RÉSEAU ACCÉLÉROMÉTRIQUE PERMANENT
FRENCH ACCELEROMETRIC NETWORK

RAP newsletter
Second Semester 2019 – Issue 29

We are testing this new form of the RAP newsletter for the second time. You will find short articles on the main scientific and technical news that punctuate the life of the network, regarding the study of earthquake hazard and risk in France. The content presented is written by many people, all of whom are involved in the RAP. If you wish, you can now submit content for the next issue (**contact**). I would like to thank all contributors and we hope that you will enjoy this new edition. Have a good reading!

Projects from the 2019 scientific call of the RAP-RESIF

Last spring, the RAP opened its sixth call for scientific, research and development projects, with the support of the French Ministry of Ecology. The five selected projects will start this fall, with the aim of presenting their work at the next RAP Biennale in fall 2020. Below are some elements to present each of these projects.

Project DEVMOD – *Development of data-driven prediction models of earthquake ground motion, and implications for seismic-hazard assessment: application to RESIF RAP and RLBP dataset, and RESORCE* (partnerships ISTerre/EOST/RISAM/IRAP/ EDF/CEA).

Based on ground accelerations recorded during earthquakes in mainland France, we will exploit the capacity of artificial neural networks to predict ground motion on the territory. The obtained neural models will provide information on the coupled effects of attenuation, magnitude-related scale effect and site conditions. The use of machine learning will make it possible to test the relevance of different estimators of ground motion, and of source and site parameters with their uncertainties. These models will then be supplemented with European data in order to estimate seismic hazard in mainland France for magnitudes Mw above five.
► Contact: Celine Beauval

Project EFFTOP – *Comparison and improvement of rapid estimation techniques for topographic site amplification* (partnerships CEREMA/ISTerre).

The project is focused on new methods for rapid estimation of the topographic amplification of earthquake ground motion. These methods, that require only a limited amount of data to be applied, have a strong potential to improve the consideration of this site effect in microzonation and site-specific studies. We propose to apply the methods to several accelerometric sites of the French Riviera with different topographic characteristics. We will compare the obtained results with the available measurements and recordings. The issue of taking into account lateral and vertical soil heterogeneities in this type of estimators will also be addressed.
► Contact: Nathalie Glinsky

Project KUMA21 – *Kumamoto 2021 benchmark* (partnerships CEREMA/ISTerre/EDF/Centrale Supelec).

This project organizes and compiles French contributions to the benchmark of ground-motion blind prediction proposed by the organizing committee of the sixth ESG (Kyoto, March 2021), following the Kumamoto earthquake in Japan. The benchmark is composed of three exercises: (1) site characterization from geophysical data and construction of a velocity model; (2) simulation of weak ground motions at the target site; (3) simulation of strong ground motions including non-linearity of the site response. These three exercises will help analyzing our ability to predict correct ground motions at the target site during the Kumamoto earthquake.
► Contact: Diego Mercerat

Project ENRICA – *Towards an enhanced characterization of RAP stations: analysis of existing data and testing of new approaches* (partnerships ISTerre/CEREMA/IRSN/CEA).

This project proposes to enhance the knowledge of RAP site conditions by identifying sites with near-surface heterogeneities, as well as key observables to extract from active seismic profiles based on surface waves to characterize the spatial variability of these heterogeneities. We also propose to explore the potential of recent methods based on *P*-wave polarization to extract the *S*-wave velocity profile. Finally, we aim to capitalize on the efforts of the RAP WG Site Conditions to produce the RAP site-characterization metadata files.
► Contact: Cecile Cornou

Project INSTAL – *Assessment of the impact of station-installation conditions (accelerometric and broadband) on the high-frequency measurement of ground motion, and proposals for improving practices* (partnerships CEA-LDG/CEA-EMSI/CEA-SA2S/EDF/ISTerre/EOST/ CEREMA).

The installation conditions of the stations can have an impact on the measurement of high-frequency ground motion (soil-structure interactions generated by the anchor slab, installation depth of the sensor). High frequencies are an important issue in seismic hazard studies, it is necessary to improve the reliability of their measurement. We propose to analyze these effects through simulations and measurements on targeted sites, to evaluate the impact on the typical parameters used in hazard studies, and then to propose a guide of good practices for the installation of new stations, based on the experience feedback of international practices.
► Contact: Fabrice Hollender
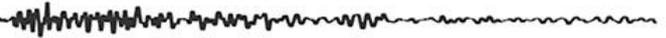
Geophysical surveys to characterize RAP site conditions

The systematic characterization of site conditions is ongoing: we are just back from a week of surveys in the Pyrenees (Figure 1). A team of 10 people (including IRSN, CEA, OSUG, OMP, and EDF) carried out measurements from 16 to 20 September 2019 at five RAP stations operated by OMP and BRGM: PYTB, PYTO, PYAD, PYLS and PYCA. When the data from this campaign will be processed (during 2020), the number of characterized RAP stations will be increased to 55 sites in metropolitan France. The acquisition plan at each station includes AVA (Ambient Vibration Arrays – passive measurements of surface waves on ambient noise) and MASW (Multi-Analysis Surface-Wave method – active measurements of surface wave propagation in vertical and horizontal polarizations). This procedure makes it possible to obtain the velocity profiles in the soil down to the seismic bedrock (down to a depth of several hundred meters if required), from which the parameter V_{S30} and the EC8 soil class are derived.

The team is now preparing the next campaign. This will take place in **Guadeloupe and Martinique**, between March 9 and April 3, 2020, thanks to the support of the MTES. We call on volunteers to carry out a week of measurements with us, the mission costs are covered by the RAP. If you are interested, do not hesitate to express your interest to the Great Organizer (**contact**).

Figure 1. A few memories from the 2019 campaign to characterize RAP site conditions in the Pyrenees, around Lourdes. Surveys organized by the RAP WG Site Conditions.

Internship topics proposed on RAP data and stations for the 2019-2020 academic year

Details on the topics can be obtained from the contacts mentioned.

Master 2 level

● Characterization of the site conditions at the RAP stations located in the West Indies – Location: ISTerre Grenoble or CEA Cadarache ▶ Contact: Fabrice Hollender

● Topographic site effect: evaluation of available methods, reliability of the seismological databases – Location: EDF Aix-en-Provence ▶ Contact: Cyril Simon

● Enhancement of the characterization of RAP stations through the development of a method based on the polarization of *P* waves – Location: ISTerre Grenoble ▶ Contact: Cecile Cornou

● Study of the site effects observed in Mayotte during the 2018-2019 seismo-volcanic crisis based on onshore seismological data – Location: BRGM Orleans ▶ Contact: Agathe Roulle

● Can twenty years of accelerometric recordings in France constrain seismic-hazard predictions for the territory? – Location: ISTerre Grenoble ▶ Contact: Celine Beauval
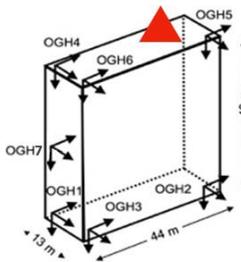
Master 1 level

● Comparison and improvement of rapid estimation techniques for topographic amplification – Location: CEREMA Sophia Antipolis ▶ Contact: Nathalie Glinsky

FOCUS

Renewal of the instrumentation of the Grenoble City Hall

The national program on permanent building instrumentation in France consists of deploying accelerometer sensors in several locations within a civil-engineering structure and recording its response to seismic loads. RAP-RESIF distributes this data in free access.

Five buildings are instrumented. These constructions each represent a category of construction that can be found on French territory. These are: the City Hall of Grenoble, a reinforced concrete tower typical of public buildings of the 1960s (Figure 2); the Earth Discovery Centre in Martinique, which is a special building built on seismic supports; the Ophite Tower of Lourdes, characteristic of social housing of the 1980s; the Prefecture of Nice, a building in charge of civil protection; and the Basse-Pointe College in northern Martinique, identical to most colleges in the Antilles. As with free-field stations, the RAP's focus has been to deploy sensitive systems with high dynamics and the ability to record low to high amplitude signals. Their use makes it possible to analyze the dynamic behavior of structures under local and/or regional earthquakes, to understand the link between their dynamics and their design, between ground motion and structural deformation, to observe soil-structure interaction, and to understand non-linear phenomena that develop in the structure, in the foundation soil and/or in the soil-structure interaction.

At Grenoble City Hall, as in the other buildings, recordings are continuous and the use of ambient vibrations reveals transient phenomena that are still poorly understood, as for example between structural rigidity (or resonance frequency) and external air temperature (Figure 3). These continuous recordings make it possible to obtain continuous 4D imagery of structures and to reveal particular dynamic behaviors, but also to develop strategies for monitoring of the integrity of structures (Structural Health Monitoring), including their natural fluctuations in order to avoid false alarms about their safety. High-performance methods, based on interferometry and deconvolution between the top and bottom of the building, can be deployed and provide information on the dynamics of the structure, but also on its non-linear response to low levels of deformation (Figure 4). These methods require a perfect synchronization of the instruments. Because it was the first instrumented in a feasibility phase, the instrumentation at Grenoble City Hall was composed of independent stations, not perfectly synchronized.

← *Figure 2. New instrumentation of the Grenoble City Hall building. The vectors indicate the position of the accelerometer sensors and the red triangle indicates the position of the Campbell weather station. @ P. Gueguen*

For these reasons, the RAP-Alps wanted to modify and modernize this instrumentation. The installation of sensors only at the top and bottom of the building limited the analysis of the structure's response in-between floors, and we had only a partial representation of its behavior. The independence of the sensors and digitizers did not allow us to have a detailed representation of the observed variations, either under earthquakes or under external forcing. The modernization (Figure 2) therefore consisted of (1) renovating the current system, by replacing the old digitizers with new-generation digitizers to synchronize all sensors; (2) installing a multi-parameter Campbell weather station at the top of the structure, synchronized with vibration records for fine analysis of correlations between structure response and atmospheric parameters; (3) adding a sensor in the intermediate floors.

This operation was supported by the Labex OSUG@2020 and RESIF. It is effective since February 2019. The installation was carried out with the support of the technical services of Grenoble City Hall (Guy Coll) and the ISTerre team (Benjamin Vial, Mickael Langlais, Philippe Gueguen, Isabelle Douste-Bacque, Ariana Astorga).
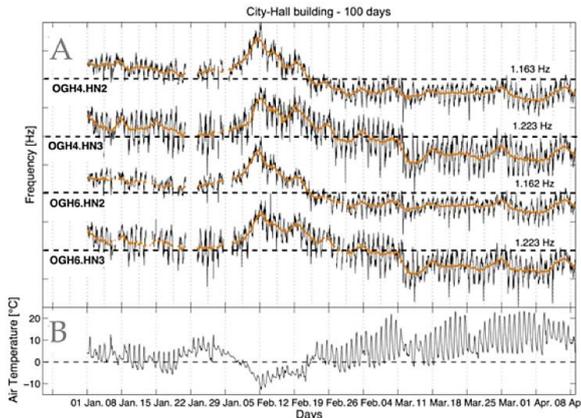
← *Figure 3. Example of the effect of temperature on the dynamic response (resonance frequency, A) of the Grenoble City Hall. The temperature series in B corresponds to a period of extreme cold during winter 2012 (from Gueguen et al. 2017).*

Figure 4. Example of wave → propagation between the top and bottom of the Grenoble City Hall, computed by seismic interferometry, for the Ubaye earthquakes of 2012 and 2014. The propagation time delay indicates a non-linear effect (change in the building response depending on the level of seismic loads). @ P. Gueguen
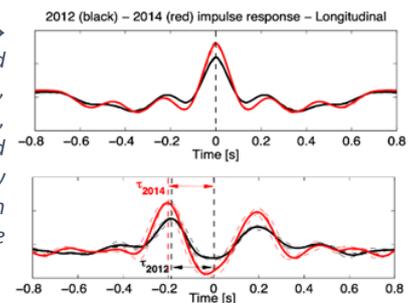
References
● Guéguen P., Langlais M., Garambois S., Voisin C., and Douste-Bacqué I. (2017). How sensitive are site effects and building response to extreme cold temperature? The case of the Grenoble's (France) City Hall building. Bulletin of Earthquake Engineering, 15(3), 889-906. doi: 10.1007/s10518-016-9995-3
● Guéguen P., Johnson P., and Roux P. (2016). Nonlinear dynamics induced in a structure by seismic and atmospheric loading. Journal of the Acoustical Society of America, 40(1). doi: 10.1121/1.4958990

Short news

Info 1 – Renewal of station MILA – The RAP has a new continuous station in **Mayotte**, operated by BRGM. The station MILA has been transmitting its continuous data since May 21, 2019 (**see the station sheet HERE**). Located in Iloni, it is installed on weathered rocks likely to amplify ground motion. The site response is to be compared with the one at the YTMZ station (**see the station sheet HERE**), located in Mamoudzou and installed on harder rock.

▶ An example of earthquake (M_L 5.0) recorded at MILA
▶ Same earthquake recorded at YTMZ

Info 2 – Data access – Find useful links for accessing RAP data and information to be provided when you use RAP data in your publications
ON THIS PAGE.

Info 3 – Latest scientific publications – You can find the list of publications 1998-2019 using RAP data **ON THIS PAGE**.

Info 4 – PhD thesis – Kelner, Maelle (2018). Analyse des processus de glissements gravitaires sous-marins par une approche géophysique, géotechnique et expérimentale : cas de la pente continentale de Nice. PhD thesis, University Cote d'Azur, 325 pages. **More information**.

Agenda

● **EPOS Seismology Workshop 2019, ORFEUS Annual Observatory Meeting and Workshop, EMSC General Assembly**, Grenoble, October 7-10, 2019. Web

● **7th International Colloquium on Historical Earthquakes & Paleoseismology Studies**, Barcelona, November 4-6, 2019. Web

● **4èmes Rencontres Scientifiques et Techniques RESIF**, Biarritz, November 12-14, 2019. Web