Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

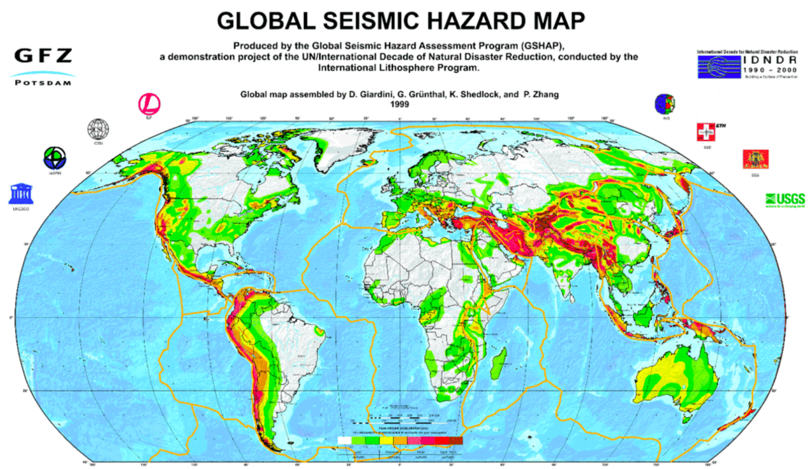
OQ - beyond tailor to fit

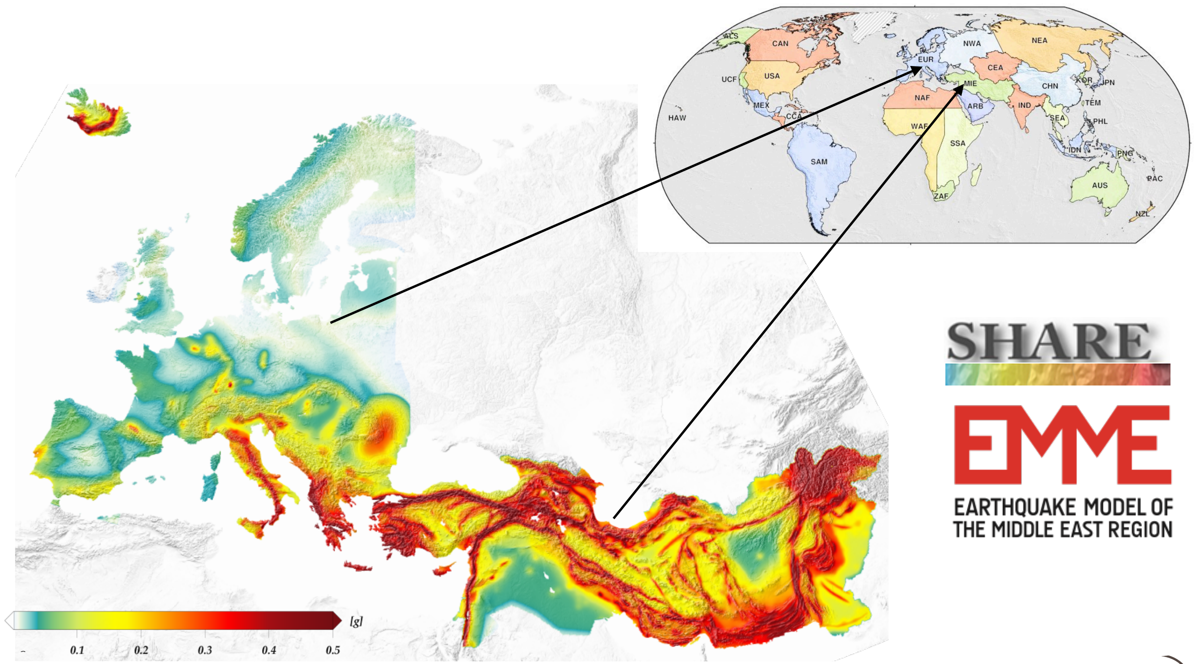
Working with the OQ Engine for site-specific, national and regional hazard assessment

Laurentiu Danciu,
ETH Zurich | Swiss Seismologic Service
Switzerland |

to begin with

- ETH Zurich - Swiss Seismological Service
- GEM1 hazard team
- In House Expertise
- GSHAP legacy (Giardini et al 1999)
- First Regional Projects: SHARE (Europe) and EMME (Middle East)
- First National Model: Seismic Hazard Model
- PEGASUS/PRP Project (P. L. A. Renault et al 2014)



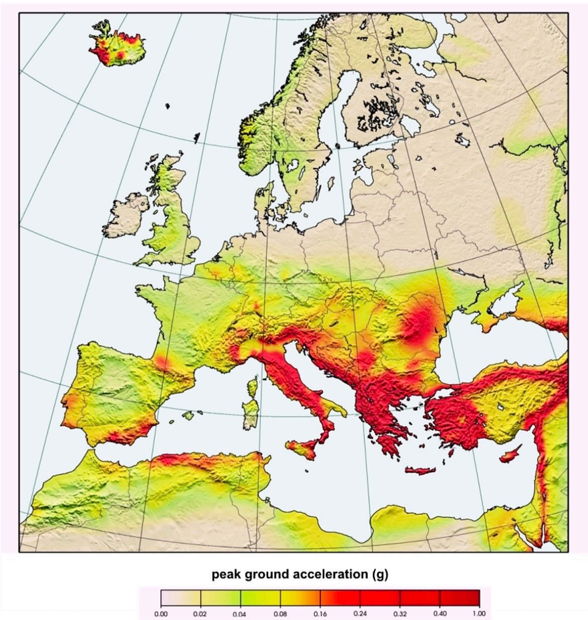


SHARE

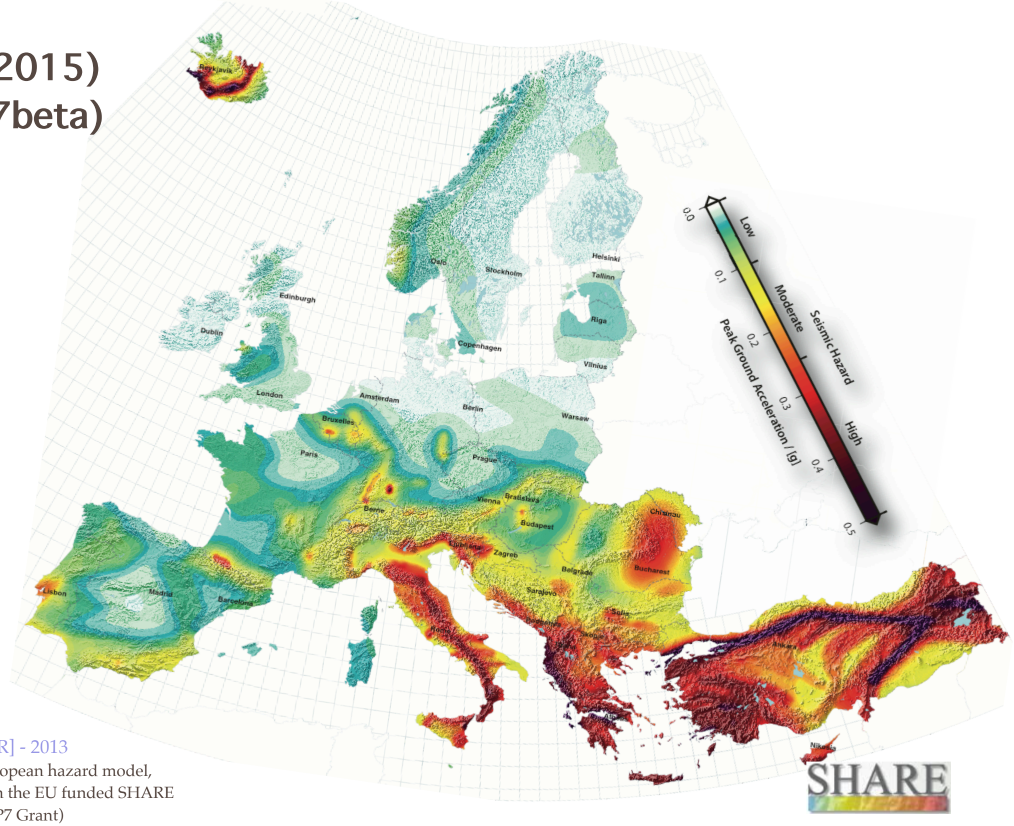
EMME
EARTHQUAKE MODEL OF THE MIDDLE EAST REGION

First steps: Regional Hazard Models

The 2013 European Seismic Hazard Model (Woessner et al 2015)
1st Regional Hazard Model Computed with OpenQuake (v.07beta)



The ESC-SESAME unified hazard model
for the European-Mediterranean region
Jimenez et al (1999)
Unity Model: Unified seismogenic source model
One Attenuation model: Ambraseys 1996,
Musson 1999, Papaioanou and Papazachos 1999



Europe [EUR] - 2013
The latest European hazard model, created within the EU funded SHARE project (EU FP7 Grant)

- 3 source models
- 960 End-Branches
- 12 Intensity Measure Types
- 7 Return Periods [50 to 10000Years]
- Mean, Median and Four Quantile
- 130 000 sites

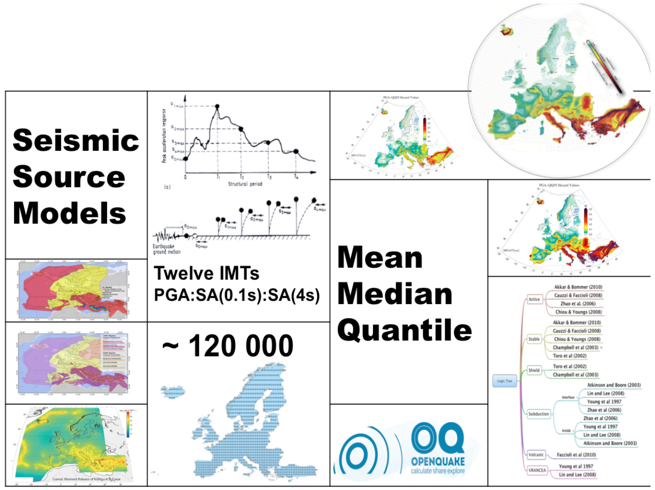
- Hazard Maps: **504**
- Hazard Curves: **9.36 mil**
- Uniform Hazard Spectra: **5.46mil**

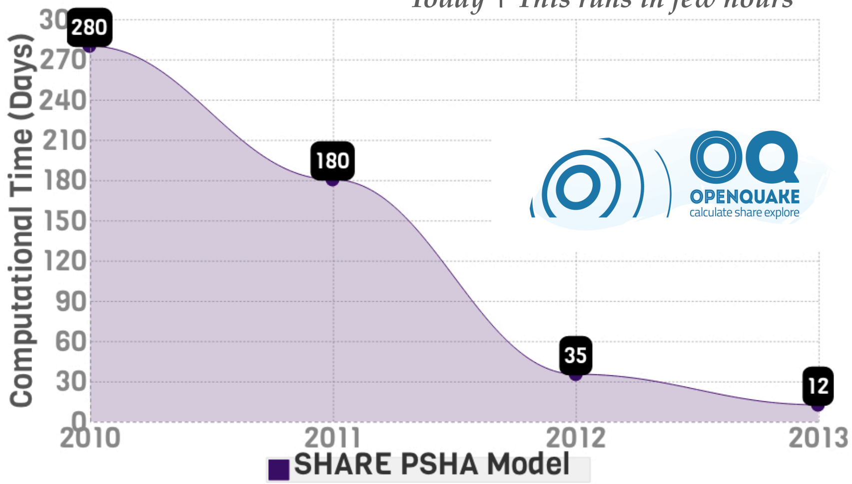
First steps: Regional Hazard Models

The 2013 European Seismic Hazard Model (Woessner et al 2015)

1st Regional Hazard Model Computed with OpenQuake (v.07beta)

- Iterative development process
  - Tailor the models
  - Add features to OpenQuake





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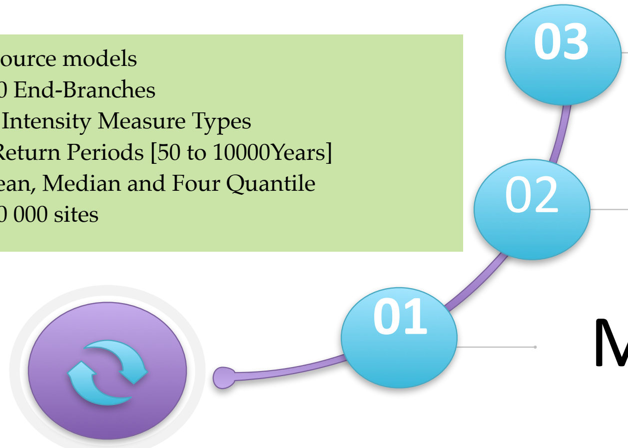


Hardware Limitations

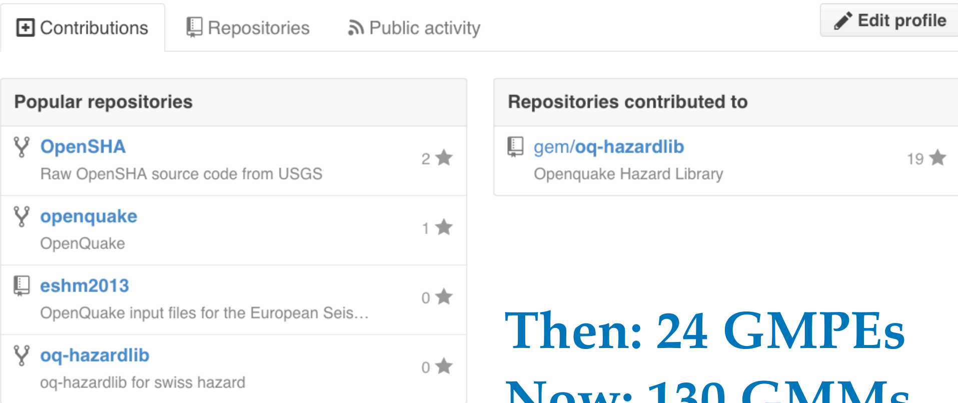
Software Limitations

Model Complexity

Iterative development process - Handling Requirements

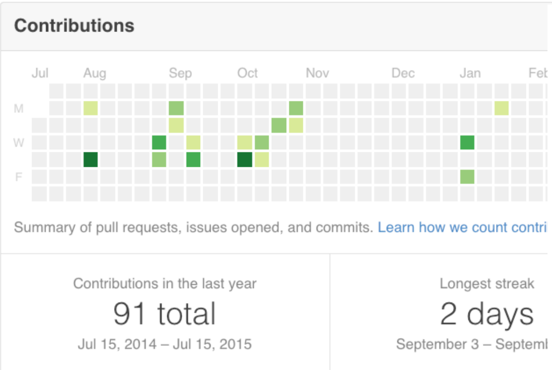
Key features: Library of the Ground Motion Models

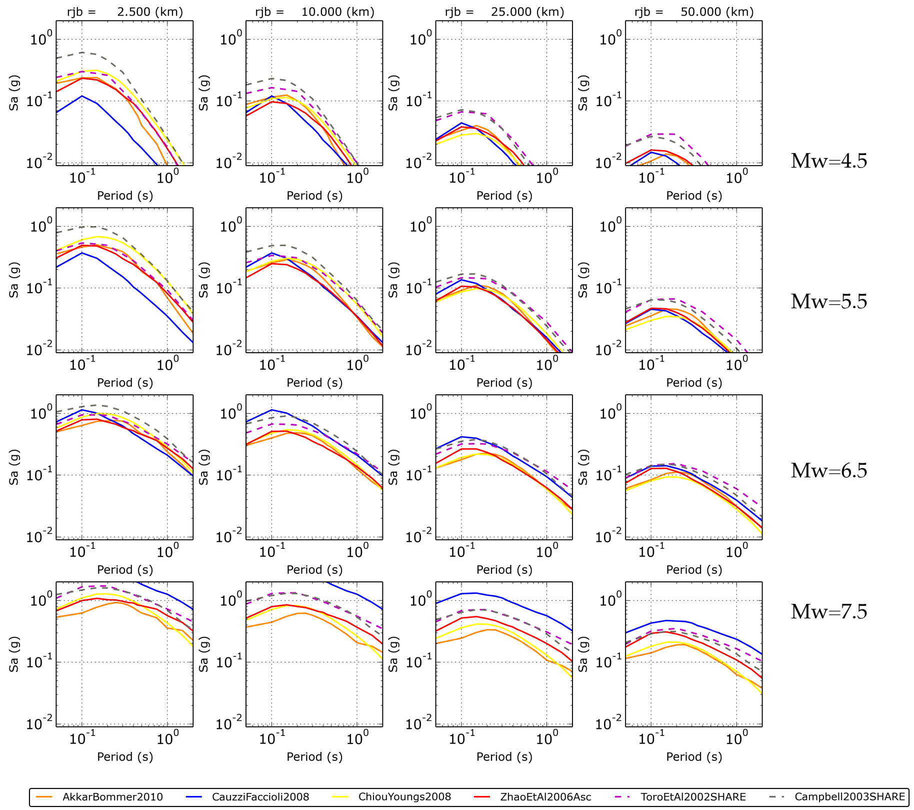
- First set of GMPEs implemented in OQ hazard library (ESHM13, NGA WEST, European & Global GMPEs)
- Establish the testing framework for GMPEs implementation
- GEM Science Tools (GSIM - toolkit, Weatherill et al 2015)



Then: 24 GMPEs

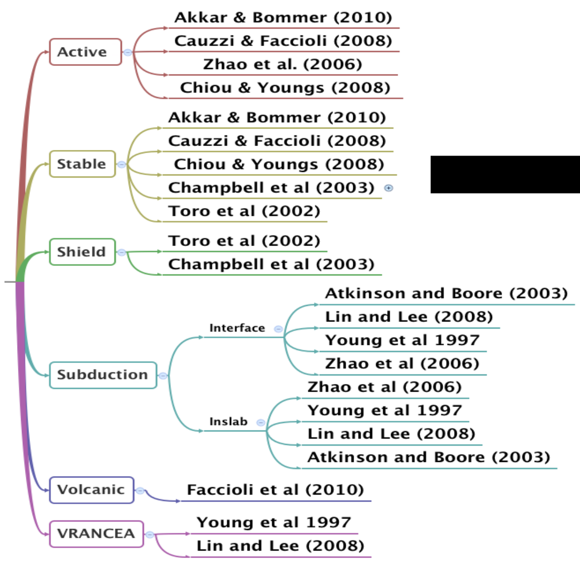
Now: 130 GMMs



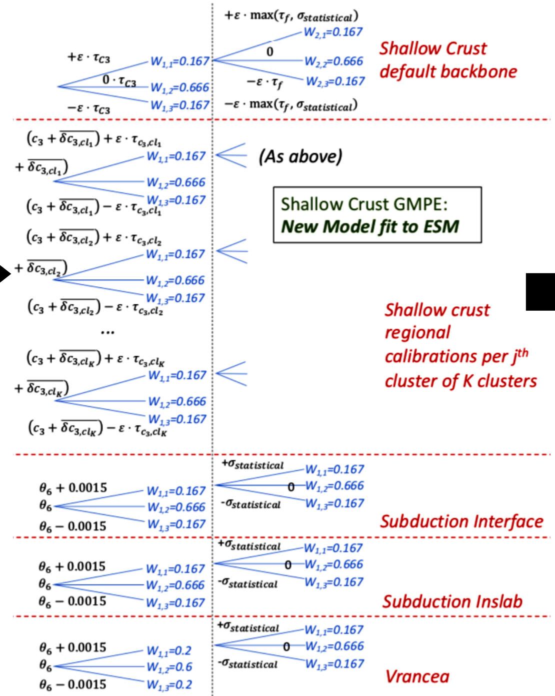


Key features: Library of the Ground Motion Models

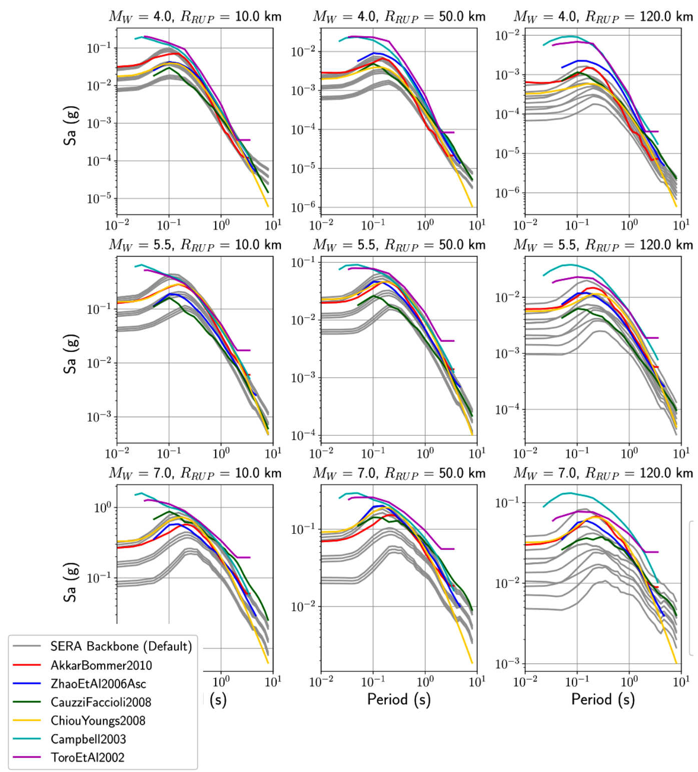
The 2020 European Seismic Hazard Map: Regional Backbone Model (Weatherill et al 2020) - OQ Hazard libraries - GSIM Trellis Plots



Multiple GMPEs



Regional Backbone Models.

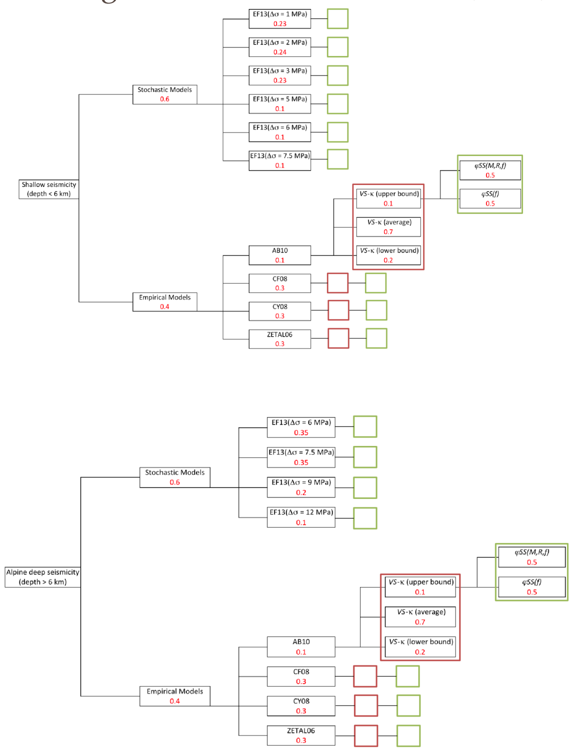


Trellis Plots

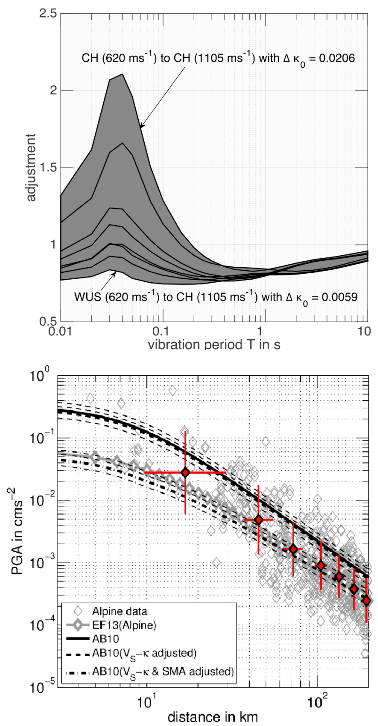
Key features: Library of the Ground Motion Models

The 2015 Swiss Hazard Model (Wiemer et al 2015)

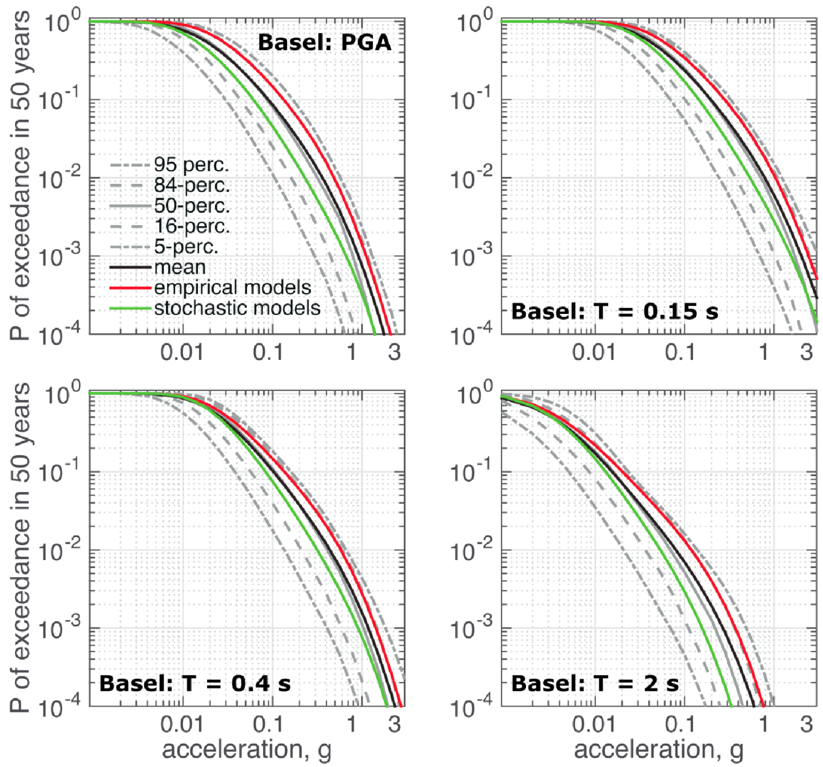
- OQ Hazard libraries - Complex Ground Motion model, stochastic and adjusted empirical ground motion models
- Vs30-kappa and small magnitude adjustments
- Single station sigma
- Extending Ground Motion Models (2014)



Wiemer et al 2015

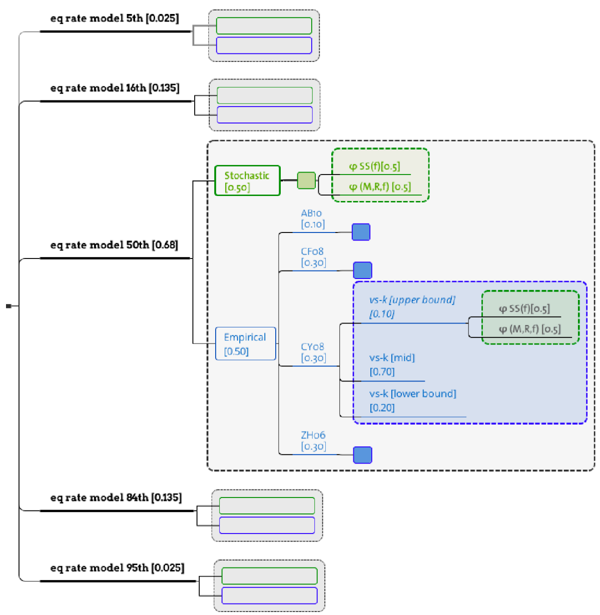


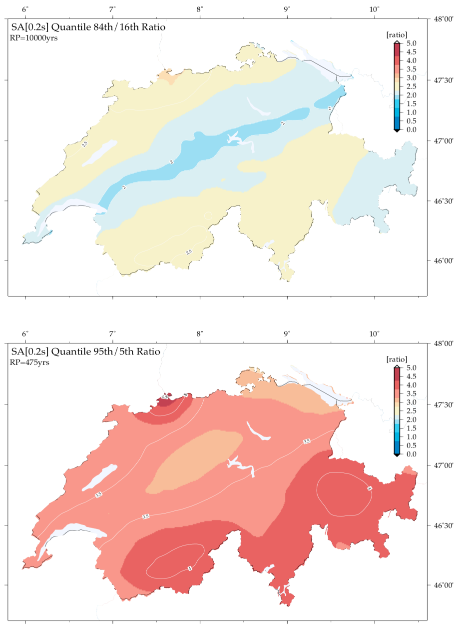
Edwards et al 2015

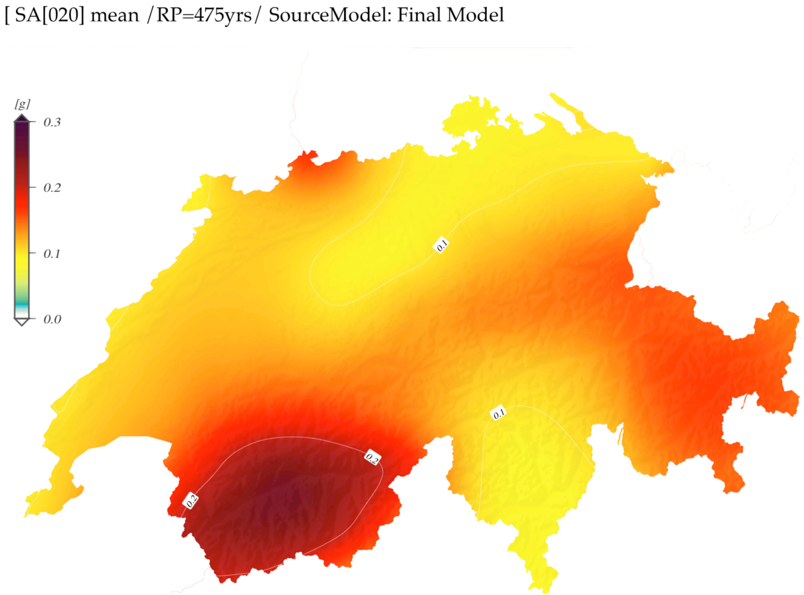


Key features: Modelling Uncertainties

- OpenQuake offers two methods for processing the logic tree:
  - Monte Carlo Sampling: useful in case of large logic trees (e.g. LT containing uncorrelated uncertainties on seismic sources)
  - Path Enumeration: useful in case of small logic trees (e.g. LT including few GMPEs, correlated uncertainties)







Computational time: 65h - 100k Sampling | full output , no post processing | 48CPUs - 256Gb RAM

2015 Swiss Hazard Model (Wiemer et al 2015)

- 5 seismogenic source model | 36 GMPEs | ~ 1M End-Branches | 100K sampled

Key features: Modelling Uncertainties

- OpenQuake offers two methods for processing the logic tree:
  - Monte Carlo Sampling: useful in case of large logic trees (e.g. LT containing uncorrelated uncertainties on seismic sources)
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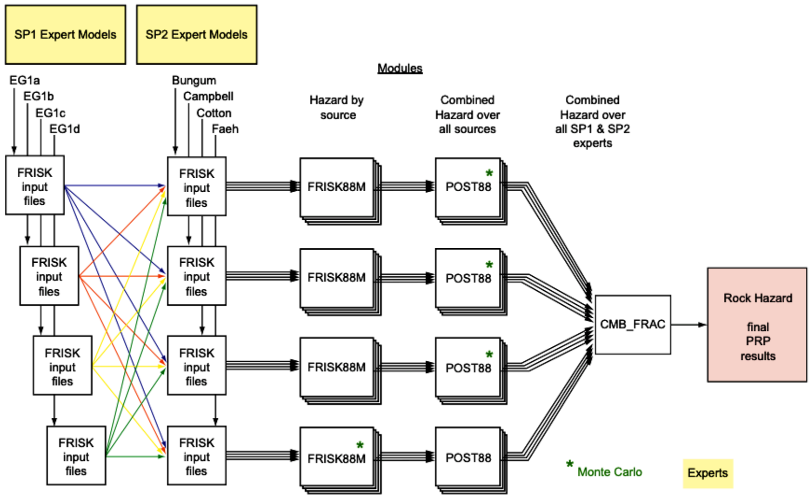
PEGASOS Refinement Project

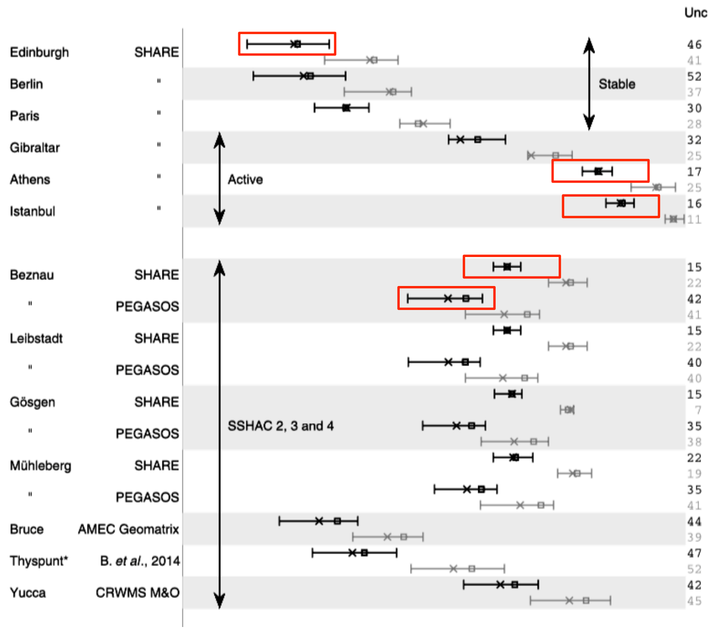
Probabilistic Seismic Hazard Analysis for Swiss Nuclear Power Plant Sites

Volume 1
- Summary Report -

by

Philippe L.A. Renault, Norman A. Abrahamson, Kevin J. Coppersmith, Martin Koller, Philippe Roth & Andreas Hölker





Douglas et al 2015

No more need to define inputs for each logic tree path and run calculation in a batch and to post-process the results of different realisations

Key features: Continuous Update and Integration

Tips for running large hazard calculations

Running large hazard calculations, especially ones with large logic trees, is an art, and there are various techniques that can be used to reduce an impossible calculation to a feasible one.

The first thing to do ¶

The first thing to do when you have a large calculation is to reduce it so that it can run in a reasonable amount of time. The simplest way to do that is to reduce the number of sites, for instance by considering a small geographics portion of the region interested, of by increasing the grid spacing. Once the calculation has been reduced, you can run it and determine what are the factors dominating the run time.

As we discussed in section common mistakes, you may want to tweak the quadratic parameters (`maximum_distance`, `area_source_discretization`, `rupture_mesh_spacing`, `complex_fault_mesh_spacing`). Also, you may want to choose different GMPEs, since some are faster than others. You may want to play with the logic tree, to reduce the number of realizations: this is especially important, in particular for event based calculation were the number of generated ground motion fields is linear with the number of realizations.

Once you have tuned the reduced computation, you can have an idea of the time required for the full calculation. It will be less than linear with the number of sites, so if you reduced your sites by a factor of 100, the full computation will take a lot less than 100 times the time of the reduced calculation (fortunately). Still, the full calculation can be impossible because of the memory/data transfer requirements, especially in the case of event based calculations. Sometimes it is necessary to reduce your expectations. The example below will discuss a concrete case.

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Michele Simionato OQ Lead Architect
https://docs.openquake.org/oq-engine/advanced/index.html

Take Away Message

- OpenQuake - A Game Changer
- Continuous improvement, facilitates evolution of models and tools
- Outstanding support for developing and implementing - hazard & risk models & tools
- GEM - excellent community engagement and support

The **OpenQuake Engine** is an open source application that allows users to compute **seismic hazard** and **seismic risk** of earthquakes on a global scale. It runs on Linux, macOS and Windows, on laptops, workstations, standalone servers and multi-node clusters. DOI: 10.13117/openquake.engine

build passing | python 3.6 | 3.7 | pypi v3.10.1 | wheel yes | code quality: python A

Current stable

Current stable version is the **OpenQuake Engine 3.10** 'Ulomov'. The documentation is available at https://github.com/gem/oq-engine/tree/engine-3.10#openquake-engine.

- What's new

Documentation (master tree)

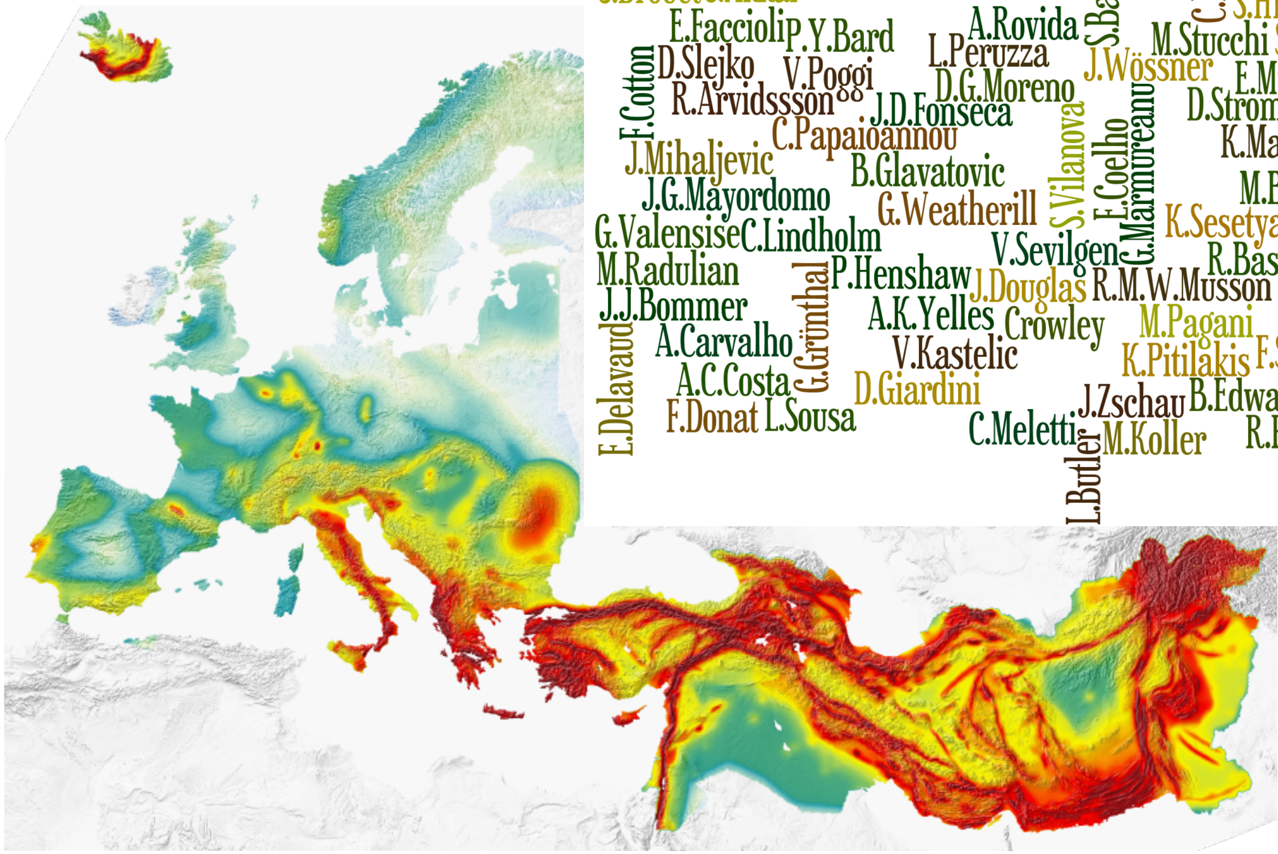
General overview

- About
- FAQ
- Manuals
- OQ Commands
- Architecture

open source

Transparent
Adaptable
Maintained
Customisable
Scalable

To many researchers and scientists contributing to the development of the regional and national models



A.Pinto S.Drouet S.Akkar E.Facciolip Y.Bard F.Cotton D.Slejko V.Poggi R.Arvidsssson J.D.Fonseca L.Peruzza A.Rovida D.G.Moreno S.Barba C.Bosse M.Stucchi J.Wössner R.Stein L.Gulen S.Hiemer B.Wyss S.Wiemer E.Mustafa D.Stromeyer K.Makropoulos D.Monelli C.Papaioannou J.Mihaljevic B.Glavatovic J.G.Mayordomo G.Weatherill S.Vilanova E.Coelho G.Marmureanu M.B.Demircioglu K.Sesetyan V.D'Amico G.Valensise C.Lindholm V.Sevilgen R.Basili H.Bungum M.Radulian P.Henshaw J.Douglas R.M.W.Musson M.Segou J.J.Bommer G.Grünthal A.K.Yelles Crowley M.Pagani A.Carvalho V.Kastelic K.Pitilakis F.Scherbaum E.Delavaud A.C.Costa D.Giardini J.Zschau B.Edwards C.Beauval F.Donat L.Sousa C.Meletti L.Butler M.Koller R.Pinho T.Nikos O.Scoti

THANK YOU!

M.Erdik S.Adamia A.Elias H.Yalçın Ö.Kale R.Jaradat C.Tuzun K.Hessami M.Sayab D.Giardini K.Sesetyan R.Durgaryan A.Arakelyan M.Al-Qaryouti T.Mammadli H.Babayan M.Demircioglu A.Axundov L.Danciu N.Tsereteli A.Khan T.Chelidze L.Gulen M.Utkucu M.Zare S.Akkar

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GEM's IT Team, present and past members: Daniele Viganò, Lars Butler, Muharem Hrnjadovic, Anton Gritsey, John Tarter

GEM Secretariat, present and past members: John Schneider, Rui Pinho, Anselm Smolka, Helen Crowley

SED-ETH Zurich : Domenico Giardini, Stefan Wiemer, Florian Haslinger

Congratulation!

THANK YOU!