**Seismic interferometry: turning noise into signal**

Lecturer: Kees Wapenaar

**Course description**

Seismic interferometry is the process of generating new seismic responses by crosscorrelating seismic observations at different receiver locations. A first version of this principle was derived in 1968 by Claerbout, who showed that the reflection response of a horizontally layered medium can be synthesized from the autocorrelation of its transmission response. This amazing result implies that, when a natural noise source in the Earth's subsurface emits waves to the surface, passive measurements of the noise at the surface can be transformed into the reflection response of the Earth's subsurface. Later Claerbout conjectured for the 3-D situation that ‘by crosscorrelating noise traces recorded at two locations on the surface, we can construct the wave field that would be recorded at one of the locations if there was a source at the other’. Schuster argued that a similar principle applies to crosscorrelations of traces in seismic shot records and introduced the principle of interferometric imaging, i.e., forming an image of the subsurface from crosscorrelated seismic traces.

In this course we first discuss the theory of seismic interferometry for 3-D inhomogeneous media. Starting with Green’s theorem, we will derive a number of relations that form the basis for seismic interferometry (amongst others these relations prove Claerbout’s conjecture) and interferometric imaging. Next we discuss a number of applications, like passive reflection seismics (useful for monitoring), improving sparse data sets and interferometric imaging for different geometries. Apart from applications in exploration, seismic interferometry has potential applications in deep seismics and global seismology. The ability to create virtual sources at every seismological station in solid-earth seismology would allow increased illumination of the target area and, consequently, reflection images with increased resolution.

3D passive subsurface imaging is not restricted to ambient seismic noise. We will discuss developments that are underway to retrieve virtual diffusive electromagnetic data from magneto-telluric noise and virtual ground-penetrating radar data from extraterrestrial electromagnetic noise. Cross-correlating seismic with electromagnetic noise observations may result in virtual electroseismic responses, with the potential of obtaining the subsurface’s poroelastic parameters. We will discuss the generalization of the theory for a wider class of linear equations, which allows the retrieval of impulse responses (Green’s functions) from noise correlations in systems ranging from quantum mechanics to mechanical structures like buildings and bridges. In the coming years there are many new applications to be expected in the field of extracting information from ambient noise.

**About the lecturer**

Kees Wapenaar is professor of Applied Geophysics at Delft University of Technology since 1999 and SEG Editor 2007-2009. He received an MSc in 1981 and a PhD in 1986, both in Applied Physics in Delft. From 1986 until 1999 he was associate professor and one of the project leaders of the Delphi consortium (a project on seismic imaging and characterization). His main research interests are wave theory and its applications in geophysical imaging and characterization, multi-component seismics and seismic interferometry. He published one book and 99 journal papers on these subjects. His research in the field of seismic interferometry started in 2002. He co-edited a supplement of Geophysics (2006) and a special issue of Geophysical Prospecting (2008) on interferometry and related subjects. He co-organized several workshops and special sessions at SEG-, AGU-, EAGE- and SEGJ-conventions. He received SEG's Best Paper in Geophysics Award (2006) and an Honorable Mention for Best Paper in The Leading Edge (2006), both for papers on seismic interferometry.