Quality Improvement of the French Permanent Broadband Stations with Shallow Posthole Installations

To cite this version:
Jerôme Vergne, Hélène Pauchet, Mickael Bonnin, El-Madani Aissaoui, Luigi Ardito, et al.. Quality Improvement of the French Permanent Broadband Stations with Shallow Posthole Installations. EGU General Assembly 2019, Apr 2019, Vienne, Austria. 2019. hal-02275873

HAL Id: hal-02275873
https://hal.archives-ouvertes.fr/hal-02275873
Submitted on 3 Sep 2019

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1) The French permanent broadband network (RESIF-RLBP)

Within the framework of the RESIF (Réseau seismologique et géodésique français) research infrastructure, a major extension of the French permanent broadband network (RLBP) has been initiated in 2011 with the objective to reach ~90 stations by 2020. This network will allow a more homogeneous coverage of the French territory, encompassing a wide variety of seismic and geological environments.

For each new potential site a test was conducted for ~3 weeks, usually burying the broadband sensor at 5-20m depth directly in the ground or within a light temporary trench (Fig. 1.2).

For the final setup, we tested various hosting infrastructures at three prototype sites and decided to promote the installation of a posthole sensor in a steel-cased shallow borehole, 5-20m deep, for all the sites in open areas (Fig. 1.3). 43 stations have already been installed this way and have been operating for 5-20 months.

Here we compare the ambient noise level for these 43 shallow borehole installations with the one recorded during the test period (section 2) and at other permanent stations installed in other kind of infrastructures (shallow vault, tunnel, cars… section 3).

2) Shallow borehole installation much better than site testing!

On average, at periods longer than 5s, surface tests show a clearer daily variability of the ambient noise level with higher noise around 12:00 UTC. These diurnal effects are usually linked to daily temperature variations mostly seen on the Z comp. (Donnay et al., 2010) and daily local sand/pressure variations, inducing tilt at sensor depth, mostly seen on the H comp. (De Angelis and Bodin, 2012). After the shallow borehole installation, these daily effects have been strongly reduced on the H comp. and almost completely removed on the Z comp.

Comparison of the median value of the noise power spectral density (PSD) between the surface test and the final borehole installation shows a general improvement on both vertical and horizontal components and for frequencies higher than 60s and periods smaller than 10s (H comp.) – 20 (Z comp.) dB at long periods but can sometimes reach more than 40dB. Note that on the Z comp. we observe almost no dispersion among the 43 sites of the median PSD at periods longer than 10s.

3) Shallow borehole stations better than most other permanent stations!

Final installation inside steel-cased borehole does also improve the high frequency noise level. Two observations illustrate this improvement.

1) we notice a change in the detection distribution (see S7A-L7A between 2-8 Hz) at surface tests and shallow borehole. The distribution of shallow borehole is generally sharper and slightly shifted towards higher detection rates.

2) we generally measure a ~5 dB decrease of the seismic energy between 5 and 20 Hz on Z, E and N components. This decrease is more significant for sites located on sedimentary geological environments.

4) Put sand around your posthole sensor and take care of the cable!

The installation method of the downhole sensor is an important factor in quality. In particular the presence of sand (Fig. 4.1) around the sensor can reduce noise by 20 dB on horizontal components than other configurations. Noise standard deviations are dramatically lower for borehole stations than for other stations for the Z component at LF and generally significantly lower at HF and LF for all the components.

The difference in standard deviations at HF mostly originate from the site selection procedure organized at the national level.

References

- Seismological Society of America (2015). RLBP stations: Controlled Experiments, Observations, and Implications ».

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* RESIF is a national Research Infrastructure, recognized as such by the French Ministry of Higher Education and Research, RESIF is managed by the RESIF Consortium, composed of 10 Research institutes (CNRS, Université de Bordeaux, Université Paris Dauphine, Université de Nantes, Université de Strasbourg, Université de Toulouse, Université Grenoble Alpes, Université de la Méditerranée, Université de Lyon, Université de Poitiers), and the French Ministry of Ecology, Sustainable Development and Energy.