The 2002 GEOTER Seismic Hazard Model for the Caribbean - Lesser Antilles

The GEOTER 2002 PSHA model for the Lesser Antilles was developed under the revision of the France seismic zonation including the overseas territories. The PSHA input model for the Lesser Antilles is described in the GEOTER Report (Martin et al., 2002) . Here we present a short description of how this model was implemented in the OpenQuake-engine.

The Seismic Source Model

The seismic source model for the Lesser Antilles describes the major tectonic structures present in the region:

- The mainly left-lateral-strike-slip faults along the north-eastern Caribbean plate boundary,
- The subduction of the North American plate in the Caribbean ones in Lesser Antilles Arc,
- The large transform right-lateral-strike-slip faults along the south-eastern Caribbean plate boundary,
- The Lesser Antilles arc with:
    1. an extensional shear zone to the north,
    2. a transitional zone in the central part, with sinistral strike-slip deformation (between the Guadaloupe and Martinique islands), and
    3. a zone of dextral oblique compression to the south related with the accretion prism parallel to the arc,

In the original model the tectonic figures are defined as area sources. The crustal source zones were modelled with a 2D geometry at a fixed depth, while for the subduction ones a 3D geometry was used for both interface and intraslab source zones (see details in annex 3). In addition, an alternative subduction model was proposed by the authors, simplifying the geometry of several intraslab sources.

In the OpenQuake-engine implementation, the source model is implemented in a unique source model file in NRML format representing the different typology and tectonic region types defined in the original model. The shallow crustal seismicity are modeled as NRML areaSource, while the subduction interface and intraslab faults are implemented as NRML complexFaultSource objects. The alternative subduction model have not been considered in the OpenQuake-engine implementation.

The map below depicts the annual occurrence rate per source (between minimum and maximum magnitudes) for the different source models included in the hazard model. Click the *show map layers* icon to view different source models and base layer maps.

.mbtiles

Total occurrence rate
(number of events / year)

- < 1e-6
- 1e-6 - 1e-5
- 1e-5 - 1e-4
- 1e-4 - 1e-3
- 1e-3 - 1e-2
- 1e-2 - 1e-1
- 1e-1 - 1
- 1 - 10
- >= 10

.my-legend .legend-title { text-align: left; margin-bottom: 5px; font-weight: bold; font-size: 80%; } .my-legend .legend-scale ul { margin: 0; margin-bottom: 5px; padding: 0; float: left; list-style: none; } .my-legend .legend-scale ul li { font-size: 80%; list-style: none; margin-left: 0; line-height: 18px; margin-bottom: 2px; } .my-legend ul.legend-labels li span { display: block; float: left; height: 16px; width: 30px; margin-right: 5px; margin-left: 0; border: 1px solid #999; } .my-legend .legend-source { font-size: 70%; color: #999; clear: both; } .my-legend a { color: #777; }

The Ground Motion Model

In the original model, three GMPEs related to the main tectonic regimes present in the region were used. A logic tree combined these GMPEs.

Active Shallow Crust	**Weight**
IPSN, 1999	0.5
Takahashi et al., 2000	0.5

Subduction Interface	**Weight**
Youngs et al., 1997	0.5
Takahashi et al., 2000	0.5

Subduction Intraslab	**Weight**
Youngs et al., 1997	0.5
Takahashi et al., 2000	0.5

In the OpenQuake-engine it was not possible to implement some of the GMPEs originally used by GEOTER 2002 (IPSN, 1999 and Takahashi et al., 2000). However, using well recognised GMPEs (Zhao et al., 2006 and Youngs et al., 1997) the results show an acceptable agrement with the maps published in the GEOTER 2002 report.

Active Shallow Crust	**Weight**
Zhao et al., 2006	1.0

Subduction Interface	**Weight**
Youngs et al., 1997	1.0

Subduction Intraslab	**Weight**
Youngs et al., 1997	1.0

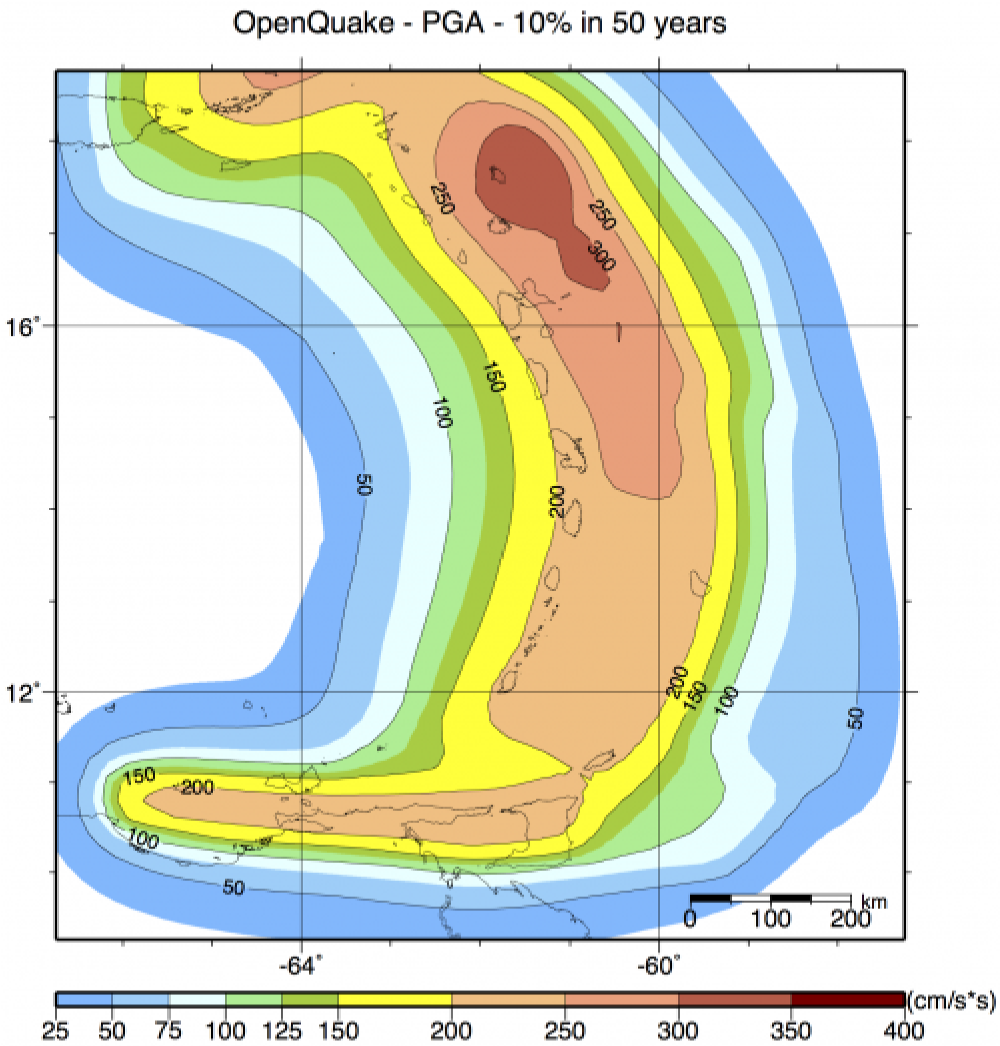
Reference site condition

A rock condition is assumed in the OpenQuake-engine implementation. The site condition is defined using a Vs30 = 760 m/s, which is equivalent to a rock condition site class in Zhao et al. (2006) and

Youngs et al., (1997).

Hazard Results

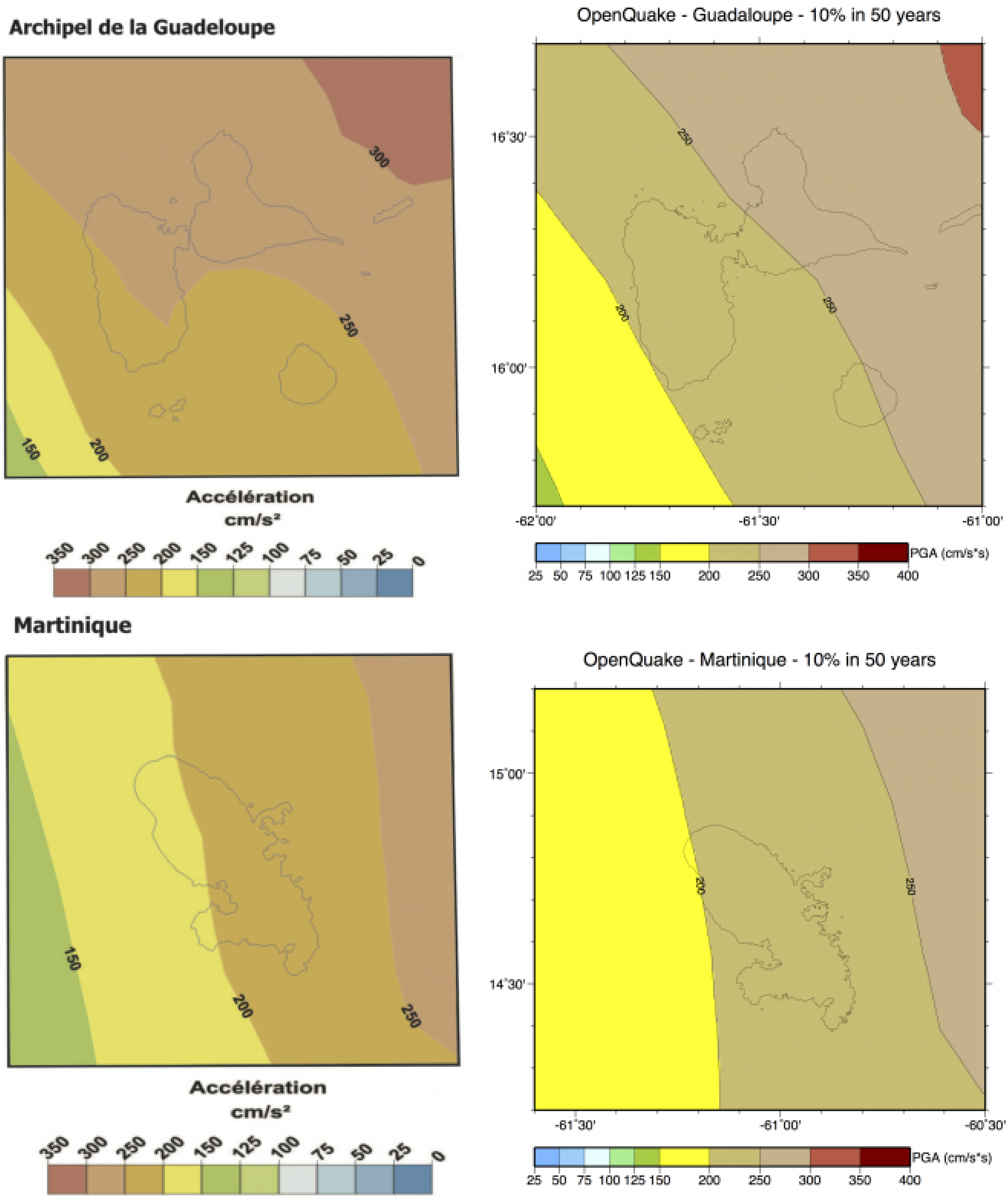
The figure below is the hazard map for peak ground acceleration, for 10% probability of exceedance in 50 years , using the OpenQuake-engine. The calculations considered Zhao et al. (2006) for active shallow crust tectonic regimes and Youngs et al. (1997) otherwise.



Comparison with GEOTER results

This is a preliminary model that does not have the same level of testing as other models implemented (i.e. USGS models) since in this specific case we did not have the original input model nor the results in an electronic format. In addition, as previously explained, we did not implement the GMPEs originally selected. However, the results show an acceptable agreement with the maps published in the GEOTER 2002 report.

The figures below show hazard maps for 10% probability of exceedance in 50 years, for the Islands of Guadeloupe and Martinique, comparing results from the GEOTER 2002 report (left) and the results computed with the OpenQuake-engine (right).



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Model Summary Table

This table summarises the main characteristics of the original implementation of this model

1	**Datasets availability**	
1.1	Earthquake catalogue	Not available. The catalogue used is a combination of local (Clement and Bernard, 2001; SRU/UWI; Rojas et al.,1993) and regional (IPGH, PDE, ISC) catalogues.
1.2	Geological database	Not available. In the seismic zonation several information was used, mainly, from Feuillet (2000) and GEO-TER n° GTR/MATE/0899-108 (GEO-TER internal report). A good description is included in Martin et al. (2002)
1.3	Strong-motion database	Not available
1.4	Site characterization database	Not available
Notes		
2	**Methodology for model development**	
2.1	Scientific participation (SSHAC levels) and review process	
2.2	Documentation describing model preparation	Martin et al.(2002) provides a general description of the methodology adopted for the creation of the hazard model.
2.3	Codes used for model preparation	Not available
Notes		
3	**PSHA input model**	
3.1	**Seismic Source Model**	
3.1.1	Area sources	Included
3.1.2	Grid sources	Not included
3.1.3	Crustal faults	Not included
3.1.4	Subduction faults	The subduction sources (interface and intra-slab) are modelled as area sources with a 3D-geometry

3.1.5	Non-parametric ruptures	Not included
3.1.6	Magnitude-area scaling relationships	Not explicitly defined in Martin et al. (2002)
3.2	**Ground Motion Model**	
3.2.0	Tectonic regionalisation	Not included, but the seismotectonic zonation follows Feuillet (200)
3.2.1	Models for active shallow seismicity	Included
3.2.2	Models for subduction interface	Included
3.2.3	Models for subduction intraslab	Included
3.2.4	Models for stable continental regions	Not included
3.2.5	Models for deep non-subduction sources	Not included
3.2.6	Models for volcanic areas	Not included
3.3	**Site Response Model**	
3.3.1	Based on GMPEs	Yes, a rock site condition is considered
3.3.2	Based on site-response analysis	No
3.4	**Epistemic uncertainties**	
3.4.1	Seismic Source Model	Included. A unique source model for shallow crustal sources, while for the subduction an alternative model is proposed, simplifying the geometry of several intra-slab sources.
3.4.2	Ground Motion Model	Included using a logic tree (see the ground motion model section)
3.4.3	Site Response Model	Not included
Notes		

4	**Hazard Input Description**	
4.1	Hazard input document	Available, [add link]
4.2	Input files	Not Available, but an extensive information about the parameter used is provides in Martin et al. (2002) - (annex 3)
Notes		

5	**Calculation**	
5.1	Software	Available upon request (CRISISv.7)

5.2	**Results**	
5.2.1	Hazard curves	Not directly available
5.2.2	Hazard maps	Not directly available
5.2.3	Uniform hazard spectra	Not directly available
5.2.4	Disaggregation	Not directly available
5.2.5	Stochastic event sets	Not considered
5.2.6	Ground motion fields	Not considered
Notes		

Download The OpenQuake-engine Input Model

The OpenQuake-engine input model (NRML format) can be downloaded at the link provided below - Please read the license and disclaimer attached to the model.

N.B. This is a model adapted by GEM Hazard Team to the OpenQuake-engine from the original model developed by Geoter. This explains minor differences you might encounter between the results presented in the OpenQuake platform and those disseminated by the original Organisation.

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