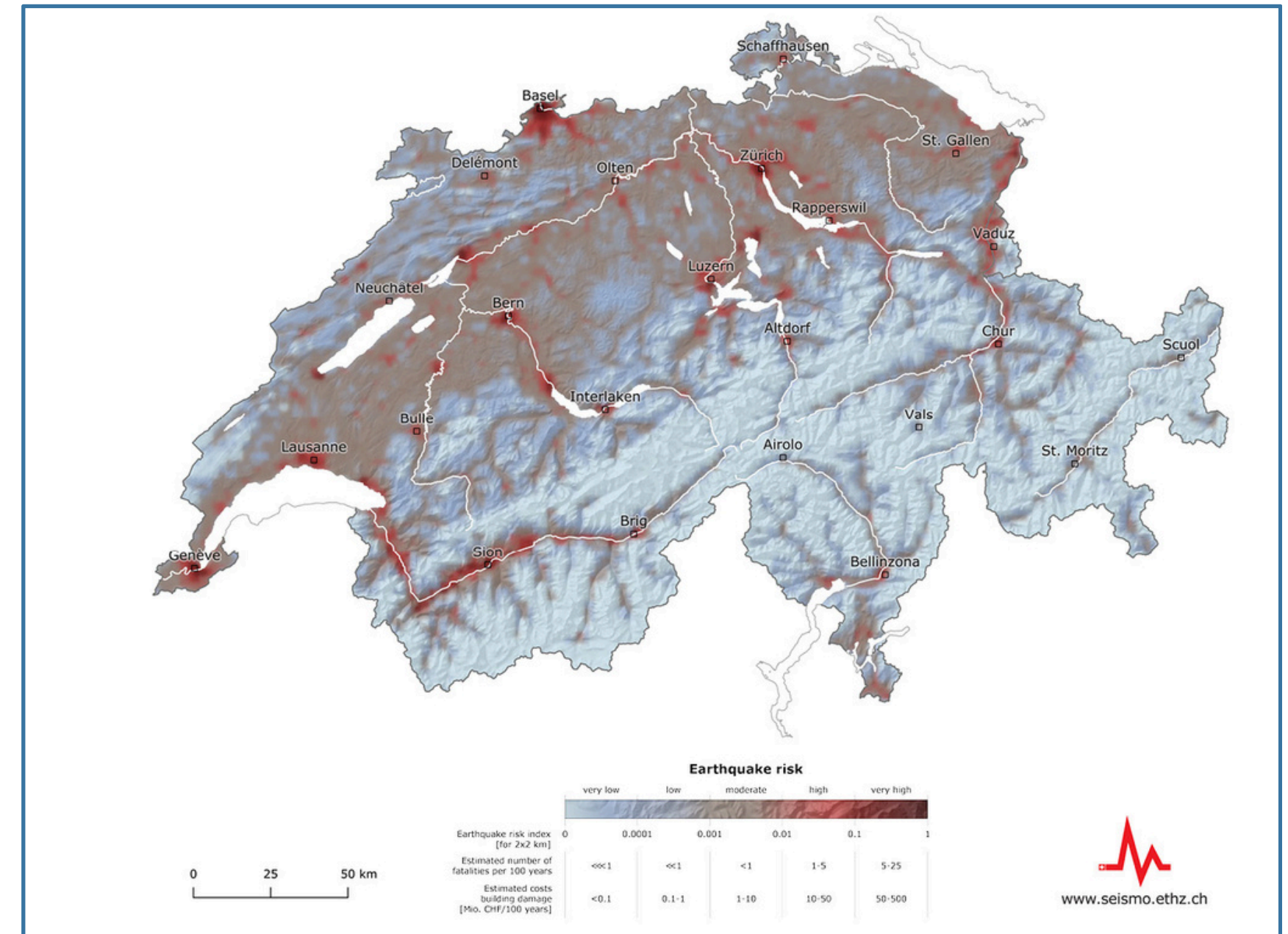
Hobbs T. E., Journeay J. M., Rao A. S. , et al. (2023). A national seismic risk model for Canada: Methodology and scientific basis. Earthquake Spectra. 39(3):1410-1434. <https://doi.org/10.1177/87552930231173446>

National seismic risk maps

Switzerland



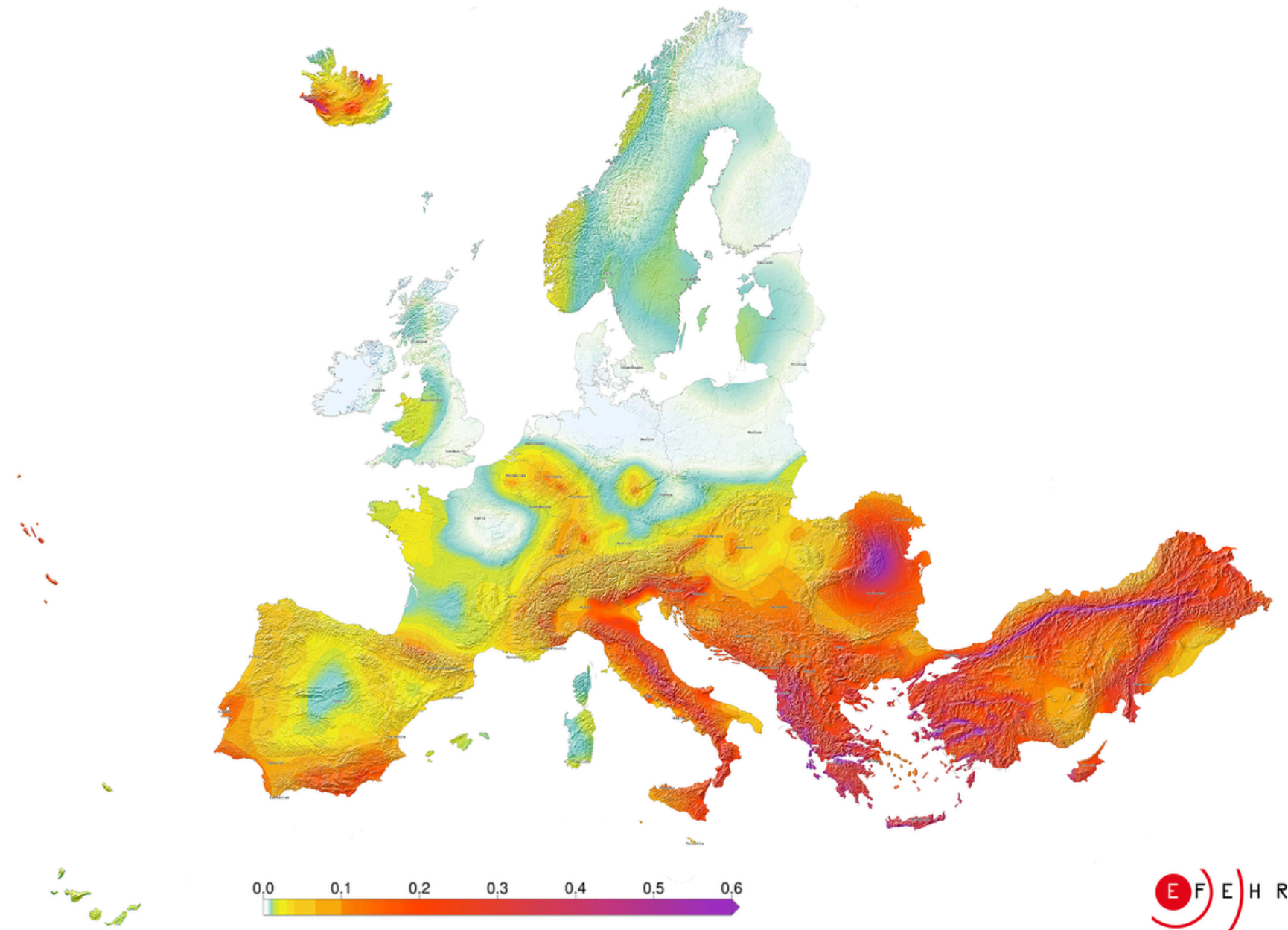
Wiemer, S., Danciu, L., et al. (2016). Seismic Hazard Model 2015 for Switzerland (SUIhaz2015), ETH Zurich. <https://doi.org/10.12686/a2>,



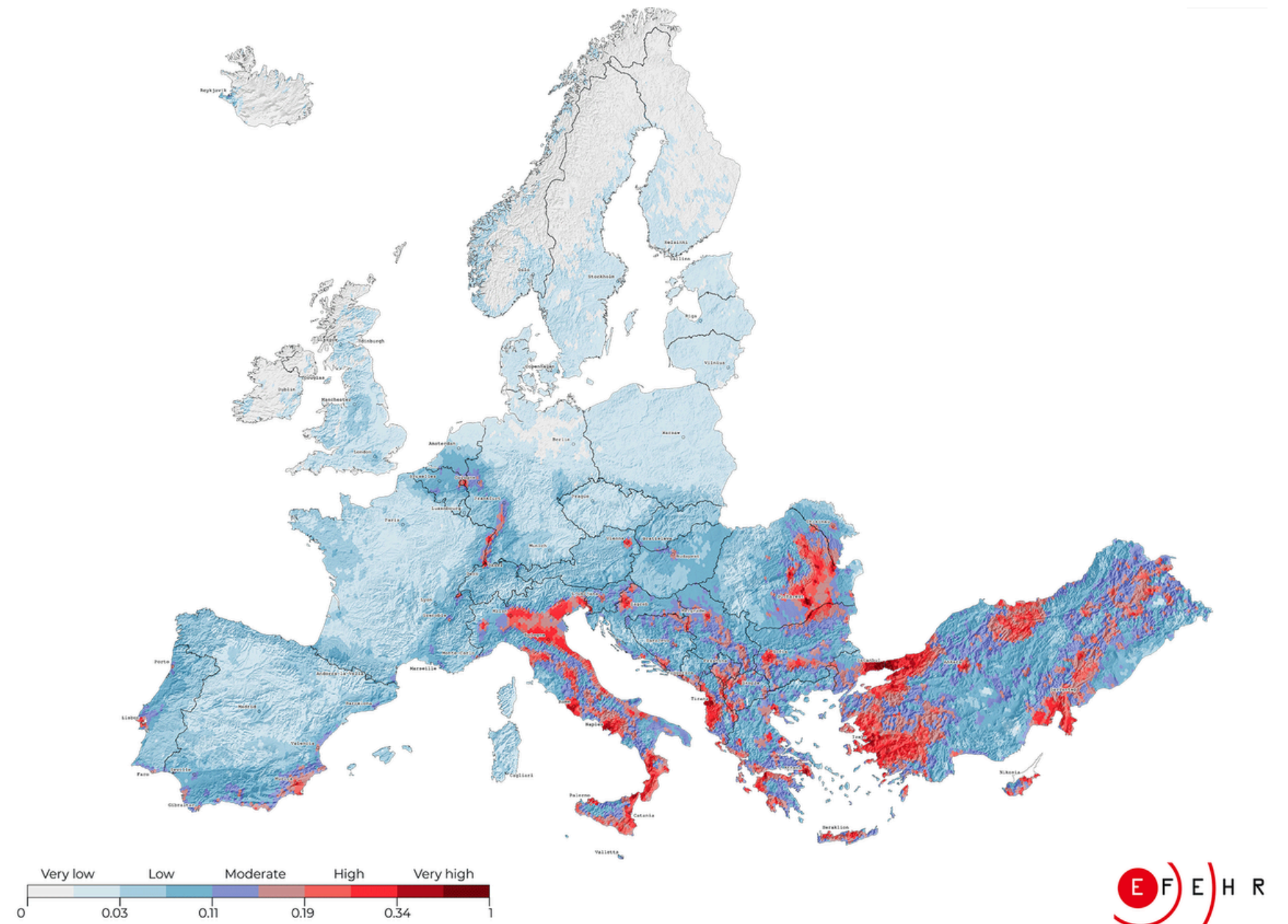
Wiemer, S., Papadopoulos, A., et al. (2023). Earthquake Risk Model of Switzerland (ERM-CH23), Swiss Seismological Service, ETH Zurich. <https://doi.org/10.12686/a20>.

Regional seismic hazard and risk maps

Europe

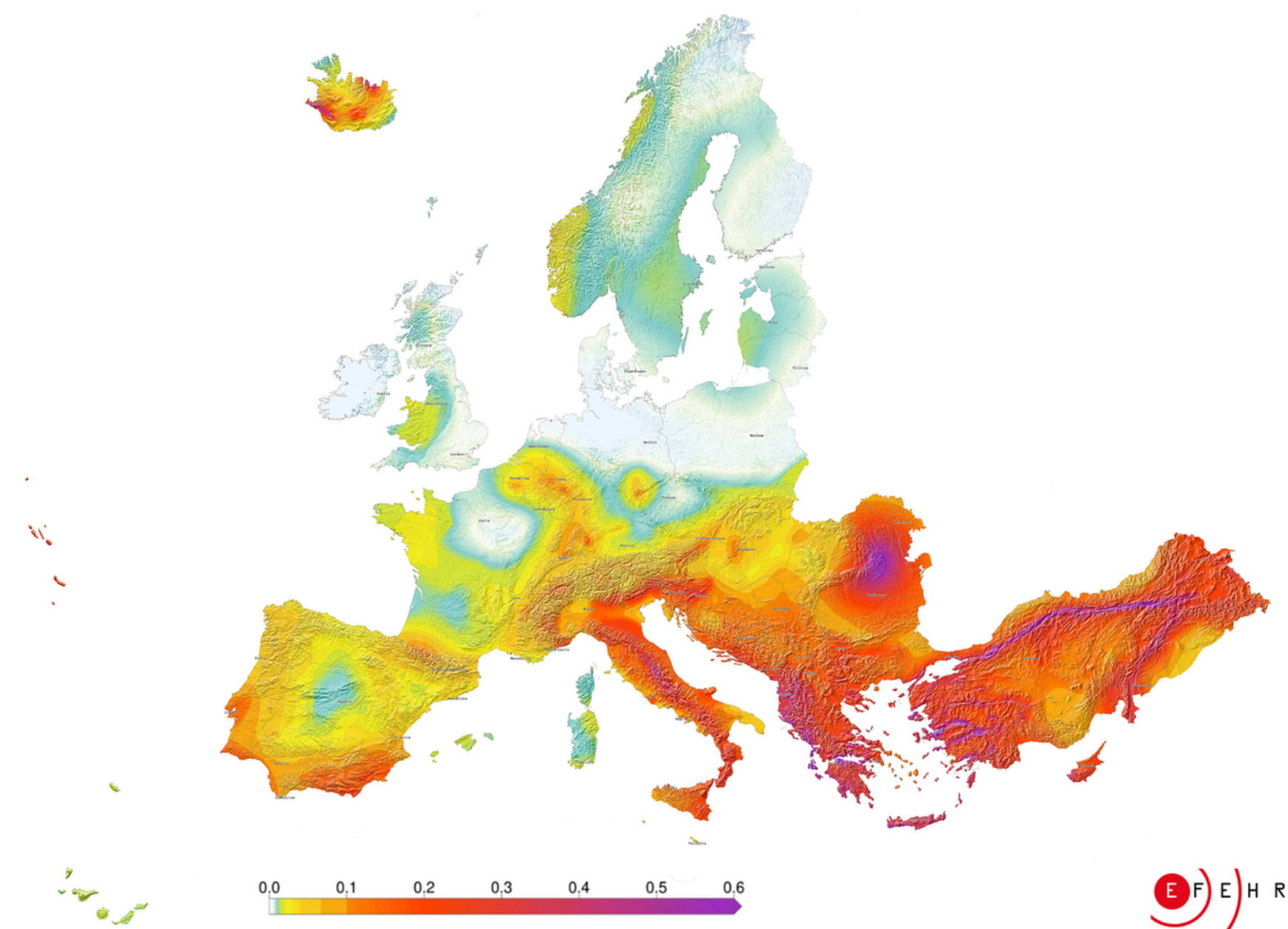


Danciu L., Nandan S., Reyes C., Basili R., Weatherill G., Beauval C., Rovida A., Vilanova S., Sesetyan K., Bard P-Y., Cotton F., Wiemer S., Giardini D. (2021) - The 2020 update of the European Seismic Hazard Model: Model Overview. EFEHR Technical Report 001, v1.0.0, <https://doi.org/10.12686/a15>

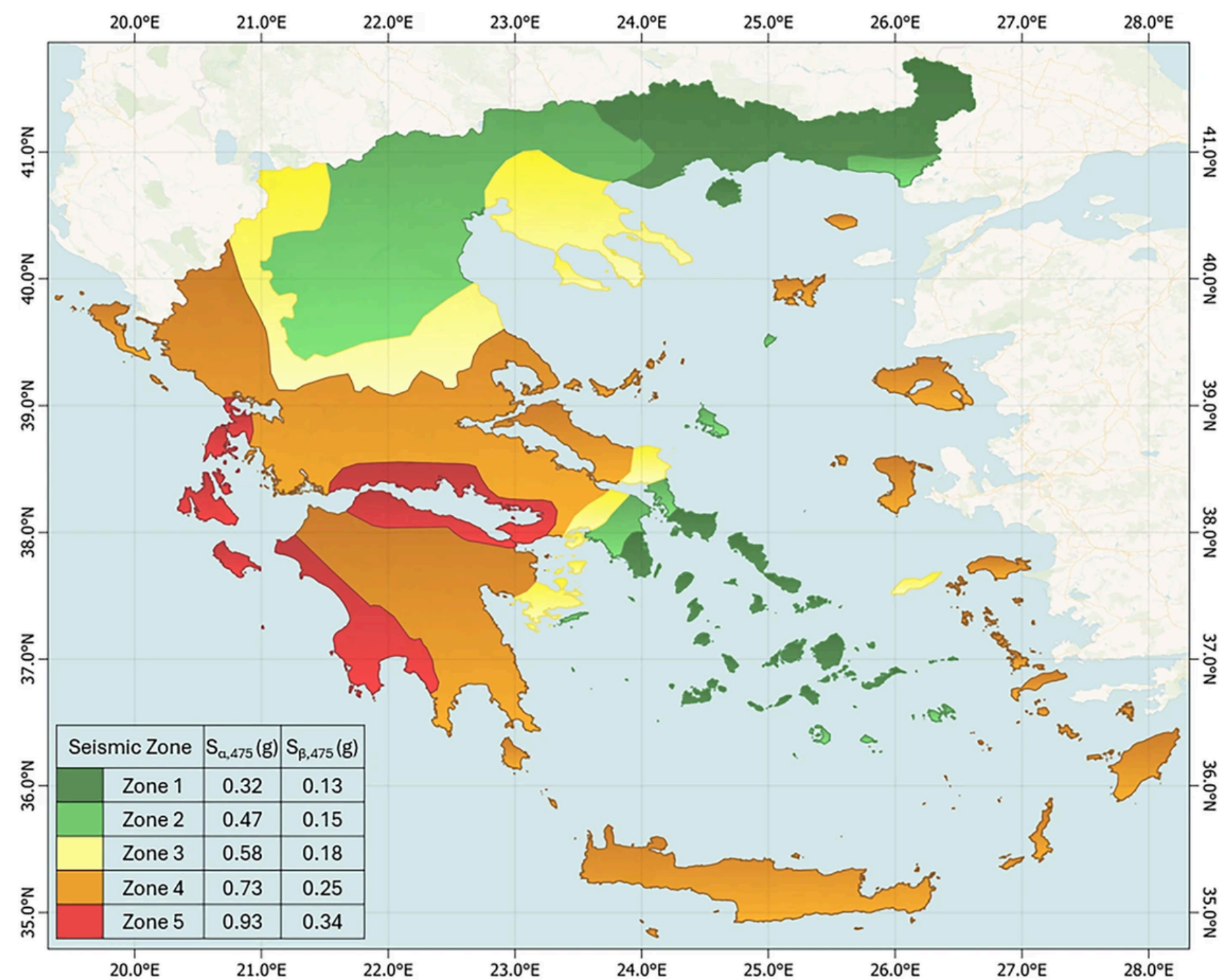


Crowley H., Dabbeek J., Despotaki V., Rodrigues D., Martins L., Silva V., Romão X., Pereira N., Weatherill G., Danciu L. (2021): European Seismic Risk Model (ESRM20), EFEHR Technical Report 002, V1.0.1, 84 pp, <https://doi.org/10.7414/EUC-EFEHR-TR002-ESRM20>

Seismic zone maps for building design codes

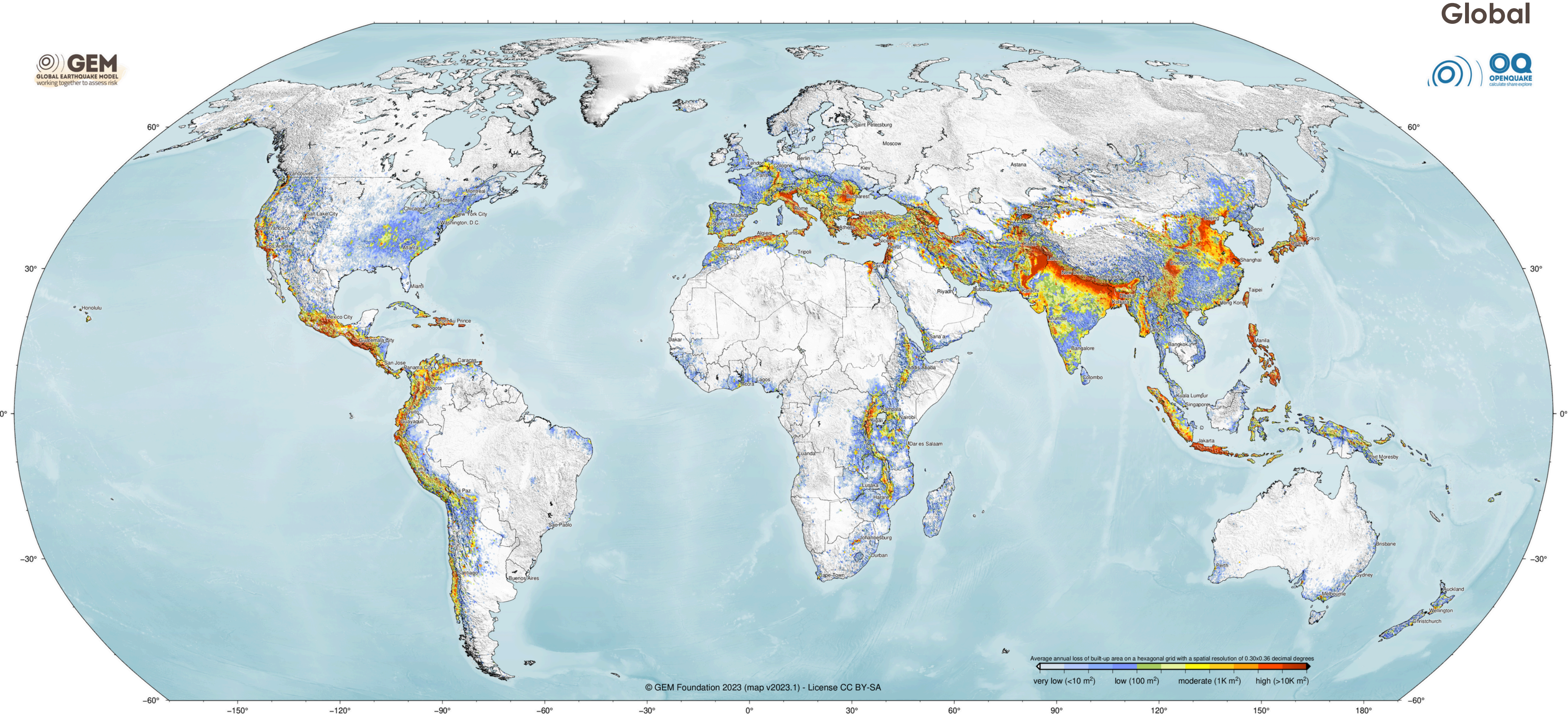


Danciu L., Nandan S., Reyes C., Basili R., Weatherill G., Beauval C., Rovida A., Vilanova S., Sesetyan K., Bard P-Y., Cotton F., Wiemer S., Giardini D. (2021) - The 2020 update of the European Seismic Hazard Model: Model Overview. EFEHR Technical Report 001, v1.0.0, <https://doi.org/10.12686/a15>

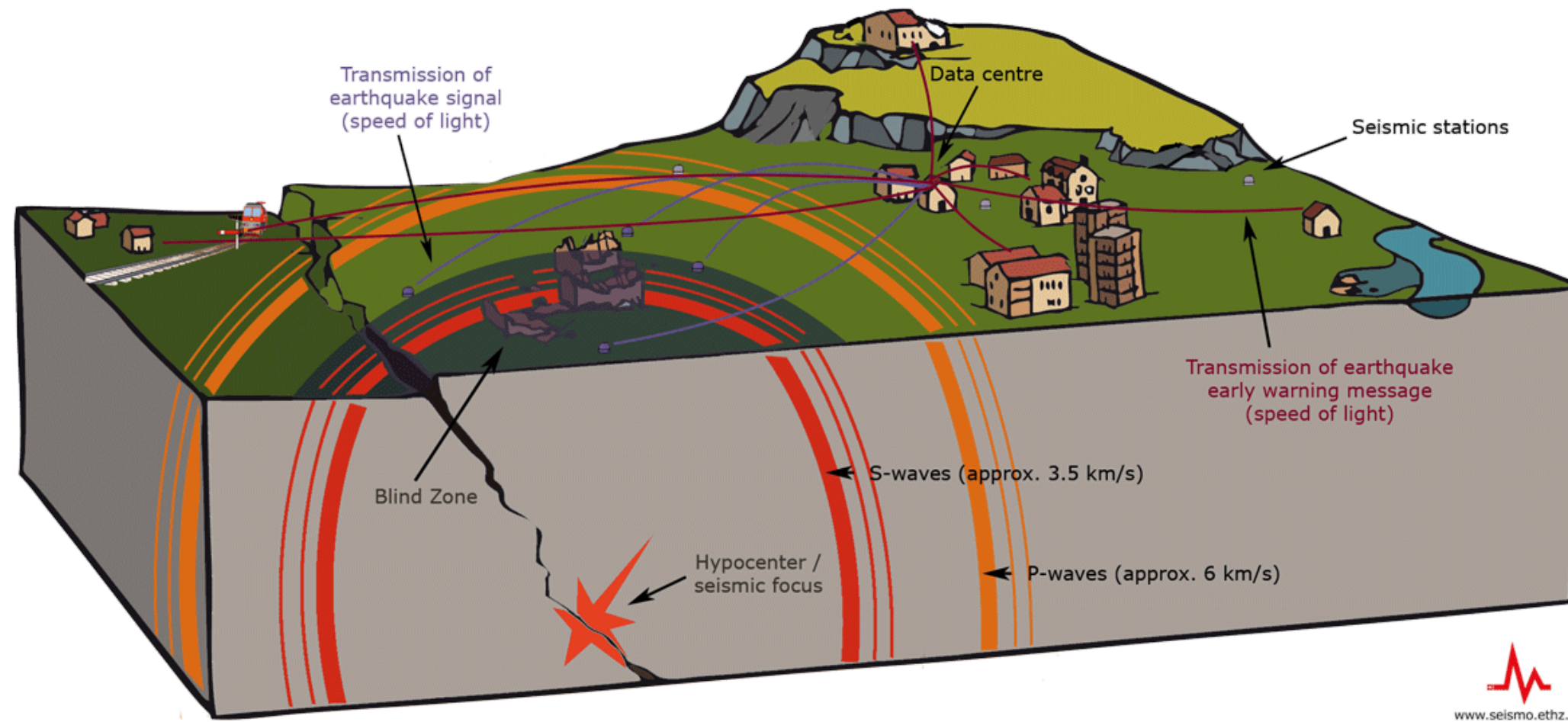


Pitilakis, K. D., Riga, E., Apostolaki, S., & Danciu, L. (2024). Seismic hazard zonation map and definition of seismic actions for Greece in the context of the ongoing revision of EC8. *Bulletin of Earthquake Engineering*, 22(8), 3753–3792. <https://doi.org/10.1007/s10518-024-01919-8>

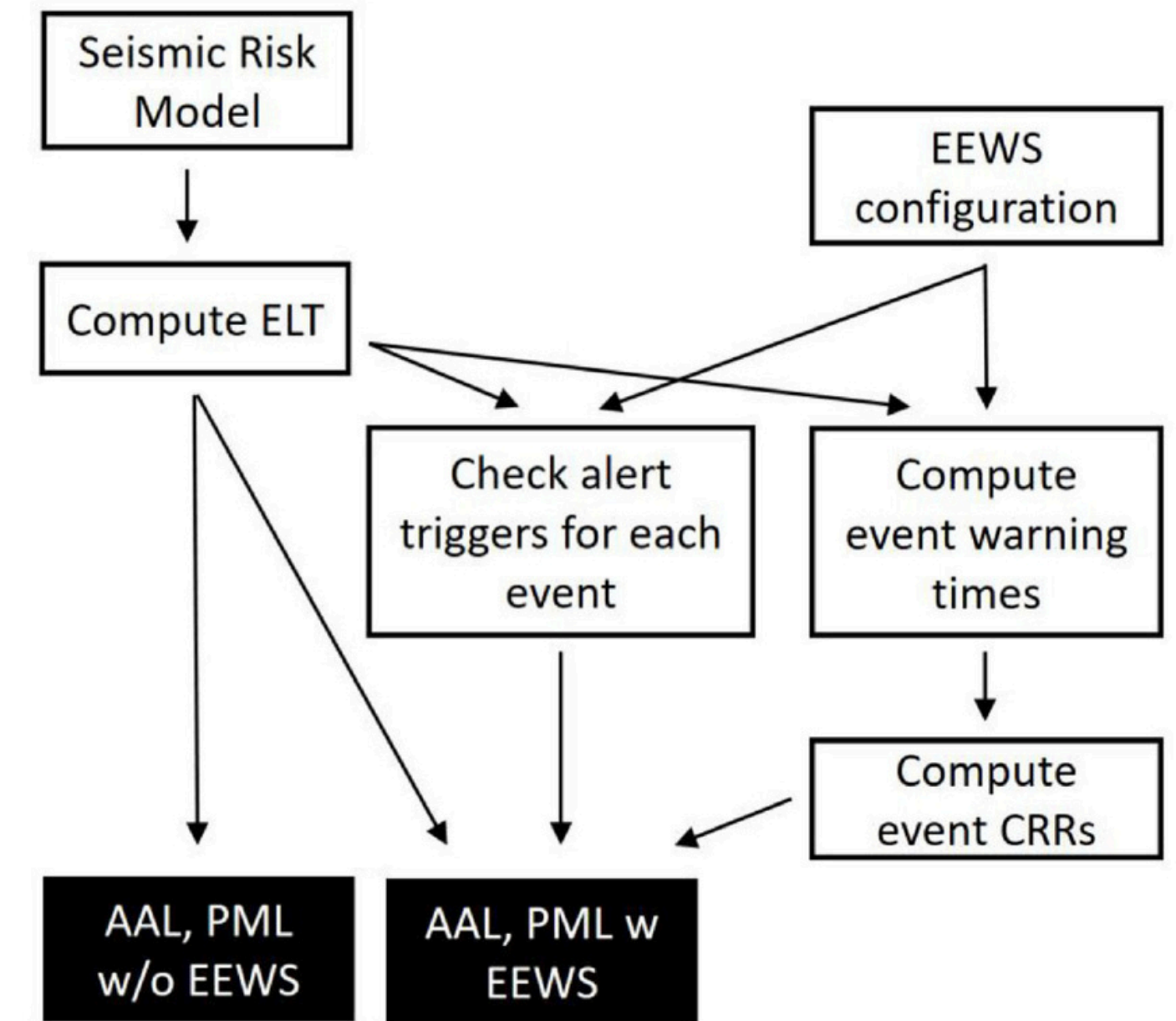
Global seismic hazard and risk maps



Earthquake early warning network optimization

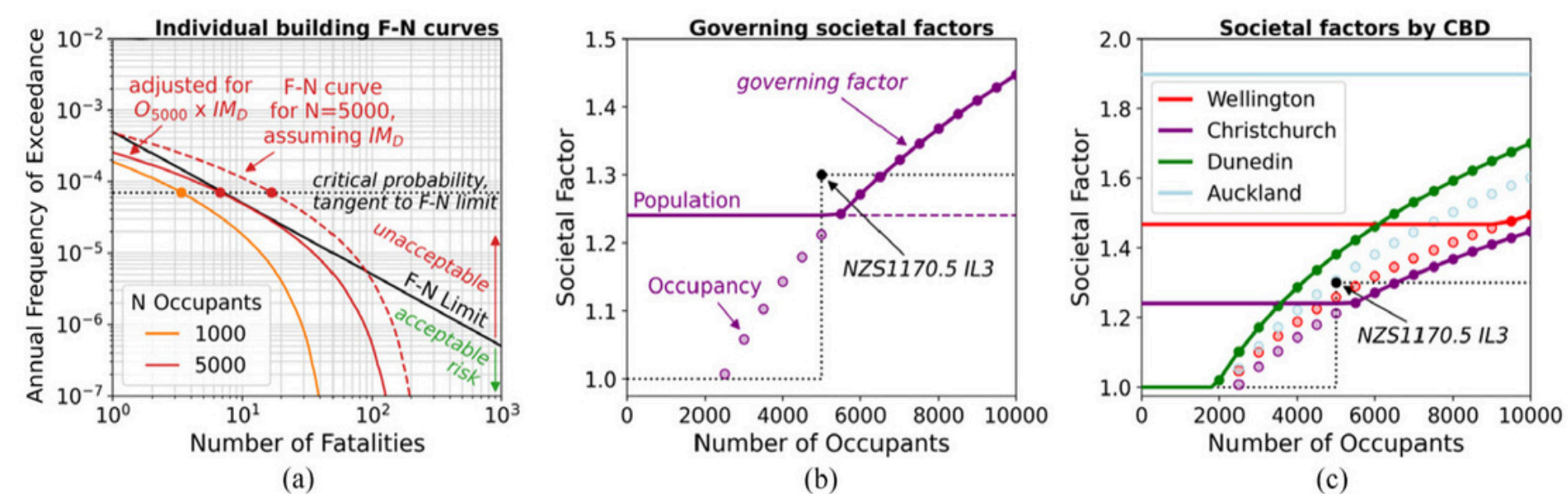
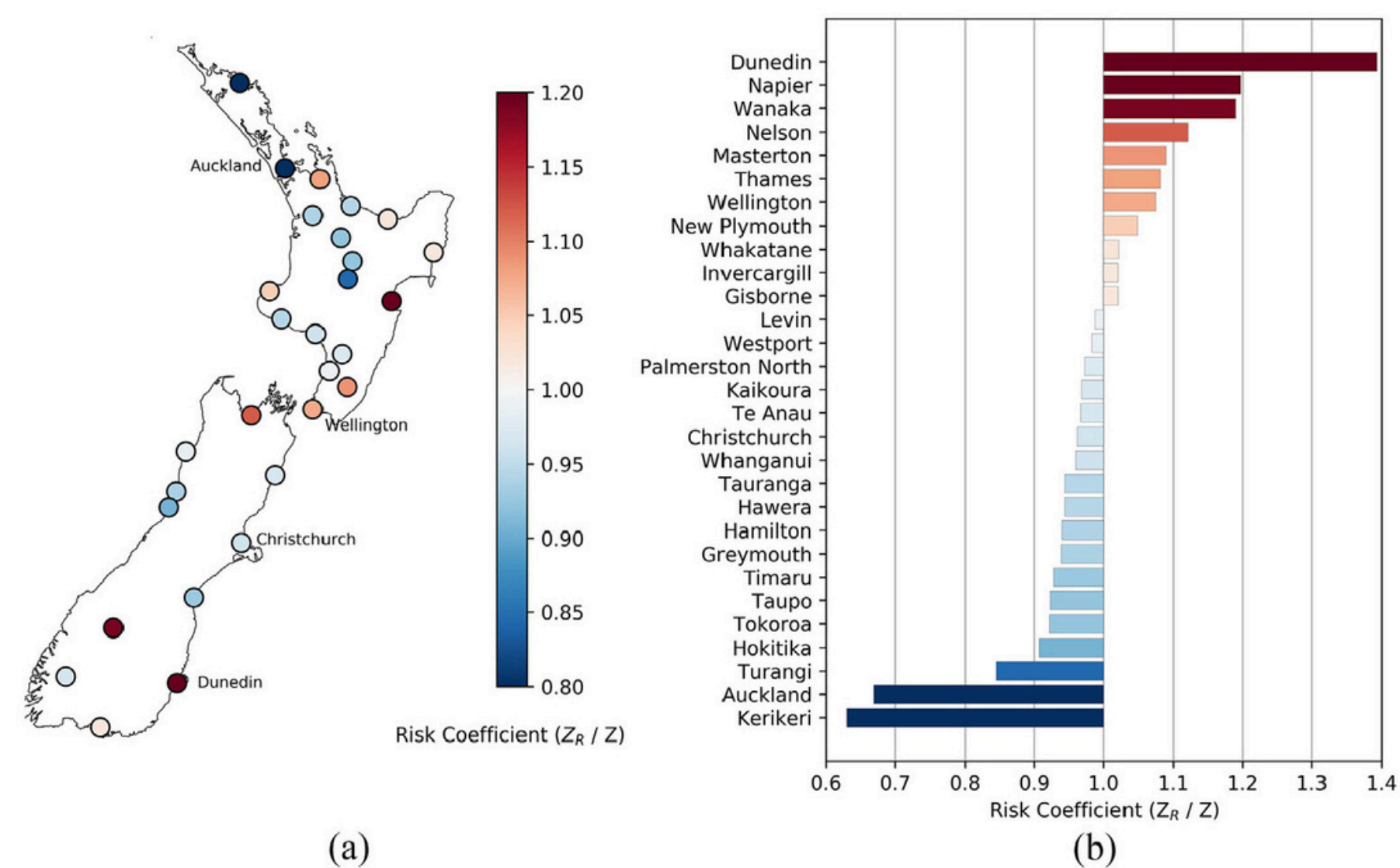
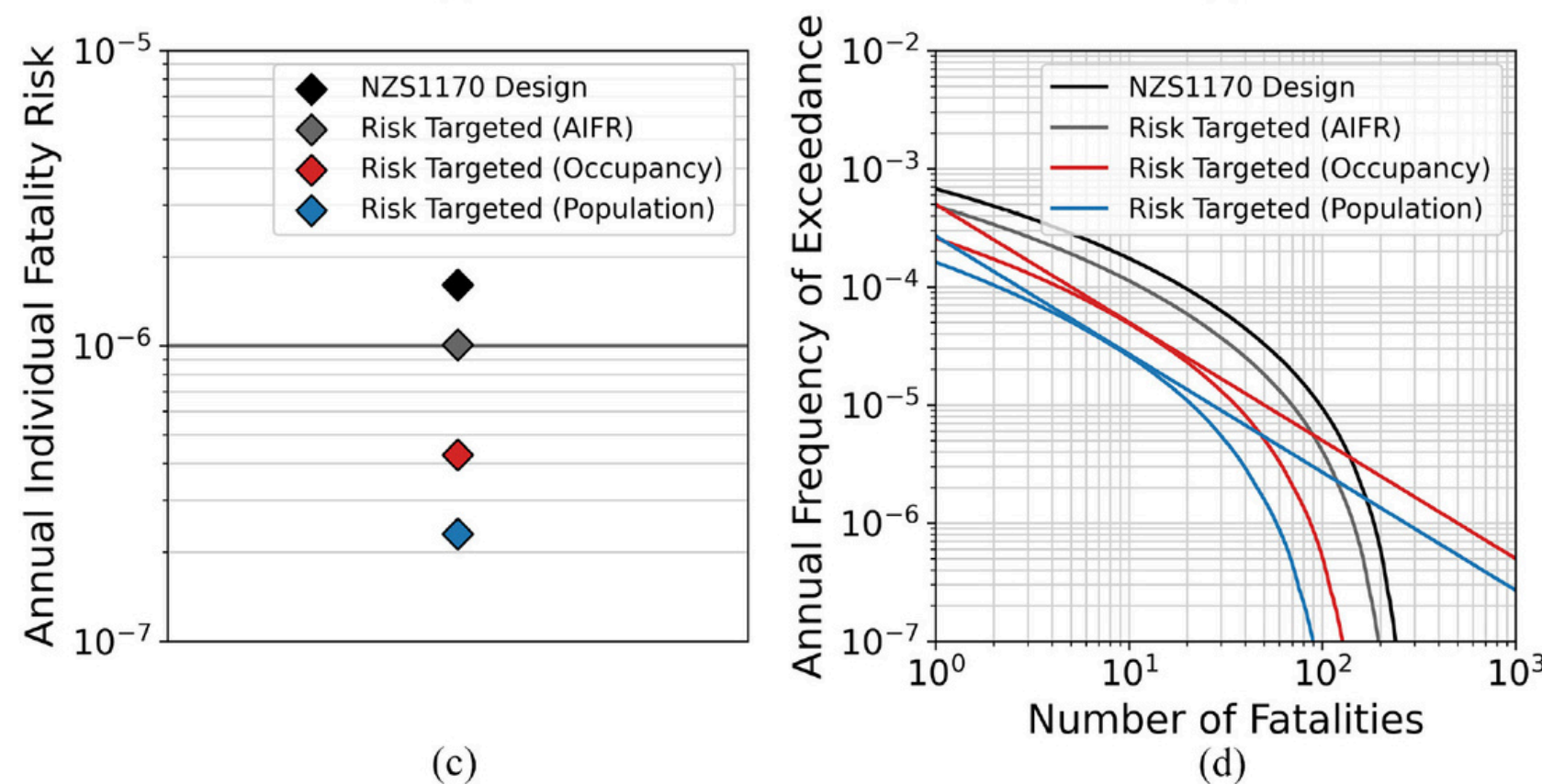
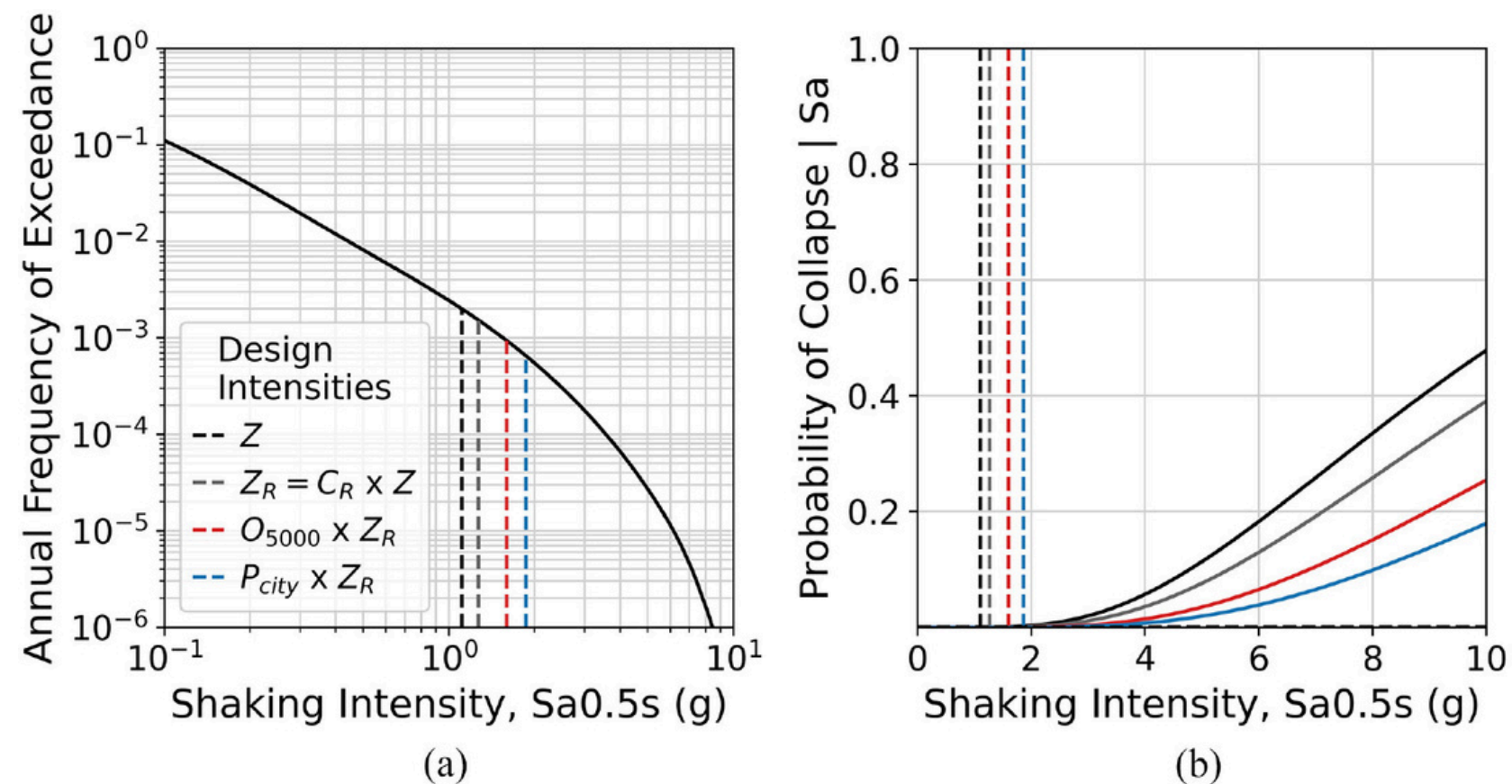


http://www.seismo.ethz.ch/en/research-and-teaching/fields_of_research/earthquake-early-warning/

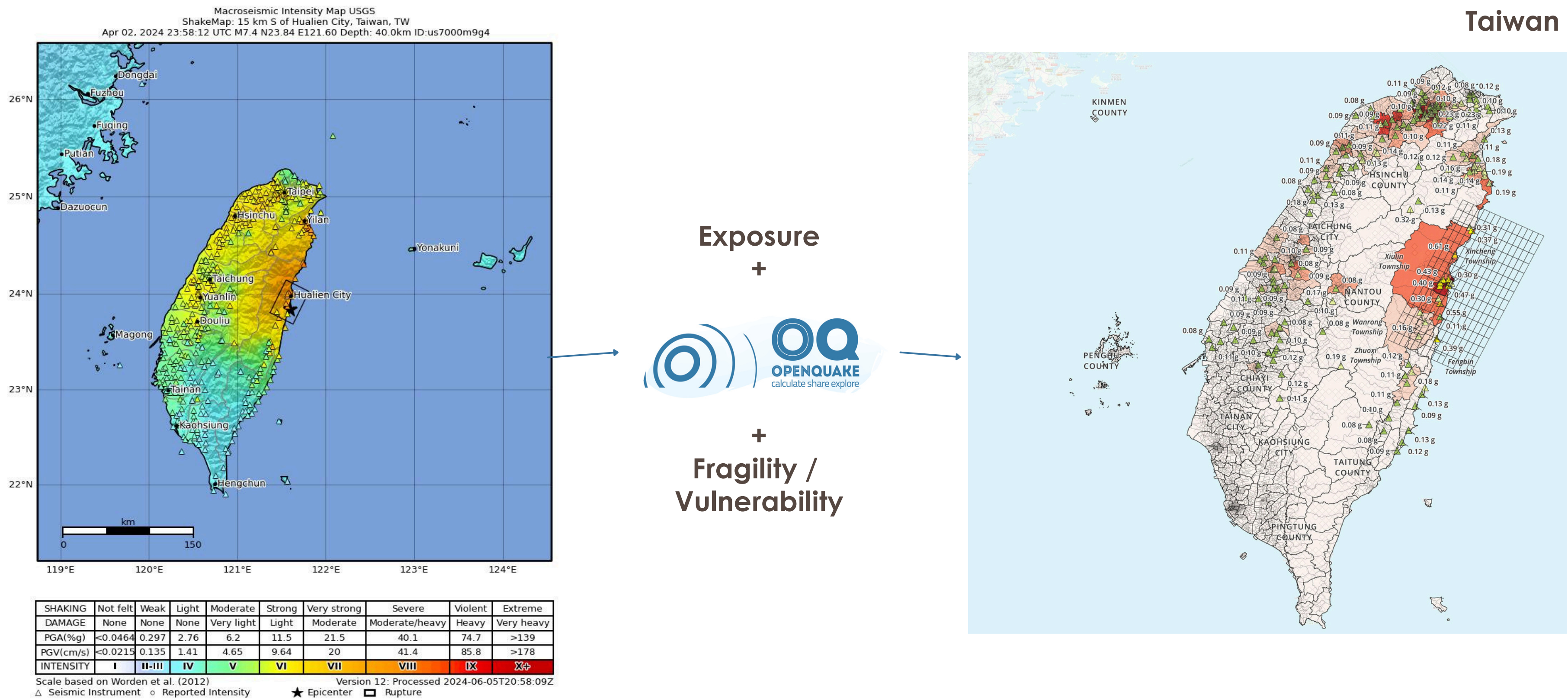


Papadopoulos et al. (2023). A framework to quantify the effectiveness of earthquake early warning in mitigating seismic risk. *Earthquake Spectra*, 39(2), 938–961.
<https://doi.org/10.1177/87552930231153424>

Risk targeted hazard for seismic design



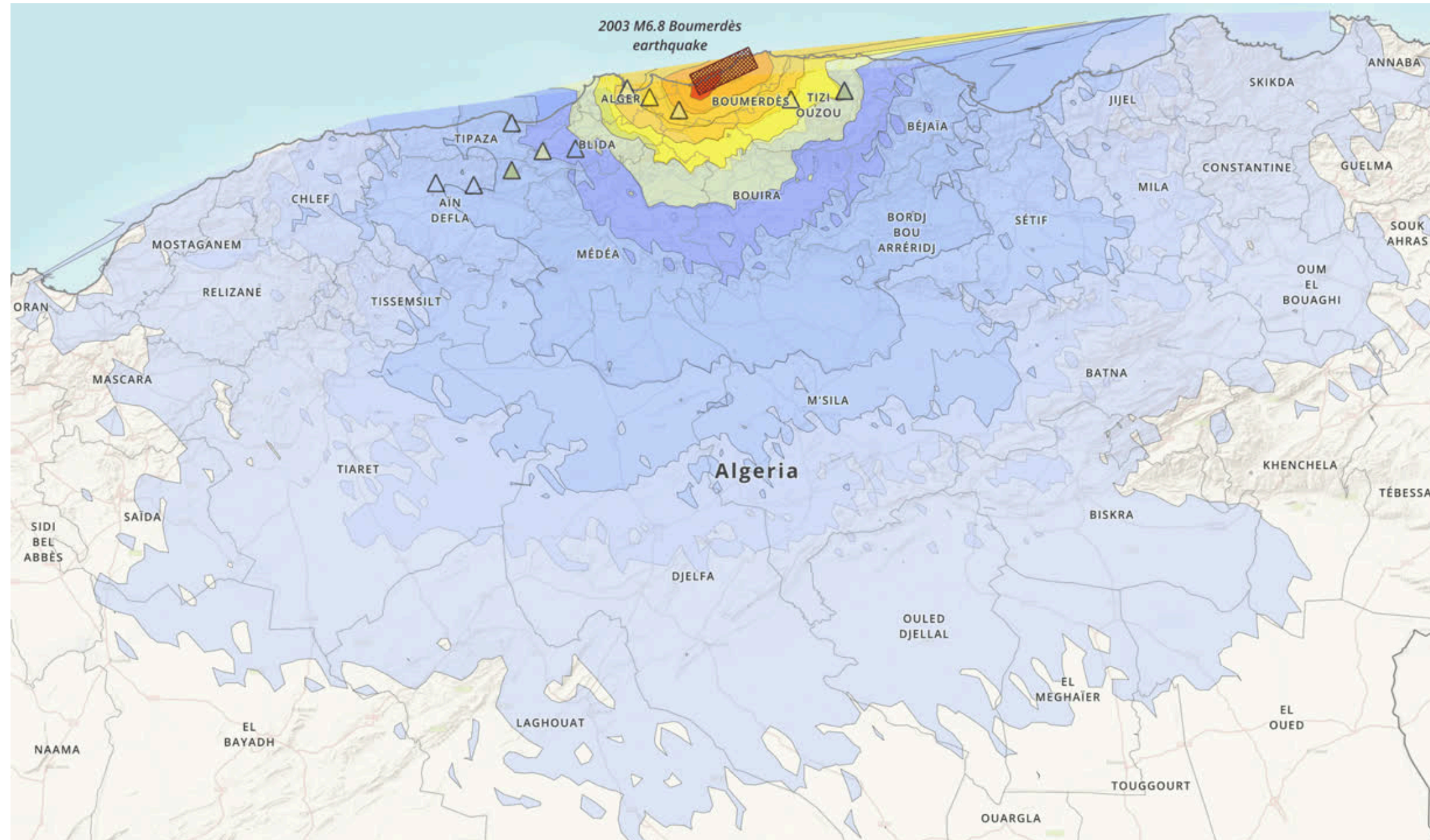
Connecting ShakeMap to OpenQuake's damage and loss calculators



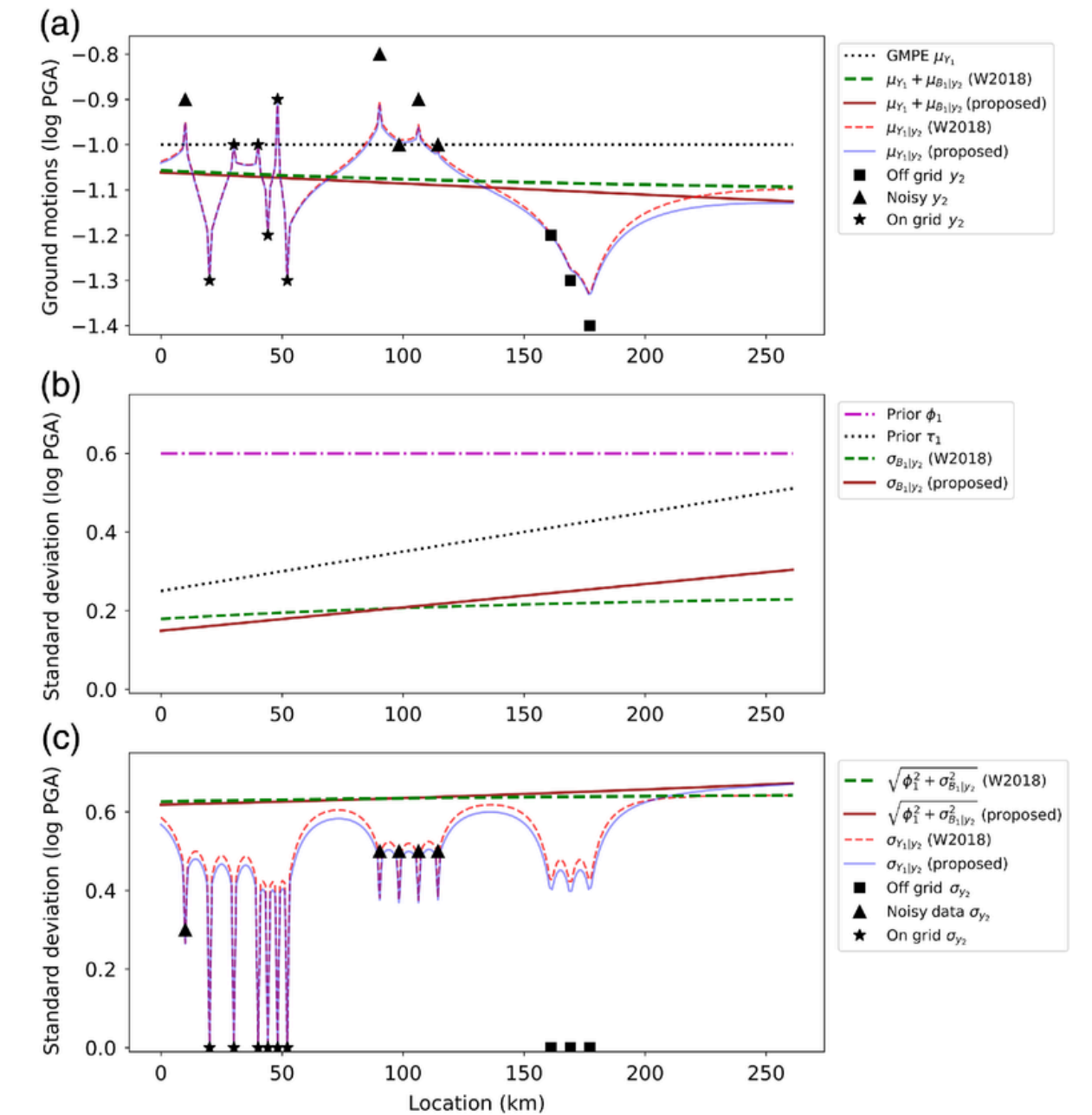
Silva V, Horspool N. (2019). Combining USGS ShakeMaps and the OpenQuake-engine for damage and loss assessment. Earthquake Engineering Structural Dynamics; 48: 634–652. <https://doi.org/10.1002/eqe.3154>

Conditioning ground motion fields on station data

Algeria



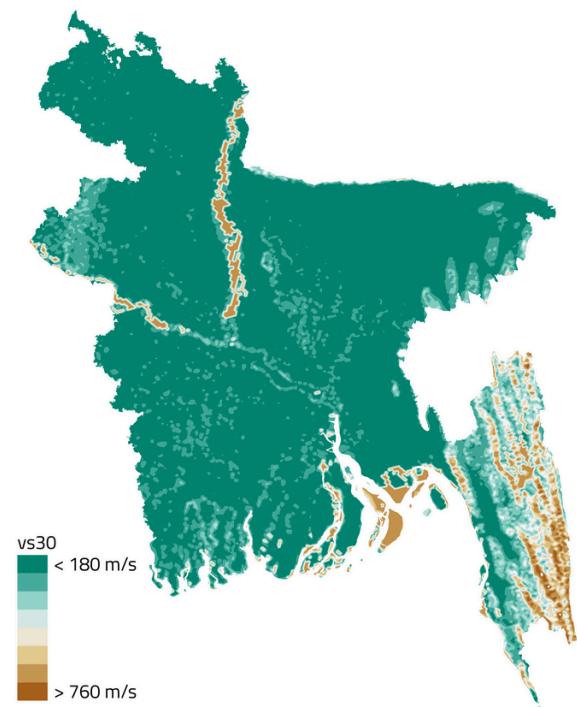
2003 M6.8 Boumerdès earthquake median PGA with and without station data



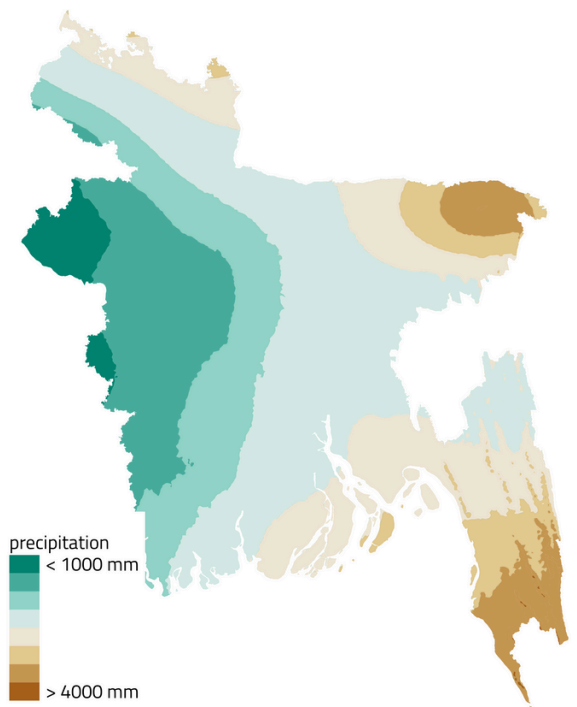
Engler et al. (2022) formulation

Davis T. Engler, C. Bruce Worden, Eric M. Thompson, Kishor S. Jaiswal; Partitioning Ground Motion Uncertainty When Conditioned on Station Data. *Bulletin of the Seismological Society of America* 2022;; 112 (2): 1060–1079. doi: <https://doi.org/10.1785/0120210177>

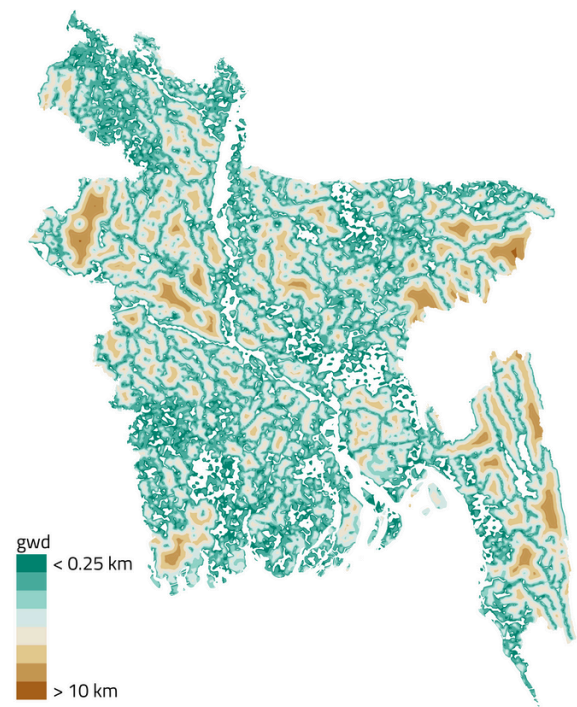
Secondary perils module – scenario and probabilistic liquefaction



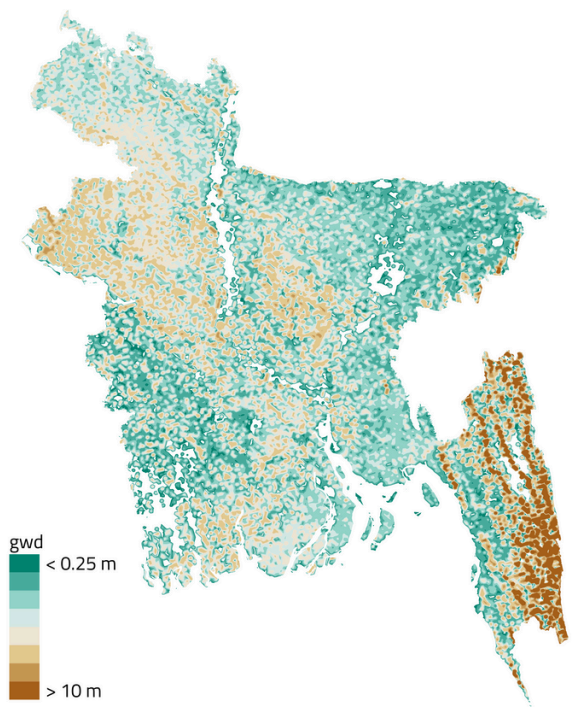
Vs30



Precipitation



Groundwater Depth

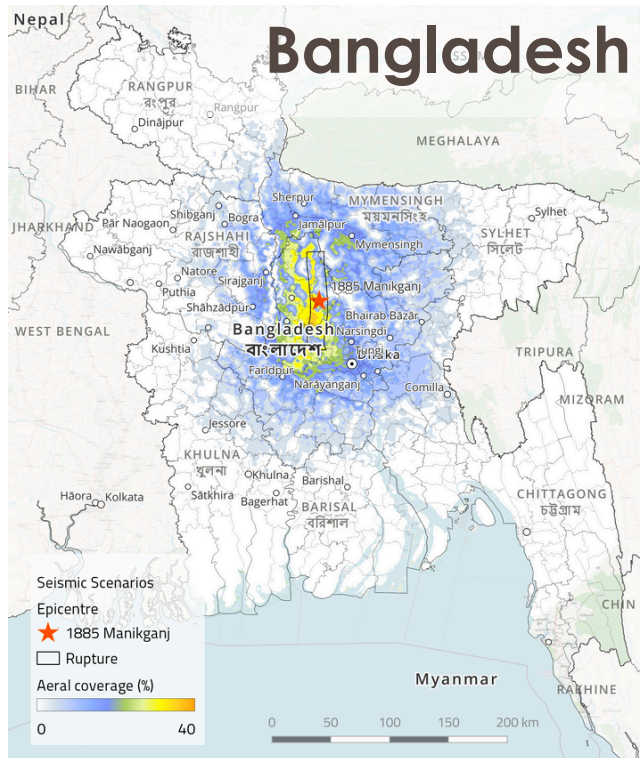


Distance to Water Body

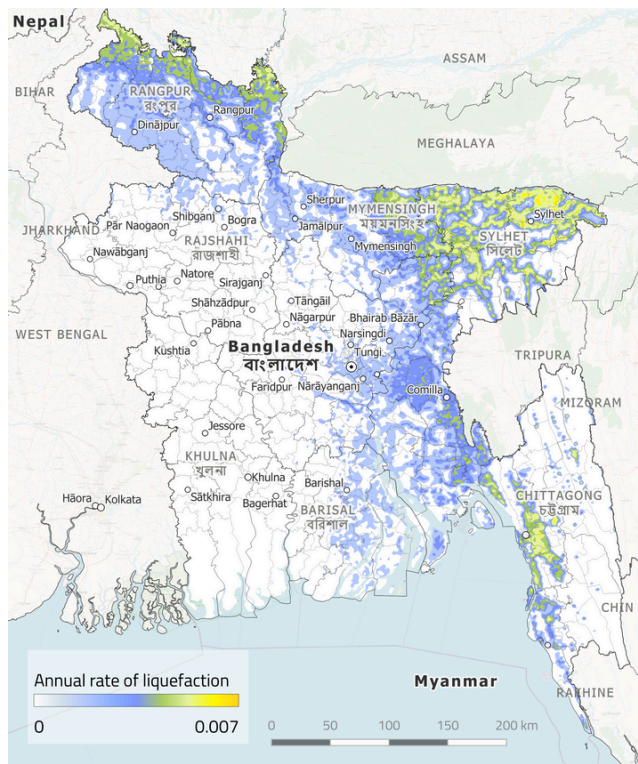


Todorovic, L., & Silva, V. (2022). A liquefaction occurrence model for regional analysis. Soil Dynamics and Earthquake Engineering, 161, 107430.

Allstadt, K. E., Thompson, E. M., et al. (2022). The US Geological Survey ground failure product: Near-real-time estimates of earthquake-triggered landslides and liquefaction. Earthquake Spectra, 38(1), 5-36.



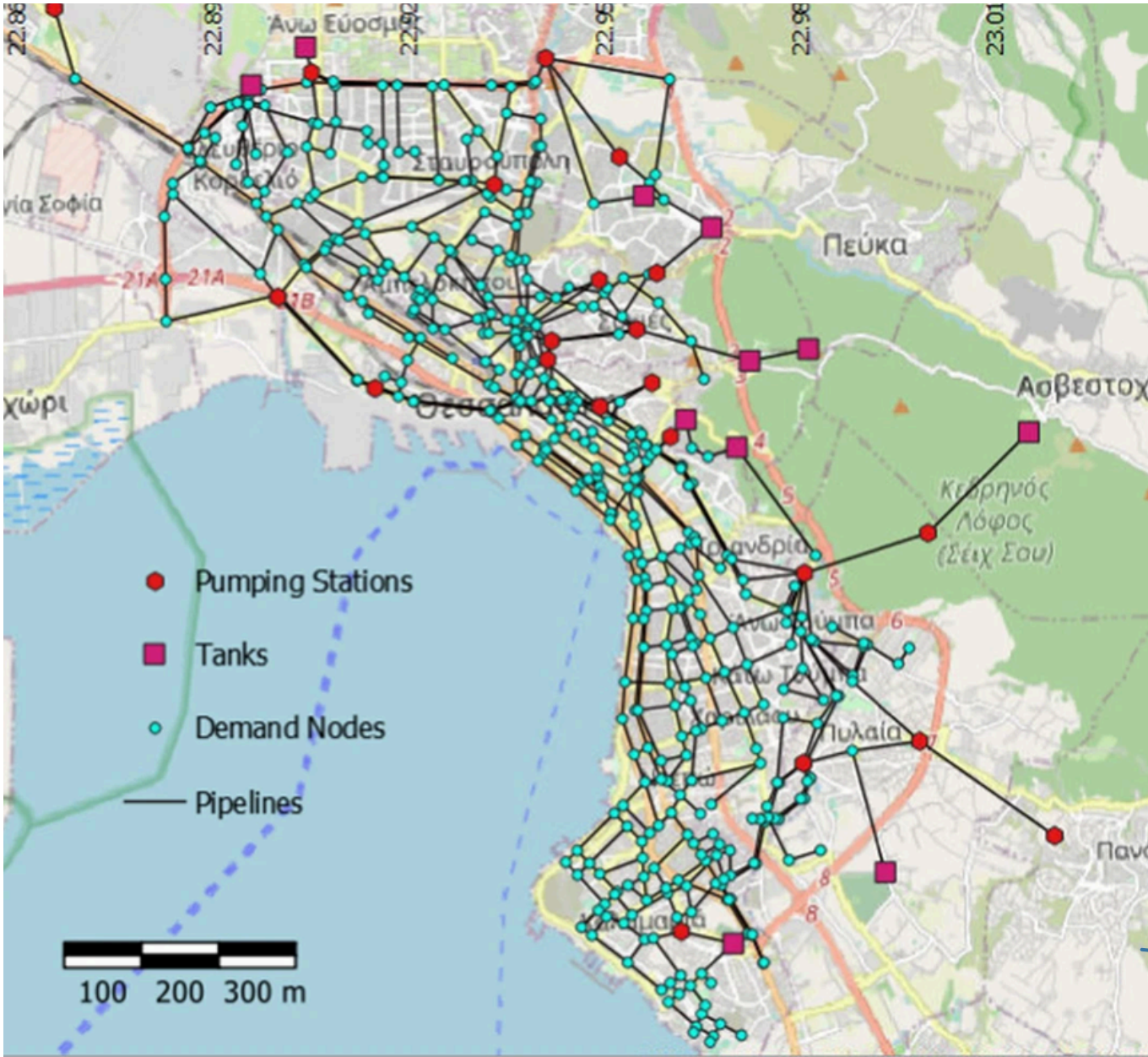
1885 M7.6 Manikganj earthquake



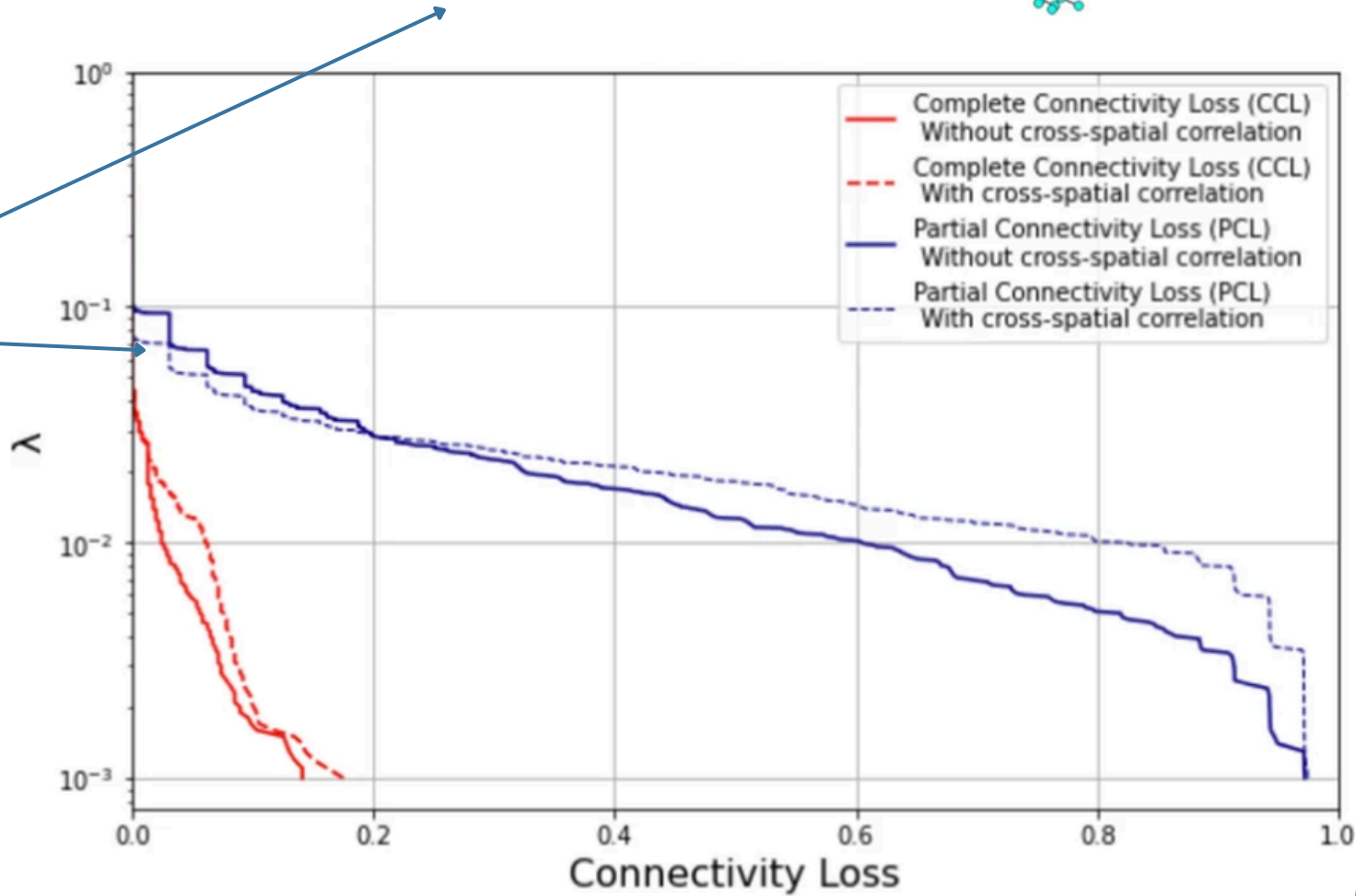
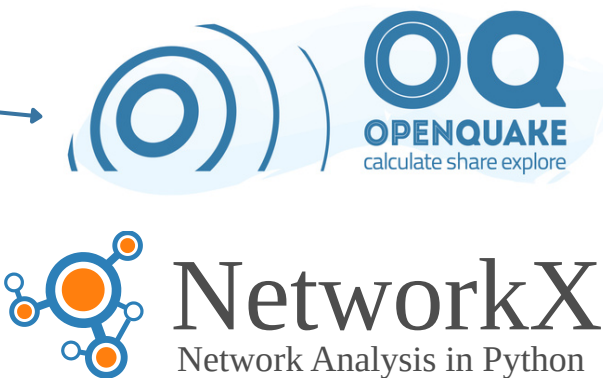
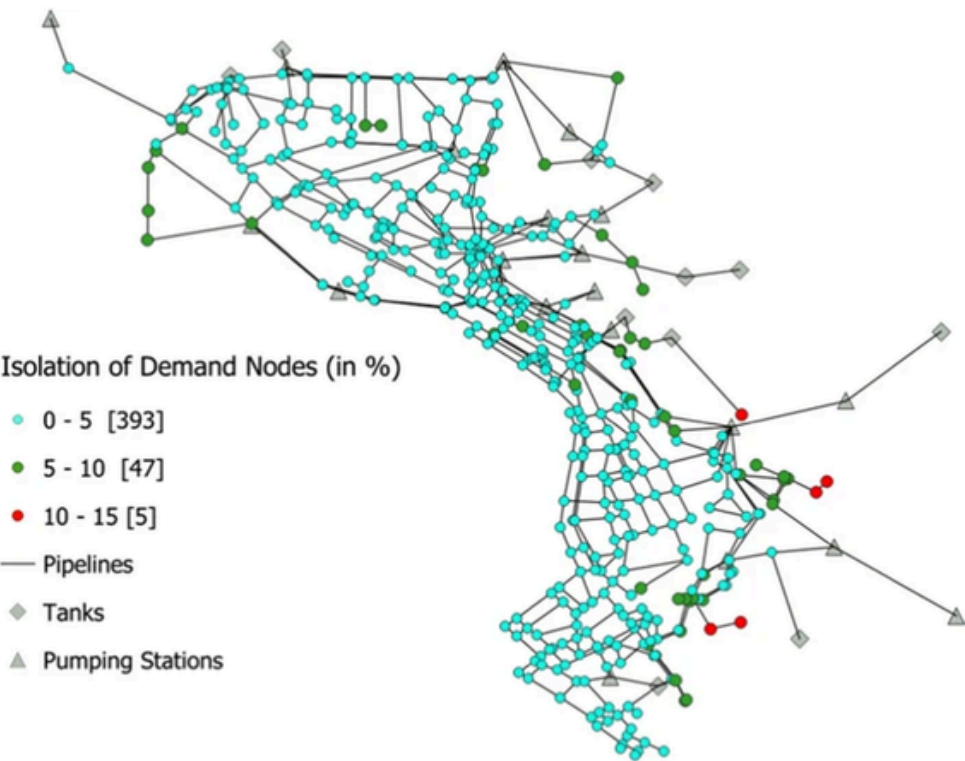
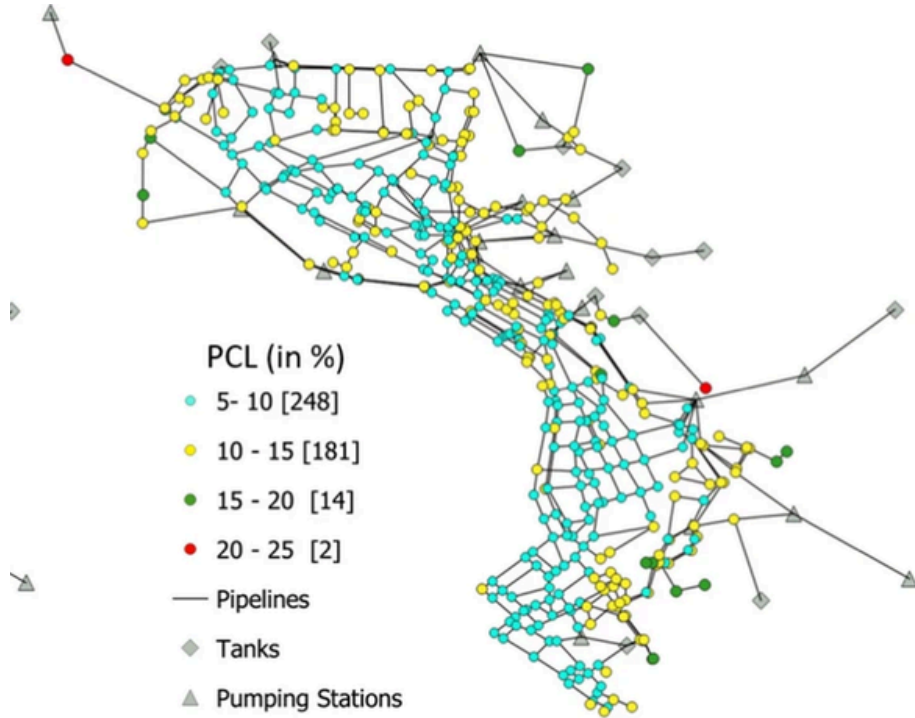
Average annual rate of liquefaction

Infrastructure risk and network connectivity loss module

Greece

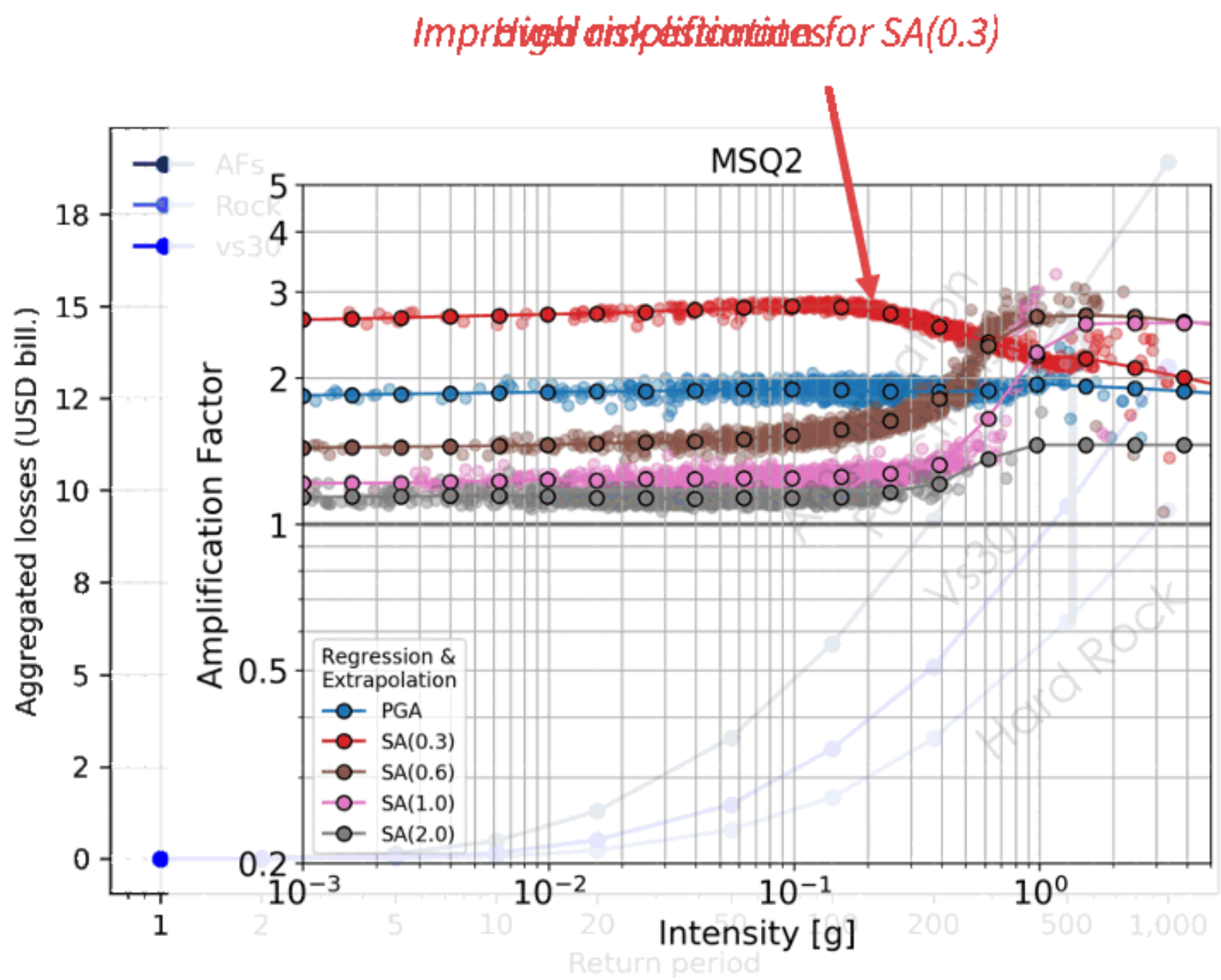
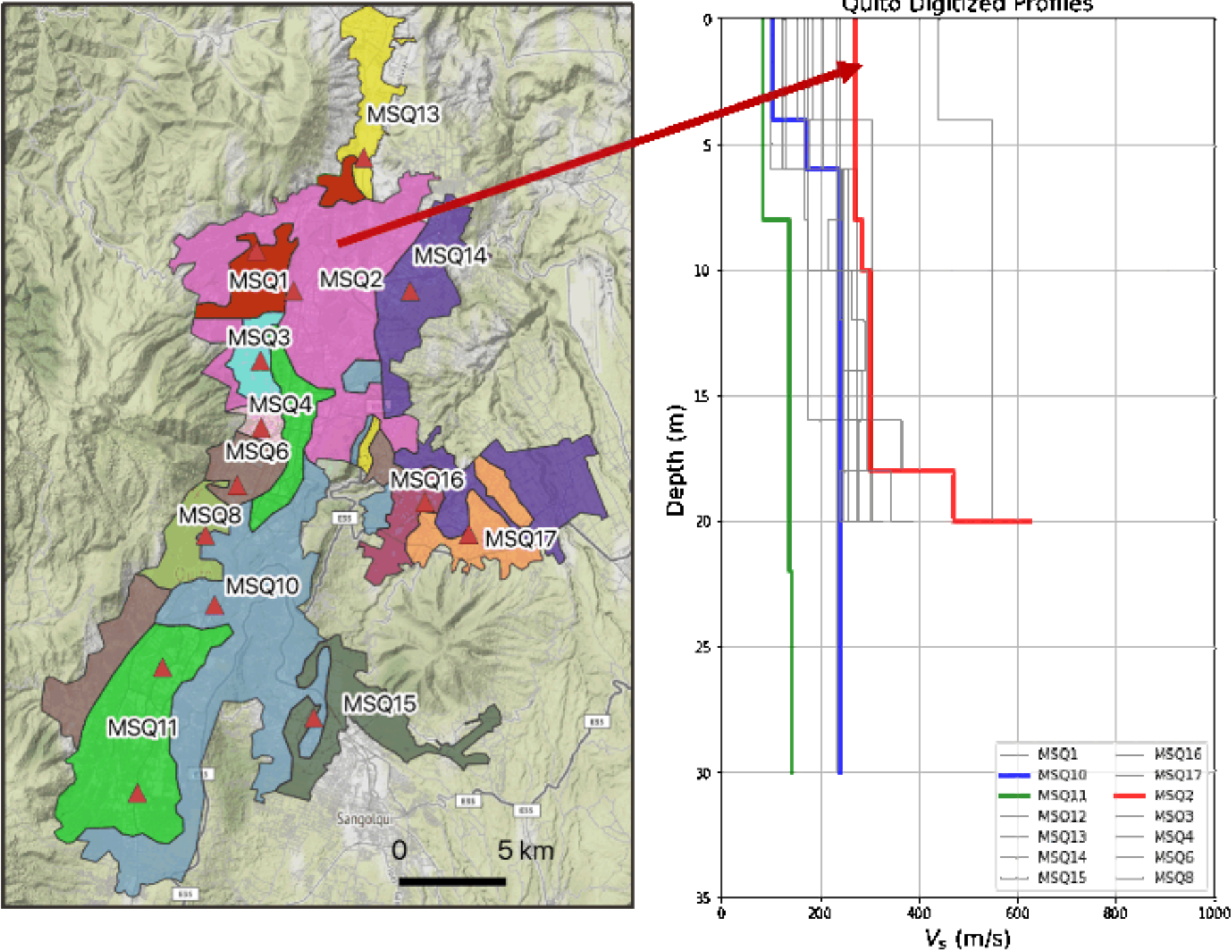


Poudel, A., Pitilakis, K., Silva, V. Rao, A. (2023). Infrastructure seismic risk assessment: an overview and integration to contemporary open tool towards global usage. Bulletin of Earthquake Engineering 21, 4237–4262.
<https://doi.org/10.1007/s10518-023-01693-z>

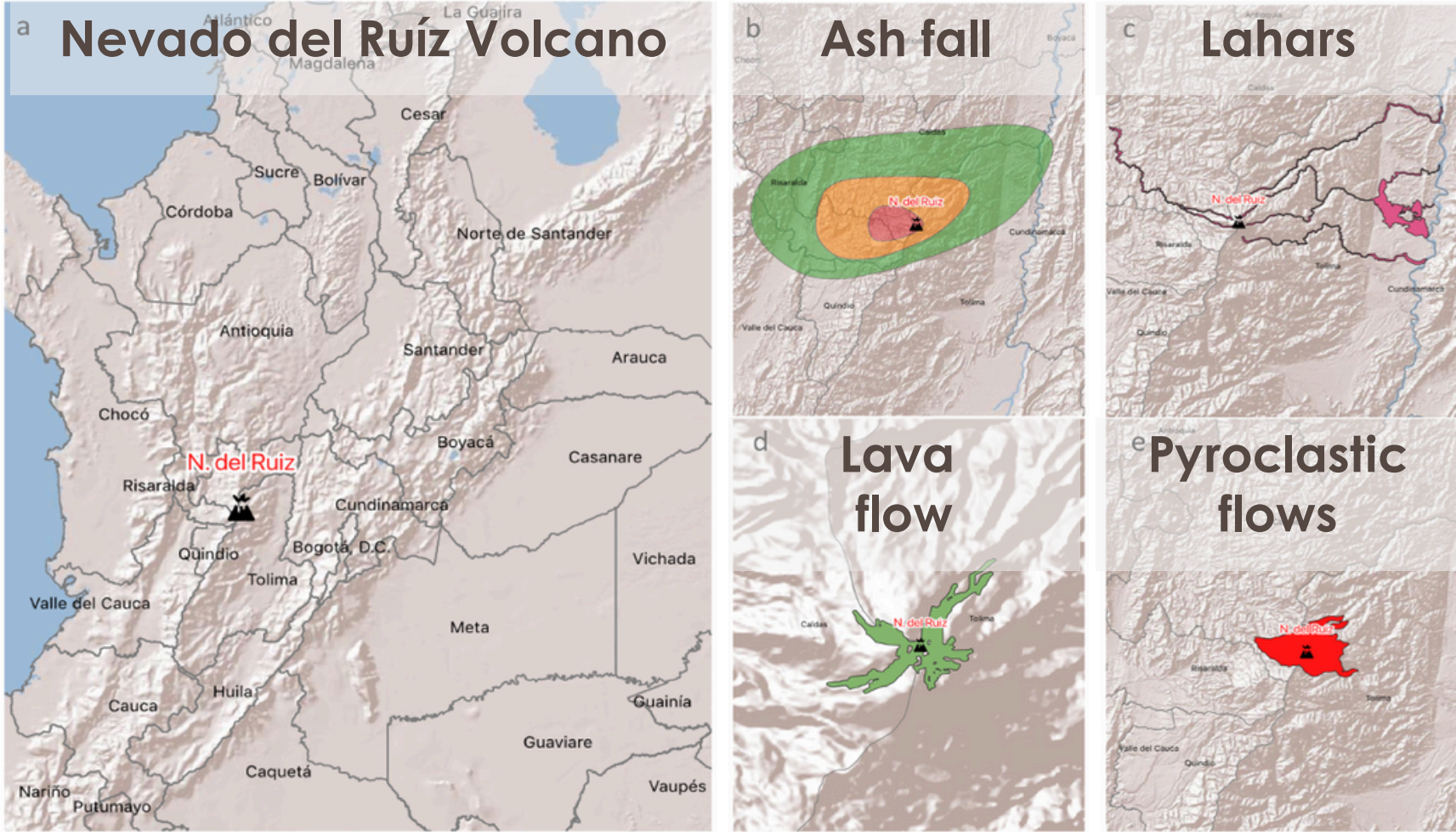


Local site effects in city-scale seismic hazard and risk analysis

Ecuador



Risk calculations for volcanic hazards



Hazard	Software	Organization	Intensity
Ashfall	Ash3d	USGS	Ash thickness & load
Lava Flow	Q-LavHa	Vrije Universiteit Brussel	Binary 0: Not affected 1: Affected
Pyroclastic Density Currents	Titan2d	Vhub & Buffalo University	
Lahar	LaharZ	USGS	

Input Preparation Toolkit

OPENQUAKE Calculate Share Explore

admin ? ? GEM

INPUT PREPARATION TOOLKIT

Exposure Fragility Consequence Vulnerability Earthquake Rupture Site Conditions Configuration File

Earthquake Scenarios Classical Probabilistic Stochastic Event-Based Volcano Scenarios

The OpenQuake volcano calculator can be used for the calculation of damage distribution statistics or individual asset and portfolio loss statistics for a portfolio of buildings starting from hazard footprints.

Four hazard perils can be considered, related to the following phenomena and codes:

- Ash fall
- Lahar
- Lava flow
- Pyroclastic flow

For AshFall only ash thickness is considered, and the other perils are assumed to be binary.

General

Description: Volcano scenario calculation

Choose at least one volcano phenomena.

☒ Ash fall ☒ Lava flow ☒ Lahar ☒ Pyroclastic flow

Ash fall

Input format ? : Default CSV format

Hazard footprint: ashfall_vol_full.csv Upload

Humidity amplification factor: 1.6

Lava flow

Input format ? : Q-LavaHa output file

Coordinate reference system [EPSG] ? : 4326

Hazard footprint: Upload

Lahar

Input format ? : Shapefile (ESRI)

Hazard footprint: Upload

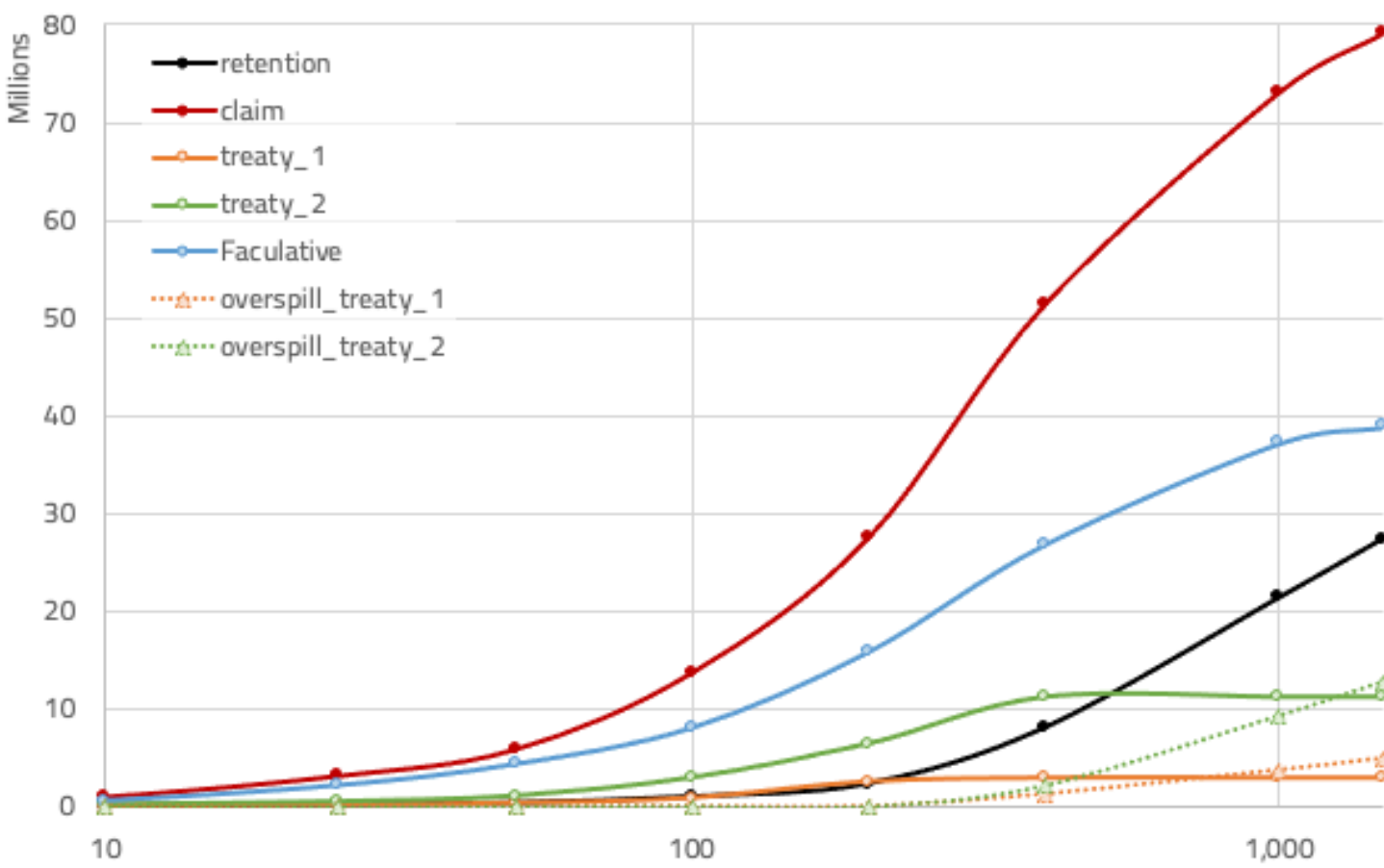
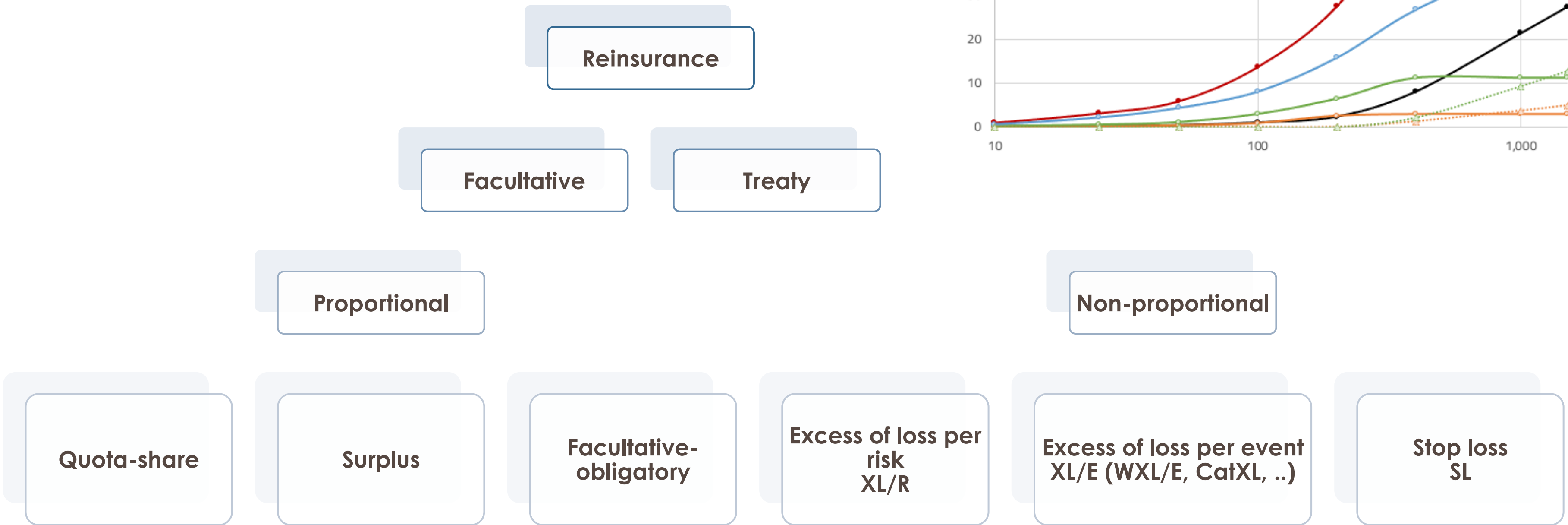
Discretization distance ? : 0.2

Hazard field ? : the shapefile field name with values

OpenQuake Platform 1.11.0-git3fc9922 | About | Terms of Use | Contact us | Feedback

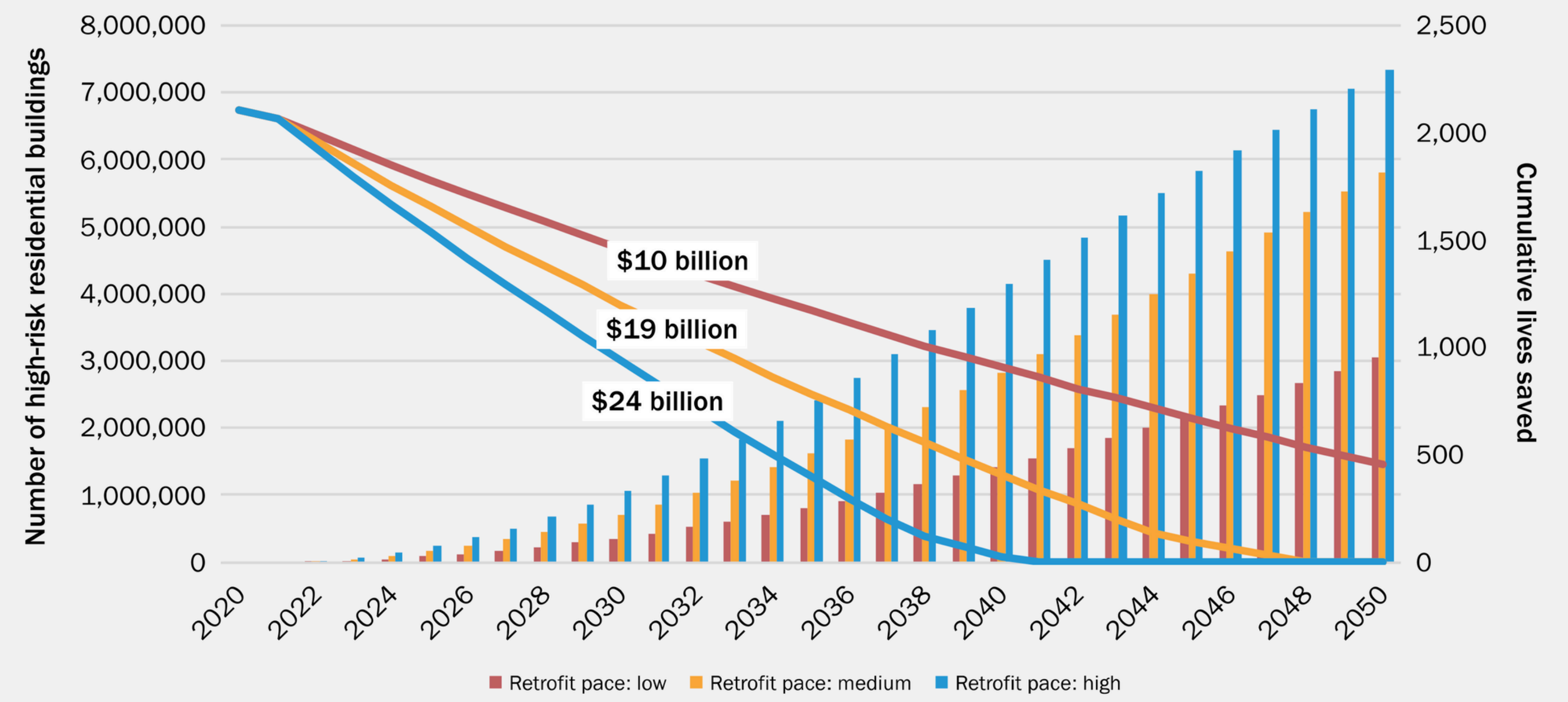
Powered by GeoNode

Insurance and reinsurance module



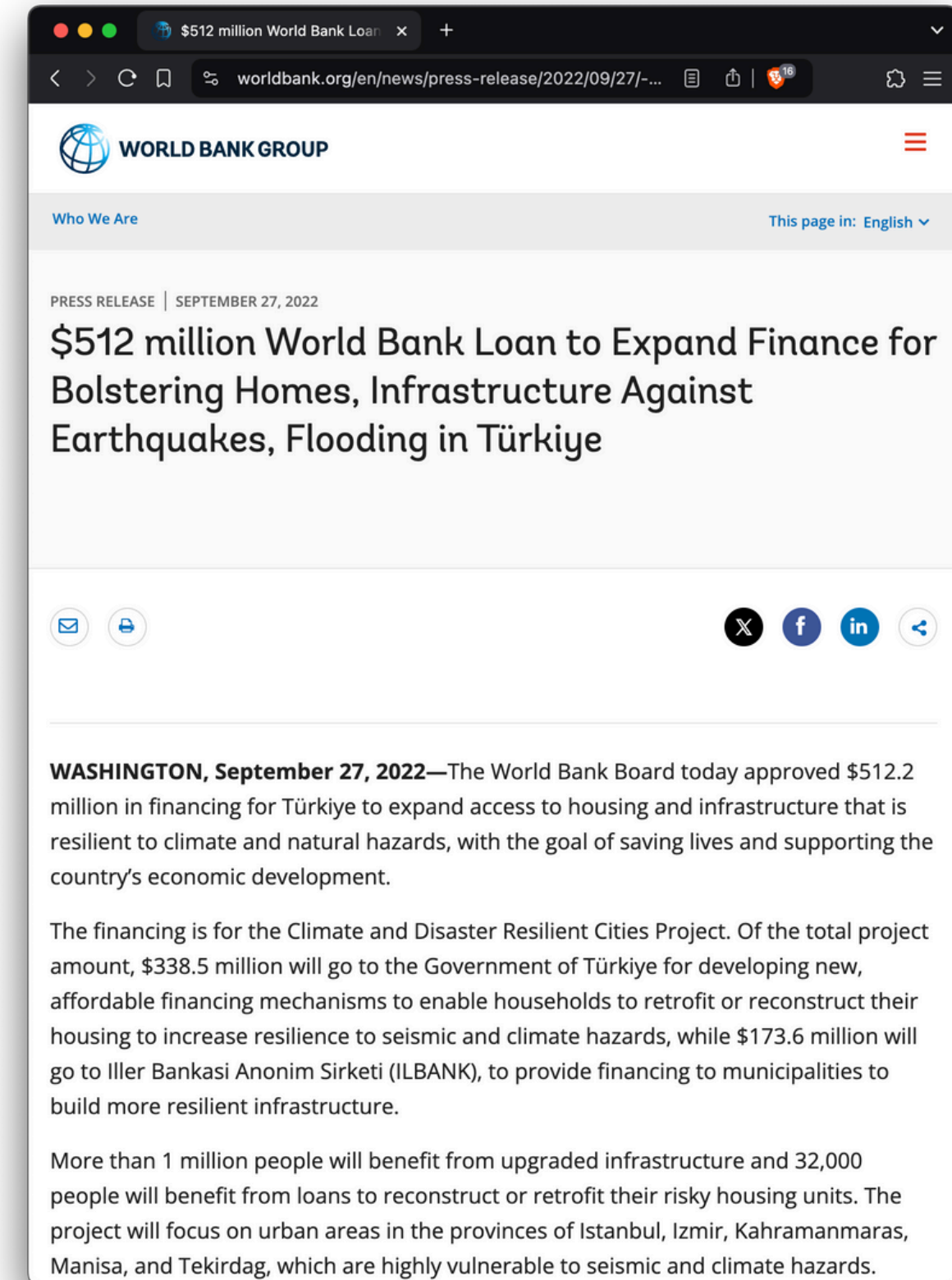
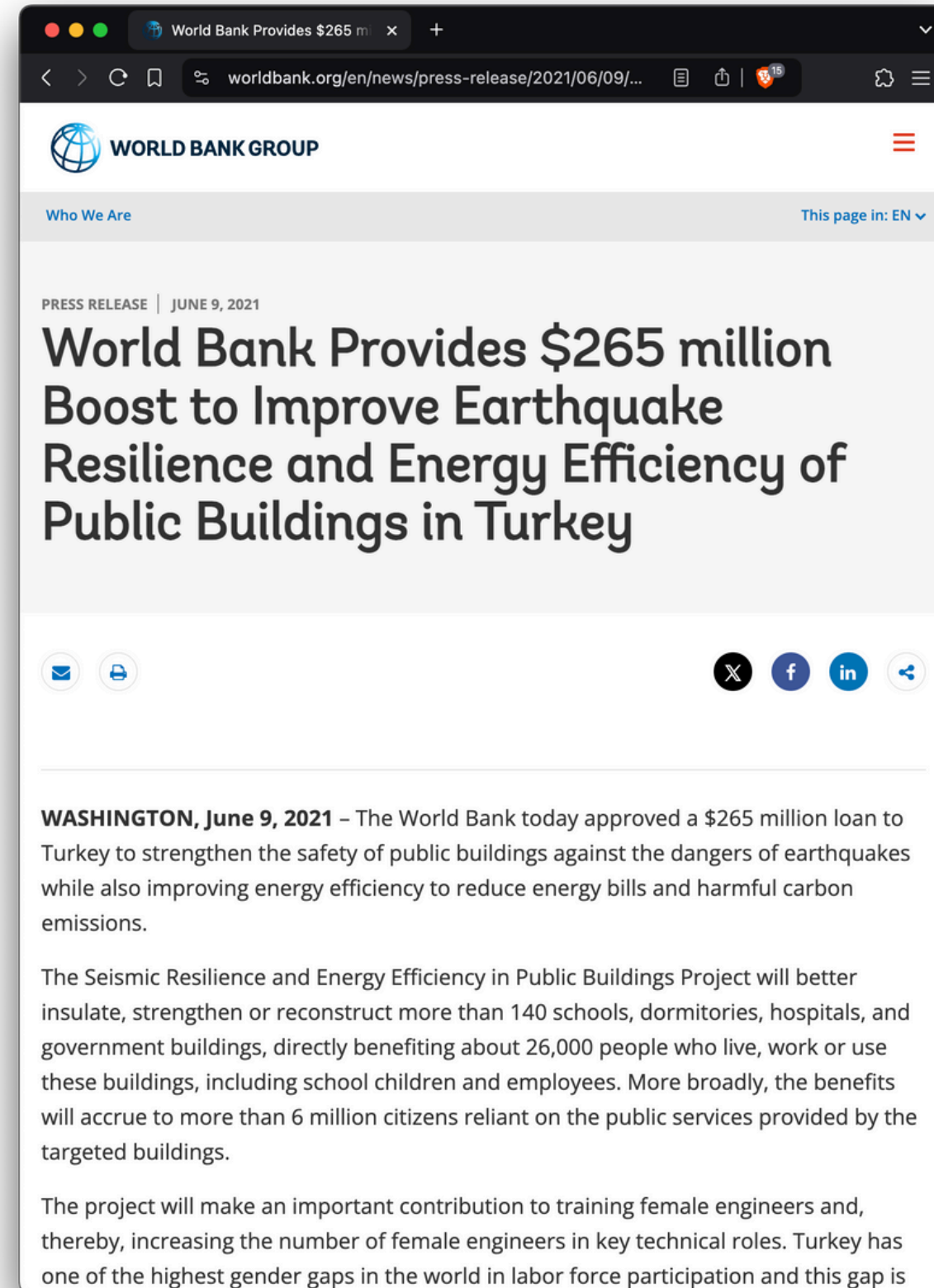
Türkiye: Cost-benefit analysis of seismic retrofits

Figure B3.1.1: Retrofitting Türkiye’s high-risk buildings: investment needs and cumulative lives saved by 2050



Source: World Bank staff calculations, based on data from the Global Earthquake Model

Türkiye: Loans for retrofitting



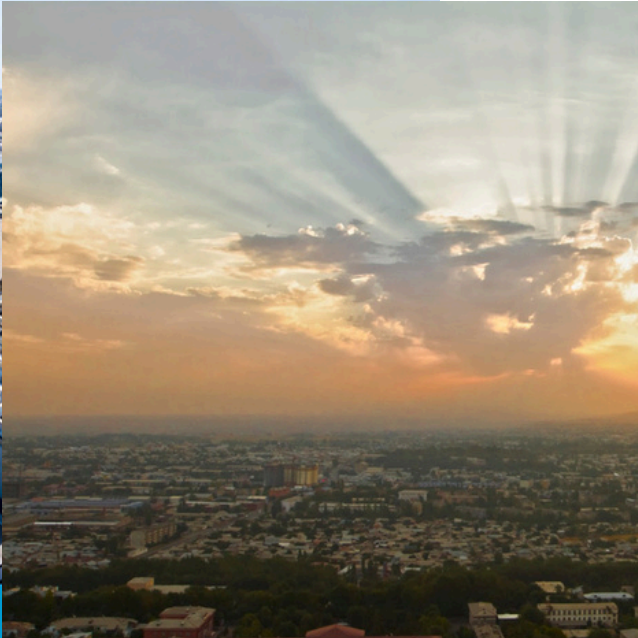
Central Asia: Asian Development Bank



COUNTRY RISK PROFILE KAZAKHSTAN

TA-9878 REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region

March 2022



COUNTRY RISK PROFILE KYRGYZ REPUBLIC

TA-9878 REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region

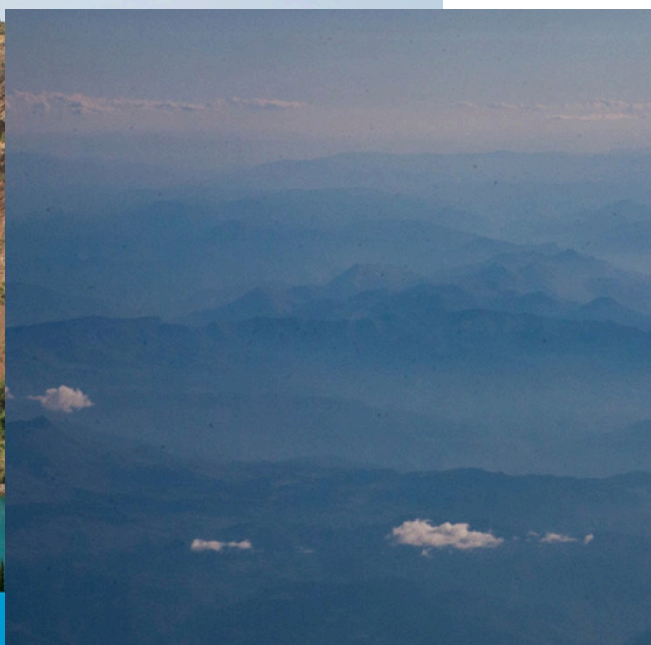
March 2022



COUNTRY RISK PROFILE TAJIKISTAN

TA-9878 REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region

April 2022



COUNTRY RISK PROFILE TURKMENISTAN

TA-9878 REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region

April 2022



COUNTRY RISK PROFILE UZBEKISTAN

TA-9878 REG: Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation Region

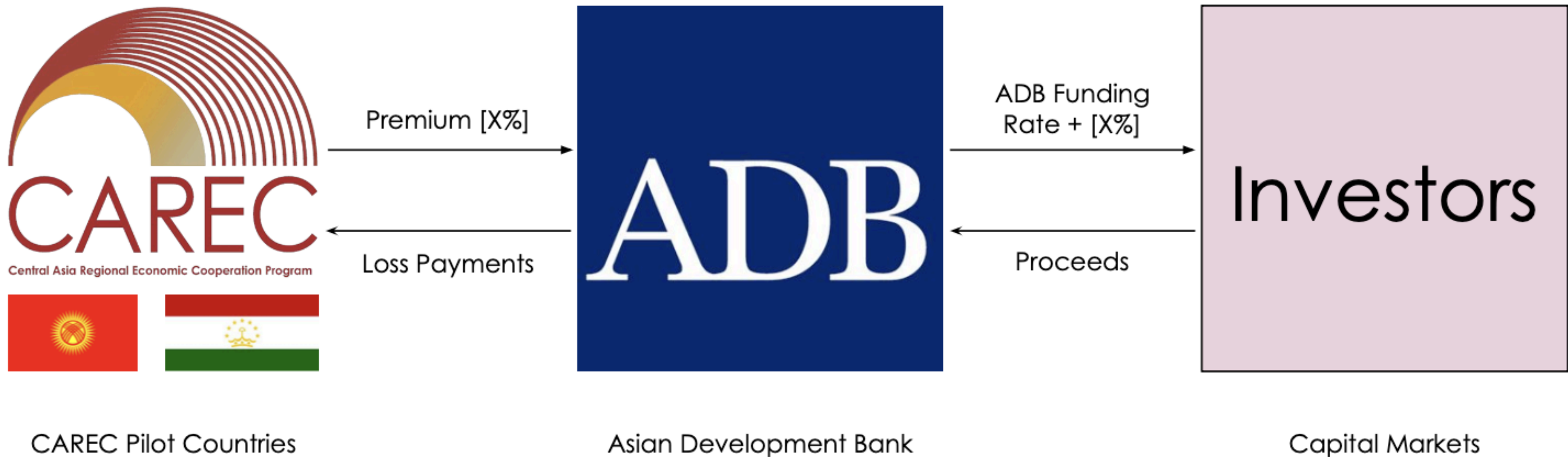
April 2022



Central Asia: Asian Development Bank

Risk Transfer Agreement

Disaster Risk Bond



Documentation, training materials, user forum, workshops



Unified development ▾

Getting Started

User Guide

API Reference

Underlying Science

Release Notes

Contributing



General overview

The OpenQuake Engine software provides calculation and assessment of seismic hazard, risk and decision-making tools via the data, methods and standards that are being developed by [Global Earthquake Model \(GEM\) Foundation](#) and its collaborators.



[Getting Started](#)



[User Guide](#)



[API Reference](#)



[Underlying Science](#)



[Release Notes](#)



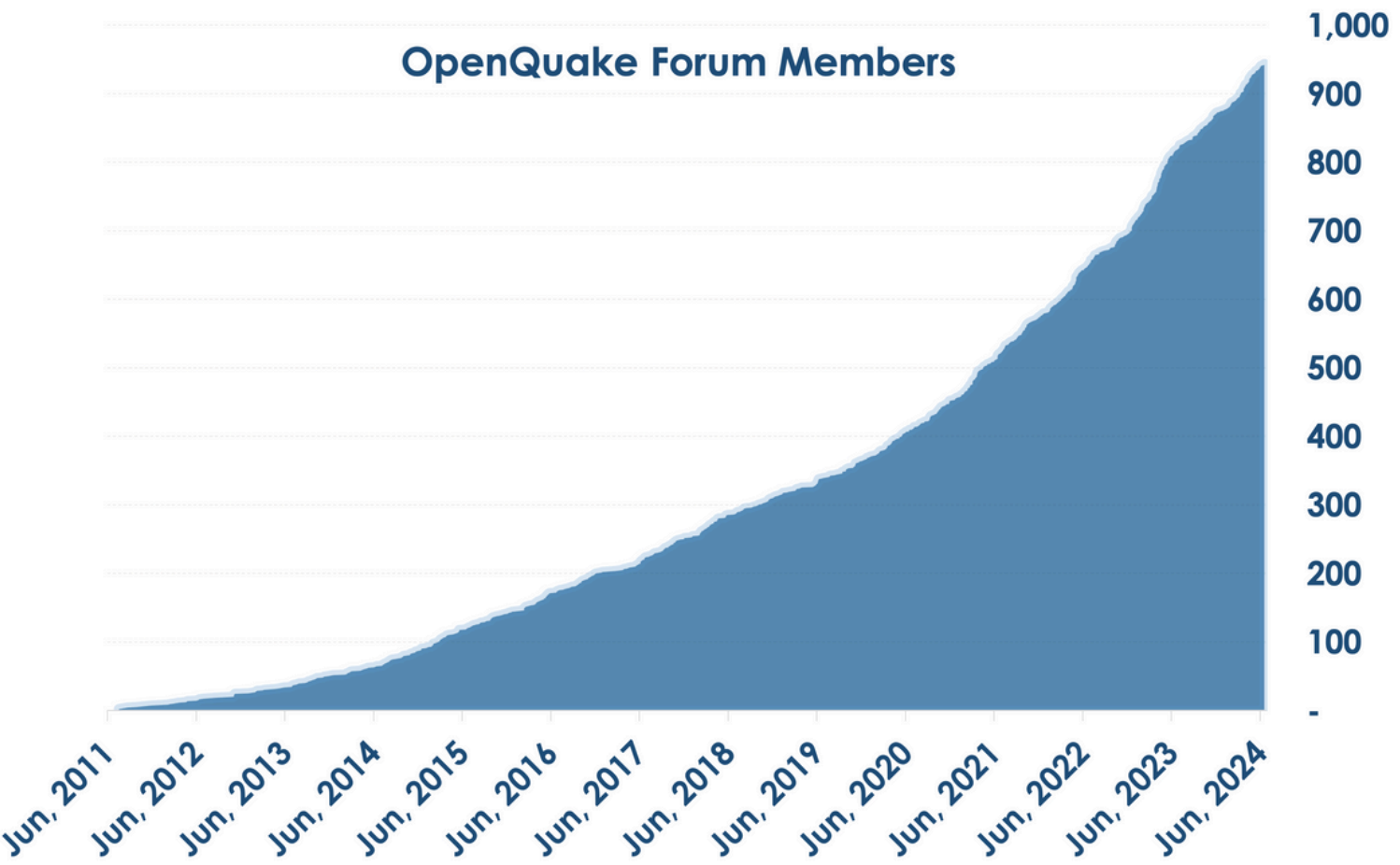
[Contributing](#)

[General overview](#)

[Introductory video](#)

[Additional information](#)

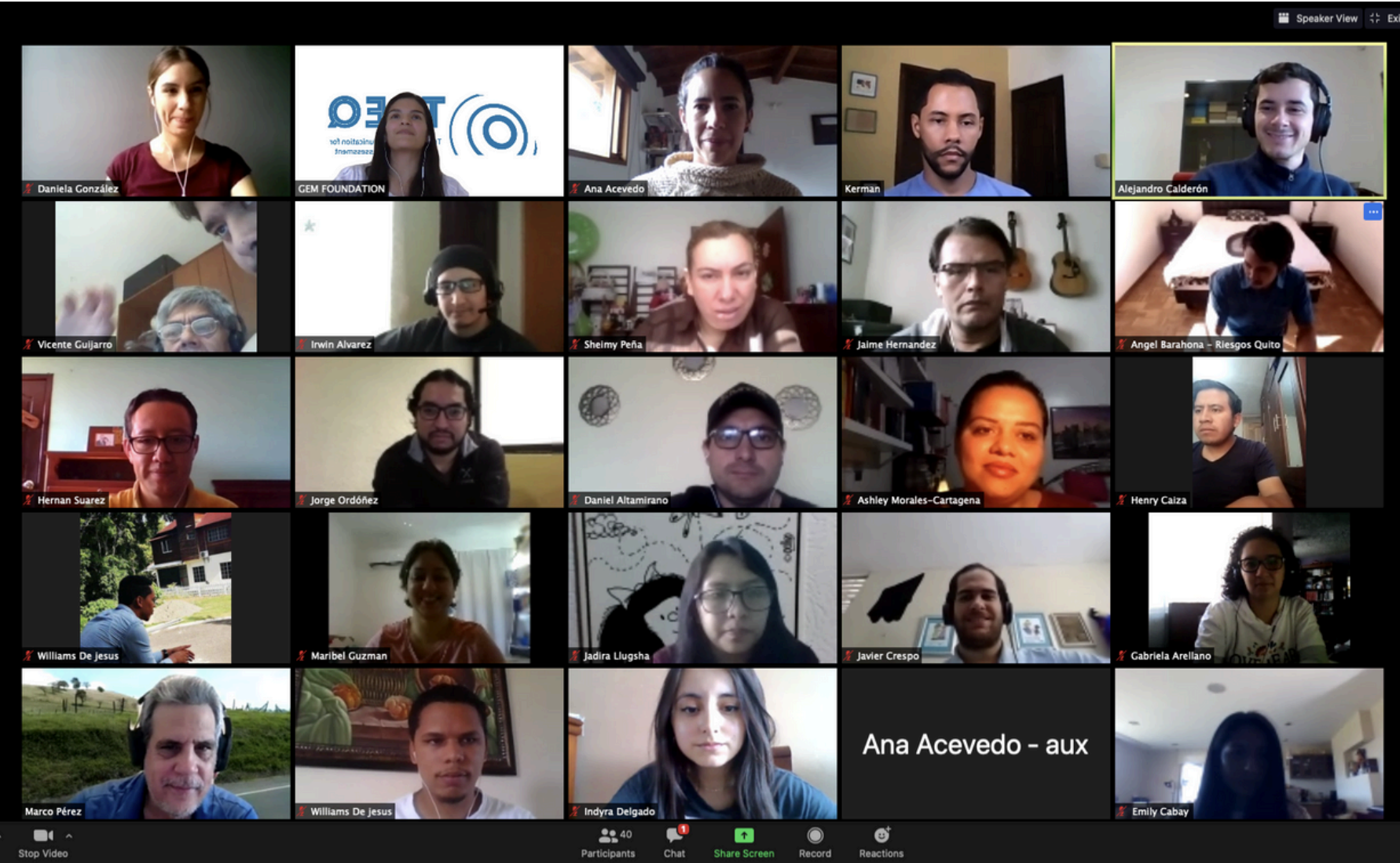
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Comprehensive web-based user manual, advanced users' guide, API reference, FAQs, and underlying science guides

Community forum of OpenQuake engine users

Documentation, training materials, user forum, workshops



<https://www.training.openquake.org/>

Free online OpenQuake training sessions

YouTube

Event-based PSHA Calculator

OpenQuake Online Training Sessions

GEM Global Earthquake Model

10 videos 13,943 views Last updated on 19 Feb 2024

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GEM Global Earthquake Model • 9.9K views • 3 years ago

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GEM Global Earthquake Model • 10K views • 3 years ago

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6 OpenQuake - Classical PSHA: Theoretical Background
GEM Global Earthquake Model • 3.7K views • 2 years ago

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YouTube playlist of OpenQuake training sessions

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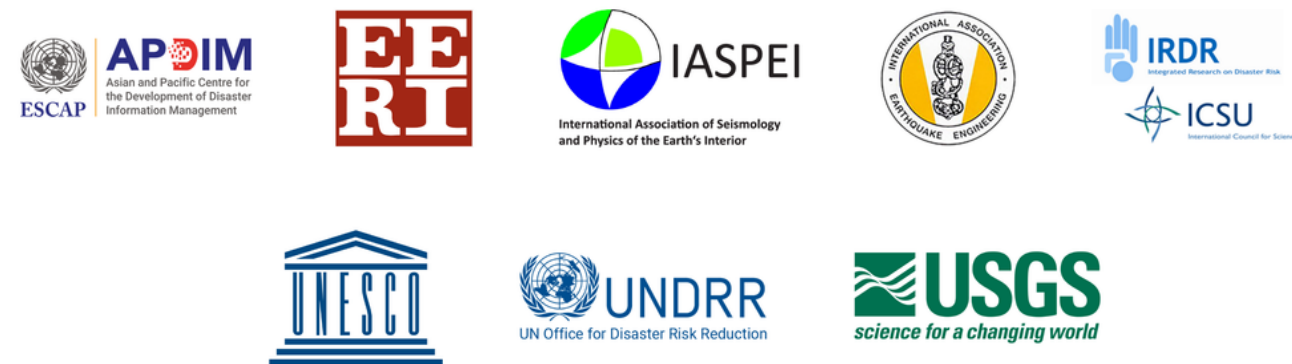
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