Ambient noise tomography of western France: the VIBRIS project
Some preliminary tests

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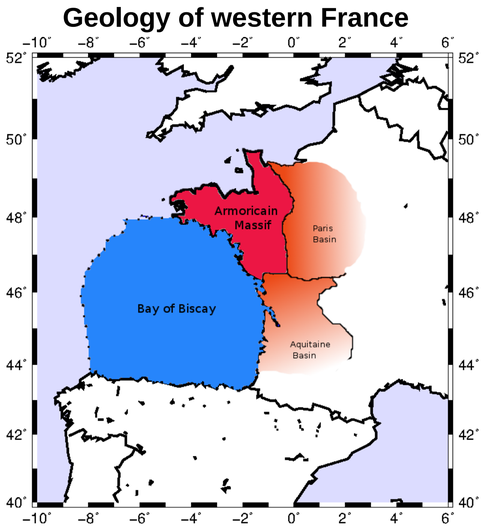
Abstract : Noise correlation functions are now widely used to infer the properties of the medium located between two sensors. However, the ability of getting reliable measurements is related to the local noise characteristics recorded at each station and also depends on how the noise is processed. We present here observations on noise correlation functions obtained using different processing schemes from a sub-array of three broad-band sensors located in western France. This study is a first step towards a surface wave ambient noise tomography of the Armoricain Massif and the Bay of Biscay as a part of the VIBRIS and PYROPE projects.

1 Geodynamical setting / questions

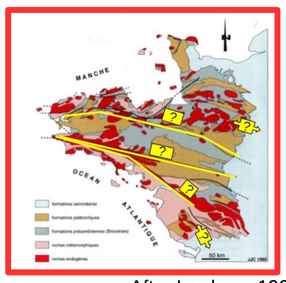
Geology of western France



➔ **Topography of the crust-mantle boundary ?**

• **Crustal & mantle velocities ?**

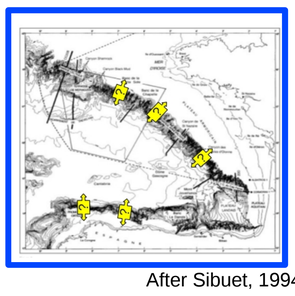
Armoricain massif



After Lardeux, 1996

- Old massif (>300Ma)
- 2 variscan shear zones
- Seismically active (Mw~2-3)

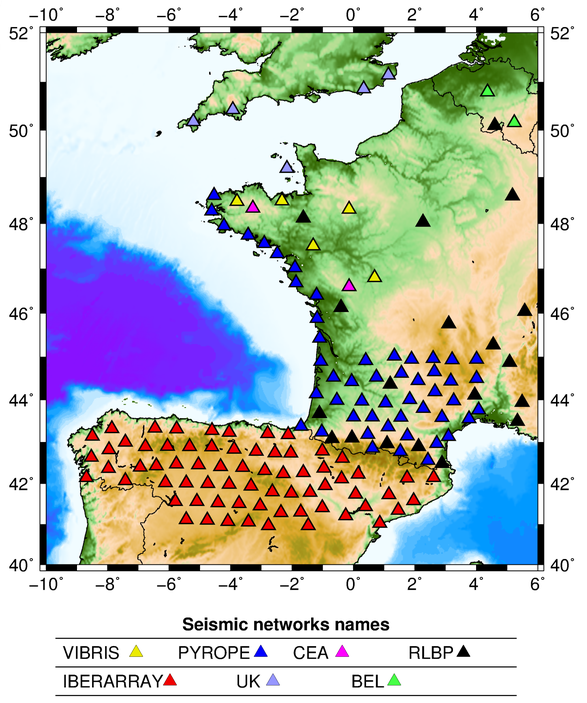
Bay of Biscay



After Sibuet, 1994

- Oceanic basin of mesozoic age (~ 136 Ma)
- High bathymetry
- Related to building of Pyrenean belt

2 Broad band seismic array



• Temporary network :

PYROPE (2011-2013) : 40
VIBRIS (2012-2013) : 5
IBERRAY (2011-2012) : 50

• Permanent network

CEA (FR) : 2
BGS (UK) : 4
ORB (BEL) : 2
RLBP (FR) : 16

100 stations
> 1 year of data

3 Processing / methodology

Merge to regular day

Test :
no single gap > 5 sec

High pass filter (fc=0,01Hz)

Demean
Detrend
Remove instrument response

Decimate 4Hz
Band-pass

Temporal whitening
(1-bit norm.)

Spectral whitening

Band pass

per day

CCGN
Cross Correlation geom. Normalized

$$\frac{\sum_{\tau=\tau_0}^{\tau_0+T} s_1(t+\tau)s_2(\tau)}{\sqrt{\sum_{\tau=\tau_0}^{\tau_0+T} s_1(t+\tau)^2 \sum_{\tau=\tau_0}^{\tau_0+T} s_2(\tau)^2}}$$

Max.lag = 800 sec

PCC
Phase Cross Correlation

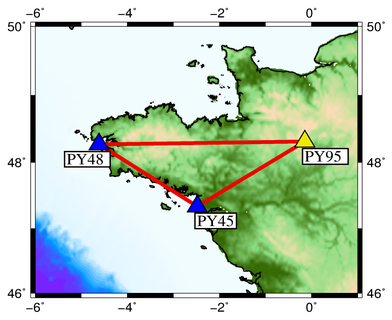
$$\frac{1}{2N}\sum_{\tau=\tau_0}^{\tau_0+T}\{|e^{i\phi(t+\tau)}+e^{i\psi(\tau)}|-|e^{i\phi(t+\tau)}-e^{i\psi(\tau)}|\}$$

Max.lag = 800 sec

Temporal linear stacking over time

4 Noise correlation function

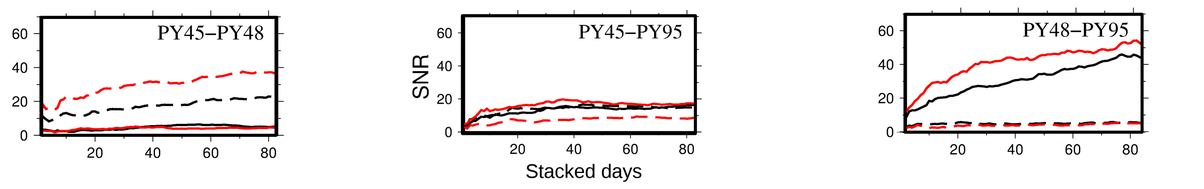
3 stations
(vertical component only)
3 months
summer 2012



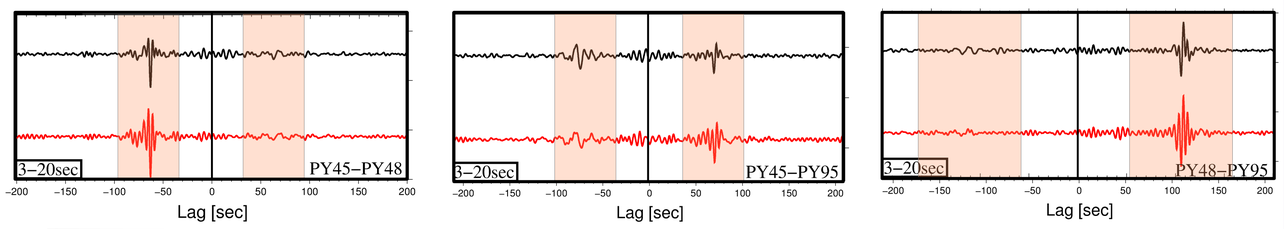
- convergence to a coherent, propagative, and robust signal.
- the "NW PCC" technique provides slightly better results than the "WW CCGN" technique. This improvement needs to be quantified.
- sources of noise highly inhomogeneous in space and frequency. Local site effects (versus global) need to be characterized.
- presence of a frequency dependent and transient near zero-lag signal that needs to be characterized.

Comparison between two processing techniques (3-20 seconds period band)

NW PCC
No temporal, no spectral whitening + Phase Cross Correlation (Schimmel, 1999)



WW CCGN
Temporal, spectral whitening + Cross Correlation Geometrically Normalized

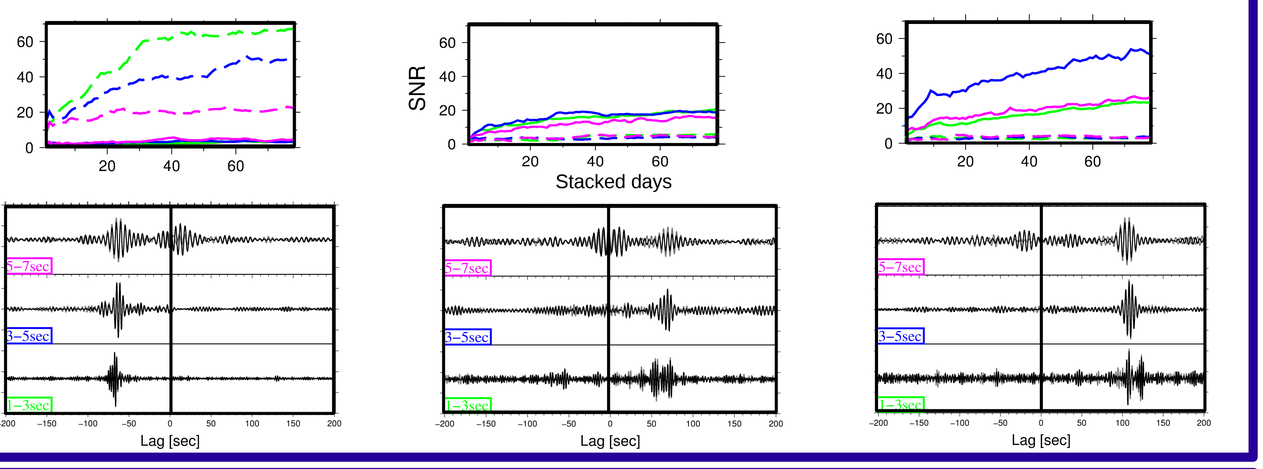


– causal part

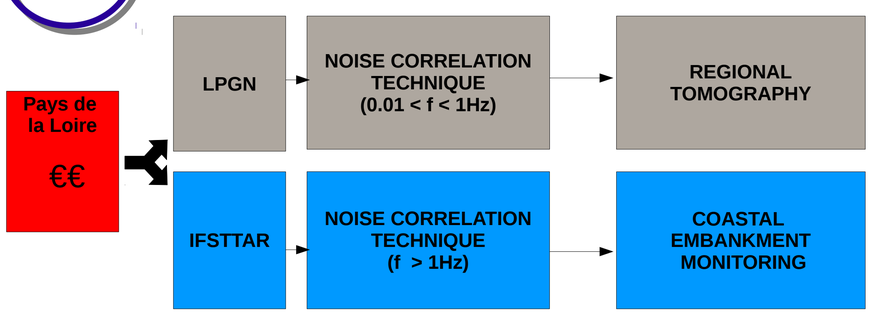
– – anticausal part

signal window used to compute signal to noise ratio

Frequency dependence analysis using Phase Cross Correlation



5 VIBRIS project



Methods : seismic field data acquisition and processing, small scale modeling, numerical simulation.

Conclusion : In these preliminary tests, we show that the phase cross correlation technique whithout whitening provides at least as good results than the geometrically normalized cross correlation technique with whitening. Thus, we conclude that it is possible to avoid strong non linear operation of normalization for processing this particular dataset. We also observe that the ambient noise recorded in western France mainly comes from the Northern Atlantic during summer, as shown by assymmetry of the noise cross correlation functions at all the three station pairs. Moreover, we observe that the speed of convergence varies as a function of the station pair and is frequency dependent in the period range between 1 and 7 seconds. These particular observations can be due to local effects that need to be characterized in a further study.

References : Lardeux, 1996, Guide geologique de la Bretagne, Ed. Masson.
Schimmel, 1999, Phase cross-correlation: design, comparisons, and applications, Bull.seism.Soc.Am, 89 ,1366-1378.
Sibuet J.C., Monti S., Pautot G., 1994. New bathymetric map of the Bay of Biscaye. C.R.Acad. Sc., 318, II,615-625.

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