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

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working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

OQ
OPENQUAKE

Introduction to GEM

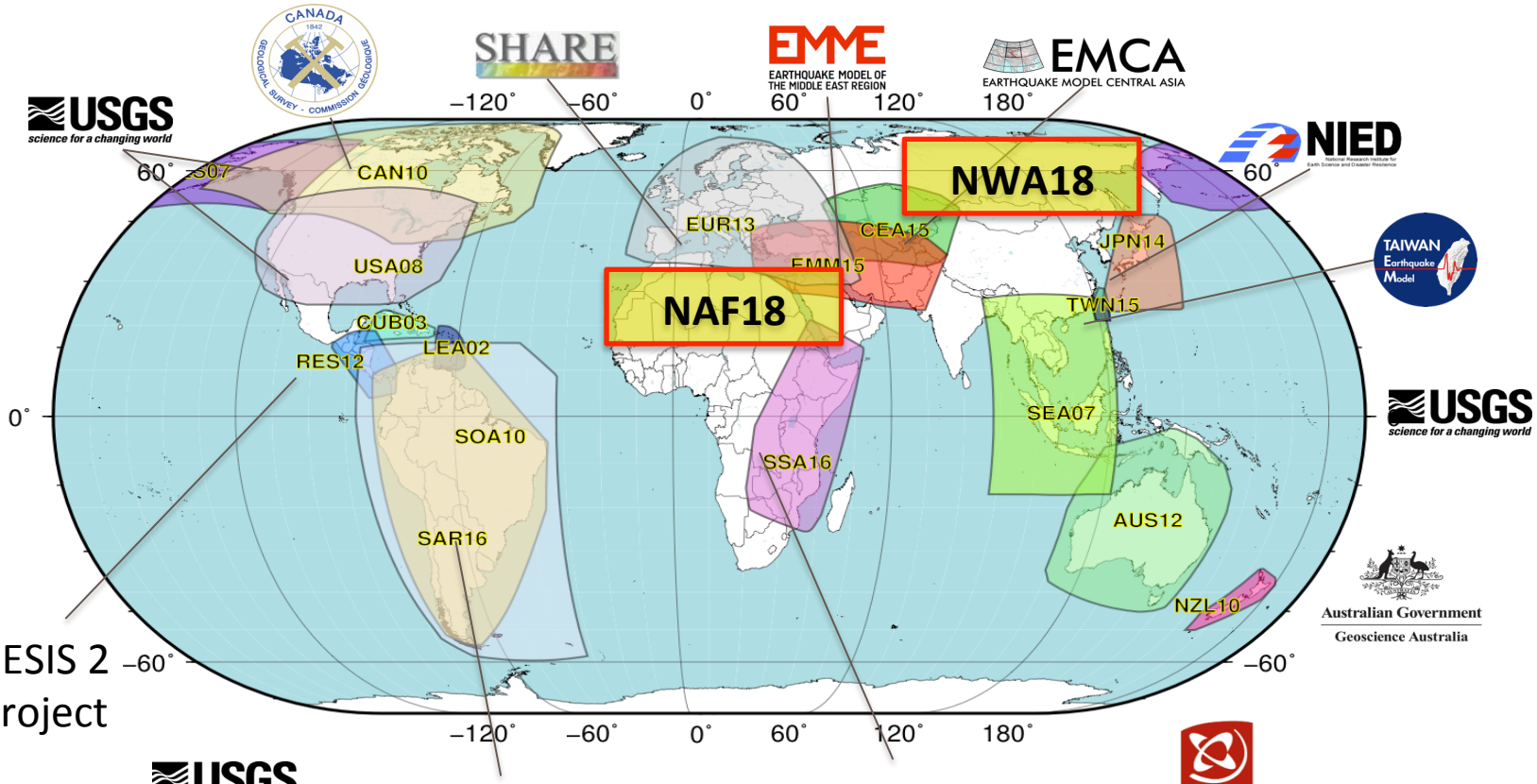
GEM (**Global Earthquake Model**) is a no-profit organization funded by public and private partners aimed to stimulate the awareness on seismic hazard and risk worldwide

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



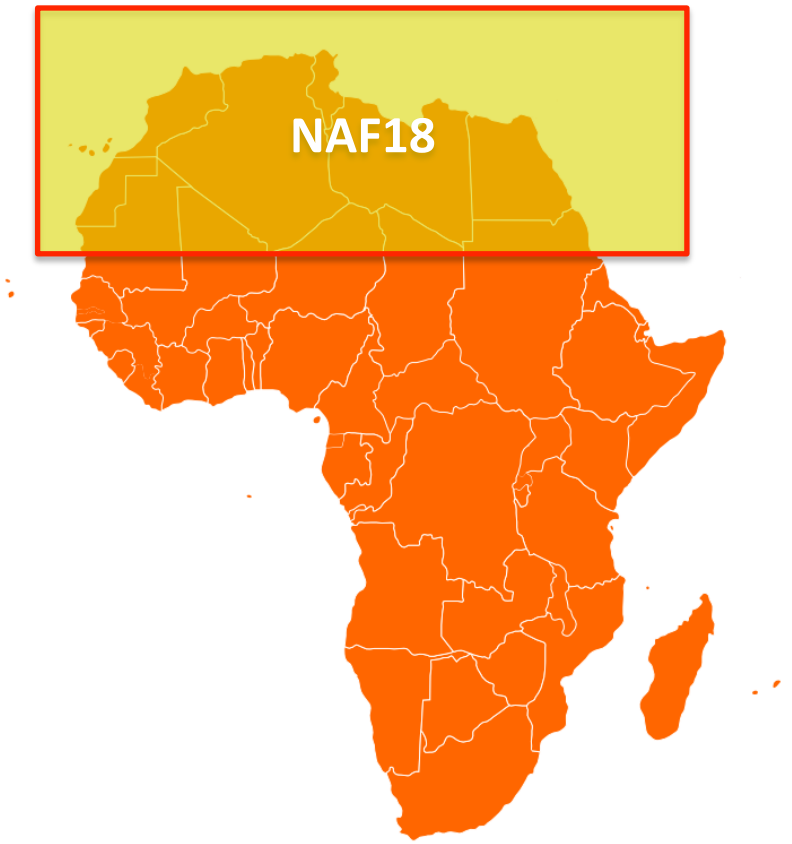
Earthquake Hazard in North Africa

① Besides the East African Rift System, significant seismicity also occurs along a wide belt bounding the Mediterranean coastline

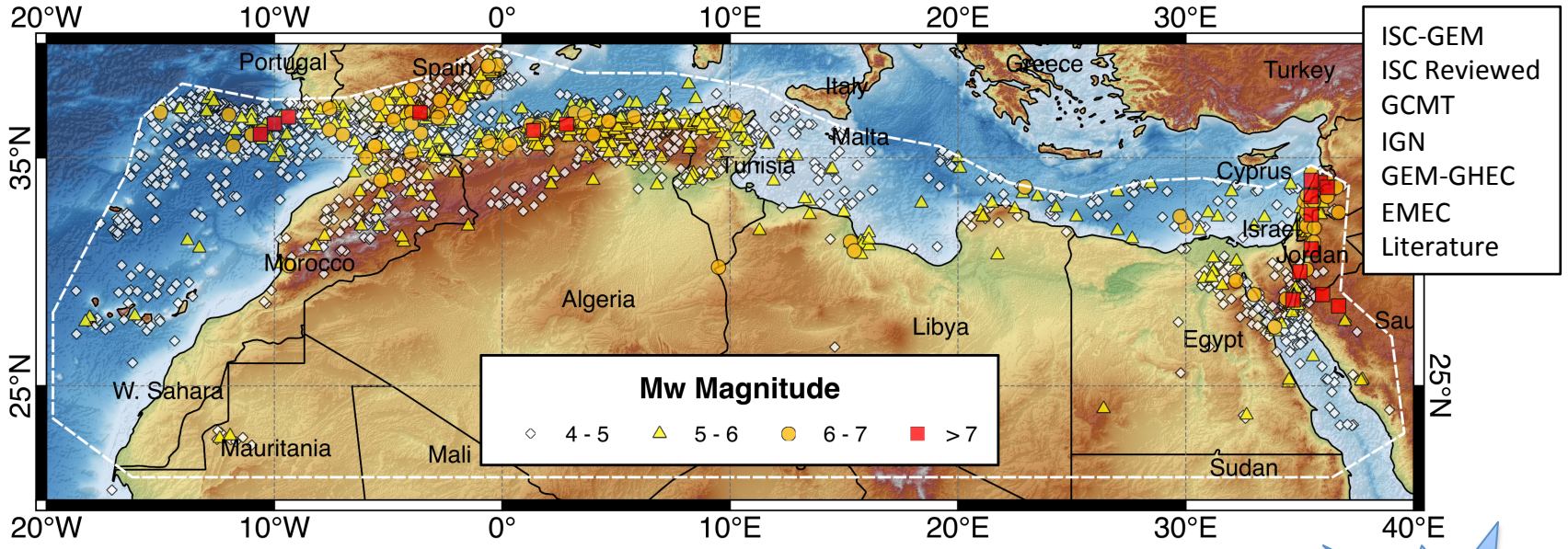
② Several past large earthquakes caused a non-negligible level of damage

③ A reliable risk assessment is therefore essential, which requires a state-of-art hazard assessment for the region

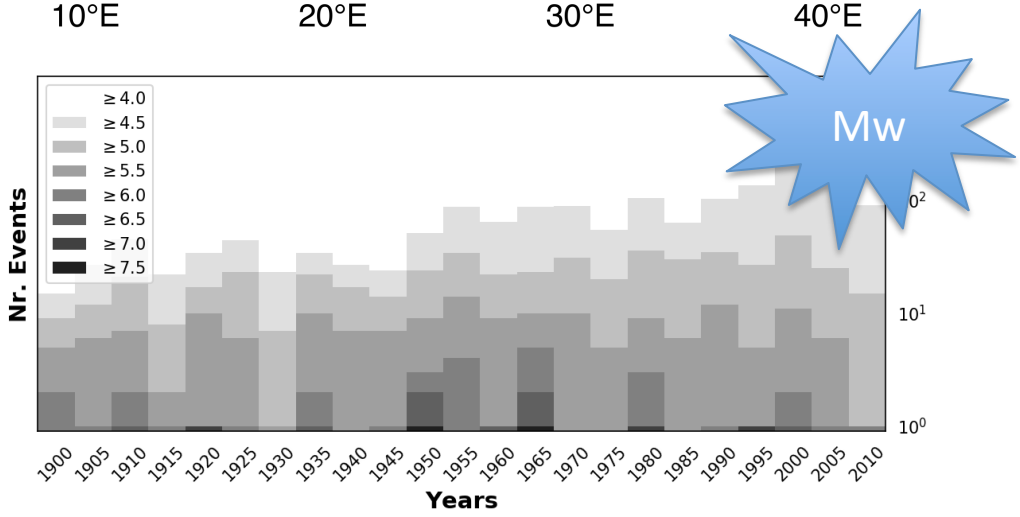
④ There is a need for a new **probabilistic seismic hazard model** based on the most recent and up to date available information



North Africa Homogenized Earthquake Catalogue



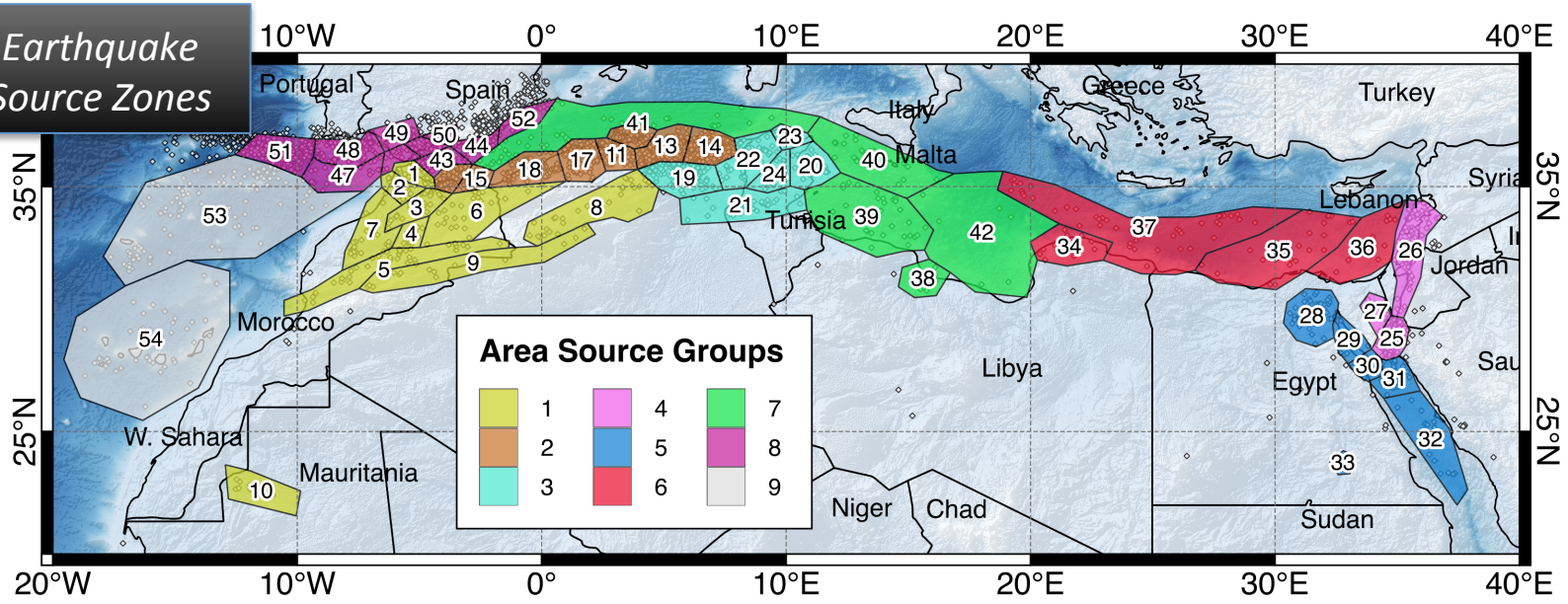
The catalogue is obtained by harmonization of **global bulletins** with data from **local agencies** and **published studies**

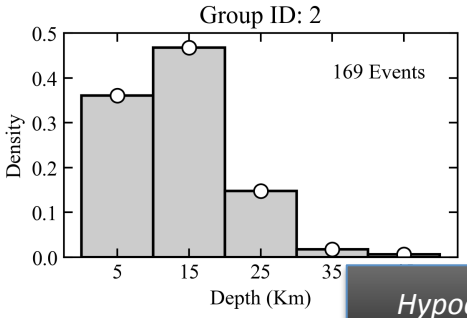


Number of Events: 5170
Year Rage: 1016 - 2013
Magnitude Rage: 4.0 - 8.5

Source Model - Regional Seismicity Analysis

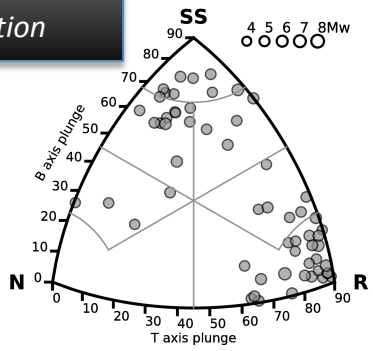
Earthquake Source Zones



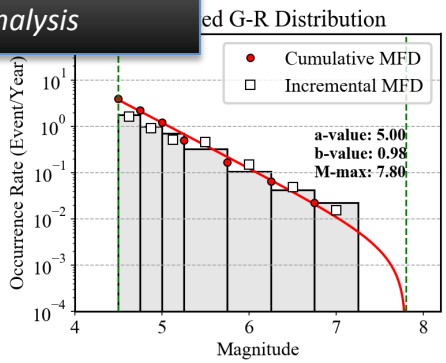


Hypocentral Depth Distribution

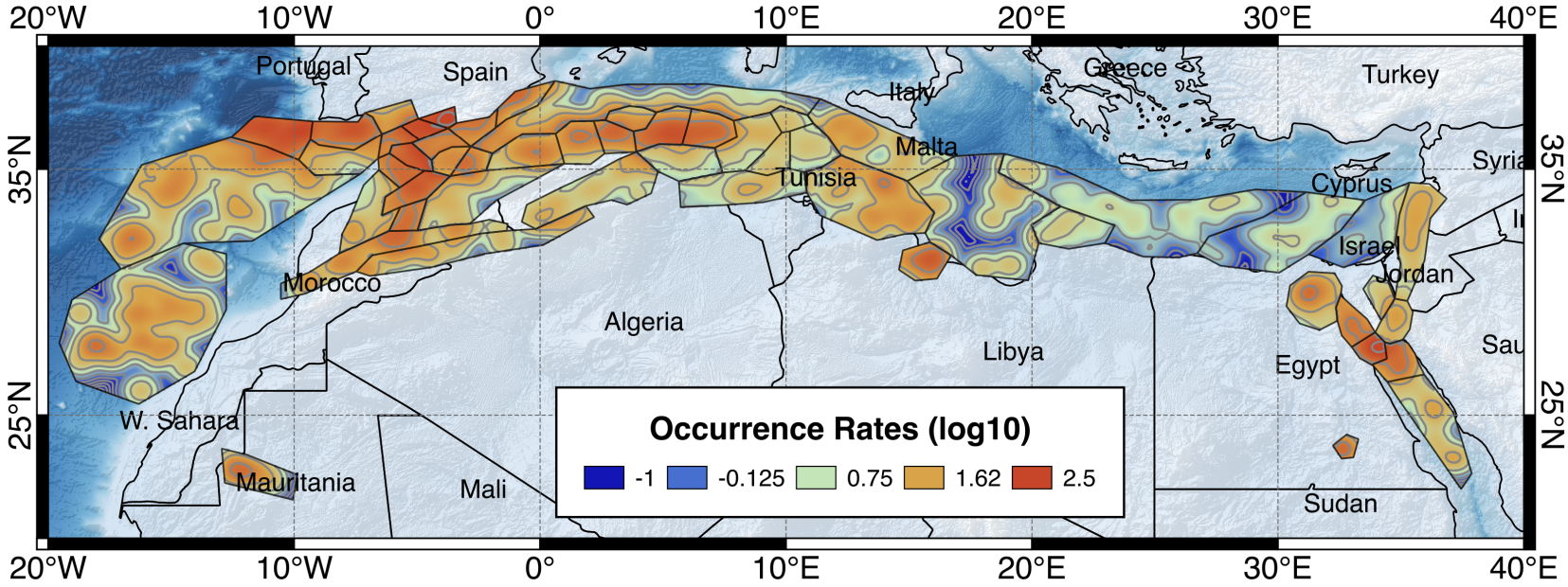
Rupture Mechanism Identification

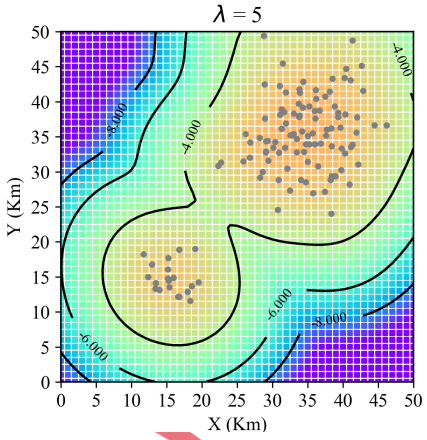


Magnitude-Frequency Analysis



Occurrence Rate Redistribution

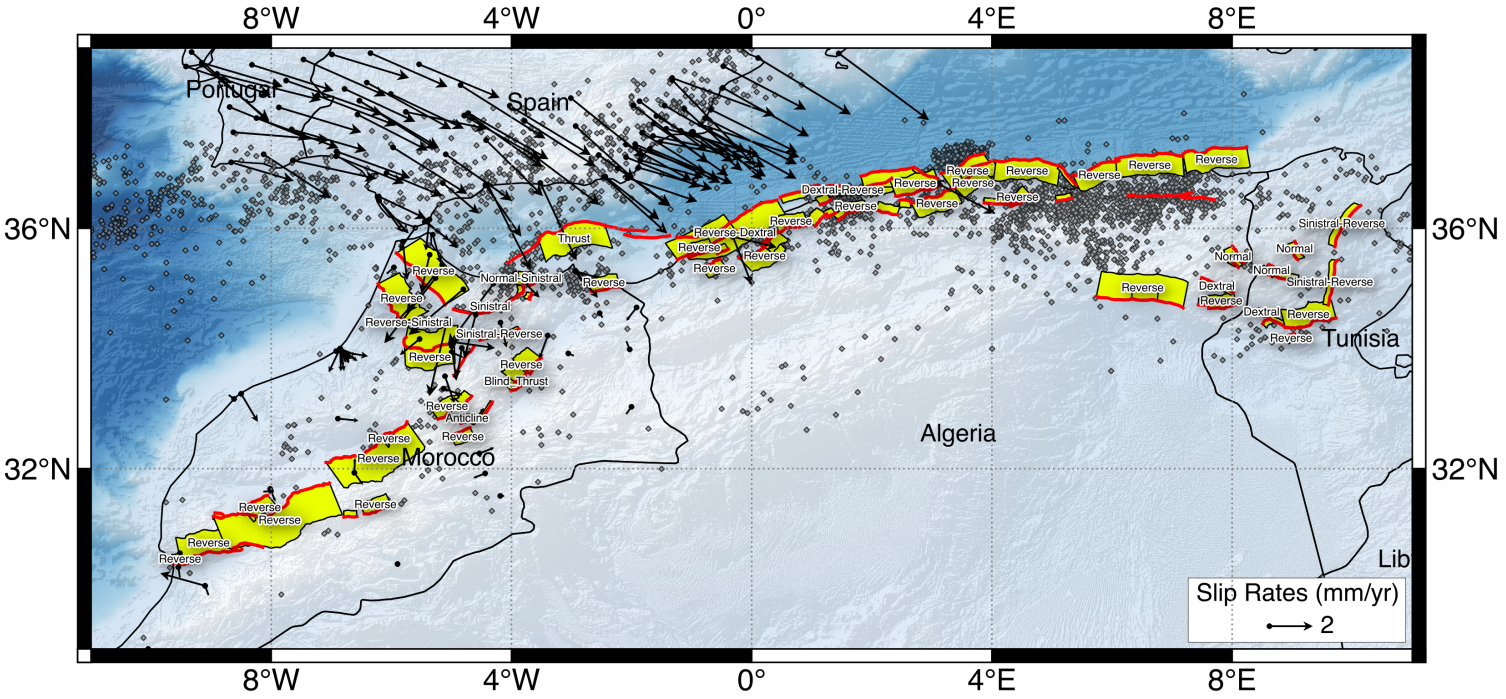




We have implemented a smoothing procedure based on **area source zonation**, where the observed rates (R) are spatially redistributed according to the seismicity pattern of the area, while keeping the overall **rate balance unmodified**:

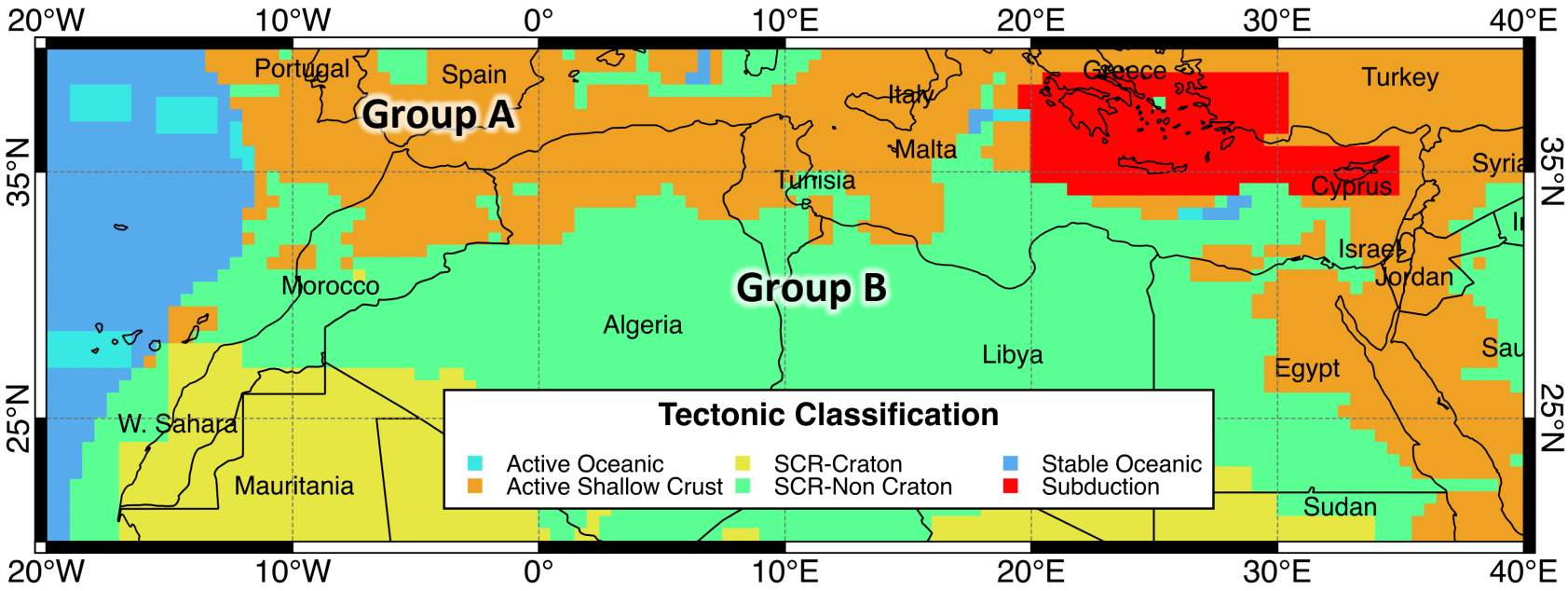
$$W_i = \sum_{j=1}^{Etot} e^{-\left(\frac{D_j}{\lambda}\right)^2} \Rightarrow R_i = \frac{W_i}{\sum_{k=1}^{Ntot} W_k} R$$

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)

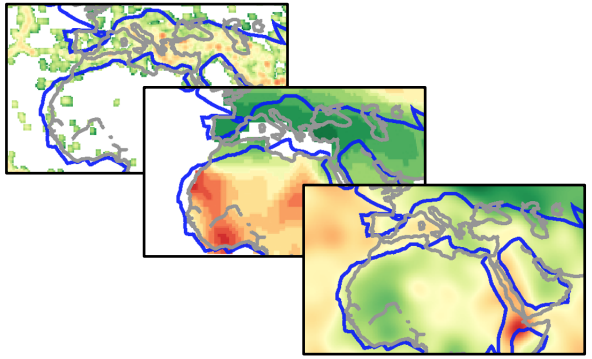
Tectonic Regionalization using Fuzzy Logic



Chen et al. 2017

Merging information from:

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



GMPE Selection and Logic-Tree Approach

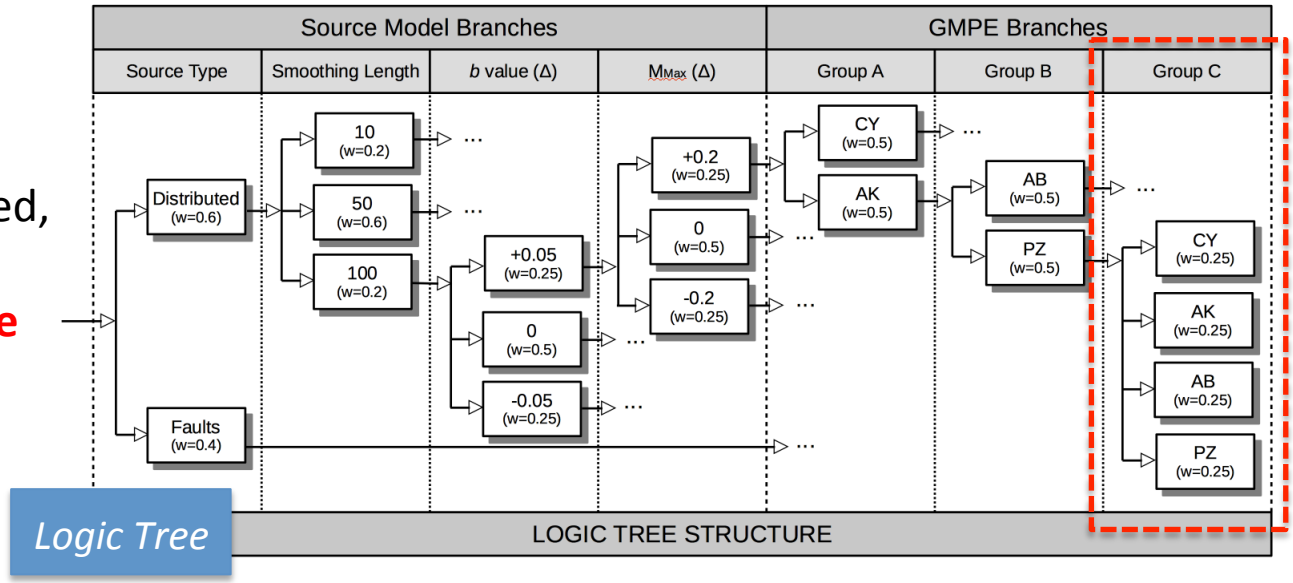
Given the peculiar seismoteconic setting of the North Africa, an **hybrid attenuation behavior** might be expected. Four suitable GMPEs have been selected:

1. Chiou & Youngs (2014)
2. Akkar et al. (2014)
3. Atkinson & Boore (2006)
4. Pezeshk et al. (2011)

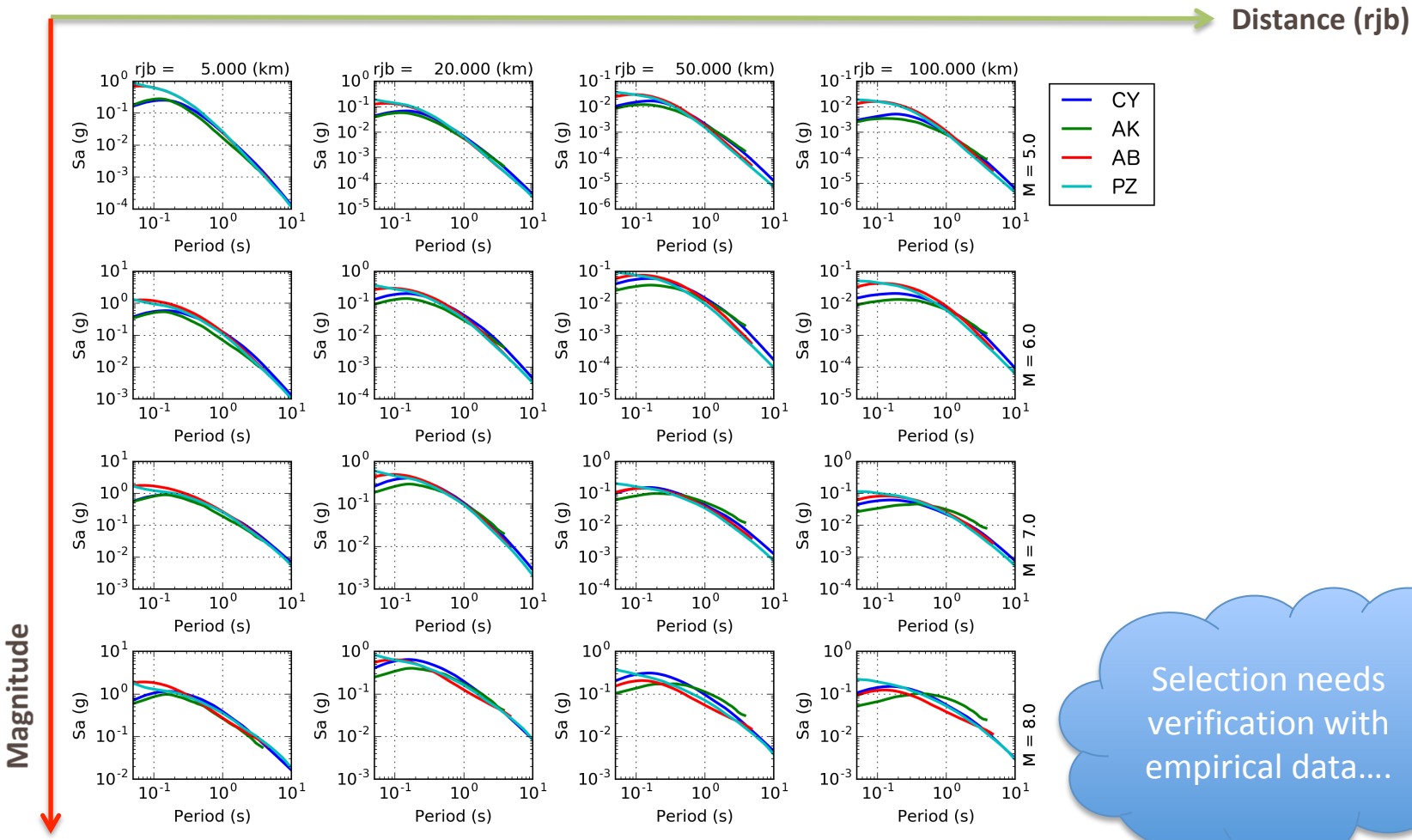
→ Active Shallow Crust (Group A)

→ Stable Continental Crust (Group B)

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



GMPE Selection – Comparing Ground Motion



Selection needs verification with empirical data….

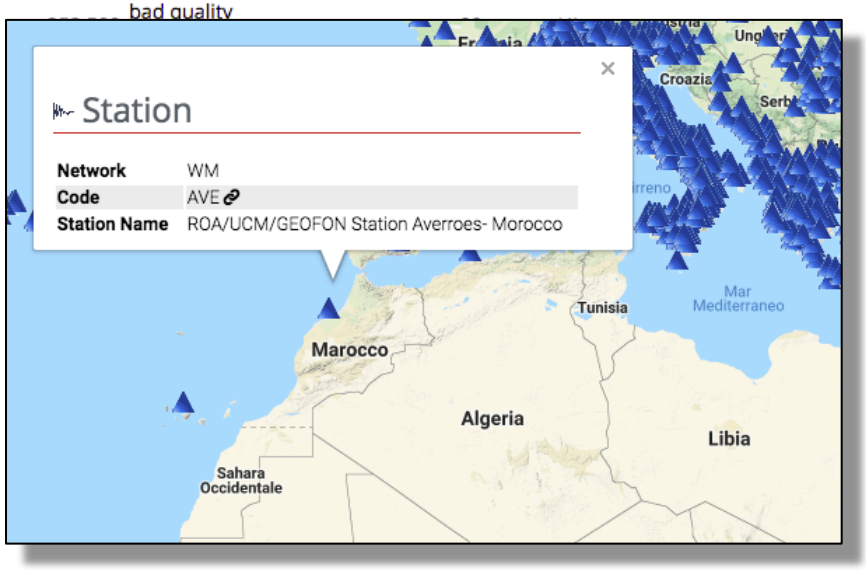
ESM Engineering Strong

within EPOS EUROPEAN PLATE OBSERVING SYSTEM

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				

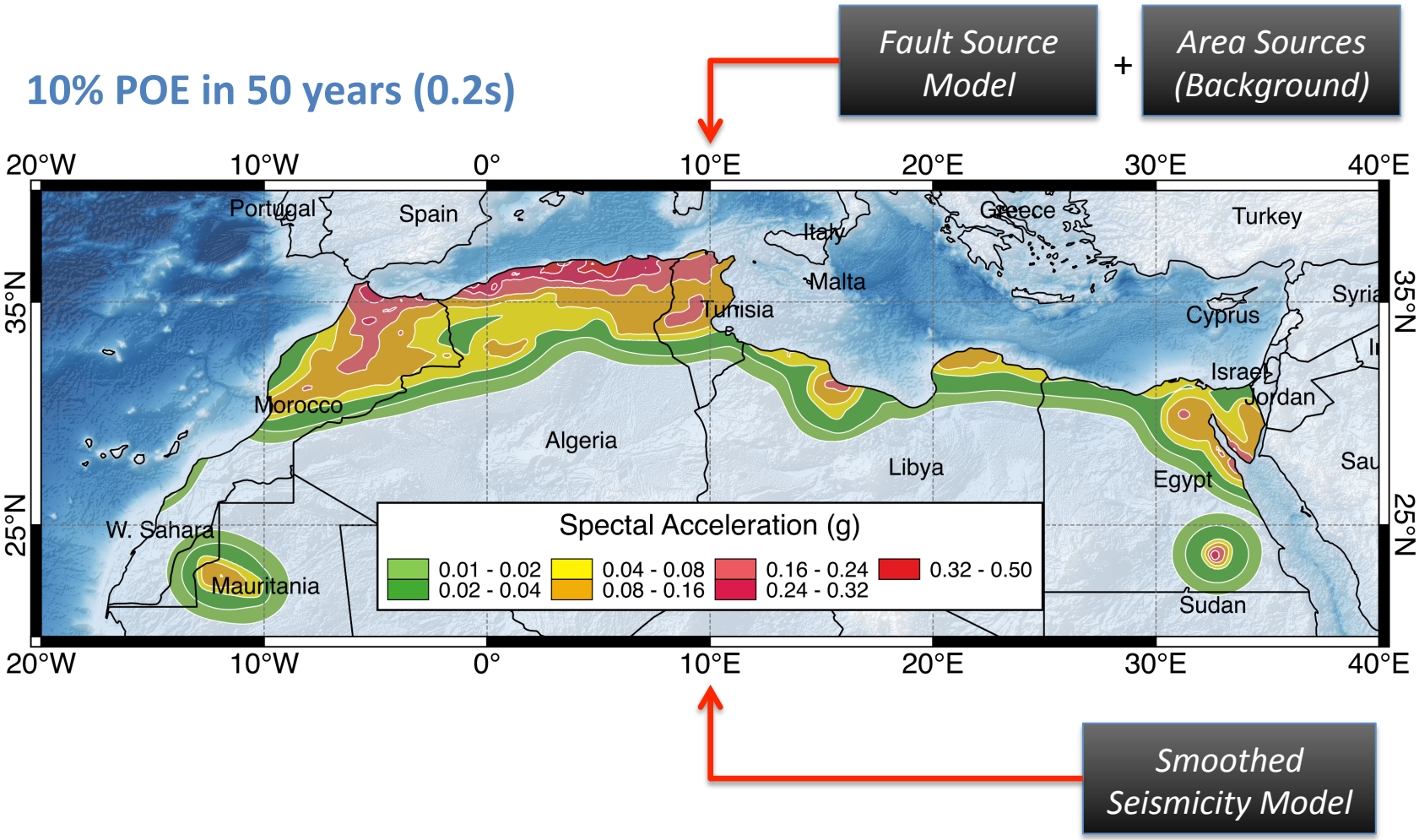
1 station in Morocco: 8 Events available
(6 usable)
2 stations in Algeria: 2 Events

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

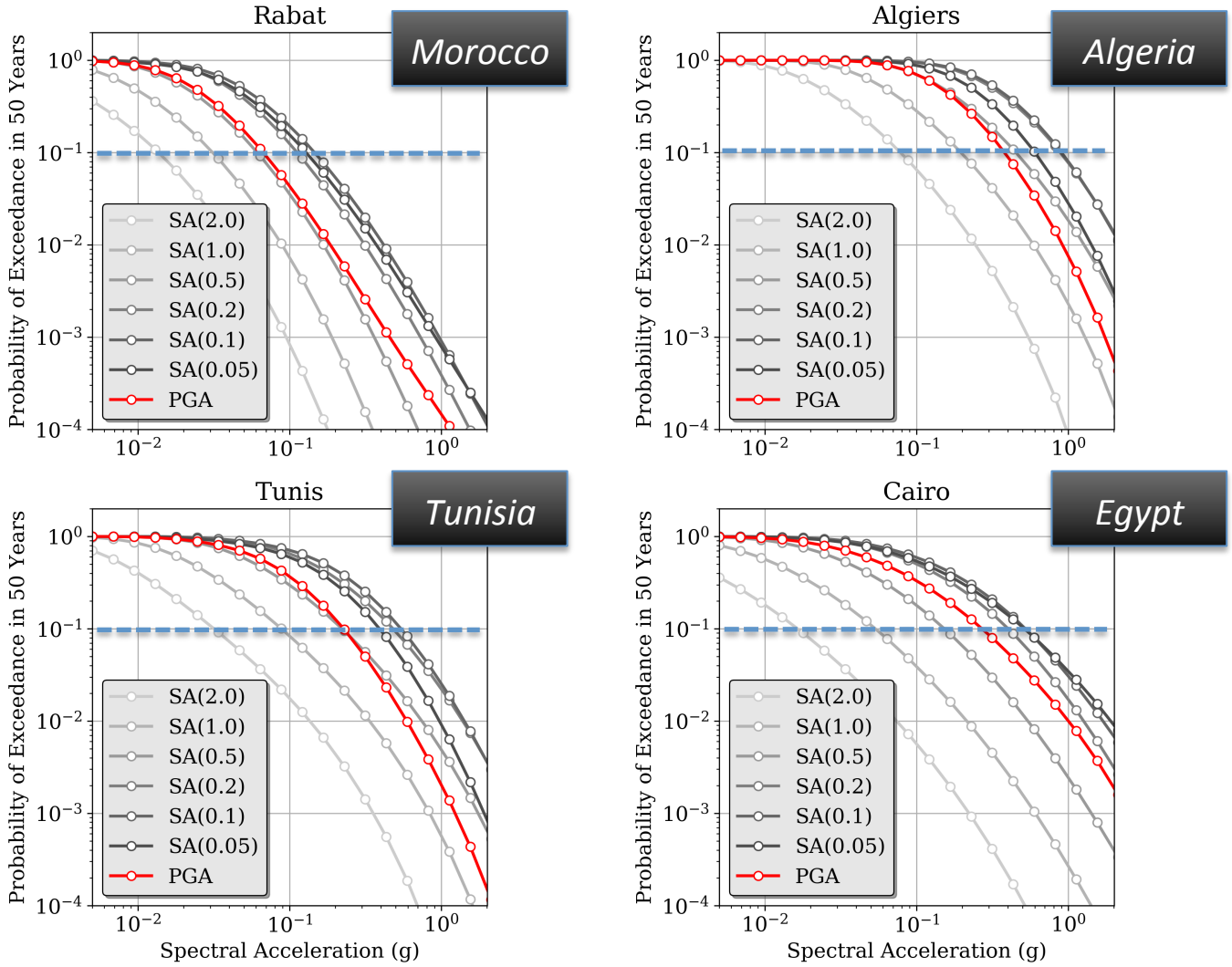


Preliminary Hazard Results

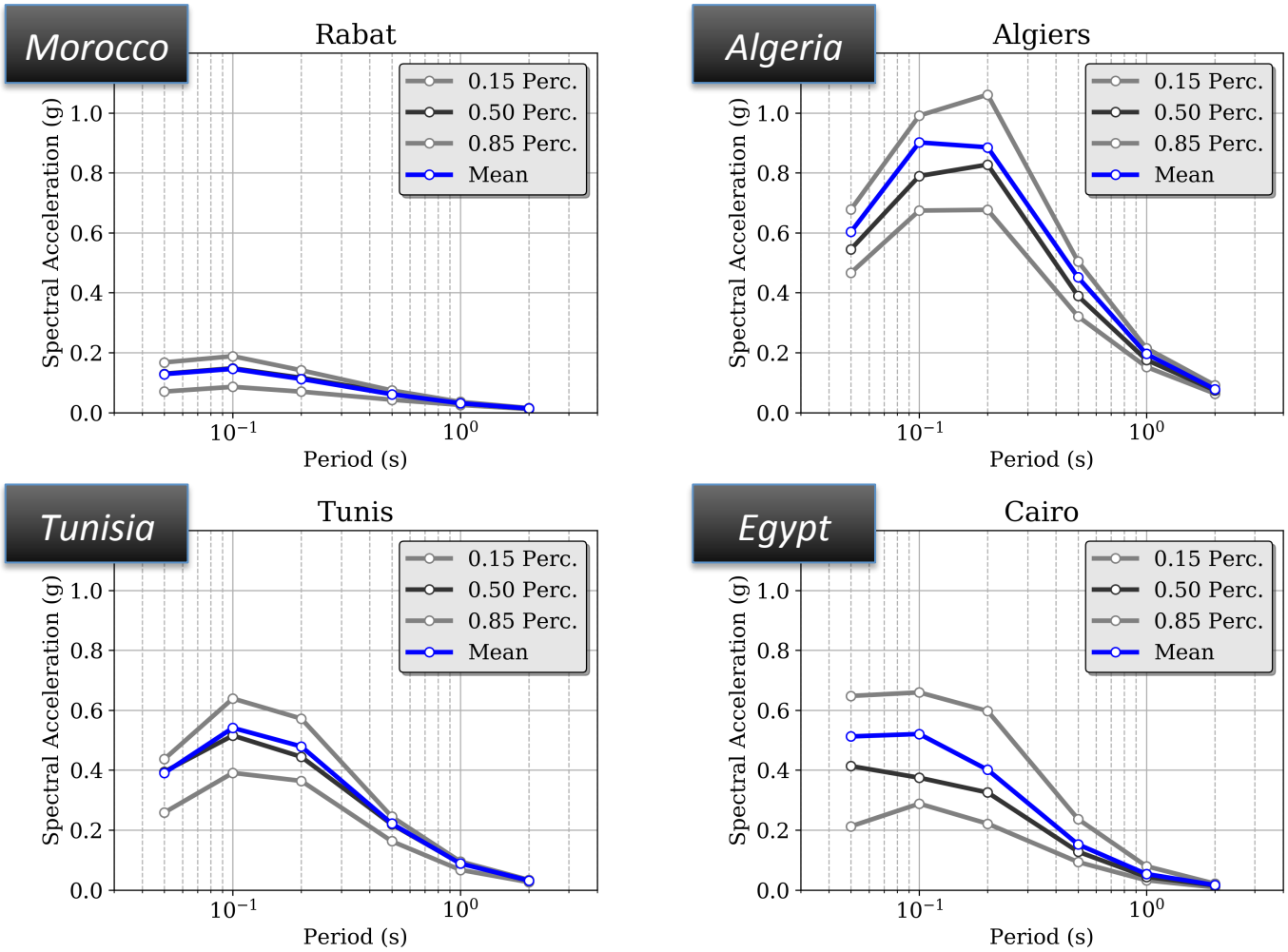
10% POE in 50 years (0.2s)



Hazard Curves @ African Capitals

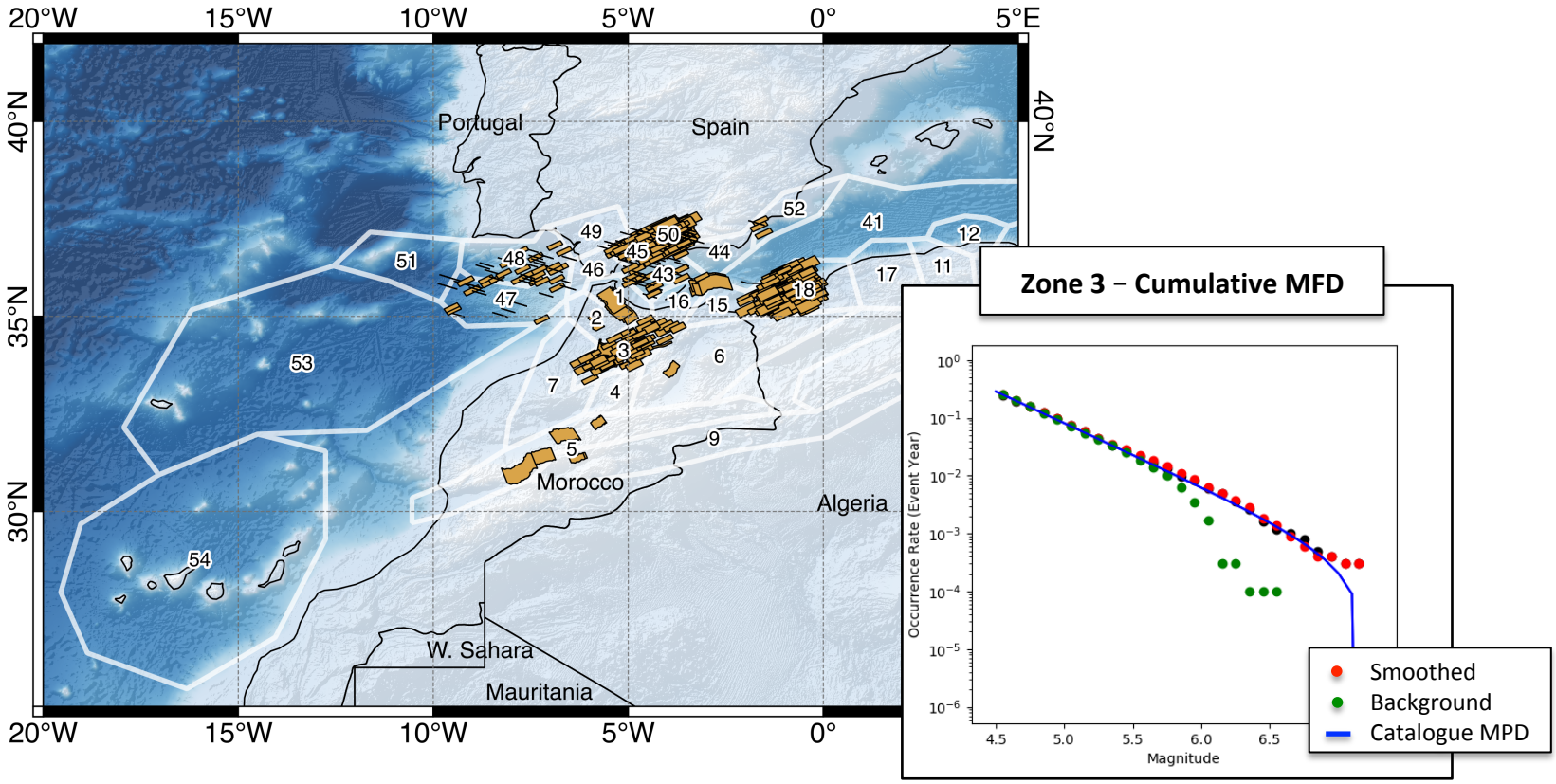


Uniform Hazard Spectra @ African Capitals



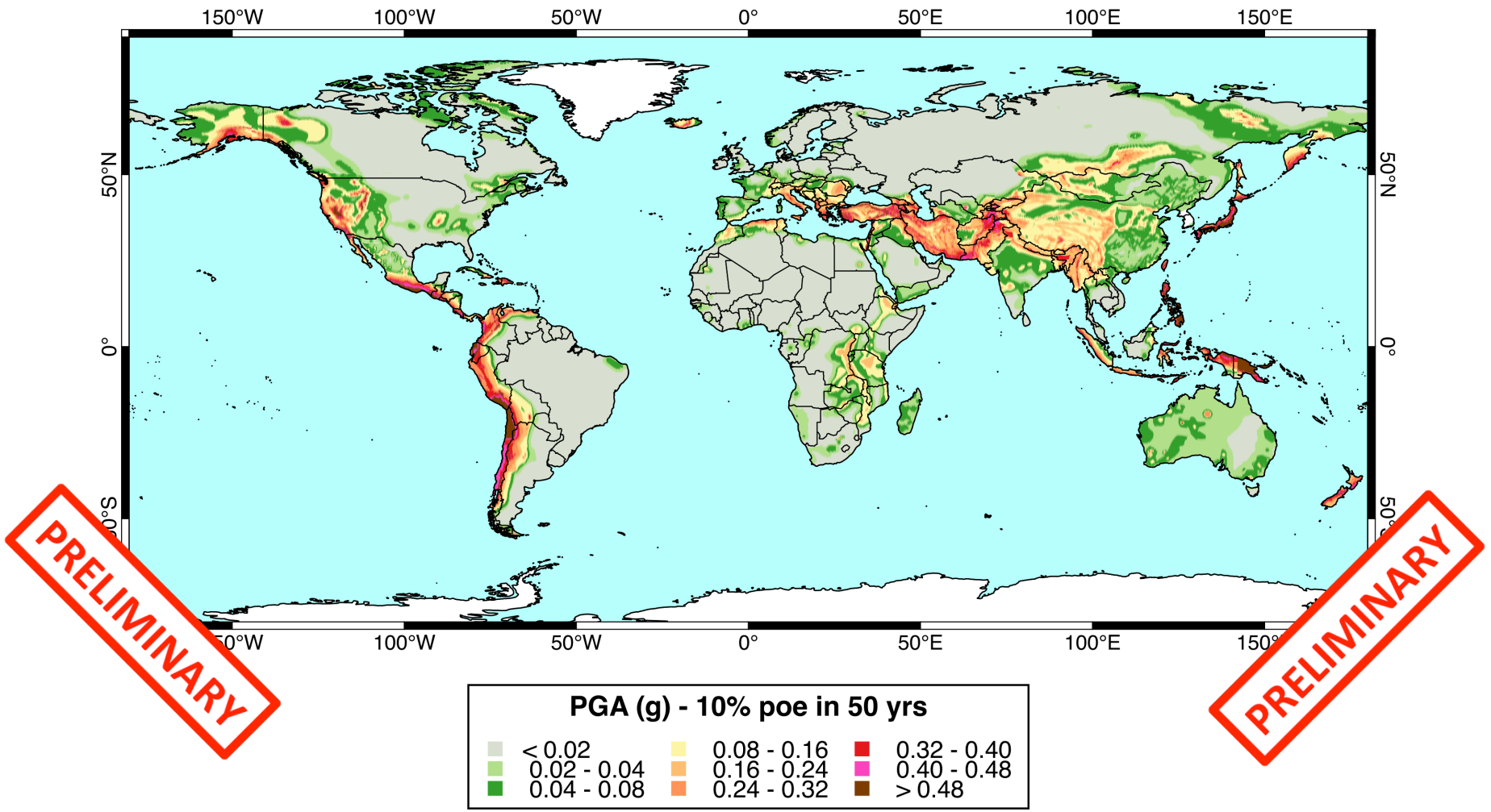
10% POE in 50 years

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 Mw>4.5

GEM Global Mosaic of Hazard Models



Missing Components / Improvements

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

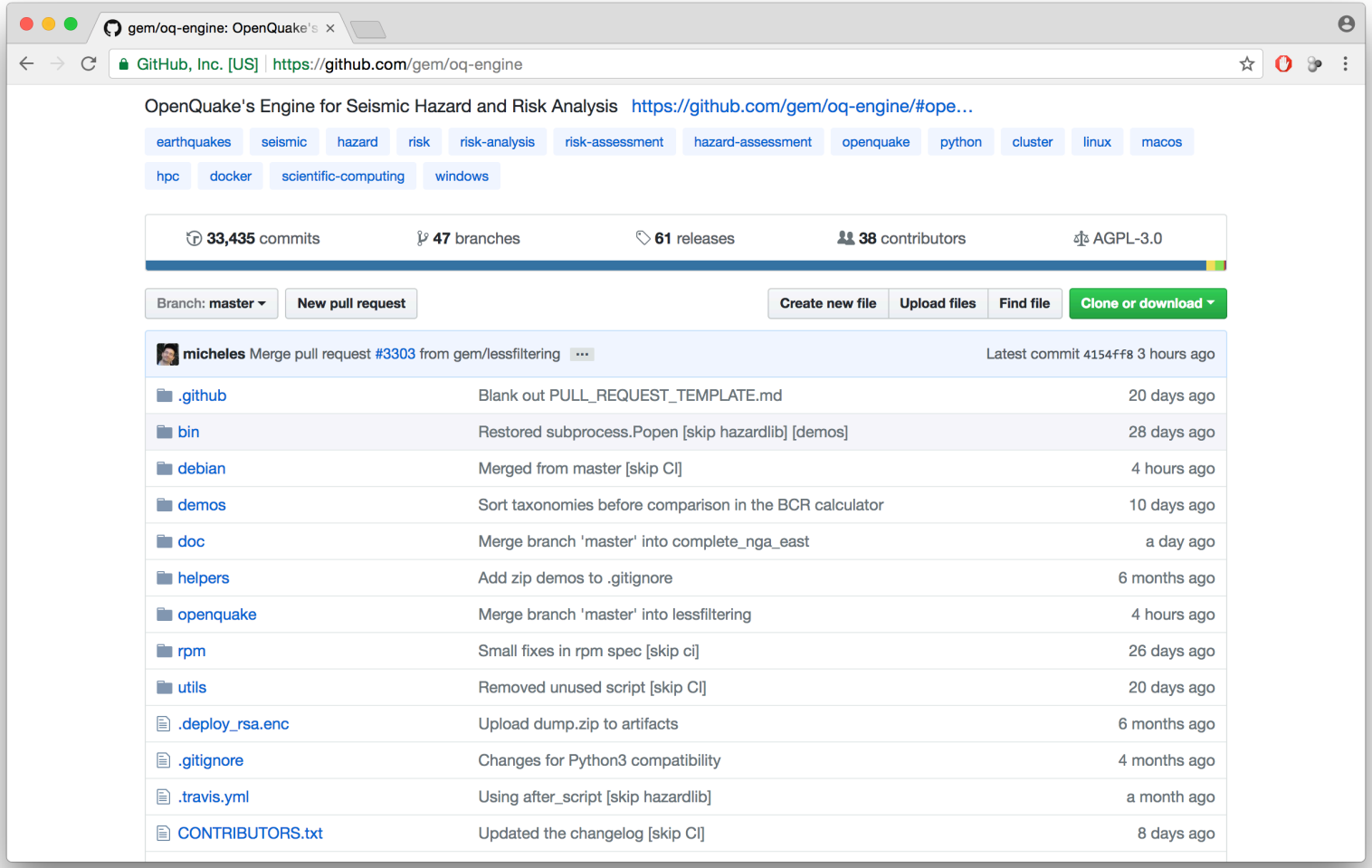
While existing components can be improved, many other components are still missing, such as:

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

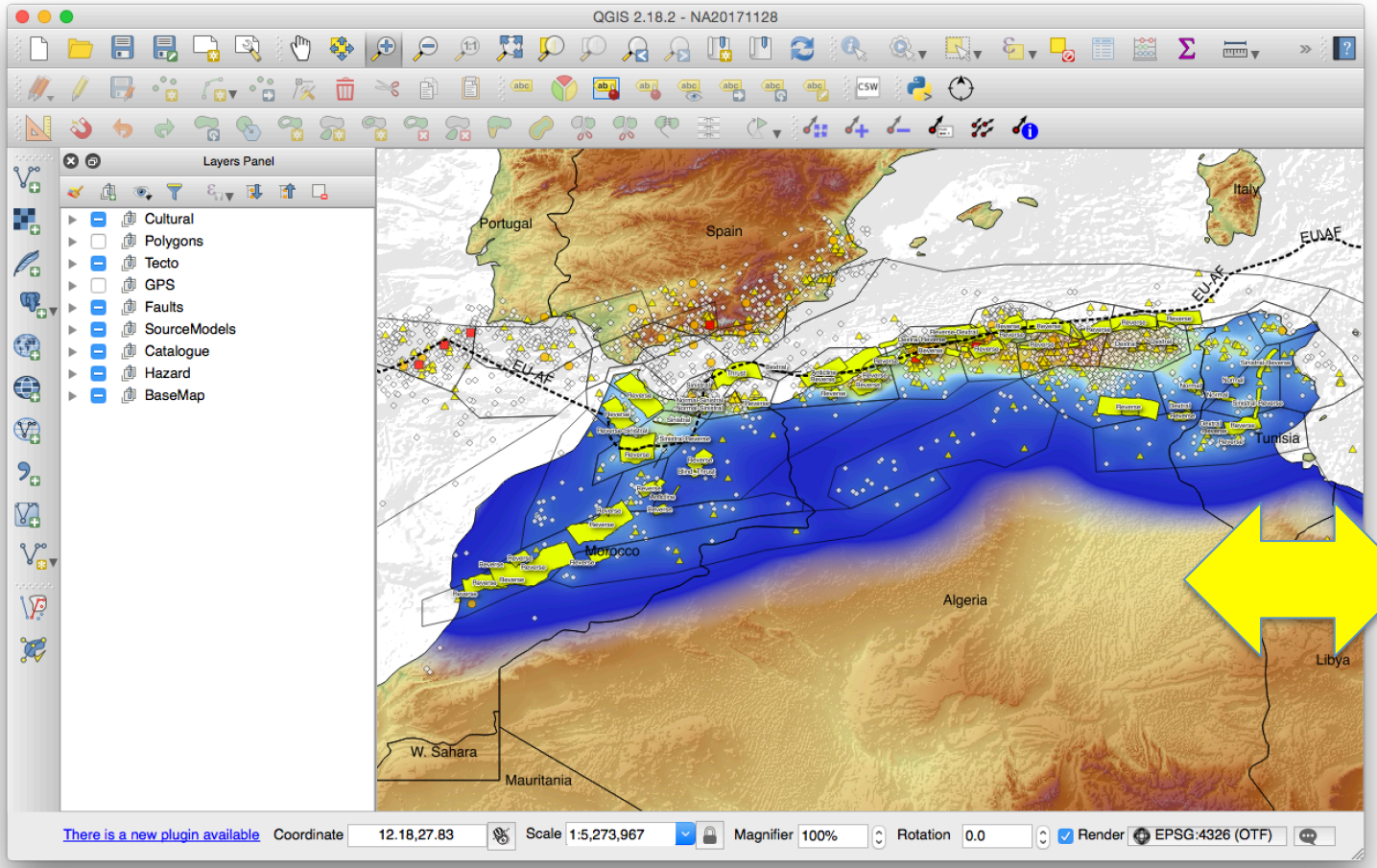
Need for a collaborative effort

Thank you!

OpenQuake Engine - GitHub repository

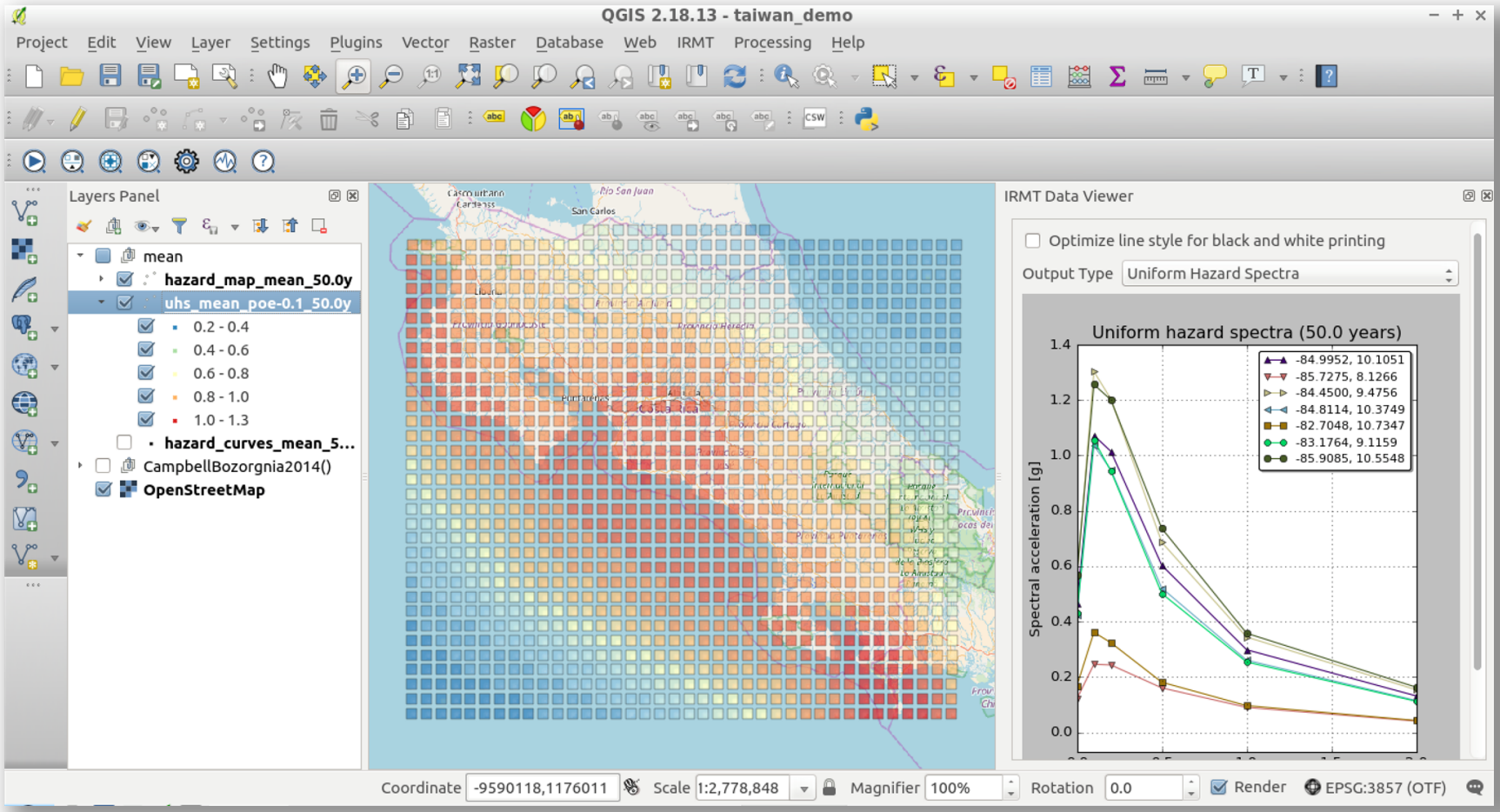


OpenQuake Engine – QGIS integration



From/To OpenQuake Source Model

OpenQuake Engine – QGIS integration (2)



GEM Global Database of Hazard Models