SIGMA-2 Closing Symposium 2022

Avignon

May 31st – June 2nd 2022

SIGMA-2 Project

SeIsmic Ground Motion Assessment project, version 2

SIGMA-2 is a Research and Development project about seismic hazard and ground motion. It is funded by a consortium of industrial companies:

EDF (France) **CEZ** (Czech Republic) **CEA** (France) **CRIEPI** (Japan)
Orano (France) **Pacific Gas & Electricity** (USA) **swissnuclear** (Switzerland)

Objectives

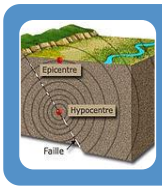
- Strengthen the **link** between **researchers and practitioners**
- Produce a **robust and stable reference** for industrial projects
- Improve data and methods to **harmonize expert judgment**
- **Reduce epistemic uncertainties** in hazard assessment

Focus

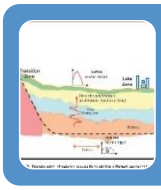
- Introduce **feedback loops** and go **beyond expert judgment**
- Focus on **low-seismicity areas** and **site-specific** approaches

Work Packages

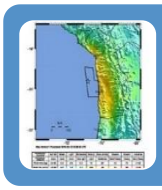
The project includes **over 50 R&D actions** organized into 6 Work Packages. Those initiatives include, for example, research contracts, consultancy, software development, master degree and PhD grants, benchmarking and workshops.



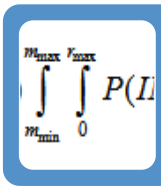
WP 1
Faults & Tectonics
Characterization of faults in low-to-moderate seismicity context



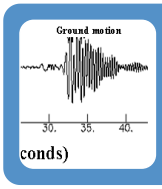
WP 4
Site response
Reduce uncertainties on ground motion at surface level, by a proper consideration of the site effect



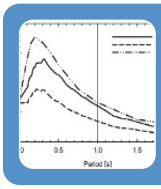
WP 2
Earthquake parameters
Refine and harmonize earthquake catalogues



WP 5
PSHA
Enhance PSHA with more realistic approaches



WP 3
Ground-motion (GM)
Deliver more realistic representations of ground motion



WP 6
GM for engineers
Produce data and results for engineering studies

Find more information on our website www.sigma-2.net

Agenda

Day 1 – Tuesday, May 31st 2022

08:00 – 9:30 Registration and Welcome coffee

09:30 – 10:00 Introduction (G. Daniel & J. Douglas)

10:00 – 12:00 Technical Session 1 "Faults, deformation and seismicity parameters"
Chair: Y. Klinger & J. Mayor

- J-F. Ritz: The Mw4.9, 2019 Le Teil unexpected surface-rupturing event (La Rouvière Fault, Cévennes Fault System, France): What does paleoseismology reveal?
- E. Nayman: Applying data mining to past earthquakes
- S. Mazzotti: Geodesy and present-day deformation in France

12:00 – 13:30 Lunch Break

13:30 – 14:50 Technical Session 2 "Advances in probabilistic seismic hazard assessment and testing"
Chair: C. Martin & K. Manchuel

- D. Baumont: Constraining seismicity parameters in PSHA application using strain rate estimates in a Bayesian framework
- Y. Fukushima: *IAEA PFDHA benchmark: Feedback (preliminary title)*

14:50 – 15:10 Coffee Break

- N. Abrahamson: *Non-ergodic ground-motion models, uncertainty propagation (preliminary title)*
- G. Weatherill: Considerations and implications of testing recent probabilistic seismic hazard analysis in Europe using Strong and Weak Motion Observations

16:00 – 18:00 Poster Session

19:30 Social Dinner at the Grand Hôtel, 34 Bd Saint-Roch, 84000 Avignon

Day 2 – Wednesday, June 1st 2022

09:00 – 10:20 Technical Session 3 "Evaluation of seismic ground motion"
Chair: J. Douglas & C. Simon

- L. Margerin: Seismic attenuation in Europe, impact on seismology parameters
- O. Ktenidou: *High frequency attenuation proxy kappa (preliminary title)*

10:20 – 10:40 Coffee Break

- P. Traversa: Reference rock ground motion assessment
- F. Hollender: Going further in the empirical estimation of site effects using coda, ambient vibrations and true free-field signals

12:00 – 13:30 Lunch Break

13:30 – 15:30 Technical Session 4 "Numerical approaches for site-specific ground motion assessment and engineering use"
Chair: A. Pecker & I. Zentner

- V. Alvez-Fernandes: *Numerical modelling of site response and non-linear* effects *(preliminary title)*
- C. Smerzini: Advances and open challenges in engineering use of physics-based numerical simulation of earthquake ground motion
- A. Kottke: Perspectives on the application of RVT in ground motion modeling, soil response, and structural dynamics

15:40 – 16:00 Coffee Break

16:00 – 17:00 Round table discussion

1. Are we correctly capturing the epistemic uncertainties in seismic hazard assessments in low to moderate seismicity countries (e.g. France, UK), where magnitude 5+ earthquakes are rare and strong-motion networks more recent than in other regions (e.g. Italy, California and Japan)?

2. How can we decide which type of data (e.g. Vs profile measurement, installation of on-site seismometer or reassessing the earthquake catalogue) collection to prioritise for a site-specific study? And, how do we convince the client/funder to invest this money?

17:00 – 17:30 Conclusion (E. Viallet)

17:30 – 18:30 Poster session

Day 3 – Thursday, June 2nd 2022 FIELD TRIPS

7h00 Departure by bus from Novotel Avignon
8h30 – 12h30 Visit of the Cruas Power Plant

Group 1 - return to Avignon:
14h00 Arrival at Novotel Avignon (1st stop)
14h30 Arrival at Avignon TGV train station (2nd stop)

Group 2 – visit of the Le Teil trenches:
13h00 Lunch and introduction of the visit
14h00 – 16h30 Visit of the Le Teil 2019 earthquake trenches
18h00 Arrival at Novotel Avignon

Posters

Nr.1 **MANCHUEL Kévin** (EDF) - SIGMA2 - WP1 synthesis

Nr.2 **BOLLINGER Laurent** (CEA) - Testing Fault Models in Intraplate Settings: A Potential for Challenging the Seismic Hazard Assessment Inputs and Hypothesis?

In this work, focused on South-Eastern France, we confront the potentially active faults database of the French metropolitan territory with a recently published catalog of historical and instrumental seismicity. Seismicity rates are corrected for completeness biases and are then compared to the predictions of several endmember tectonic models. The rates of earthquakes predicted by the tectonic models appear six to eighteen times higher than the historical and instrumental observations.

Nr.3 **SPACEK Petr** (Masaryk University) - New seismogenic source model for the Czech Republic

Nr.4 **NAYMAN Emmanuelle** (EDF) - SIGMA2 - WP2 synthesis

Nr.5 **ITURRIETA Pablo** (GFZ) - Sharing and reproducing experiments of earthquake forecasting: designing a Floating Testing Experiment for Italy.

Testing is essential to extend our knowledge of earthquake processes and to validate seismicity forecasting models. Although the legitimacy of testing is attained through the experiment's reproducibility, this is seldom exempt from limitations. To improve current scientific practices, the Collaboratory for the Study of Earthquake Predictability (CSEP) released an open-source software, known as pyCSEP, to facilitate testing procedures and make their implementation transparent. Based on it, we designed a prospective Floating Testing Experiment for Operational Earthquake Forecasting (OEF) in Italy, which is completely open, accessible and reproducible by the scientific community and also waives the need of a complex computational architecture. With the onset of this experiment, we aim to understand the impact of key assumptions and the parameter space of short-term forecasting methods, and to validate an individual model's use in OEF.

Nr.6 **MAYOR Jessie** (EDF) - Pyrenean site effects as seen by macroseismic data

We propose to detect and map site effects in Pyrenees (southwestern France) from macroseismic data (SISFRANCE database). To reach these goals, we design isoseismals thanks to a data-driven approach which consists in estimating an average trend f of each intensity data points (IDPs) according to their closest neighbours. Then, the residual between the IDP and the resulting value of f allows to quantify the local site term. The main outcomes show that macroseismic site effects are essentially controlled by geomorphological features. In particular, we detect 7 localities that systematically stands out.

Nr.7 **MAYOR Jessie** (EDF) - Clustering and calibration of intensity prediction equations for Metropolitan France

Nr.8 **HELLER Grégoire** (IRAP) - Towards improved instrumental magnitude estimates from coda wave analysis

We present a new method to extract source parameters (and magnitude Mw) from high frequency seismic data, by correctly modelling attenuation (scattering ans intrinsic absorption) in a realistic model of Earth's lithosphere.

Nr.9 **VERGNE Jerôme** (EOST-ITES) - FRlitho3D : Building a 3D reference model of the lithosphere beneath metropolitan France

This poster will present the FRlitho3D initiative (funded ANR project 2022-2025) aiming at building reference geophysical models of the lithosphere beneath metropolitan France which is are key elements to improve seismic hazard assessment.

Nr.10 **TRAVERSA Paola** (EDF) - SIGMA2 - WP3 synthesis

Nr.11 **KTENIDOU Olga-Joan** (National Observatory of Athens) - Improving signal usability at higher frequencies through noise modeling - Is one man's trash another man's treasure?

Any kind of spectral analysis relies on a judgment of seismic signal quality. Usually we compute the signal-to-noise ratio (SNR) and reject data where it is low, typically penalizing higher frequencies. The recent technique of Pikoulis et al. (2020) stochastically models the noise spectrum so as to improve the signal spectrum and render it usable at frequencies higher than before. We demonstrate the efficacy of this noise-modeling technique over the traditional

noise-avoiding one by computing kappa for recorded and simulated data. We render data down to SNR=1 usable without relying on any particular assumptions, even under unusual noise conditions/peaks.

Nr.12 **GIROUX Bernard** (INRS-ÉTÉ) - Robust quantitative in situ estimation of seismic attenuation

We propose workflow to quantify the seismic attenuation using vertical seismic profile data acquired in shallow geotechnical boreholes. The main objective is to produce near-surface profiles for the damping coefficient. This processing flow is based on an innovative approach to correct geometrical spreading and on two techniques to estimate the seismic quality factor.

Nr.13 **LEHMANN Fanny** - First calibration of the physics-based ground motion model of the 2019 Mw4.9 Le Teil earthquake

The 2019 Mw earthquake that occurred at Le Teil village was recorded by 17 stations of 3-component accelerometers, within an area of 50km around the epicenter (French Accelerometric Network). We used these records to calibrate the numerical simulation. The seismological P- and S-wave speed profiles used result from a 3D weighted average model for Metropolitan France. In addition, the topography was included in the spatial discretization. A good agreement between synthetic and recorded time histories was found, despite the simplicity of the geological and source model.

Nr.14 **RAMADAN Fadel** (INGV) - Vertical-to-horizontal ground-motion scaling for acceleration response spectra in France

The work introduces a correction factor of an existing Vertical-to-Horizontal ground motion model to be applied to the French shallow crustal events. The corrective coefficient is derived by the analysis of the residuals and is effective at distances <15 Km and in the magnitude range [3-5.2]. The work also has a special consideration for a recent event (Montelimar) in which the observed vertical ground motion has been remarkably high.

Nr.15 **LANZANO Giovanni** (INGV) - Identification of reference rock sites in Italy

The goal of this work is the assessment of reference rock site ground motion levels in Italy. We identify 116 reference rock stations and model the generic-to-reference ground motion scaling factors. We improve the predictions of rock ground motion for site response analyses and other engineering applications.

Nr.16 **BAHRAMPOURI Mahdi** (UCLA) - Applicability of the NGA-West2 Damping Scaling Factors to Ground Motions Recorded in France

Nr.17 **SUNG Karen** (UC BERKELEY)

Nr.18 **SIMON Cyril** (EDF) - SIGMA2 - WP4 synthesis

Nr.19 **BEDR Samir** (CEREMA) - A NEW GEOTECHNICAL DATABASE FOR DYNAMIC SOIL PROPERTIES - Considering Resonant Column and Cyclic Triaxial Tests performed in France

Dynamic soil properties are key parameters for seismic site analysis. These properties can be expressed in terms of variation of normalized equivalent shear modulus (Geq/G_0), damping ratio (D) and normalized excess pore water pressure (Δu/p') with the single amplitude shear strain (γ_SA). These properties can be measured using laboratory tests or in situ tests. These tests, which are expensive and difficult to perform, are often archived in different formats that do not facilitate their use and interpretation for further analysis. This poster presents the work accomplished in the framework of SIGMA2 project by EDF and Cerema, devoted to collecting French experimental data from Resonant Column (RC) and cyclic Triaxial tests (CTX) performed by EDF and Cerema over the last 40 years. It accompanies the collection of the collected data that were homogeneously grouped and structured in a database useful to: 1) provide future statistical analysis on the variability of the physical variables describing the soils tested and of the results obtained, 2) establish correlations among relevant parameters, 3) deduce analytical predictions equations and 4) compare between analytical predictions related to other databases already published in literature. The level of completeness of the here-proposed database and the possibility to use it jointly with other already-existing databases, open plenty of perspectives concerning the definition of the G_eq/G_0, D and Δu/p' curves as function of γ_SA. Next steps of the work will be dedicated to further analysis devoted to the quantification of the uncertainties affecting the dynamic soil properties.

Nr.20 **KORRES Michail** (EDF) – Coupled 3D physics-based simulations for seismic source-to-structure response: Application to the Kashiwazaki-Kariwa nuclear power plant

The influence of several parameters (source, geology, SSI approach) of the large-scale simulation problem and their impact on structural response were examined. The geological profile has an important influence on both site and structural response. A SEM-FEM weak coupling approach based on the domain reduction method (DRM) was tested towards traditional SSI approaches (FEM - plane wave, BEM-FEM). The DRM generates a higher response compared to simplified engineering approaches.

Nr.21 **PRACHAR Ivan** (IP consult) - GIS Database - a useful tool for evaluating nuclear power plant sites

GIS Database - respectively Geoscience information databases were compiled for both Czech nuclear power plants (ETE and EDU) and also for the ETE and EDU region. These databases contain both information or maps from publicly available WMS portals and the results of investigations (drilling, geophysical measurements, trenching, geological mapping, etc.) in the near region and at the site of the nuclear power plant. This information can be freely combined, analyzed and presented.

Nr.22 **GRENDAS Ioannis** (CEA) - Can site effects be estimated with respect to a distant reference station? Performance of the spectral factorization of coda waves.

In recent years, the knowledge of the Site Amplification Factor (SAF), constitutes a significant objective in approaching the real Seismic Hazard at a target site. This poster presents an application of a new approach in estimation of the Site Amplification Factor, with respect to a distant reference (rock) station. By this approach the restricted criterion of the adjacent stations (target and reference) of the commonly used Standard Spectral Ratio (SSR) technique (Borcherdt, 1970), is relaxed. This new technique is based on the Spectral Ratio of the apparent Source Time Functions (STF) (including SAF effect) of an earthquake at both target and reference site. The apparent STF computation is achieved by the application of the single record analysis of Spectral Factorization Method (SFC), on the coda wave part, as analytically introduced by Sèbe et al., (2018). SAFs results of this approach, for specific stations in France and Greece, are presented here, in comparison with the corresponding SAFs computed by SSR and Generalized Inversion Technique (GIT) applications.

Nr.23 **RISCHETTE Pauline** (CEA) - Qualification of SmartSolo nodes for optimizing the characterization of the site conditions of the French permanent broadband network stations (RLBP)

The characterization of the seismological stations of the RAP and RLBP networks has long been conducted using broadband seismometers (Güralp CMG6TD or Lennartz LE-3D/5s). The use of nodes (DTCC SmartSolo), faster to install and deployable in larger numbers, would allow the optimization and acceleration of characterization campaigns. The study presented here was performed in order to compare the performance of these different sensors. This comparison was carried out using measurements realized in several contexts: during huddle tests, where the similarity of the ambient noise recordings is analyzed, by AVA and H/V processing from acquisitions in real conditions using pairs of SmartSolo nodes and Güralp CMG6TDs in colocation at each measurement point, and by tests to study the coupling of the nodes. The results obtained show that it is quite feasible to use nodes for AVA measurements. However, for H/V measurements, we recommend at this stage to continue using conventional seismometers in low-noise contexts.

Nr.24 **BUSCETTI Margaux** (CEA) - RESIF RAP and RLBP database of Earthquake Ground Motion in Mainland France: 2019-2021 update

This poster presents the update of the RESIF RAP and RLPB database for mainland France (initial implementation by Traversa et al. 2020), now covering the period 1996-2021. The database includes RESIF stations records of earthquakes with local magnitude 3.0-5.2, occurred between 1996 and 2021 in mainland France and neighboring countries. While previous versions of the database were built based on ObsPy libraries, the 2019-2021 update was performed using the stream2segment package (Zaccarelli et al. 2019). This tool allows to automate the segment downloading and to avoid possible fdsn errors related to large volume of data download, or requests performed over plurals services. The poster shortly presents the data download and processing parameters that were used, the statistical analysis of the collected data and the estimate of Vs30 metadata at each RESIF station using topographic slope proxy (Wald and Allen 2007) when no direct measure was available. The V&V process performed over the whole database is briefly summarized as well.

Nr.25 **ZENTNER Irmela** (EDF) - SIGMA2 - WP5 synthesis

Nr.26 **SAINT-MARD Ludivine** (EDF) - BPT-model applied to the Moyenne Durance Fault

In PSHA calcul, the earthquake occurrence's is modeled by a Poissonian assumption. However this assumption is not realistic for characteristic and maximal earthquakes. We propose to explore non-poissonian model, especially the Brownian Passage Time model. To assess the interest to use it in a low-to-moderate seismic area such as France, we apply the BPT-model on one of the most seismic and characterized fault in France: the Moyenne Durance Fault.

Nr.27 **GALLAHUE Molly** (Northwestern University) - Why do standard hazard maps overpredict shaking in France, California, and elsewhere?

Seismologists have recently begun assessing how well PSHA models and corresponding maps forecast the shaking that actually occurs. Salditch et al. (2020) found that current PSHA maps for California appear to overpredict shaking relative to the California Historical Intensity Mapping Project (CHIMP) dataset of the maximum observed shaking from the largest California earthquakes between 1857 and 2019. Qualitatively similar results have been obtained in France, Italy, and Japan. We explore several factors that could contribute to the overprediction and examine their effects on hazard maps.

Nr.28 **LACOUR Maxime** (UC Berkeley) - Efficient non-ergodic hazard calculation with epistemic uncertainty for areal sources

Nr.29 **SENFAUTE Gloria** (EDF) - SIGMA2 - WP6 synthesis

Nr.30 **FASAN Marco** (University of Trieste) - Development of macroseismic Intensity-based fragility functions

Nr.31 **MASSON Frédéric** (EOST) - The Alceste project

Nr.32 **ZENTNER Irmela** (EDF) - Innovations and challenges in seismic risk assessment for NPP addresses by METIS project

Acknowledgement

We would like to thank all the SIGMA-2 project team for their involvement in the project:

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WP1: Kévin MANCHUEL & Laurent BOLLINGER
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WP4 : Cyril SIMON & Evelyne FOERSTER
WP5: Irmela ZENTNER & Norm ABRAHAMSON
WP6: Gloria SENFAUTE & Julien BERGER

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