Noise Interferometry Challenges for Subsurface Imaging

by

Arie Verdel (Delft University of Technology) and Kees Wapenaar (Delft University of Technology)

In conventional seismic exploration, the construction of a detailed subsurface image requires high-quality reflection recordings from a dense grid of seismic sources. Such data acquisition is costly. At the same time, seismic data is increasingly used in time-lapse applications such as for the monitoring of reservoir fluid flow during the production of hydrocarbons or for the surveillance of sequestered CO2. The total cost of such studies is for a large part determined by the size of the total time-lapse data volume.

From recent publications on the use of correlation properties of ambient noise it appeared that it is possible to construct the subsurface impulse response (Green's function) between two sensors at the surface of the Earth, purely from the continuous recordings of the permanent natural vibrations of the Earth's surface. The required data processing, cross-correlation and summation, is often referred to as 'seismic interferometry'. It exploits the diffusive character of the natural background noise in the subsurface and it provides the means to perform imaging of the subsurface without the use of any manmade sources. It thus could provide an interesting alternative for conventional seismic: it could become a cheap, fast, accurate, easy and environmentally friendly alternative for controlled sources. Combined with the recent developments in recording technology, ambient noise interferometry allows the use of dense semi-permanent grids of high-quality, cheap broadband sensors: several studies have demonstrated that time-lapse measurements obtained with noise interferometry are indeed very robust. An important spin-off of interferometry processing is the insight that large cost savings could be achieved in active-source data acquisition because the same data quality can be obtained with fewer sources and/or receivers.

In this paper, data processing aspects and challenges are discussed for the use of seismic noise interferometry for subsurface imaging.