MINISTERE DE L'HABITAT ET DE L'URBANISME

CENTRE NATIONAL DE RECHERCHE APPLIQUEE EN GENIE PARASISMIQUE

C.G.S.

Approche probabiliste du calcul d'aléa sismique en surface libre avec considération non ergodique de l'effet du site. Exemple d'application pour des sites réels

Code du projet : CGS/DAS/2020/01

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Équipe de recherche: Modélisation numérique en aléa sismique et sismologie

Division Aléa sismique (DAS)

Le projet est subdivisé donc en deux étapes comme suite :

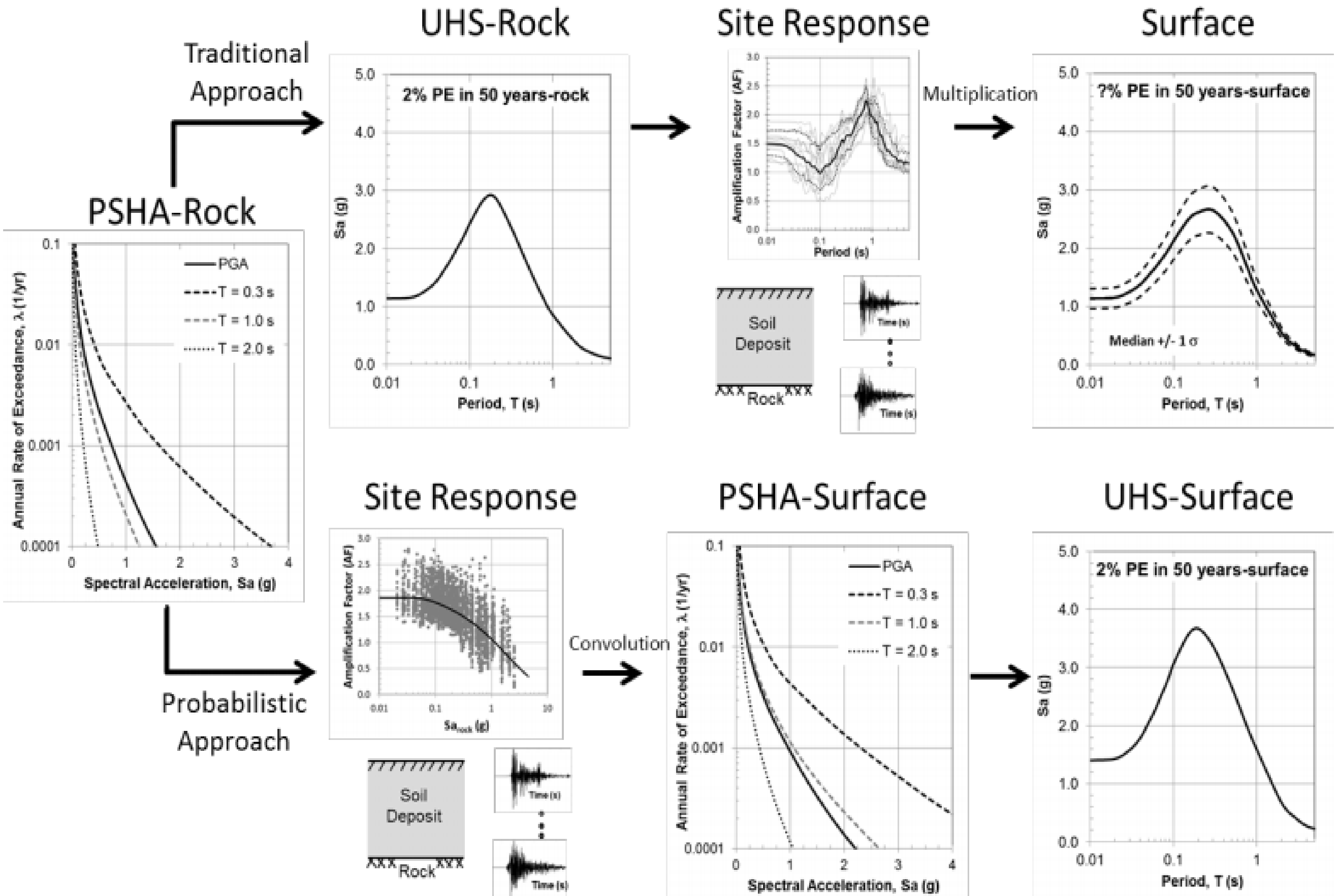
PHASE	CODE INFORMATIQUE	INTITULE	OBSERVATIONS
1	CGS/DAS/2020/01/01	Modélisation 1D de la réponse du sol et traitement des enregistrements.	
2	CGS/DAS/2021/01/01	Implication de l'effet du site dans la méthode probabiliste PSHA et analyse des incertitudes liées aux effets du site.	

Les résultats escomptés à travers ce projet de recherche sont :

1. Calcul de la fonction d'amplification par modélisation numérique 1D de la propagation des ondes avec prise en compte des incertitudes.

2. Calcul fonction d'amplification par exploitation des enregistrements locaux.

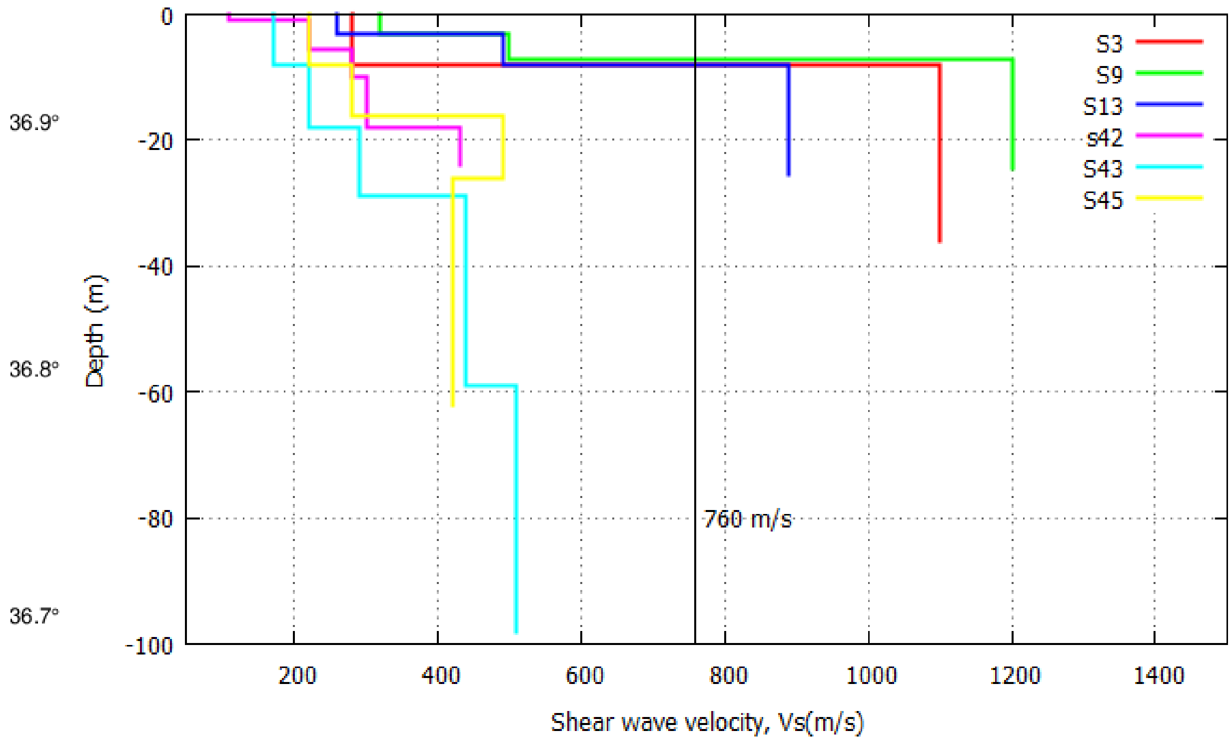
3. Proposition d'une approche intégrée pour le calcul purement probabiliste d'aléa sismique pour un site spécifique pour un projet d'importance vitale.



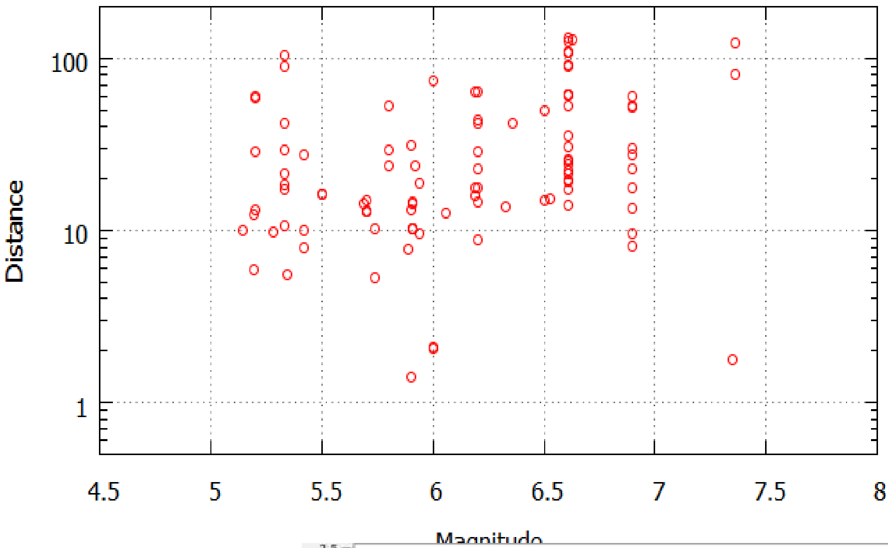
UHS-Rock
Site Response
Surface
Traditional Approach
2% PE in 50 years-rock
Sa (g)
Period, T (s)
Amplification Factor (AF)
Period (s)
Multiplication
?% PE in 50 years-surface
Median +/- 1 σ
PSHA-Rock
PGA
T = 0.3 s
T = 1.0 s
T = 2.0 s
Annual Rate of Exceedance, λ (1/yr)
Spectral Acceleration, Sa (g)
Soil Deposit
Rock
Time (s)
Site Response
PSHA-Surface
UHS-Surface
Probabilistic Approach
Convolution
Sa_rock (g)
2% PE in 50 years-surface

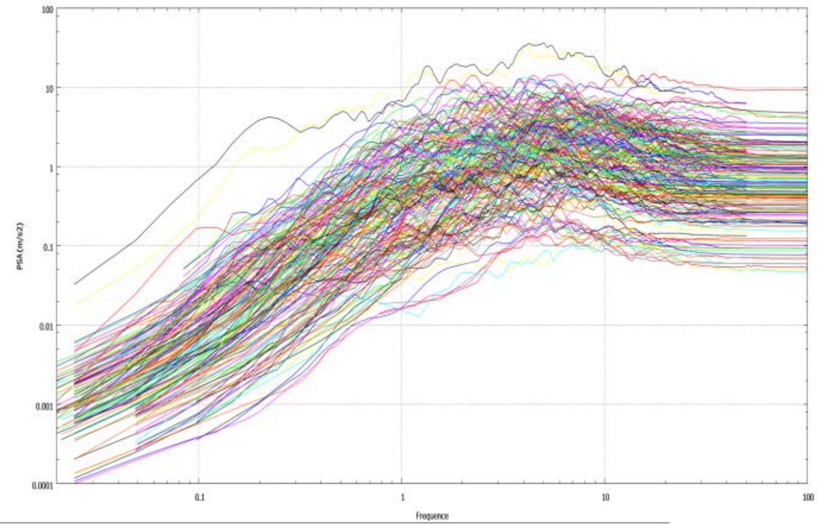
Modélisation 1D de la réponse du sol et traitement des enregistrements.

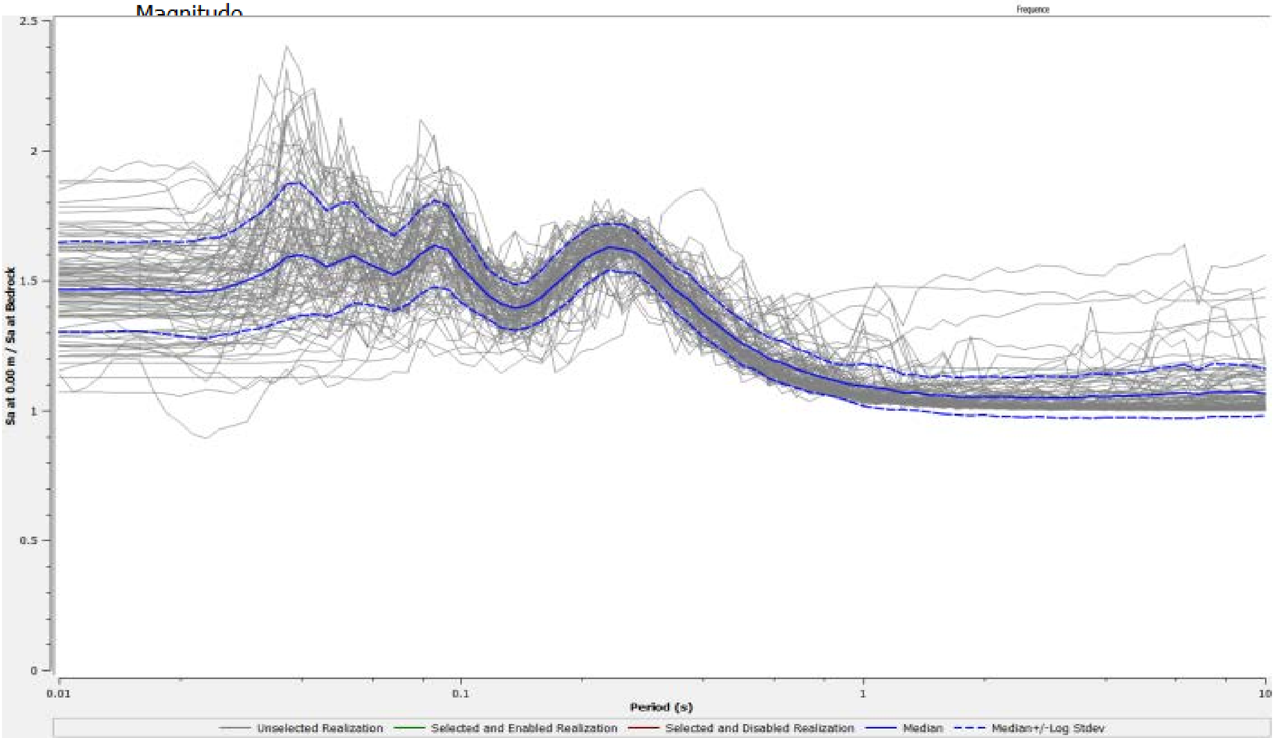
- Méthode numérique GRA (Ground Response Analysis)



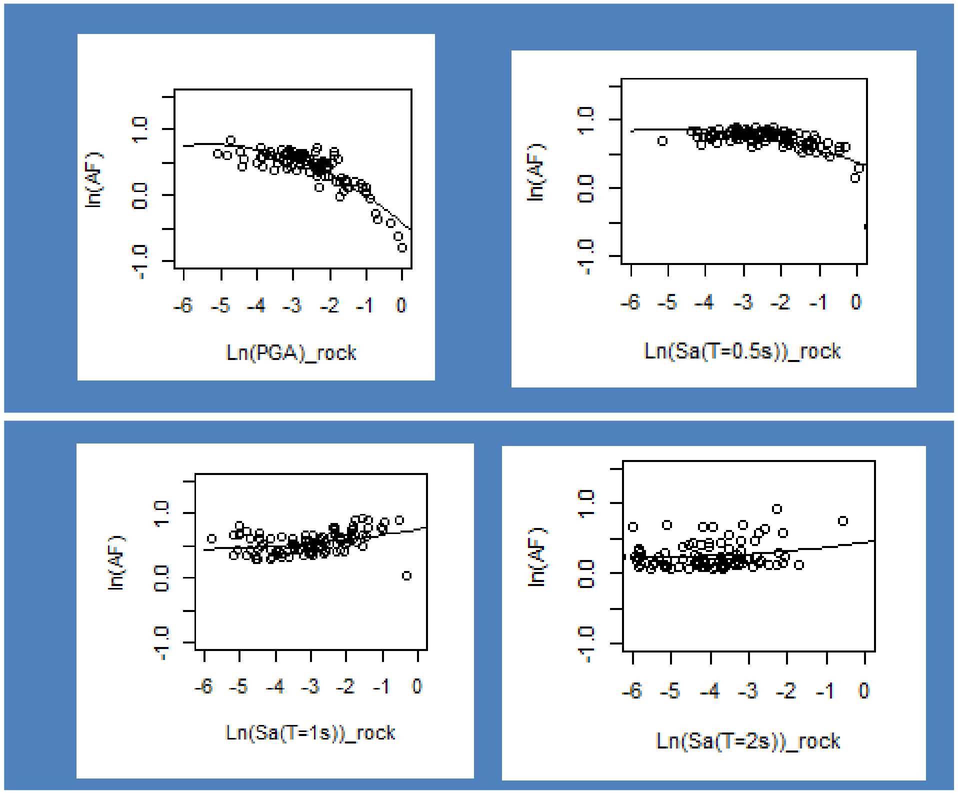
a) Distribution des magnitudes et distances (*M*, *R*) sélectionnées. b) et leurs spectres de réponses (Amortissement de 5%) (Rocher, Vs>500 m/s).







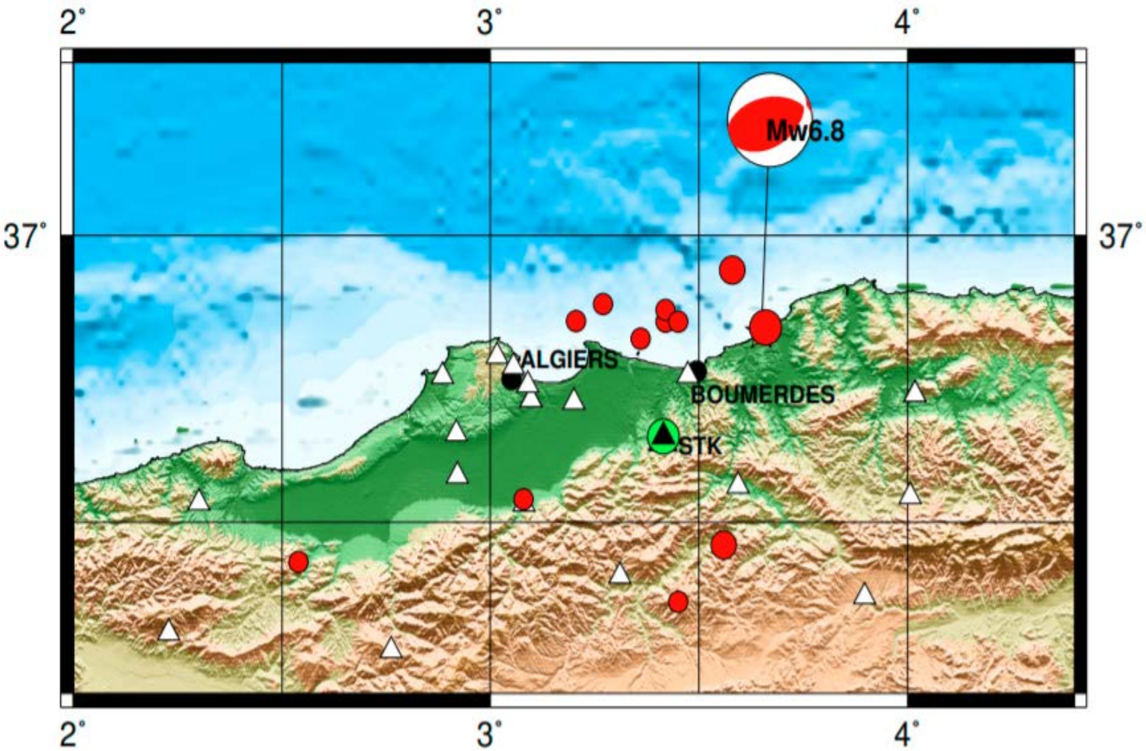
Analyse de régression sur la fonction d'amplification du profile S43



$$\mu_{\ln(AF)} = f_1 + f_2\left(\frac{X_{\mathrm{IMref}} + f_3}{f_3}\right)$$

Periods	S43		
	$f1$	$f2$	σ_{lnAF}
PGA	0.55	-0.39	0.16
0.2s	0.60	-0.28	0.15
0.4s	0.67	-0.18	0.107
0.5s	0.59	-0.11	0.064
0.75s	0.57	-0.03	0.31
1.0s	0.43	0.08	0.07

- Méthode empirique (à partir des enregistrements)



Date	Time	M_w	Depth (Km)	Location
21/05/2003	18:44:21	6.8	12	36.98 N 3.36 E
27/05/2003	17:11:29	5.7	8	36.939 N 3.578 E
28/05/2003	06:58:41	5	10	36.88 N 3.27 E
29/05/2003	02:15:02	4.9	10	36.82 N 3.36 E
10/1/2004	18:38:15	4.7	10	36.9898 N 3.3715 E
1/12/2004	18:42:49	4.5	10	36.85 N 3.45 E
5/12/2004	08:30:59	4.4	10	36.92 N 3.38 E
1/2/2008	07:33:40	4.6	10	36.825 N 3.473 E
22/2/2014	19:30:15	4.3	14.3	36.809 N 3.662 E
1/8/2014	04:11:16	5.4	10	36.856 N 3.181 E
28/05/2016	00:53:17	5.4	10	36.46 E 3.56N
10/02/2016	02:28:20	4.6	10	36.54N 3.08E

Table Liste des événements utilisés dans cette étude (Mw>4.0)

La fonction d'amplification spectrale est calculée comme étant le rapport entre les spectres de réponse enregistrés à la surface et les spectres de réponse au rocher prédits par GMPE (Stewart et al. 2017). Ce rapport est le résidu (R_{ij}) du spectre de surface par rapport celui de GMPE au bedrock.

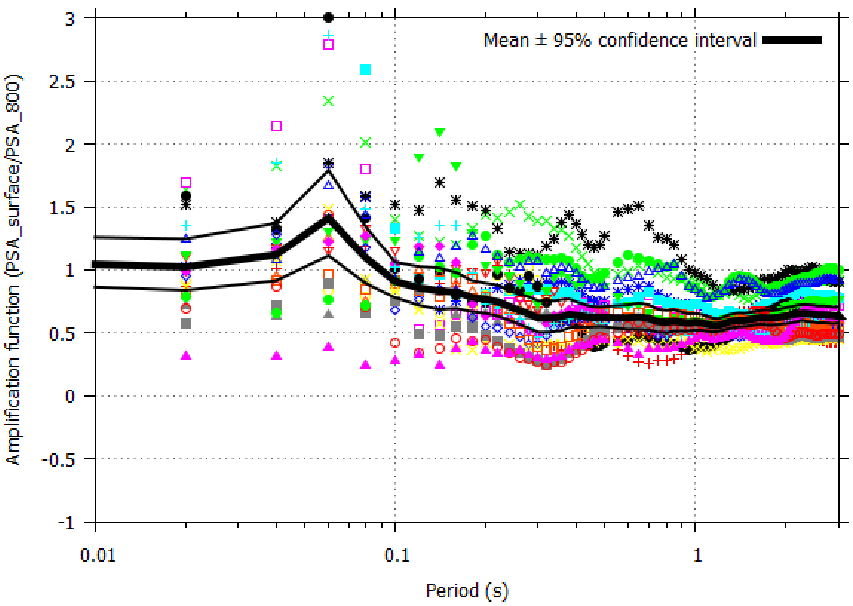
$$R_{ij} = \ln(z_{ij}) - (\mu_{lnz})_{ij}$$

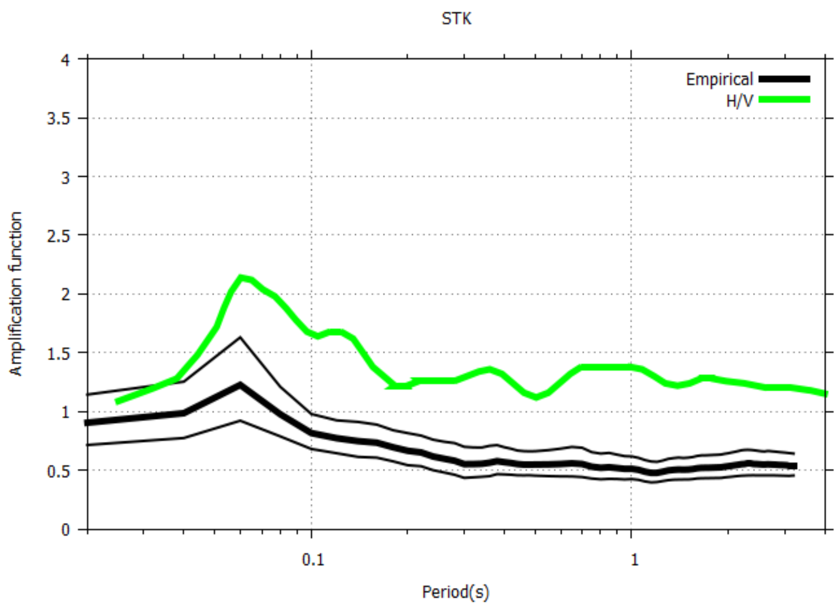
$$\delta \mathrm{W}_{\mathrm{ij}} = R_{ij} - \eta_{E,i}$$

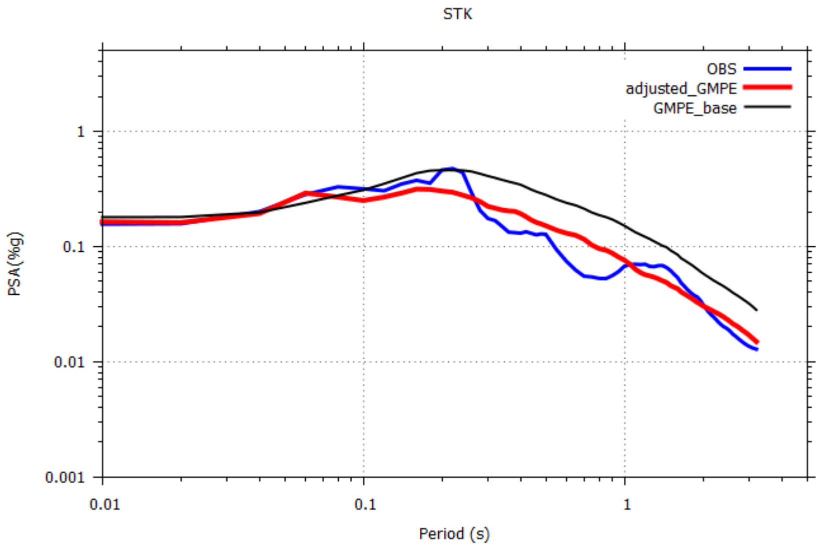
$$\eta_{E,i} = \frac{1}{N_i} \sum_{j=1}^{N_i} R_{ij}$$

$$\eta_{Sj} = \frac{1}{N_j} \sum_{i=1}^{N} \delta \mathrm{W}_{ij}$$

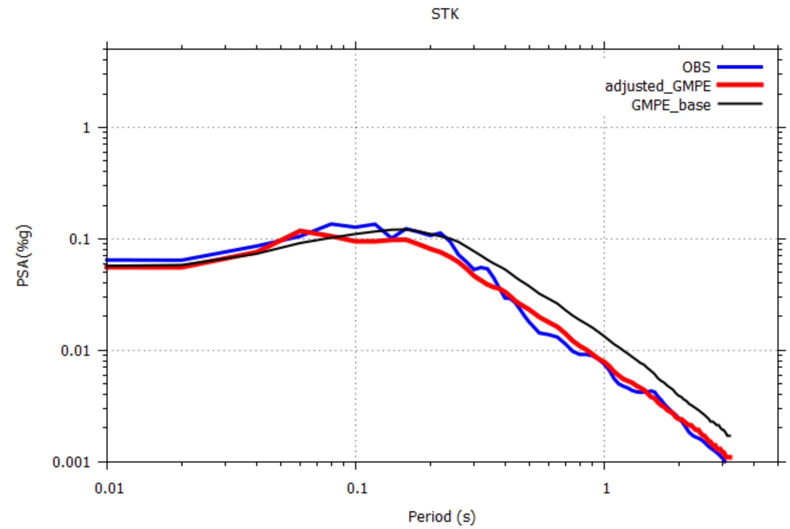
- Fonction d’amplification Obtenue pour le site de Keddara STK



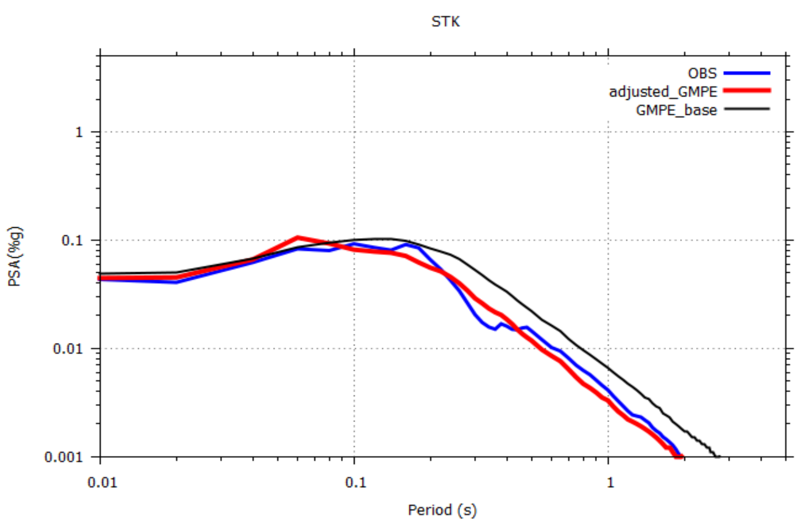




2003 M 6.8 Boumerdes earthquake



2013 M 5.4 Algiers earthquake

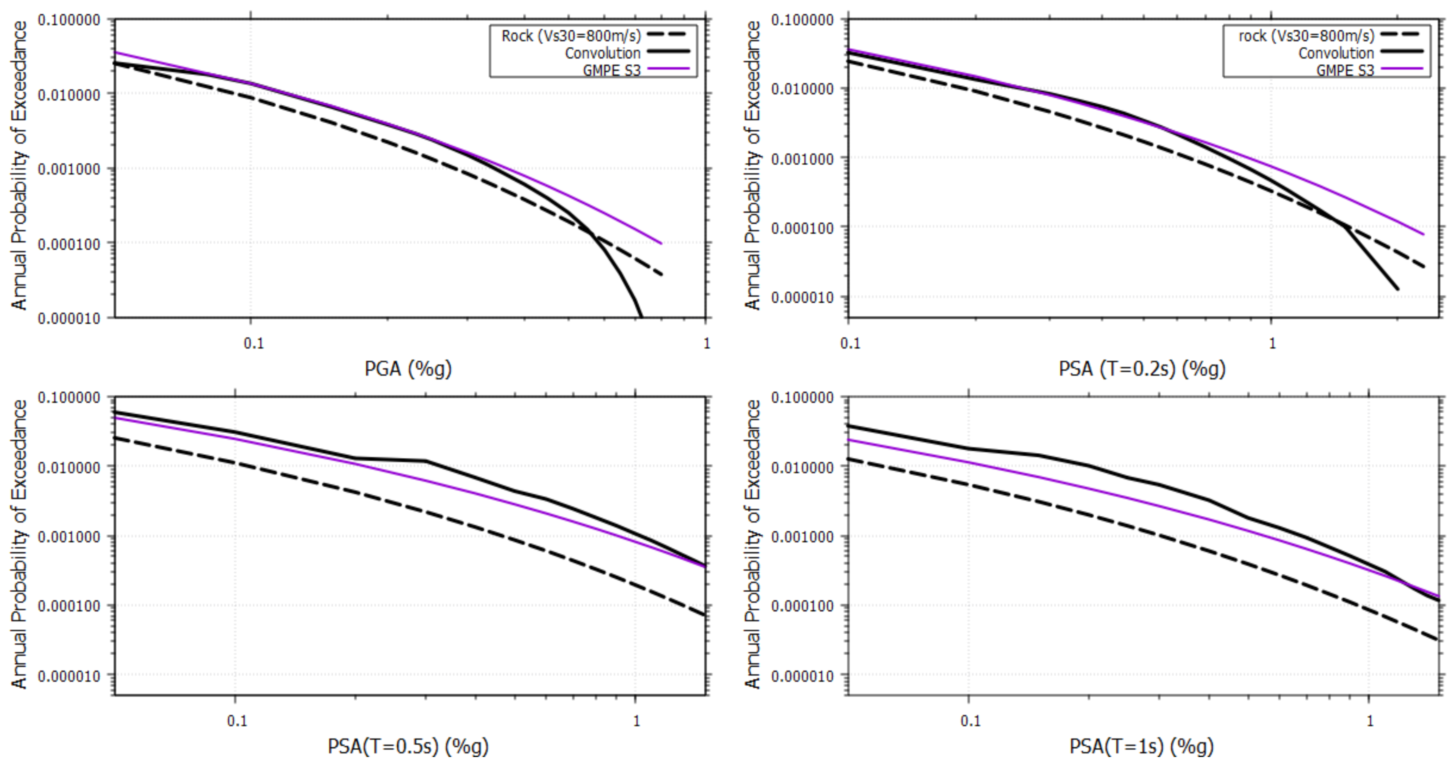


2004 M 4.7 Boumerdes EQ (aftershock).

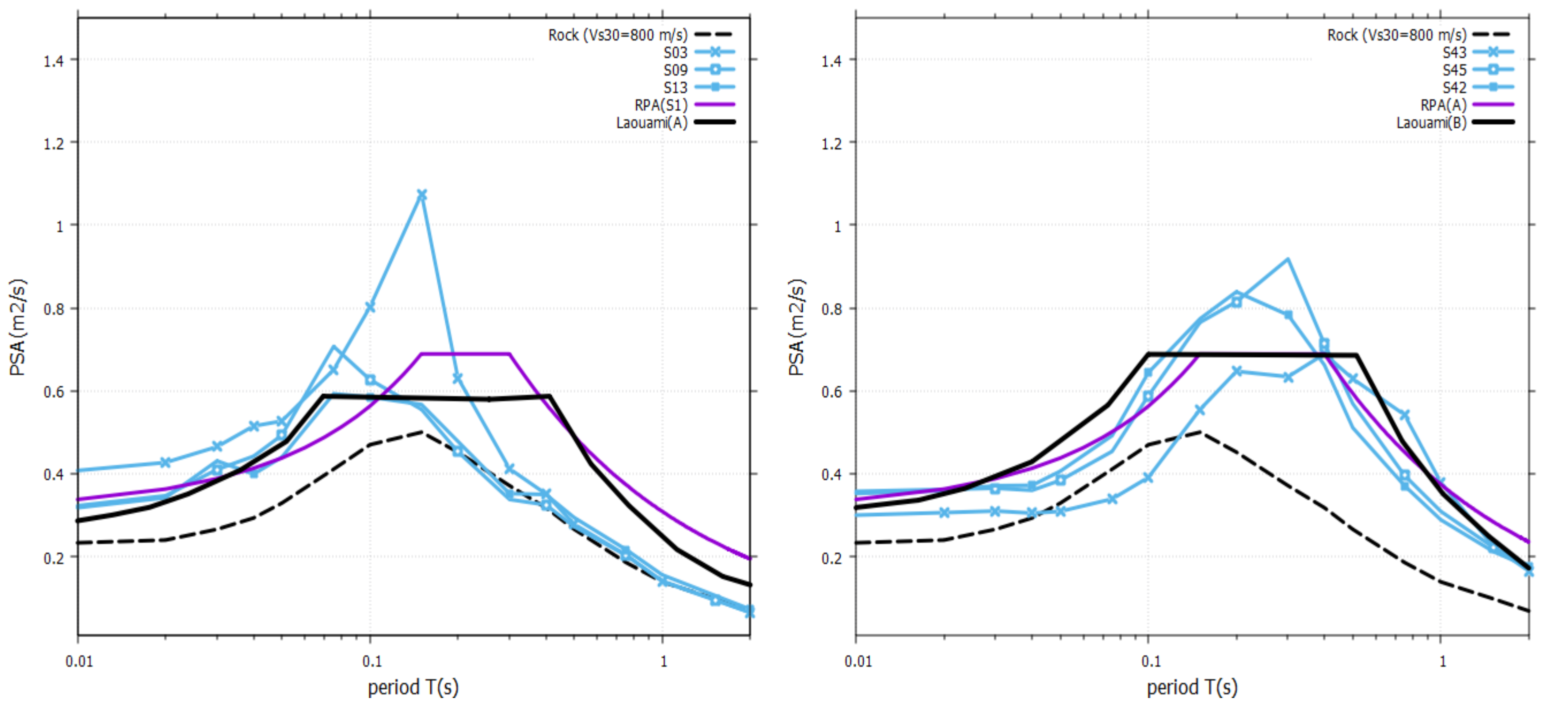
Phase 2: Implication de l'effet du site dans la méthode probabiliste PSHA et analyse des incertitudes liées aux effets du site.

Le produit de convolution entre la courbe d'aléa sismique au rocher et la probabilité de la fonction d'amplification comme proposé par Bazzuro et al (2004) comme suit :

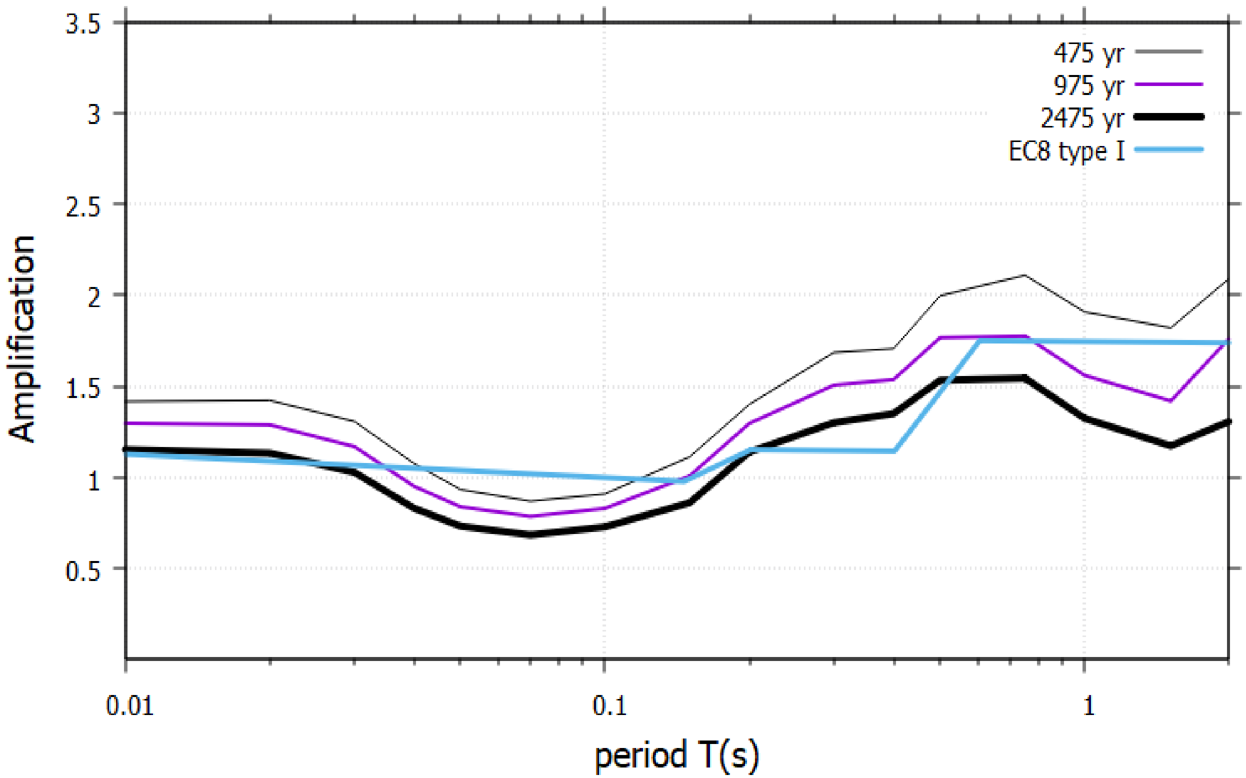
- $\lambda_z(z) = \int_0^{\infty} P\left[Y > \frac{z}{x} \middle| x\right] \lambda_X(x) dx$



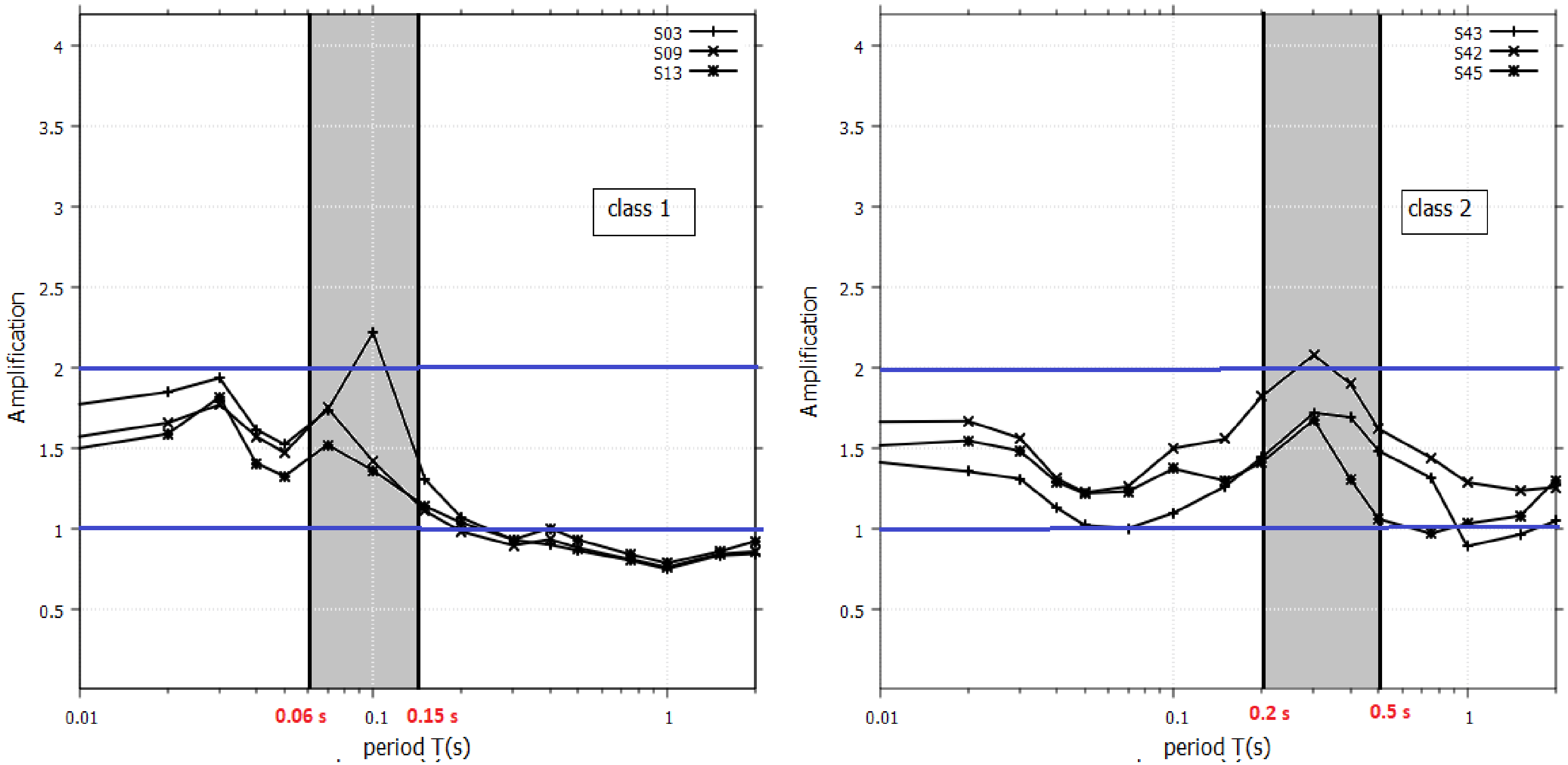
Courbe d'aléa sismique en surface et au rocher pour le PGA et le PSA(T), T=0.2s, 0.5s et 1.0s pour S43



Comparaison entre surface_UHS et le spectre règlementaire algérien RPA99/2003), la ligne noir représente le spectre propose par laouami.

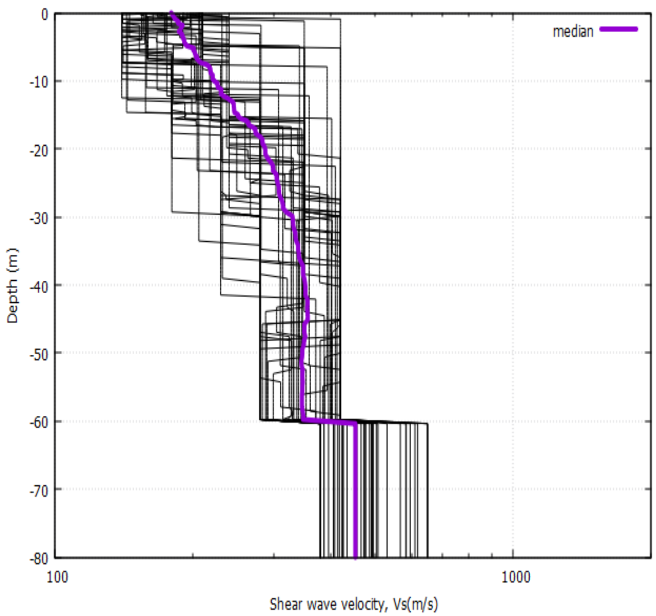


Amplification functions with respect to the reference rock (Vs= 800 m/s) for S43 (Vs30= 270 m/s) and comparison with amplification factor provided by EUROCODE8 type 1.

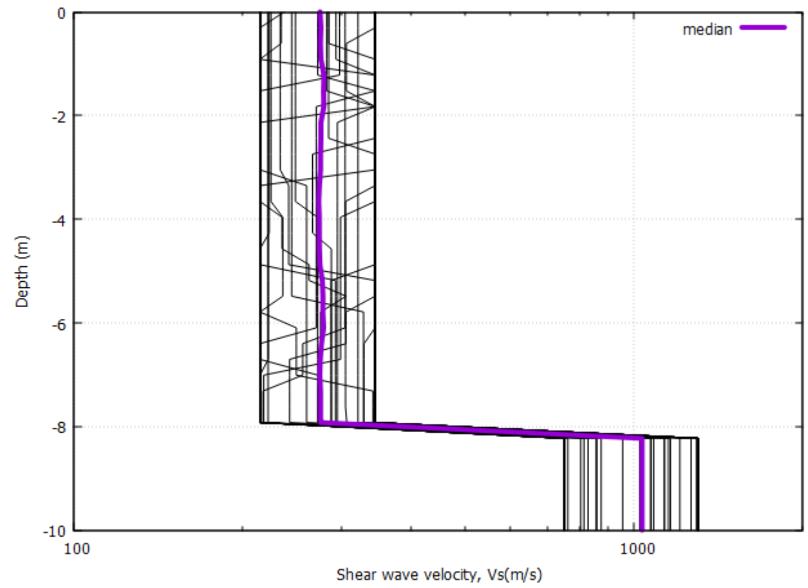


Amplification functions for the two soil classes for return period of 475 years

- Analyse des incertitudes liées aux effets du site



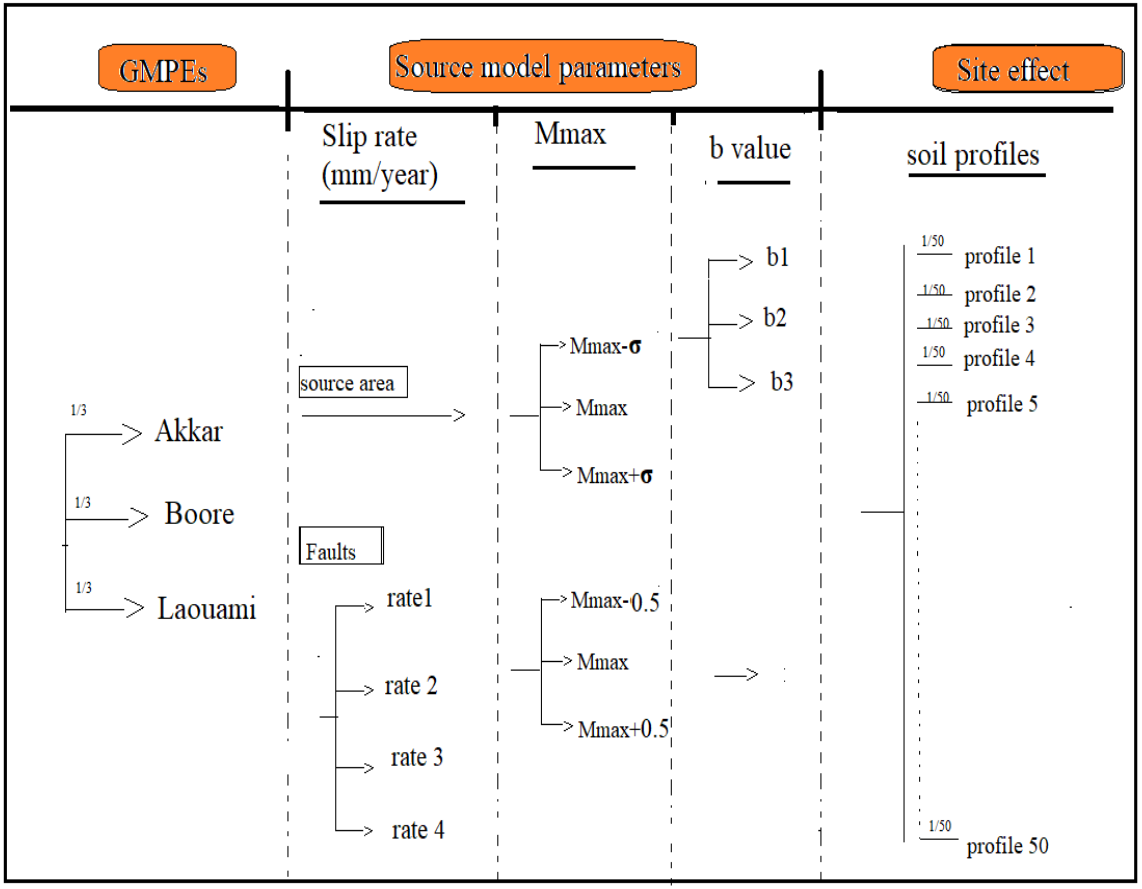
S43



S03

- Analyse des incertitudes liées aux effets du site

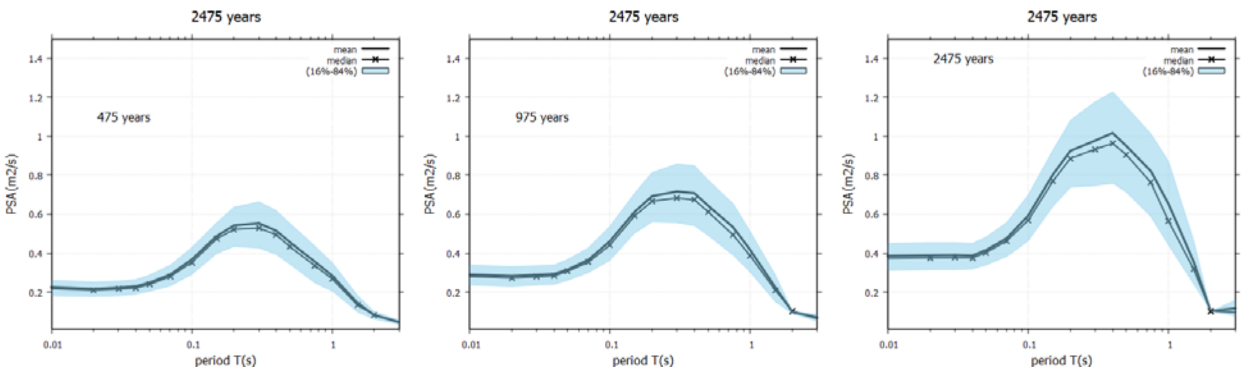
Arbre logique



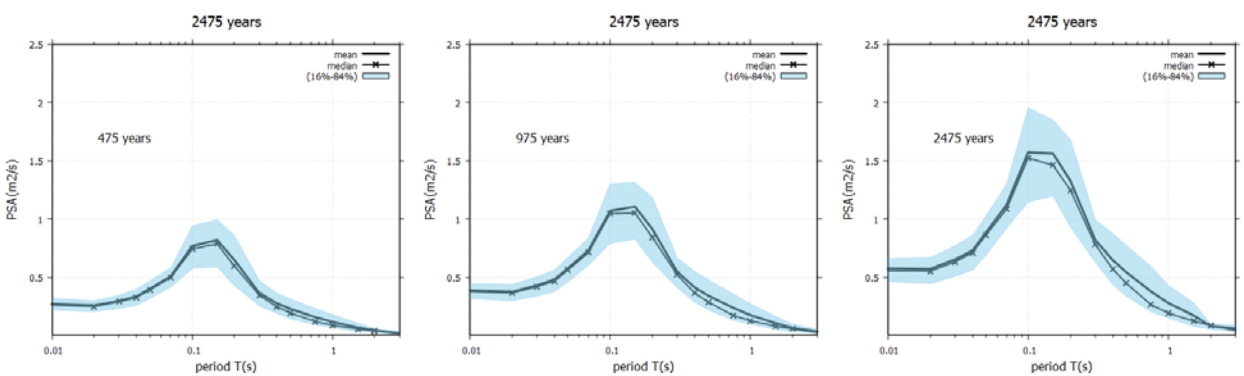
Analyse des incertitudes liées aux effets du site

Surface_uniform Hazard spectral dispersion due to epistemic uncertainty

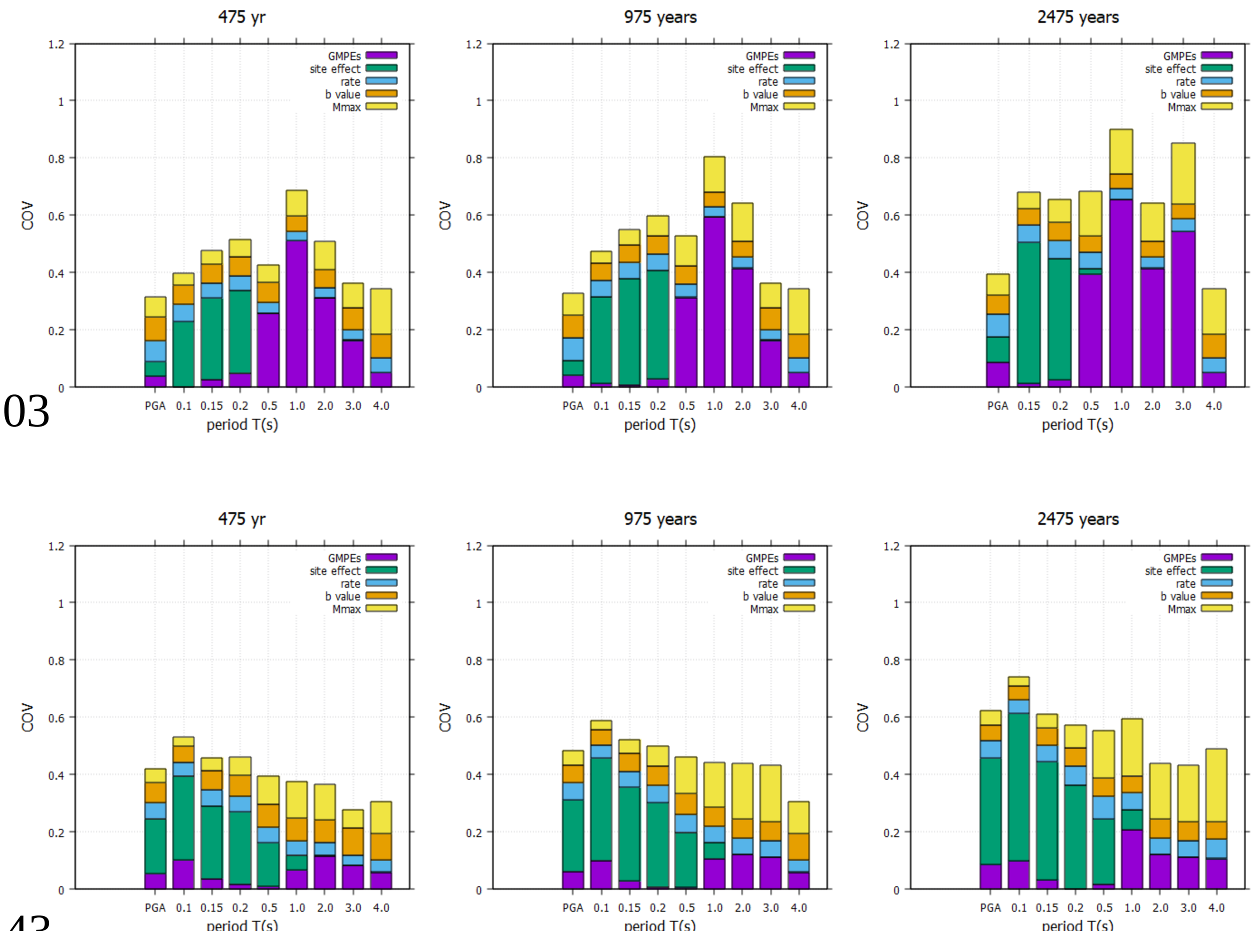
- S43



- S03



Analyse des incertitudes liées aux effets du site



S03

S43

Total COV values and the impact of different parameters on the total dispersion of results.

Valorisation des résultats

Empirical spectral amplification functions for a reference site near Keddara dam in Algeria using strong motion data.

Faouzi Gherboudj[1] Toufiq Ouzandja[1] Rabah Bensalem[1]

Abstract

This paper deals with empirical spectral amplification function for a reference site (STK) near Keddara dam in Algeria using local strong ground motion of earthquakes of magnitudes Mw 4.0-6.8. Amplification function is obtained as the 5% damped mean spectral ratio of surface observed and the rock predicted ground motions and it is compared to the ambient vibration HVSR which shows a good agreement in terms of fundamental frequency and curve tendency. In addition, recorded ground motions are compared to surface predicted motion with modified GMPE, the site term of the local ground motion prediction equation is adjusted based on the obtained amplification function of the free field STK site. Examples of the M 6.8, M5.4 and M4.7 earthquakes show clearly the advantage of using the adjusted Ground Motion Prediction Equations (GMPE) for predicting surface ground motion. Site effect characterization and the adjusted GMPE presented in this study provide the basis elements toward partially non ergodic site specific-Probabilistic seismic hazard assessment (PSHA) application based on local strong motion data in Algeria.

Keywords: *empirical amplification function, strong motion, GMPE, spectral ratio*

Application of fully probabilistic Site-specific PSHA in Algeria and sensitivity analysis to site effect.

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Abstract

This study deals with fully probabilistic site-specific seismic hazard application for Algiers city. Results are presented first for a reference rock site (Vs30=800 m/s) using three ground motion prediction equations and both area sources and active faults. Site effect is then integrated into PSHA using convolution method to obtain surface hazard curves and surface uniform hazard spectra for two classes of real soil profiles belonging to two different geological formations in Algiers city. Also, we obtain probabilistic amplification function for each soil classes corresponding to 10% exceedance probability in 50 years.

In addition, epistemic uncertainty related to site effect is integrated in the non-ergodic probabilistic framework through logic tree approach. Based on Toro's model, soil profile variability in terms of shear wave velocity and layer thickness is considered and fifty soil profiles are generated. Sensitivity analysis is then conducted, it shows high impact of site effect uncertainty on short period spectral accelerations while the impact of GMPEs selection, M_{max} and b value uncertainties is more important for long periods.

Keywords: PSHA, 1D site effect, UHS, Convolution method, sensitivity analysis