GEM

GLOBAL EARTHQUAKE MODEL

working together to assess risk

Global Earthquake Hazard Overview

Marco Pagani, Julio Garcia, Robin Gee, Kendra Johnson, Valerio Poggi, Michele Simionato, Richard Styron, Daniele Viganò, Laurentiu Danciu, Damiano Monelli, Graeme Weatherill

hazard@globalquakemodel.org

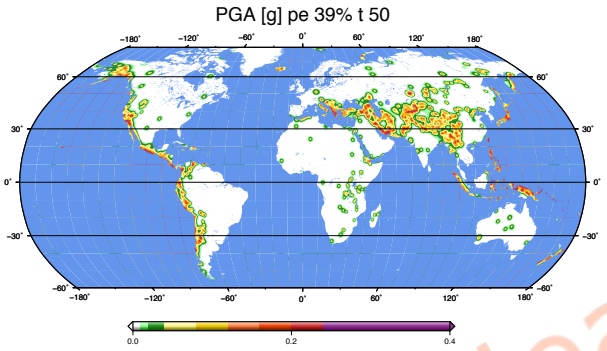
OQ OPENQUAKE

Global Earthquake Model 2018
December 5th, 2018 – Pavia, Italy

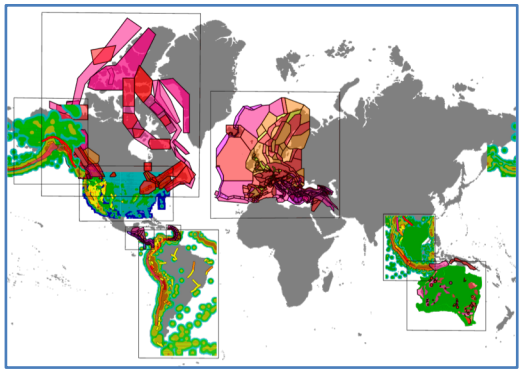
2018 – Release of the first GEM global hazard map

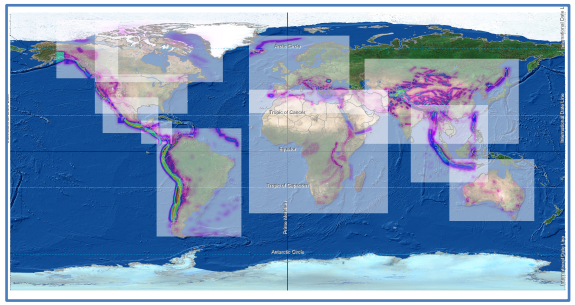
2014 – Released 1st collection of hazard models for the OQ engine

2015 – GEM Global Hazard and Risk Modelling task force



2012 – GAR Global Model





2010 – GEM1 global model

2009

Presentation outline

- GEM's global hazard model framework
- The mosaic of hazard models:
  - Compilation criteria
  - Components
- The 2018 global hazard map
- What's next?

Global Earthquake Hazard Overview

GEM's global hazard model framework

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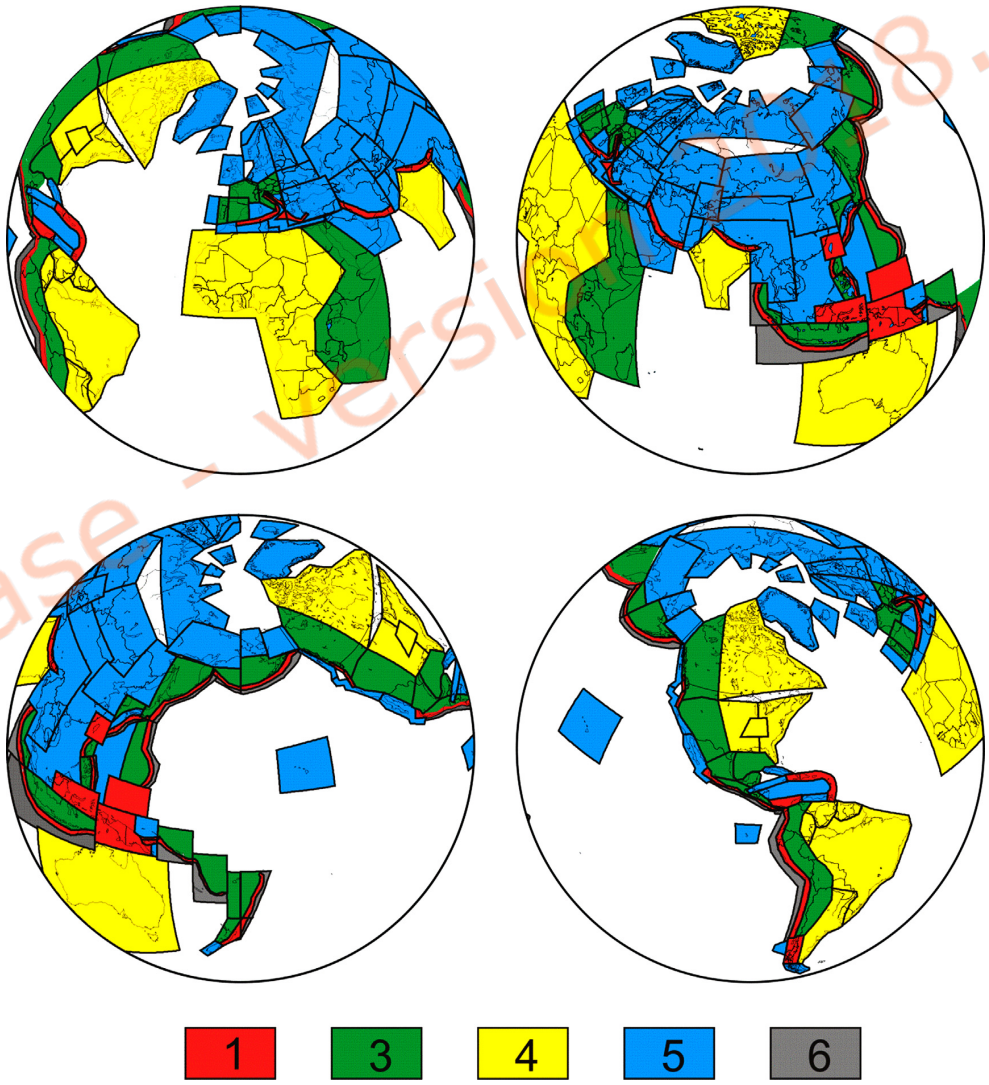
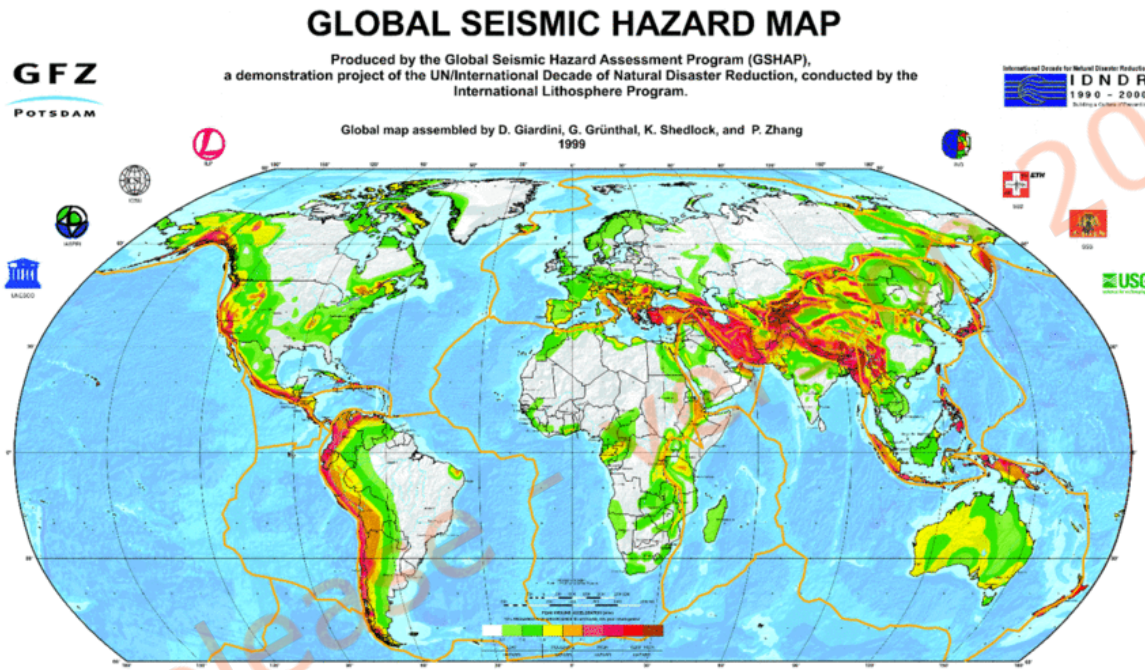
Strategies for building a global PSHA model

- **One global hazard model** developed by a single organisation
- **A combination of regional/national models** created by a large pool of organisations (à la GSHAP)



Ordaz et al. (2014)

The GSHAP project



PROS

- Outstanding technical and scientific achievement
- Involved a large community of scientists from all over the world
- Represented a significant improvement of our knowledge on seismic hazard globally

CONS

- Static (i.e. without updates)
- Not completely reproducible (not all the models are still accessible)

Some pros & cons of the mosaic approach

Pros

- Summarizes the most recent openly accessible national/regional models
- High local buy-in and community participation
- Best option for risk-assessment
- Best way to promote best practice and appraise state-of-the-art globally

Cons

- Models not (or partly) developed following a homogenous methodology

GEM's global hazard model framework

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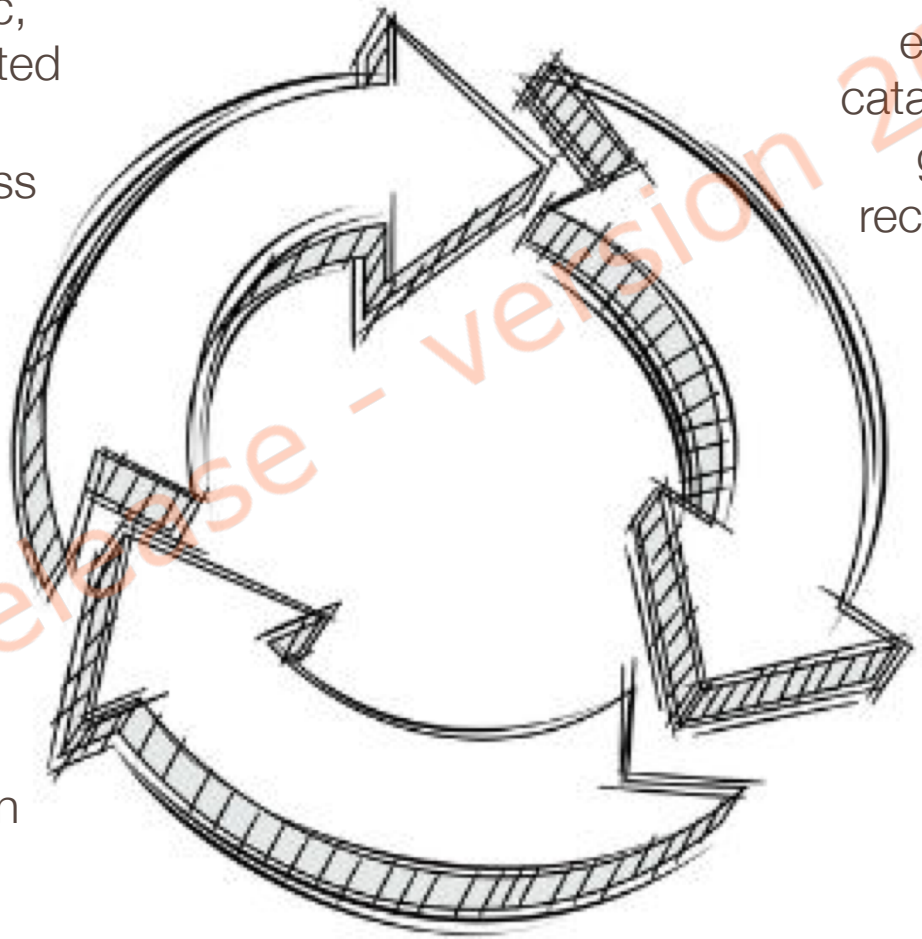
QA and testing
Important topic, not yet integrated into the model building process

Basic datasets
e.g. earthquake catalogues, strong ground-motion recordings, active fault DBs



GEM's Mosaic of Hazard Models
A global collection of regional and national seismic hazard models

Tools for Hazard Model Construction and Calculation
e.g. tools for the preparation of earthquake occurrence models, the OpenQuake engine

Global Earthquake Hazard Overview

GEM's mosaic of hazard models: compilation criteria

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A multi-tier approach

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In a decreasing order of preference:

Tier 1

Models developed in the context of partnerships, such as a regional or national programmes/projects, where new hazard models are created within open, collaborative efforts

Tier 2

Hazard models from information publicly distributed through scientific journals or openly accessible from scientific organisations (e.g. from their websites)

Tier 3

Models created either by the GEM Secretariat and/or a partner organisation, without open collaboration and joint ownership

Models described using the same file format

A set of models ready for the OQ engine

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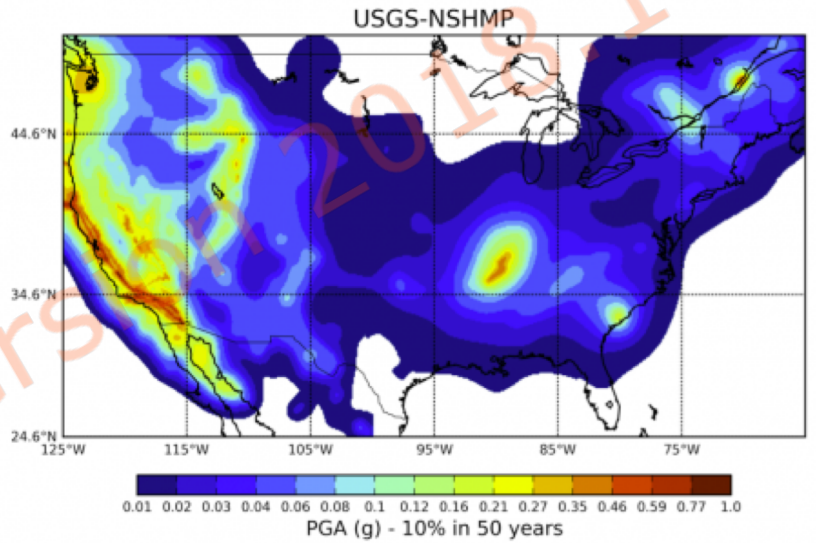
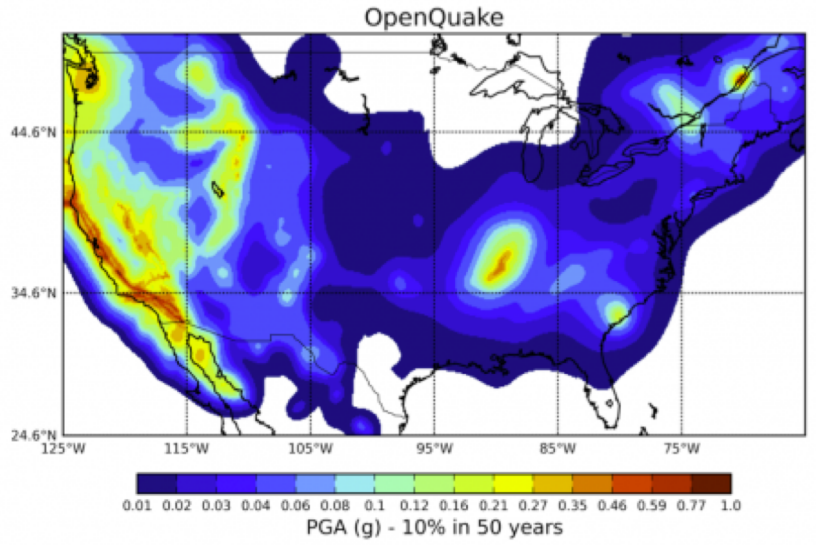
Models for Tier 1 and 2 are either:

- Originally implemented for the OQ engine (e.g. SHARE model for Europe)

or

- Converted by GEM from an original version (e.g. USGS 2014)
- Converted by a supporting organization from an original version (e.g. NZL model by GNS Science – see Horspool et al. 2017 – Proceedings 16th WCEE)





Global Earthquake Hazard Overview

GEM's mosaic of hazard models: The components of the mosaic

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Models' typology

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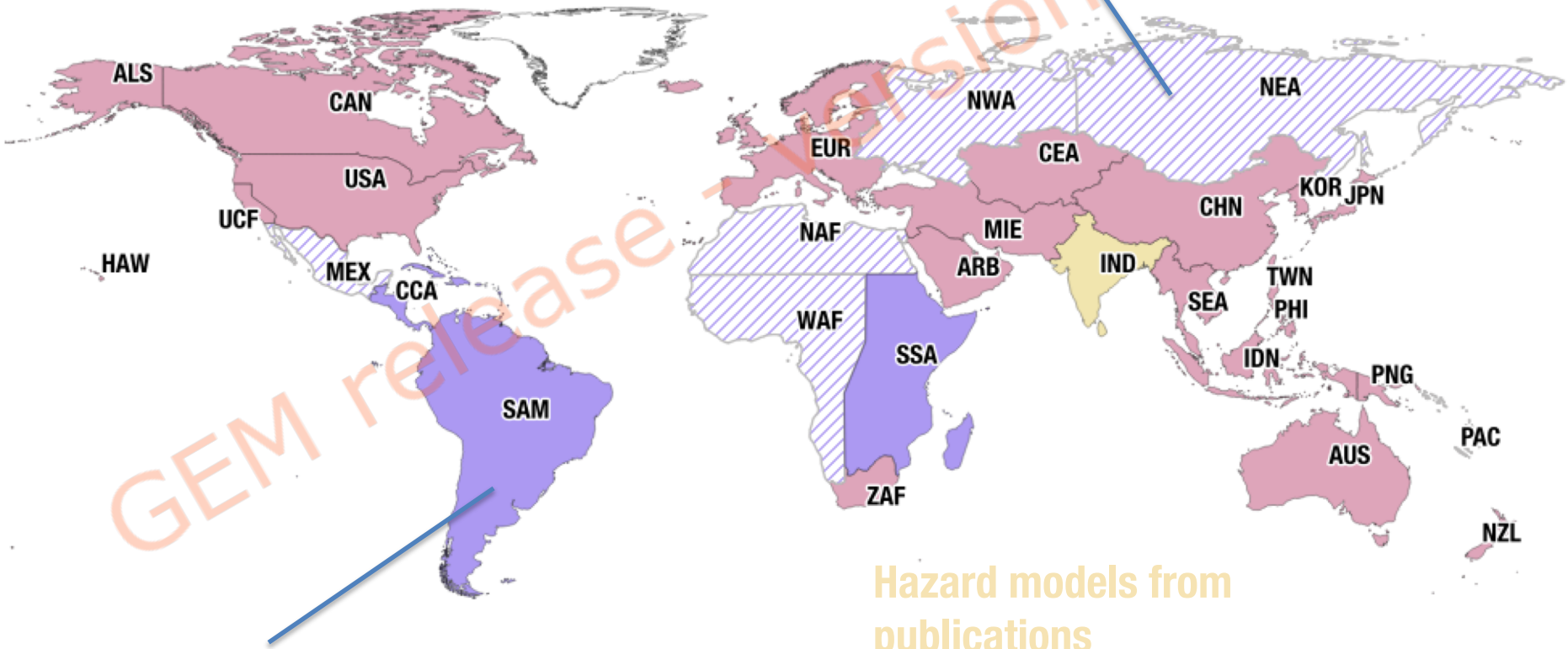
Regional and national hazard model

i.e. hazard models implemented by national agencies

GEM Internal Hazard model

Models implemented by the GEM Hazard Team

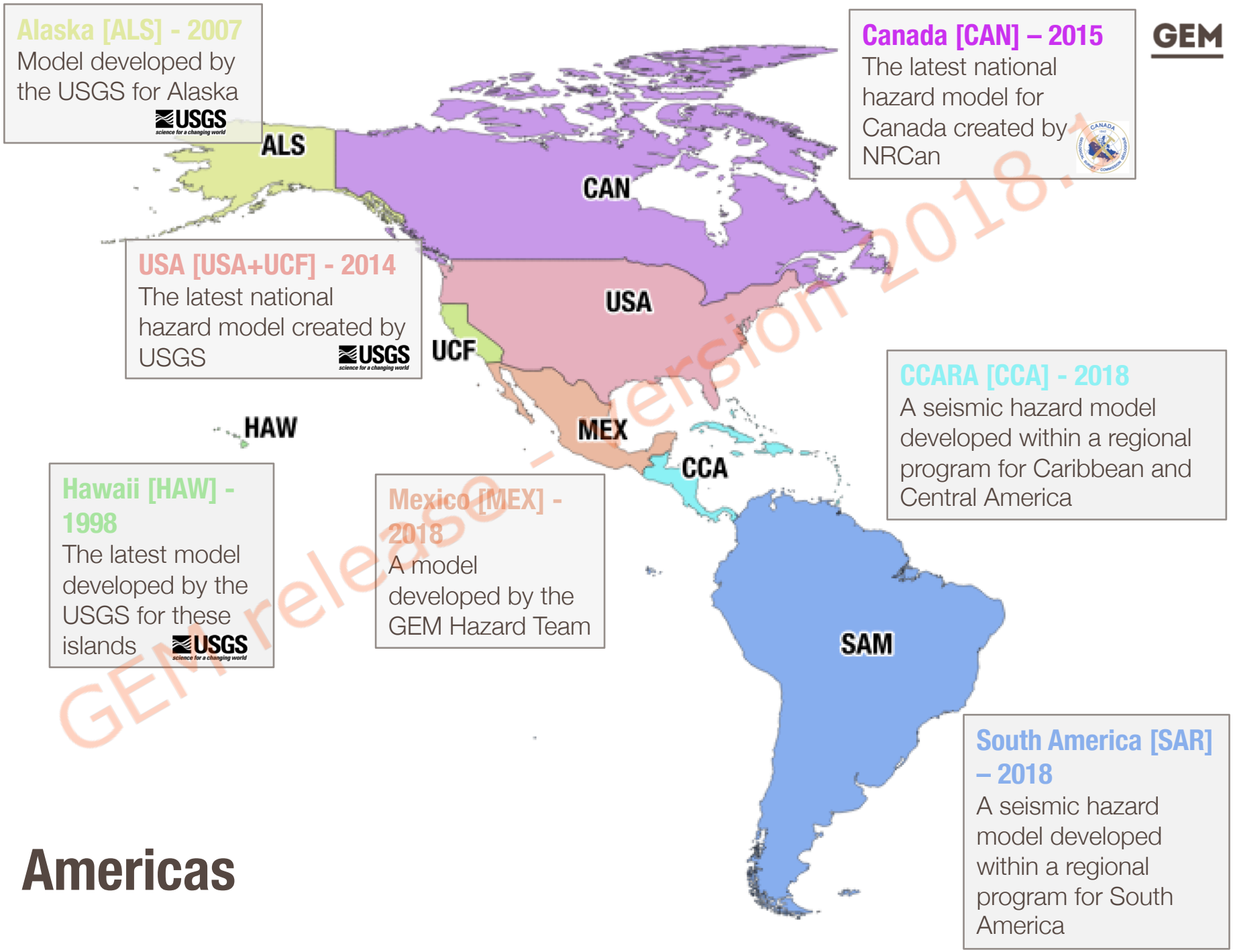


Hazard models coordinated by GEM

Models implemented by the GEM Hazard Team within regional projects

Hazard models from publications

Models implemented using information included in scientific papers


Alaska [ALS] - 2007
Model developed by the USGS for Alaska
USGS
science for a changing world
ALS
Canada [CAN] – 2015
The latest national hazard model for Canada created by NRCan
GEM
CAN
USA [USA+UCF] - 2014
The latest national hazard model created by USGS
USGS
science for a changing world
USA
UCF
HAW
MEX
CCA
CCARA [CCA] - 2018
A seismic hazard model developed within a regional program for Caribbean and Central America
Hawaii [HAW] - 1998
The latest model developed by the USGS for these islands
USGS
science for a changing world
Mexico [MEX] - 2018
A model developed by the GEM Hazard Team
SAM
South America [SAR] – 2018
A seismic hazard model developed within a regional program for South America
GEM release - version 2018.1
Americas

Europe and Africa

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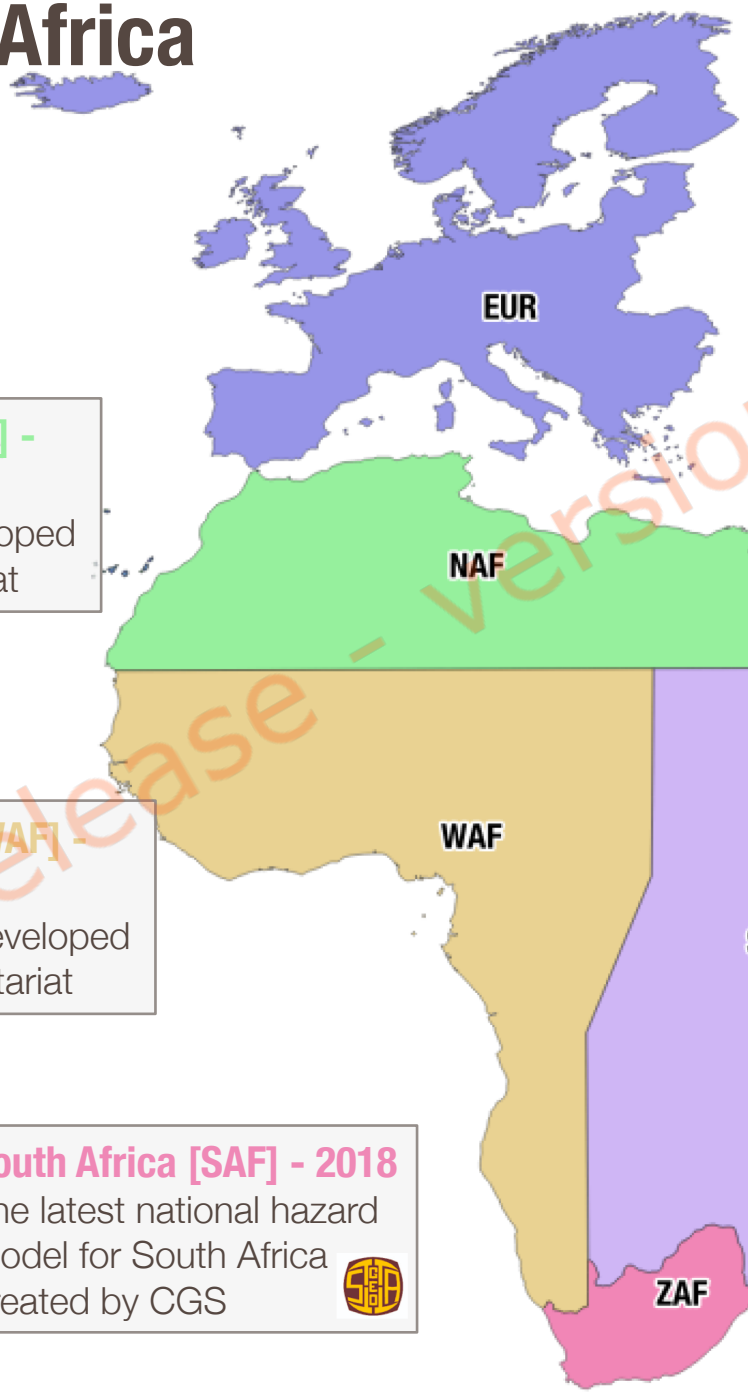


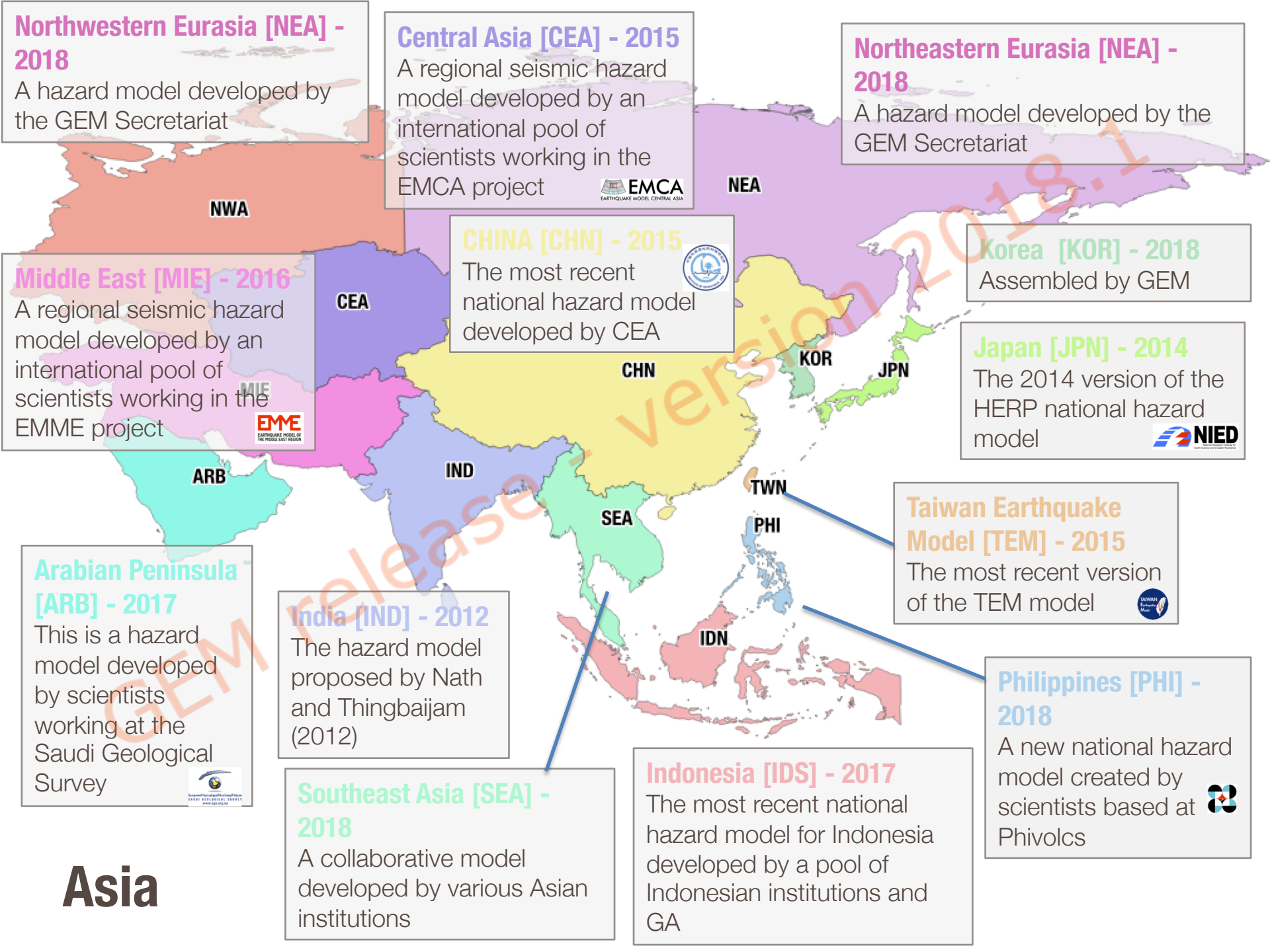
Europe [EUR] - 2013
The latest European hazard model, created within the EU funded SHARE project

Northern Africa [NAF] - 2018
A hazard model developed by the GEM Secretariat

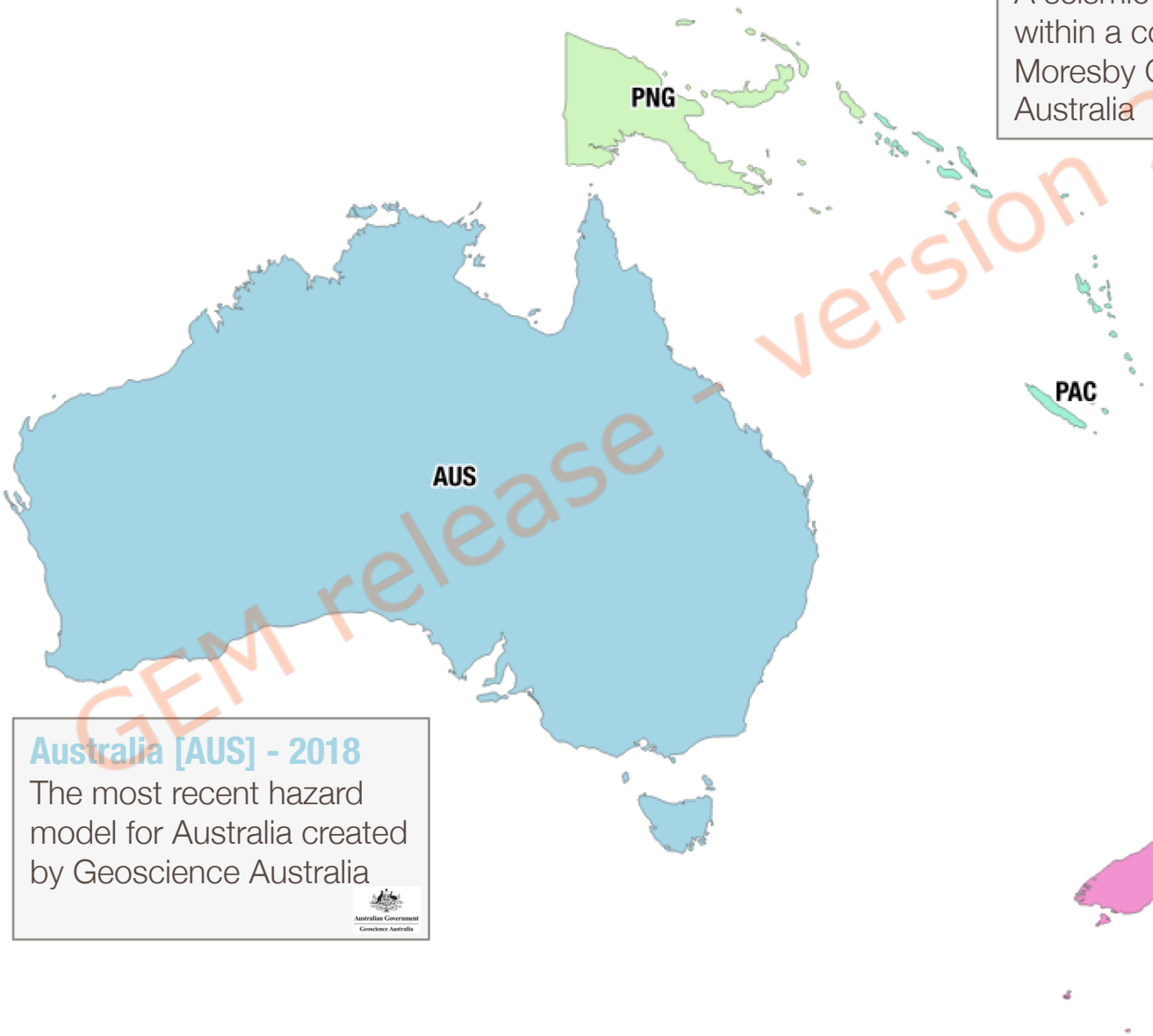
Western Africa [WAF] - 2018
A hazard model developed by the GEM Secretariat

Sub-Saharan Africa [SSA] - 2016
A seismic hazard model created GEM in collaboration with the AfricaArray initiative

South Africa [SAF] - 2018
The latest national hazard model for South Africa created by CGS


Northwestern Eurasia [NEA] - 2018
A hazard model developed by the GEM Secretariat
Central Asia [CEA] - 2015
A regional seismic hazard model developed by an international pool of scientists working in the EMCA project
EMCA
EARTHQUAKE MODEL CENTRAL ASIA
Northeastern Eurasia [NEA] - 2018
A hazard model developed by the GEM Secretariat
NWA
NEA
CHINA [CHN] - 2015
The most recent national hazard model developed by CEA
Korea [KOR] - 2018
Assembled by GEM
Middle East [MIE] - 2016
A regional seismic hazard model developed by an international pool of scientists working in the EMME project
MIE
EMME
EARTHQUAKE MODEL OF THE MIDDLE EAST REGION
CEA
CHN
KOR
JPN
Japan [JPN] - 2014
The 2014 version of the HERP national hazard model
NIED
ARB
IND
TWN
SEA
PHI
Taiwan Earthquake Model [TEM] - 2015
The most recent version of the TEM model
Arabian Peninsula [ARB] - 2017
This is a hazard model developed by scientists working at the Saudi Geological Survey
India [IND] - 2012
The hazard model proposed by Nath and Thingbaijam (2012)
IDN
Philippines [PHI] - 2018
A new national hazard model created by scientists based at Phivolcs
Southeast Asia [SEA] - 2018
A collaborative model developed by various Asian institutions
Indonesia [IDS] - 2017
The most recent national hazard model for Indonesia developed by a pool of Indonesian institutions and GA
Asia
GEM released version 2018.1

Oceania



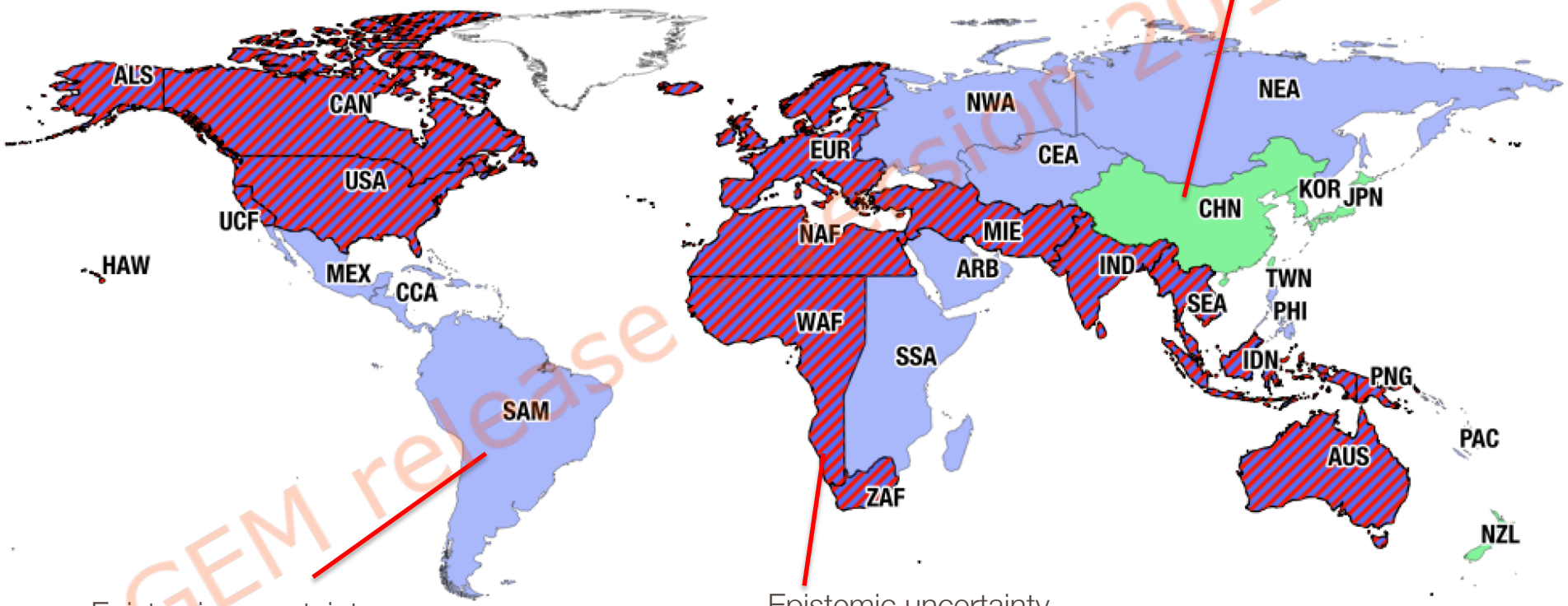
Papua New Guinea [PNG] - 2016
A seismic hazard model developed within a collaboration between the Port Moresby Observatory and Geoscience Australia

Pacific Islands [PAC] - 2018
A hazard model developed by the GEM Secretariat

New Zealand [NZL] – 2010 upgraded
The latest national hazard model released for New Zealand

Australia [AUS] - 2018
The most recent hazard model for Australia created by Geoscience Australia

Some info: epistemic uncertainty modelling



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Global Earthquake Hazard Overview

The 2018 Global Hazard Map

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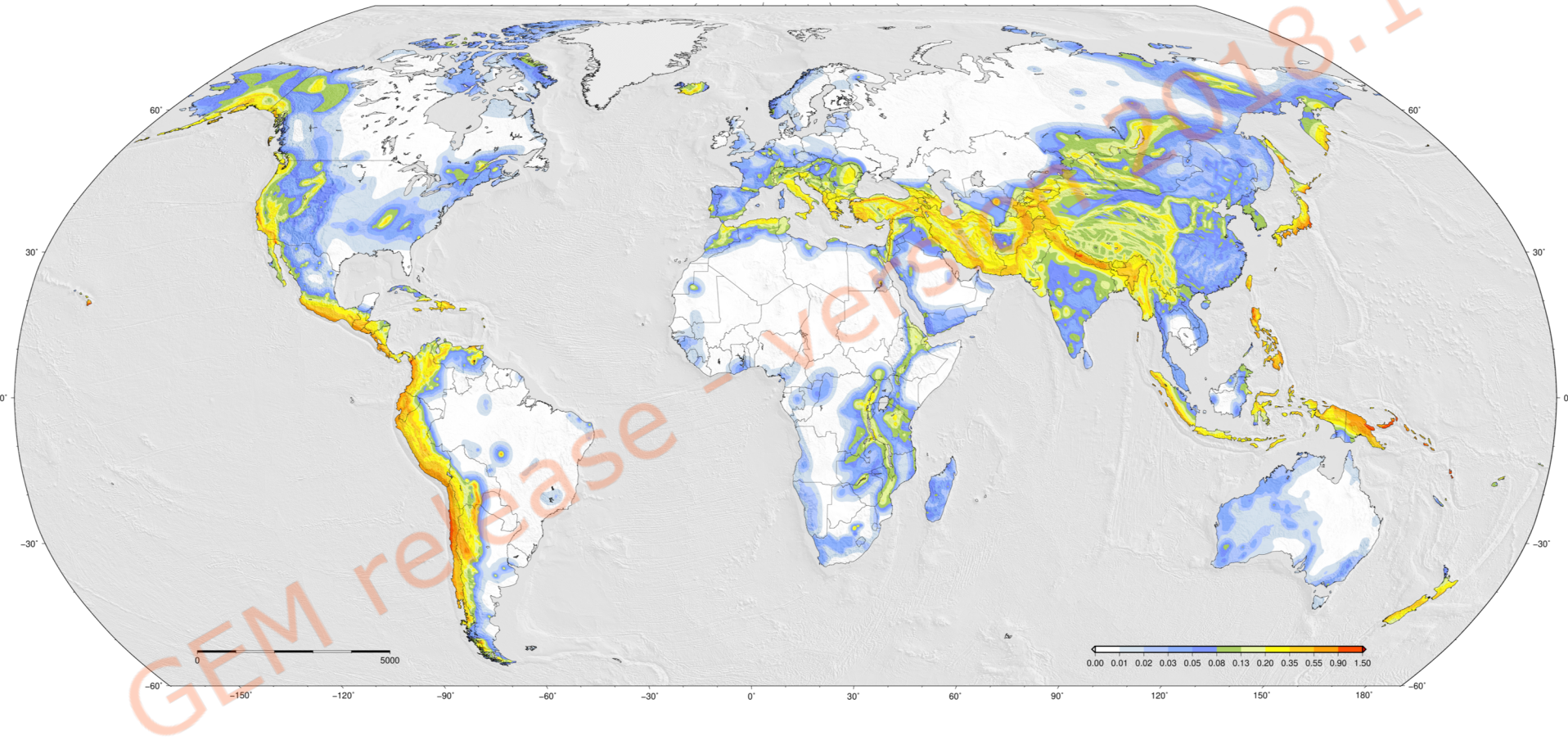
The map



PGA 10% probability of exceedance in 50 years, on reference soil conditions of 760/800 m/s. It was obtained by assembling the outputs of the 30 models considered.

Some info

30 Hazard Input models (SSC + GMM Characterisation)

Seismic Source Characterisation

For the calculation of the hazard maps we used:

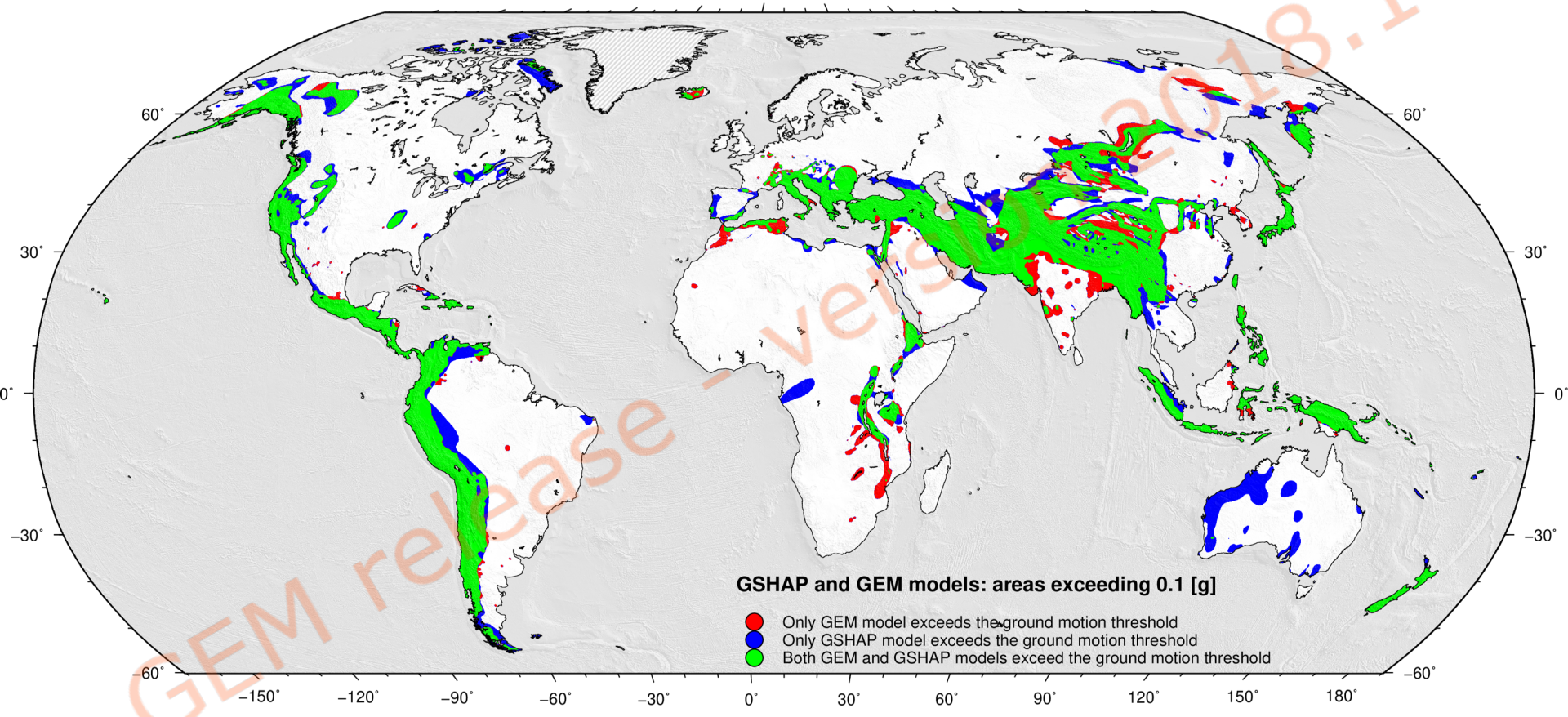
- 105 seismic source input models
- About 3.5M sources (more than 25000 fault sources)
- About 1.8 billion ruptures

Ground Motion Characterisation

For the calculation of hazard maps we used

- 90 Ground Motion Prediction Equations all implemented into the OQ engine

Comparisons with GSHAP



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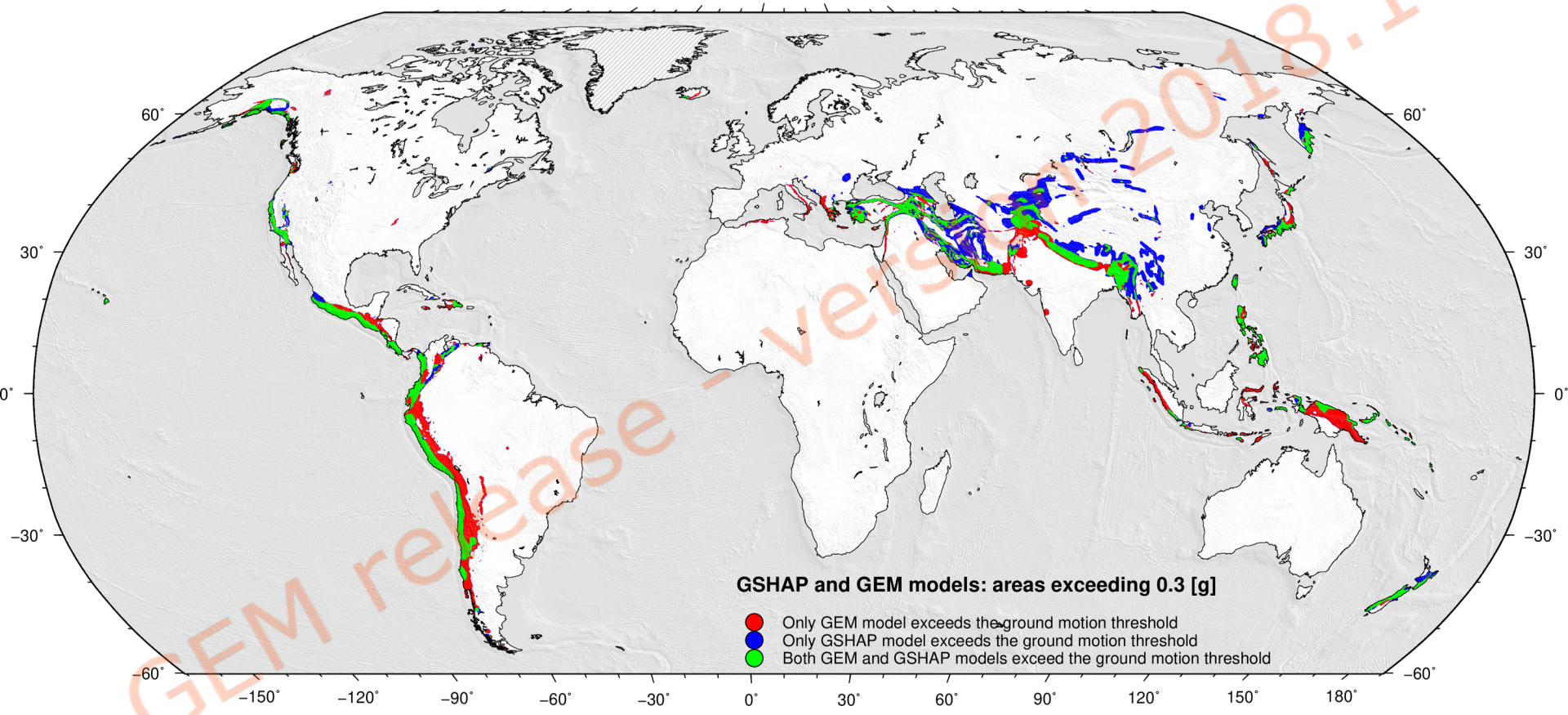

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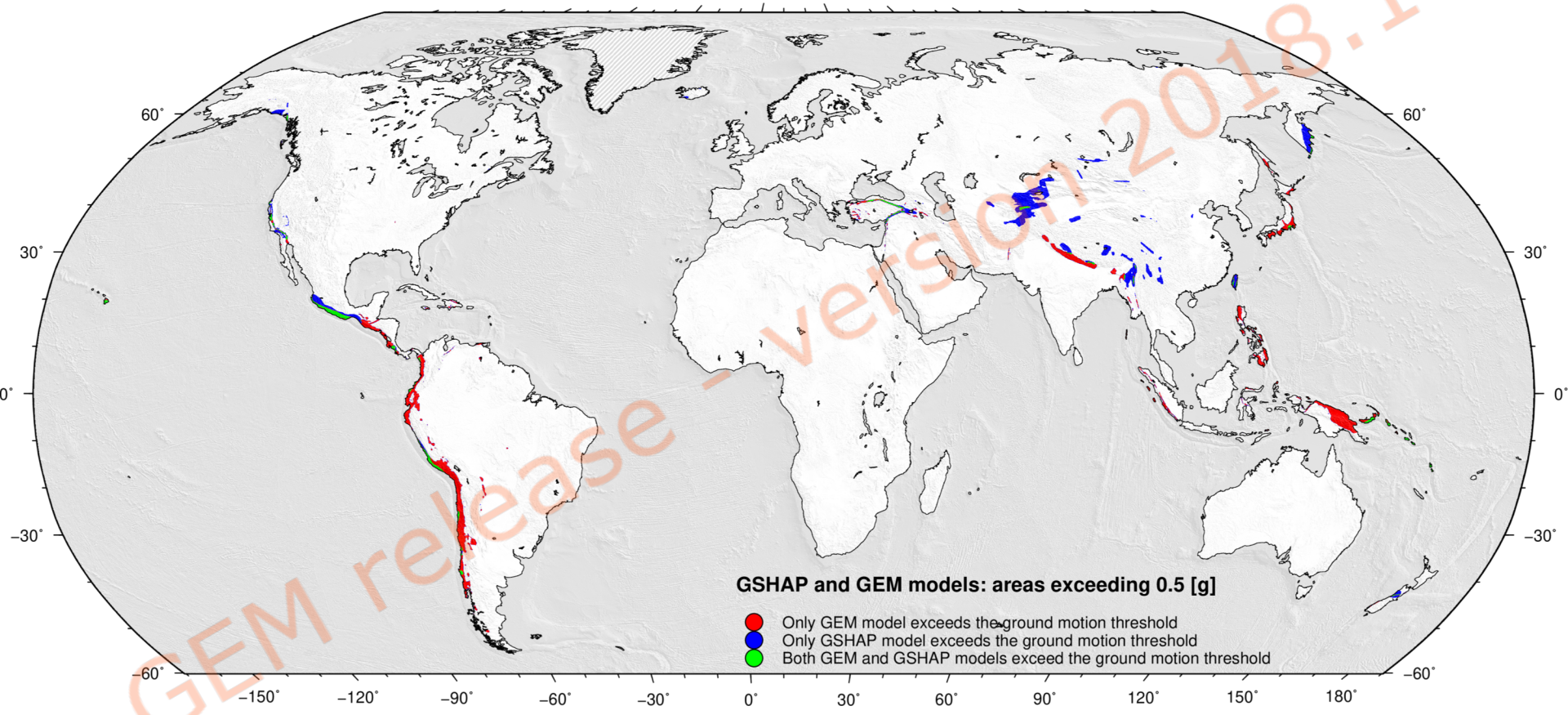

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What's next?

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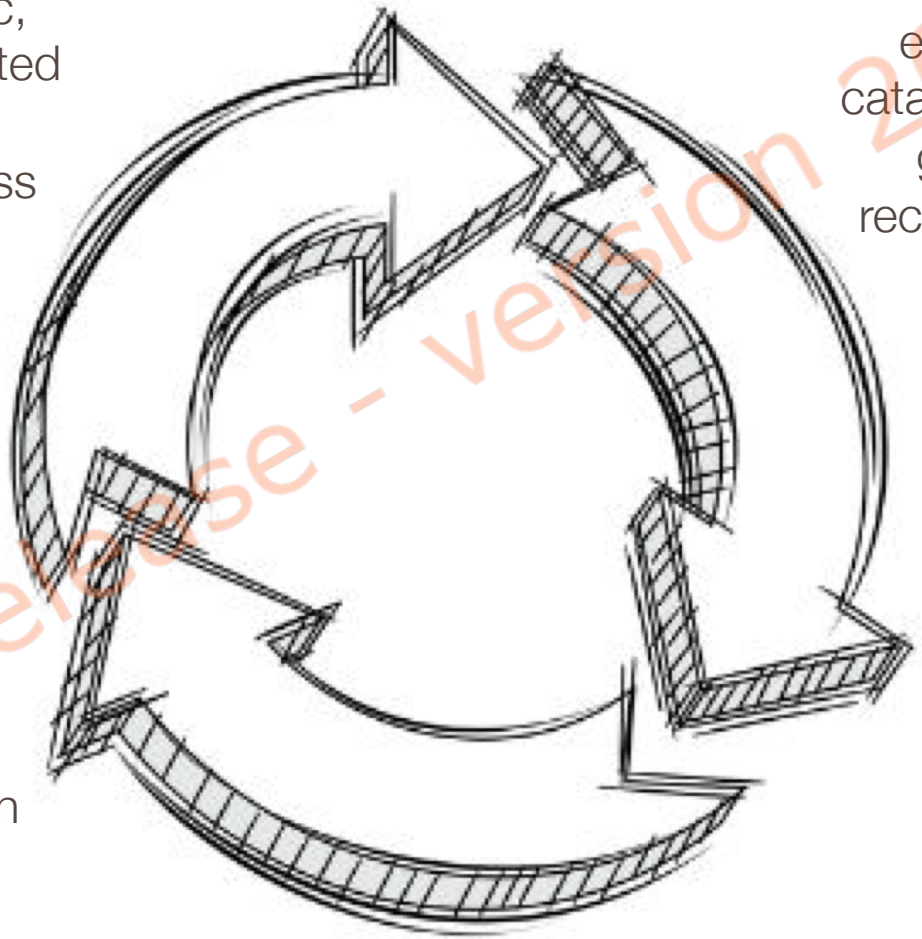

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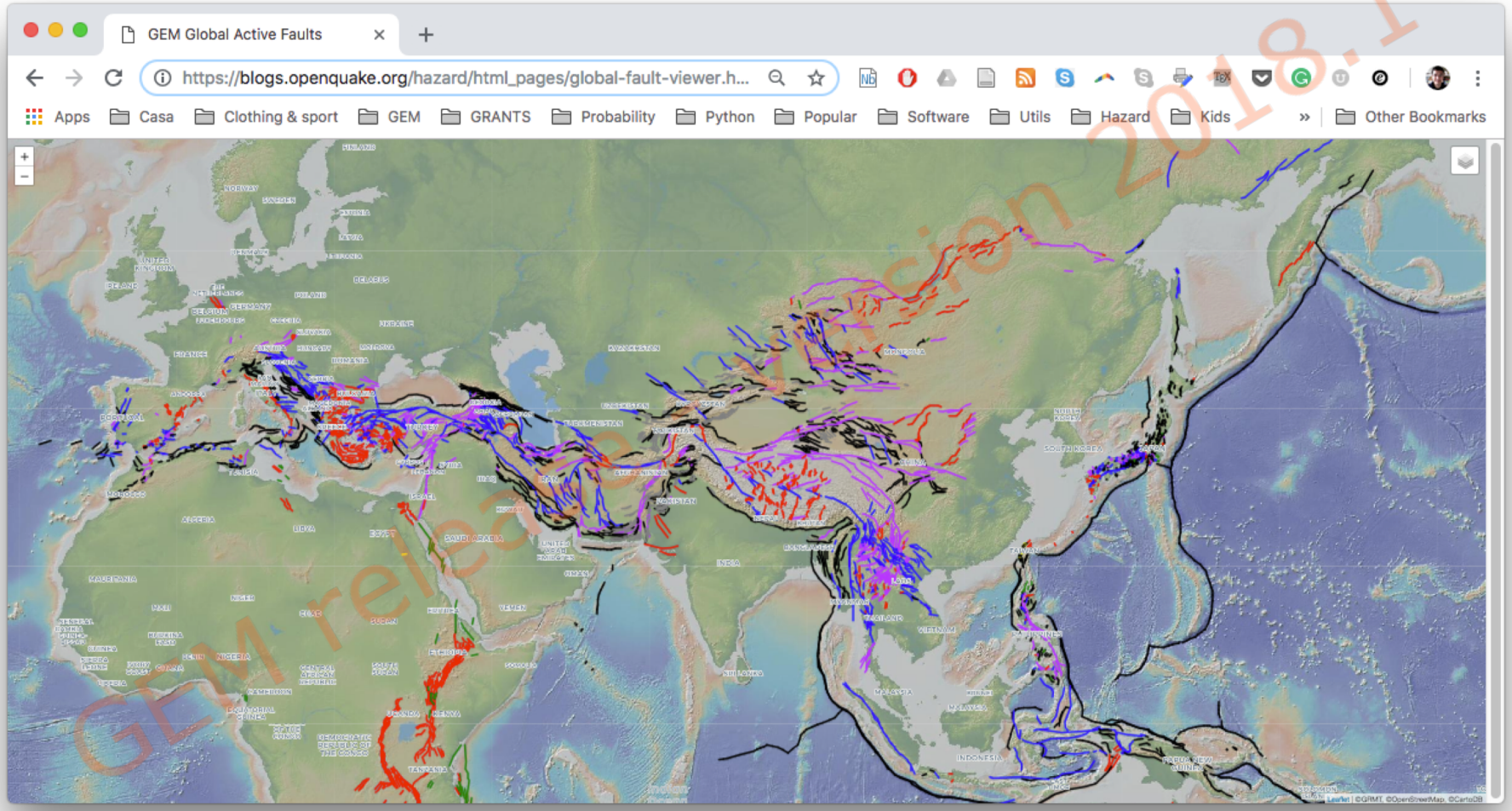
A global collection of regional and national seismic hazard models

Tools for Hazard Model Construction and Calculation
e.g. tools for the preparation of earthquake occurrence models, the OpenQuake engine

GEM's hazard mosaic: a dynamic framework



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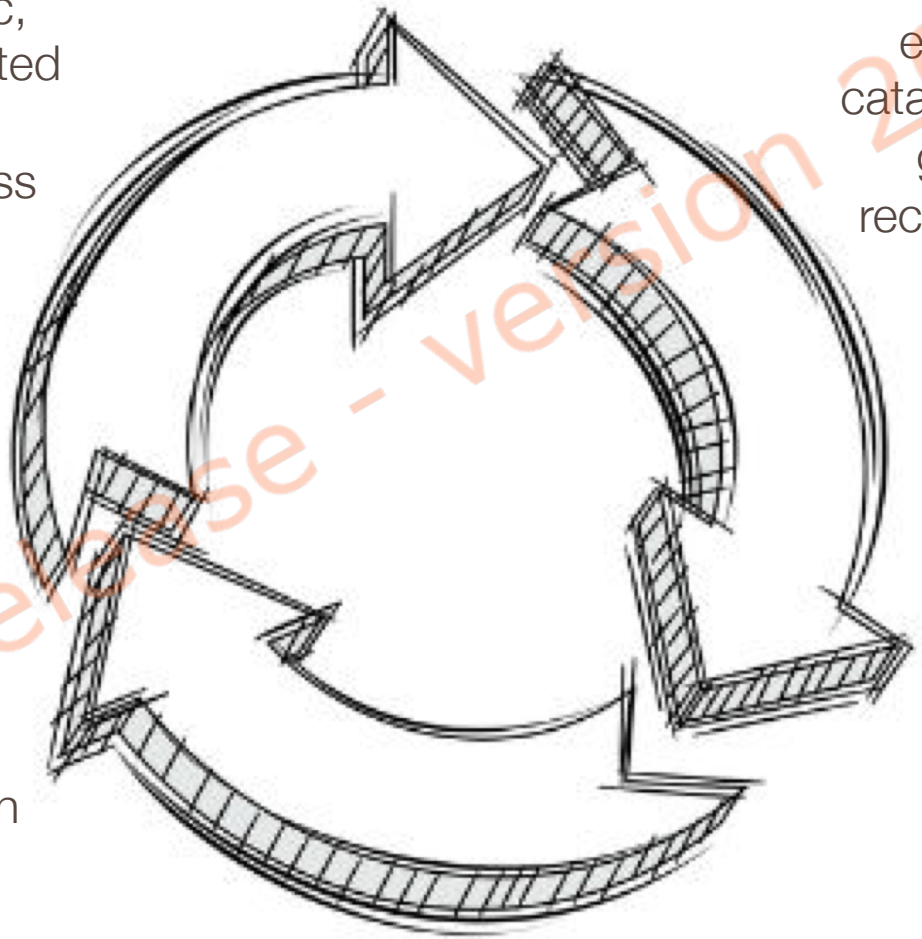

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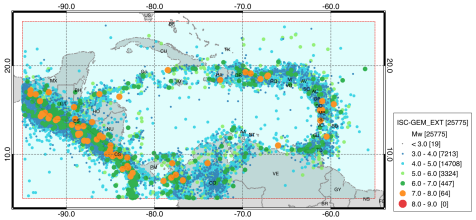
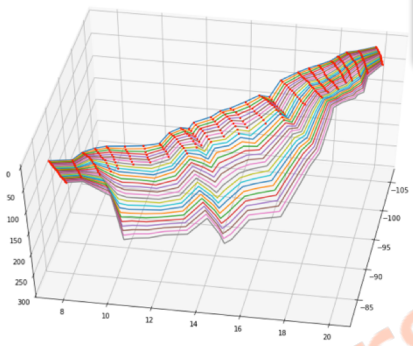
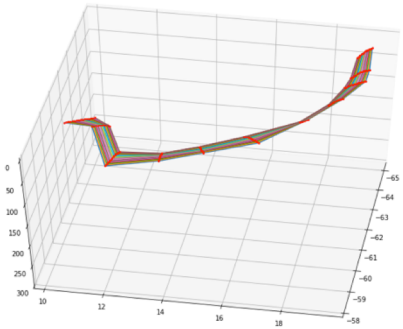


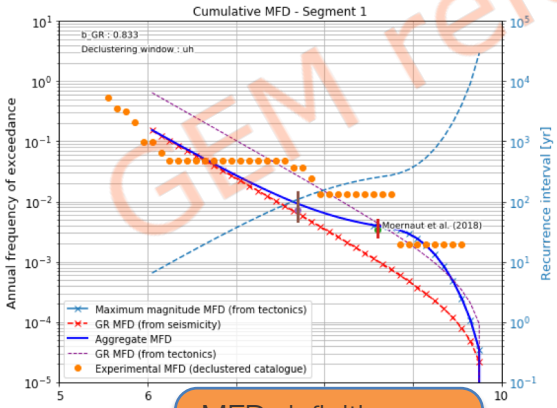
Catalogue homogenization



Top-of slab geometry

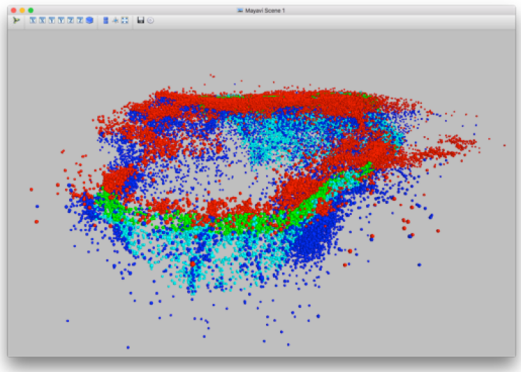


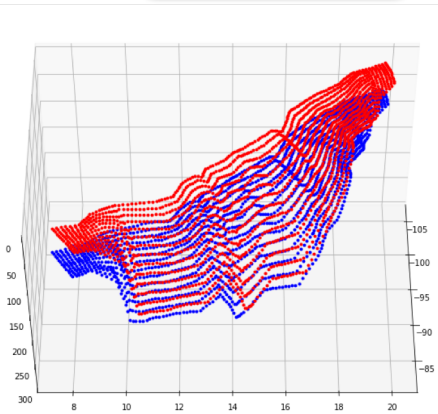
Interface geometry



MFD definition:
- Interface
- In-slab

Regionalization of seismicity





Bottom-of slab geometry

GEM's global hazard model framework

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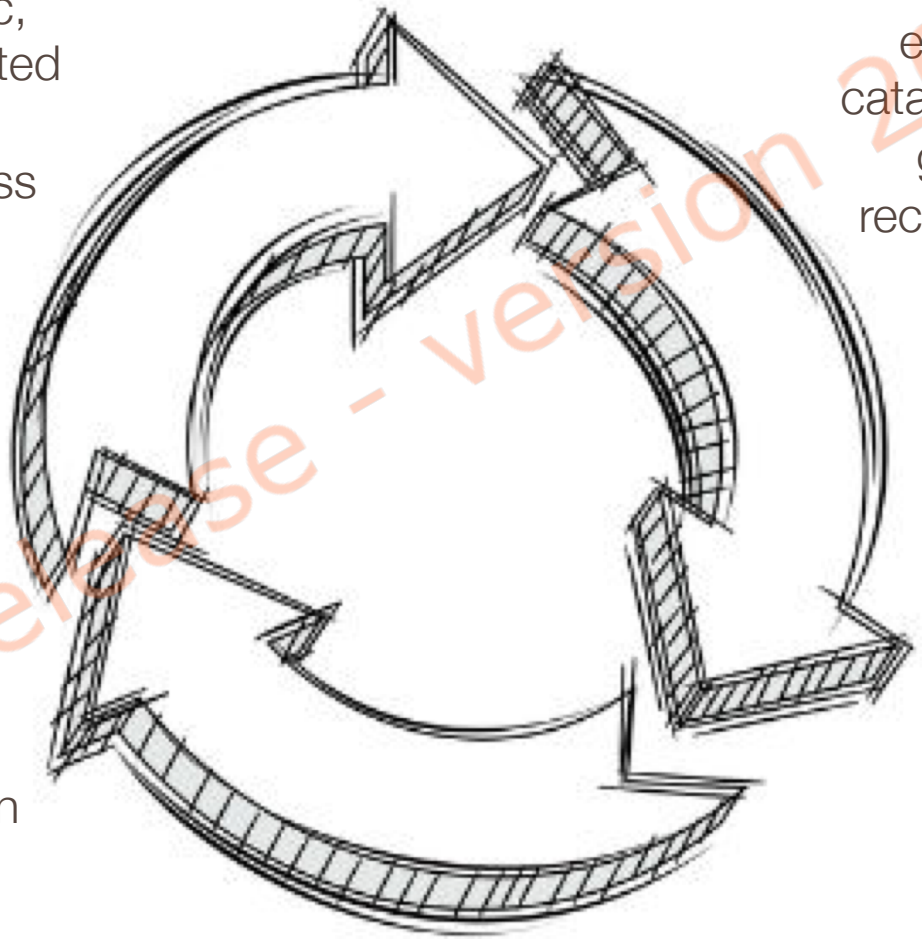

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GEM's hazard mosaic: a dynamic framework

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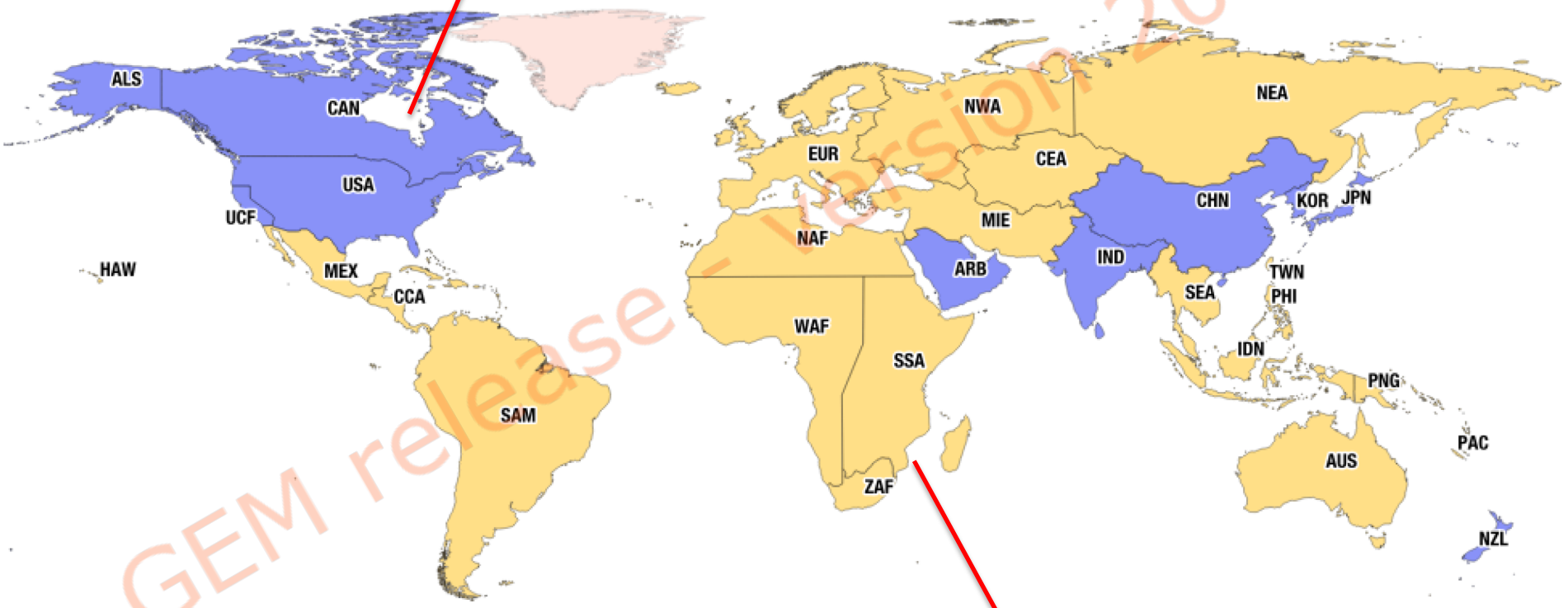
'Translated' hazard models

i.e. hazard models implemented using a different PSHA code and translated into the OQ engine format

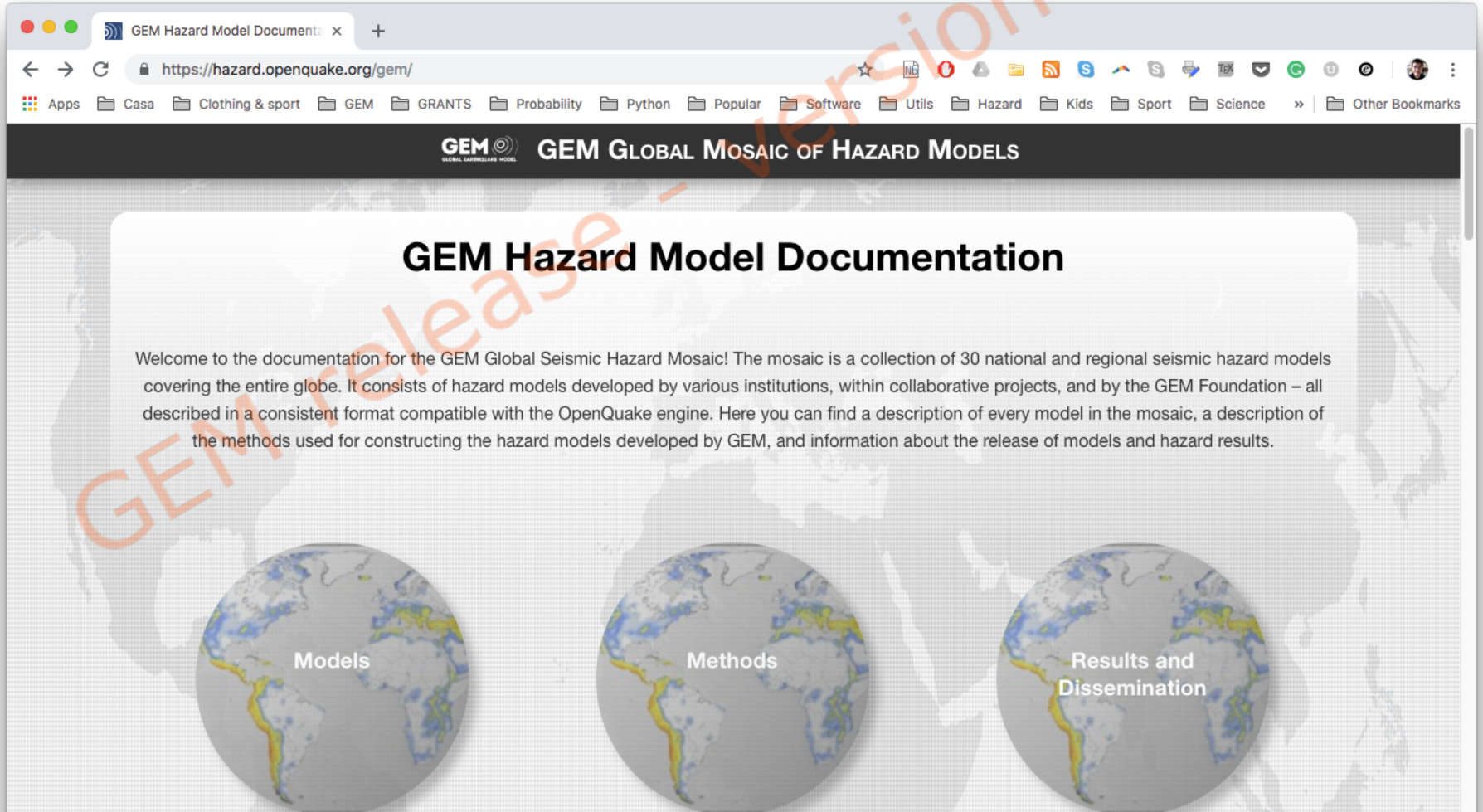


OQ engine hazard models

i.e. hazard models included in the mosaic and originally implemented using the OQ engine

Future activities

- Gradually release the hazard models (on-line documentation, publications on peer-reviewed journals, on-line distribution of models and results)



Future activities (contd)

- Collaborate and assist various organizations/projects currently developing new hazard models

- Upgrade the mosaic with new models e.g.
  - Korean peninsula
  - Most recent Japan model
  - USA 2020
  - Canada 2020
  - SERA model (Europe)

- Release future updates of the global hazard map

Acknowledgements

- The public and private organizations that supported GEM

- The staff at the GEM Secretariat

- The organizations and scientists that contributed to the construction of the mosaic

- Organizations and initiatives that collaborated with the hazard team

Thank you