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Advancing Seismic Risk Analysis through an Integrated Web Service for Ground Motion Record Selection and Scaling

Gerard J. O'Reilly[1], *Volkan Ozsarac*[2], *Davit Shahnazaryan*[2]

1 – Associate Professor, IUSS Pavia, Italy

2 – Postdoctoral Researcher, IUSS Pavia, Italy

IUSS
Scuola Universitaria Superiore Pavia

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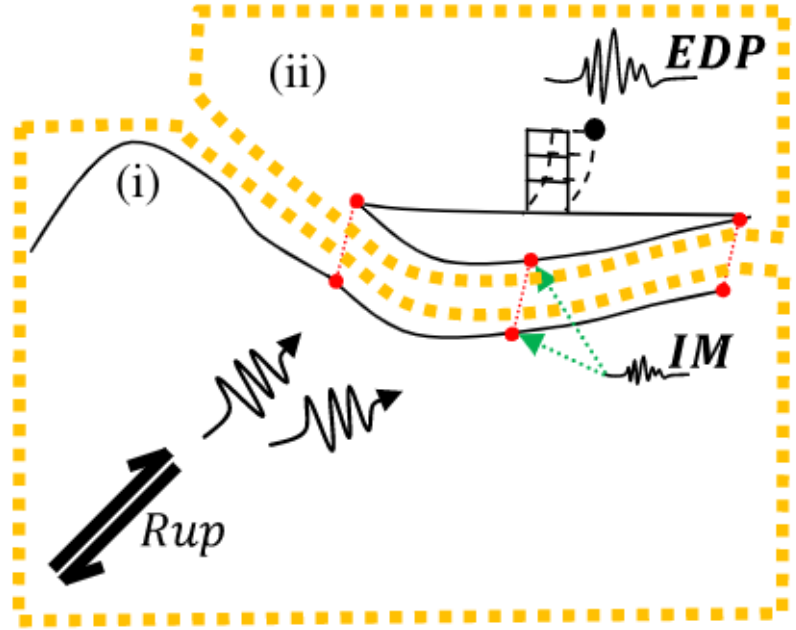
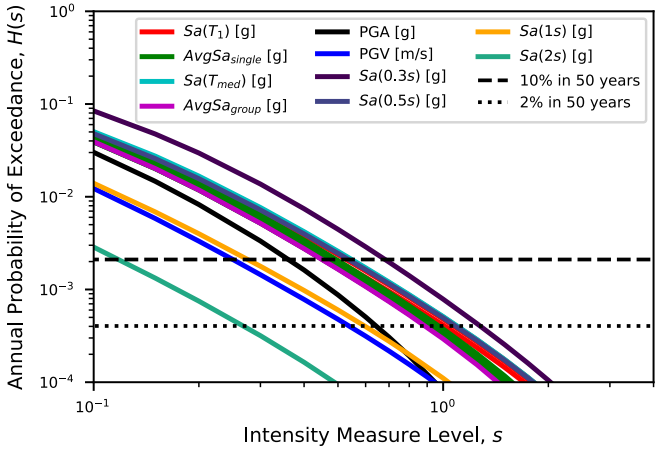
RISK-DATA-ENGINEERING

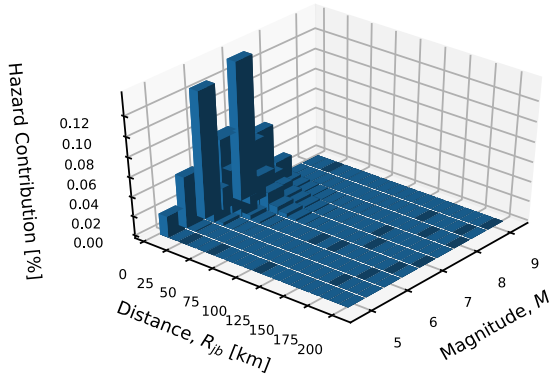
ROSE
Centre for Training and Research on Reduction of Seismic Risk

An engineering perspective on hazard and risk

- An intensity measure (IM) is the interface parameter linking seismological and engineering aspects in seismic design and assessment
- GMMs are used as part of PSHA to evaluate the probability of exceeding an IM level for a specific location over a given period of time
- Engineers then use the same IM to examine the subsequent response of structures and to evaluate seismic response



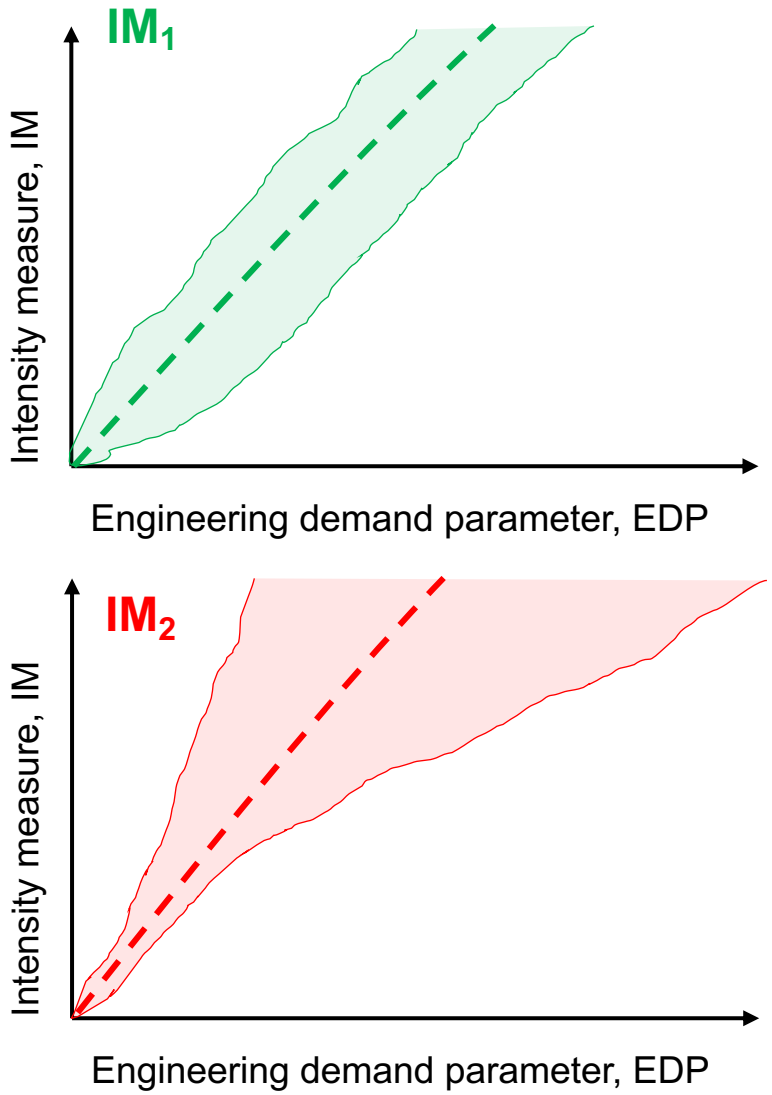




Bradley, B. A. (2012). The seismic demand hazard and importance of the conditioning intensity measure. Earthquake Engineering & Structural Dynamics, 41(11), 1417–1437. https://doi.org/10.1002/eqe.2221

Intensity measures

- Recent research has studied different IMs for engineering applications
- Many alternative IMs better describe structural response for engineering applications



Intensity measures

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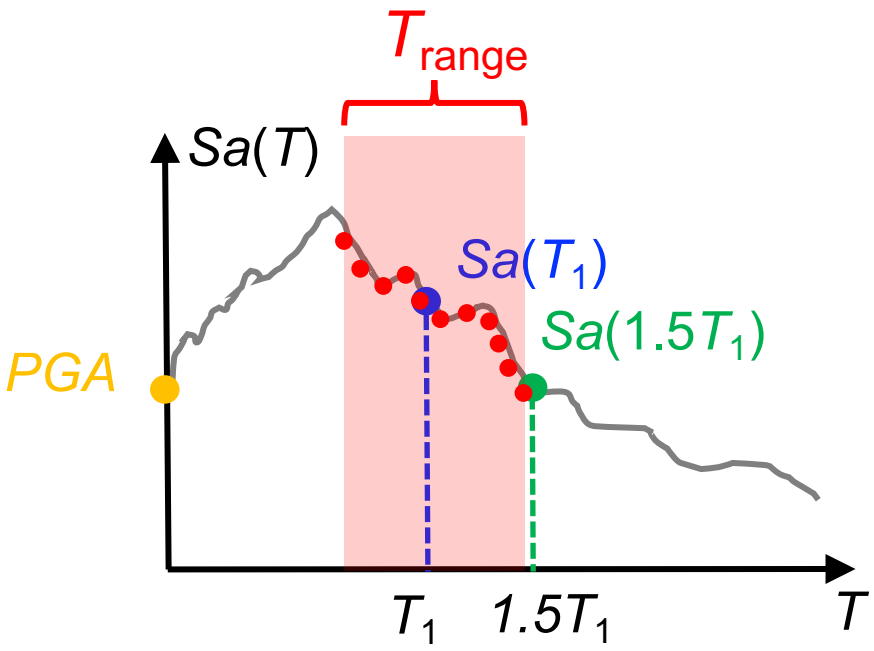
- Many alternative IMs better describe structural response for engineering applications
- These range from
  - The classic spectral acceleration at periods other than the first mode of vibration – $Sa(1.5T_1)$
  - An averaged value of spectral acceleration at several periods – $Sa_{avg}(T)$
  - IMs that consider the velocity characteristics – *FIV3*
  - IMs that incorporate durations and pulses



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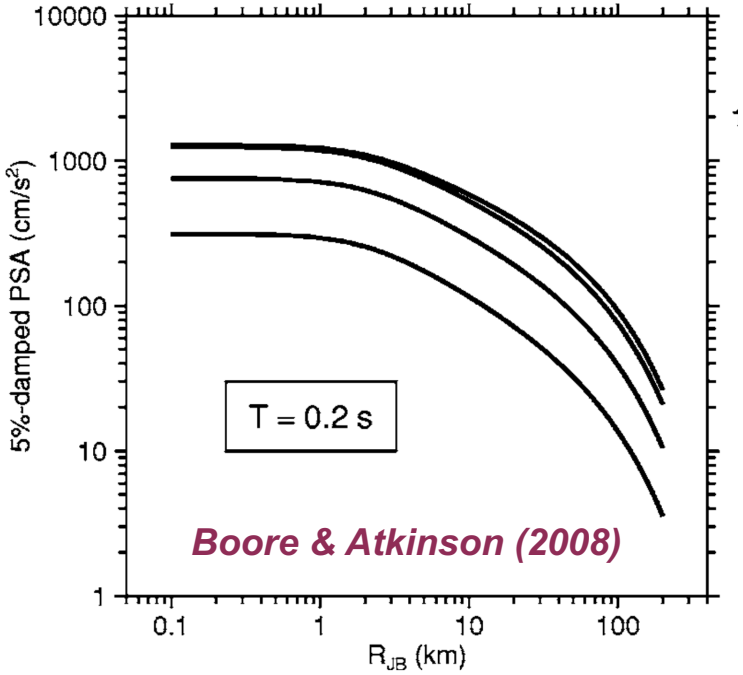
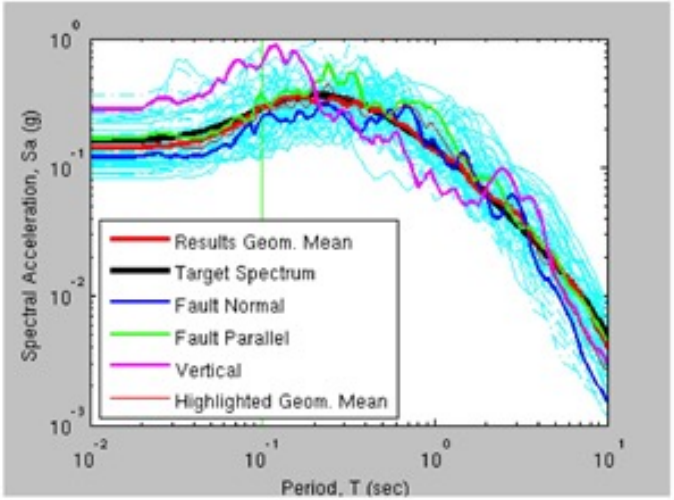
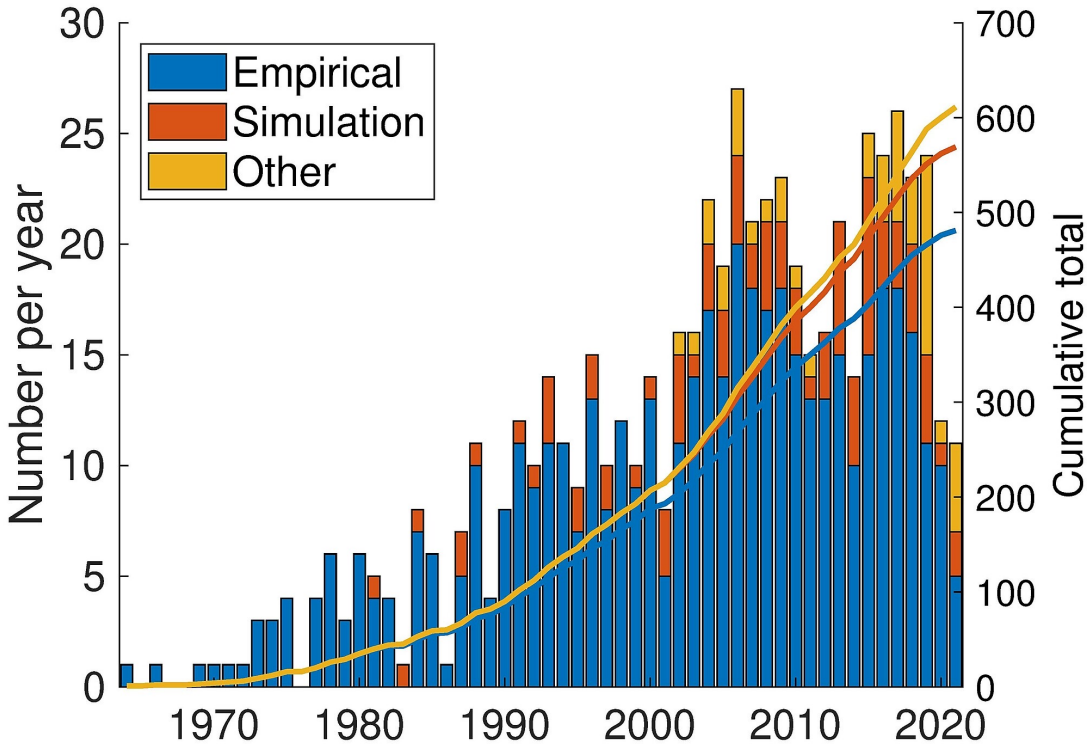
  - IMs that consider the velocity characteristics – *FIV3*
  - IMs that incorporate durations and pulses
- Many ground motion models **do not cover** these IMs
- Many record selection tools **do not allow** selection for engineering purposes based on these





Development of hazard analysis tools

- There has been a steady development of ground motion models (GMMs) to characterise the probabilistic distributions of ground-shaking
- Among other parameters, these typically tend to differ in terms of:
  - Intensity measure
  - Ground motion database and filtering criteria
  - Regional context
  - Modelling fitting techniques
  - Etc.



http://www.gmpe.org.uk

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  - Intensity measure
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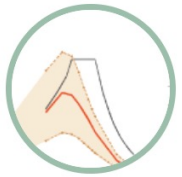
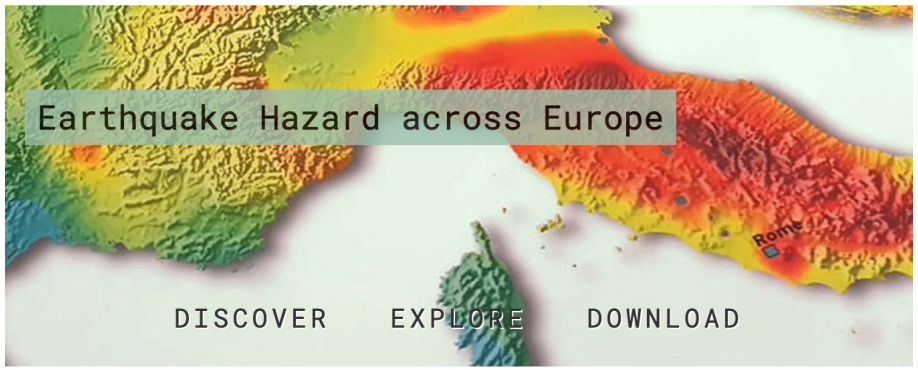
  - Etc.
- There has been a notable development of seismicity models and computational tools to conduct probabilistic seismic hazard analysis (PSHA):
  - ESHM 2013 and 2020
  - OpenQuake engine



Hazard Spectra

Hazard Curves

Hazard Maps



The hazard.EFEHR web platform provides access to interactive tools such as seismic hazard models, products and information. Distributed data, models, products and information are based on research projects carried out by academic and public organisations.

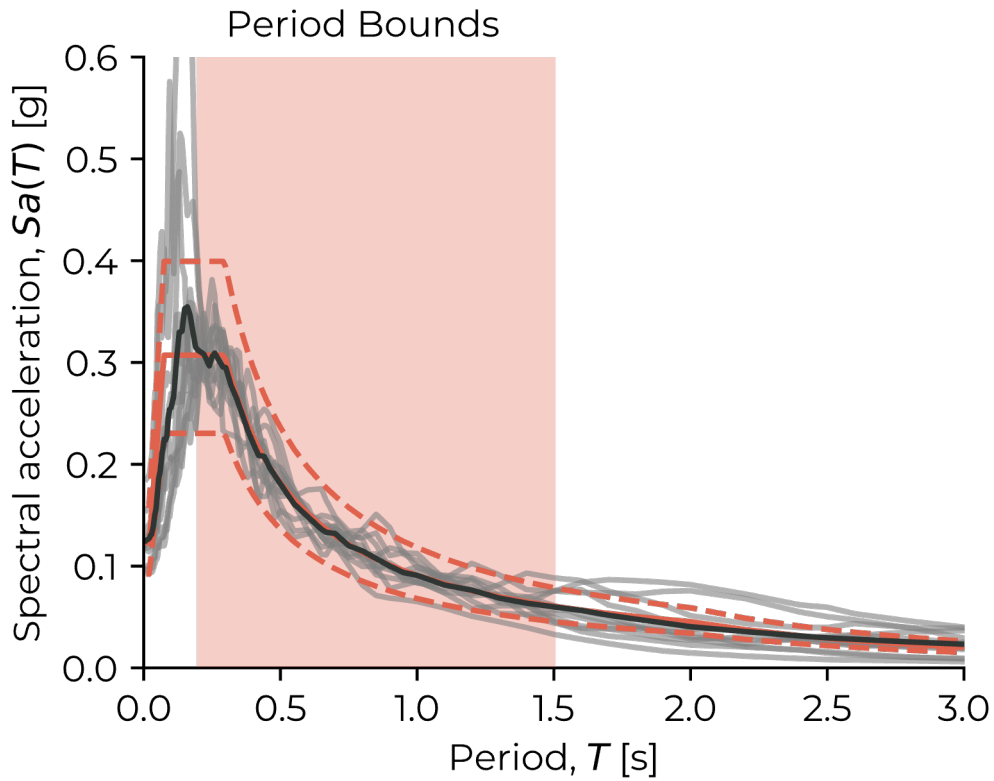
Currently, the seismic hazard models and resources for Europe, the Middle East, the GSHAP global model and the Swiss Seismic Hazard Model are available.

Access the seismic hazard tools below:

Utilisation of seismic in engineering practice

- Several approaches exist to identify the target hazard characteristics for ground motion record selection
  - Uniform hazard spectrum
  - Conditional spectrum
  - Unconditional spectrum (Scenario analysis)
  - Other generalised methods
- These records can be either natural, simulated, scaled, etc.

Uniform hazard spectrum
- Typically required by building codes



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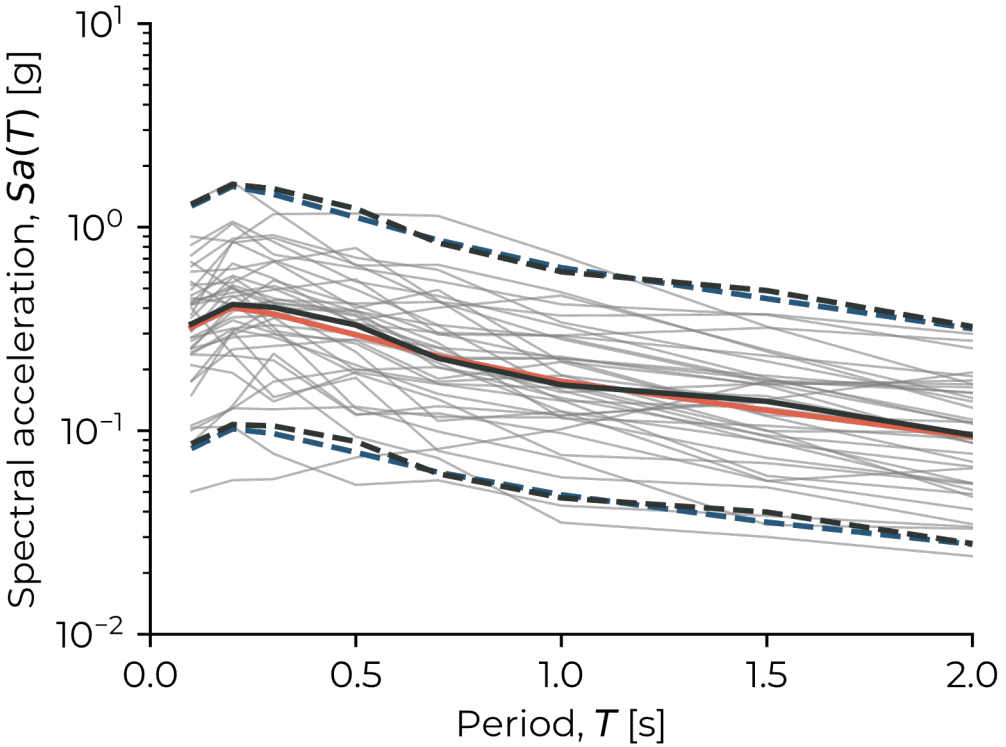
Unconditional spectrum
- Useful for analysing the consequences of specific earthquake scenarios



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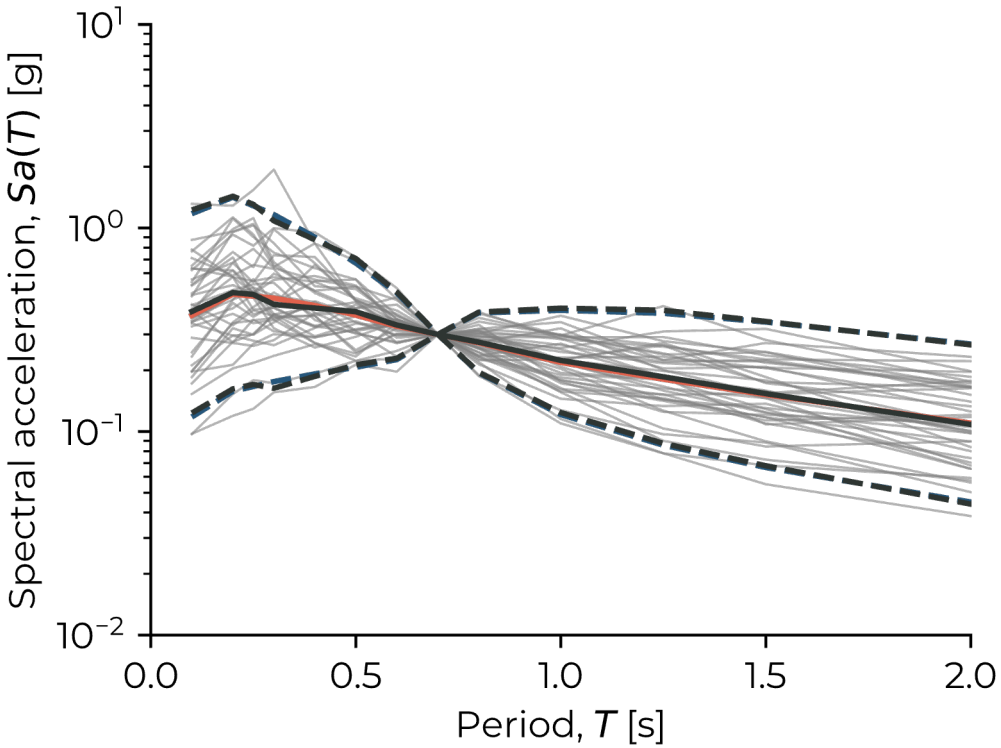
Conditional spectrum

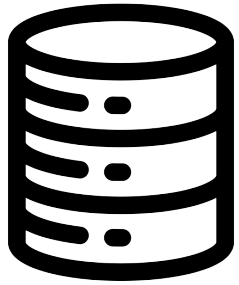
- Useful for hazard-consistent analysis for multiple stripe analysis



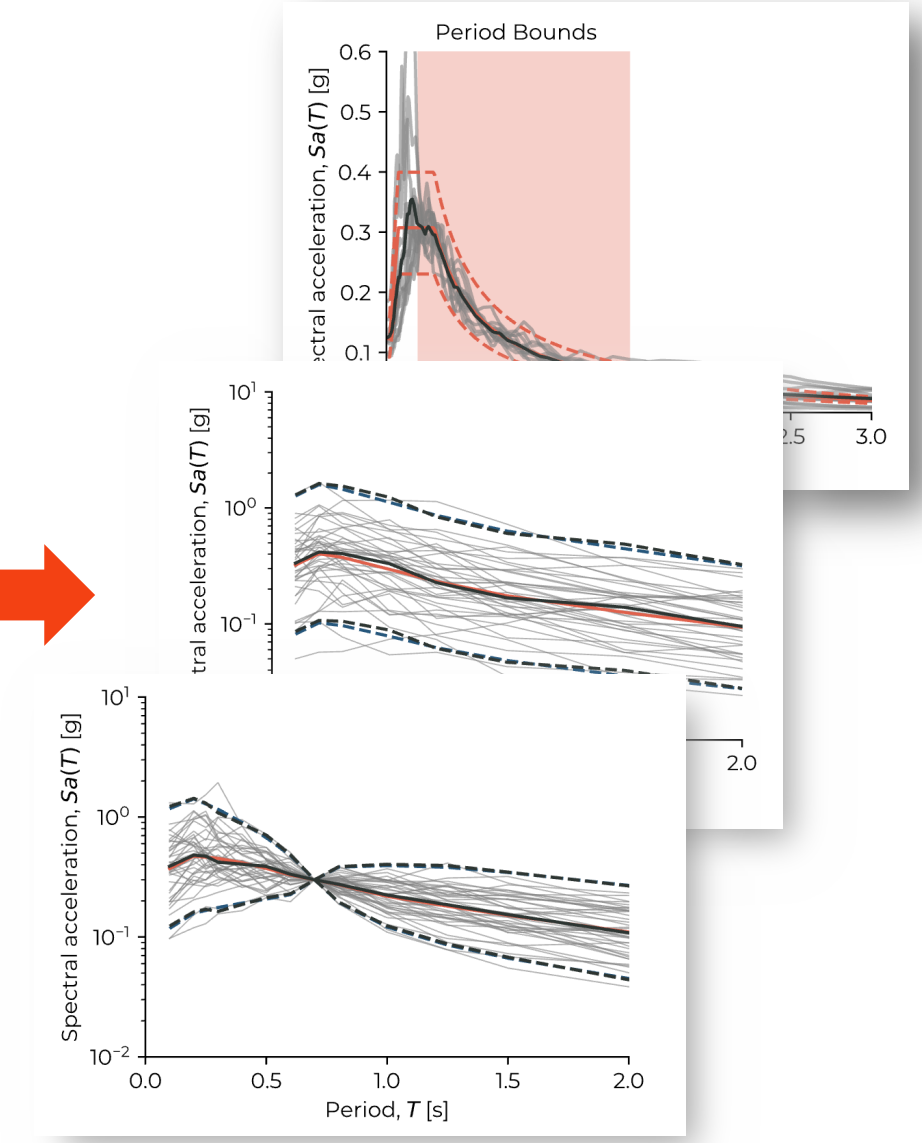
Overview

- There is a lot of valuable information on engineering seismology
- To be fully utilised in engineering practice, it needs to be better integrated with web services and APIs
- It needs to incorporate recent engineering research
- We have developed a tool that does these things

Ground motion databases



Expert knowledge



Online platform

- An online platform has been developed to integrate many of these existing services and know-how
- It is designed to fill the gap between seismic hazard analysis and engineering practice

Seismology and hazard

Practical engineering

R-CRISIS

OPENQUAKE

SEISMOSOFT
EARTHQUAKE ENGINEERING SOFTWARE SOLUTIONS

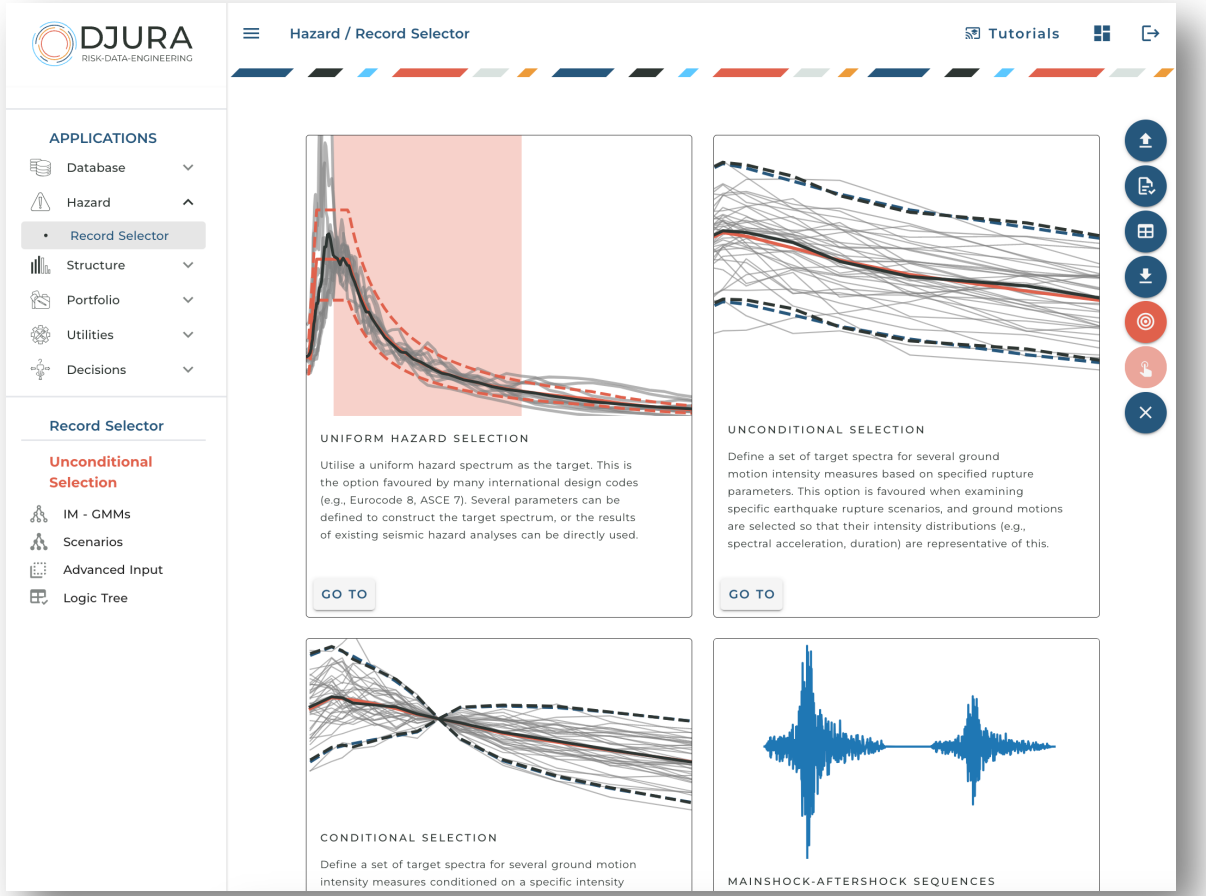
Workflow

EFEHR

OpenSees

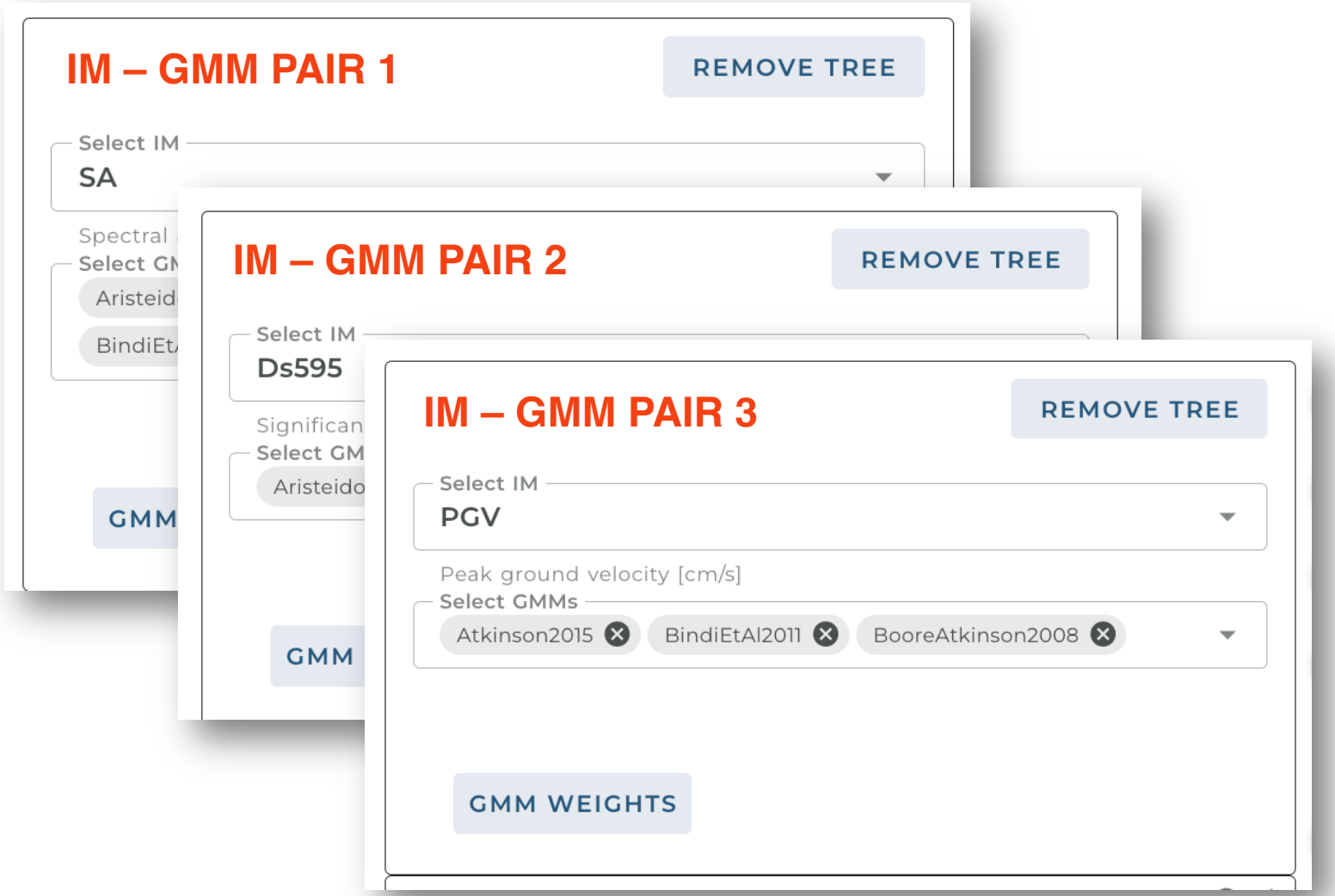
SAP2000

www.apps.djura.it



Generalised Conditional Spectra

- It can handle multiple IM and GMM combinations
- It considers several rupture scenarios
- The analyst just needs to feed it the outputs of PSHA



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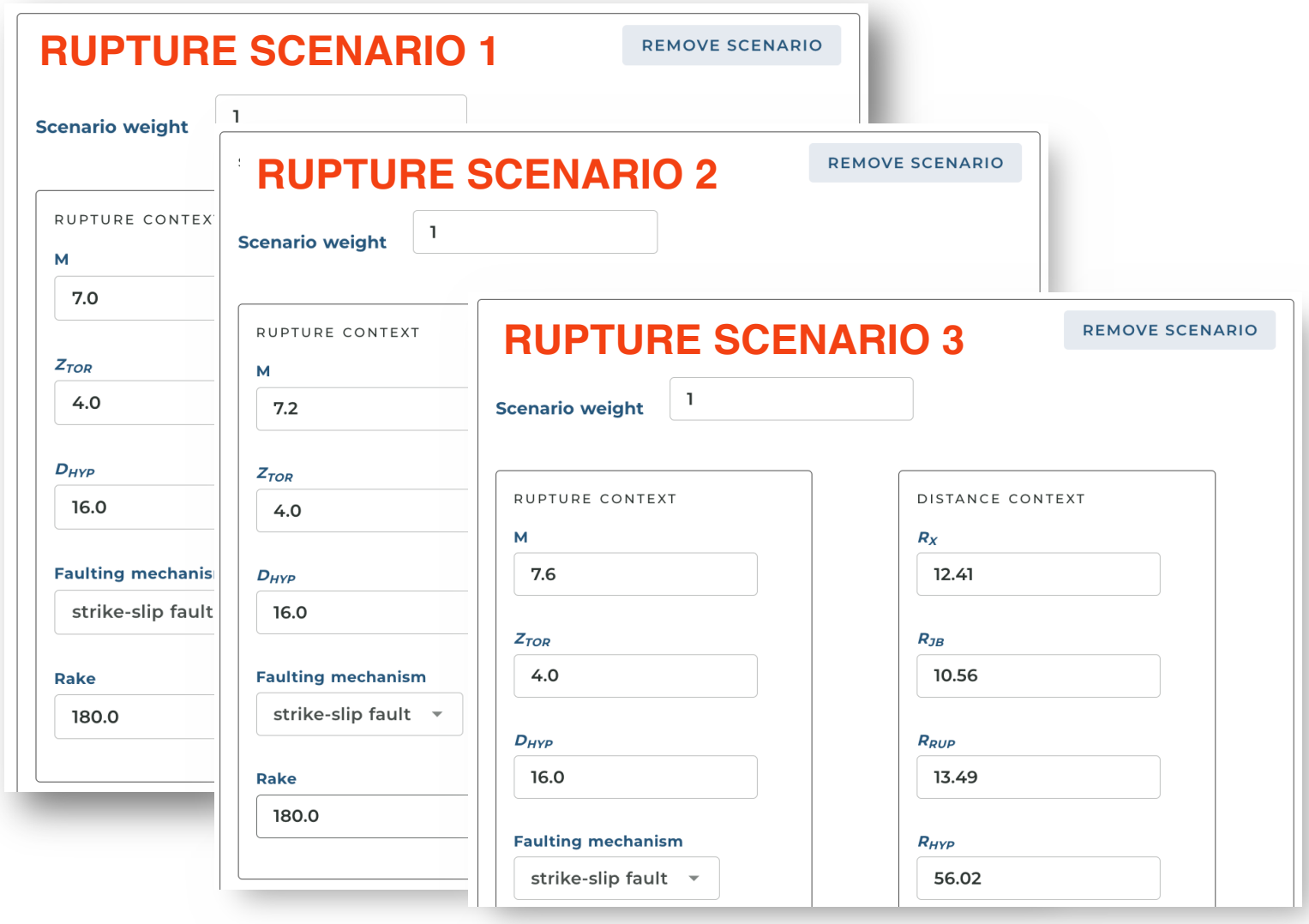
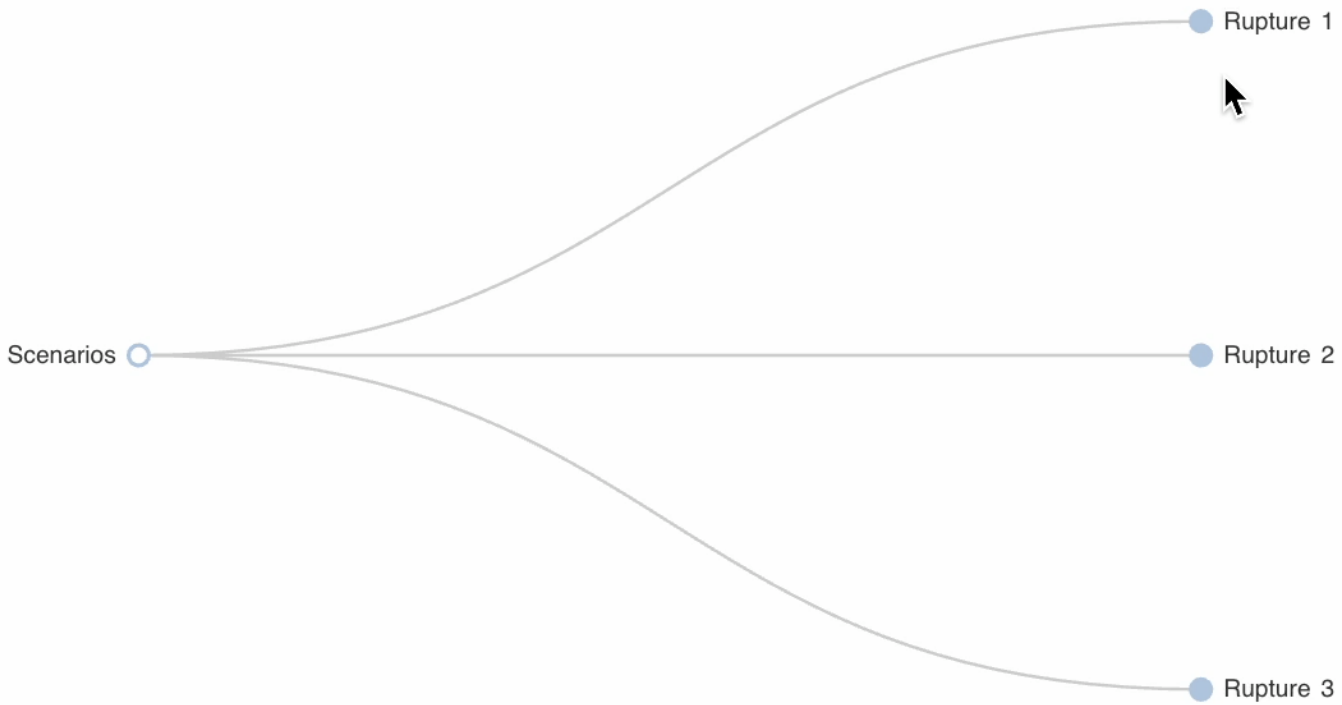


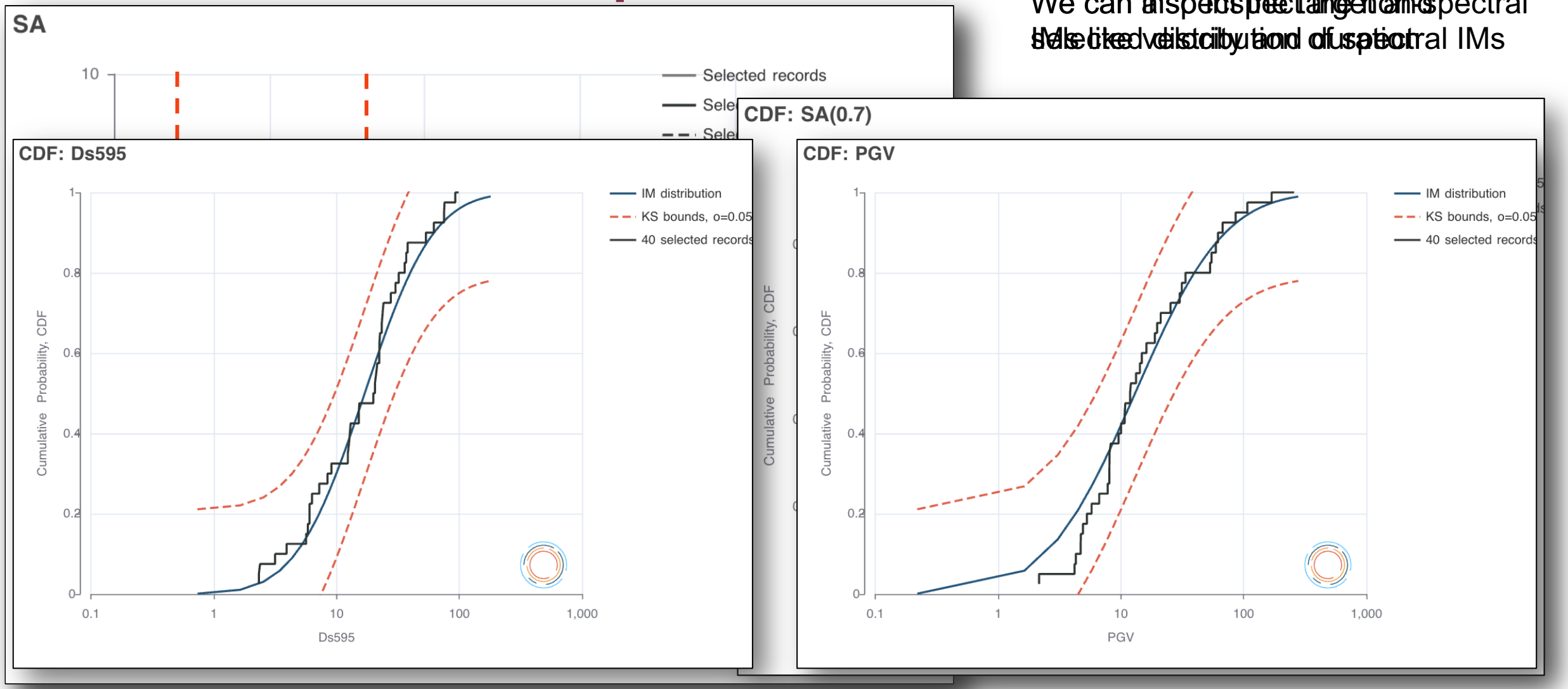
Generalised Conditional Spectra

- Visualise the full logic tree
- In terms of rupture scenarios and GMMs
- Inspect the individual weights and contributions



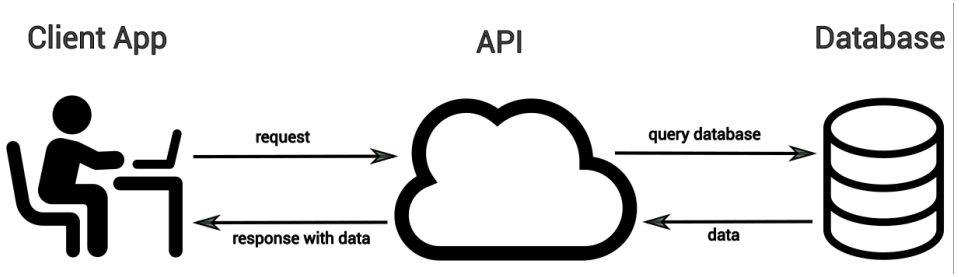
Record Selector Outputs

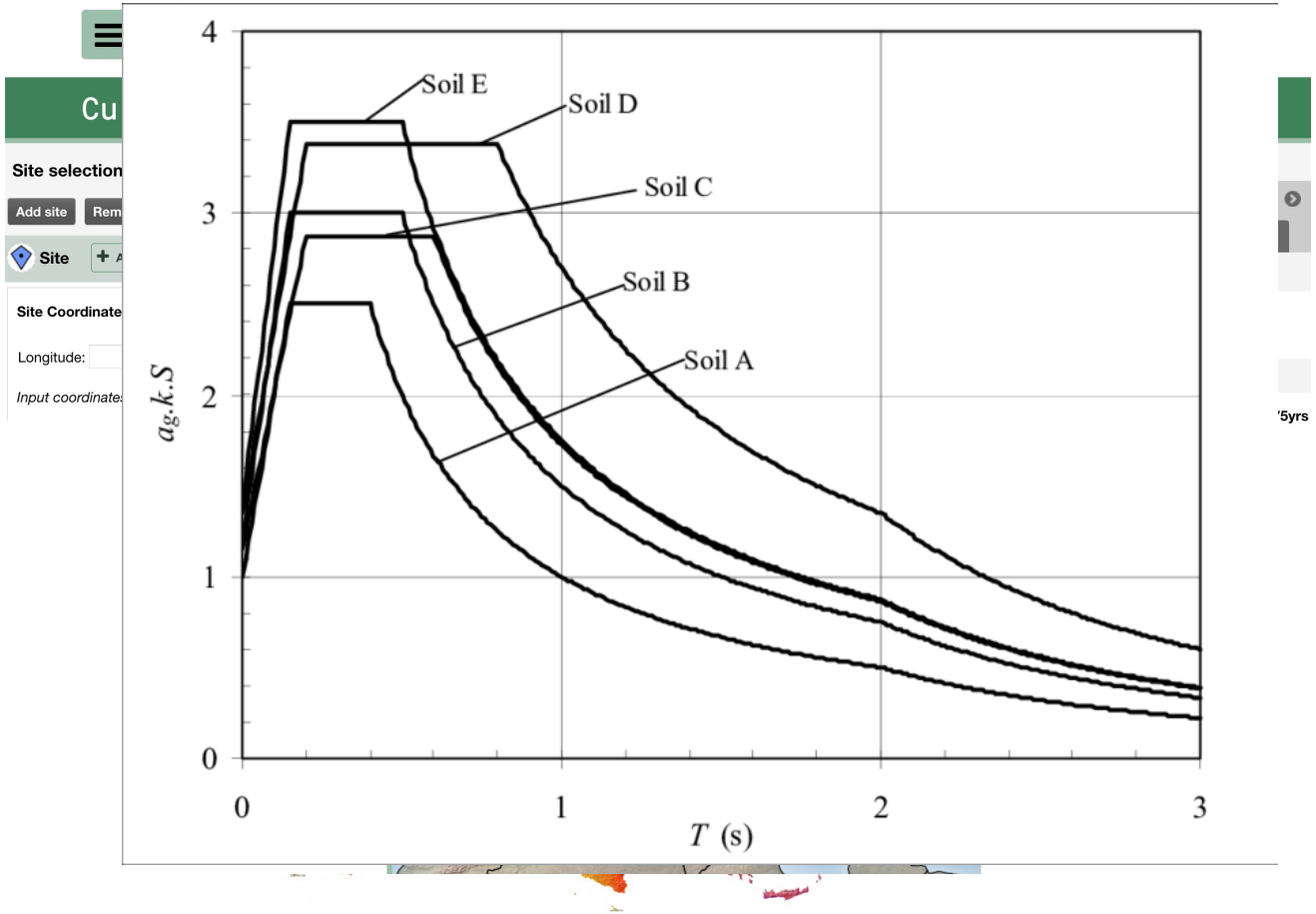
We can also inspect the target and selected distribution of spectral IMs



Integration with EFEHR via web services

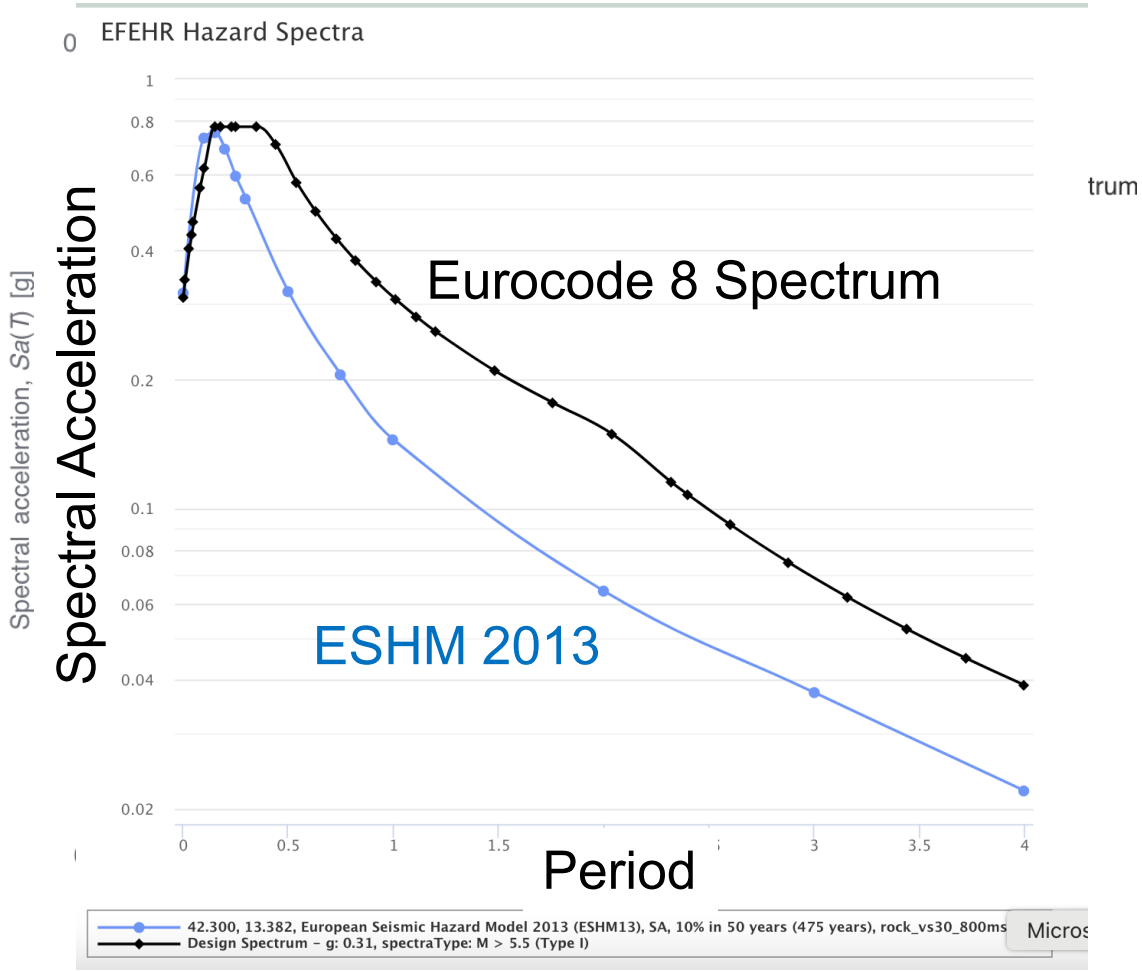
- One of the most significant developments on a European level is the integration with EFEHR's hazard platform
- There is a wealth of knowledge on the latest hazard models for all of Europe
- When possible, this would be preferable to smoothed code spectra that at times can not be aligned with detailed hazard analyses
- We can do this with web services





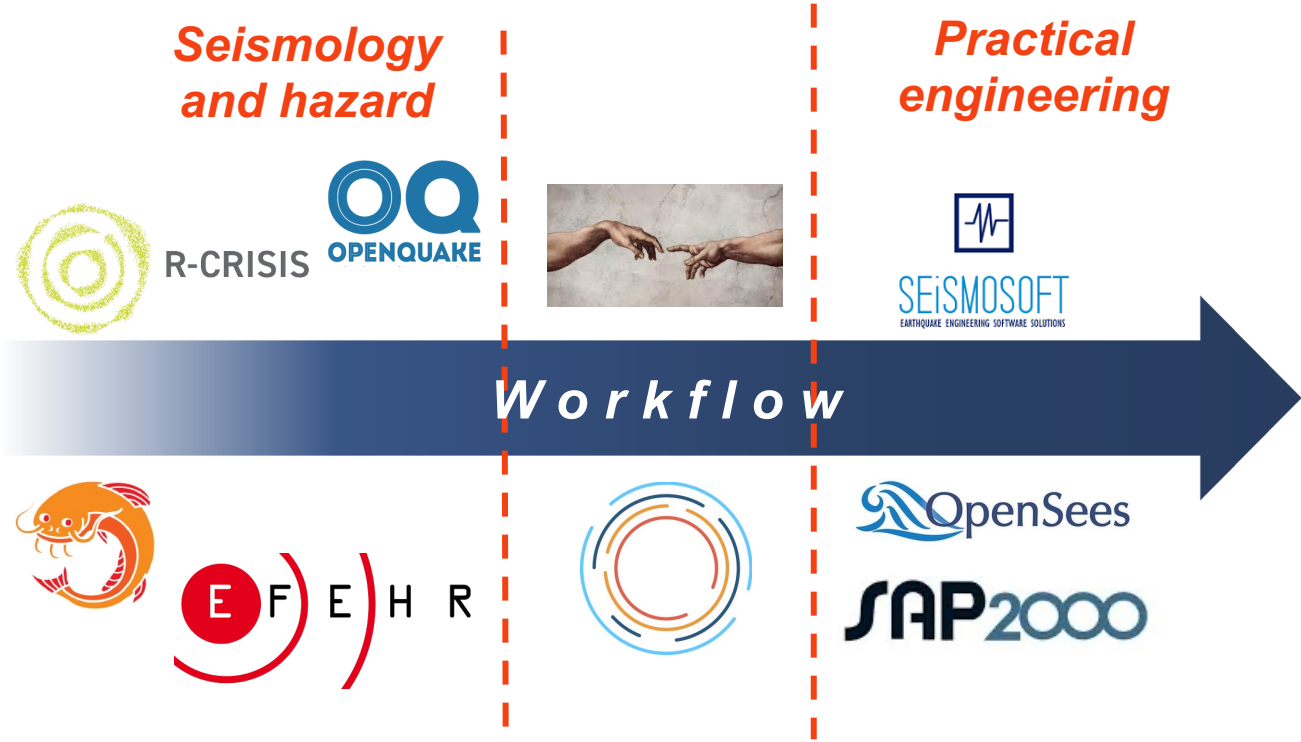
Integration with EFEHR via web services

- The user needs to input the longitude and latitude of their site
- They are then prompted for a series of parameters:
  - Model: ESHM 2013 and 2020
  - Probability of Exceedance (POE): 0.5, 0.39, 0.1, 0.05, 0.02, 0.01
  - Investigation time span: 50 years
  - Site class: Soil class A (Rock)
  - Hazard disaggregation type: mean, percentiles
- This is more desirable in many instances, as it represents the actual hazard based on updated models
- Not an analytical function based on data from the 1990s



Conclusions

- Ground motion record selection is a vital part of practical engineering
- This ranges from vulnerability model development all the way to risk models
- Practical engineering design and verification depend a lot on this, too
- There is sometimes a gap in tools and know-how when transferring research knowledge to practice and widespread use
- This tool is implemented as a user-friendly GUI and also API
- It can be used directly from Python or Matlab on your machine
- The development of these tools aims to address that



Questions?

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