The GEM's Probabilistic Earthquake Hazard Model of Morocco

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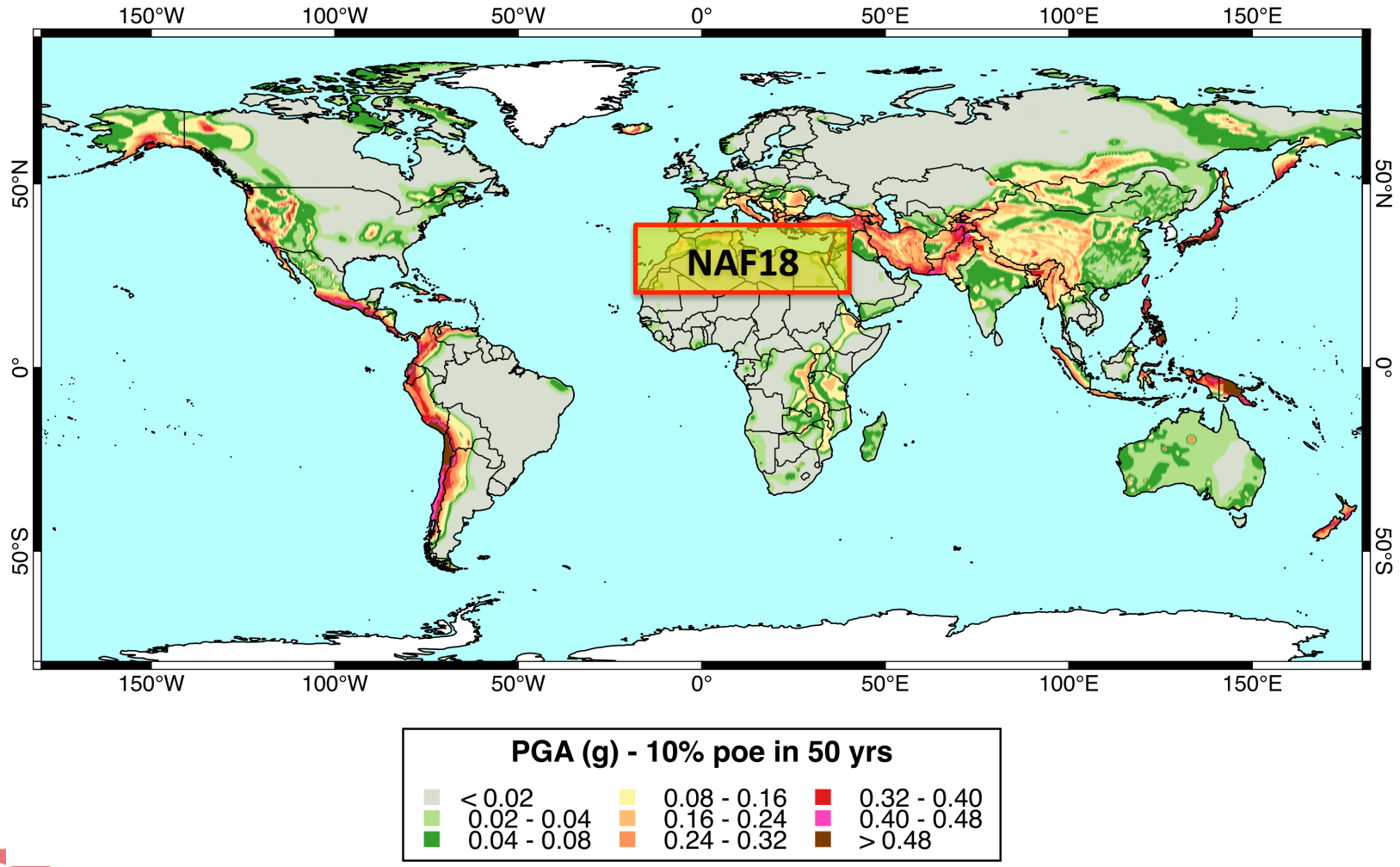
Global Earthquake Model (GEM), Pavia Italy

working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

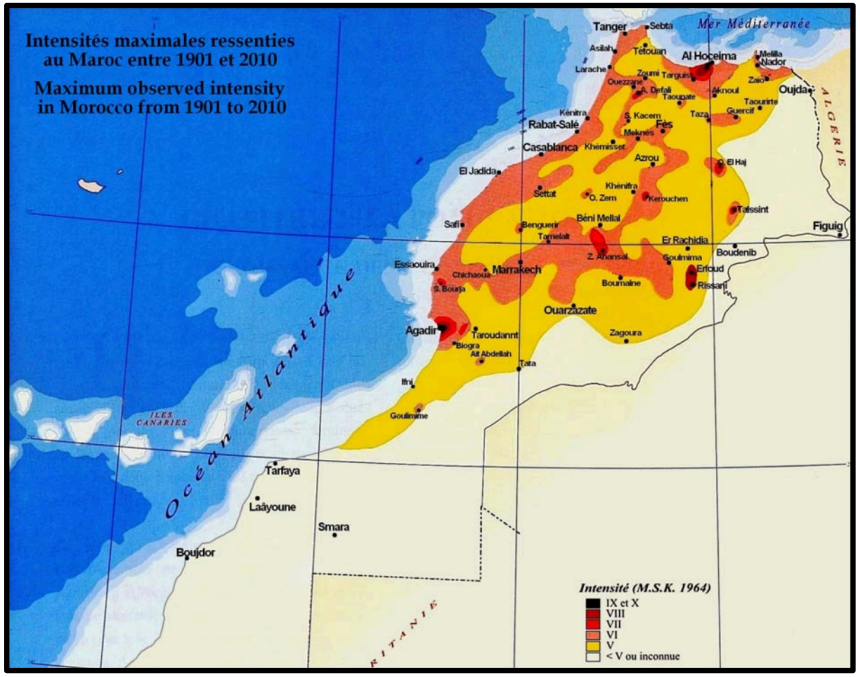
OQ
OPENQUAKE

GEM Global Mosaic of Hazard Models



Seismicity of Morocco

Seismicity of Morocco is moderate, although highly destructive earthquakes are reported from instrumental catalogues, such as the **Agadir** (1960, Mw 5.9) and **Al Hoceima** (2004, Mw 6.3) events, which caused respectively about 12000 and 629 fatalities each, and from historical sources (the **Fez** and **Meknes** intensity IX events).

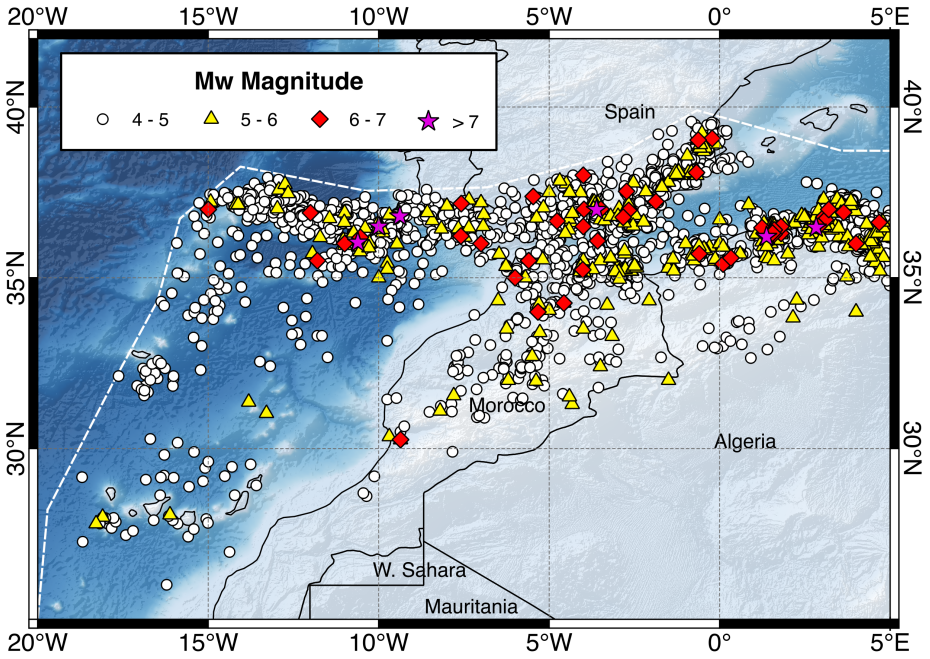


Cherkaoui and El Hassani 2012

On-shore seismicity can be grouped in at least two main seismic provinces of the **Atlas** and the **Betic-Rif** structural domains.

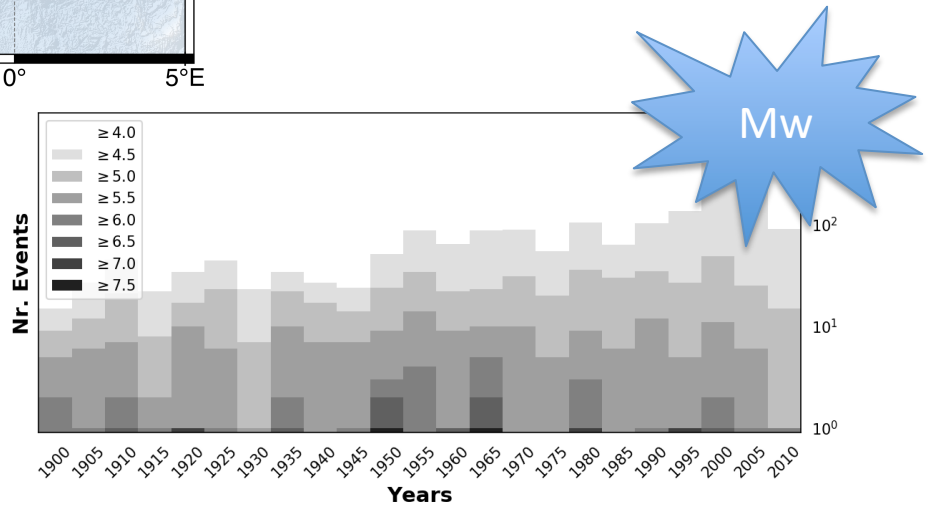
Off-shore seismicity is predominantly located in the Atlantic along the **Azores-Gibraltar shear belt** and in the **Aboran Sea**.

North Africa Homogenized Earthquake Catalogue



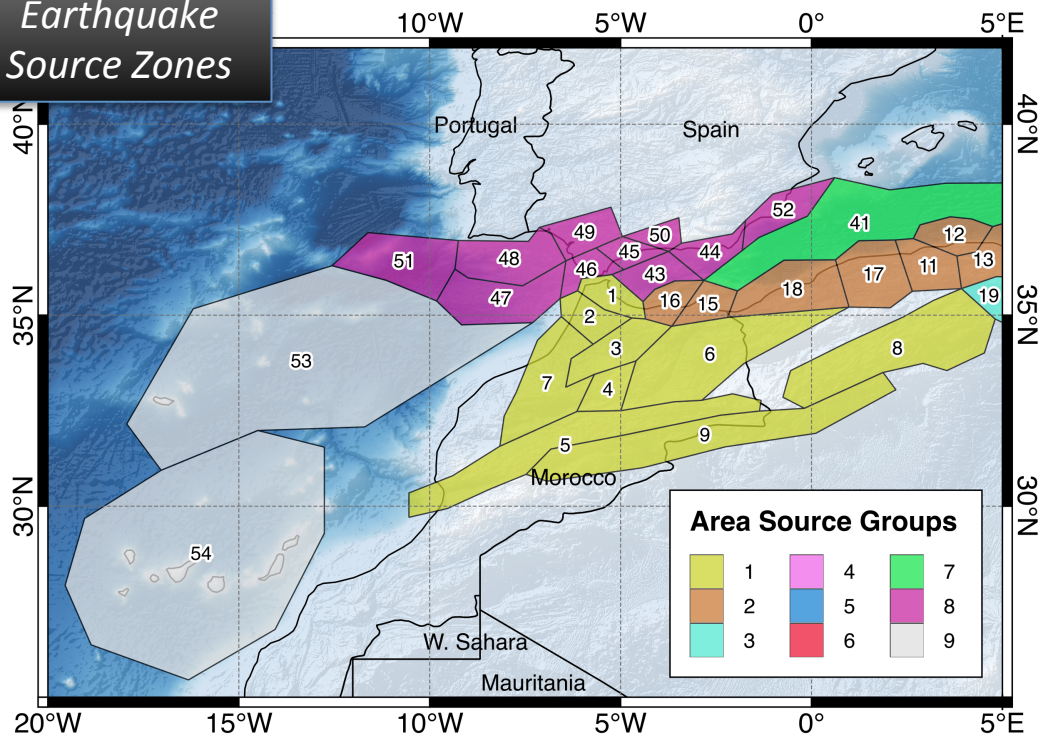
The catalogue is obtained by harmonization of global bulletins with data from local agencies and published studies

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



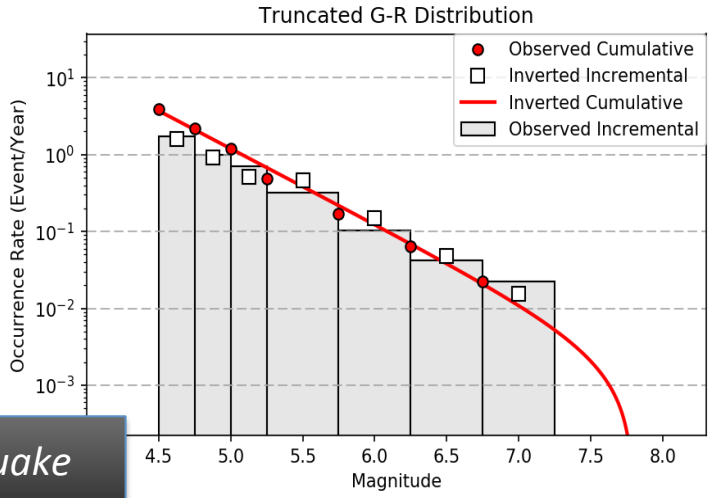
Source Model - Regional Seismicity Analysis

Earthquake Source Zones



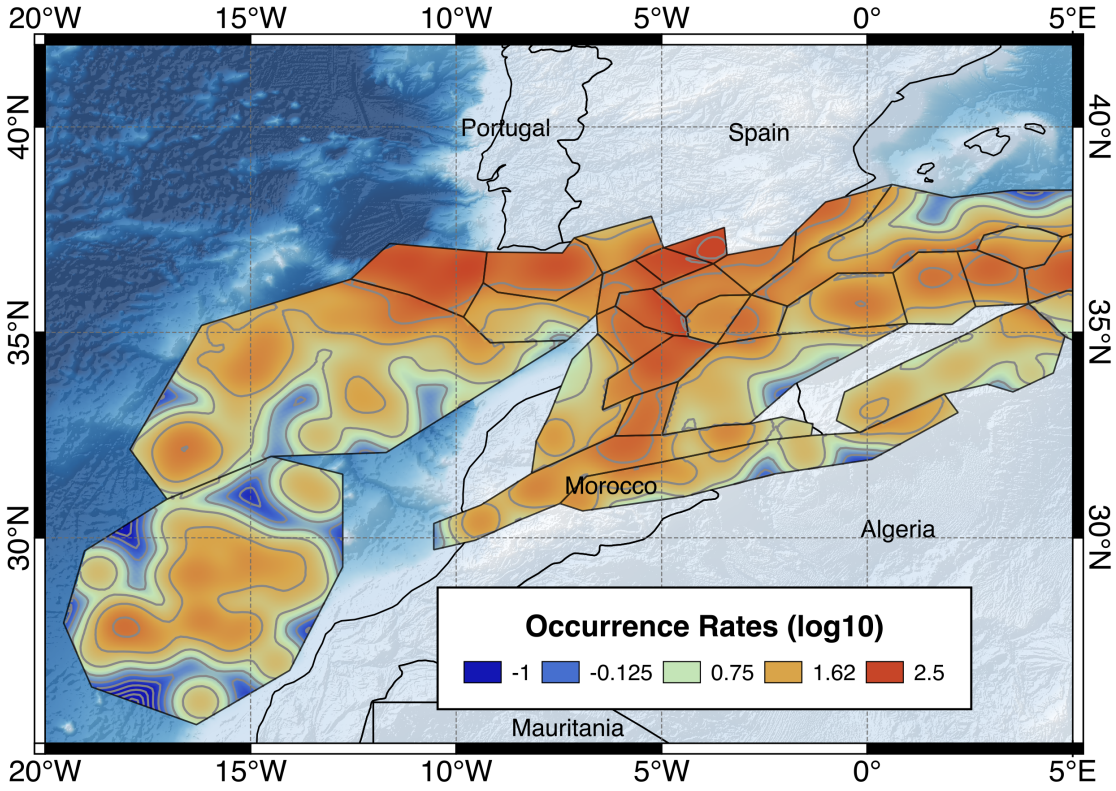
The study area has been subdivided into source zones of supposedly homogenous seismic potential

Occurrence parameters and source properties have been characterised for each separate source zone



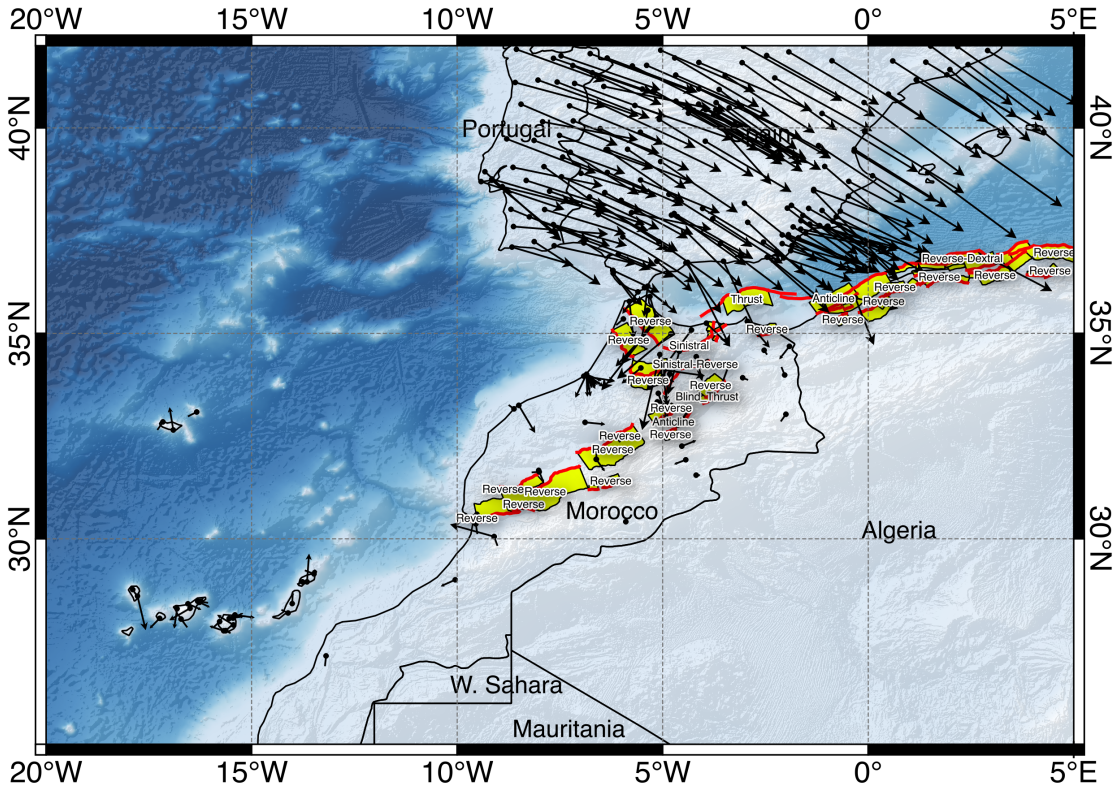
Earthquake Rates

Occurrence Rate Redistribution



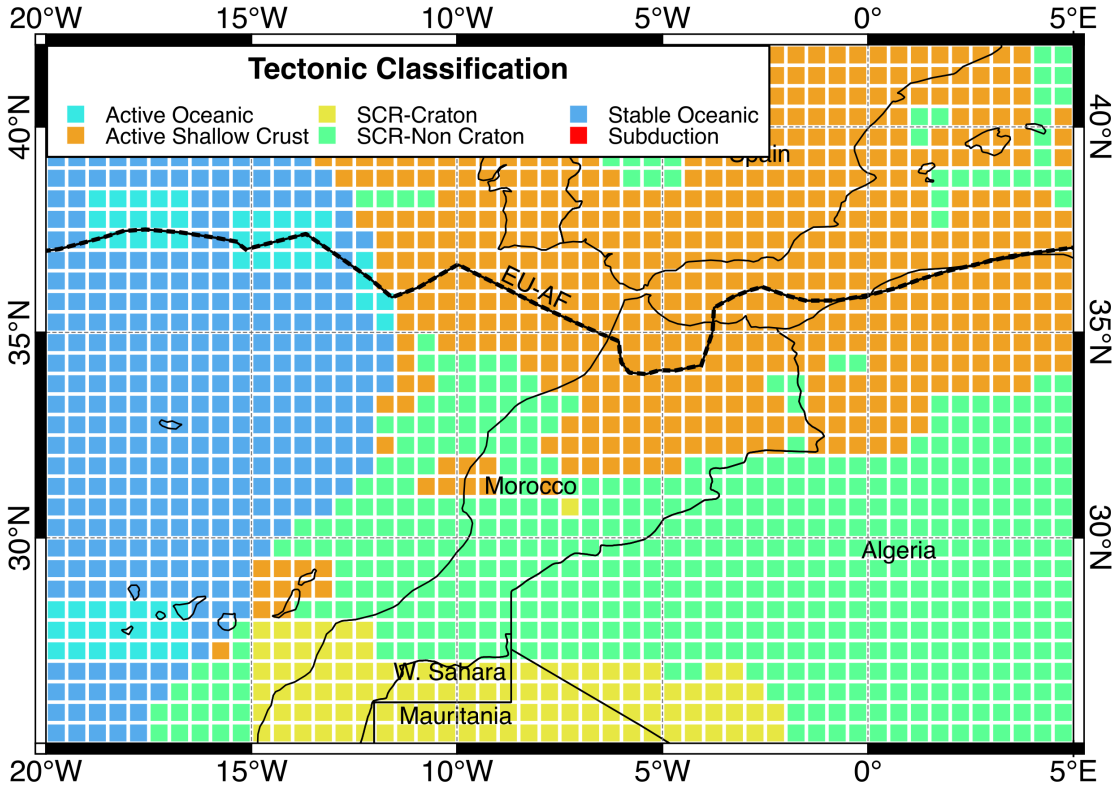
Distributed seismicity is modelled combining a smoothed seismicity approach with the use of source zonation. Such approach allows for spatial variation of source properties, such as b-values, faulting style and hypocentral distribution.

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

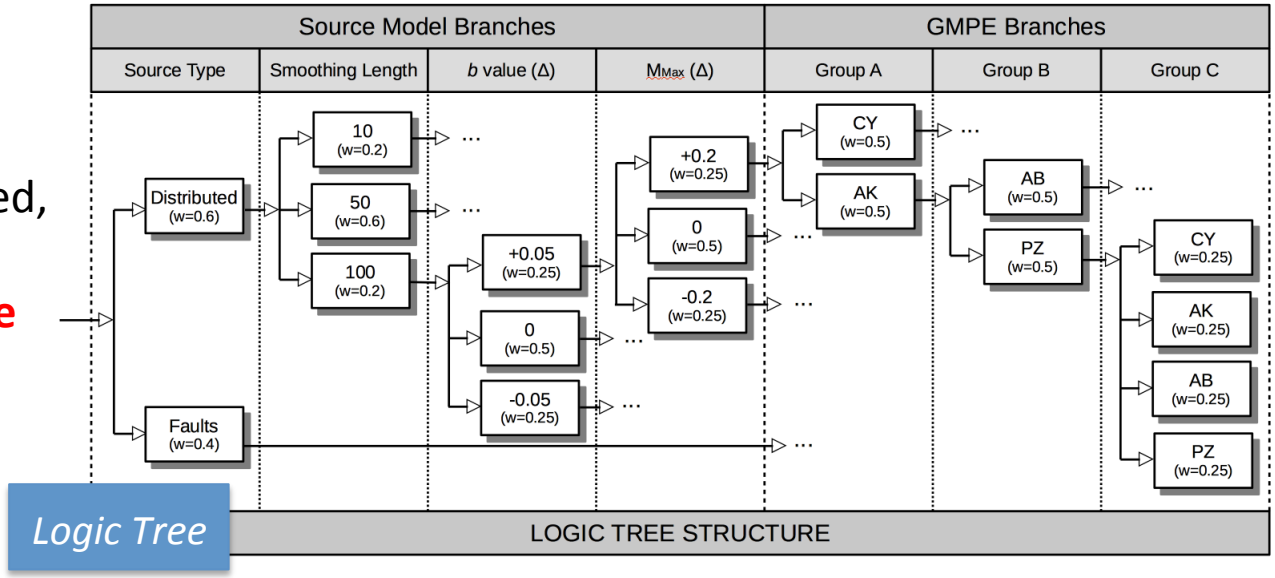
Given the peculiar seismoteconic setting of the North Africa, an **hybrid attenuation behavior** might be expected. Four suitable GMPEs have been selected:

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

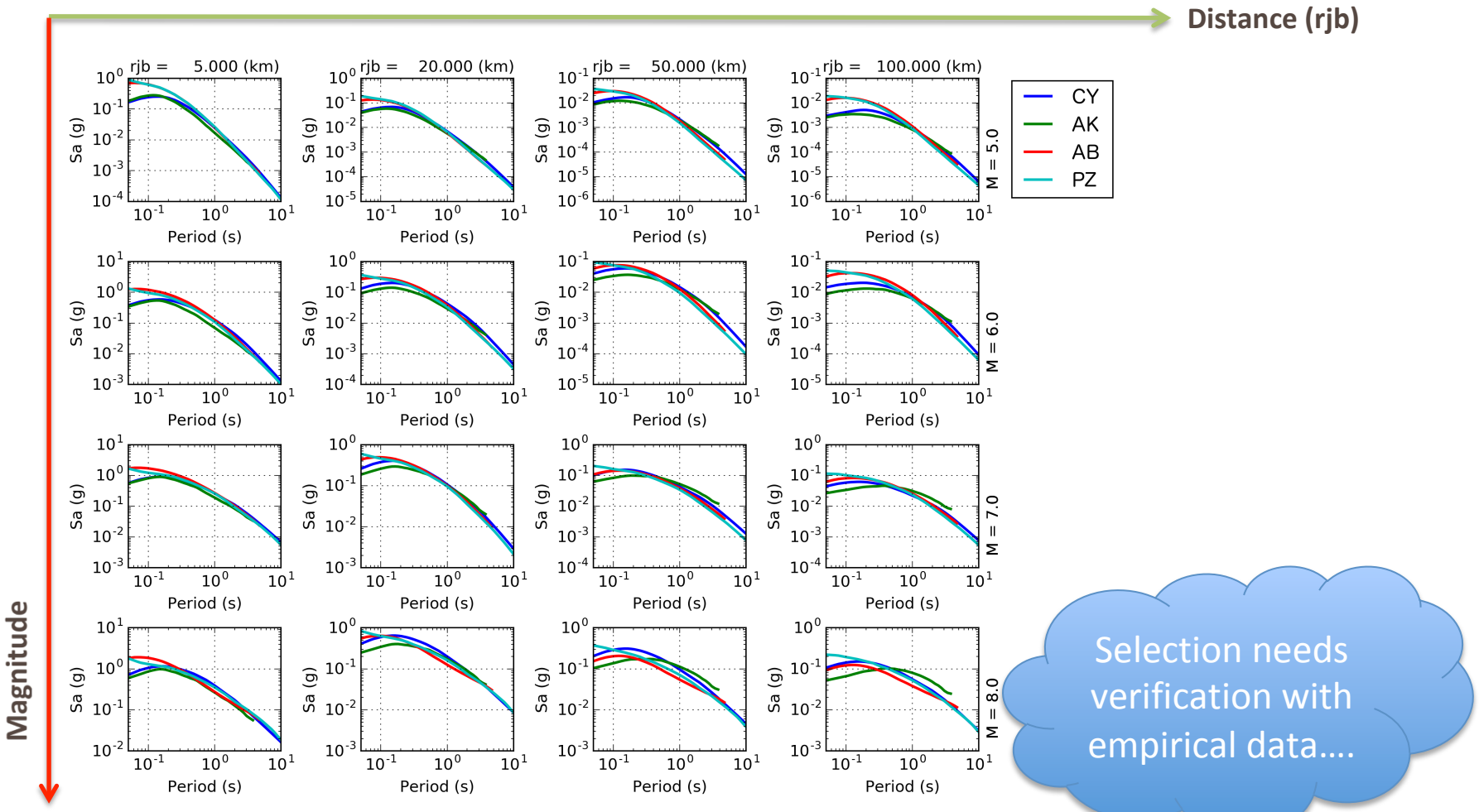
→ Active Shallow Crust (Group A)

→ 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….

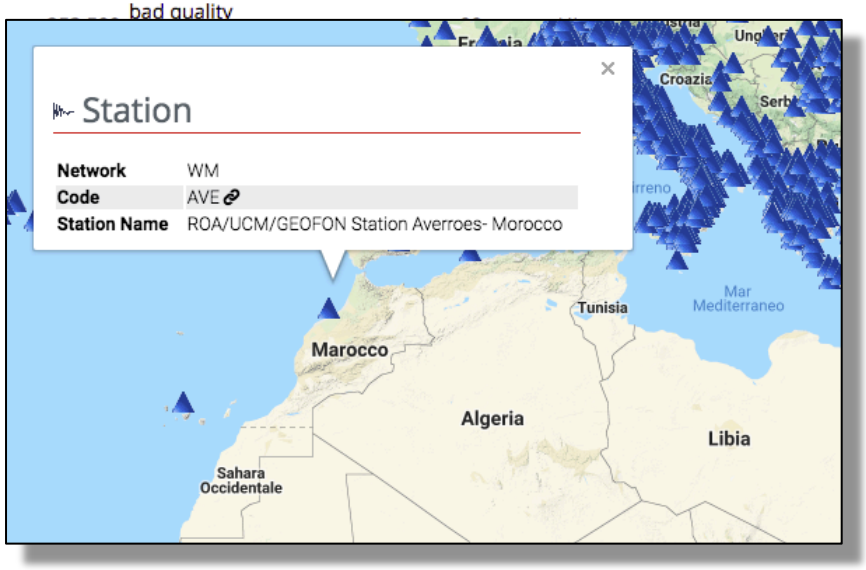
ESM Engineering Strong

within EPOS EUROPEAN PLATE OBSERVING SYSTEM

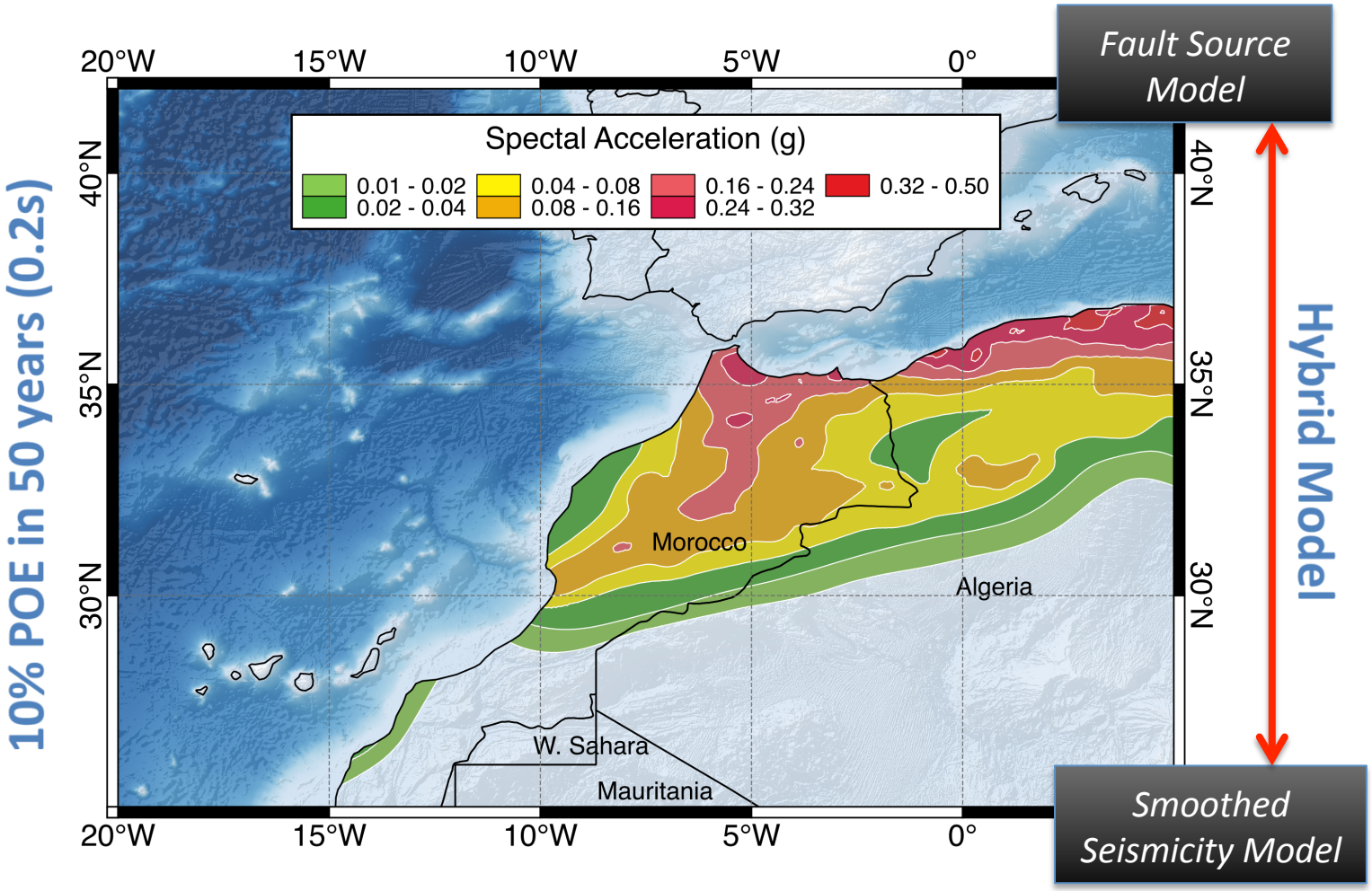
Event id	Date	M_W	M_L	Style of faulting	Stat. Code	EC8	R epi. [km]	Processing	Corr. PGA [cm/s^2]	PGV [cm/s]	Location	Instrument
EMSC-20160125_0000009	2016-01-25 04:22:03	6.3	5.7	Strike-slip faulting	WM.AVE		430.700	manually processed	0.877	0.312	00	HL
EMSC-20140415_0000028	2014-04-15 07:56:47		4.2	Unknown	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

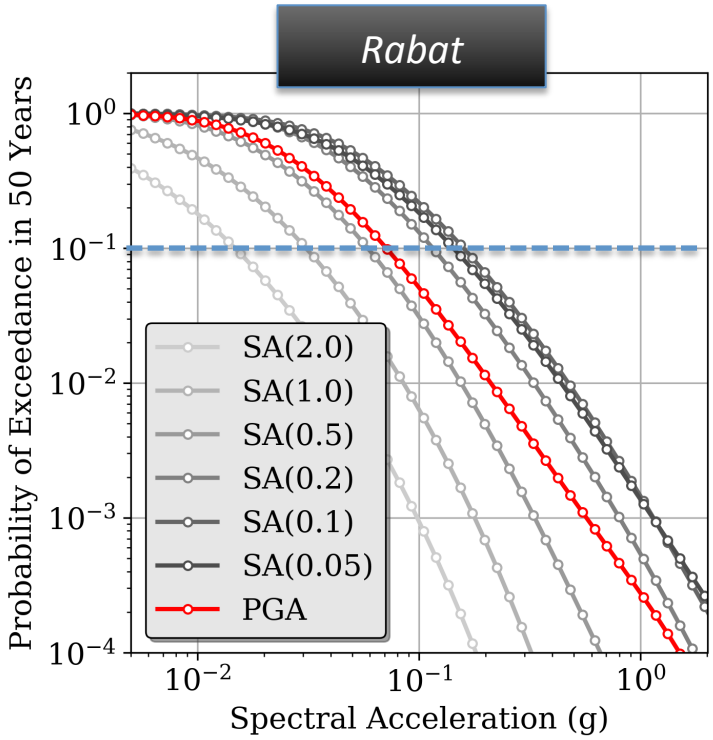
Need data from local agencies (e.g. CRAAG)
or neighboring countries

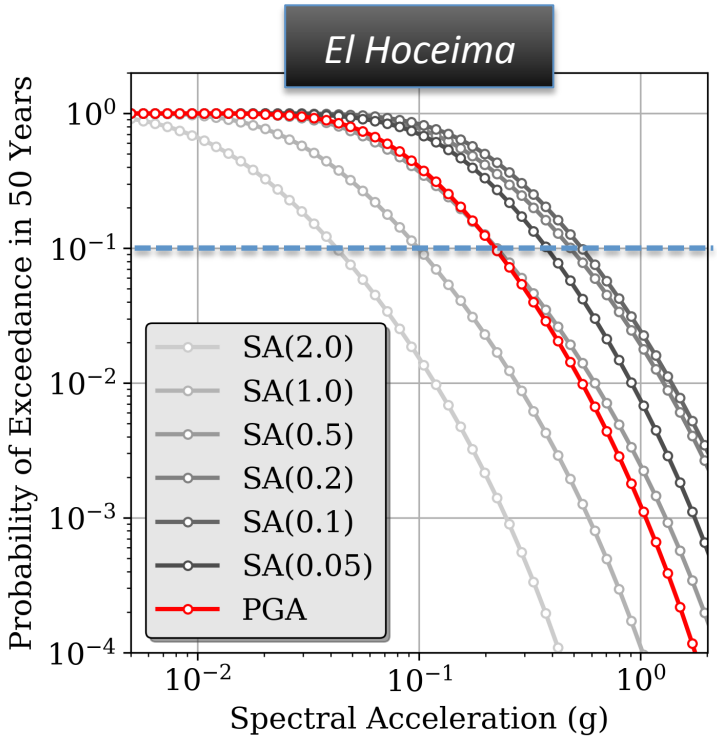


Calculation Results: Hazard Maps

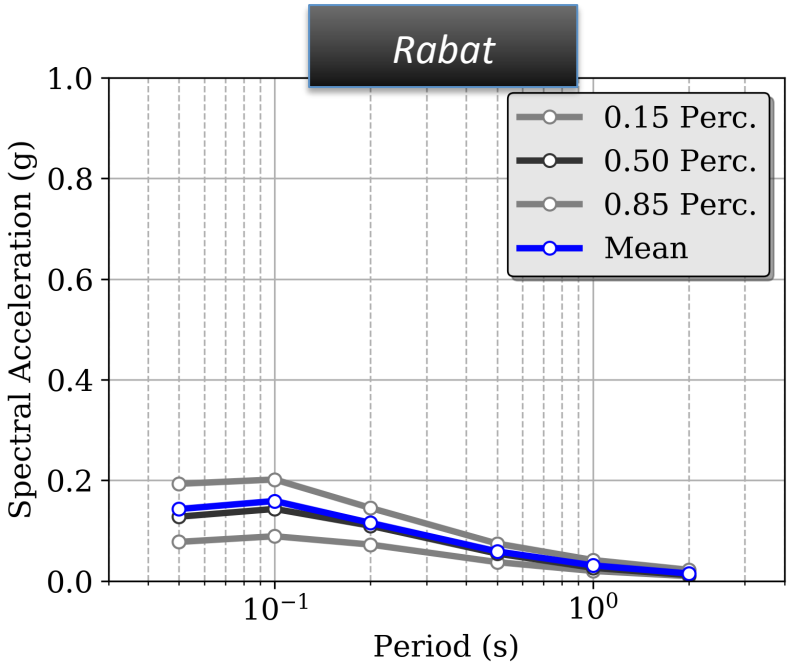


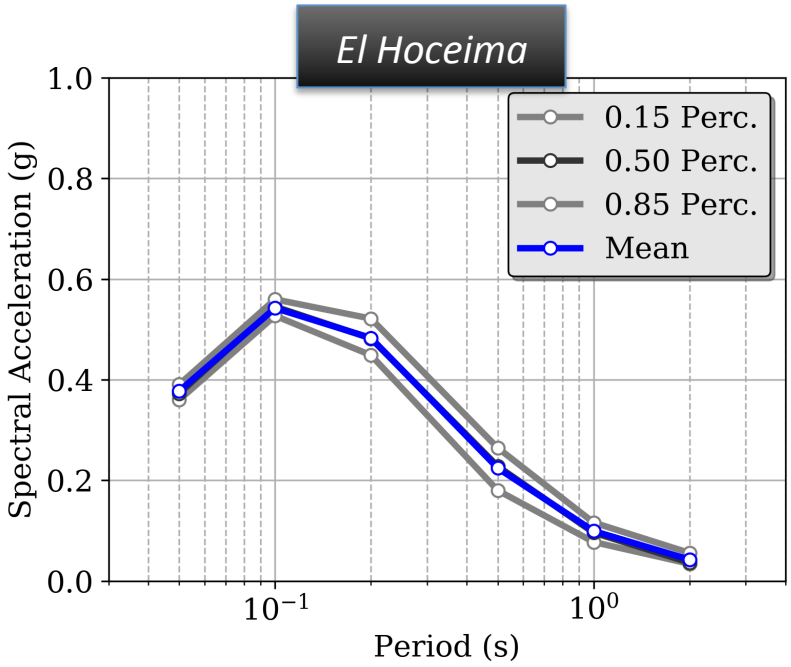
Calculation Results: Hazard Curves





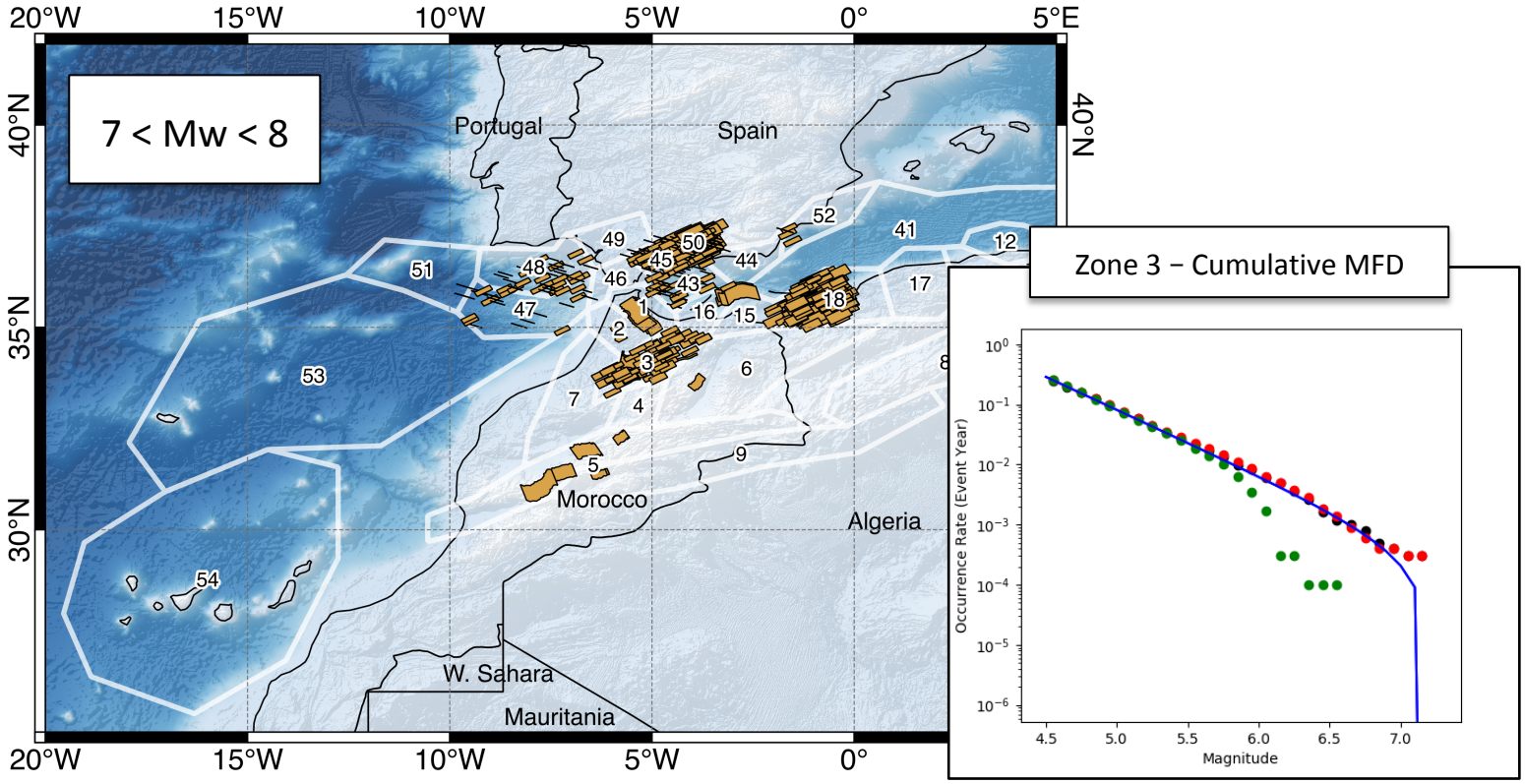
Calculation Results: Uniform Hazard Spectra





10% POE in 50 years

Model Verification: Stochastic Event Set



- Stochastic earthquake catalogue for a 10.000 years investigation time
  - About 815.000 ruptures with Mw>4.5
  - Only sources relevant for Morocco have been considered
    - Sampling of the full logic-tree

Outlook

The Morocco hazard model is presently derived from the regional PSHA Model of GEM for Northern Africa, which is part of the GEM's global mosaic.

Nonetheless, the model can be further improved by:

- better selection of existing GMPEs through the use of empirical data
- implementation of a local GMPE
- Integration of new information on active faults and local GPS data
- site-specific seismic hazard analysis