GEM

GLOBAL EARTHQUAKE MODEL

working together to assess risk

The OpenQuake Engine Hazard: Past, Present and Future

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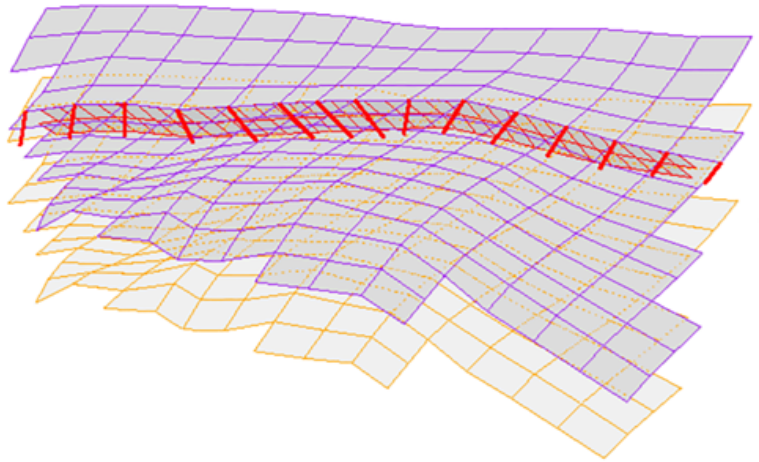
OPENQUAKE

- From Summer 2010 until end of 2011, OpenSHA was the hazard component of the OQ Engine
- On Jan 2012 we merged the first PR in an independent python library called ‘nhlib’ that later became ‘hazardlib’
- OQ Engine (hazard) development divided in 3 periods: 2010-2014, 2015-2018, 2019-

Components: Seismic Source Characterization

Since 2014 OpenQuake Engine offers a stable set of earthquake sources including:

- Two typologies of sources for modelling distributed seismicity (points and areas)
- Three typologies of fault sources (simple fault, complex fault, characteristic fault)
- Non-parametric sources (i.e. a list of ruptures each one with a probability of 0, 1, .. occurrences in a given time span)



Components: Ground-Motion Characterization

On the ground motion modelling side the library of empirical ground-motion models kept on growing, with large contributions from the community.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2015-2018

OQ Engine Hazard: Main features

Versatility

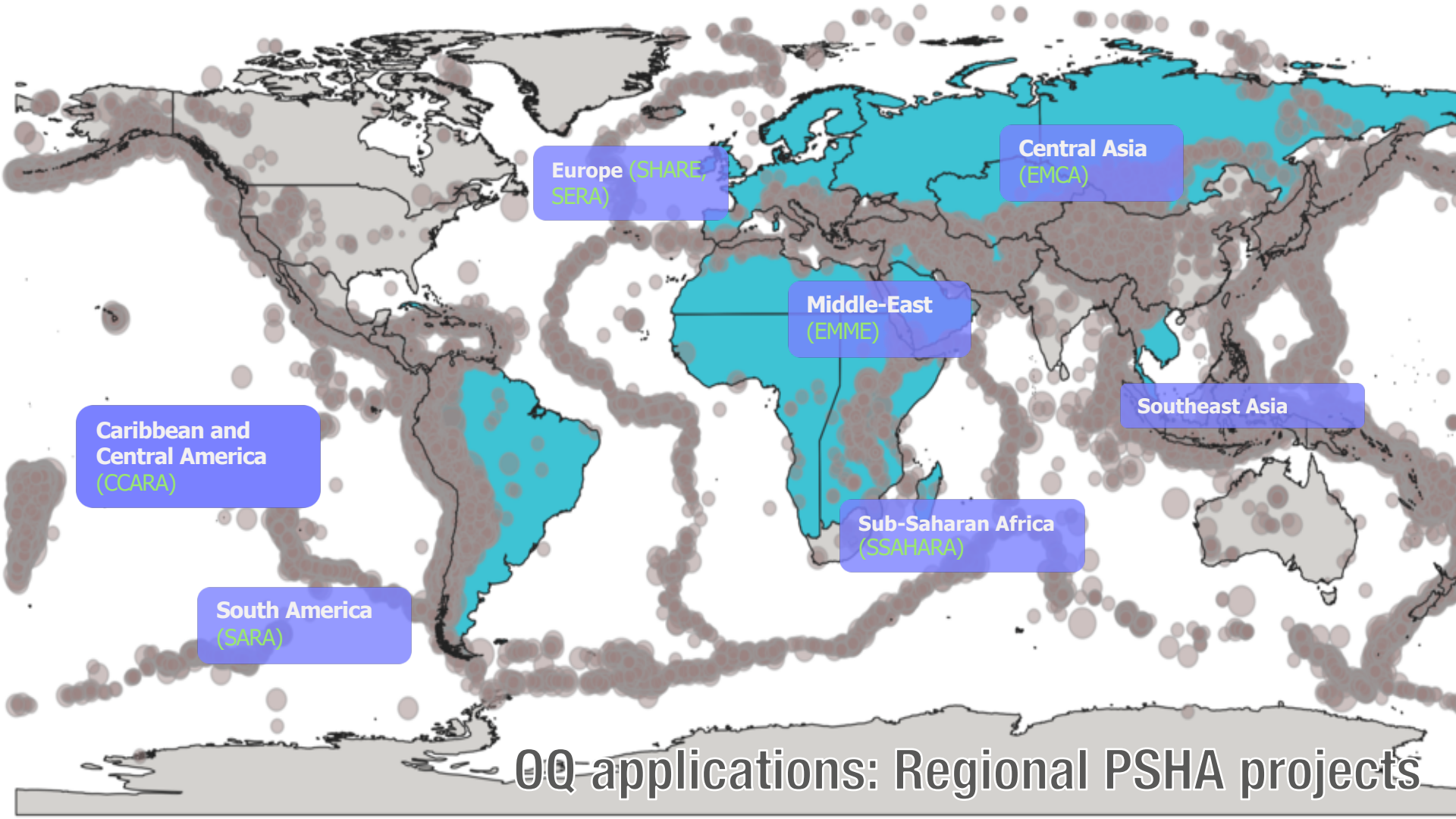
- Can be used as a library (components of the OQ Engine used in the USGS Shakemap System)
- Supports most of the publicly accessible hazard models available globally
- Works with the risk component

Testing

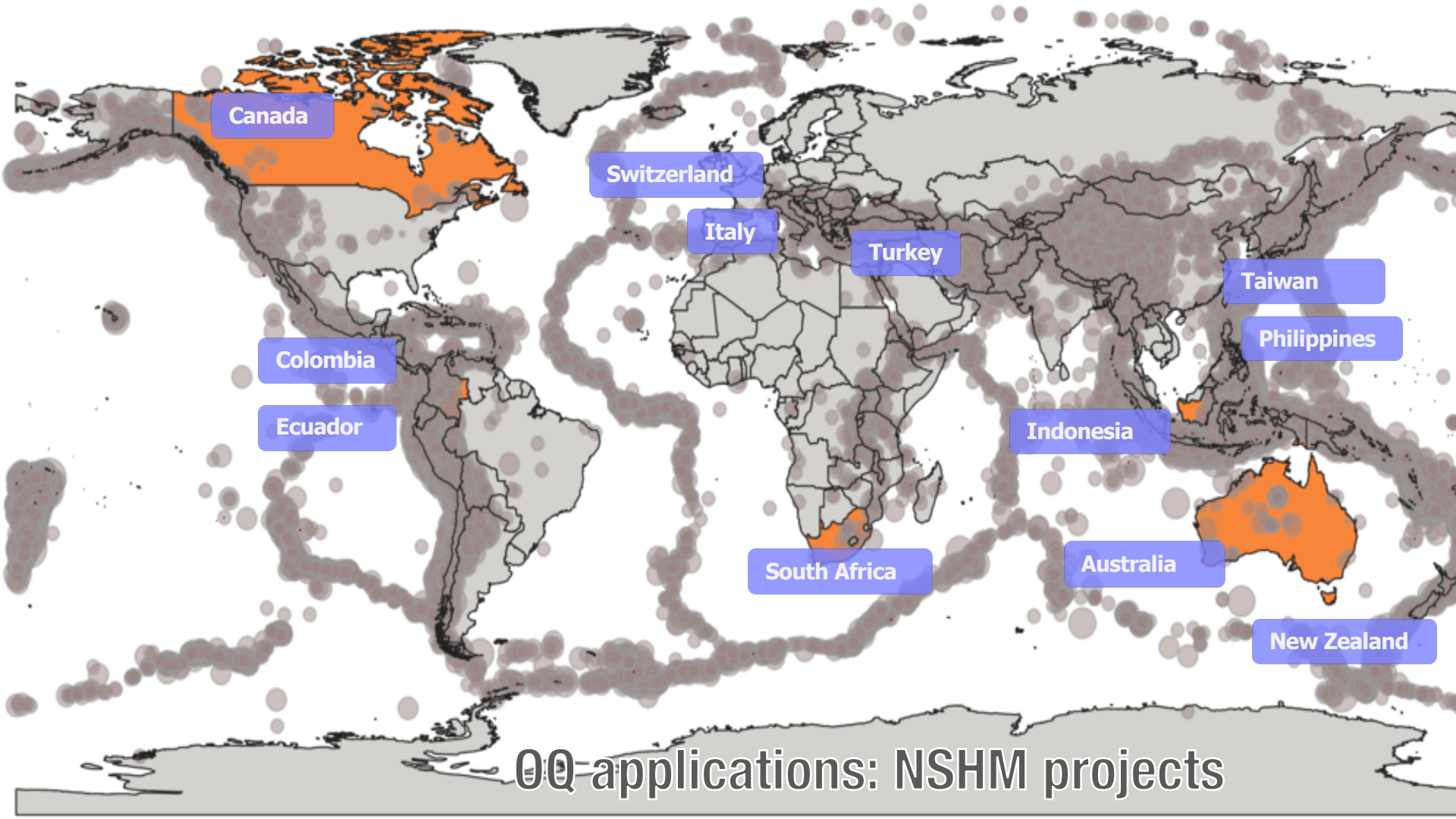
- Unit-testing
- End-to-end testing

Large GMM Library
with more than 130 models

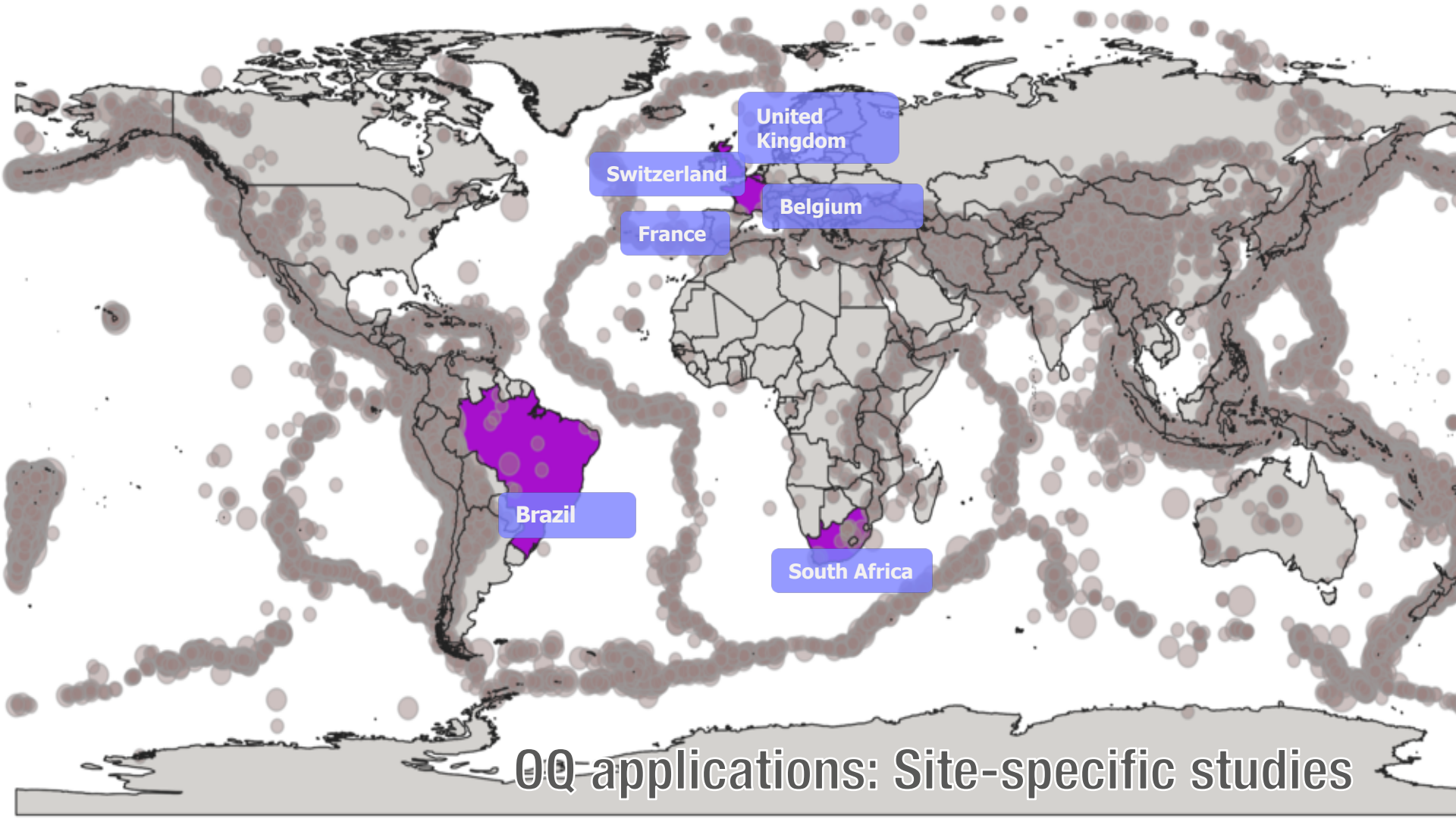
User defined LTs
For SSC and GMC



OQ applications: Regional PSHA projects



OQ applications: NSHM projects

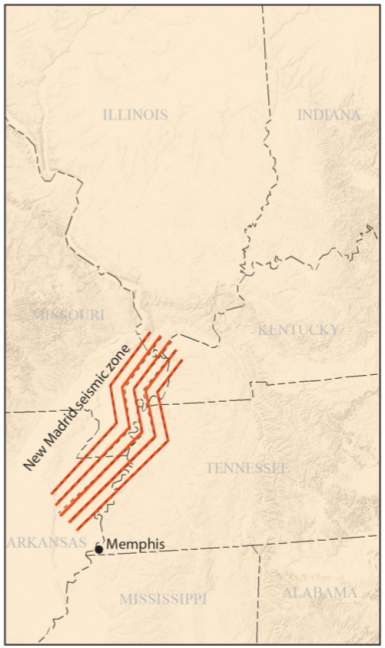


OQ applications: Site-specific studies

Experimental features

Computing hazard for a cluster of ruptures

Follows the implementation used by the USGS for modelling ruptures in the New Madrid area




```
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xmlns:gml="http://www.opengis.net/gml">
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            <sourceGroup name="group 1"
            tectonicRegion="Active Shallow Crust"
            cluster="true" tom="PoissonTOM"
            occurrence_rate="0.001">

            <nonParametricSeismicSource
            id="1" name="Fake"
            rup_weights="0.2 0.8"
            tectonicRegion="Some TRT">
            …
            </nonParametricSeismicSource>

            <nonParametricSeismicSource
            id="1"
            name="Fake Non Parametric Source"
            rup_weights="0.2 0.8"
            tectonicRegion="Some TRT">
            …
            </nonParametricSeismicSource>

            </sourceGroup>
    </sourceModel>
</nrml>
```
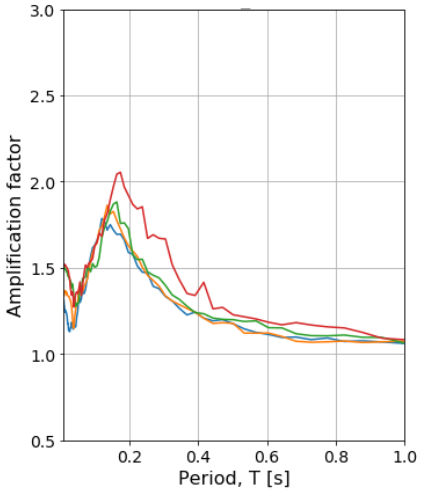
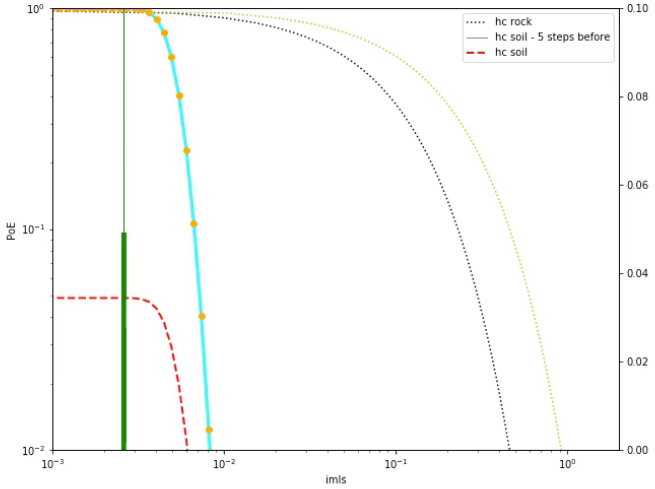

Experimental features

Computing hazard using amplification functions

- The user specifies in the input an amplification function for each site (or category of sites)



- Three calculation options available:
  - Convolution approach
  - Kernel approach
  - Event based approach



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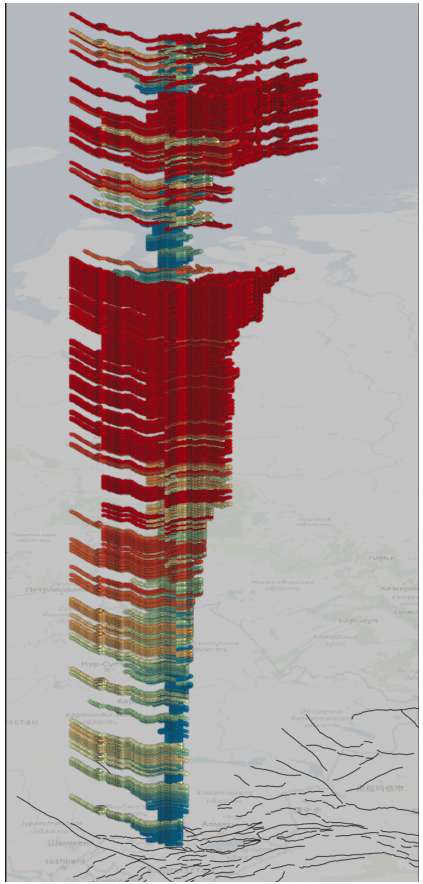
Future

Better support rupture sets from fault system solutions (e.g. UCERF3, SHERIFS)

Collaborating with the USGS and GNS Science at generalizing their description and optimizing calculation based on this typology of earthquake source

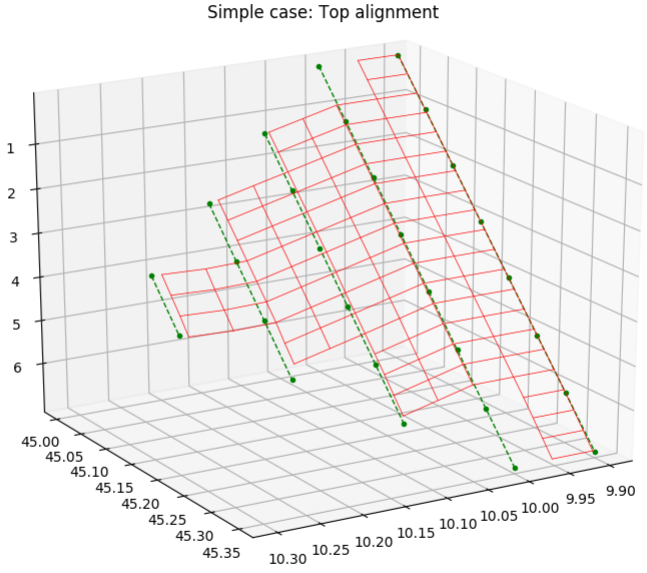


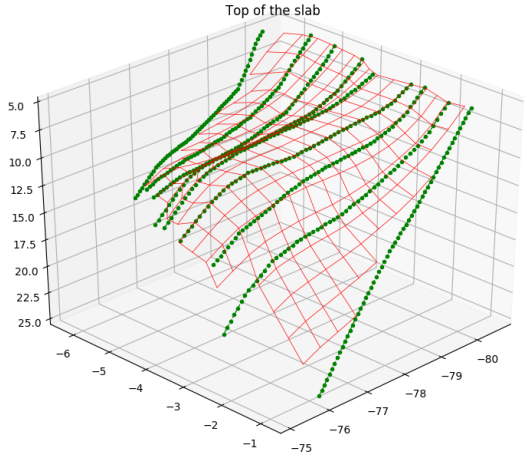
Chartier et al. (in preparation)

Future

New fault typology

Simple and complex faults both have pros and cons. The former lacks of flexibility in describing the geometry. With the latter, floating ruptures can be in some cases difficult.





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Future

Non-ergodic GMMs

There is an increasing number of GMMs that – using a variety of approaches – relax the ergodic assumption.

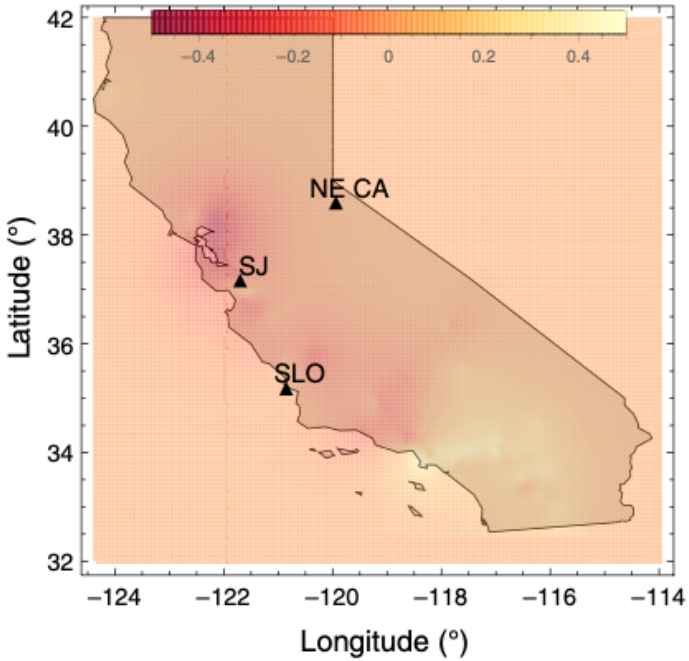


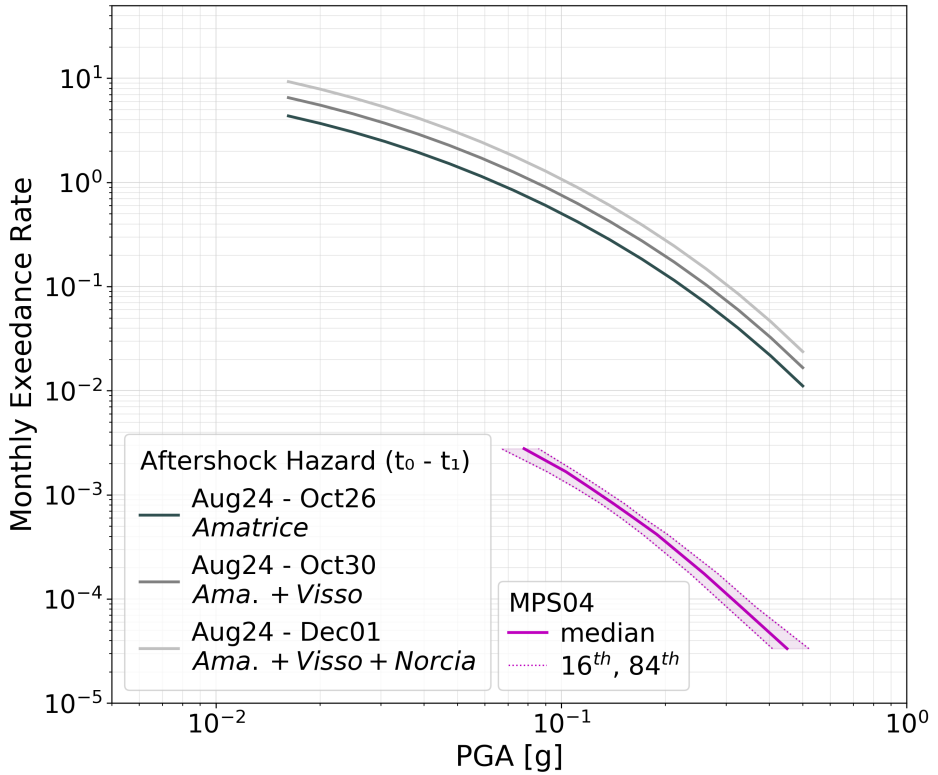
Figure 3. Spatially varying adjustment coefficients $\delta\theta_4(\vec{x}_{\text{source}})$, controlling geometrical spreading, for $T = 0.2$ s. Adapted from Landwehr *et al.* (2016). The sites for which nonergodic PSHA is calculated are also plotted. The color version of this figure is available only in the electronic edition.

Abrahamson et al. (2019)

Future

Incorporating the contribution of aftershocks and foreshocks

We plan to first implement the Boyd (2012) approach and to extend it in a second phase.



Gee et al. (submitted)

METIS
Seismic Risk Assessment for Nuclear Safety

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Thank you!


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