PSHA Workshop, Lenzburg, Switzerland - 5 to 7 September 2017
Future directions for probabilistic seismic hazard assessment at a local, national and transnational scale

Seismic Hazard Maps for the French Metropolitan Territory

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Objectives

The goal of the present study is to exploit as much as possible the outcomes of the SIGMA project (Pecker et al., 2017) in order to produce a new seismic hazard map for metropolitan France. SIGMA led to improvement of key "ingredients" of the PSHA: (1) a new seismic catalogue for France has been produced; (2) area source models have been updated with emphasis on fault systems; (3) uncertainties on magnitude-frequency distributions are fully propagated; (4) new GMPEs specific for France have been developed .

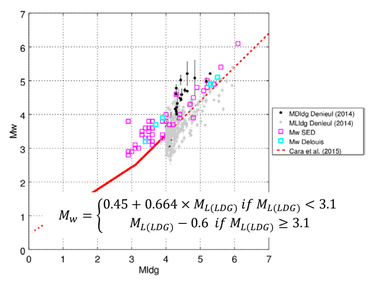
Earthquake catalogue

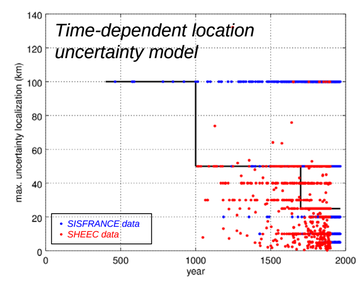
Input data

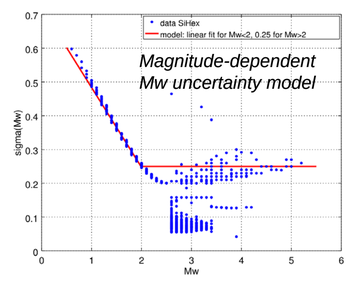
- FCAT-17 catalogue (Poster by P. Traversa C6- Session1) which is an outcome of SIGMA combining historical events (based on SISFRANCE) with re-evaluated hypocentral depth and Mw, with updated location and Mw based on coda analysis of instrumental events (SiHex catalogue)
- The FCAT-17 catalogue includes events up to 2009 and its geographical extension is limited to a 20 km buffer around French borders and coastlines. Hence the catalogue has been complemented using:
  - The SHEEC catalogue for the period 1000-2006
  - the original SiHex catalogue which covers a greater area for the period 1962-2009
  - The LDG bulletins for the period 2010-2016

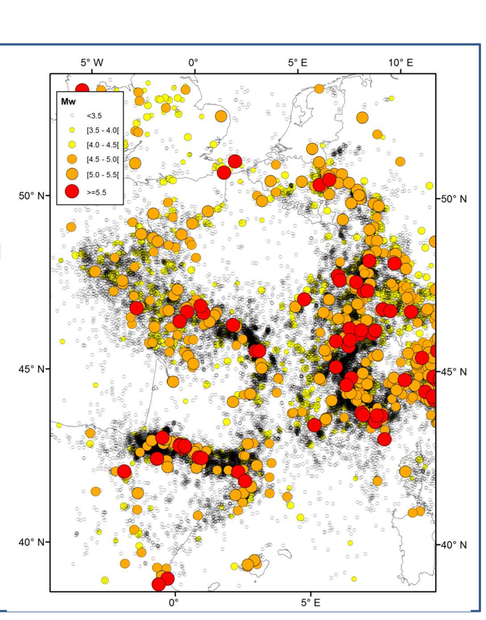
Processing

- Identification and removal of duplicate events
- Conversion of LDG magnitudes (ML or Md) into Mw using the SiHex conversion scheme
- Analysis of location and magnitude uncertainties included in the input catalogues in order to define models (time- or magnitude- dependent) for events without associated uncertainty
- Declustering using Gardner & Knopoff (1974) algorithm together with the space and time windows of Burkhard & Grünthal (2009)









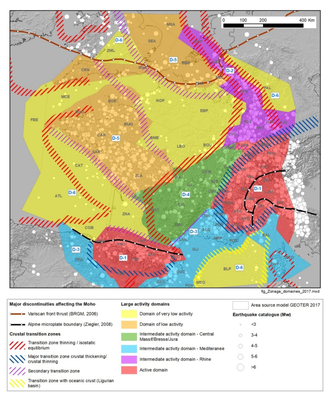
SSC model

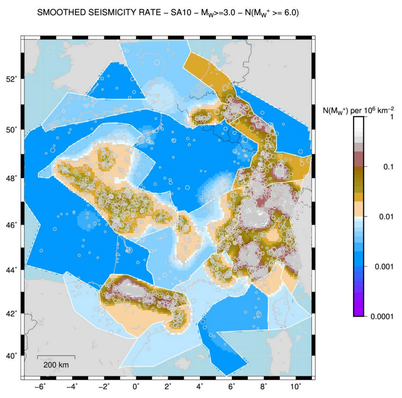
Area source models

- EDF model (includes outcomes of SIGMA for the Southeastern part of France)
- IRSN model (Baize et al., 2013)
- GEOTER model based on large seismotectonic domains following geophysical discontinuities and further sub-divided into area sources

Smoothed seismicity model

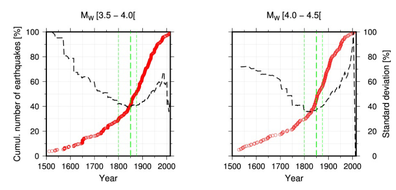
- Spatially-adaptative kernels (Helmstetter et al., 2007) using the 10th closest neighbors





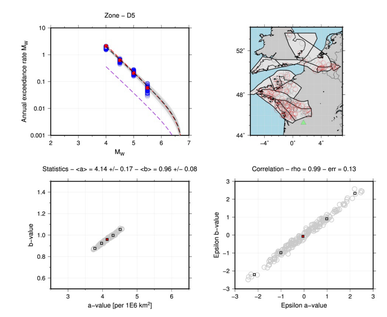
Completeness periods analysis

- Region-dependent completeness
- Statistical analysis of the catalogue (Stepp method, Hakimhashemi & Grünthal, 2012)
- Best-estimate as well as upper and lower values of completeness year are determined



Seismic activity

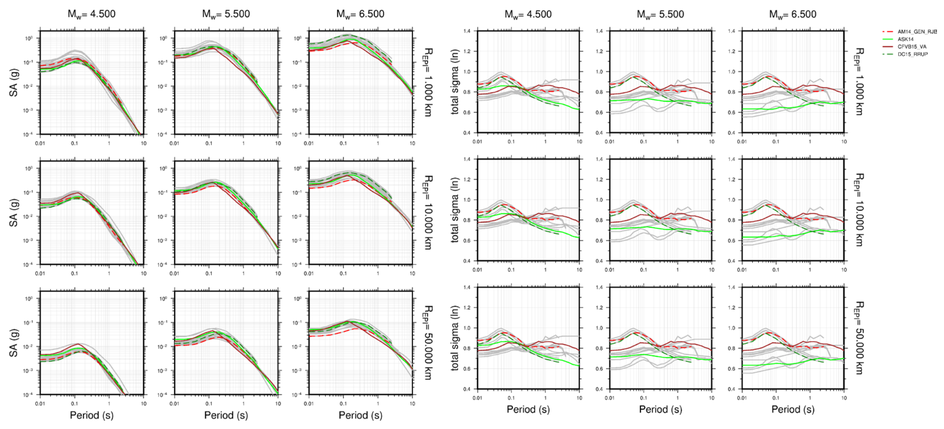
- GR models computed using penalized maximum-likelihood method (EPRI, 2012)
- Earthquakes location, Mw and completeness periods uncertainties are propagated
- First step: estimate regional b-values based on the large seismotectonic domains using a prior b-value equal to 1.0
- Second step: compute GR model for each area source using the regional b-values as priors
- Mmax. Bayesian approach based on prior Mmax distributions tailored for the French context (Ameri et al., 2015). A specific distribution has been determined for each large seismotectonic domain.



GMC model

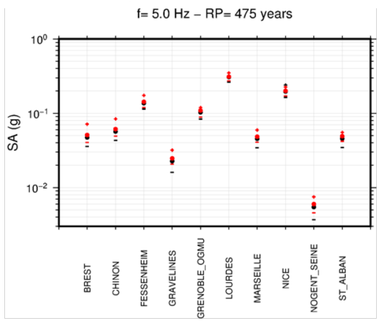
Selection of GMPEs

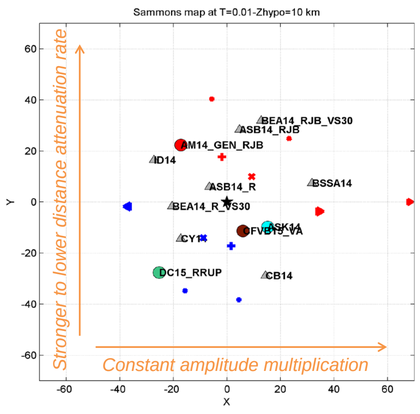
- Pre-selection of 16 GMPEs (NGA2 models, RESORCE models and 2 SIGMA models adapted to the French context)
- Selection based on expert judgment:
  - Ameri (2014) (generic/RJB)
  - Abrahamson et al., (2014)
  - Cauzzi et al. (2015) (variable reference v_{S30} option)
  - Drouet & Cotton (2015) (RRUP)



Analysis of the epistemic uncertainty coverage

- Tentative comparison of the center, body and range of the 4 selected GMPEs versus the pre-selection
  - Trellis plots
  - Sammon's maps
  - Simple PSHA calculation tests

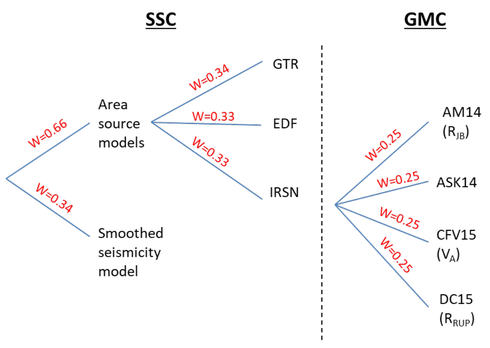




Results

Logic-tree

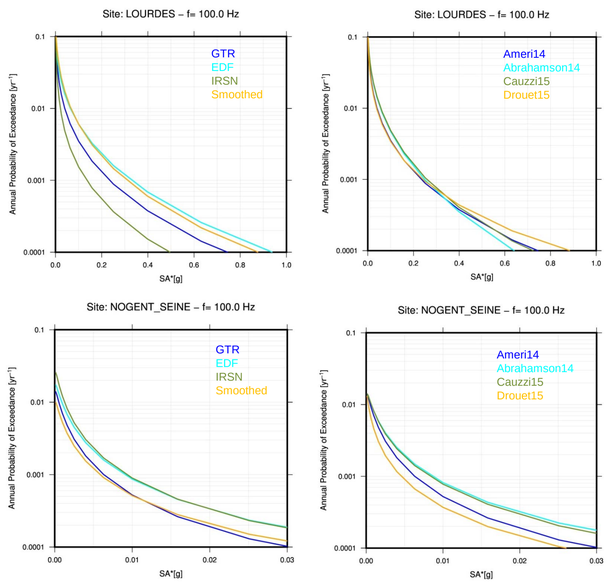
- SSC and GMC aimed at capturing epistemic uncertainty after various sensitivity analyses
- Uncertainty linked source geometry, GMPEs, Mmax, depth and seismic activity parameters (a- and b-values) is propagated



PSHA parameters

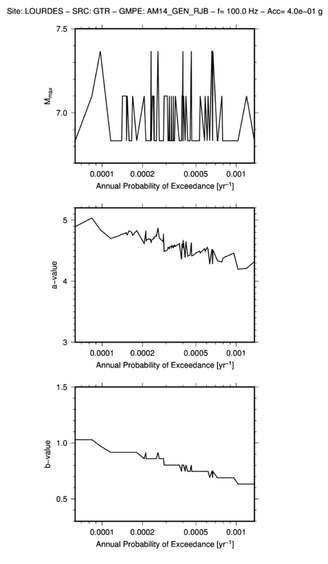
- PSHA software: SHAToolbox (in-house GEOTER)
- Mmin=4.5
- Integration distance 200 km
- Grid of points with inter-distance of 10 km
- Rock site conditions considered (v_{S30}=800 m/s)

SSC sensitivity

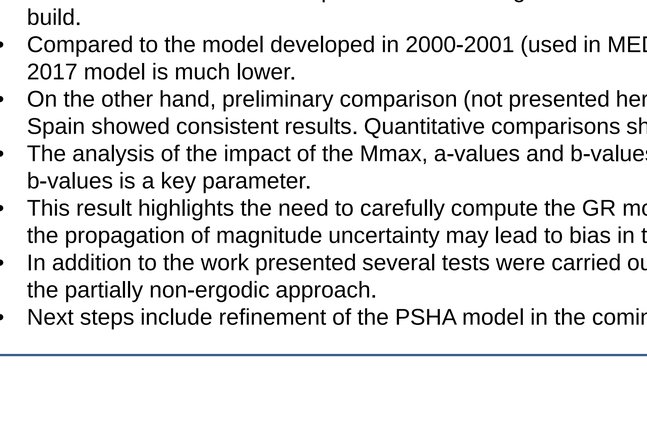


GMC sensitivity

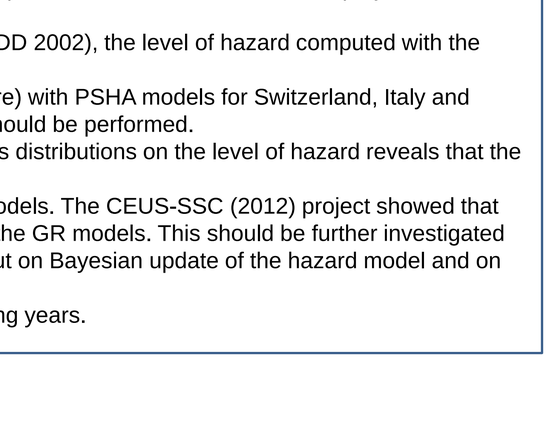
Sensitivity to Mmax, a- and b-values sampling



GEOTER 2017 model



MEDD 2002 model



Conclusions

- A new PSHA model for metropolitan France using as much as possible outcomes of the SIGMA project has been build.
- Compared to the model developed in 2000-2001 (used in MEDD 2002), the level of hazard computed with the 2017 model is much lower.
- On the other hand, preliminary comparison (not presented here) with PSHA models for Switzerland, Italy and Spain showed consistent results. Quantitative comparisons should be performed.
- The analysis of the impact of the Mmax, a-values and b-values distributions on the level of hazard reveals that the b-values is a key parameter.
- This result highlights the need to carefully compute the GR models. The CEUS-SSC (2012) project showed that the propagation of magnitude uncertainty may lead to bias in the GR models. This should be further investigated
- In addition to the work presented several tests were carried out on Bayesian update of the hazard model and on the partially non-ergodic approach.
- Next steps include refinement of the PSHA model in the coming years.