

# The 2010 RESIS-II Seismic Hazard Model for Central America

As part of the RESIS-II cooperation project a PSHA model has been developed by a seismic-hazard team from Costa Rica, Guatemala, Honduras, Nicaragua, el Salvador, Panama, Norway and Spain ([Benito et al., 2010, 2012](#)). In this context a parametric earthquake catalog for the region was compiled and homogenized to moment magnitude,  $M_w$ . The seismotectonic models proposed in the previous phase (RESIS-I) were revised and two seismogenic zonations proposed (see details below). After a comparison with local strong motion data (statistical analysis of residuals) a set of GMPEs associated with the tectonic regimes present in the region (active shallow crust, volcanic, subduction interface, and subduction intraslab) were defined.

The original seismic hazard calculation was made using CRISIS2007 code in a grid of  $0.1 \times 0.1$  degrees (aprox 10 km), for return periods of 200, 1000, and 2500 years. As a result, maps in terms of peak ground acceleration (PGA) and spectral accelerations SA (T) for periods of 0.1, 0.2, 0.5, 1, and 2s were obtained, as well as uniform hazard spectra (UHS) for six major cities of the region.

## Basic Datasets

### The parametric earthquake catalogue

Based on the catalogue proposed by [Rojas et al. \(1993\)](#), and with the contribution of data and experts from each country, a regional parametric catalog covering the last 500 years was created. The revision and depuration process was made using local experts following an “expert criteria scheme”. The magnitude was homogenized to  $M_w$ , using local conversion relations ([see Benito et al., 2010](#)) and the completeness analysis was made following the [Stepp \(1973\)](#) method. In [Benito et al. \(2012\)](#) a reference is made to the declustering analysis, but a detailed information about how it was made is not included.

## The Seismic Source Model

Following the major tectonic structures in the region:

- The subduction zone in the plate boundary Cocos -Caribbean,
- The volcanic chain (the faults related to),
- The Polochic - Motagua transform fault in the North America - Caribbean plate boundary,
- The Panamá fracture zone in the Cocos-Nazca boundary and
- The north Panamá deformed belt.

A regional seismogenic zonation with three tectonic regimes (active shallow crustal, subduction interface, and subduction intraslab) was defined. All the source zones were defined as area sources. The crustal zones ( $h \leq 25$  km) have been modeled with a 2D geometry, while a 3D geometry was considered for interface ( $25 \text{ km} < h \leq 60$  km) and intraslab source zones ( $h > 60$  km), with exception of the interface zone related to the north Panamá belt (flat zone at 50km of depth). A detailed

description of the source zones is included in [Benito et al. \(2010\)](#).

The PSHA model is implemented using basically the information published in [Benito et al. \(2012\)](#). The source model is implemented in a unique source model file in NRML format representing the different typology and tectonic region type defined in the original model. In the active shallow crust the source zones are modelled as NRML [areaSource](#), while in the subduction region the source zones are modelled as NRML [complexFaultSource](#) representing both, interface and intraslab sources.

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.

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

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.my-legend .legend-source { font-size: 70%; color: #999; clear: both; }  
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```

## The Ground Motion Model

After a preliminary selection of GMPEs developed from tectonic environments similar to those of Central America, an analysis of residuals following the criteria proposed by [Scherbaum et al. \(2004\)](#) and using local strong motion data were made. The models that better fit the local data were used in the hazard calculation as a logic tree with four major branches:

<b>GMPEs (Active Shallow Crust)</b>
<a href="#">CLI94: Climent et. al. 1994</a>
<a href="#">ZHA06: Zhao et. al. 2006</a>
<b>GMPEs (Subduction Interface)</b>
<a href="#">YOU97: Youngs et. al. 1997</a>
<b>GMPEs (Subduction Intraslab)</b>
<a href="#">YOU97: Youngs et. al. 1997</a>

ZHA06: Zhao et. al. 2006

### Scheme of the GMPE logic tree

Branch	Combination	Weight
1.	CLI94 (Active Shallow Crust) + YOU97 (Sub. Interface) + YOU97 (Sub. Intraslab)	0.25
2.	CLI94 (Active Shallow Crust) + YOU97 (Sub. Interface) + ZHA06 (Sub. Intraslab)	0.25
3.	ZHA06 (Active Shallow Crust) + YOU97 (Sub. Interface) + YOU97 (Sub. Intraslab)	0.25
4.	ZHA06 (Active Shallow Crust) + YOU97 (Sub. Interface) + ZHA06 (Sub. Intraslab)	0.25

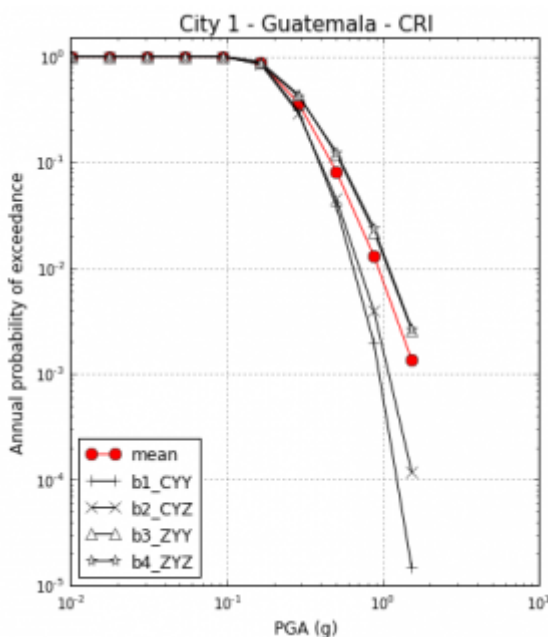
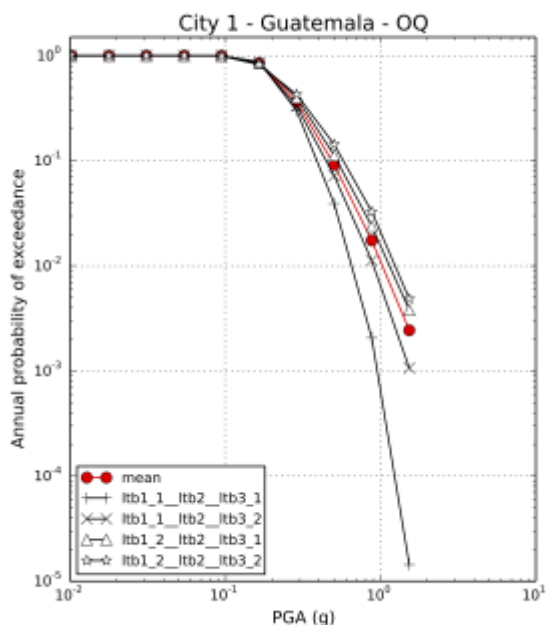
### Reference site condition

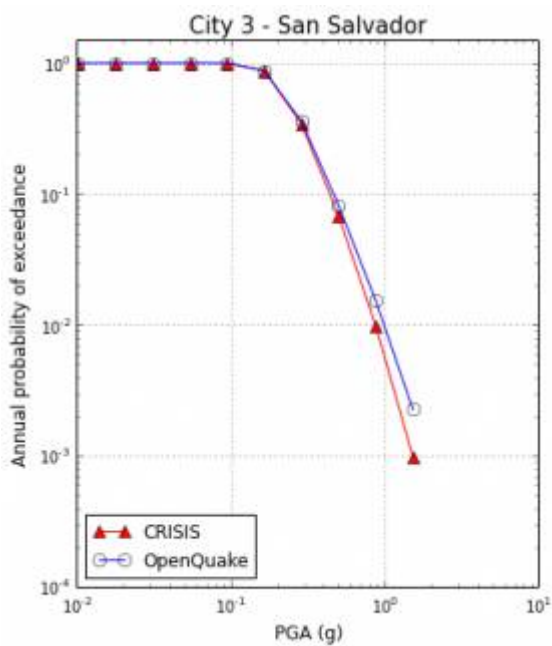
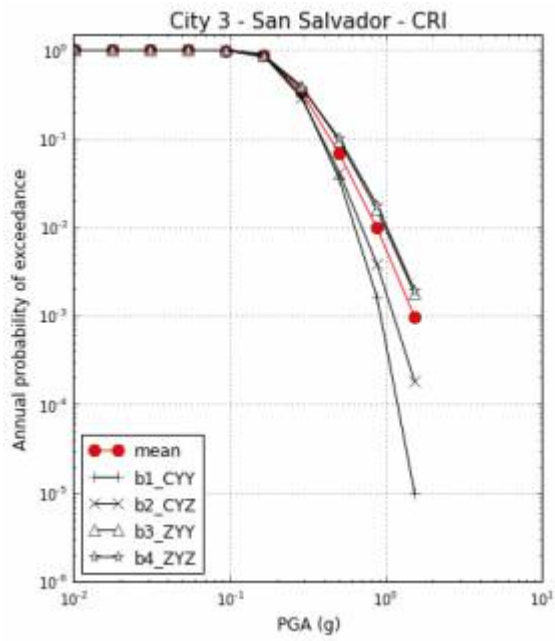
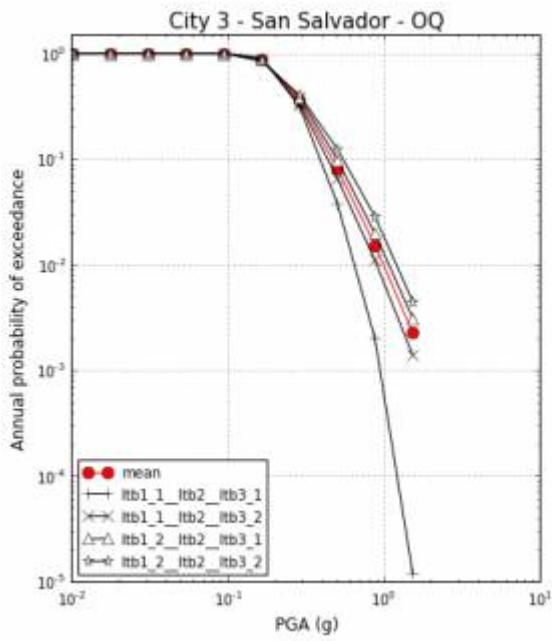
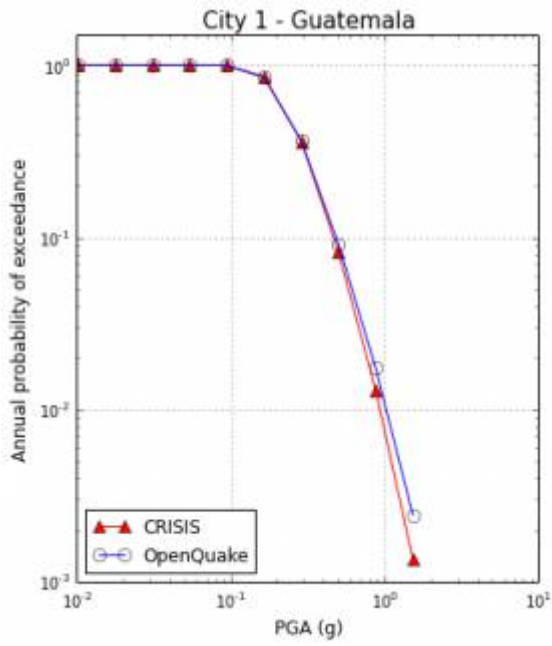
The site condition is defined using the Vs30 value in the GMPEs having this parameter as predictor variable (YOU97 and ZHA06), the remaining GMPE (CLI94) is used with coefficients already calibrated for rock conditions.

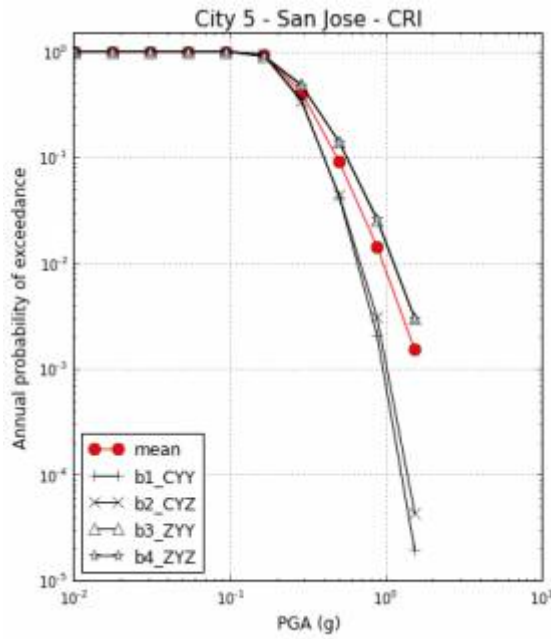
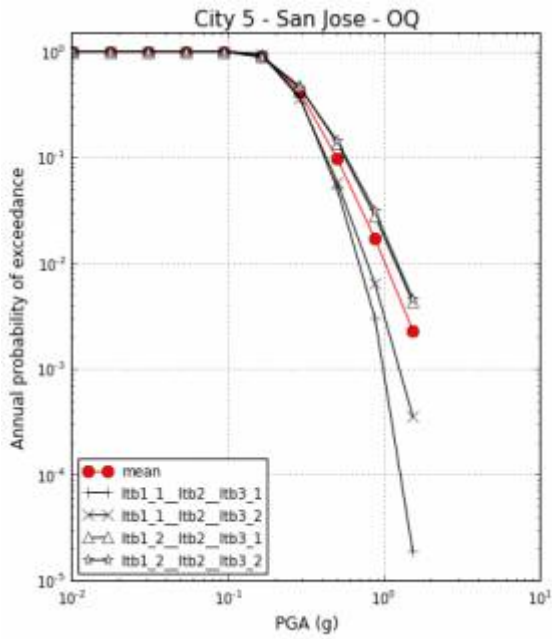
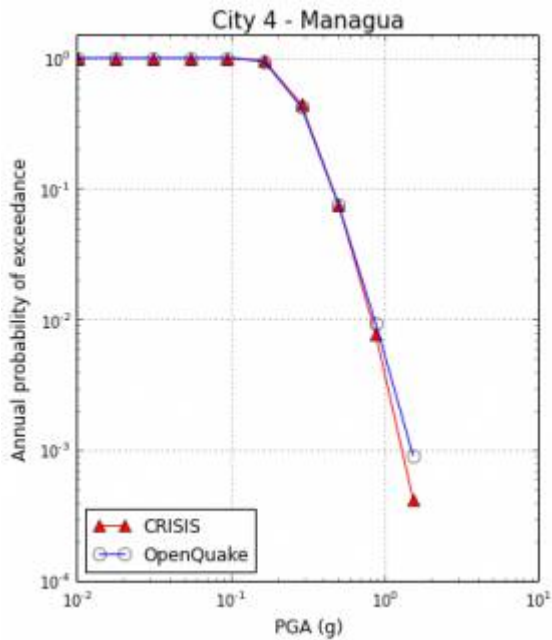
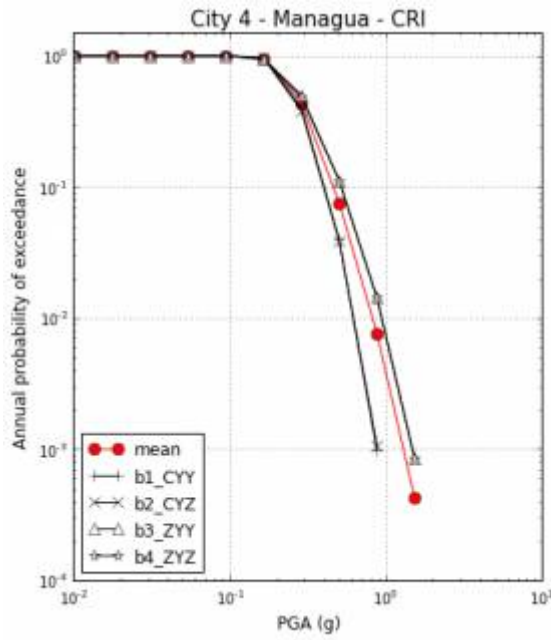
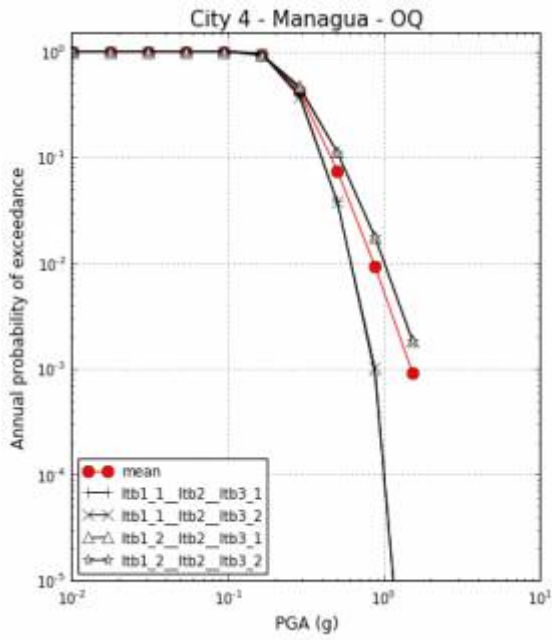
## Hazard Results

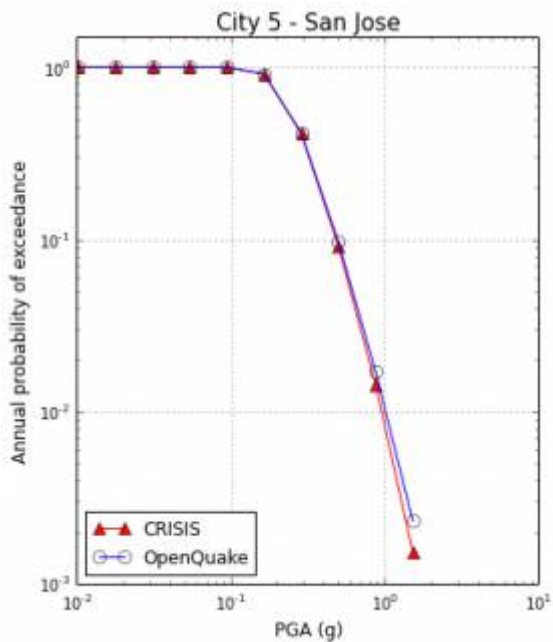
### Hazard curves

The calculation is made using the combination proposed in Benito et al.(2010) and hazard curves and maps are obtained. The figures below represent hazard curves for peak ground acceleration, for 10% probabilities of exceedance in 50 years, using the OpenQuake-engine and CRISIS for the major cities in the region. The black lines represent the results obtained in a single branch, while the red and blue ones are the mean curves from the OpenQuake-engine and CRISIS respectively. The agreement between the original results and the implemented ones is more than acceptable as seen in the figures.



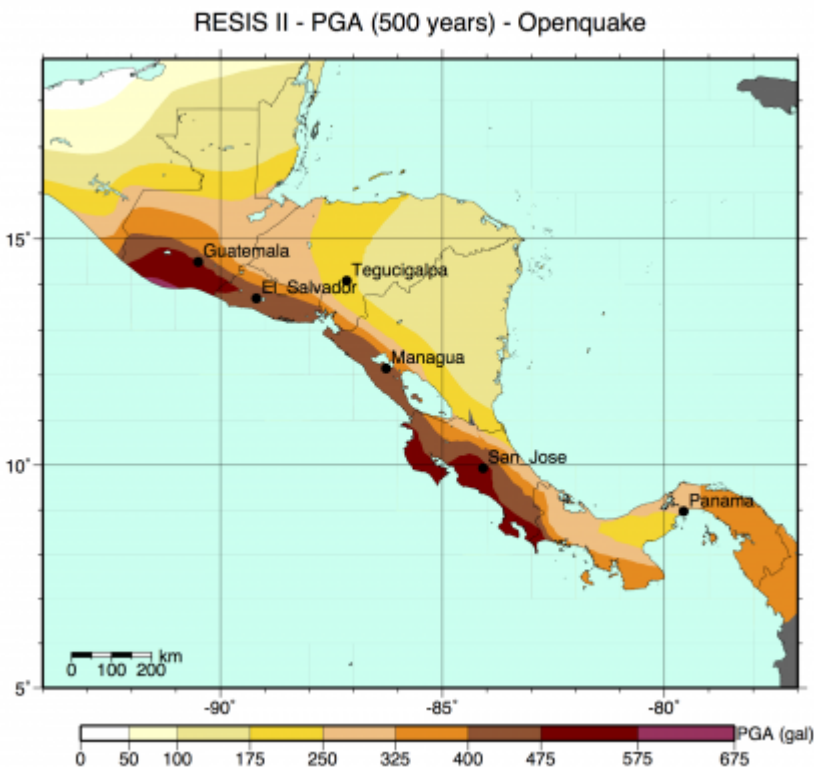






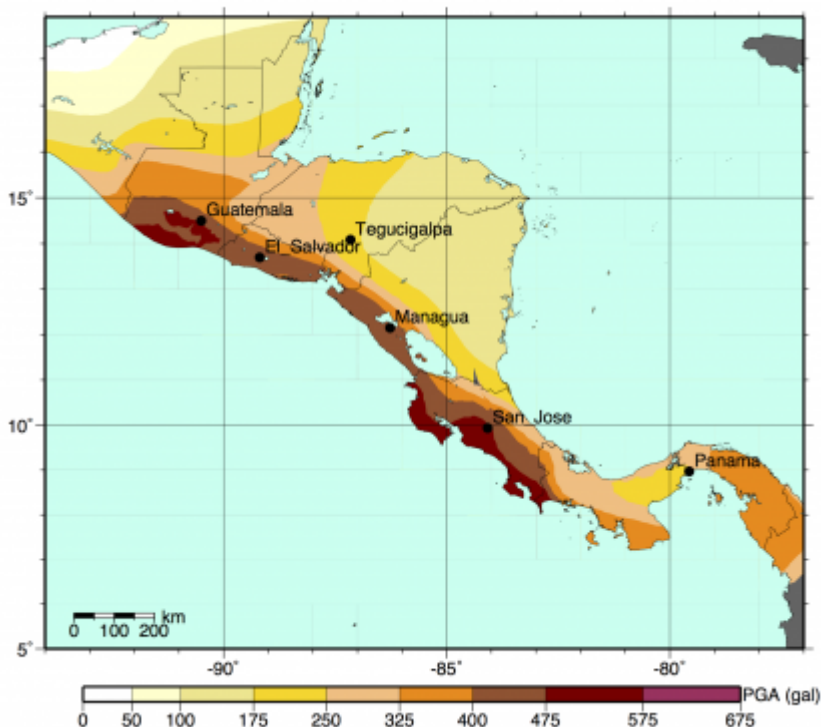
### Hazard maps

The following are mean hazard maps, for 9.52% probability of exceedance in 50 years, computed with the OpenQuake-engine and CRISIS. The maps confirm a good agreement between the original and implemented models. However, a map showing the absolute difference gives a more detailed and quantitative picture of the differences. The largest ones are located along the Guatemala and El Salvador coast and are associated with the subduction interface sources and the different approaches used to model the earthquake ruptures in the OpenQuake-engine and CRISIS. It is worth noticing that differences in the implementation of Zhao et al. (2006) in CRISIS and the OpenQuake-engine for low/median magnitude values were found. Further analysis is required to better constrain what are the sources of the discrepancies.

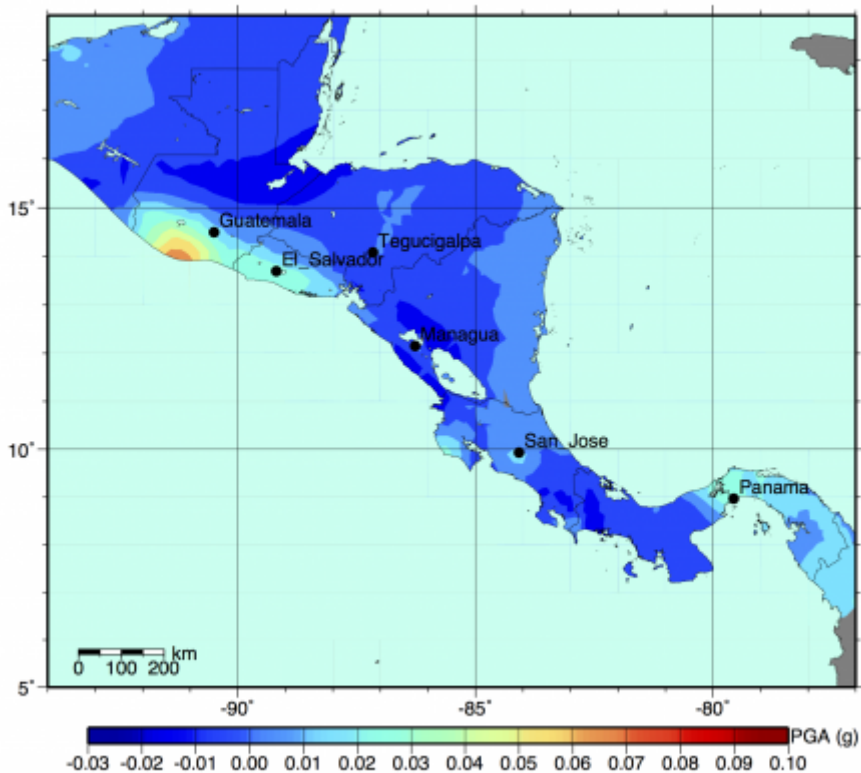




RESIS II - PGA (500 years) - CRISIS



RESIS II - PGA (500 years) - Absolute difference (OQ - CRI)



## References

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## Model summary table

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

<b>1</b>	<b>Datasets availability</b>	
1.1	Earthquake catalogue	Partially Available
1.2	Geological database	Not Available
1.3	Strong-motion database	Not Available
1.4	Site characterization database	Not Available
Notes		
<b>2</b>	<b>Methodology for model development</b>	
2.1	Scientific participation (SSHAC levels) and review process	
2.2	Documentation describing model preparation	Partially Available
2.3	Codes used for model preparation	Not available
Notes		



<b>3</b>	<b>PSHA input model</b>	
3.1	<b>Seismic Source Model</b>	
3.1.1	Area sources	YES
3.1.2	Grid sources	NO
3.1.3	Crustal faults	YES
3.1.4	Subduction faults	YES
3.1.5	Non-parametric ruptures	NO
3.1.6	Magnitude-area scaling relationships	- Wells and Coppersmith (1994) and Brune (1970)
3.2	<b>Ground Motion Model</b>	
3.2.0	Tectonic regionalisation	Not available
3.2.1	Models for active shallow seismicity	YES
3.2.2	Models for subduction interface	YES
3.2.3	Models for subduction intraslab	YES
3.2.4	Models for stable continental regions	NO
3.2.5	Models for deep non-subduction sources	NO
3.2.6	Models for volcanic areas	NO
3.3	<b>Site Response Model</b>	
3.3.1	Based on GMPEs	YES
3.3.2	Based on site-response analysis	
3.4	<b>Epistemic uncertainties</b>	
3.4.1	Seismic Source Model	Not Included
3.4.2	Ground Motion Model	Included using a logic tree (see <a href="#">the ground motion model</a> section)
3.4.3	Site Response Model	Not included
Notes		
<b>4</b>	<b>Hazard Input Description</b>	
4.1	Hazard input document	Not available
4.2	Input files	Not available
Notes		
<b>5</b>	<b>Calculation</b>	
5.1	Software	Available upon request (CRISISv.7)
5.2	<b>Results</b>	
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		

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