

Probabilistic Seismic Hazard Assessment of North Africa: a GEM's Product

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working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

OO
OPENQUAKE

Introduction to GEM

GEM (Global Earthquake Model) is a no-profit organization funded by public and private partners aimed to stimulate the awareness on seismic hazard and risk worldwide

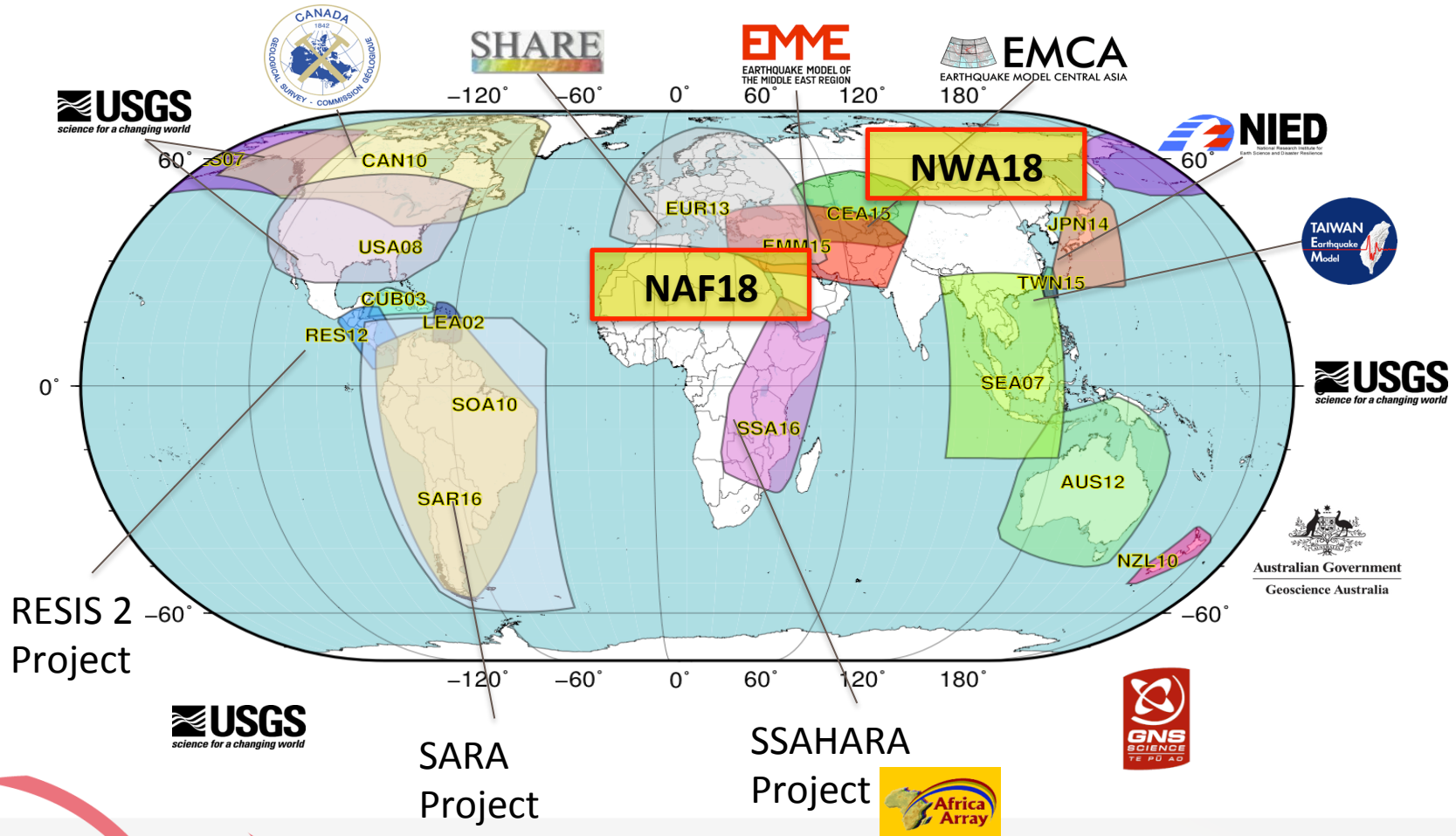
The overall goal of the **hazard component** of the GEM community is:

- the construction of a global mosaic of open hazard models
- to provide the community with tools (such as **OpenQuake**), datasets and knowledge to achieve this goal



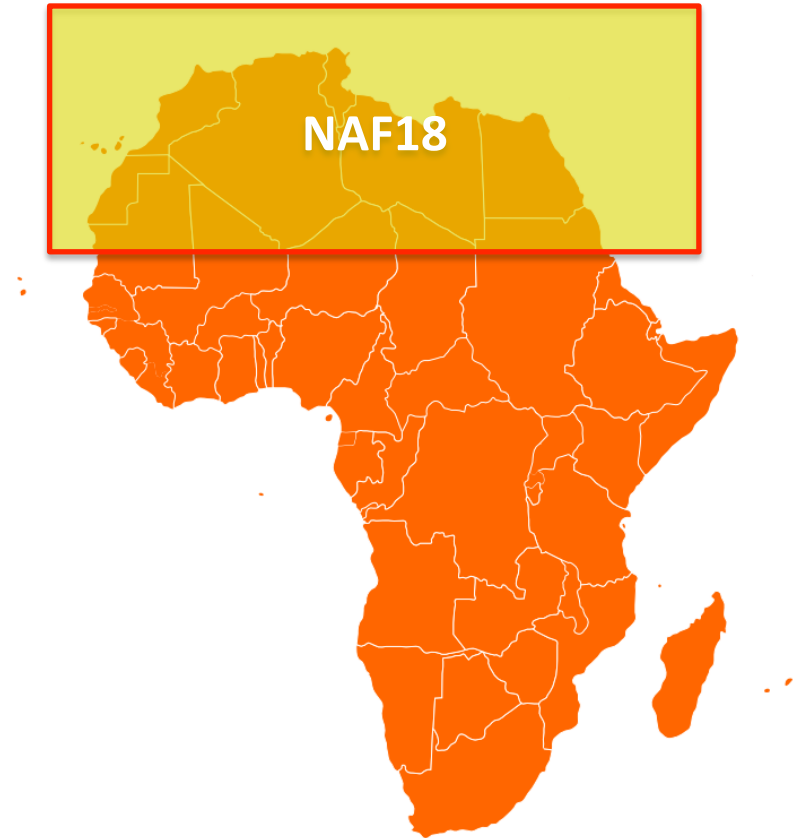
GEM Global Database of Hazard Models

The DB contains hazard models developed by national agencies and international projects which are openly distributed

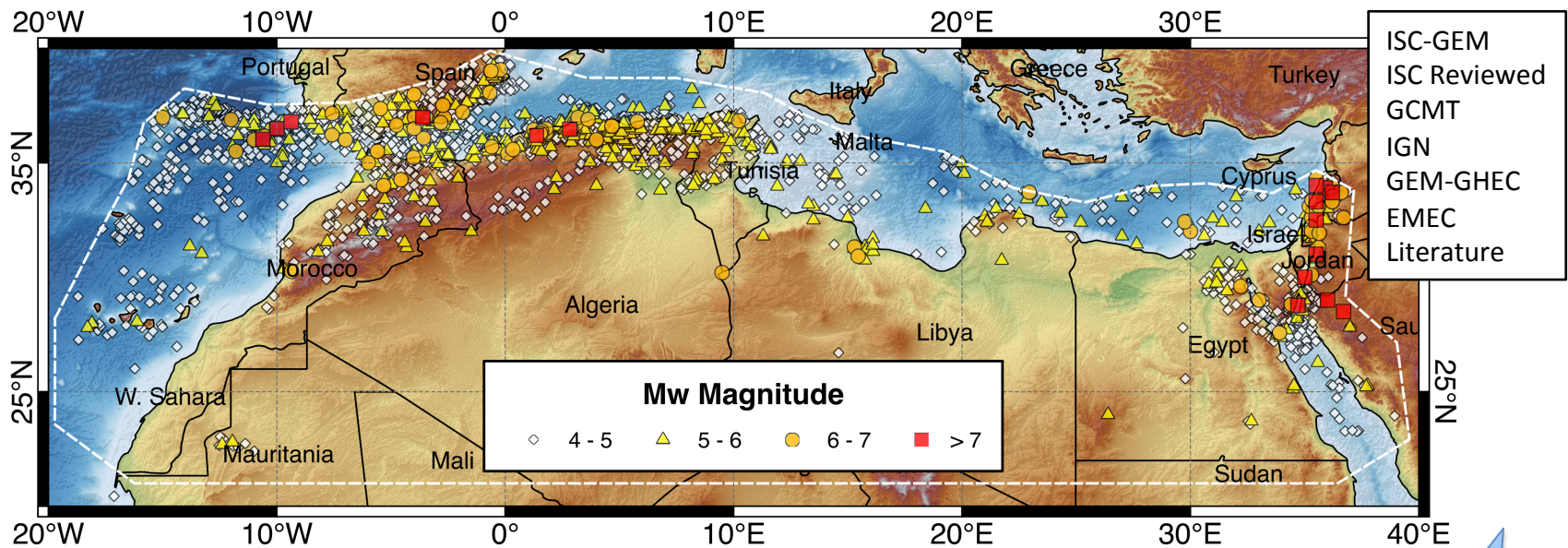


Earthquake Hazard in North Africa

- ① Besides the East African Rift System, significant seismicity also occurs along a wide belt bounding the Mediterranean coastline
- ② Several past large earthquakes caused a non-negligible level of damage
- ③ A reliable risk assessment is therefore essential, which requires a state-of-art hazard assessment for the region
- ④ There is a need for a new **probabilistic seismic hazard model** based on the most recent and up to date available information

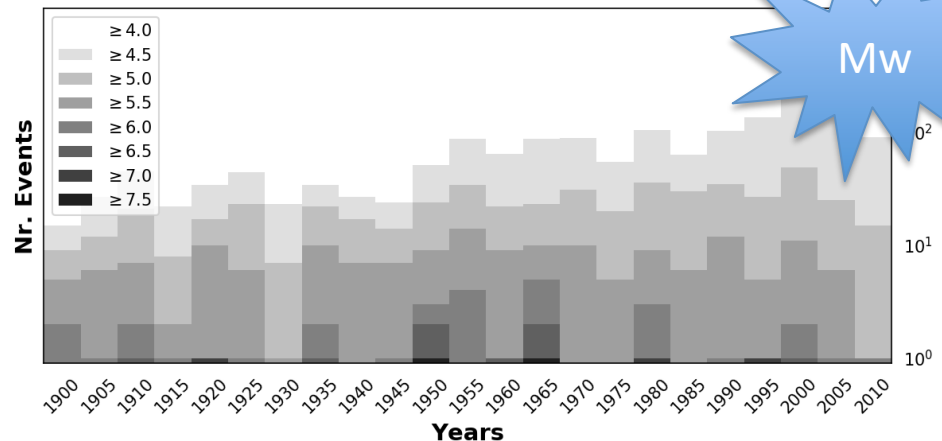


North Africa Homogenized Earthquake Catalogue

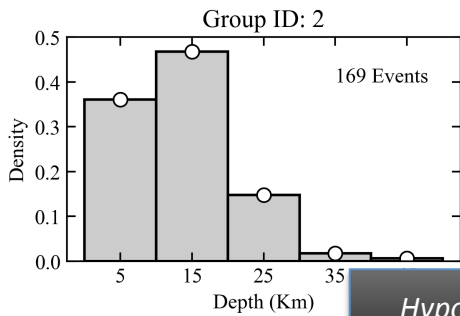
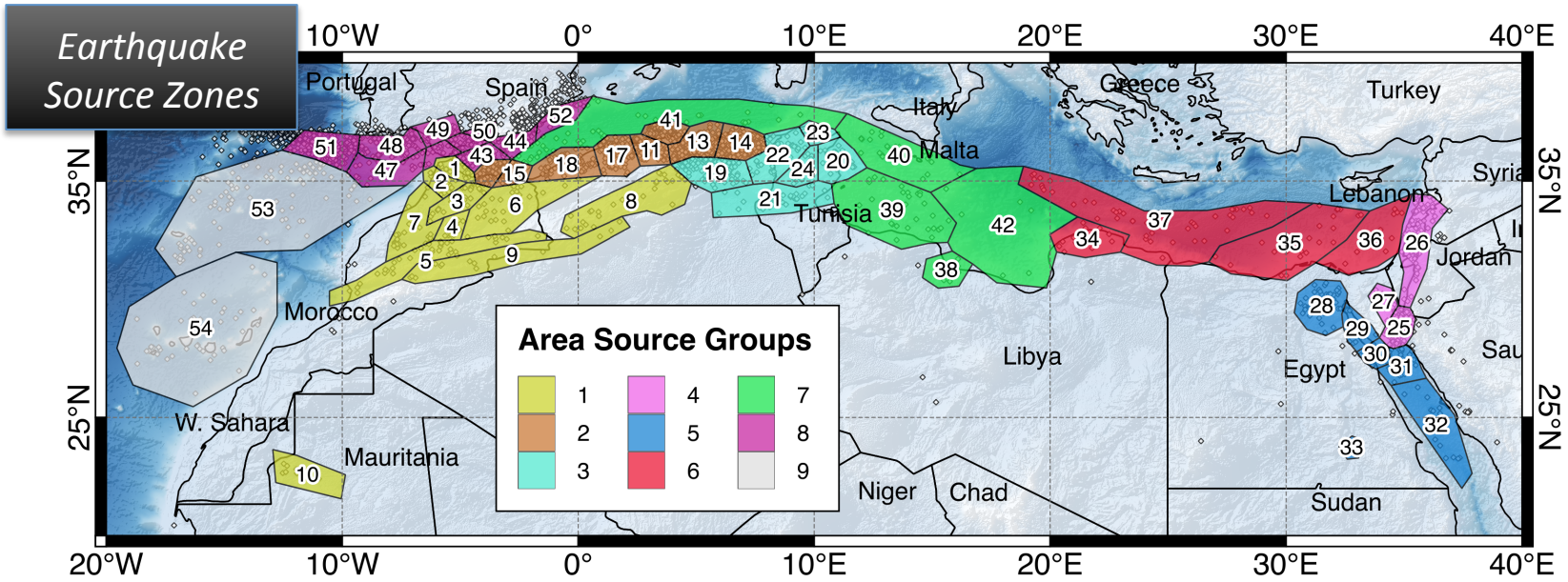


The catalogue is obtained by harmonization of **global bulletins** with data from **local agencies** and **published studies**

Number of Events: 5170
 Year Range: 1016 - 2013
 Magnitude Range: 4.0 - 8.5

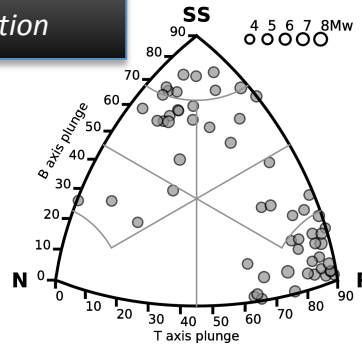


Source Model - Regional Seismicity Analysis

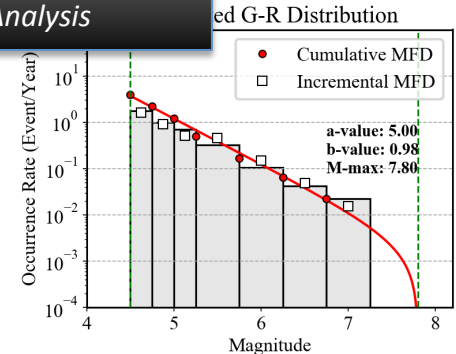


Hypocentral Depth Distribution

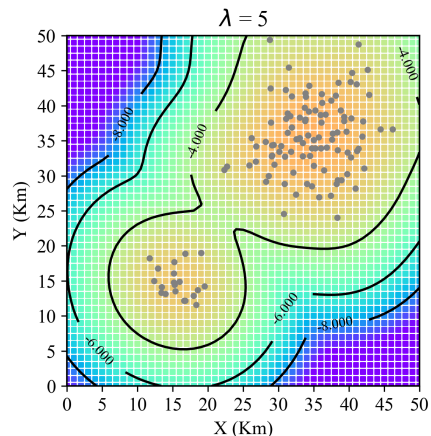
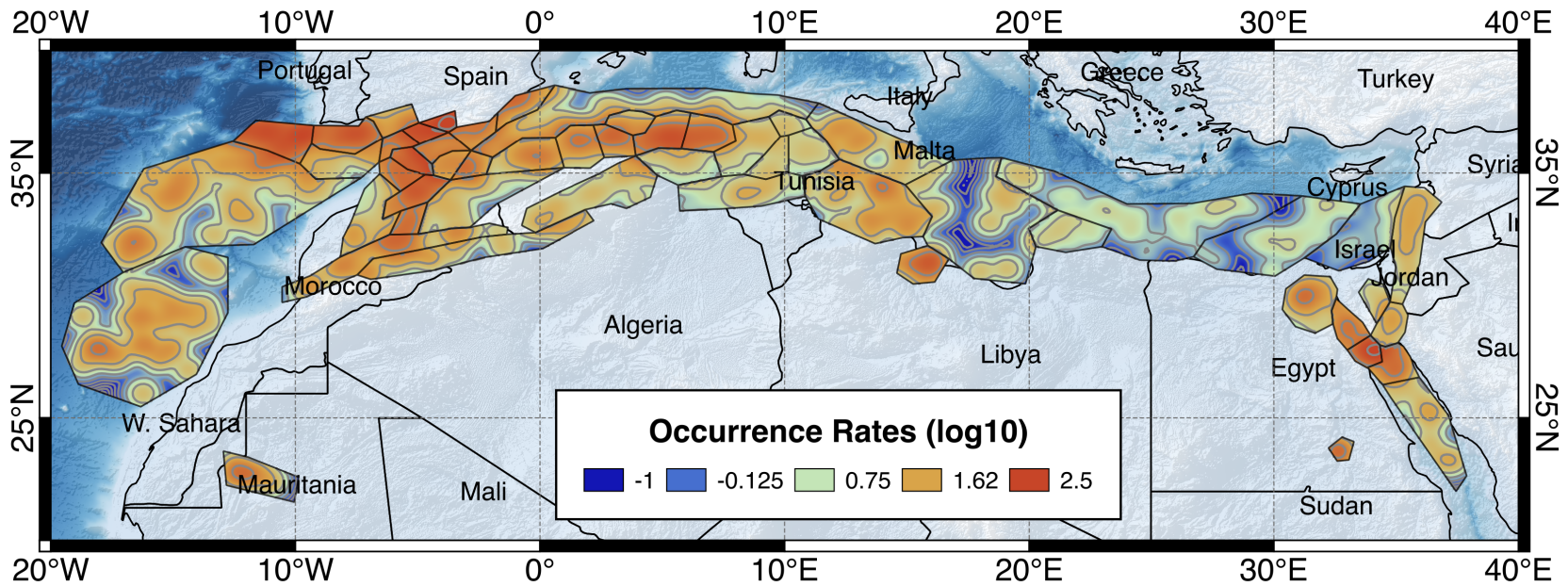
Rupture Mechanism Identification



Magnitude-Frequency Analysis



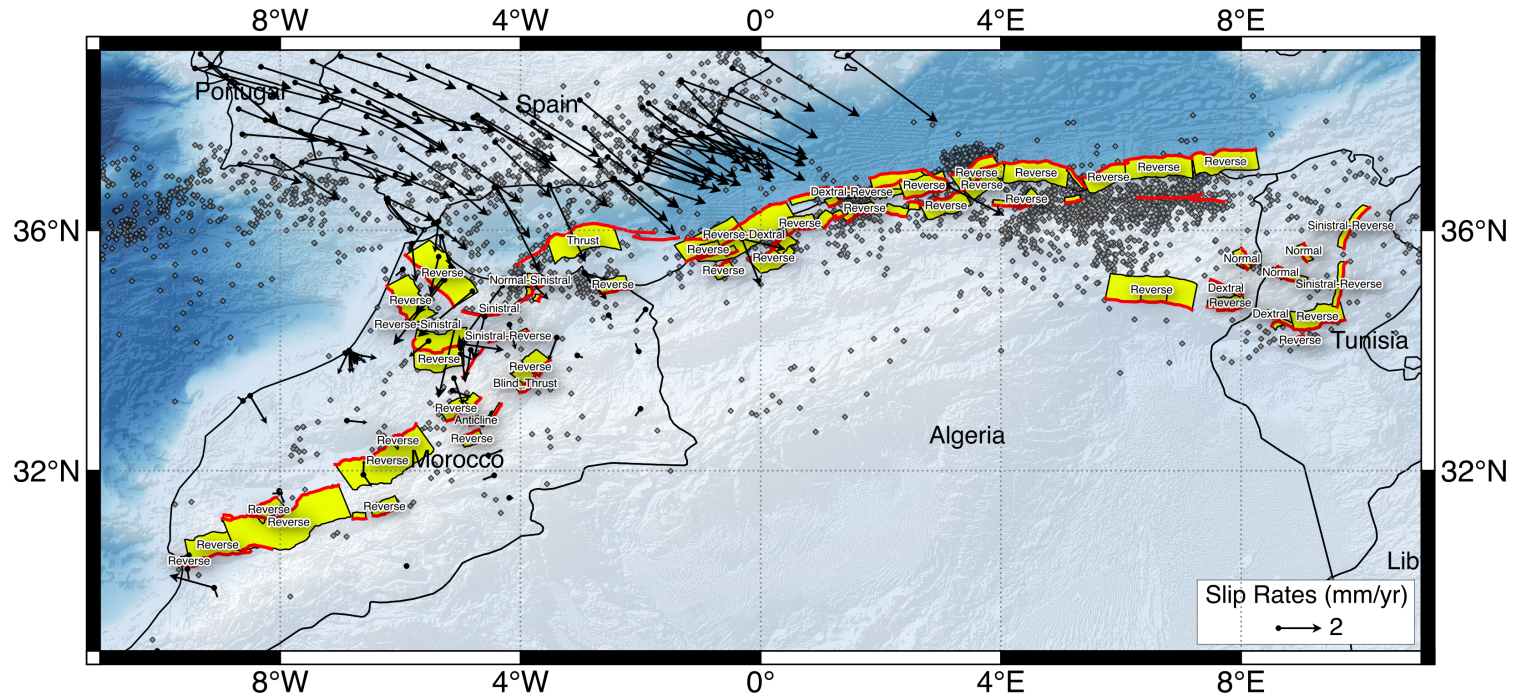
Occurrence Rate Redistribution



We have implemented a smoothing procedure based on **area source zonation**, where the observed rates (R) are spatially redistributed according to the seismicity pattern of the area, while keeping the overall **rate balance unmodified**:

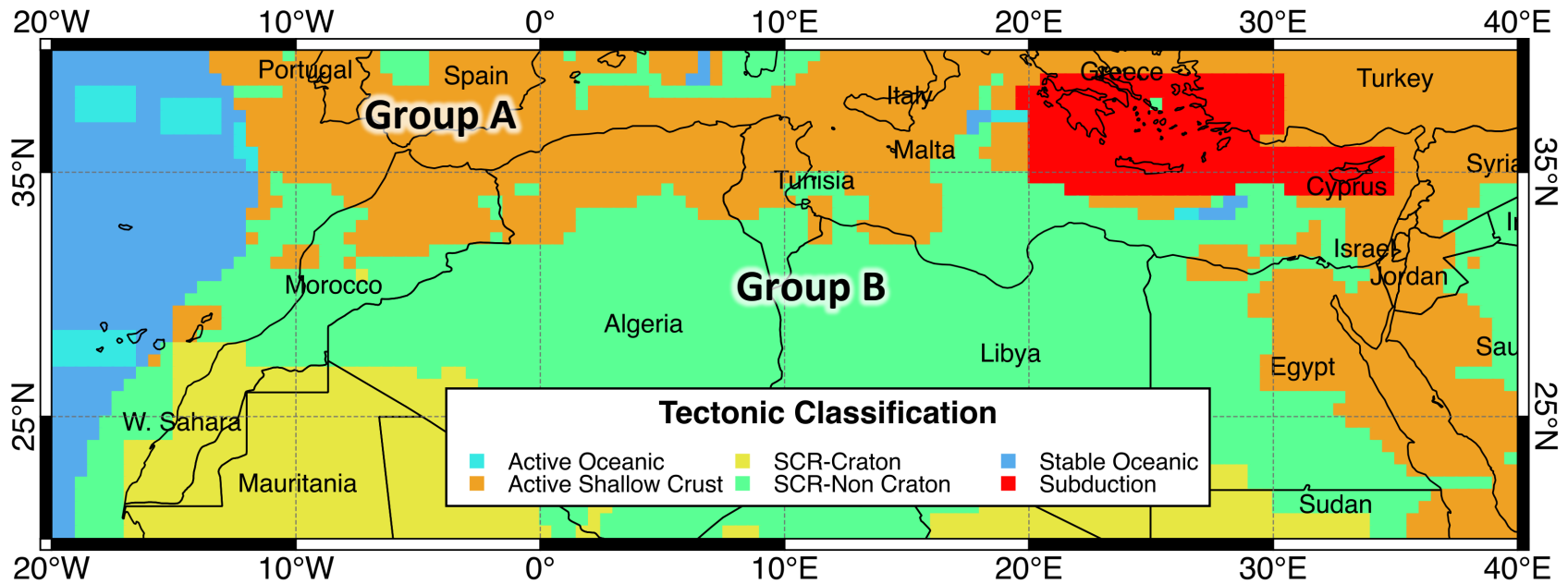
$$W_i = \sum_{j=1}^{Etot} e^{-\left(\frac{D_j}{\lambda}\right)^2} \quad \longrightarrow \quad R_i = \frac{W_i}{\sum_{k=1}^{Ntot} W_k} R$$

Global Active Fault Database



- New database of active faults from Morocco to Sinai
- 143 structures mapped from literature, satellite imagery, topography, seismicity
- Slip taken from literature or estimated from GPS
- Public and open-source (Creative Commons Attribution license)

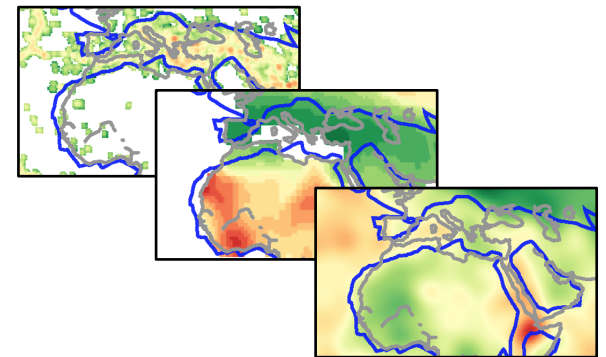
Tectonic Regionalization using Fuzzy Logic



Chen et al. 2017

Merging information from:

- Seismicity (magnitude)
- Smoothed Moment rate
- S-wave velocity
- Q_{LG} distribution

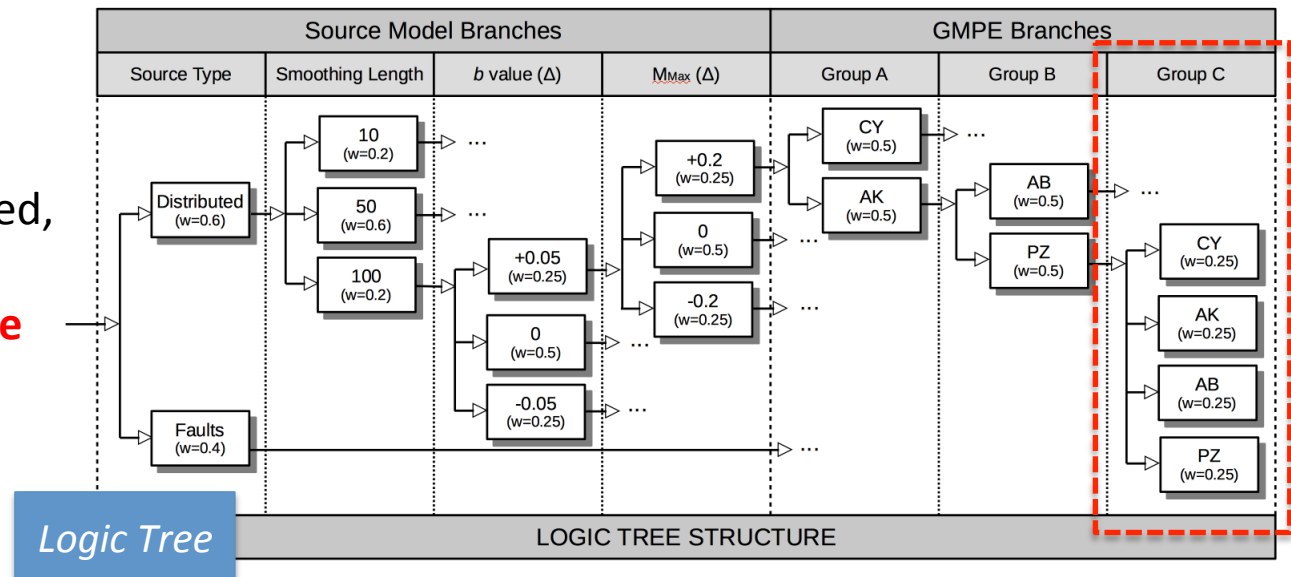


GMPE Selection and Logic-Tree Approach

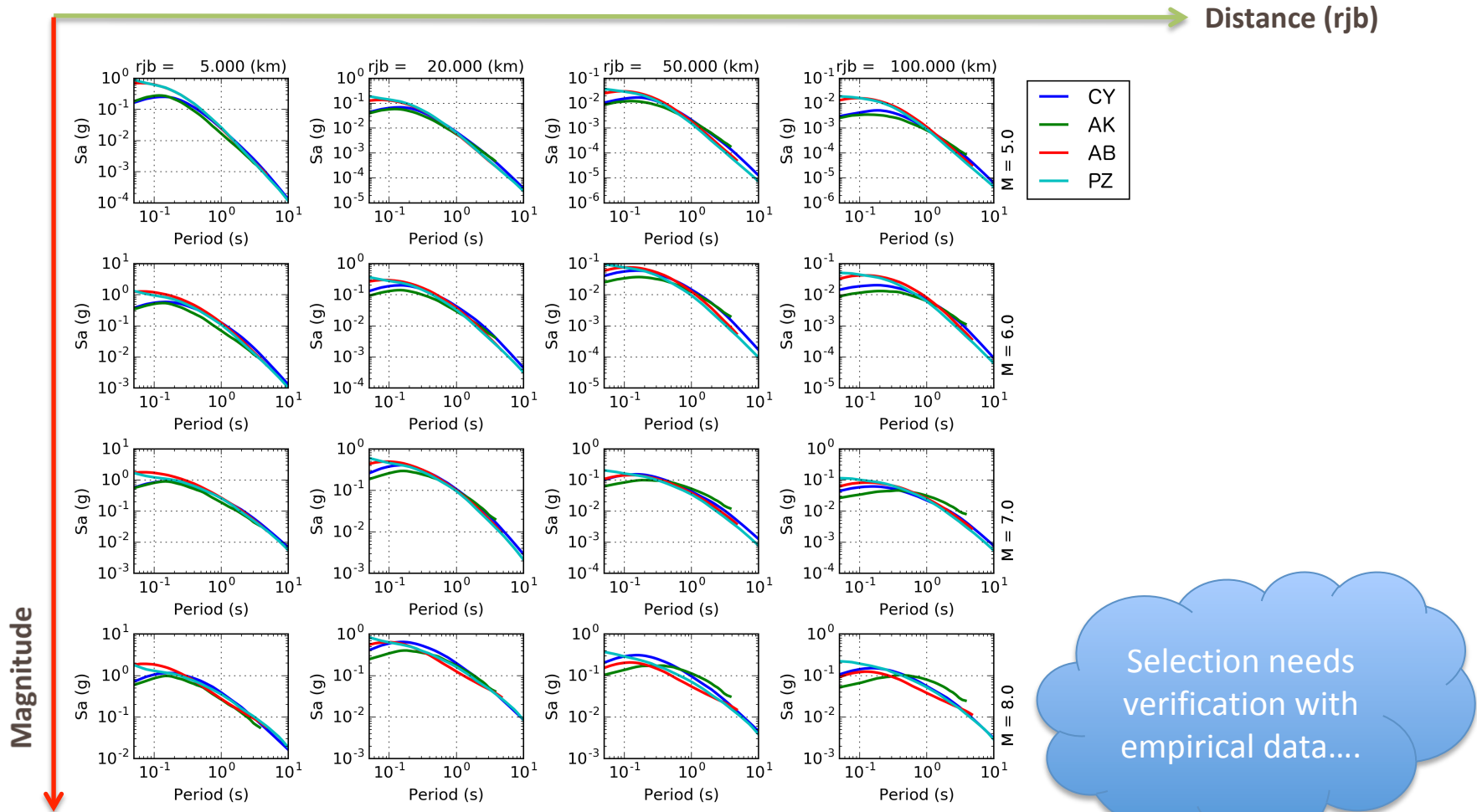
Given the peculiar seismotectonic setting of the North Africa, an **hybrid attenuation behavior** might be expected. Four suitable GMPEs have been selected:

- ① Chiou & Youngs (2014)
 - ② Akkar et al. (2014)
 - ③ Atkinson & Boore (2006)
 - ④ Pezeshk et al. (2011)
- Active Shallow Crust (Group A)
- Stable Continental Crust (Group B)

Three main **tectonic groups** are then identified, each with a different GMPE **weighting scheme**



GMPE Selection – Comparing Ground Motion



Event id	Date	M _w	M _L	Style of faulting	Stat. Code	EC8	R epi. [km]	Processing	Corr. PGA [cm/s ²]	PGV [cm/s]	Location	Instrument
EMSC-20160125_0000009	2016-01-25 04:22:03 🔗	6.3	5.7	Strike-slip faulting	WM.AVE 🔗		430.700	manually processed	0.877	0.312	00	HL
EMSC-20140415_0000028	2014-04-15 07:56:47 🔗		4.2	Unknown	WM.AVE 🔗		217.700	manually processed	0.466	0.032	00	HL
EMSC-20120218_0000001	2012-02-18 00:28:27 🔗		4.1	Strike-slip faulting	WM.AVE 🔗		208.100	manually processed	0.408	0.017	00	HL
EMSC-20140512_0000020	2014-05-12 03:53:20 🔗		3.5	Unknown	WM.AVE 🔗		157.100	manually processed	0.193	0.008	00	HL
EMSC-20130414_0000075	2013-04-14 21:43:15 🔗		4.3	Unknown	WM.AVE 🔗		214.900	manually processed	0.091	0.006	00	HL
EMSC-20111226_0000066	2011-12-26 04:33:54 🔗		3.6	Unknown	WM.AVE 🔗		211.600	manually processed	0.035	0.002	00	HL
EMSC-20111224_0000354	2011-12-24 14:15:52 🔗		4.1	Unknown	WM.AVE 🔗		70.900	bad quality record			00	HL
EMSC-20131216_0000017	2013-12-16 07:06:20 🔗	4.7	4.8	Strike-slip faulting	WM.AVE 🔗			bad quality				

1 station in Morocco: 8 Events available
(6 usable)

2 stations in Algeria: 2 Events

Need data from local agencies (e.g. CRAAG)
or neighboring countries

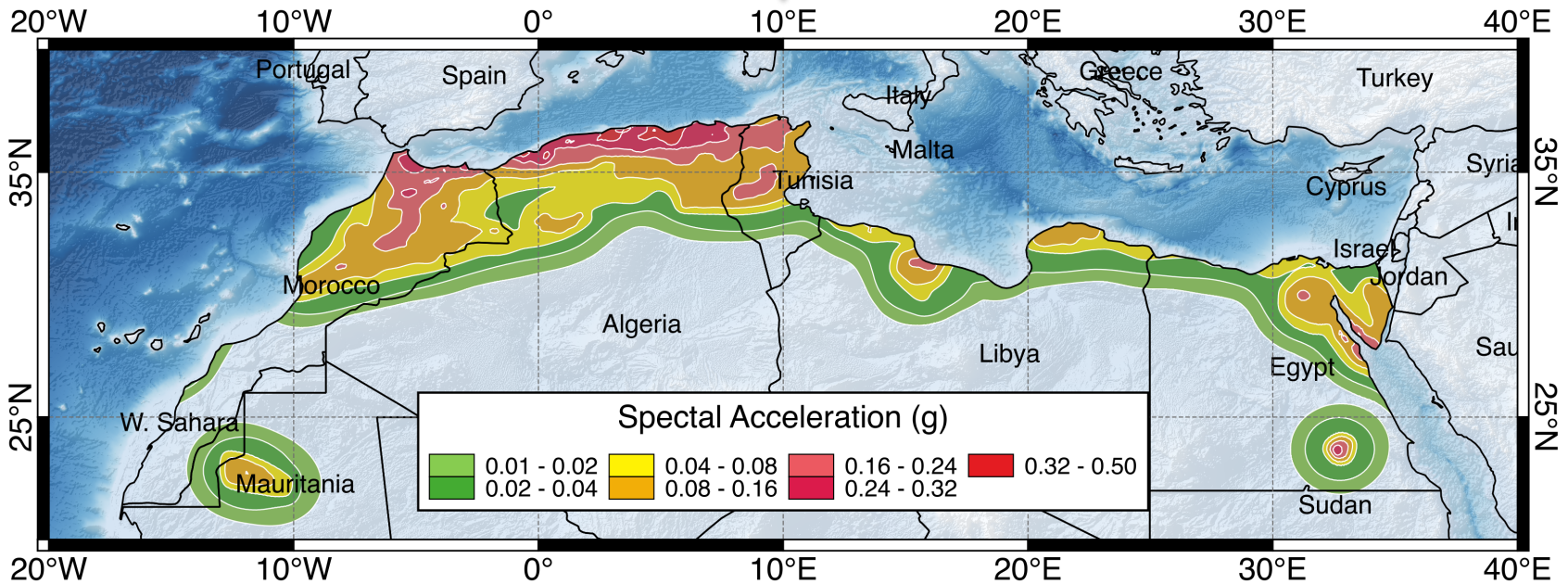


Preliminary Hazard Results

10% POE in 50 years (0.2s)

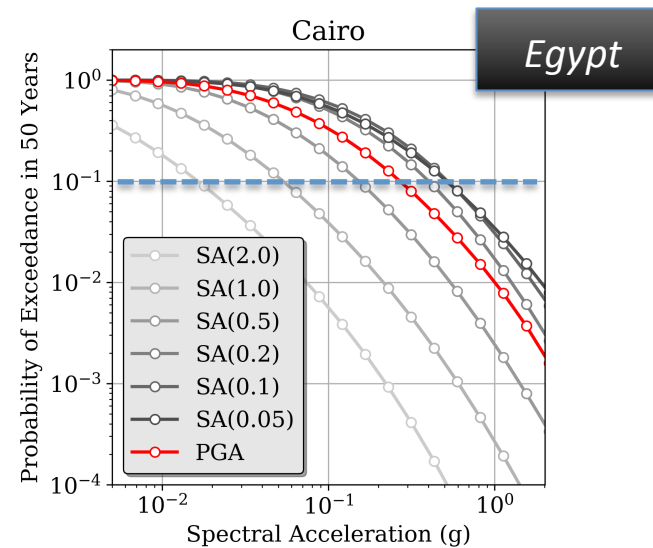
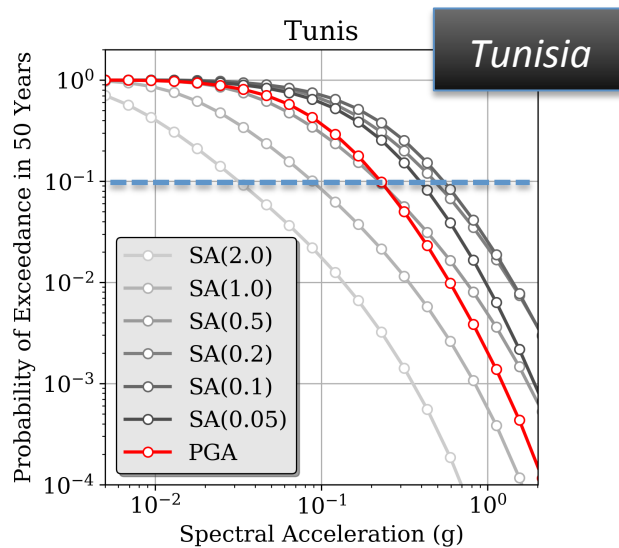
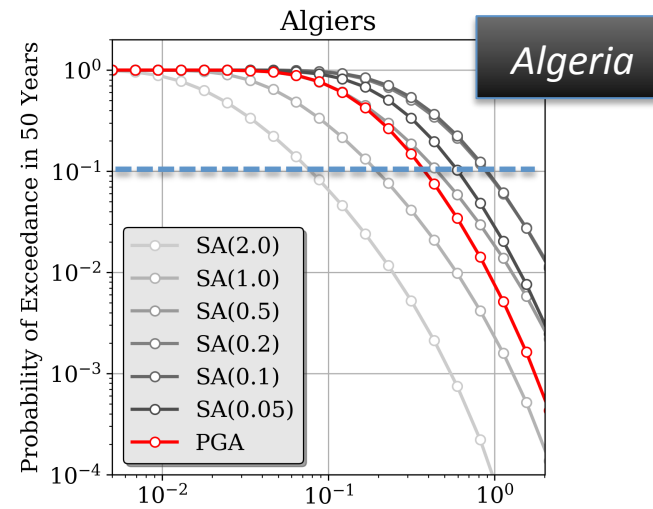
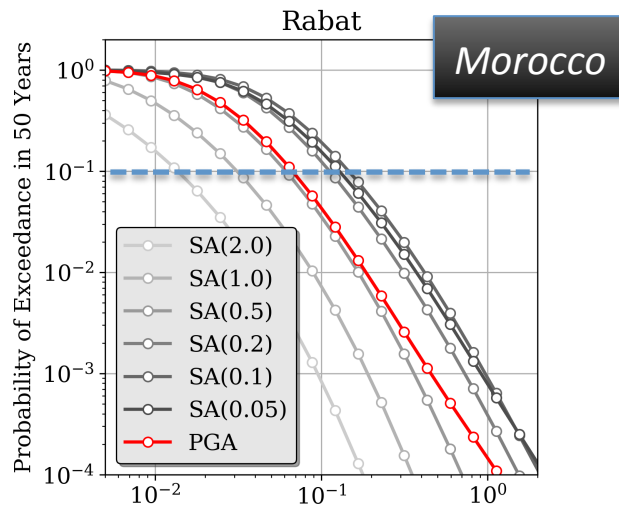
Fault Source Model

Area Sources (Background)

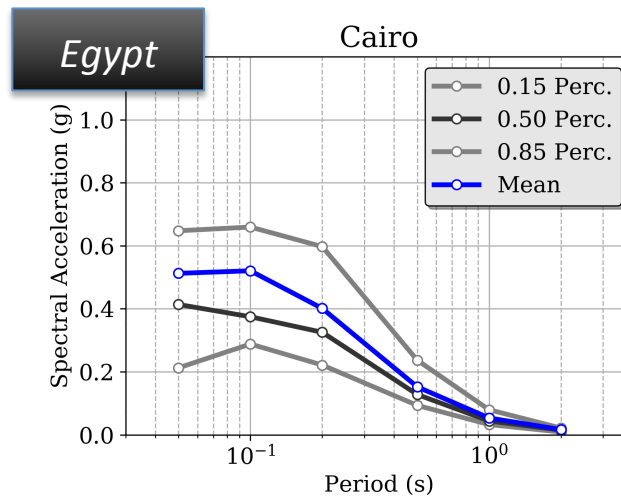
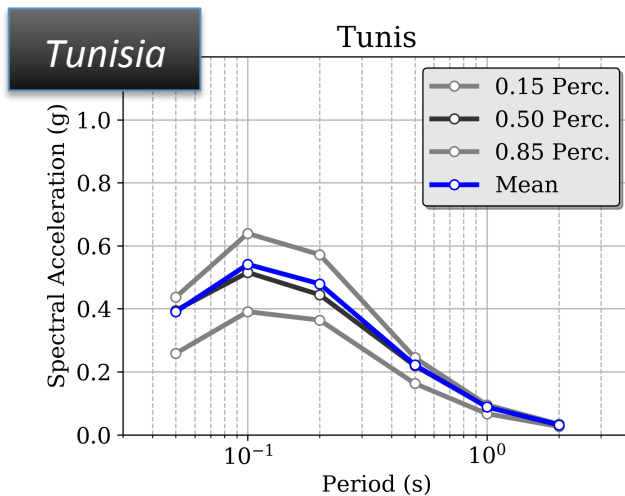
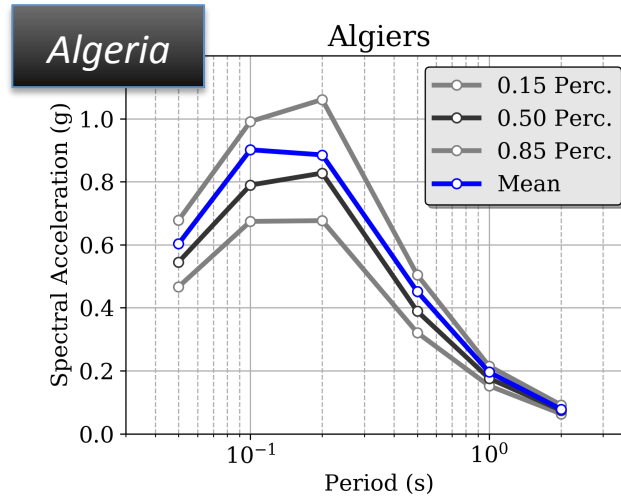
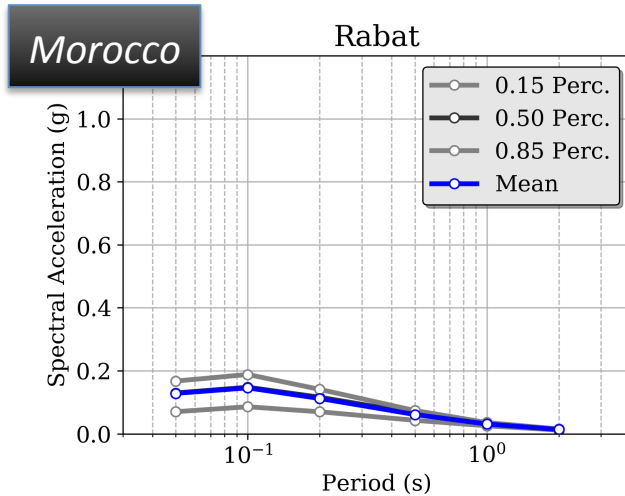


Smoothed Seismicity Model

Hazard Curves @ African Capitals

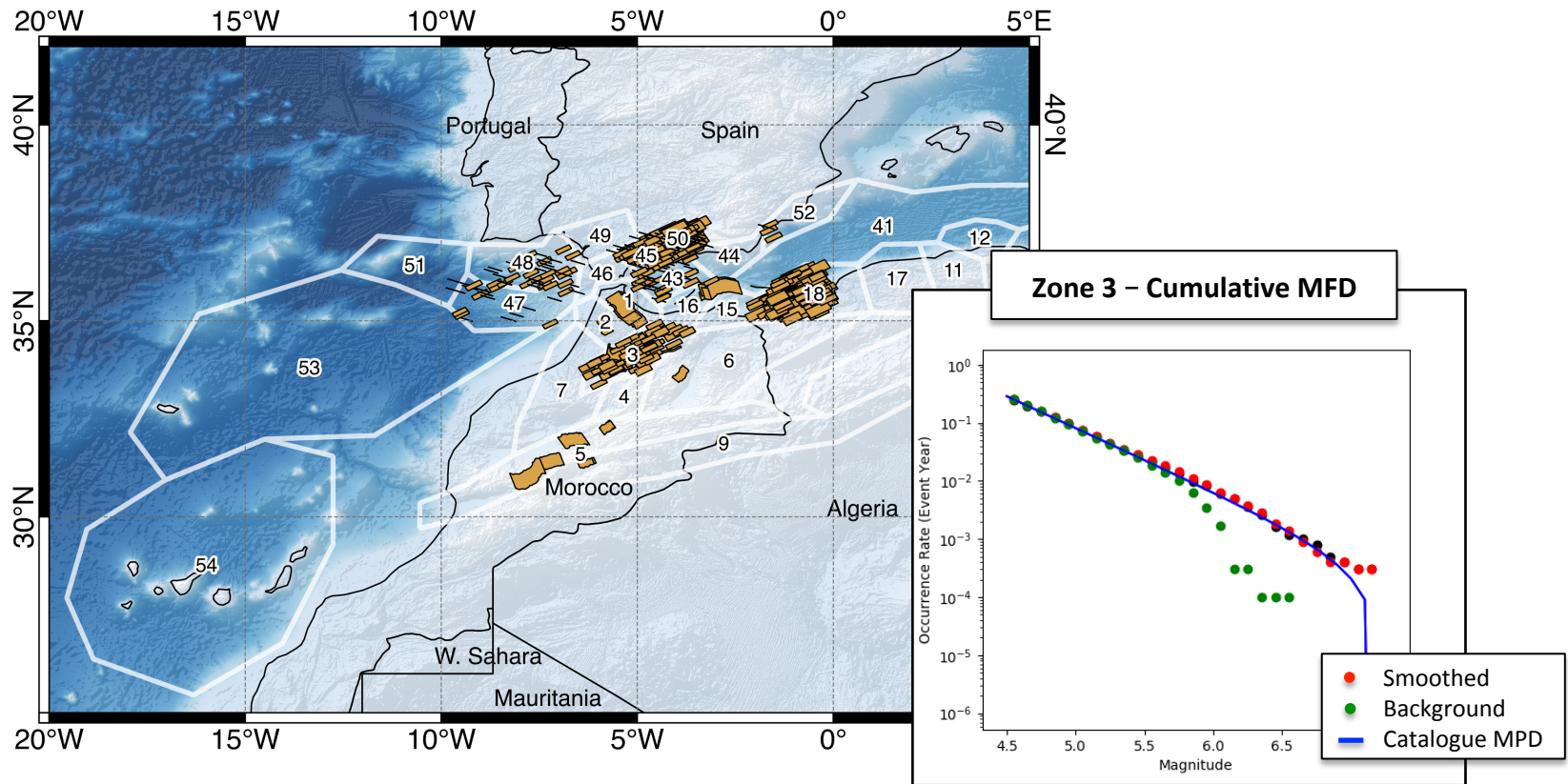


Uniform Hazard Spectra @ African Capitals



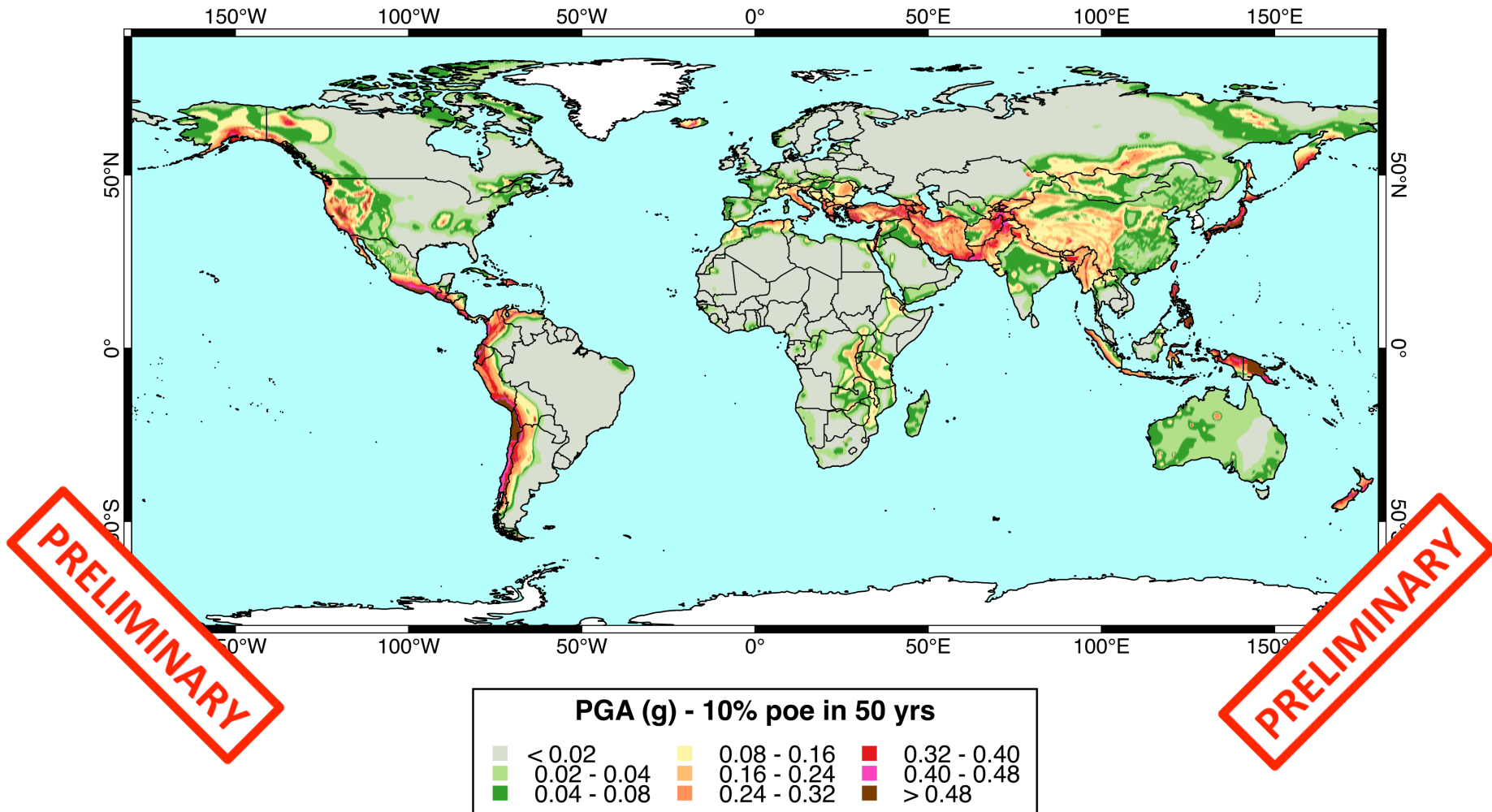
10% POE in 50 years

Model Verification: Stochastic Ruptures



- Stochastic earthquake catalogue for a 10.000 years investigation time
 - Relevant sources have been considered for verification
 - Sampling of the full logic-tree
 - All ruptures with $M_w > 4.5$

GEM Global Mosaic of Hazard Models



Missing Components / Improvements

The North-Africa Hazard model is presently just a GEM product, but it is meant to be improved and expanded with the collaboration of the African and worldwide scientific community

While existing components can be improved, many other components are still missing, such as:

- Integration of local hazard studies
- **Strong motion recordings** from local networks
- **Site-specific studies** and microzonation

Need for a
collaborative
effort



Thank you!

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Please attribute to the GEM Foundation with a link to
www.globalquakemodel.org

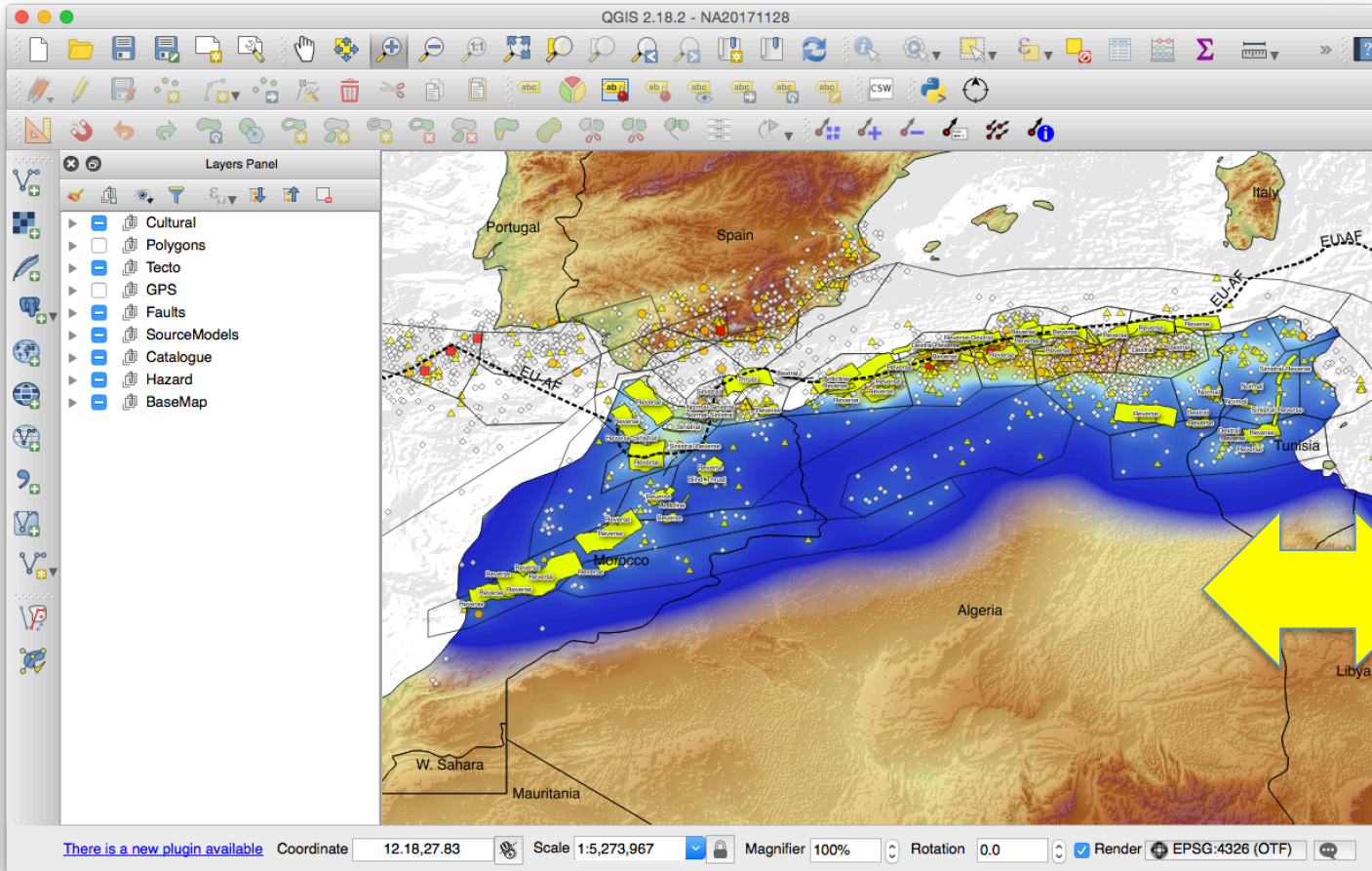


OpenQuake Engine - GitHub repository

The screenshot shows the GitHub repository page for 'OpenQuake's Engine for Seismic Hazard and Risk Analysis'. The repository is located at <https://github.com/gem/oq-engine>. It features a header with various topic tags such as earthquakes, seismic, hazard, risk, risk-analysis, risk-assessment, hazard-assessment, openquake, python, cluster, linux, macos, hpc, docker, scientific-computing, and windows. The repository statistics include 33,435 commits, 47 branches, 61 releases, 38 contributors, and the AGPL-3.0 license. Below the statistics, there are buttons for 'Branch: master', 'New pull request', 'Create new file', 'Upload files', 'Find file', and 'Clone or download'. The commit history is displayed in a table with columns for the commit message and the time since the commit.

Commit Message	Time since commit
Blank out PULL_REQUEST_TEMPLATE.md	20 days ago
Restored subprocess.Popen [skip hazardlib] [demos]	28 days ago
Merged from master [skip CI]	4 hours ago
Sort taxonomies before comparison in the BCR calculator	10 days ago
Merge branch 'master' into complete_nga_east	a day ago
Add zip demos to .gitignore	6 months ago
Merge branch 'master' into lessfiltering	4 hours ago
Small fixes in rpm spec [skip ci]	26 days ago
Removed unused script [skip CI]	20 days ago
Upload dump.zip to artifacts	6 months ago
Changes for Python3 compatibility	4 months ago
Using after_script [skip hazardlib]	a month ago
Updated the changelog [skip CI]	8 days ago

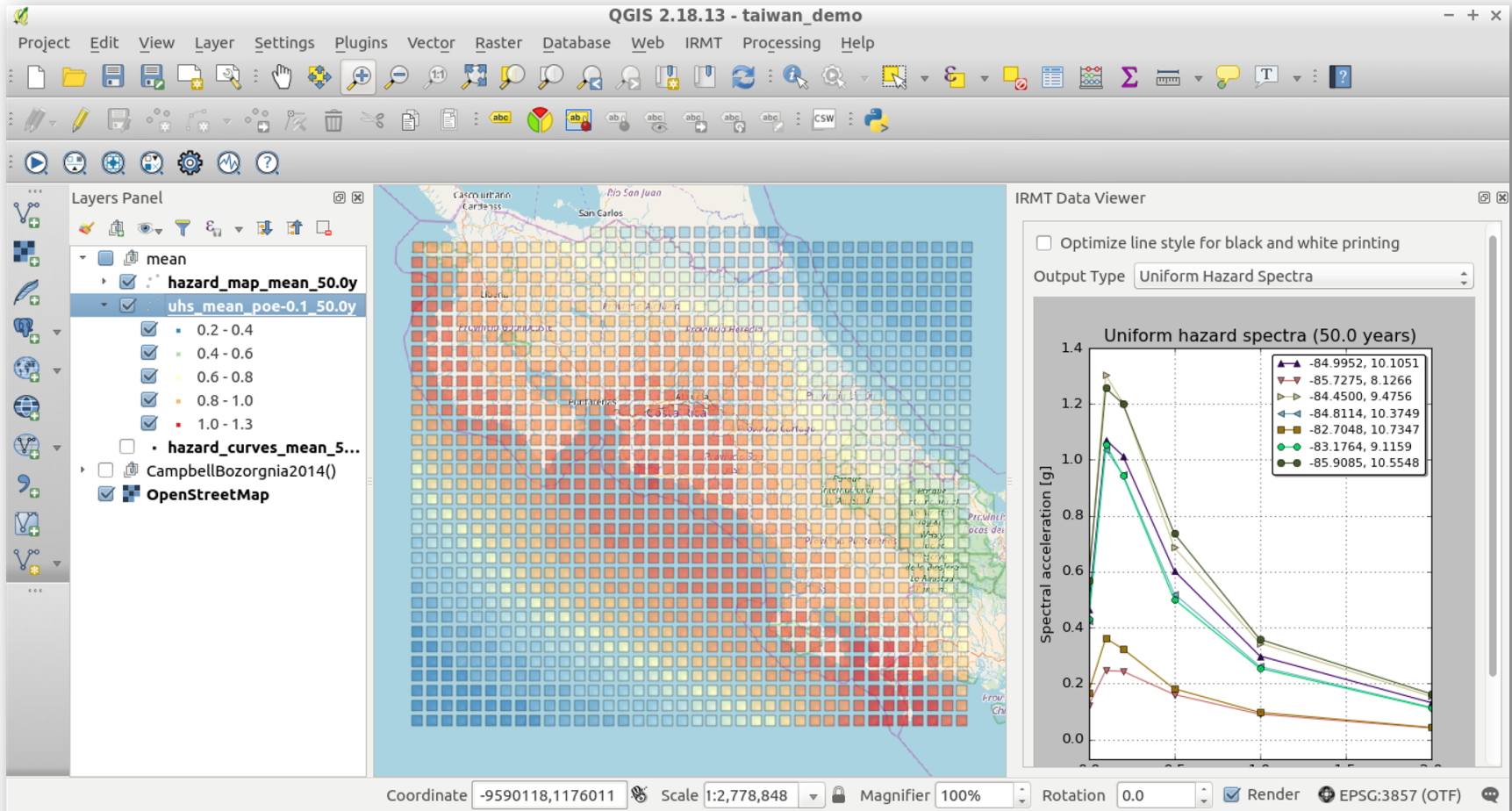
OpenQuake Engine – QGIS integration



From/To
OpenQuake
Source
Model



OpenQuake Engine – QGIS integration (2)



GEM Global Database of Hazard Models

