PhD thesis project 2015 UEB (accord cadre UEB – DGA)

Title : **T-wave 3D modeling**
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DGA research field: Environnement et Géosciences

The *Laboratoire Domaines Océaniques* is deploying since 2002 arrays of autonomous hydrophones in the Indian and Atlantic oceans for monitoring hydroacousitc waves in the 0 to 120 Hz bandwidth, which corresponds to the oceanic noise generated by geologic (earthquakes, volcanic eruptions), biologic (baleen whales) and human (shipping) activities, as well as other natural sources (sea state, ice cracks and tremors). The laboratory holds several years of continuous recording of these oceanic noises, related, in particular, to the geologic activity of seafloor spreading ridges (e.g. Goslin et al. 2012).

The interpretation of acoustic waves generated by the sub-marine seismicity (0-40hz), known as T-waves, is still in its early age. Even though by simple triangulation, sources can be precisely located and are assumed to be matching the earthquake epicenters, many major questions are still fully open : for example, about the size of the seismic/acoustic conversion zone, the role of the sea-bottom topography in the generation and propagation of T-waves, the link between earthquake magnitude and the recorded acoustic amplitude, the link between geologic (tectonic vs magmatic) processes causing an earthquake and the shape of the hydroacoustic signal, etc.

One way to address these outstanding questions is to solve numerically the forward problem of generating and propagating T-waves. An earlier thesis (Balanche et al. 2009) treated the problem of the conversion of seismic to acoustic waves in the simple case of a flat interface between the oceanic crust and the water column. The main result was that earthquakes producing shear waves are more prone to produce T-waves that will propagate in the water column over long distances. A later thesis (Jamet et al. 2013) treated the problem with a 2D modeling method using spectral elements (SPECFEM-2D). This approach, tested on a large magnitude earthquake in the Central Atlantic, recorded both on land (localization, focal mechanism) and at sea by 4 hydrophones, predicts very similar T-waves to those recorded. It takes into account the physical properties of the water column and the oceanic crust, the geometry of the crust/water interface and the characteristics of the source, and emphasizes the important role of the seafloor topography and of the focal mechanism (i.e. radiation pattern of the source) in the generation and propagation of T-waves.

The proposed thesis will pursue this earlier work with a 3D approach (SPECFEM-3D, developed at the Laboratoire de Mécanique et d'Acoustique de Marseille). Going 3D is justified by the important role of the uneven topography in epicentral areas along seafloor spreading ridges and submarine faults, which invalidates the hypothesis that all seismic rays from the source follow flat trajectories. Using well-known seismic events, the work will investigate the appropriate dimension of the model (2.5D vs 3D) and identify the most influent parameters. Another field to explore is the effects of long-distance propagation (> 500 km) and thus of lateral variation in the acoustic properties of the water column.

Balanche A., **Guennou C.**, Goslin J., Mazoyer C., 2009. Generation of hydroacoustic signals by oceanic sub-seafloor earthquakes : a mechanical model, *Geophys. J. Int., 177 : 476-480.*

Goslin, J., **Perrot, J., Royer, J.-Y.**, Martin, C., Lourenço, N., Luis, Dziak, R.P., Matsumoto, H., Haxel, J., Fowler, M.J., Fox, C.G. & S. Bazin, 2012. Spatio-temporal distribution of the seismicity along the Mid-Atlantic Ridge north of the Azores from hydroacoustic data: insights into seismogenic processes in a ridge-hotspot context, *Geochem. Geophys. Geosys.*, Q02010, doi:10.1029/2011GC003828.

Jamet, G., **Guennou, C., Guillon, L. & Royer, J.-Y.**, 2013. T-wave generation and propagation: a comparison between data and spectral element modeling, *J. Acoust. Soc. Am.*, 134 : 3376-3385, 10.1121/1.4818902.