Sisprobe workshop at Schmidt Institute of Physics of the Earth – 17 June 2019

Noise-based passive seismic methods have gained much popularity in crustal seismology studies in recent years. These methods are based on the proportionality of the Green's function with the cross-correlated noise seismograms recorded in a diffuse seismic wavefield. An attractive feature of this approach is that no active or controlled seismic sources are required.

The goal of Sisprobe – a company based in Grenoble, France – is to use these new ambient noise methods in industrial problems, including exploration for minerals and hydrocarbons, seismic hazard assessments and monitoring of oil/gas fields and geotechnical applications.

In exploration for mineral and hydrocarbon deposits, small self-contained autonomous seismic sensor nodes are deployed over the area of interest. These nodes are quick to deploy – a few hundred can easily be deployed each day by a small team – and can record continuous seismic data for a period of a few weeks. The signal consists of ambient vibrations from ocean/land interaction, wind, railways, road traffic and other human activities, traveling mainly as surface waves. No active seismic sources (vibroseis trucks, explosives, etc) are required! Each seismic sensor is mathematically transformed into a virtual seismic source, which is used to measure the dispersion of each frequency of surface waves. An inversion with these dispersion curves then results in a 3D S-wave velocity model of the sub-surface. Standard seismic sensor nodes allow imaging down to a few kilometers, with resolution proportional to depth. The use of low-frequency (broadband) sensors allows imaging down to the MoHo interface.

The same ambient noise surface wave tomography approach can be used to produce an S-wave velocity profile for the ground beneath critical sites (e.g. nuclear, chemical plants, etc.) which is important for reliable seismic hazard assessments.

Body waves can also be recovered from the ambient noise recorded by surface sensors. Both surface and body waves (direct and scattered) can be used to monitor the cap-rock above a hydrocarbon deposit which is being extracted or stimulated.

In our presentations, Prof Nikolai Shapiro (Institut de Physique du Globe de Paris) will introduce the concept of ambient noise Greens function retrieval and summarise the theoretical foundations – the "noise cross-correlation theorem" that establish equivalence between the impulsive response of the media and the correlation of random signals (noise) – and pay attention to the conditions necessary for practical aplications, illustrating this with examples of tomography and monitoring from crustal seismology. Dr Richard Lynch (Sisprobe) will then give some case studies and examples of industrial applications,

including exploration in hard rock settings for mineral deposits, imaging in geotechnical settings and monitoring of a gas field.