A new PSHA model for Sub-Saharan Africa using OpenQuake and the GEM Modelling Toolkits

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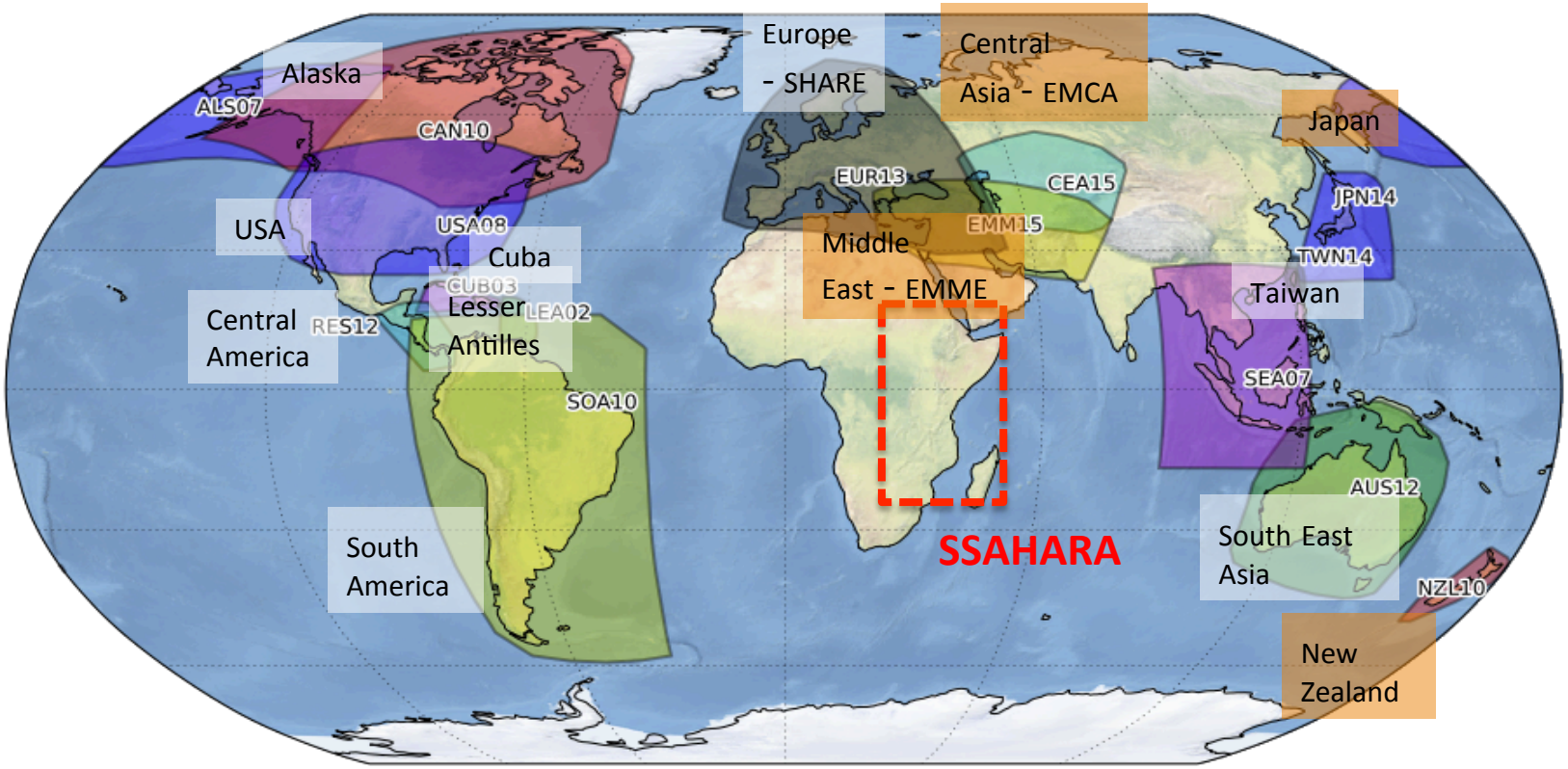
working together
to assess risk

GEM GLOBAL EARTHQUAKE MODEL

OQ OPENQUAKE

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 Sub-Saharan Africa

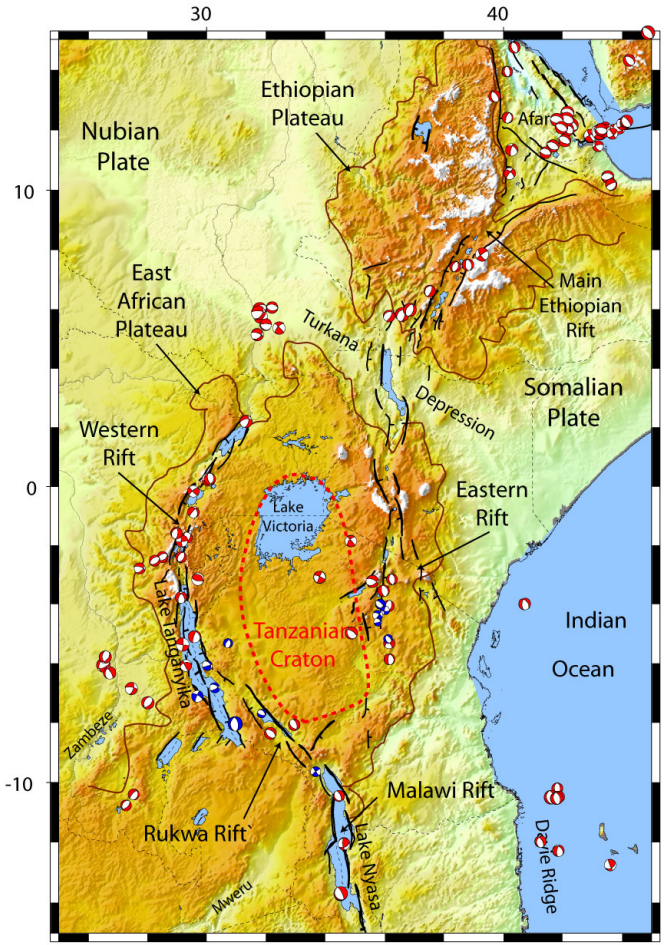
① The **East African Rift System** (EARS) is the major active tectonic feature of the **Sub-Saharan Africa** (SSA) region

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 A part from few **local studies**, the last open regional model (**GSHAP**) is almost 20 years old

⑤ There is a need for a new **probabilistic seismic hazard model** based on the most recent and up to date available information



From Eric Calais' Website

The Sub-Saharan Africa Hazard Model

Sub-Saharan Africa (SSA) Hazard Model is a pilot project led by **GEM** and **AfricaArray** and supported by **U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT** (**USAID**)

USAID
FROM THE AMERICAN PEOPLE

Original goals:

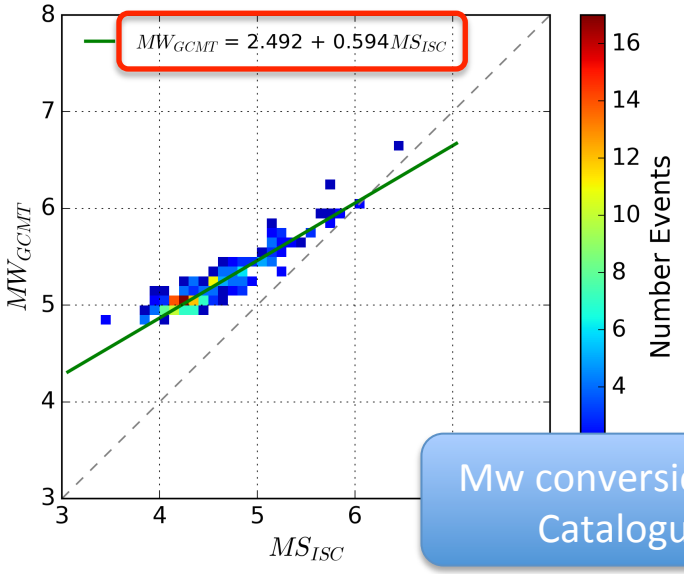
- Development of an explorative hazard model for SSA region
- Assess the usefulness of **AfricaArray** data for hazard mitigation

Available components / achievements:

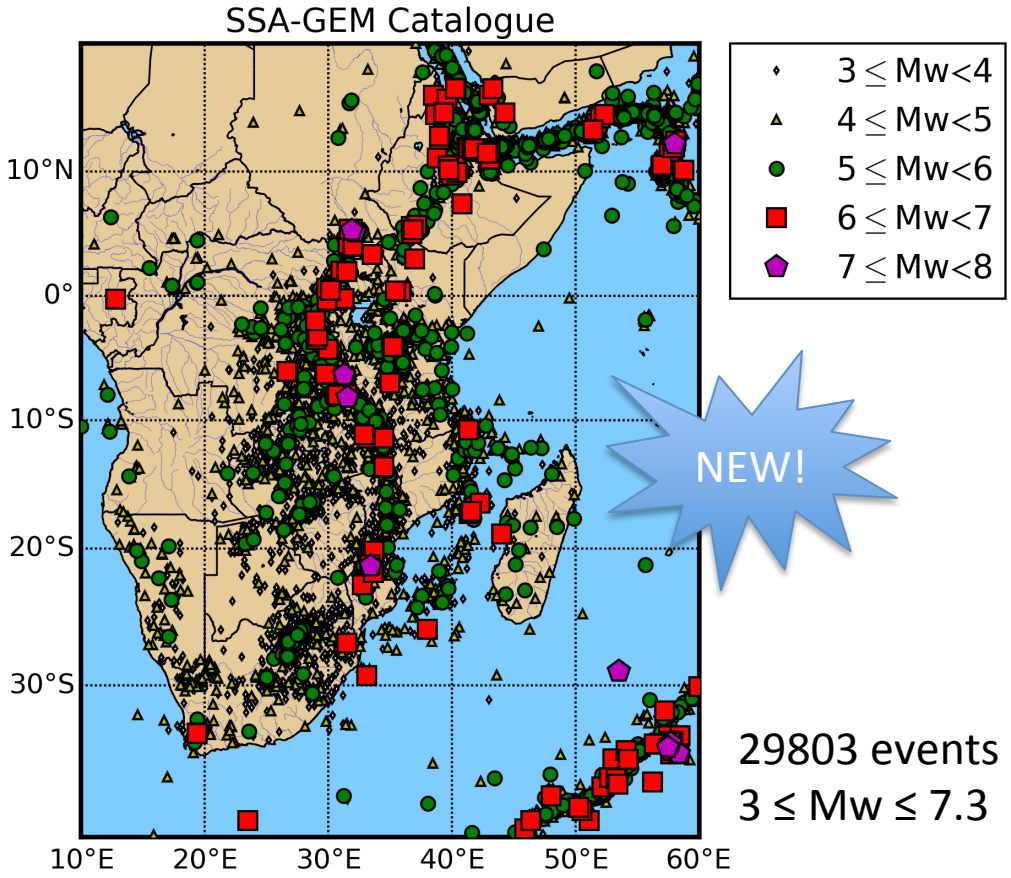
- Improved earthquake catalogue
- Source zonation model and regional seismicity analysis
- Probabilistic seismic hazard model
- Strain rate model

SSA Hazard Model – Improved Earthquake Catalogue

SSA Catalogue is obtained by harmonization of global bulletins with data from local agencies and regional projects, particularly from the **AfricaArray** framework



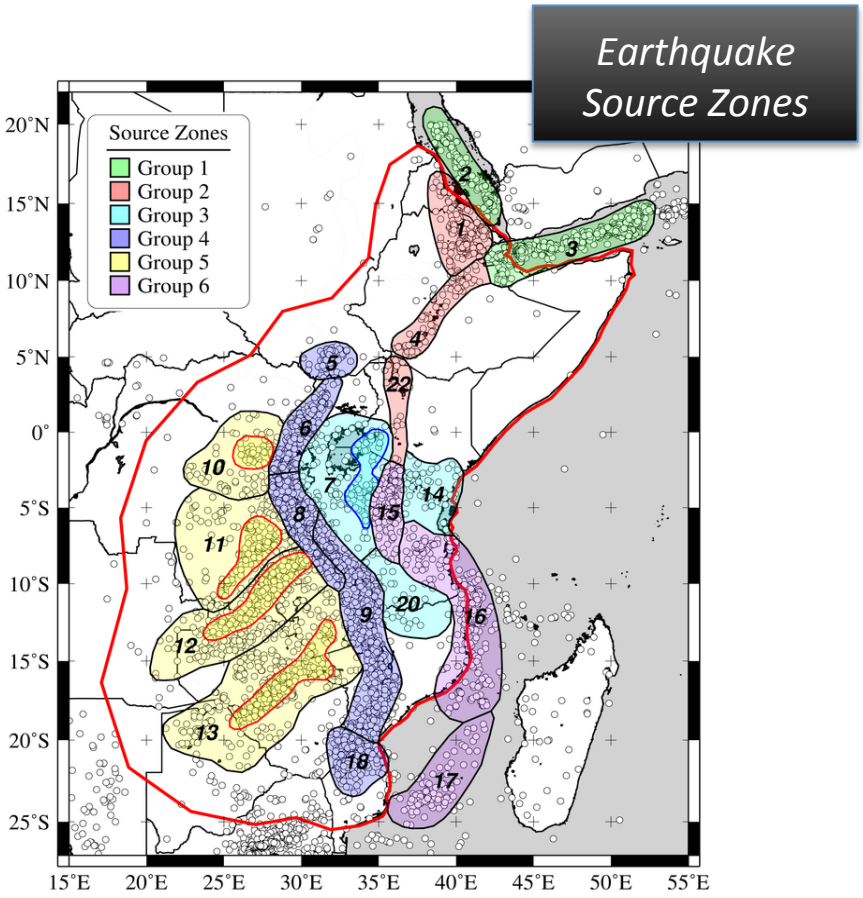
Mw conversion using GEM Catalogue Toolkit



NEW!

29803 events
3 ≤ Mw ≤ 7.3

Source Zone and Source Groups



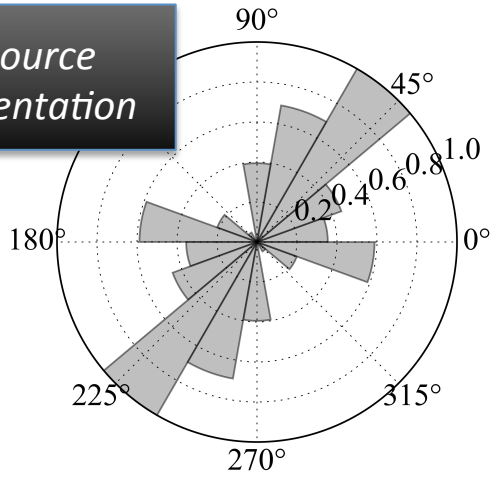
Based on:

- Previous studies
- Seismicity
- Surface Faults
- Plate boundaries
- Strain models

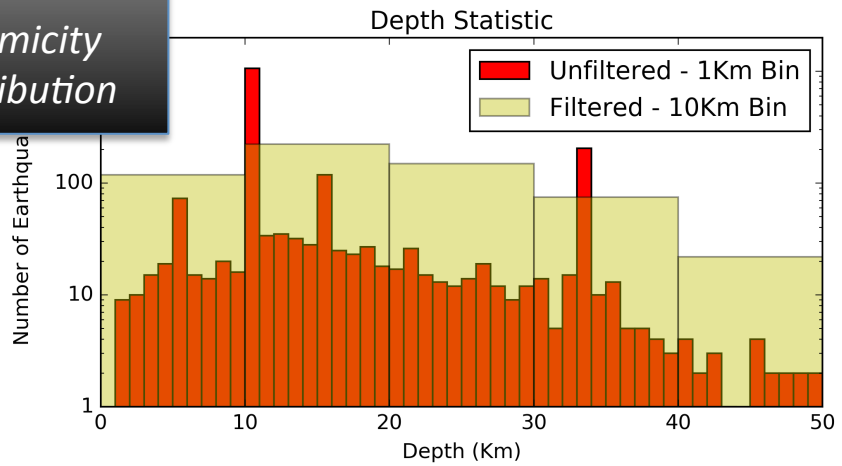
Group	Source	Name
1	2	South Read Sea
	3	Gulf of Aden
2	1	Afar Depression - Eritrea
	4	Main Ethiopian Rift
	22	North Kenya - Lake Turkana
3	7	Lake Victoria
	14	South Kenia
	20	Rowuma Basin
4	5	South Sudan
	6	Western Rift - Lake Kivu
	8	Western Rift - Tanganika
	9	Malawi - Nyasa Rift
	18	South Mozambique
5	10	Walikale and Masisi
	11	Luama rift
	12	Mweru - Katanga - Upemba
	13	Kariba - Okavango
6	15	Eastern Rift
	16	Davie Ridge
	17	Mozambique channel

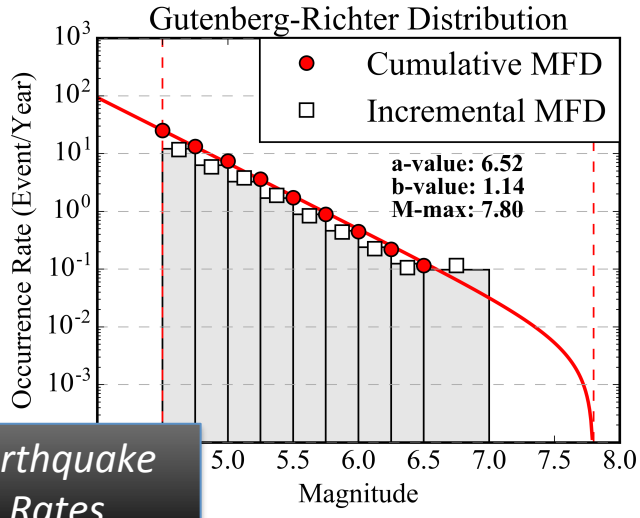
SSA Hazard Model – Regional Seismicity Analysis

Source Orientation

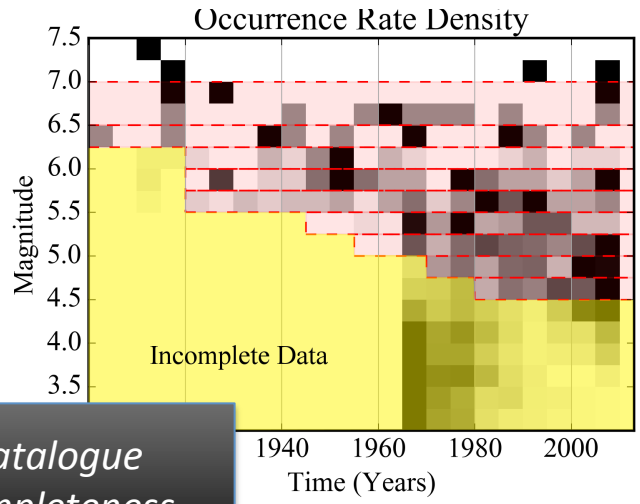


Seismicity Distribution





Earthquake Rates



Catalogue Completeness

GMPE Selection and Logic-Tree Approach

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

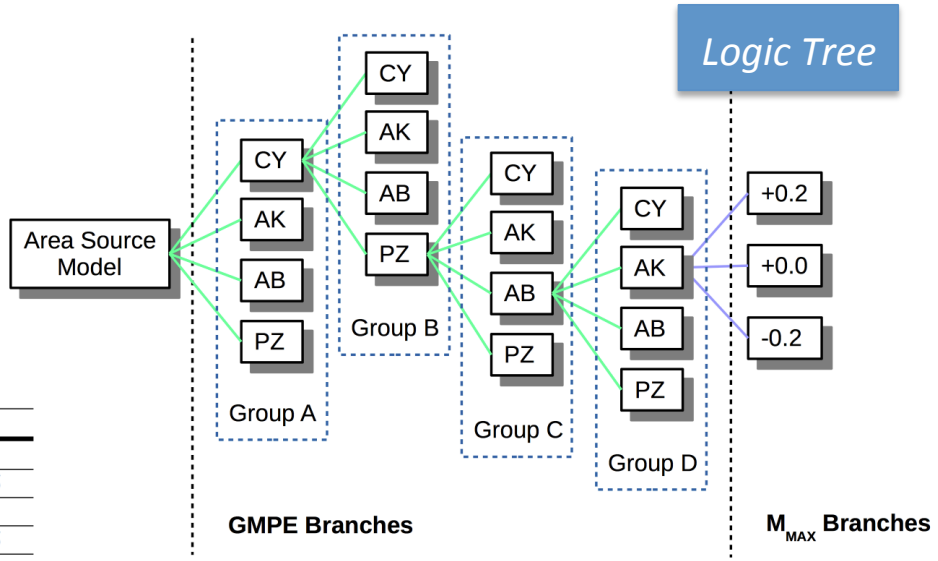
1. Chiou & Youngs (2014)
2. Akkar et al. (2014)
3. Atkinson & Boore (2006)
4. Pezeshk et al. (2011)

→ Active Shallow Crust

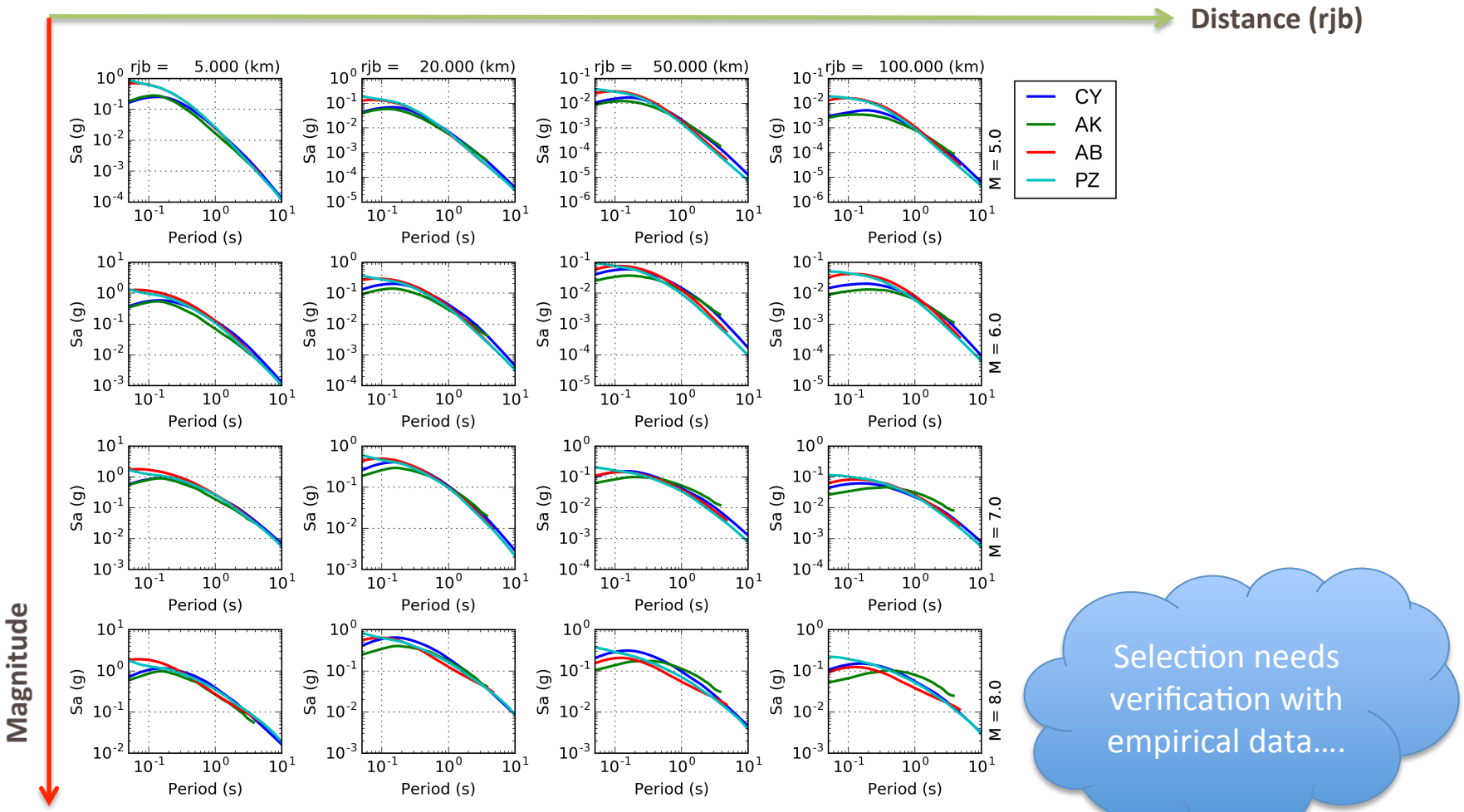
→ Stable Continental Crust

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

Group ID	Source ID	CY	AK	AB	PZ
A	1, 2, 3, 4, 17	0.5	0.5	0	0
B	5, 6, 8, 9, 1, 8, 22	0.375	0.375	0.125	0.125
C	15	0.25	0.25	0.25	0.25
D	7, 10, 11, 12, 13, 14, 16, 20	0.125	0.125	0.375	0.375



GMPE Selection – Comparing Ground Motion



Selection needs verification with empirical data….

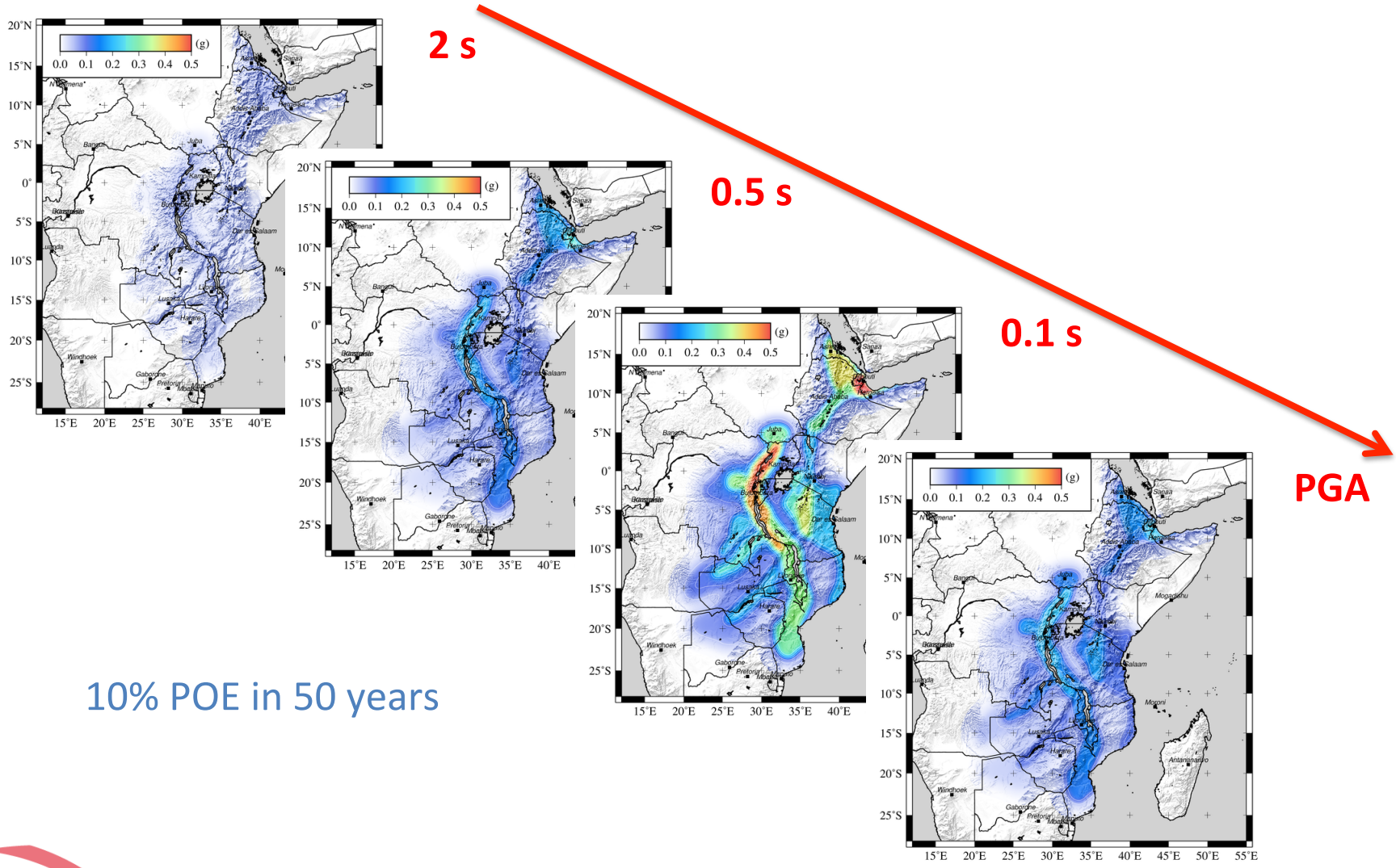
Hazard Calculation Using OpenQuake

The Sub-Saharan Africa Hazard model has been calculated for:

- 2722 sites (about 50km resolution), 192426 ruptures
- 2% and 10% PoE in 50 Years (R.P. of 2474 and 474 years, respectively)
- Outputs: hazard curves, uniform hazard spectra (UHS), hazard maps
- Spectral periods: PGA, 0.05*s*, 0.1*s*, 0.2*s*, 0.5*s*, 1*s* and 2s
- Statistic: mean hazard and percentiles (0.15, 0.5 and 0.85)
- Rock reference conditions (Vs^{30}=600m/s); no site-specific response

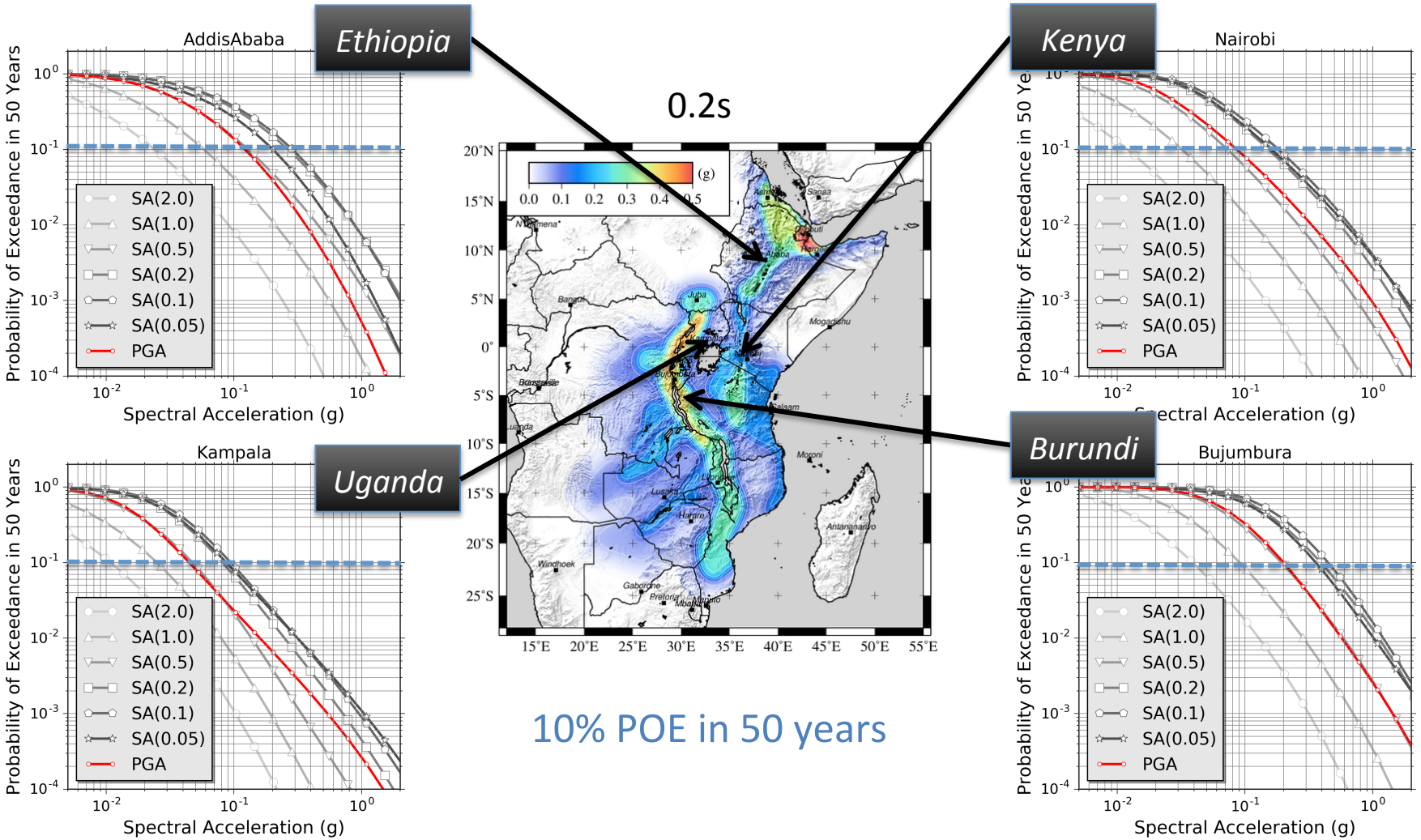
6.3 hours on 256 cores

Hazard Maps @ Different Spectral Ordinates

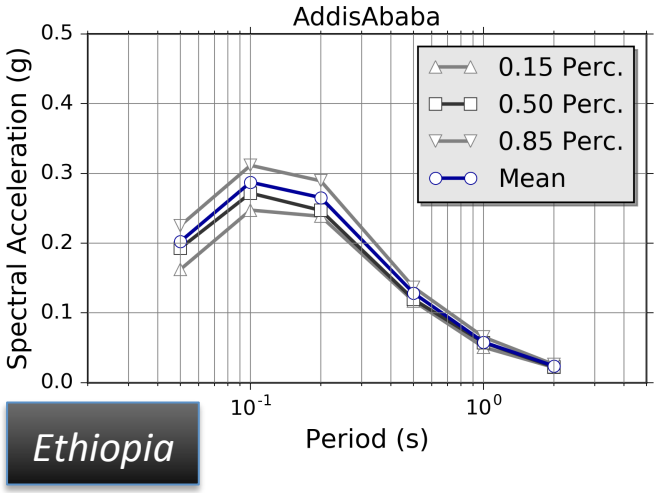


10% POE in 50 years

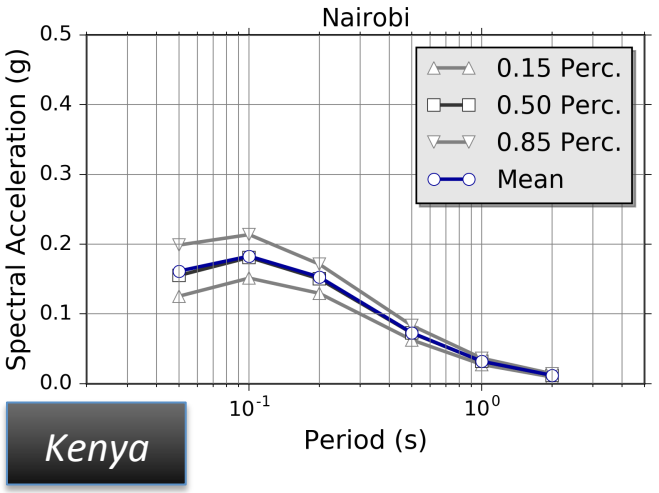
Hazard Curves @ African Capitals



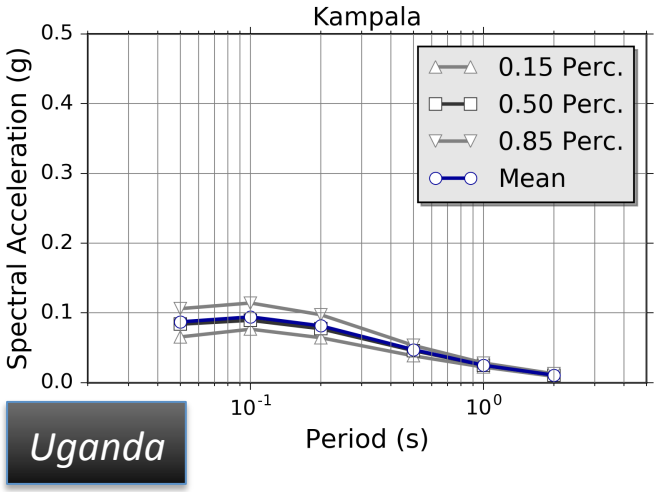
UHS @ African Capitals



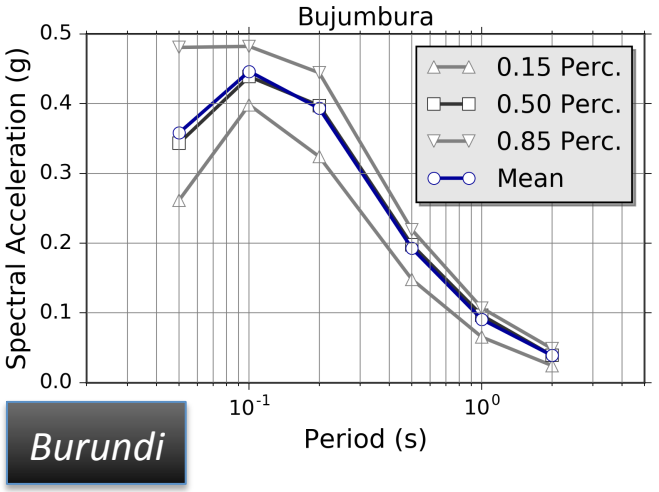
Ethiopia



Kenya



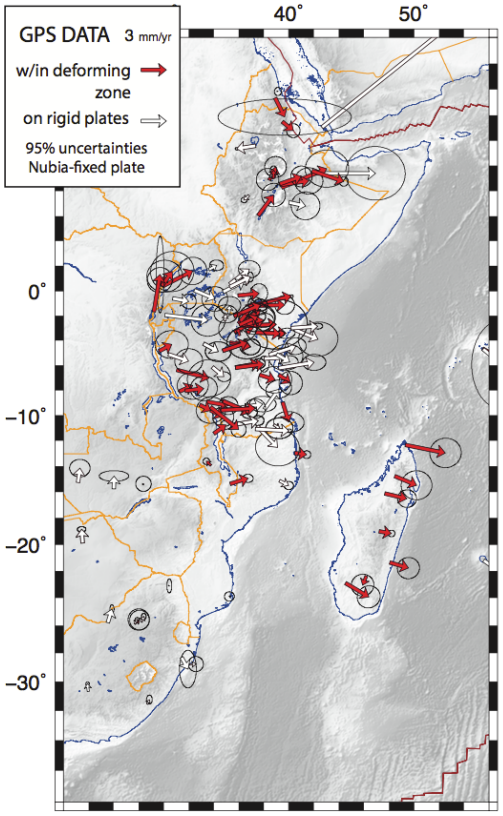
Uganda



Burundi

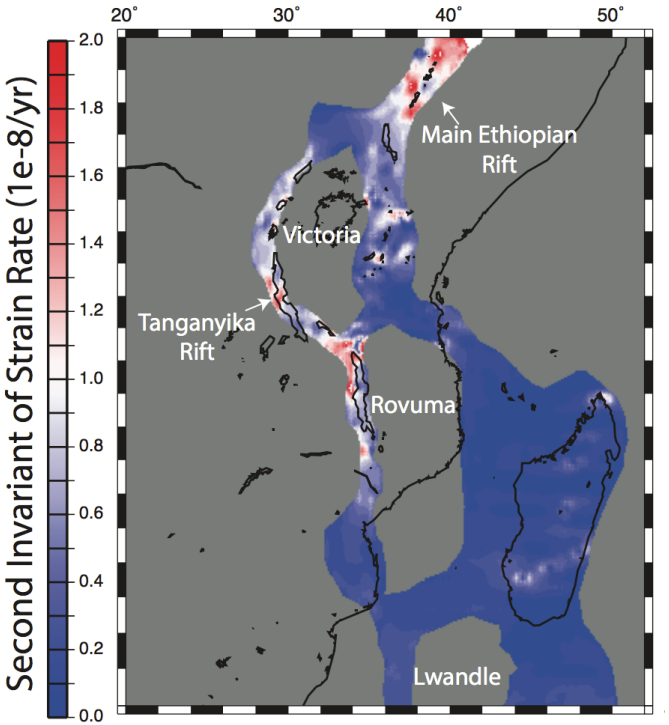
10% POE in 50 years

SSA Hazard Model – Strain Rate Model



Stamp et al. 2015

A geodetic strain-rate model from observed GPS displacement have been elaborated with a collaboration between African and US scientists



FUTURE GOALS

- Better estimate of low occurrence rates
- Constraint on maximum magnitude

Conclusions - Missing Components

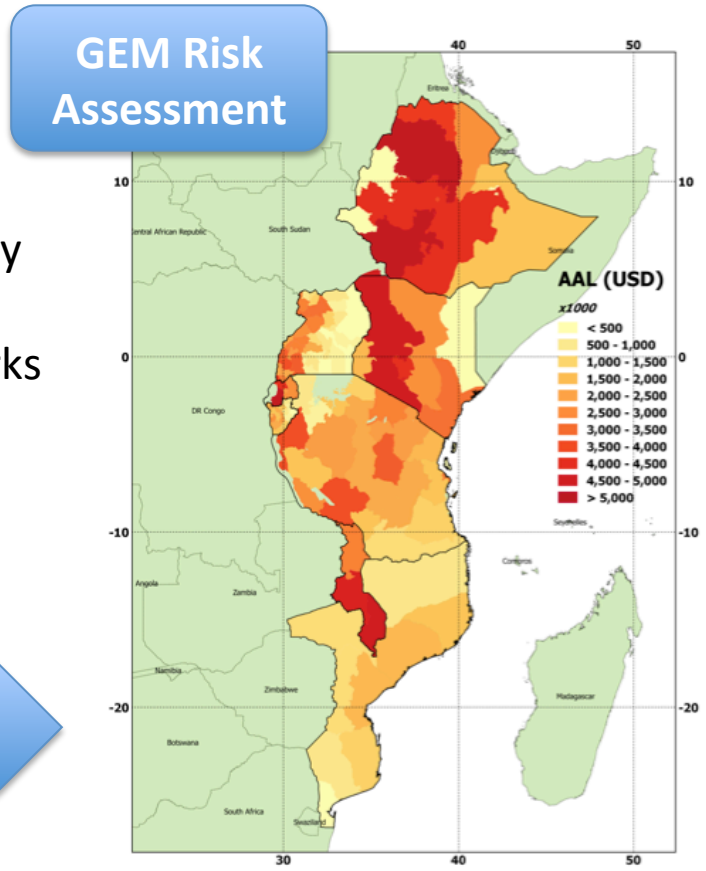
The SSA Hazard model is presently in a **pilot version**, that will be eventually improved and expanded within future collaborations with African scientific community

Many components are still missing, such as:

- Active faults information and paleoseismicity
- Integration of local hazard studies
- Strong motion recordings from local networks
- Site-specific studies and microzonation

Outlook:

- Extend model to a **continental scale**
- Extend model to a **national scale** and integrate with **local building codes**



Thank you!

Comparing PGA Results