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

Valerio Poggi, Julio Garcia, Richard Styron, Robin Gee

*Global Earthquake Model (GEM), Pavia Italy*

36th General Assembly of the

**European Seismological Commission**

September 3rd, 2018, Valletta - Malta

working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

OQ
OPENQUAKE

# Introduction to GEM

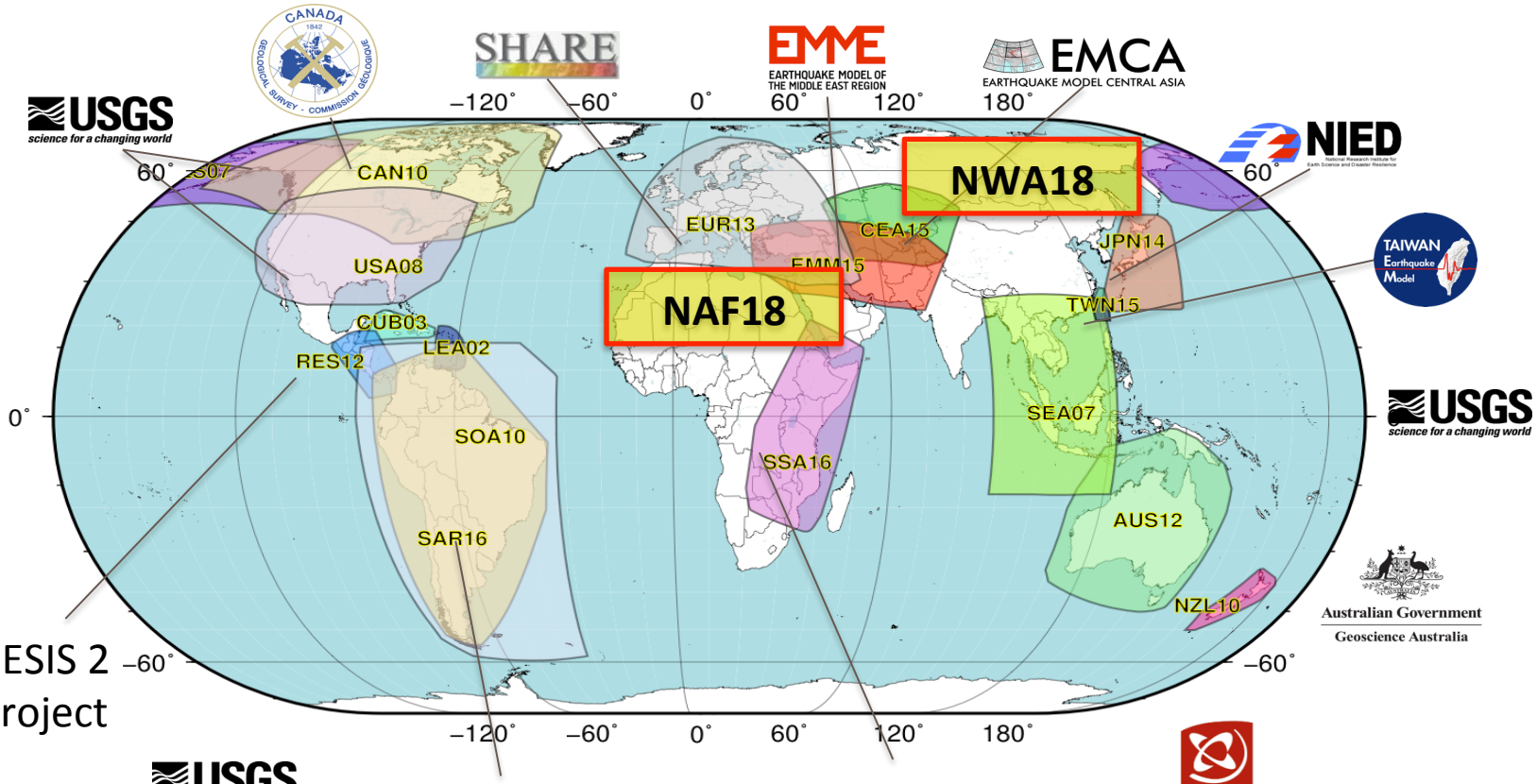
**GEM** (**Global Earthquake Model**) is a no-profit organization funded by public and private partners aimed to stimulate the awareness on seismic hazard and risk worldwide

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



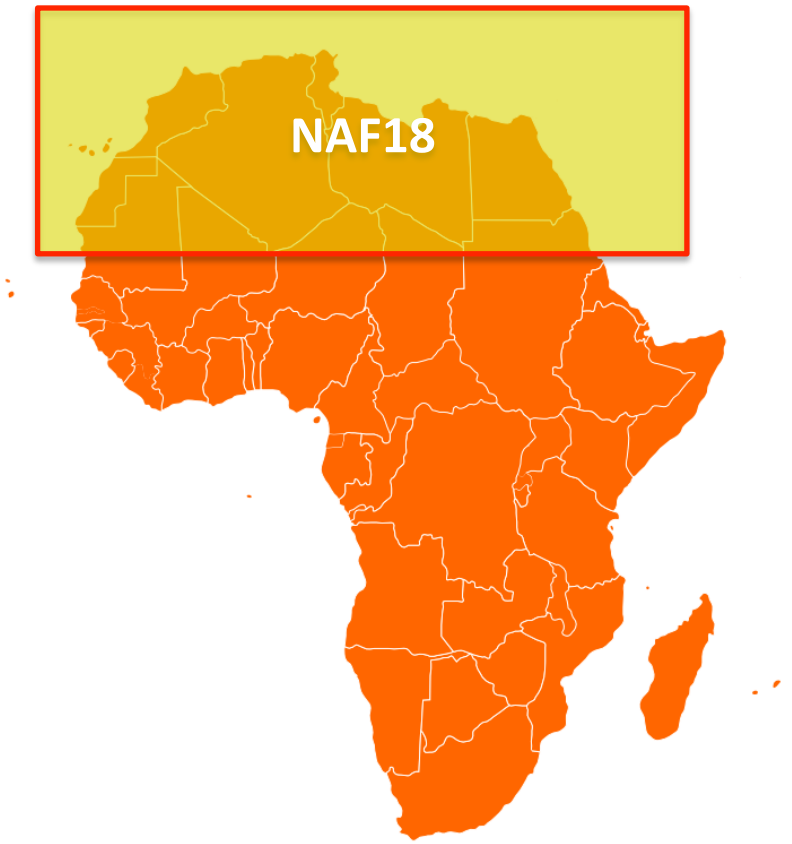
# Earthquake Hazard in North Africa

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

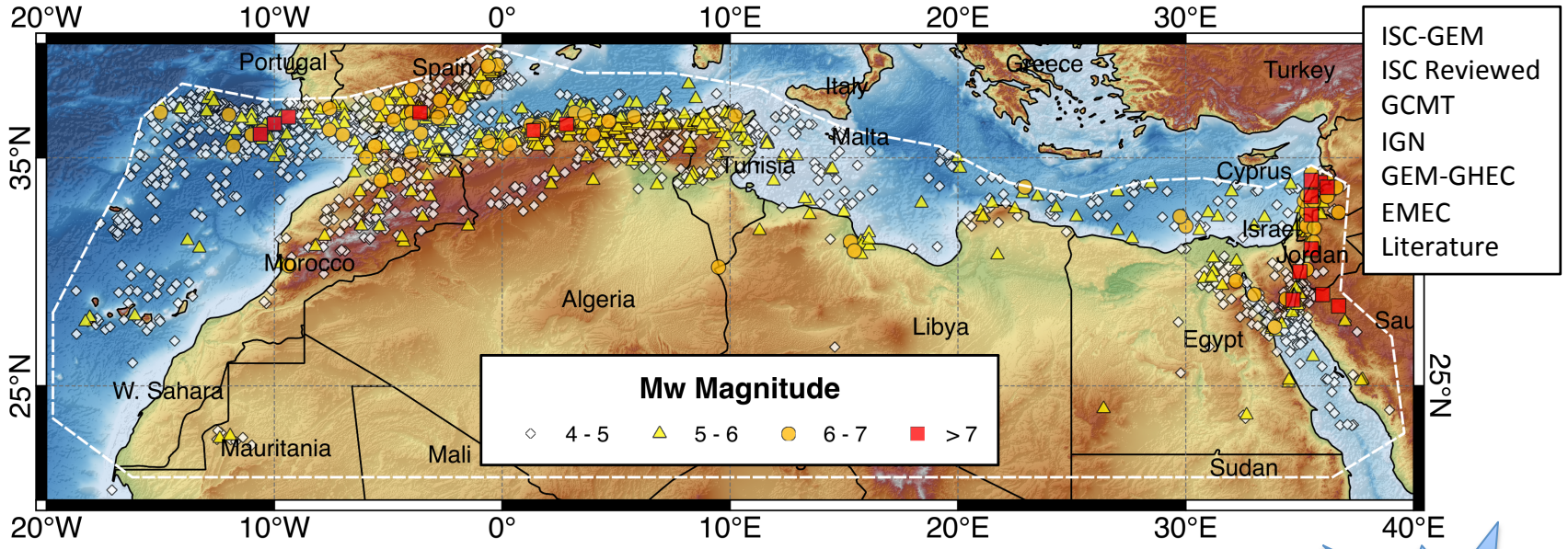
② Several past large earthquakes caused a non-negligible level of damage

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

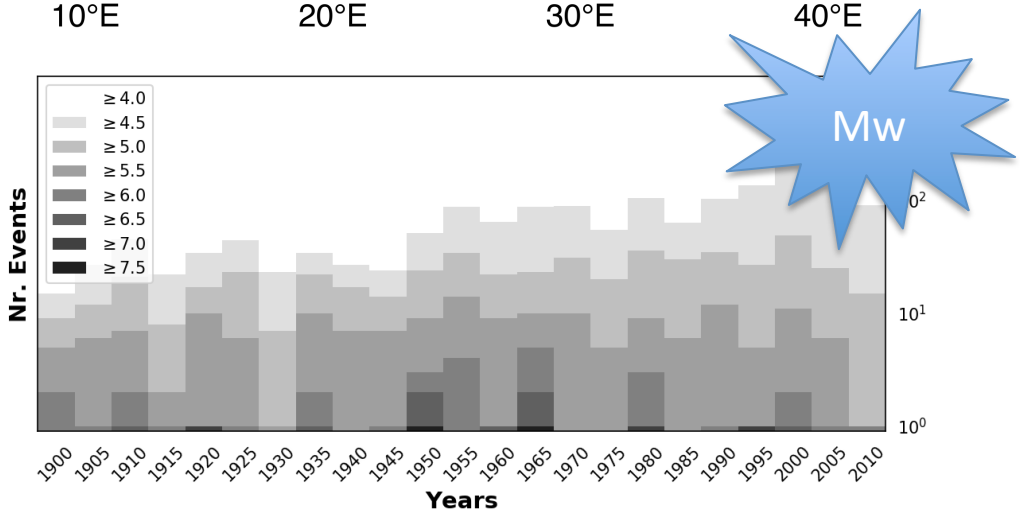
④ There is a need for a new **probabilistic seismic hazard model** based on the most recent and up to date available information



# North Africa Homogenized Earthquake Catalogue



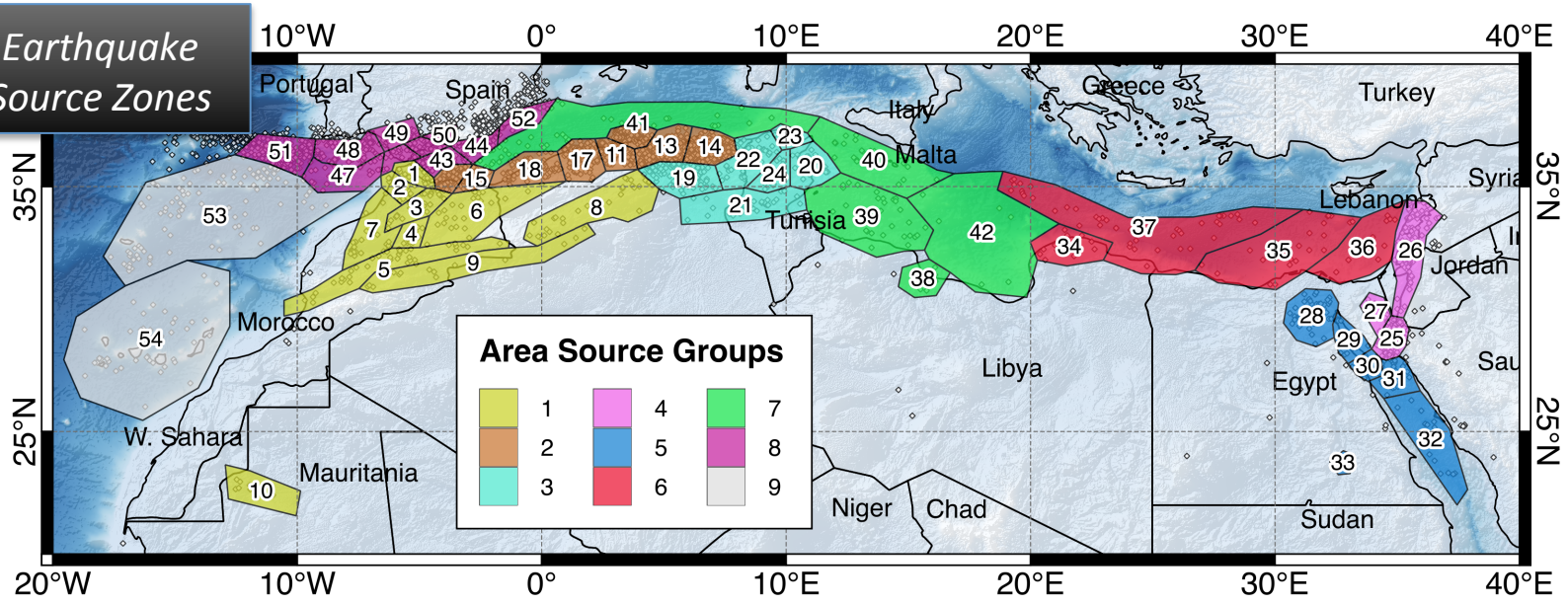

The catalogue is obtained by harmonization of **global bulletins** with data from **local agencies** and **published studies**

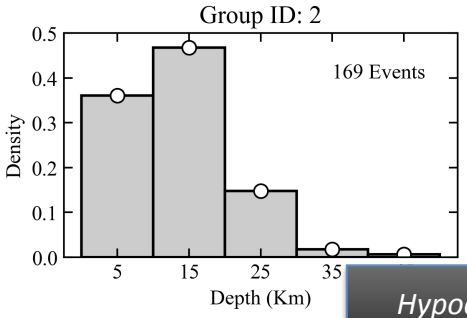



Number of Events: 5170
Year Rage: 1016 - 2013
Magnitude Rage: 4.0 - 8.5

# Source Model - Regional Seismicity Analysis

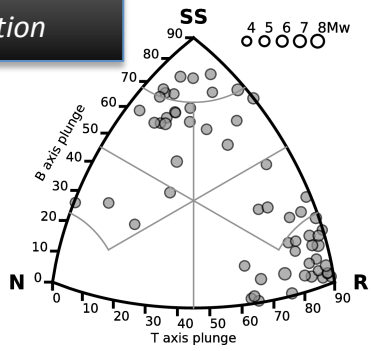
*Earthquake Source Zones*



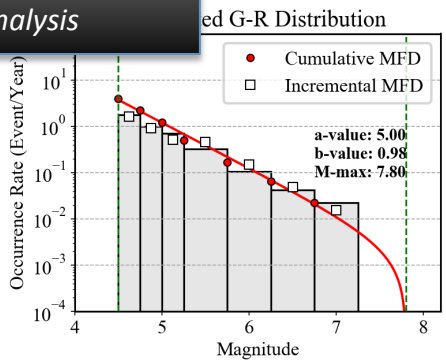




*Hypocentral Depth Distribution*

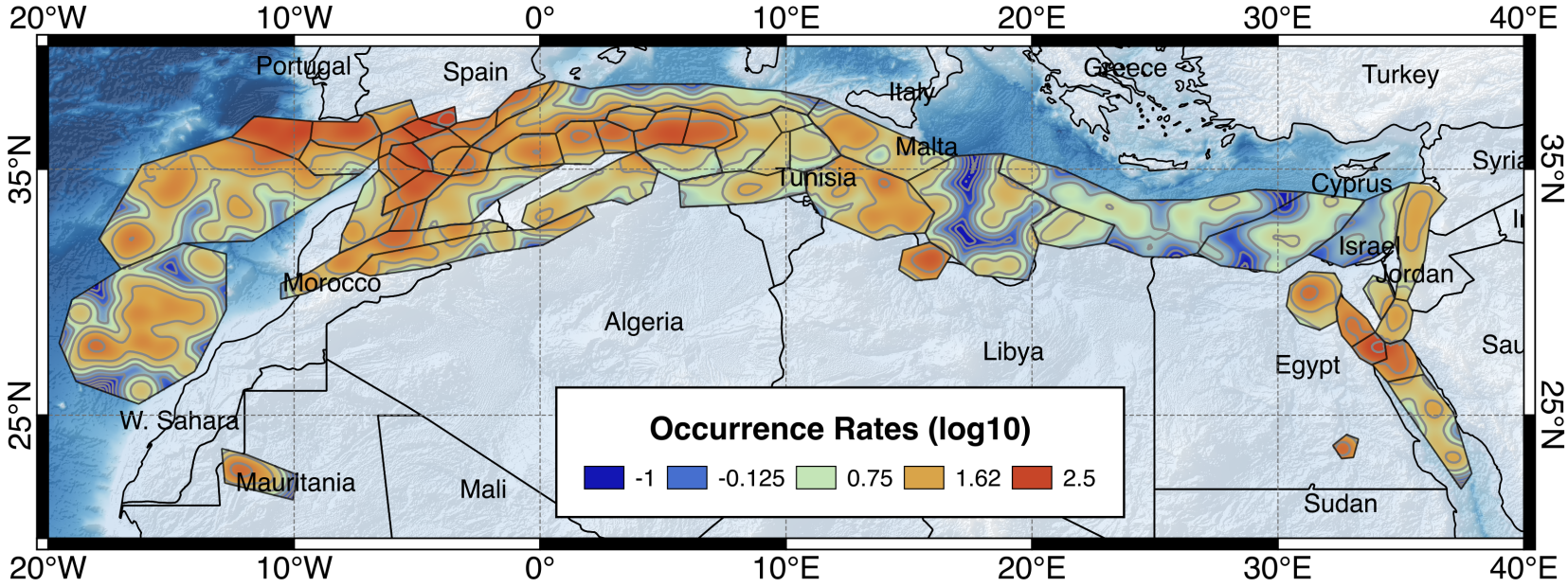
*Rupture Mechanism Identification*

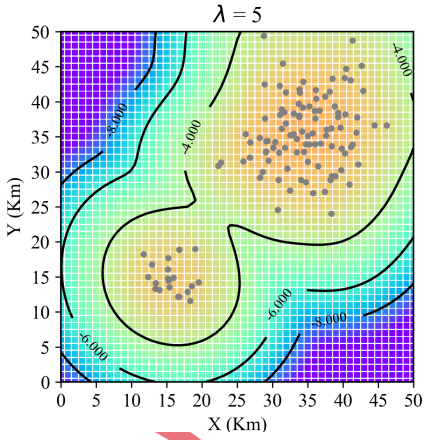



*Magnitude-Frequency Analysis*



# Occurrence Rate Redistribution

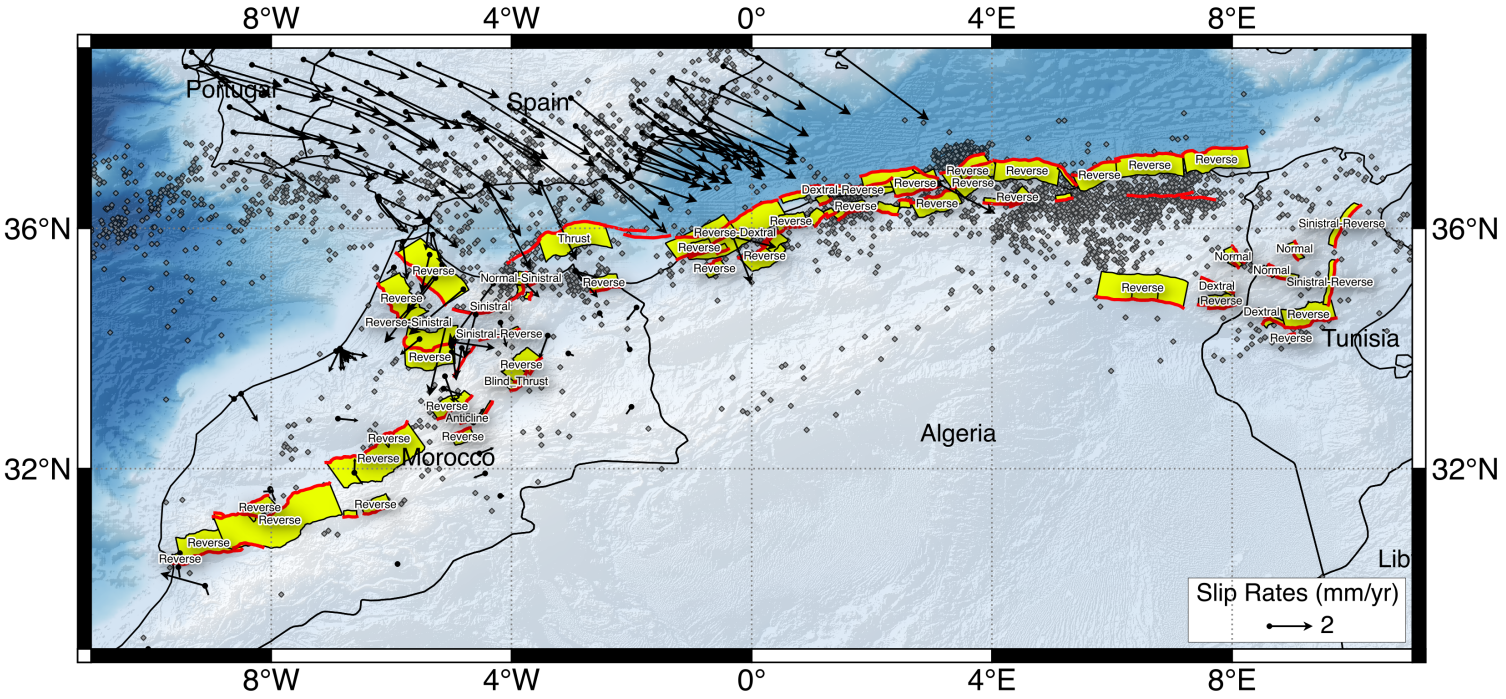



We have implemented a smoothing procedure based on **area source zonation**, where the observed rates (R) are spatially redistributed according to the seismicity pattern of the area, while keeping the overall **rate balance unmodified**:

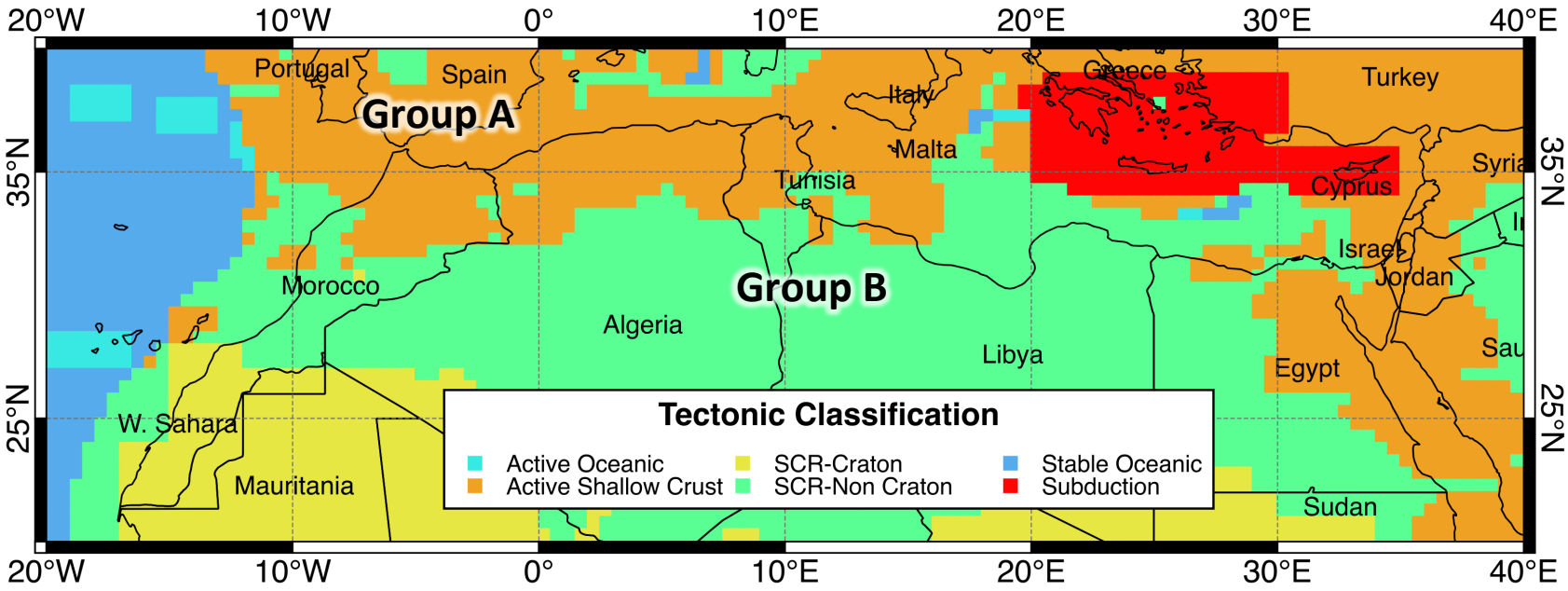
$$W_i = \sum_{j=1}^{Etot} e^{-\left(\frac{D_j}{\lambda}\right)^2} \Rightarrow R_i = \frac{W_i}{\sum_{k=1}^{Ntot} W_k} R$$

# 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)

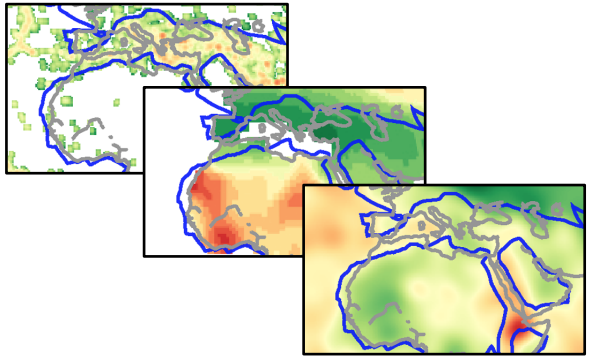
# Tectonic Regionalization using Fuzzy Logic




Chen et al. 2017

Merging information from:

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



# GMPE Selection and Logic-Tree Approach

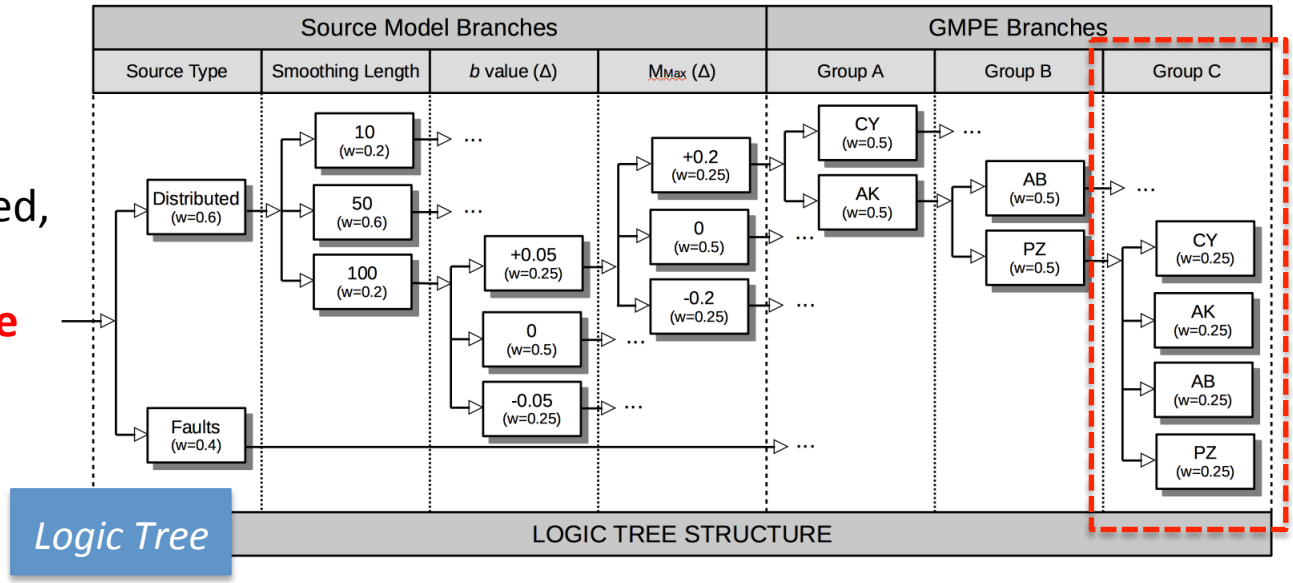
Given the peculiar seismoteconic setting of the North Africa, an **hybrid attenuation behavior** might be expected. Four suitable GMPEs have been selected:

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

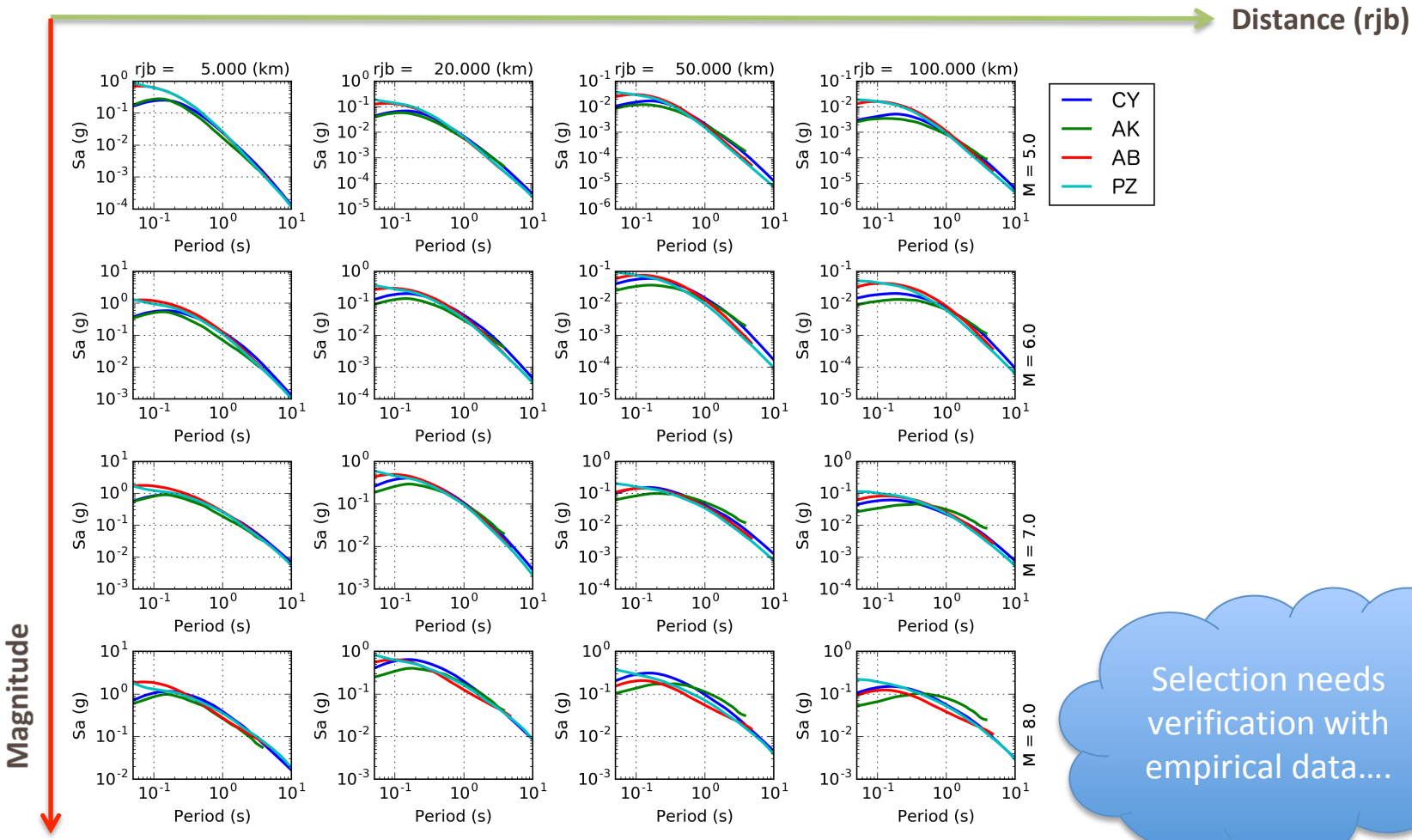
→ Active Shallow Crust (Group A)

→ 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….

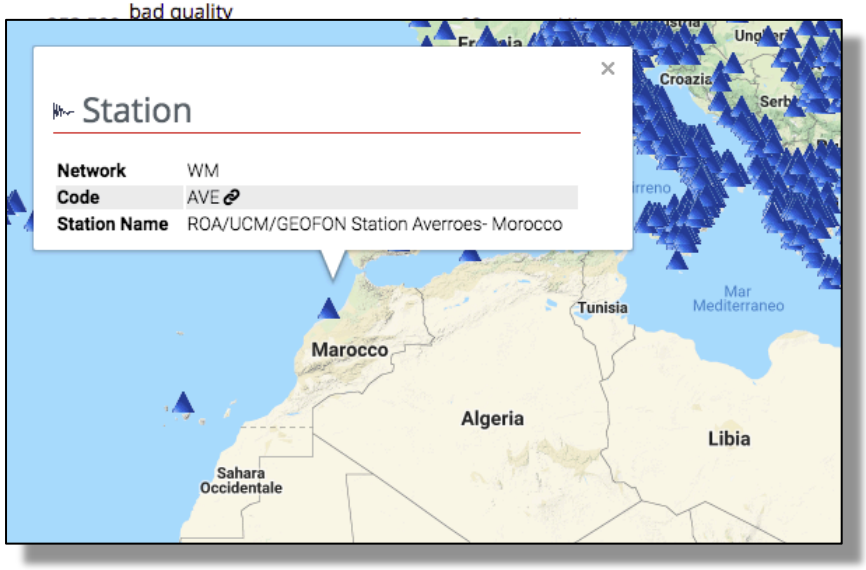
# ESM Engineering Strong

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 | | | | |

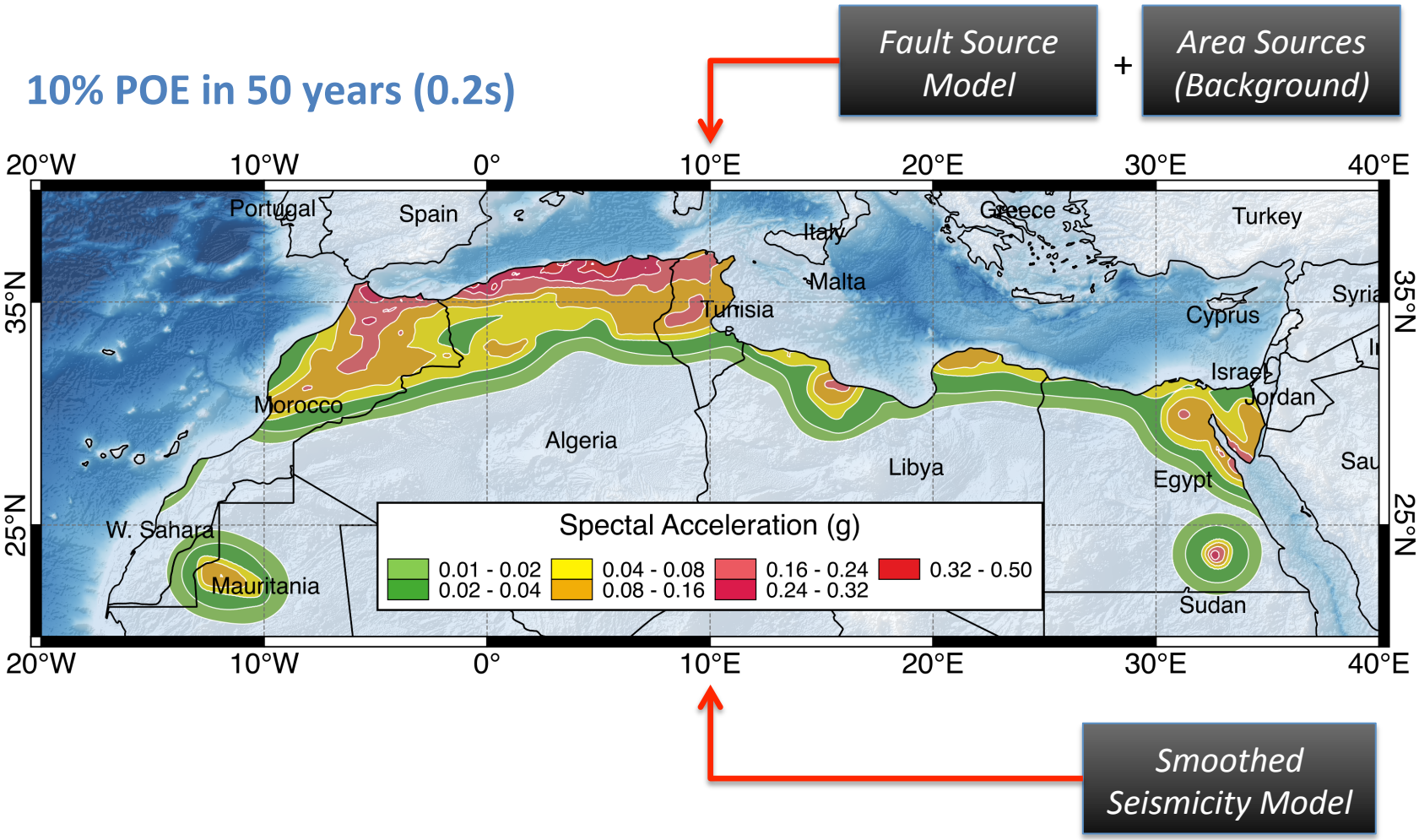
1 station in Morocco: 8 Events available
(6 usable)
2 stations in Algeria: 2 Events

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

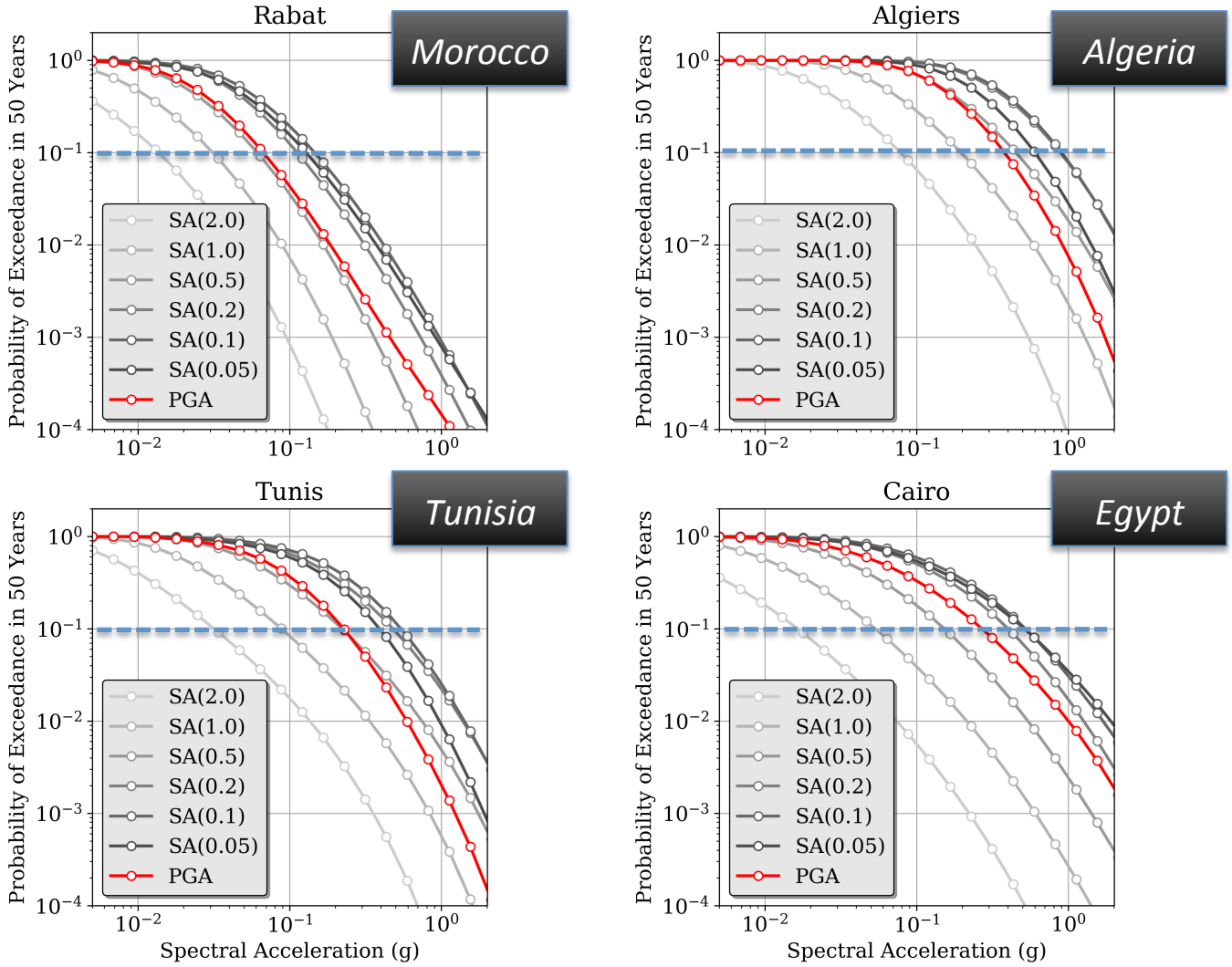


# Preliminary Hazard Results

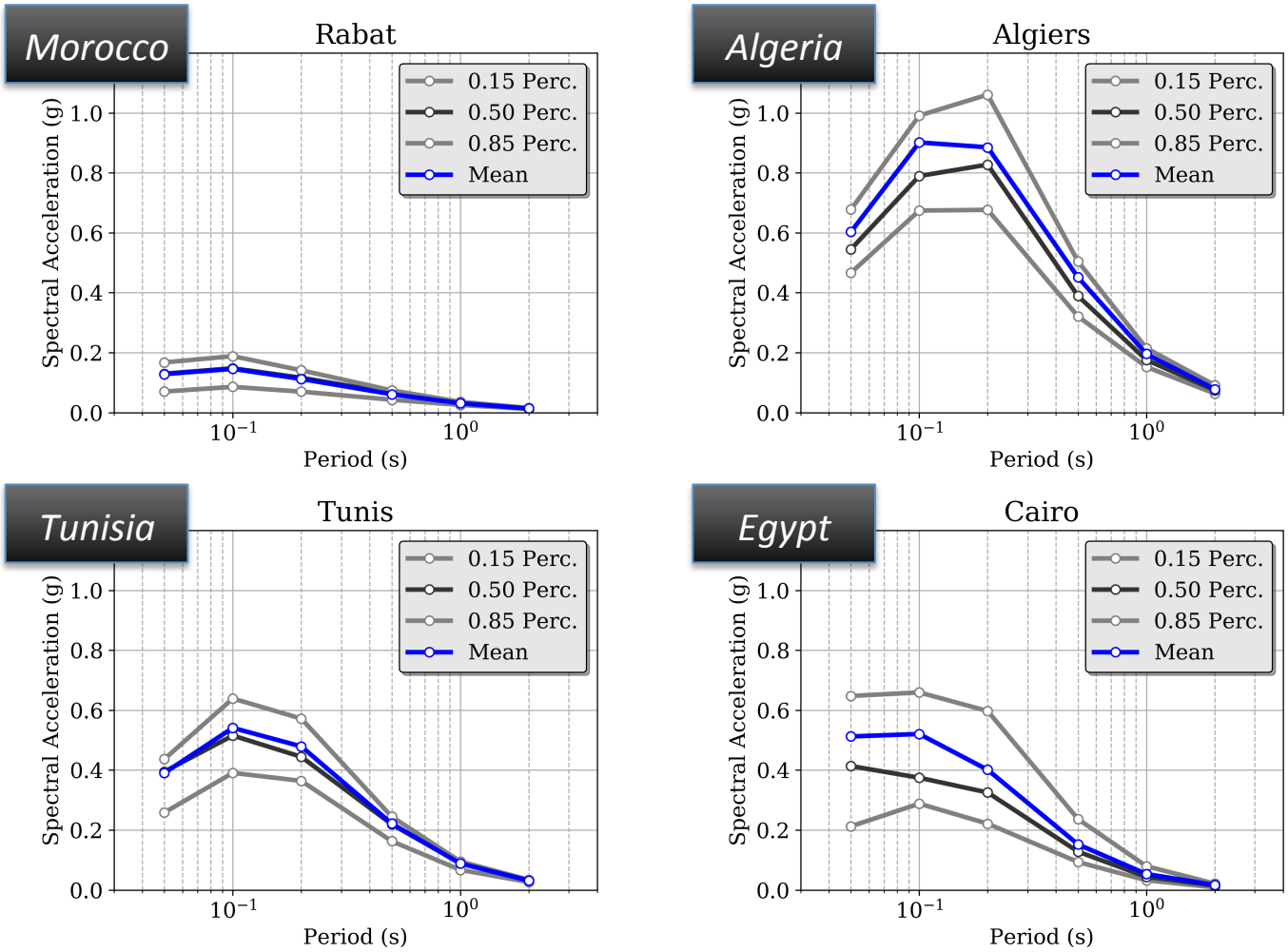
## 10% POE in 50 years (0.2s)



# Hazard Curves @ African Capitals

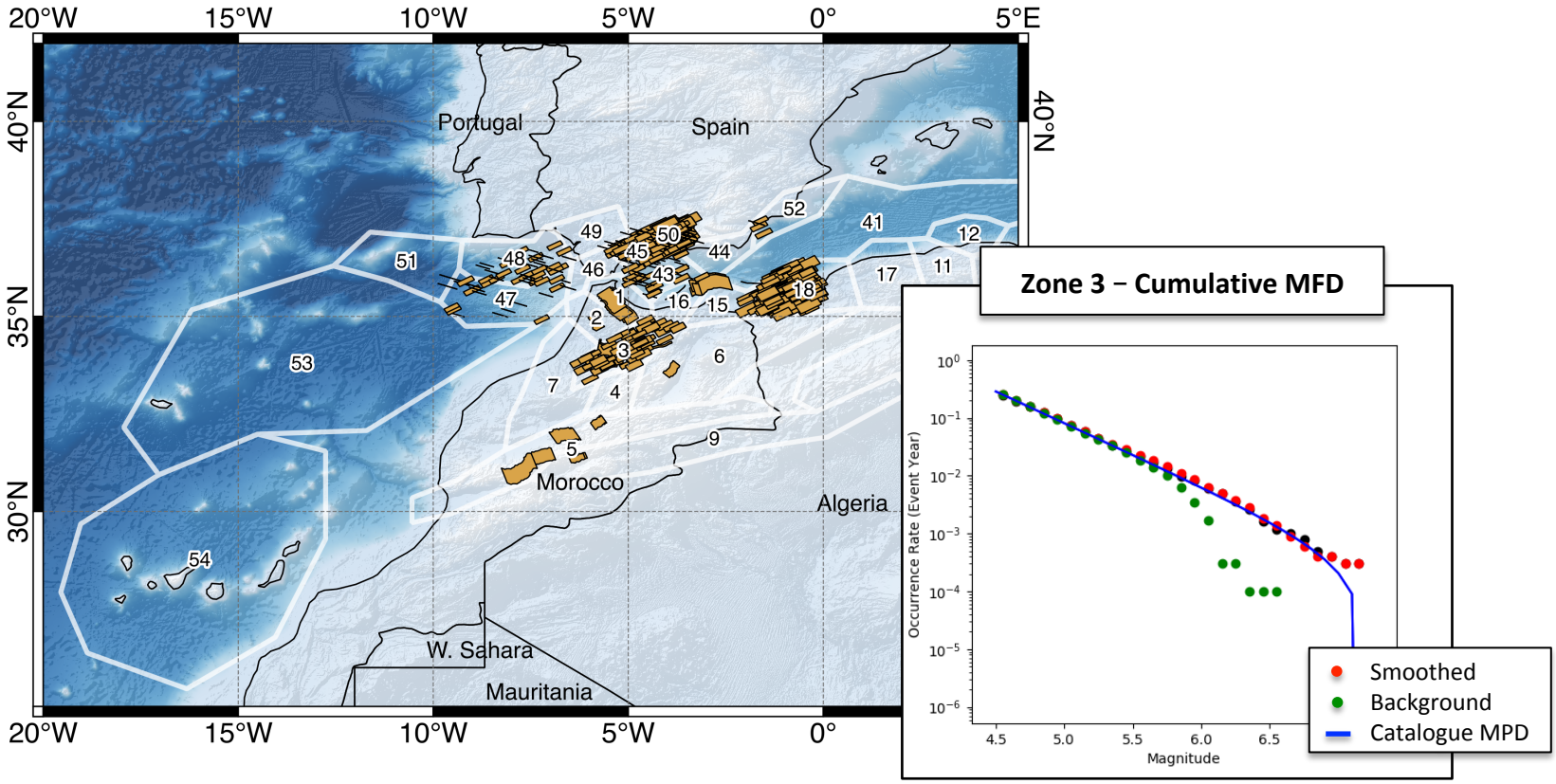


# Uniform Hazard Spectra @ African Capitals



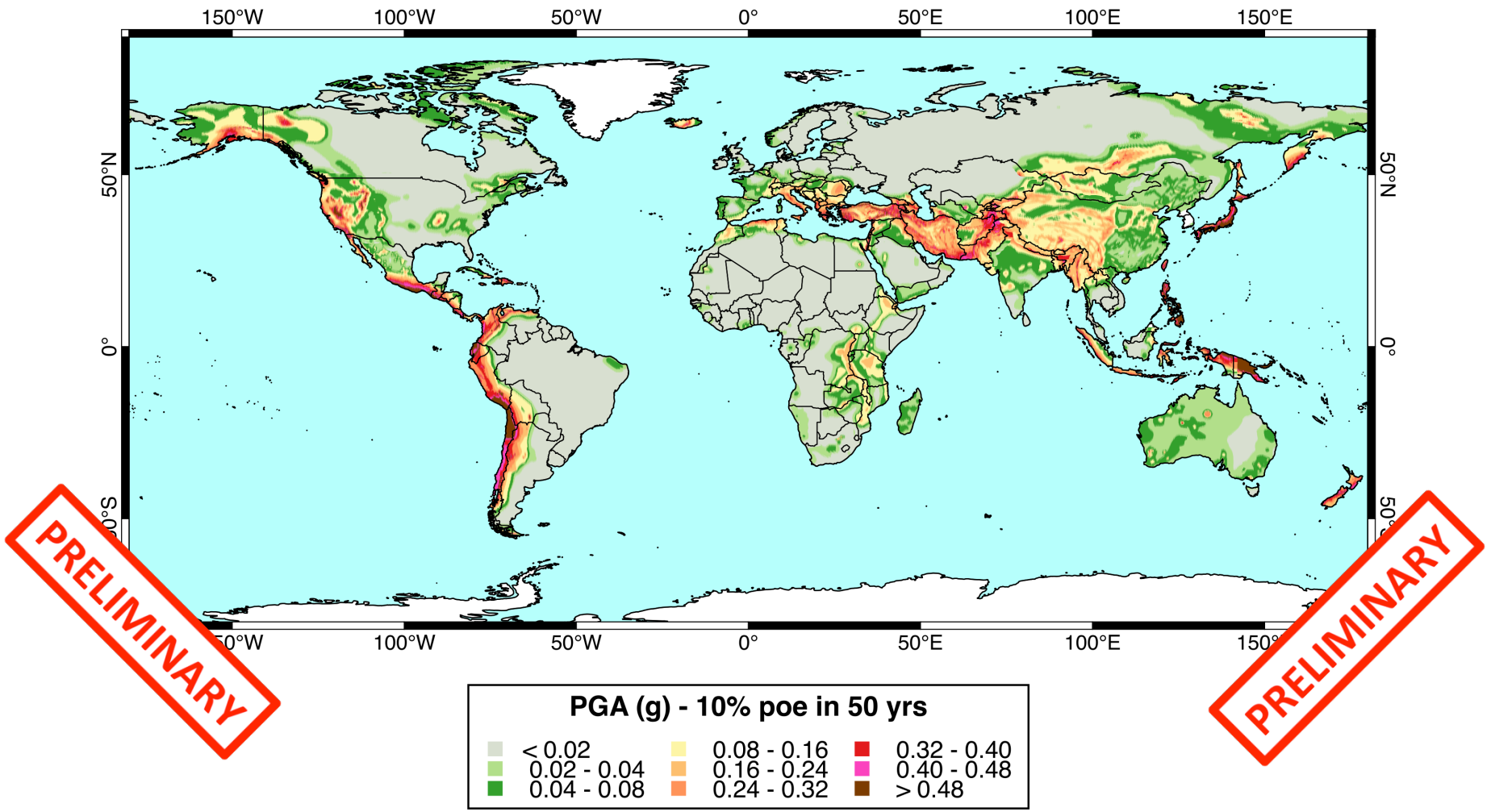

10% POE in 50 years

# 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 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:

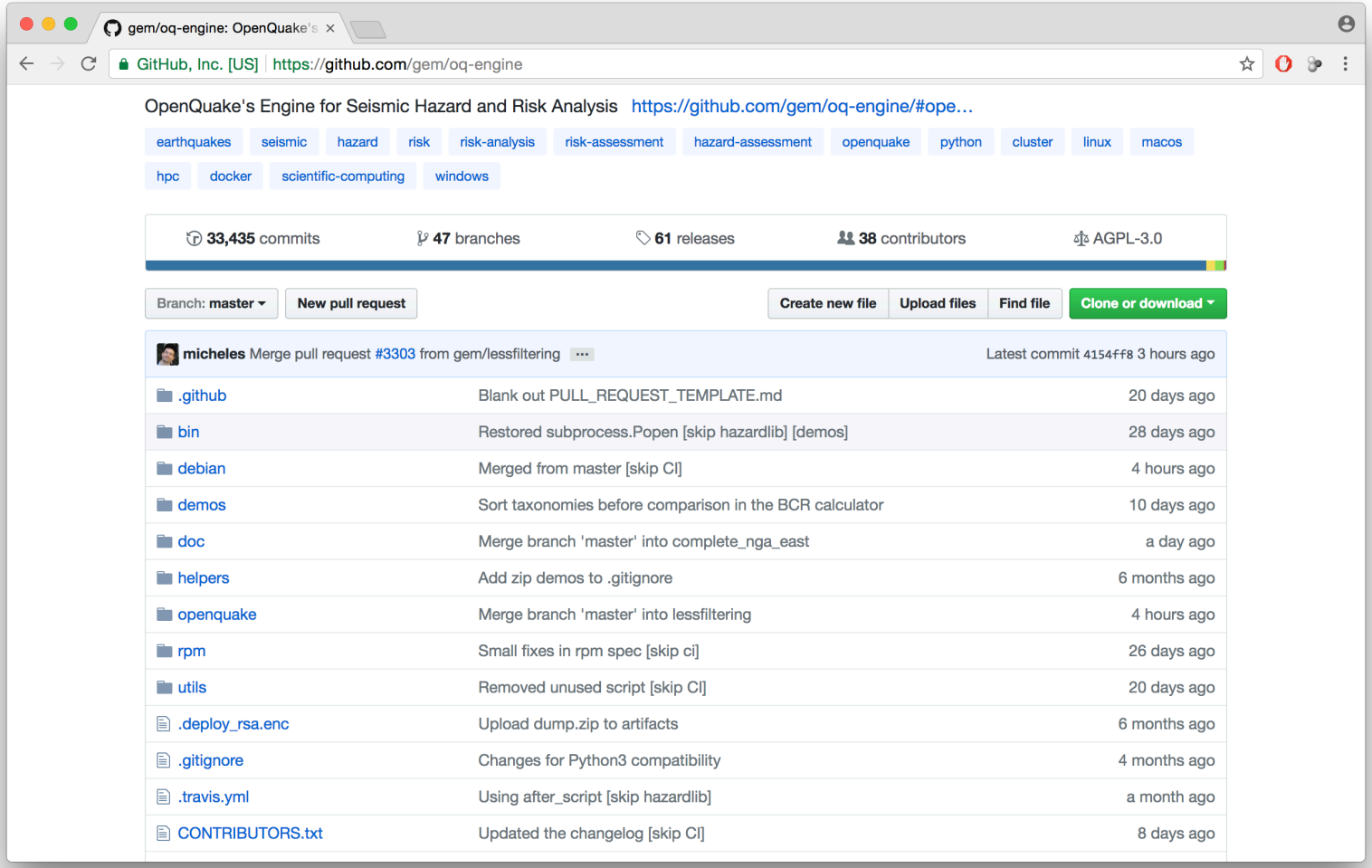
- Integration of local hazard studies
- **Strong motion recordings** from local networks
- **Site-specific studies** and microzonation

**Need for a collaborative effort**

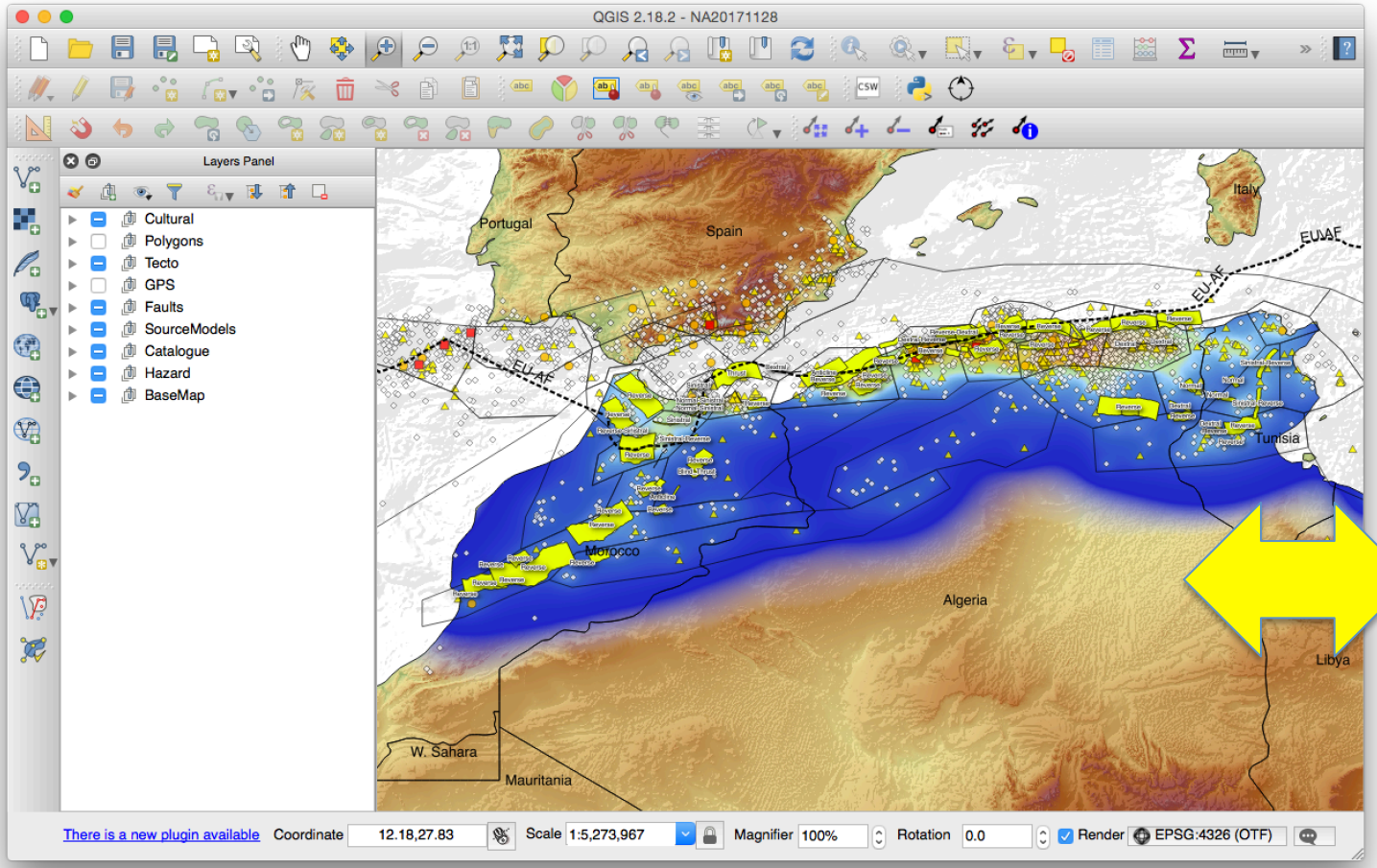
# Thank you!



# OpenQuake Engine - GitHub repository

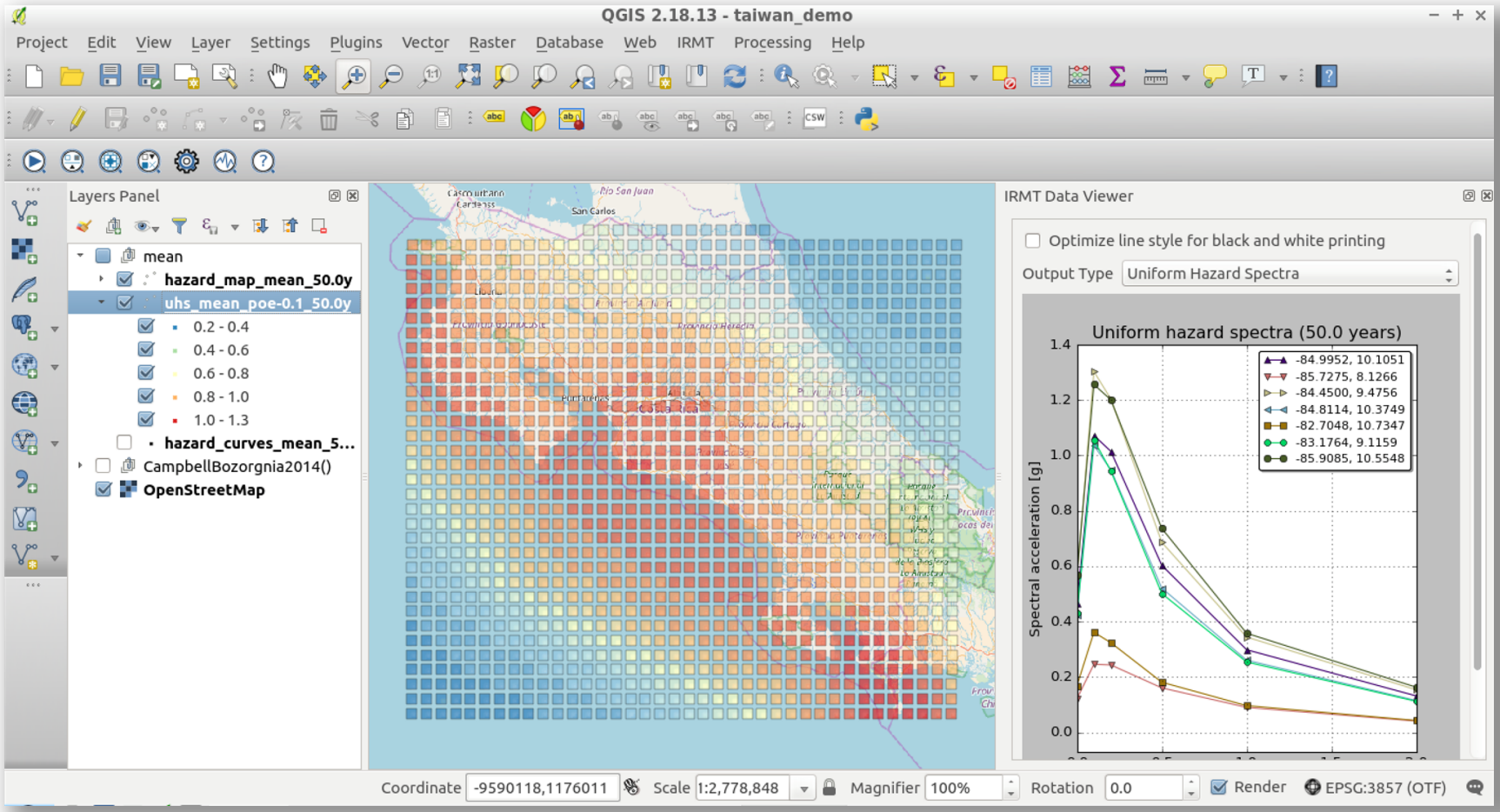


# OpenQuake Engine – QGIS integration




From/To OpenQuake Source Model

# OpenQuake Engine – QGIS integration (2)



# GEM Global Database of Hazard Models