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Seismic interferometry by crosscorrelation and by multidimensional deconvolution: a systematic comparison

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In recent years, seismic interferometry (or Green's function retrieval) has led to many applications in seismology (exploration, regional and global), underwater acoustics and ultrasonics. One of the explanations for this broad interest lies in the simplicity of the methodology. In passive data applications a simple crosscorrelation of responses at two receivers gives the impulse response (Green's function) at one receiver as if there were a source at the position of the other. In controlled-source applications the procedure is similar, except that it involves in addition a summation along the sources.

It has also been recognized that the simple crosscorrelation approach has its limitations. From the various theoretical models it follows that there are a number of underlying assumptions for retrieving the Green's function by crosscorrelation. The most important assumptions are that the medium is lossless and that the waves are equipartitioned. In heuristic terms the latter condition means that the receivers are illuminated isotropically from all directions, which is for example achieved when the sources are regularly distributed along a closed surface, the sources are mutually uncorrelated and their power spectra are identical. Despite the fact that in practical situations these conditions are at most only partly fulfilled, the results of seismic interferometry are generally quite robust, but the retrieved amplitudes are unreliable and the results are often blurred by artifacts.

Several researchers have proposed to address some of the shortcomings by replacing the correlation process by deconvolution. In most cases the employed deconvolution procedure is essentially 1-D (i.e., trace-by-trace deconvolution). This compensates the anelastic losses, but it does not account for the anisotropic illumination of the receivers. To obtain more accurate results, seismic interferometry by deconvolution should acknowledge the 3-D nature of the seismic wave field. Hence, from a theoretical point of view, the trace-by-trace process should be replaced by a full 3-D wave field deconvolution process. Interferometry by multidimensional deconvolution is more accurate than the trace-by-trace correlation and deconvolution approaches but the processing is more involved. In the presentation we will give a systematic analysis of seismic interferometry by crosscorrelation versus multi-dimensional deconvolution and discuss applications of both approaches.